Podcast 003 - Fuel

Welcome back to another talk, this time a more technical one about a system on the Boeing 737 NG. Today we will be chatting about the fuel system on the aircraft.

We will start off by discussing the system architecture on a basic level, and then move onto the controls and indications and finally finish up with a review about refuelling and how to de fuel and also the ground transfer of fuel when it is occasionally required.

The first thing to mention is that there are 3 fuel tanks on the B737NG, - 2 wing tanks known as number 1 and 2 respectively. Each tank has a surge tank where overflow fuel is collected and drained back into their respective main tanks. We also have a centre tank which lies between the wing roots within the fuselage area and extends out into the wing structure. As a rough approximation, tanks 1&2 can hold about 3.9T each and the centre tank about 13.1T – dependant on density, making a total useable fuel quantity of about 20T (which of course is ample to get from the UK to the South of Turkey, even in the middle of a hot summer's night…)

There are water scavenge ejector pumps in each tank which remove water to prevent corrosion. On the underside of each wing, there are fuel tank vents (located near the wing tips). These are required to maintain a small positive air pressure to the fuel in all tanks – useful to prevent a vacuum forming when the fuel gets consumed.

Each wing tank has 2 fuel pumps, a Forward and an Aft pump. These are powered by the two separate AC transfers busses for redundancy, so each wing tank has 2 independent sources of electric power for its fuel pumps. Confusingly, the wing tank pumps are actually located in the centre tank but draw their fuel from the forward and aft sections of the wing tanks respectively.

The centre tank also has 2 pumps, a left and a right pump. These pumps operate at a higher output pressure, ensuring the centre tank fuel gets used first to aid load distribution and wing loading promoting aircraft structural integrity - and thus better fuel economy. It is not possible to gravity or suction feed from the centre tank, due to the tank's location.

A limitation in the FCOM states intentional dry running of a centre tank pump (low pressure light) is prohibited. This minimises the risk of explosion and to avoid the pump from dry running. Some aircraft have an auto shut off system that will shut off the associated Centre tank pump 15 seconds after the illumination of the LOW-PRESSURE light. This mitigates the risk, but the limitation still stands.

Whilst we're talking about FCOM limitations I should also mention that Inflight, do not reset a tripped fuel pump or fuel pump control circuit breaker. I believe this is due to the potential spark risk as you just don't know why that breaker has tripped.

The engine fuel manifolds are interconnected by means of a cross feed valve, manually selectable by the pilot on the overhead panel. This valve is controlled by a DC motor operated

from the battery bus. Thus, it is possible to feed each engine by both wing tanks by using the cross-feed valve.

Each of the 6 pumps has a pressure sensor at its output and will illuminate a LOW PRESSURE on the overhead panel if the pressure detected is below normal.
If the system detects both low pressure conditions in any of the three tanks, you'll get a MASTER CAUTION, and the SYSTEM ANNUNCIATOR FUEL.

There is another pump within the system, which cannot be manually controlled – and that is the Center Tank Fuel Scavenge Pump. As its name suggests, this pump sweeps up any remaining fuel in the centre tank. It operates when the main tank Forward pump is switched on, and it starts when the left-wing tank, is about half full. Once activated, it will run for the remainder of the flight, with no controls or indications in the flight deck.

The APU is fed from the Number 1 wing tank too, with an optionally fitted APU fuel Boost Pump. Again, there are no indications or controls that the aircraft has this optional APU fuel pump, but if not, the APU is fed by suction from the number 1 left wing tank.

Another component of the Boeing 737NG fuel system is the optionally fitted NGS, or nitrogen generation system. Simply described this system converts bleed air to nitrogen enriched air (removing the flammable oxygen to about 12%) and feeds that air into the centre tank to reduce the flammability in that tank. The system works without any pilot involvement, and as it is a secondary safety system (the fuel tanks are primarily protected by precluding ignition sources), the NGS can be inoperative and dispatchable under MEL procedures.

So that simply describes the main components and architecture of the B737 fuel system. Now we will look at controls and indications in the flight deck, and the refuelling panel.

On the overhead, there is a Fuel Control Panel, with toggle switches for the pumps, and various warning lights. As described above, each of the 6 controllable pumps has a LOW-PRESSURE light, which will come on amber when the sensor detects a below normal pump output pressure.

There is the rotary cross feed selector, controlling the cross-feed valve (linking the fuel manifolds) – a valve light, illuminating bright blue whilst in transit, and a somewhat dimmer blue once the valve is fully open.

There are 2 fuel filter bypass lights, sensing downstream of fuel manifolds. These illuminate amber if there is an impending or actual fuel filter bypass due to a contaminated filter. If the filters get clogged, As the name suggests, the fuel will just bypass the filters on its way to the engine. This is an important indication as it is telling you you could be feeding contaminated fuel to that engine and if you get this light on both sides you are looking at a land at the nearest suitable airport.

There is a fuel temperature gauge, sensing the fuel temperature in the number 1 tank. If you get into a fuel temperature low condition, this is if the temperature is approaching the limits

of either 3 degrees above the fuel freezing point or -43 degrees Celsius whichever is higher then you are in to the QRH which will direct you to increase speed, change altitude or deviate to a warmer airmass.

As an aside, max fuel temperature is 49 degrees Celsius. If fuel gets above 32 degrees, you may get problems cooling the hydraulic EMDP.

The fuel quantity is displayed in three varying formats depending on fit, and these are all on the upper display unit, showing the useable fuel in the related fuel tank. On one format Boeing have even provided a total useable fuel indication, saving your blushes as you try to add three numbers together without the use of your phone's calculator app.

There are three Amber fuel message warnings that can occur on the upper display Fuel indication:

The first one is the amber LOW alert. This will illuminate on the main tank indications when the fuel remaining in either main tank is less than 2000 pounds, or 907. Kgs. (This is an option, and some aircraft the LOW alert will trigger at 1000lbs)

You could also get an Amber CONFIG alert. This will only be on the centre tank fuel indication display and will illuminate if the centre tank fuel quantity is greater than 726 kgs (1600lbs) and both centre tank fuel pumps are producing low or no pressure. Ie basically a wrong configuration. This warning is inhibited below 363 kgs (800lbs).

The last warning possible is the amber IMBAL alert. This will occur on either of the main tank fuel displays and there is no prize of a weekend off in the summer season for guessing that this indicates a fuel imbalance. It will display in amber, on the lower side when the main tanks Differ in quantity by 1000lbs or 453kgs. Just as an aside, this IMBAL alert is inhibited by the arguably more important, fuel LOW alert.

Finally, we will discuss the fuelling process and the general principle of how to balance and occasionally defuel the aircraft on the ground.

There are no gravity fuelling ports, so fuelling occurs by connecting a fuel hose to the fuelling receptacle, located within the fuelling panel under the right wing. Unless you are exceptionally tall or can persuade your first officer or Captain to sit on your shoulders, you won't be able to reach this, so thankfully the fueller will have a little ladder for him/her to connect up and dial in your requested fuel amount. Your only problem now, is how to tell your tired fueller in the middle of the night that you want 8.7 tonnes of fuel, where English (or Welsh) is not their mother tongue. A good felt tip pen is recommended for writing on the palm of your hand.

Within the fuelling panel there are three gauges, corresponding to each tank. There is a selectable switch to control the fuelling valve in each tank, above the gauge. Corresponding to each switch is also a blue valve position light, which will illuminate when the fuelling valve switch is open, and the related tank is not full. For aircraft fuelling to occur DC power needs

to be provided for the fuelling panel, valves and gauges. This means you need to have the aircraft Battery switch ON as with the Battery switch off the Fuel power control relay is relaxed. If you needed to refuel with no AC power and a depleted battery, then you would have no quantity indication and no overfill protection.

There are six fuel measuring sticks in each main tank and 4 in the centre tank, enabling you (or hopefully an engineer) to obtain a fuel amount reading in each tank, should the gauges fail. There will be procedures in the AMM to help with this as is not an easy or everyday occurrence.

A manual defueling valve is located in the right-wing defueling station outboard of engine 2. It is opened for defueling and tank to tank transfer operations. There are detailed procedures within the AMM and possibly your ground handing manual to perform such tasks which involve the correct configuration of pumps and cross-feed selector

Thanks for being involved today and we look forward to welcoming you back on our next episode soon. Until then why not sign up to the newsletter at B737podcast.com for extra info, or simply join us on social media and keep those sectors with us going.