



Fuel



Fuel Uses

- **Fuel has several uses on a modern civil airliner:**
 - Power the engines
 - Control of the aircraft centre of gravity and mass distribution
 - Heat sinking for other systems

- The fuel system comprises of tanks, plumbing, pumps and control to facilitate these multiple uses.

Example question!

- What is fuel used for on a civil airliner?
 - a) Powering the engines, de-icing the wings, adjusting the flight trim?
 - b) De-icing the wings, adjusting the flight trim, cooling hydraulic fluid?
 - c) Powering the engines, cooling hydraulic fluid, adjusting the trim?
 - d) Powering the engines only?

What is it?

- Jet fuel is typically kerosene based (e.g. Jet A-1 the world wide standard fuel)
- Jet A-1 has a higher flash point and is less flammable than piston engine fuels (e.g. *AVGAS AViation GASoline*) making it safer to handle.
- Fuel used for international aviation generally attracts no tax (*compare with 175% tax on petrol*)

Some numbers

- A380....

MTOW ~ 570 tons

Made up of;

Plane ~280 tons

Cargo ~ 90 tons

Fuel ~ 200 tons

(320,000 litres or 70,000 gallons)

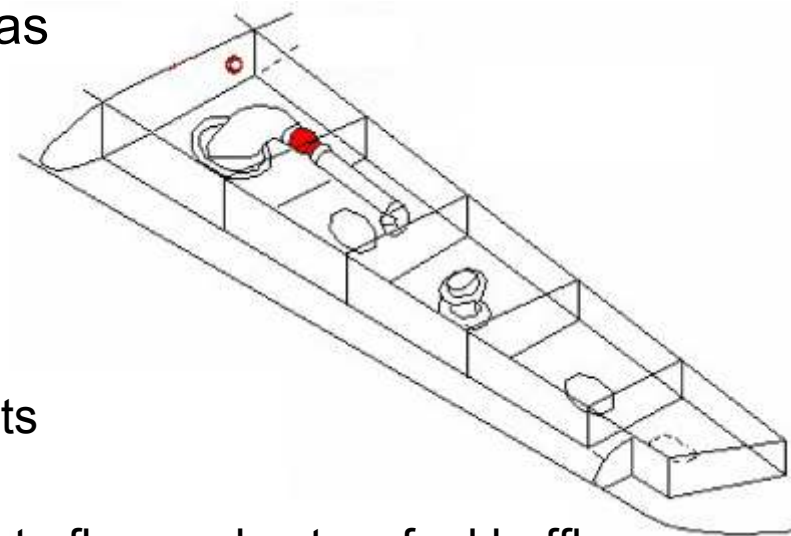
Maximum range ~ 9,500 miles

Fuel economy ~1/8 mile per gallon.



Fuel storage

- The most efficient location to store the fuel is within the wing box (referred to as the “wet wing”)
 - All joint and access panels must be suitably sealed
 - A natural tendency of the fuel to flow towards pumps located at the wing roots is essential.
 - Intermediate ribs have to allow the fuel to flow and act as fuel baffles (to prevent sloshing during manoeuvring).
 - The wet wings may extend to the fuselage centre line or end at the root ribs.
 - Provisions for protection of the tank in the case of belly landing (skid) must be made.



Fuel storage

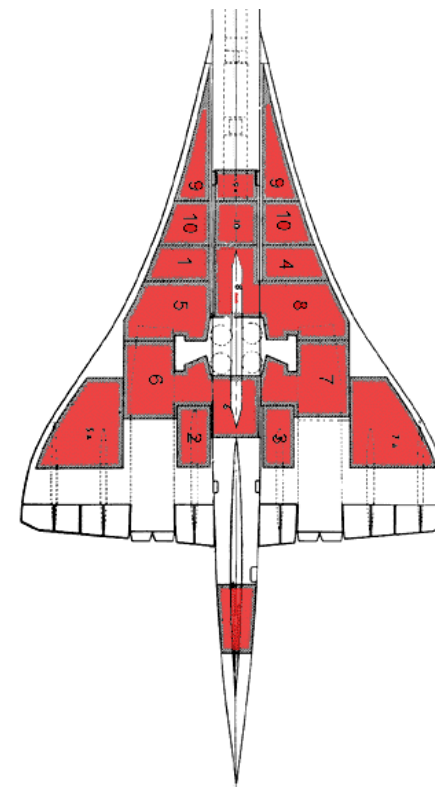
- Generally 90% of wing volume between spars and skin outer surface is usable; although this may vary from only 75% near the tip to 95% near the root.
 - Loss is made up of
 - Structure displacement : 5%
 - Expansion space (mandatory) : 2%
 - Trapped air : 1%
 - Unusable fuel : 0.5%
 - Equipment displacement : 1%
 - Sealant : 0.5%
- In the case where the fuel volume in the wing is not sufficient, fuel may be stored elsewhere
 - Cabin under floor
 - Aft fuselage or tail cone
 - Cabin tanks ahead of the fuselage pressure bulkhead
 - Wet empennage (trim tanks)



Fuel tanks



Generic civil airliner

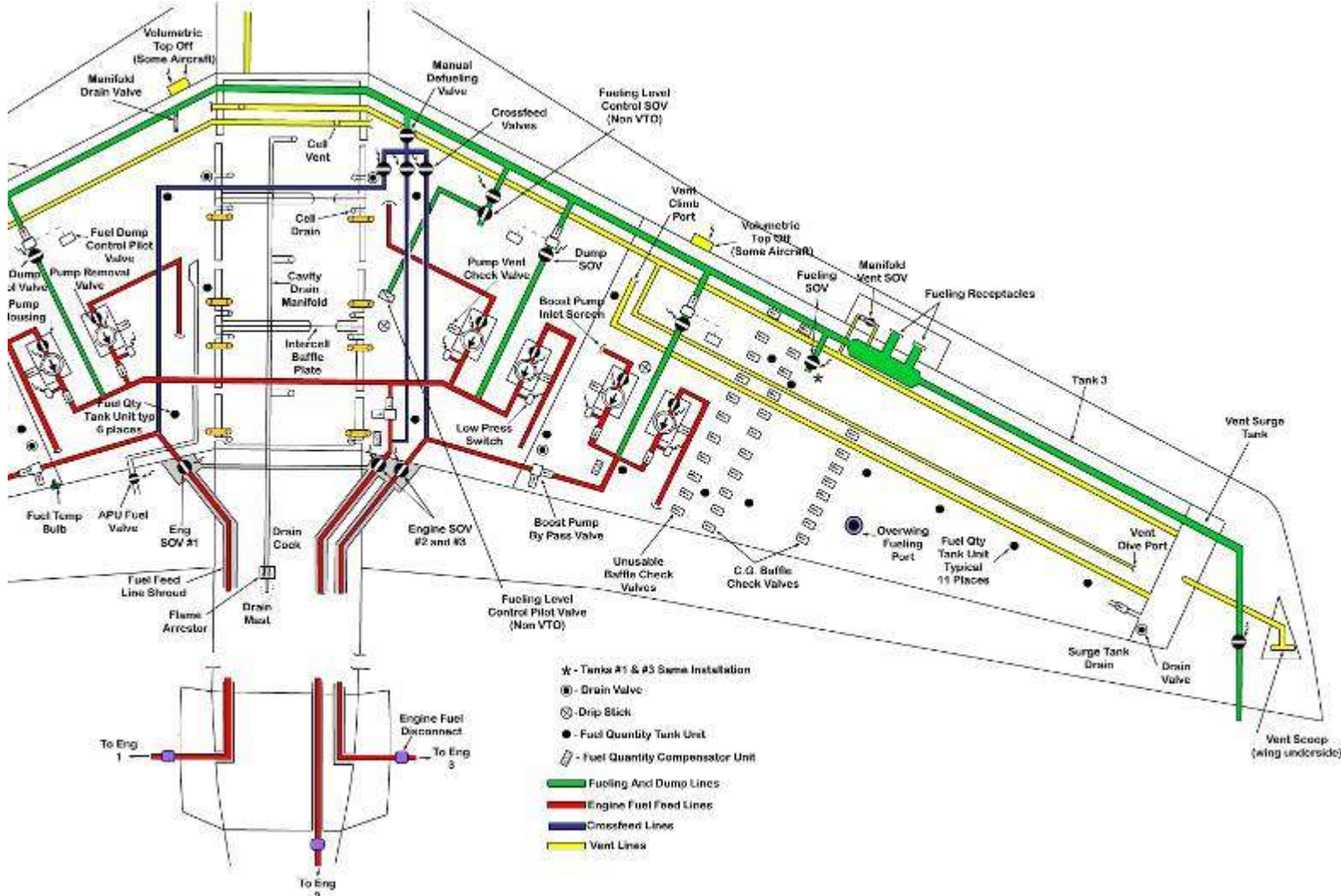


Concorde

Fuel gauging

- Since running out of fuel has dire consequences it is important to put enough in and know how much is used.
- Capacitance systems - Measure the variation of capacitance between the two concentric tubes immersed in the fuel.
- Ultra sonic systems - Measure the time of an echo from the fuel surface.
- Fuel measuring systems are referred to by their precision;
 - Class I approx. 5% accurate in-flight
 - Class II approx. 2% accurate in-flight (business and regional aircraft)
 - Class III approx. 1% accurate in-flight (long-range business and commercial aircraft); best precision today is no better than 0.5% accurate

727 fuel system



Fuel delivery

- The ideal primary delivery system is by gravity; It is simple, lightweight, cost effective and very reliable.
 - Not utilised as a primary delivery system for almost all modern transport aircraft.
- Most aircraft use powered systems;
 - Motive flow
 - It uses a small quantity of high pressure fuel provided by a mechanical pump at the engine to power a jet (ejector) pump at the wing tank.
 - Apart from the HMU at the engine, this system uses no mechanical moving parts, making it simple, low cost, and extremely reliable
 - Hydraulic/electric pumps



Re-fuelling

- Gravity fuelling is done by pouring fuel through an opening on top of the wing at around 75% wing tank span
 - This location is chosen such that it is impossible to over-fuel the aircraft.
 - Fuel brought to this level should leave a large enough “air bubble” for the proper functioning of the fuel system
- Modern aircraft also have single point pressurized refuelling capability
 - A panel typically at a wing root or under a wing allows a connection to a standard fuel nozzle from a fuelling truck
 - Pressure of 40 to 50 psi for fuelling and -8 to -3 psi for de-fuelling
 - Typical fuelling rates are about 150 Gallons per minute



Fuel Issues

- Fuel freezing
 - Water in fuel may freeze out and cause a blockage.
 - Fuel is monitored for water content and can be heated.
- Venting/inerting of the fuel tanks
 - Tanks must be vented to allow air in and out during use and re-fuelling
 - This creates 'ullage' - space above the liquid fuel filled with air and fuel vapour. At certain ratios the mixture of fuel-to-air is explosive.
 - Inerting involves using a gas, e.g. nitrogen to fill the void rather than air. Other systems use a bladder to contain the fuel.
 - The technology is costly and the general approach has been to limit ignition sources through regulation.