CPL Theory
Aircraft Systems (CSYA)

CSYA 2 – Fuel System

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3. Disclaimer

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FUEL GRADES

Fuel Grades

The types of fuel you may come across include:

- **Aviation Gasoline (AVGAS) – used for piston engines**
    1. 100/130 – coloured green
    2. 100LL (used more commonly) – coloured blue
- Aviation Turbine Fuel (AVTUR) – coloured clear or straw
- Motor Gasoline (MOGAS) – coloured red

Fuel Grades

- AVTUR should never be used in piston engines. This could cause:

    1. Warping of the cylinder and piston heads
    2. Corrosion of the exhaust valves and outlets
    3. Possible melting of the cylinders themselves

- MOGAS may be approved for specific aircraft engines but is generally not used as it is more volatile and can cause:

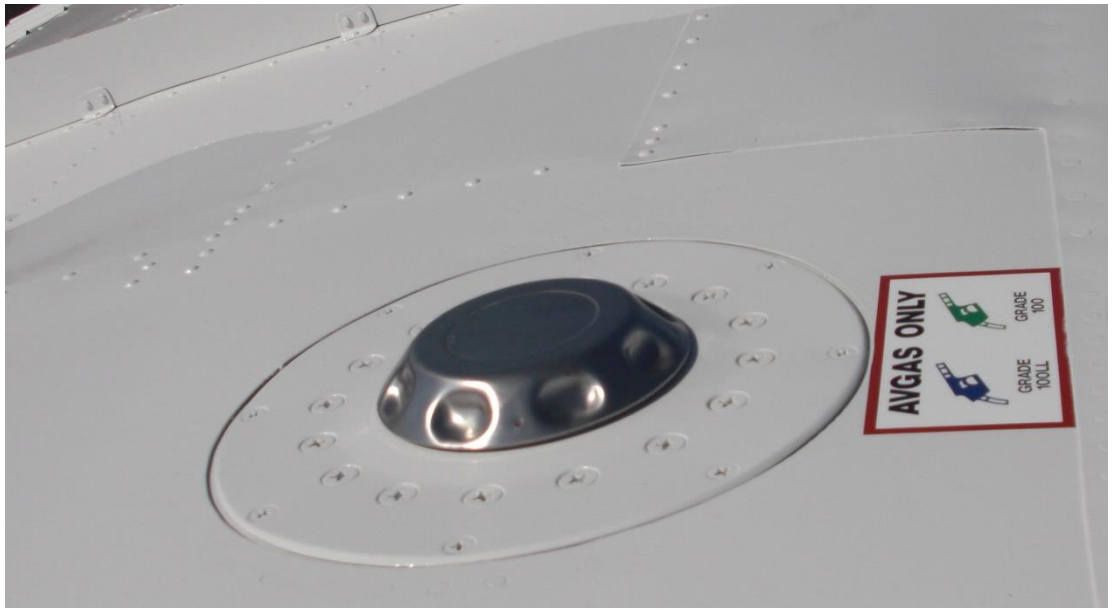
    1. Lower power output
    2. Spark plug fouling
    3. Fuel vaporisation
    4. Detonation

Fuel Grades

FUEL CONTAMINATION

Fuel Contamination

- The most common contamination is water
- It can leak into ground fuel tanks and reach aircraft tanks via the fuel trucks
- It can also enter aircraft fuel tanks through the fuel caps if not secured tightly or if the seals are worn
- Water will cause a loss of power and possibly an engine failure



Fuel Contamination

- Other types of fuel contamination include:
  - Rust
  - Sand
  - Dust
  - Micro-organisms

All have a similar effect to that of water

- Be especially cautious when fuelling from drums e.g. in the outback
- Always check the drum fuel with water detection paste and check the date of expiry (shelf life of 6 months)
- Ensure the drum is tilted and drain from the high side
- If the drum pump has no filter, use a chamois cloth to filter the fuel

REFUELLING PRIOR TO OVERNIGHT PARKING

Refuelling Prior to Overnight Parking

Advantage:

- Full tanks will ensure that as the temperature drops overnight, water will not be able to condense on the tank walls and contaminate the fuel

Disadvantages:

- As the temperature rises in the morning, the fuel will expand and some could vent from the tank, creating a fire hazard on the tarmac

- If you refuel early in the morning, the fuel will be the coldest and densest. Therefore, you will be able to fill the same tank volume with a greater quantity of fuel molecules (i.e. more fuel for your money!)

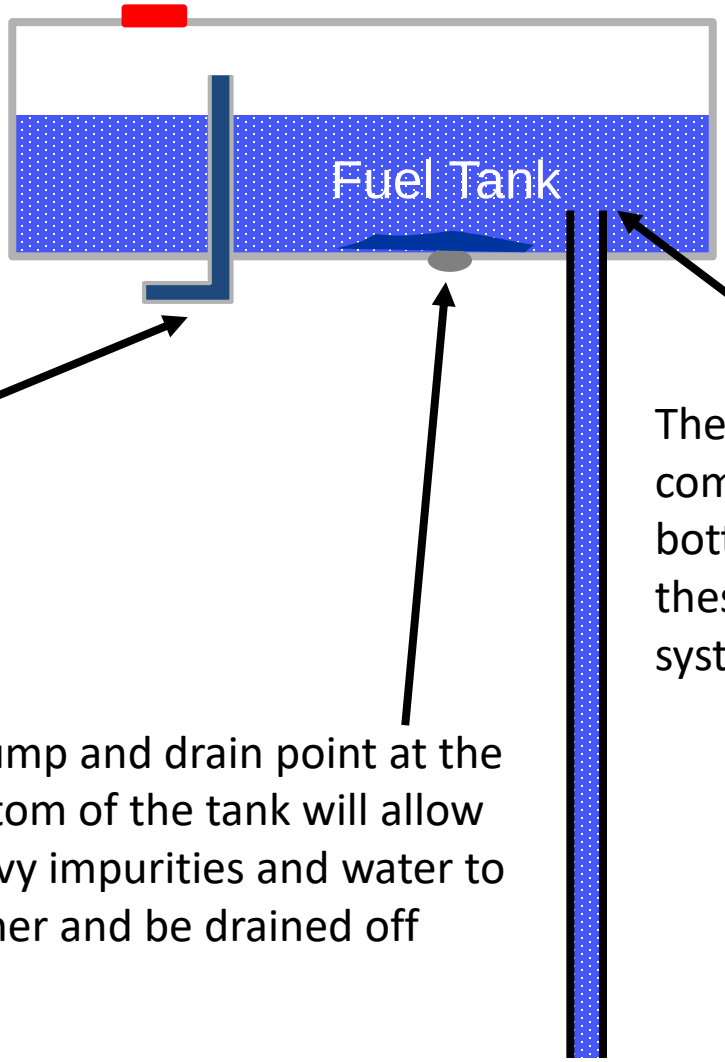
FUEL TANKS

Fuel Tanks

- Fuel is stored in fuel tanks, usually installed in the wings

- C172 Tank Capacity:
  - 56 US Gallons Total (28 USG per tank)
  - 53 US Gallons Useable Fuel

Fuel Tanks



Fuel tanks also have vents to the atmosphere so that the air pressure above the fuel in the tank remains the same as outside as altitude is changed

A sump and drain point at the bottom of the tank will allow heavy impurities and water to gather and be drained off

The fuel supply line actually commences higher than the bottom of the sump to prevent these impurities from entering the system (known as a standpipe)

Fuel Tanks

If these vents became blocked, then the reduced pressure inside the tank could cause a reduced fuel flow and even engine failure.

FUEL SELECTOR

Fuel Selector

- Allows the pilot to select the tank from which fuel will be taken
- Incorrect fuel tank selection can lead to fuel starvation and is the most likely cause of an engine failure
- For the majority of C172 Operations, the fuel selector will be on BOTH

Fuel Shut-Off Valve

- C172 also has a fuel shut-off valve (red level) used to shut off the fuel supply to the engine in an emergency e.g. engine fire
- To shut off the fuel, pull the lever all the way out

AUXILIARY FUEL PUMP

Auxiliary Fuel Pump

- The auxiliary fuel pump (electric boost pump) has 3 main uses:

  1. Prior to start to provide enough fuel pressure to prime the engine

  2. Prior to start or during flight to purge any vapour from the fuel lines

  3. In the event of a mechanical pump failure

- In some aircraft, it is also recommended that the boost pump be used for critical manoeuvres such as take-off, landing and changing tanks. This is not required in the C172

Fuel Vaporization

- The fuel system is only designed for fuel in a liquid form

- When the conditions are:

    1. High temperature

    2. Low atmospheric pressure

  the liquid fuel is able to expand in the fuel lines and may bubble to form vapour

- Because gas can expand and compress, fuel may not continue to flow through the fuel lines – this is known as **"vapour lock"** and can cause engine failure

- At **high power settings**, the fuel must travel through the fuel lines faster – this may also increase the likelihood of vaporisation

Fuel Vaporization

- **Cavitation** is when the vaporisation occurs within the fuel pump itself (usually on the inlet side where the pressure is the lowest)
- Fuel vaporisation will be indicated by a **low/fluctuating fuel pressure**
- To combat this, the **boost pump** should be turned on
- When an engine is heat-soaked (hot), it may also be difficult to start due to fuel vaporisation
- To combat this, operate the prime pump with the mixture at ICO
- This will let cool fuel from the tanks flow through the engine and cool the fuel lines, purging any vapour and reducing the chance of further vaporisation

PRIMER

Primer

- Before start, the engine must be primed (a small amount of fuel must be pumped directly into the cylinders) to aid in engine starting (particularly on cold days)

- In the C172, this is achieved through the fuel injection system

- In most light aircraft, priming is achieved through two main ways:

    1. Pumping the throttle

    2. A separate primer control

- Pulling the control out fills the primer with fuel and pushing it in delivers this fuel to the cylinder intake ports

- Note: if the primer is not locked when the engine is running, excessive fuel will be drawn through the priming line into the cylinders, which could stop the engine due to a 'rich mixture cut.'

FUEL STRAINER

Fuel Strainer

- The strainer acts as a filter, removing any impurities from the fuel as it passes down the fuel supply line

MECHANICAL FUEL PUMP

Mechanical Fuel Pump

- Operating continuously while the engine is running, the mechanical (engine-driven) fuel pump is what pumps fuel along the fuel line from the tanks

- In high-wing aircraft (C172), fuel flows via gravity through the:
  - Fuel selector
  - Auxiliary pump
  - Fuel strainer

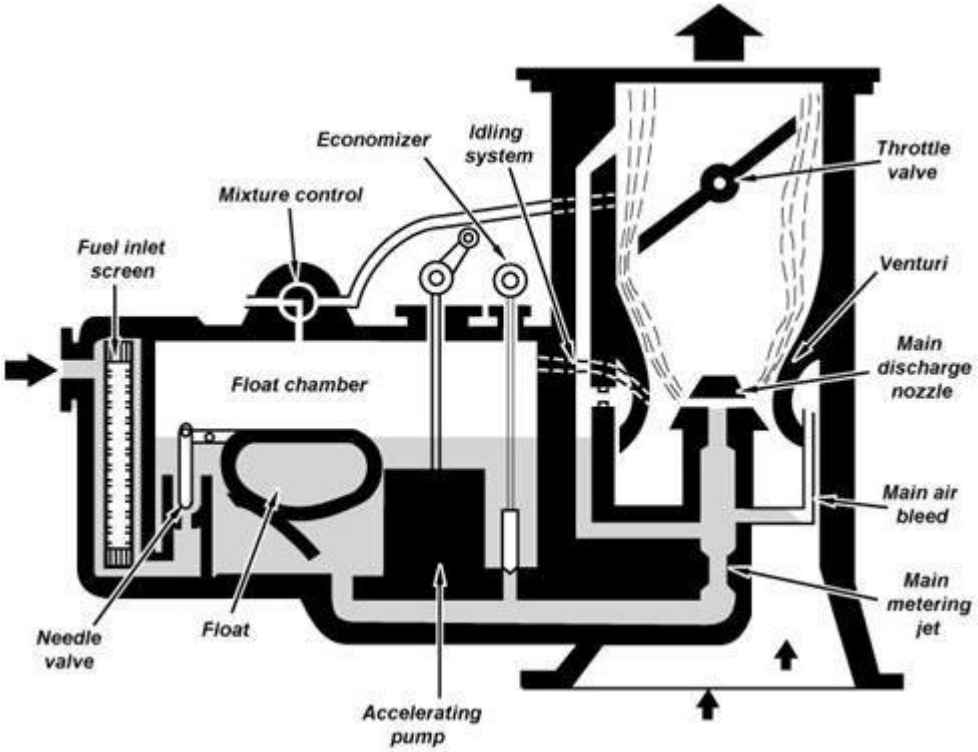
After that, the mechanical fuel pump will pump the fuel to the carburettor or fuel injection system

- In low-wing aeroplanes, where the tanks are lower than the engine, the fuel pump is also required to lift fuel to the carburettor/fuel injection system

CARBURETTOR

Carburettor

- Not fitted to CAE C172 fleet, some light aircraft have carburetted engines
- As we have seen, this is where fuel is mixed with air before delivery to the cylinders

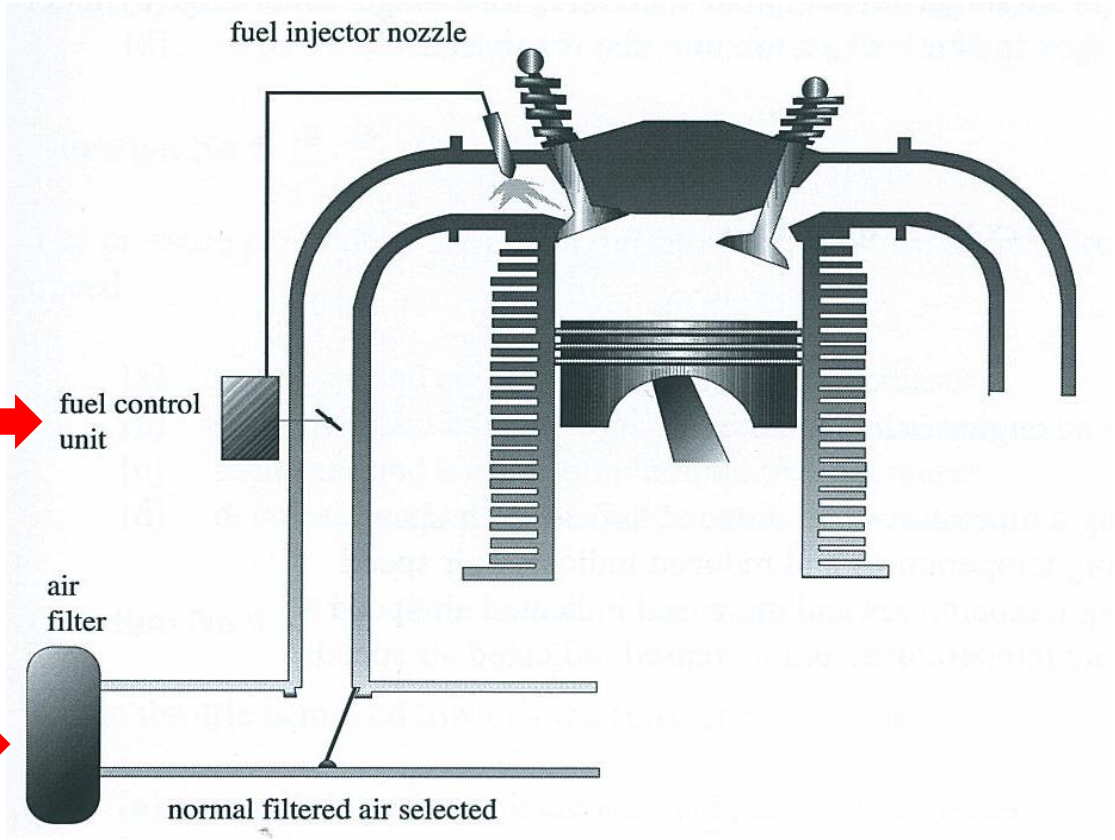


FUEL INJECTION

Fuel Injection

- CAE C172 fleet has fuel injected engines

- Instead of fuel and air mixing in a carburettor before travelling to the cylinders, fuel is directly metered into the cylinder intake valve

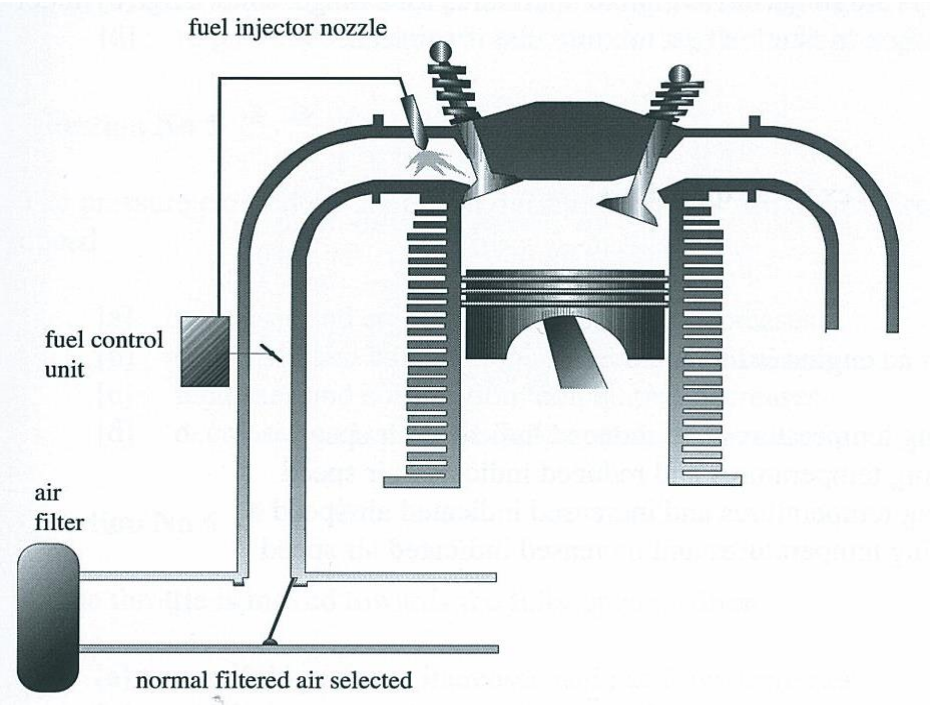


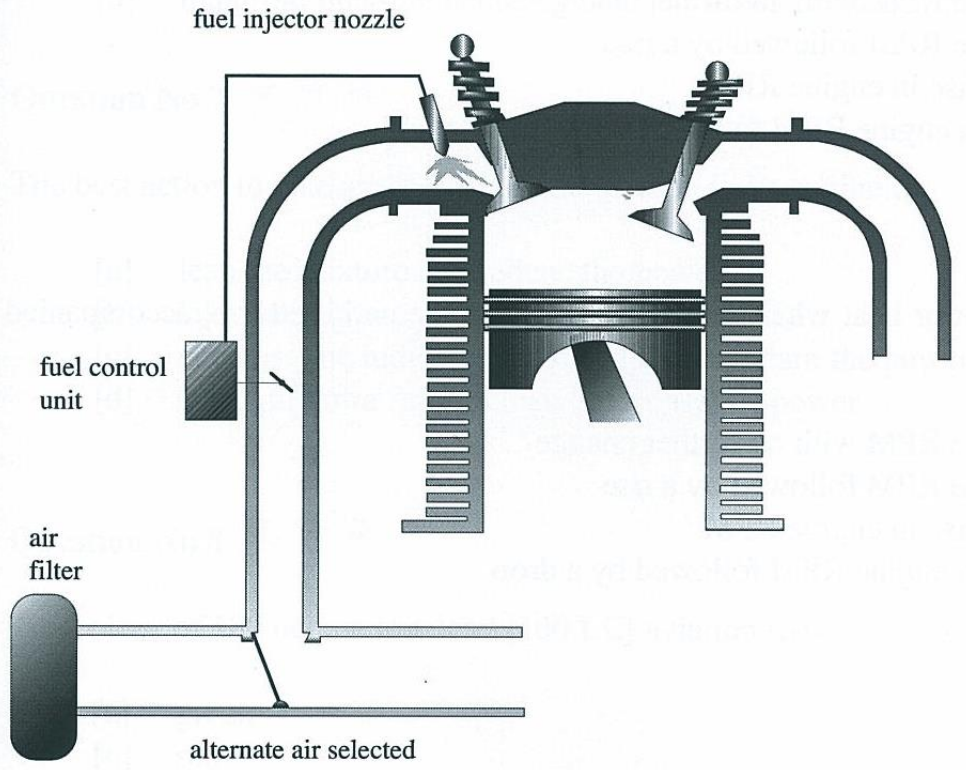
Fuel from tanks (via engine pump)

Air intake

Fuel Injection

- If the normal air intake becomes blocked, an alternate air source can be used





- Using alternate air will reduce performance slightly as the air from inside the cowling is slightly lower in pressure (but this is better than no air!)

Fuel Injection

- The basic function is as follows:

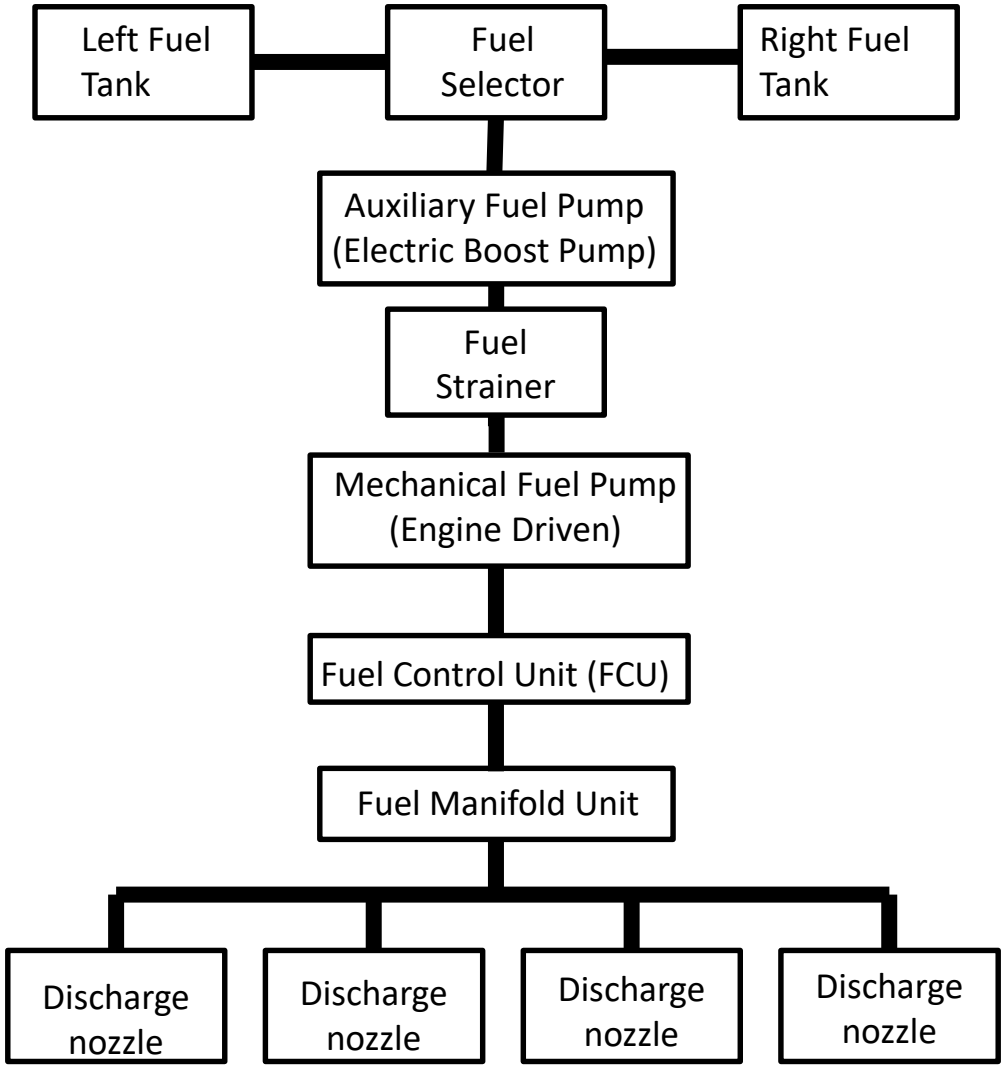
1. After flowing through the selector, auxiliary pump and strainer, the fuel is pumped to a Fuel Control Unit (FCU) via the mechanical fuel pump

2. The FCU replaces the carburettor – it meters fuel based on the mixture control setting, sending it to the Fuel Manifold Valve at a rate controlled by the throttle

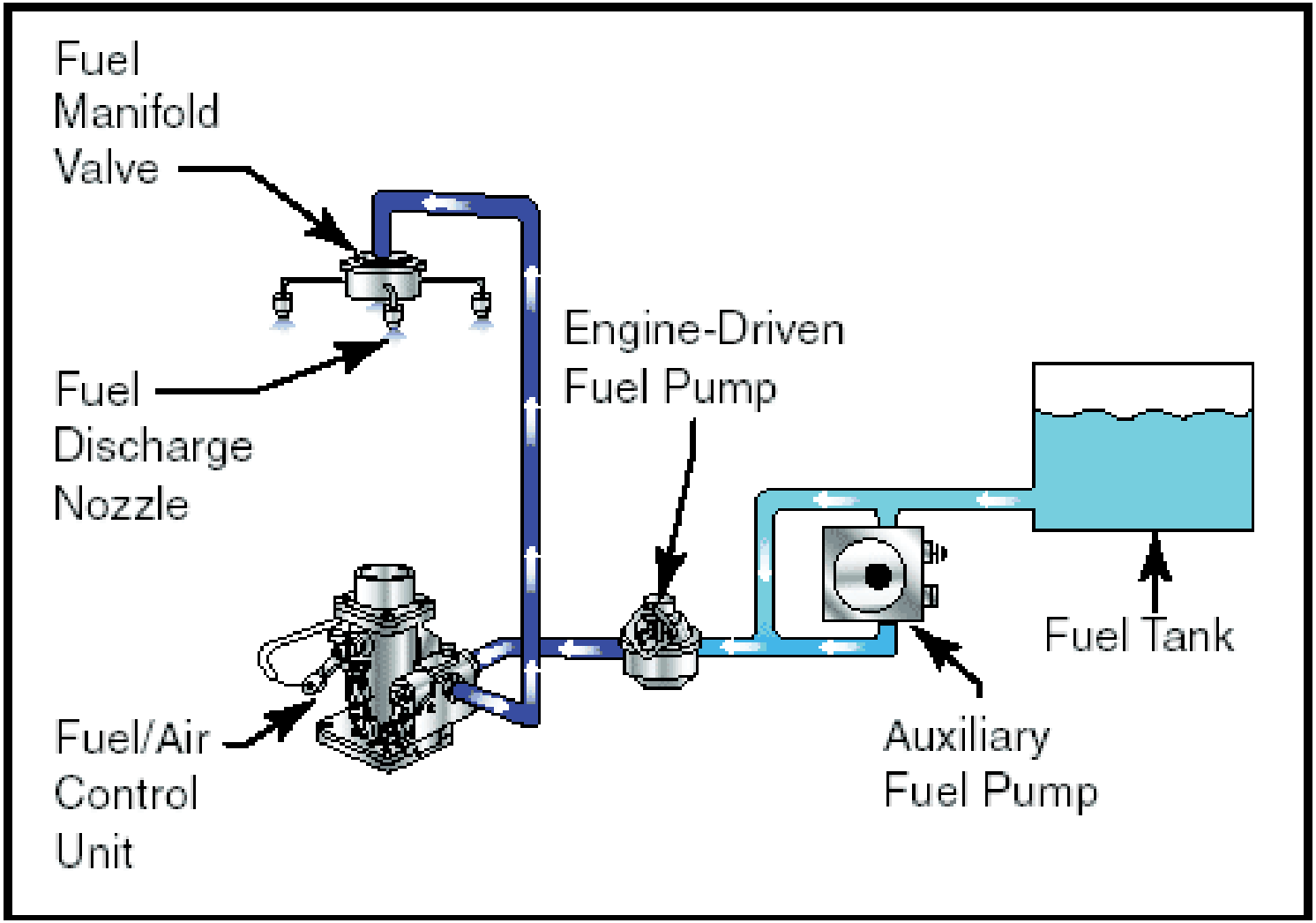
3. At the Fuel Manifold Valve (or Unit), the fuel is distributed through fuel lines to individual discharge nozzles located in each cylinder head

4. The discharge nozzles spray a fine mist of fuel directly into each cylinder intake port where it mixes with the air entering the cylinder via the intake manifold

Fuel Injection



Fuel Injection



CARBURETTORS vs. FUEL INJECTION

Fuel Injection

Advantages:

- No carburettor icing
- Better fuel flow and faster throttle response
- More precise control of mixture and better distribution to each cylinder
- Can be operated at unusual attitudes (unlike carburettors)
- Efficient for high performance engines with high fuel demands

Disadvantages:

- Hot starting difficult due to vapour locking (electric boost pump can help)
- Thin fuel lines → more susceptible to vapour lock, blockage & contamination
- More expensive and complex – carburettors are relatively cheap, simple and have few moving parts

FUEL QUANTITY GAUGES

Fuel Quantity Gauges

- Allows pilot to monitor fuel quantity
- Generally, these are not reliable (whether electric or direct) and should not be trusted, especially when the aircraft is not in straight and level flight
- A conversion card has been installed in the aircraft next to the ASI

VH-CFI 10/4/01
Fuel Calibration in litres useable.

L/H	Ind	R/H
0	0	0
27	5	33
46	10	52
69	15	74
90	20	90
102	26	102

FUEL PRESSURE GAUGE

Fuel Pressure Gauges

- Indicates the health of the fuel system

High Fuel Pressure Indication:

- A blockage in the fuel system

Low Fuel Pressure Indication:

- A lack of fuel in the system, possibly due to:
  - A leak
  - Fuel pump failure
  - Selection of a dry tank

Best action is to turn the electric boost pump on and, in the case of low fuel quantity, land ASAP

Low/Fluctuating Fuel Pressure Indication:

- Fuel vaporisation in the fuel lines