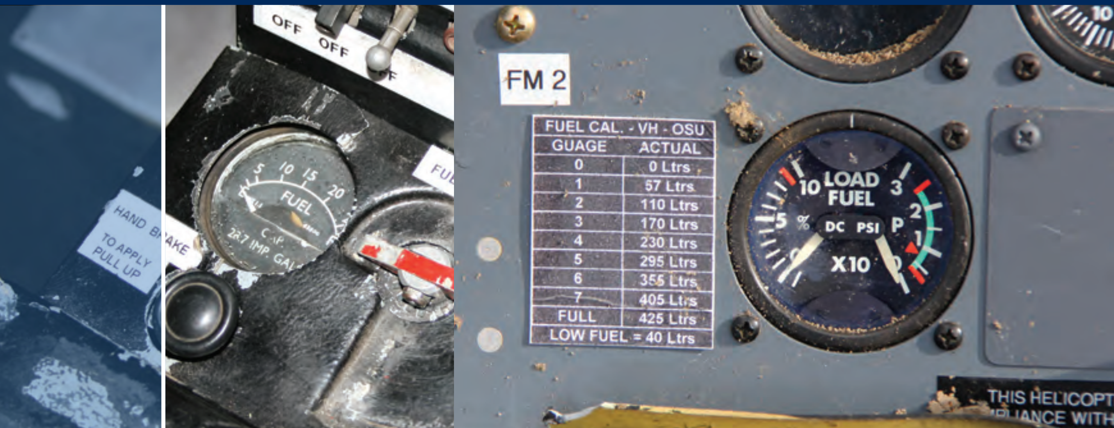
Australian Government

Australian Transport Safety Bureau



ATSB TRANSPORT SAFETY REPORT

Aviation Research and Analysis – AR-2011-112

Avoidable Accidents No. 5

Starved and exhausted: Fuel management aviation accidents

Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Aviation Research and Analysis - AR-2011-112

Avoidable Accidents No. 5

Starved and exhausted: Fuel management aviation accidents

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory Agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in:

- independent investigation of transport accidents and other safety occurrences;
- safety data recording, analysis and research; and
- fostering safety awareness, knowledge and action.

The ATSB does not investigate for the purpose of apportioning blame or to provide a means for determining liability.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and, where applicable, relevant international agreements.

When the ATSB issues a safety recommendation, the person, organisation or agency must provide a written response within 90 days. That response must indicate whether the person, organisation or agency accepts the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

Postal address: PO Box 967, Civic Square ACT 2608
Office location: 62 Northbourne Ave, Canberra, Australian Capital Territory
Telephone: 1800 020 616; from overseas + 61 2 6257 4150
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117; from overseas + 61 2 6247 3117
E-mail: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

ISBN: 978-1-74251-237-2

Introduction

Safe flight depends on reliable power. Despite the money and effort spent on ensuring aircraft engines are reliable, equally reliable systems are needed to ensure that engines always get the fuel they need.

This report discusses procedures that pilots can use before and during a flight to help them be absolutely sure they will have sufficient fuel to land at their destination aerodrome with reserve fuel intact. It does not discuss procedures to ensure fuel quality, such as checking all fuel drain valves for contaminants or using approved fuel, although these remain important. Nor does it discuss fuel system integrity measures, such as the maintenance of fuel filler cap seals.

The report will look at two main reasons why fuel stops getting to an engine during flight.

- **Fuel exhaustion** happens when there is no useable fuel remaining to supply the engine(s).
- **Fuel starvation** happens when the fuel supply to the engine(s) is interrupted although there is adequate fuel on board.

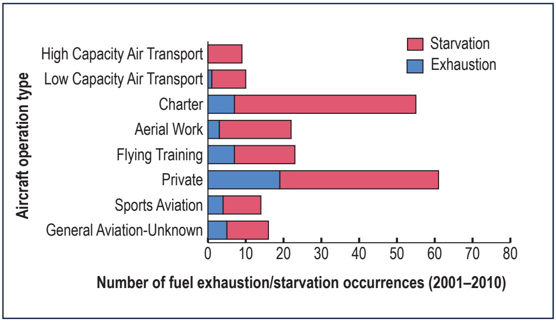
Key messages

- Accurate fuel management starts with knowing exactly how much fuel is being carried at the commencement of a flight. This is easy to know if the aircraft tanks are full, or filled to tabs. If the tanks are not filled to a known setting, then a different approach is needed to determine an accurate quantity of usable fuel.
- Accurate fuel management also relies on a method of knowing how much fuel is being consumed. Many variables can influence the fuel flow, such as changed power settings, the use of non-standard fuel leaning techniques, or flying at different cruise levels to those planned. If they are not considered and appropriately managed then the pilot's awareness of the remaining useable fuel may be diminished.
- Keeping fuel supplied to the engines during flight relies on the pilot's knowledge of the aircraft's fuel supply system and being familiar and proficient in its use. Adhering to procedures, maintaining a record of the fuel selections during flight, and ensuring the appropriate tank selections are made before descending towards your destination will lessen the likelihood of fuel starvation at what may be a critical stage of the flight.

Reported fuel occurrences

It is difficult to make a realistic assessment of how widespread fuel mismanagement events are. The ATSB receives, on average, 21 reports of fuel exhaustion or starvation occurrences each year. However, for every occurrence when power fails because fuel is no longer getting to the engine, it is likely that there are many occurrences when there was less fuel available than there should have been. It is also likely that not all fuel mismanagement occurrences are reported to the ATSB.

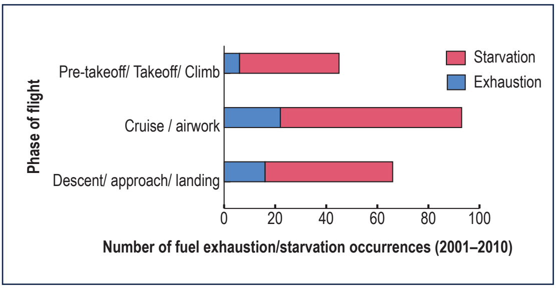
The existing data indicates that fuel mismanagement is three-times more likely to involve fuel starvation than exhaustion, and is mostly likely to occur in private operations and charter operations.



Of the reported fuel exhaustion occurrences from 2001 to 2010, most (82 per cent) led to a forced or precautionary landing off an aerodrome or ditching (but no fatalities or serious injuries).

In contrast, for reported fuel starvation occurrences, only 46 per cent led to a forced or precautionary landing or ditching, while 22 per cent led to a diversion to another aerodrome or a return to the take-off aerodrome. However, 11 (7 per cent) led to collision with terrain, and there were 10 fatalities and 18 serious injuries in the 10 years.

It is possible that starvation occurrences, which generally involve aircraft with multiple fuel tanks and require the pilot to diagnose an engine failure with little expectation of a fuel supply problem, result in pilots considering more options than just a forced landing (as with exhaustion occurrences), sometimes leading to inappropriate choices and fatal outcomes.



Fuel exhaustion or starvation can and do occur in any phase of flight, including takeoff. Most reported occurrences have been in the cruise or in the descent, approach and landing phases of flight. However, a quarter for fuel starvation occurrences involved the taxi, takeoff and climb phases.

Source: ATSB

Fuel exhaustion: Not knowing how much fuel is on board

Fuel exhaustion happens when an aircraft runs out of usable fuel before the flight is finished. Exhaustion occurrences are normally either the result of a gross error in the fuelling of an aircraft before flight, or the result of a number of seemingly minor aspects in fuel planning and management during the flight.

Incidences of fuel exhaustion often happen close to the flight's destination and, if it occurs when the aircraft is close to landing, it may offer the pilot less time and opportunity to successfully manage the situation.

Certain types of flight regularly carry just enough fuel for the flight, with little margin. Flying schools and gliding towing operations may only refuel aircraft after two or three flights, so the last flight before refuelling can have less fuel margin. Charter operations may be flying with minimum fuel required because a flight's profitability will depend on carrying the maximum payload, which means no unnecessary fuel be carried. Such operations will be more vulnerable to any inaccuracies in the pilot's knowledge about the amount of fuel on board. However, fuel exhaustion accidents and incidents occur in all types of aviation operations. They are normally related to a lack of awareness of information that is readily available at the pre-flight planning stage. This includes both the amount of fuel on board, and the rate of fuel consumption.

The chance of fuel exhaustion is reduced if the pilot accurately determines the amount of fuel on board prior to starting. This should entail the use of a fuel quantity cross-check using a number of sources, including

- Fuel quantity gauges
- Dipsticks
- Flowmeters/ totalisers
- Calculations from previous refuels and fuel usage, (regularly checked for accuracy).

The amount of fuel on board should be thought of, not as a quantity, but as a flight time. For a consistent combination of altitude, power setting and mixture setting, the fuel burn will be constant, but changing winds and deviations due to weather conditions will vary the groundspeed and therefore the range. Your fuel status should be regularly updated, at least every hour, to ensure you maintain an adequate reserve[1].

An aircraft that is carrying only just enough flight[2] fuel for the planned flight, but which encounters unanticipated headwinds and perhaps has to fly at a lower level is eating into its fuel reserves. Those reserves are there to be used in unforeseen circumstances and many aircraft arrive safely at their destination having used a portion of the allocated reserve fuel. However an aircraft's fuel supply should not reach a state where, upon arriving at its destination it can accept no further delay,

The following case studies look at some of the methods used for assessing fuel quantity and maintaining knowledge of fuel usage during flight.

1 The required fuel, in addition to flight fuel, that is not planned for normal use, but remains available for unplanned events where all other useable fuel has been consumed. This fuel is to be used only when there is no other safer alternative.

2 Flight fuel refers to all the fuel that is expected to be used during the planned flight, including holding fuel and fuel for planned diversions.


Source: ATSB

Knowing the fuel on board at start-up

One source of fuel quantity information

Investigation AO-2009-026

In June 2009, a Bell 206 helicopter was 5 minutes short of its destination with a pilot and four passengers on board, when a fuel boost pump low pressure warning light illuminated briefly. The pilot believed there was sufficient fuel to complete the flight, and continued until the power failed. The pilot then conducted an autorotative landing; however, the high rate of descent caused substantial damage to the helicopter and injuries to some of the occupants. A passenger took a photograph during the landing which showed the fuel quantity gauge indicating there was still fuel available, however fuel exhaustion had occurred.

A subsequent check of the helicopter and its fuel system showed that the fuel gauge may have been over reading. The operator's practice when calculating the quantity of fuel to be added during refuelling relied on the fuel gauge reading, without using an independent method to crosscheck that reading against the actual fuel tank quantity.

Lessons learnt

Because the pilot was only relying on the fuel quantity gauge to assess fuel quantity, he would not have known if the fuel quantity indication had become faulty. Without a cross-check from a second source of fuel quantity information, the pilot had no assurance that the information was correct and could only assume that the gauge indication was the correct quantity of fuel remaining.


Source: ATSB

Three sources of fuel quantity information, and only one was correct

Investigation number AO-2010-025

In April 2010, a Victa Airtourer was conducting its fifth flight since refuelling, when the engine lost power due to fuel exhaustion. The pilot conducted a forced landing onto a road, resulting in substantial damage to the aircraft, but no injury to the pilot, the only person on board. The pilot reported that he had used a dipstick to assess that there was sufficient fuel for the flight, and that the fuel quantity indicator provided a similar indication of fuel quantity, showing the tank was about half full. Unfortunately, the pilot used an incorrect (but not uncommon) method of using the dipstick that resulted in an over-reading of the fuel onboard. Furthermore, a close inspection of the aircraft's flight and fuel log would have revealed that the fuel gauge and the dipstick indications showed a fuel usage that was half the expected usage.

Lessons learnt

The ATSB investigation revealed that a number of factors worked against the pilot involved in this fuel exhaustion accident, some of which were outside his control. Cross-checking the dipstick reading against the fuel gauge indication was an effective method for spotting errors; however, a quick mental calculation would have shown a significant discrepancy between the indicated fuel quantity and the expected fuel usage. The discrepancy could have alerted the pilot that something was wrong with the available fuel quantity information.


Source: Greg Wilson

Knowing the rate of fuel consumption

A different power setting leads to a different fuel consumption rate

Investigation number 200500993

In March 2005, a Robin 2160 aircraft was returning from a flight to break-in a newly overhauled engine. Shortly before arriving at the destination aerodrome, the engine lost power and the aircraft crashed on a suburban street. The pilot escaped with minor injuries and reported that he had been using higher power settings for the engine run-in; however, the pilot had used the fuel consumption rate for normal power settings. The aircraft ran out of fuel at a time that was consistent with fuel usage at the higher power settings.

Lessons learnt

Aircraft flight manuals often provide data that shows the fuel consumption rate at standard power settings with the mixture leaned. If those settings are used, an assessment of the fuel remaining should be correct. However, even small changes in engine operating technique, such as leaning or a small increase in rpm, can make a big difference to fuel flow.

If the aircraft does not provide a fuel flow indication, then fuel flow can only be established by using consistent power settings. The use of these settings is necessary for safety when conducting a fuel critical flight.

Source: ATSB

Unplanned delay not accounted for in fuel planning

Investigation number 200102444

In June 2001, A Cessna 172 was being flown south along the West Australian coast to Perth. The pilot refuelled at Geraldton with sufficient fuel for the trip. Forty five minutes after departure, the pilot returned to Geraldton because of bad weather en route. Later that day, when the weather improved, the pilot took off again and flew to Jandakot Airport, near Perth. The pilot reported that he experienced strong headwinds during the flight. The engine lost power because the aircraft ran out of fuel shortly before reaching its destination, and crashed during a forced landing in a suburban area.

If fuel is thought of as 'time in the tanks' instead of a quantity, then diversions or stronger headwinds will not affect the time remaining.

Lessons learnt

Flights are planned on the basis of expected en route conditions. Monitoring a flight's progress allows a pilot to assess if the flight is maintaining an adequate fuel reserve, and to make timely decisions if the flight conditions change.

Fuel starvation: Leaving the fuel supply on an emptying tank, when there is a fuller tank avaliable

These occurrences are sometimes referred to as ‘finger-troubles’, on the basis that a pilot did not ‘use his/her fingers’ to select the tank with more fuel remaining. It is probably more helpful to look at why the pilot did not make that selection in the first place.

The simpler an aircraft’s fuel system, the easier it is to avoid selecting the wrong tank. A Cessna 150, with a separate fuel tank in each wing, has a very simple fuel selection, either ‘off’ or ‘on’. Although the Cessna 172 and 182 have a similar fuel system, the fuel selector has four selections; ‘off’, ‘both’ wing tanks at the same time, or either wing tank. In contrast, the Piper single engine training fleet all have separate wing tanks, but only one tank can be selected at any one time.

Once a selection of tanks is available, there is a greater chance of selecting the empty one, and the greater the number of tanks, the greater the chance of a mistake. The risks are increased when pilots forget to change tanks during the cruise when workload is lower, or when pilots forget to select the appropriate tank prior to the approach to land. Although tank selection for approach and landing is often specified in the aircraft flight manual, following this procedure will only be successful if the pilot has also ensured that there is sufficient fuel in the required tank for landing.

These risks are best managed by the strict application of a standard procedure, fuel logs and checklists. If a pilot is disciplined in always writing down a tank change with the time of the change, then any doubt about whether a tank was changed can be checked against the fuel log. If a tank change had been forgotten, then there will be enough information available to work out how to rebalance the fuel quantities. The use of a fuel log is discussed in the next case study.

Source: ATSB

Pre-flight fuel calculation

Three different calculations of fuel quantity information, based on one incorrect information source

Investigation AO-2007-017

In June 2007, a Brasilia turboprop aircraft conducting a charter flight with 31 people on board lost power from its left engine shortly before landing at its destination. The flight crew conducted a missed approach and landed about 12 minutes later.

The fuel tank supplying the left engine had no fuel remaining, and the fuel quantity indicator was over-reading because of a mechanical defect. Other methods of calculating the fuel quantity existed, but were not used effectively.

- The aircraft was equipped with a fuel totaliser, which would provide an indication of the fuel consumed during a flight, but most of the operator's flight crew obtained the fuel consumed by calculating the difference between the 'total fuel quantity at departure' and the 'residual' fuel at the end of the flight. Both of the fuel quantities used for this calculation were initially derived from the fuel quantity indicator, which therefore bypassed the increased reliability that was available by using information from the independent fuel totaliser.
- The tanks were only rarely filled, which lessened the opportunity to obtain an accurate knowledge of the fuel quantity in the tanks. This is common for charter operations where maximum payload is normally a consideration.
- The wrong fuel density was used when converting from litres to kilograms of fuel. This conversion was a normal part of fuel management in this aircraft, and produced an inaccuracy of about 2 per cent.
- The 'dripless measuring sticks' installed on the aircraft were not used to reconcile fuel discrepancies. Instead, discrepancies in the fuel quantity were normally reconciled to the unrecorded fuel used by the auxiliary power unit.

Various methods were available to assess fuel quantity on this aircraft; however, the methods had been modified so they were all based on information that was originally derived from the fuel quantity indicator. The undue reliance placed on the accuracy and reliability of the fuel quantity indicating system meant that when the fuel quantity indicating system became faulty, the flight crews were not aware of the potential for engine fuel starvation. Cross-checking the fuel quantity indicating system with the 'dripless measuring sticks' installed on the aircraft before flight would have highlighted the problem.

Although there was fuel on board, the factors that contributed to this fuel starvation incident could have quite easily resulted in complete fuel exhaustion.

Lessons learnt

Accurate knowledge of fuel quantity at the start of a flight is essential for any fuel-critical operation. All subsequent assessments are derived from that initial number. If only one fuel quantity measurement is used, then it is not possible to find out if that system is working properly because you have nothing to compare your information against.

Separate, independent fuel quantity cross-checks provide a much more reliable system for knowing how much fuel is being carried at the start of a flight.

Switching to the correct fuel tank at the right time

Not selecting the correct tank before approaching to land

Investigation number 200603140

In June 2006, a Beechcraft A36 Bonanza was conducting a private flight from Kununurra, West Australia, to Bathurst Island, Northern Territory, with one person on board. The aircraft crashed in woodland about 1km short of the runway at Bathurst Island. The pilot, who was the only occupant, was fatally injured.

The aircraft was equipped with four fuel tanks, two main tanks, one in each wing, and one tip tank in each wing, with the use of the tip tanks restricted to level flight only. There was evidence from the wreckage that there had been sufficient fuel in each of the main tanks. The pilot had a written a fuel log indicating the left tip tank had been selected on reaching cruise altitude, and the right tip tank selected when the left tip tank was nearly empty. It is likely that the pilot omitted to select a main tank before descending from cruise altitude, and the right tip tank ran dry at a low altitude with insufficient time available to restore fuel supply to the engine.

Lessons learnt

Although the tip tanks had been used during the cruise and a fuel log confirmed the fact, the use of a pre-descent checklist to ensure that the correct tank was selected well before approaching the ground could have reduced the chance of this starvation event. Running dry at a low altitude reduced the opportunity to recover from the power loss.

Reserve fuel in a separate tank to that selected during a fuel-critical flight

Investigation number AO-2008-022

In April 2008, a Piper Cherokee Six aircraft was conducting inter-island charter operations between Mackay and the Whitsunday Islands ferrying tourists. The flight was just taking off for the last of six flights since refuelling to return to Mackay with the pilot and four passengers on board, when the engine lost power and the pilot ditched the aircraft. None of the occupants were badly injured and they were rescued from the water by helicopter.

This aircraft used four fuel tanks, two main tanks and two wing tip tanks. Fuel could only be drawn from one tank at any one time. The company fuel policy was to carry flight fuel in the tip tanks and to alternate between the tip tanks with each flight. Reserve fuel was carried separately in the main tanks.

The operator's fuel management system appeared to be logically safe: however, it resulted in the last takeoff being conducted with the fuel supply not being selected from the tank with the greatest quantity of fuel. There was little margin for error because the flights were planned to consume nearly all the flight fuel, and there was a greater potential for flight variation with six takeoffs and landings between refuelling. The quantity of fuel remaining in the selected tip tank could have been affected by increased fuel flow or increased flight durations, or incorrect fuel tank selection. The system was also not error-tolerant, because the flights were conducted at relatively low altitude. This meant that in the event of a power interruption due to a tip tank running dry, little time was available for the pilot to switch to one of the main tanks to restore fuel flow to the engine.

Lessons learnt

The more tanks you have to choose from, the greater the potential to make a mistake and to select the wrong fuel tank. Forgetting to change the fuel selection, or not being sure whether you remembered to change the fuel selection, can be managed by the disciplined use of a fuel log to record fuel usage. A pilot may forget, but if fuel selections are written down, then the fuel log can act as an effective reminder (along with adherence to checklists).

Source: ATSB

Misdiagnosis of starved engines

Investigation number AO-2008-048

In July 2008, a Piper Navajo PA-31 aircraft had flown a charter operation carrying passengers from Mount Isa Queensland to a mine camp. On the return flight, with only the pilot on board, both engines failed when the aircraft was on descent and about 10 minutes from its destination. The pilot conducted a forced landing in sparsely wooded terrain and sustained serious injuries during the accident sequence.

This aircraft type had four fuel tanks, with one main tank in each wing and one outer tank in each wing. Under normal circumstances, the tanks fed fuel to the engine mounted on that wing. The outer tanks were normally used in the cruise on longer flights, and the main tanks were used for all the other phases of flight.

In this flight, the pilot had selected the outer tanks for use in the cruise, and was planning to use nearly all of the fuel in the outer tanks before selecting the main tanks for the last part of the flight. Although the pilot was expecting to change tanks soon, he was not prepared for the sudden loss of power when the fuel supply to one engine was exhausted. The pilot conducted engine power recovery drills, but did not change the fuel selection to supply fuel from the main tank that still had sufficient fuel remaining. When the second engine lost power, the pilot concentrated on retaining control of the aircraft, and prepared for a forced landing.

After the accident, the fuel supply was still selected from the outer fuel tanks. There was no fuel in either outer tank; however, there was sufficient fuel remaining in each main tank to complete the flight. The pilot reported that he had diagnosed the initial power loss as an engine malfunction, rather than a fuel starvation problem.

Lessons learnt

The risk of fuel starvation is reduced if the appropriate tank is selected before descending toward the destination after ensuring it also contains adequate fuel for landing. This task is normally conducted during the pre-descent checks for aircraft with more than one tank with good reason, because changing tanks is easily forgotten once you become busier in the circuit pattern.

Pre-flight tank selection

Fuel selected from a nearly empty tank before take off

Investigation number 200303599

In August 2003, a Piper PA31-350 Chieftain aircraft departed from Albury Airport for a flight to Bathurst with a pilot and six passengers on board. As the aircraft was climbing through 5,000 ft after departing from Albury, the right low fuel light illuminated and the right engine then lost power. The pilot initiated a diversion to nearby Holbrook Aerodrome; however, about 1 minute later, the left low fuel light illuminated and the left engine also lost power.

The pilot had little choice other than to conduct a forced landing into a field. The aircraft was substantially damaged; however, no one was injured.

The aircraft had the same fuel tank layout as a Piper Navajo, although the cockpit fuel selection controls were different. The main tanks had been filled before the flight and the outer tanks were nearly empty. After the accident, the main tanks were observed to be full, and the outer tanks were empty.

The pilot operating handbook checklist required the fuel selectors to be selected to the main tanks before takeoff. However, it was a normal company procedure to conduct pre take-off engine run-up checks with the fuel selected to the outer tanks, to ensure fuel supply from the outer tanks worked properly before flight.

The circumstances were consistent with the aircraft operating from fuel supplied from the nearly empty outer tanks until those tanks ran dry.

Lessons learnt

There is a need for good pilot knowledge and proficiency with aircraft systems and procedures, as well as ensuring that pilots are sufficiently trained to ensure that an unexpected fuel management problem can be managed safely, all the way down to a safe landing. However it is preferable that pilots avoid such situations by the use of sound standard operating procedures (SOP's) and the diligent use of checklists.

Source: ATSB

Pilots of larger aircraft face the same issues

Investigation number AO-2007-036

In August 2007, a Boeing 737-400 aircraft was being operated on a scheduled passenger service from Perth, Western Australia to Sydney, New South Wales. About 2 hours 40 minutes into the flight, the master caution light illuminated associated with low output pressure of the aircraft's main (wing) tank fuel pumps. The pilot in command observed that the centre tank fuel pump switches on the forward overhead panel were selected to the OFF position and he immediately selected them to the ON position.

The main fuel tanks were low on fuel and the investigation estimated that there was about 100 kg in each of the main tanks. The centre fuel tank contained about 4,700 kg of fuel when the master caution occurred. The flight continued on the flight planned route and landed at Sydney 51 minutes after the initial illumination of the master caution light.

On most flights in this aircraft type, fuel is used only from the main fuel tanks for the entire flight. On longer flights such as Perth to Sydney, however, the centre fuel tank is required to be used, with the fuel from this tank getting used first before the fuel is used from the main tanks for the remainder of flight and landing.

The investigation determined that a number of factors contributed to the occurrence. However, in common with other incidents described in this publication, the pilots did not notice that the centre tank fuel pump switches were not in the ON position as some pre-flight checklist procedures were not diligently adhered to and the en-route review of the fuel status by the flight crew was ineffective.

Lessons learnt

It is not just the single pilot operation that is at risk of fuel starvation and exhaustion events. All pilots, including those in multi-crew operations and no matter what their flight experience level, are vulnerable to human error and its consequences.

Conclusion

Fuel exhaustion is more likely to occur on flights when there is little flight fuel margin; that is landing with just reserve fuel on board. In these circumstances, particular attention to detail in fuel management is warranted.

The chance of fuel exhaustion can be reduced by:

- using more than one source of information to obtain consistent results about the fuel on board before flight
- the use of a consistent procedure that is regularly checked to know the exact rate of fuel consumption
- monitoring the flight to ensure that sufficient fuel will remain on board in the event of unplanned delays.

Fuel starvation usually happens when the selected tank is run dry. In addition to the factors relevant to fuel exhaustion, the chance of starvation can be further reduced by:

- ensuring the pilot is fully familiar with the operation of the fuel system for both normal and abnormal operations
- adhering to pre-flight procedures and checks to ensure the correct tank is selected before takeoff and landing
- using a fuel log during flight to provide a record of the fuel usage from each tank
- selecting the appropriate tank before descending to the destination and ensuring that tank has adequate fuel for landing.

Further reading and resources

The ATSB published a detailed research report *Australian Aviation Accidents Involving Fuel Exhaustion and Starvation* in 2003 on the same subject. This is avaliable on the Safety Awareness section of the ATSB website.

The Civil Aviation Safety Authority's (CASA) Civil Aviation Advisory Publication, CAAP 234-1 Guidelines for aircraft fuel requirements, provides information and guidance on fuel requirements for aircraft required by Civil Aviation Regulations 220 and 234 (www.casa.gov.au). At the time of publication, CASA was in the process of amending CAAP 234.

Australian Government

Australian Transport Safety Bureau

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608
Australia
1800 020 616
www.atsb.gov.au

The Australian Transport Safety Bureau is Australia's national transport safety investigator.