Aviation Safety

Fuel Starvation/Fuel Exhaustion

Safety Leaflet

IGA 7

The purpose of this Safety Leaflet is to make pilots aware of the potential hazards associated with the subsequent loss of power resulting from a fuel starvation/fuel exhaustion incident and also to remind them of their responsibilities with regard to ensuring that they carry adequate fuel to be able to conduct a flight safely.

There have been several accidents in Ireland over the past few years in which fuel starvation or fuel exhaustion were deemed to be either a causal or contributory factor. This problem is not unique to Ireland and it is worth noting that current figures released by the FAA have highlighted that approximately 1700 fuel related accidents occur in the USA on an annual basis. That equates to almost 5 fuel related incidents per day.

To try and understand the problem it is worth establishing what are the main causes.

Fuel starvation **occurs when the fuel supply to the engine(s) is interrupted even though there may still be useable fuel on board the aircraft.**

Fuel starvation incidents generally occur as a result of fuel mismanagement such as the result of a pilot selecting the incorrect, or empty, fuel tank during flight. In this situation it is not uncommon for there to be a delay in restarting an engine if it has been run completely dry and the selector valve is then selected to a tank containing fuel. In addition, on some aircraft types the engine may need to be primed before it can be restarted.

Fuel starvation can also happen during manoeuvers such as "side slipping" during an approach to land which, if the fuel in the tank is at a low level, can result in "un-porting" of the fuel supply pick-up as the fuel is forced away from the pick-up point due to the 'G' forces.

Fuel starvation may occur as a result of a phenomenon known as "vapour lock", however, this is more common in older aircraft fuel systems where the fuel is supplied to a carburettor by a low pressure engine driven pump which is located in the engine compartment. Vapour lock occurs due to evaporation in the fuel line between the tank and the pump which in turn enters the pump disrupting the fuel supply long enough for the float chamber in the carburettor to drain either partially or completely causing fuel starvation in the engine.

Fuel starvation may also occur as a result of fuel contamination such as water or debris making its way into the fuel lines resulting in some form of blockage or disruption in the supply.

Fuel exhaustion **occurs when there is no useable fuel remaining in the tank(s) to supply the engine(s).**

Fuel exhaustion can occur as a result of many factors such as:

- **Not having sufficient fuel onboard prior to embarking on a flight.**
- **The wind encountered reduces the ground speed below that which had been planned for and the pilot does not monitor or recalculate the fuel reserves en-route.**
- **The flight may not be able to be carried out at the altitude or flight level used during planning resulting in a higher fuel burn than had been expected.**
- **The power/mixture settings are not managed in the manner that had been used during planning resulting in a higher fuel burn than had been expected.**
- **Fuel siphoning or leaking from the tank(s) during flight such that they no longer contain the quantity of fuel that the pilot expects. Siphoning will most likely occur as a result of an un-secured fuel cap.**

Fuel starvation or exhaustion can and do occur in any phase of flight including take-off. It is worth noting, however, that the majority of fuel related accidents occur during the descent and landing phase of flight close to the intended destination and, if it occurs in the final stage of a landing, it may not afford the pilot the opportunity to successfully manage the situation.

How can a pilot ensure that he has adequate fuel to be able to carry out a flight, or series of flights, safely? This can best be achieved by applying the following basic rules or principles:

Phase of Flight	Recommended Actions
Planning	**Ensure that you carry out thorough planning to calculate how much fuel you will need for the flight using the established fuel burn rate and apply a sensible margin for safety.**
Pre-flight Inspection	**Carry out a thorough pre-flight inspection, including a physical check of both the quality and quantity of fuel on board the aircraft.** **Aircraft fuel gauges can be notoriously inaccurate so it more reliable to "dip" the tanks to establish how much fuel is onboard. However, make sure that your dipstick is calibrated to suit your aircraft type, the aircraft is parked on level ground and the fuel level has been allowed to stabilise before you dip.** **If you are refueling the aircraft prior to your flight then carry out a reconciliation between what has been delivered and what there is in the tank after refueling is completed.** **Be aware, however, of potential errors that can be caused by the need to convert from metric to imperial; metric to US; US to imperial or vice versa including from a volumetric measurement to a weight as in some aircraft.** **The best option is to make sure the tanks are full if weight and balance as well as performance limitations allow max fuel to be carried.**
Inflight	**Check that your progress along your route agrees with what you had planned.** **Carry out regular fuel checks and compare your actual fuel usage against what you had planned.** **(If there is any discrepancy in either of the above then consider diverting or carrying out a precautionary landing while you still have sufficient fuel on board).** **Consider leaning the mixture during cruise flight to reduce the fuel burn rate.** **If you need to change between fuel tanks during flight make sure that you do so in a safe flight configuration (straight and level and at a safe height) and that the selection is positive and successful.** **Work out and establish you own personal "Minimum Landing Fuel" based on the guidance given by the aircraft handbook or manual and DO NOT go below it.** **Be aware of the effect that manoeuvring the aircraft harshly can have on the fuel supply especially when the tanks are at a low fuel state.**
Landing	**If you need to change between fuel tanks prior to landing then apply the same procedure as during the inflight phase.** **Ensure that the mixture has been re-selected to maximum/rich for the approach and landing.** **Be aware of the possibility of disrupting the fuel supply should you have to "side slip" during the approach.**
After Landing	**The practice of refilling the fuel tanks at the end of the flying day not only ensures that you know how much fuel you have on board for the next flight but can also help to prevent condensation from forming in partially filled fuel tanks when an aircraft is left to stand idle for any period.**

Other Considerations

Where an aircraft is being used to carry out repetitive short sectors, such as in a flying school or club, do not rely on information passed on by a previous crew. The responsibility for ensuring that the aircraft has adequate fuel for the flight rests solely with the pilot carrying out the flight.

Remember that the fuel burn rates quoted in the aircraft manual or handbook are predicated on a new aircraft, engine and propeller. Try and establish and use a realistic fuel burn rate for your own aircraft when carrying out fuel planning.

Accurate fuel management starts with knowing exactly how much fuel is being carried at the commencement of a flight. This is easy to establish if the tanks are full, however, if the tanks are not filled to a known setting then an alternative method must be used to accurately establish the fuel quantity.

Accurate fuel management also relies on establishing a method of determining how much fuel is being burned. There are many variables that can affect the fuel burn rate such as the power setting, the effect of flying at different altitudes or levels, flying at different airspeeds, the technique used to adjust the mixture, etc. If these factors are not taken into account and managed by the pilot then your awareness or knowledge of the fuel remaining on board during flight will be reduced.

Maintaining an adequate fuel supply to the engine during flight relies on a pilot's knowledge of the aircraft fuel system and being familiar and proficient in its use.

Establishing and using appropriate procedures such as maintaining records of fuel uplifts and the fuel quantity on board after fuelling, carrying out a reconciliation after fuelling, monitoring your fuel usage in flight and being prepared to carry out inflight re-planning, where appropriate, will all lessen the possibility of you falling victim to a fuel exhaustion event.

When Things Go Wrong!

Example 1

The pilot of a private single engine aircraft made a request to the airfield fuel company for a fuel uplift of 30 litres per tank. The request was misunderstood and instead of 30 litres being added to each tank only 30 litres was added in total split between the two tanks.

The charge for the fuel was added to the aircraft owners account but he did not carry out a reconciliation of the actual fuel uplift against the fuel requested nor did he carry out a visual inspection of the fuel quantity in the tanks.

The owner then departed on a cross country flight and after approximately two hours the left fuel tank ran dry followed shortly afterwards by the right tank resulting in the engine stopping due to fuel exhaustion. The pilot carried out a forced landing into a field which resulted in the collapse of the undercarriage and damage to the engine and propeller. Thankfully there were no injuries.

Example 2

The pilot of a Cessna 172 did not obtain an adequate weather forecast prior to departing on a cross country flight following a route he had flown many times before. On departure he stated that his fuel was approximately equal to what he had carried on previous trips but on this occasion he was carrying two passengers and some luggage.

En-route he experienced a head wind of some 35 kts and approximately 15 nm short of his destination the engine stopped due to fuel exhaustion. The pilot carried out a forced landing which resulted in minor injuries to the pilot and passengers and significant damage to the aircraft.

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