Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Investigation – AO-2007-036

Preliminary

Fuel related event – 50 km NW of Swan Hill, Vic
11 August 2007
VH-TJE
Boeing 737-476

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Abstract

On 11 August 2007, a Boeing 737-476 aircraft, registered VH-TJE, was being operated on a scheduled passenger service between Perth, WA to Sydney, NSW. The flight crew consisted of a pilot in command, who was the pilot flying, and a copilot. The aircraft took off from Perth at 0544 Western Standard Time. About 2 hours 40 minutes later, the master caution light illuminated associated with low output pressure of the aircraft's main 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.

The investigation is continuing.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

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

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

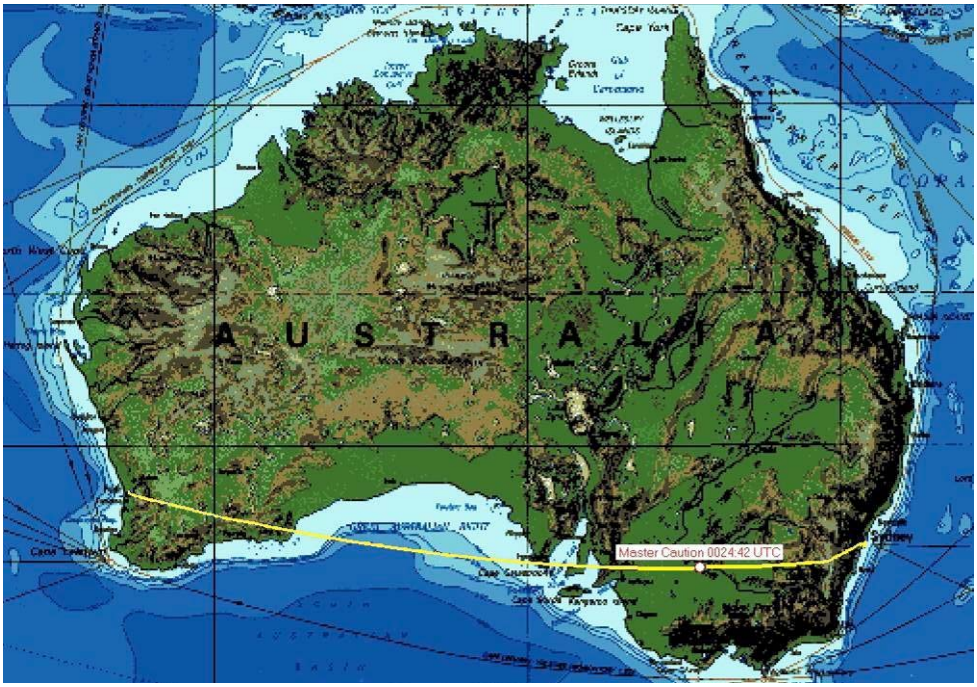
FACTUAL INFORMATION

Sequence of Events

On 11 August 2007, a Boeing 737-476 aircraft, registered VH-TJE, was being operated on a scheduled passenger service between Perth, WA to Sydney, NSW. The flight crew consisted of a pilot in command, who was the pilot flying, and a copilot. The aircraft took off from Perth at 0544 Western Standard Time[1], which was 1 hour 13 minutes before sunrise.

About 2 hours 40 minutes later, at 0824.42[2] (Figure 1) the master caution light illuminated, associated with low output pressure of the main tank fuel pumps. The main fuel tanks in the Boeing 737 series aircraft were located in each wing. A centre fuel tank, located in the wing centre section, was used for carrying additional fuel on longer flights, such as from Perth to Sydney.

Figure 1: Route flown with illumination of the master caution light indicated



The pilot in command observed that the centre tank fuel pump switches on the forward overhead panel were selected to the OFF position (Figure 2) 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

1 The 24-hour clock is used in this report to describe the local time of day, Western Standard Time (WST), as particular events occurred. Western Standard Time was Coordinated Universal Time (UTC) +8 hours.

2 The master caution light illuminated at 0024.42 UTC while the aircraft was 50 km NW of Swan Hill, Vic. The time zone has been maintained in WST to provide context to the aircraft's departure time, and crew flight and duty times.

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.

Figure 2: Overhead fuel control panel of VH-TJE photographed from the pilot in command's seat

Pre-departure and inflight

The crew arrived at Perth Airport at 0445 and carried out their normal flight planning tasks. They arrived at the aircraft at about 0515 and commenced their procedures and inspections for the scheduled 0545 departure.

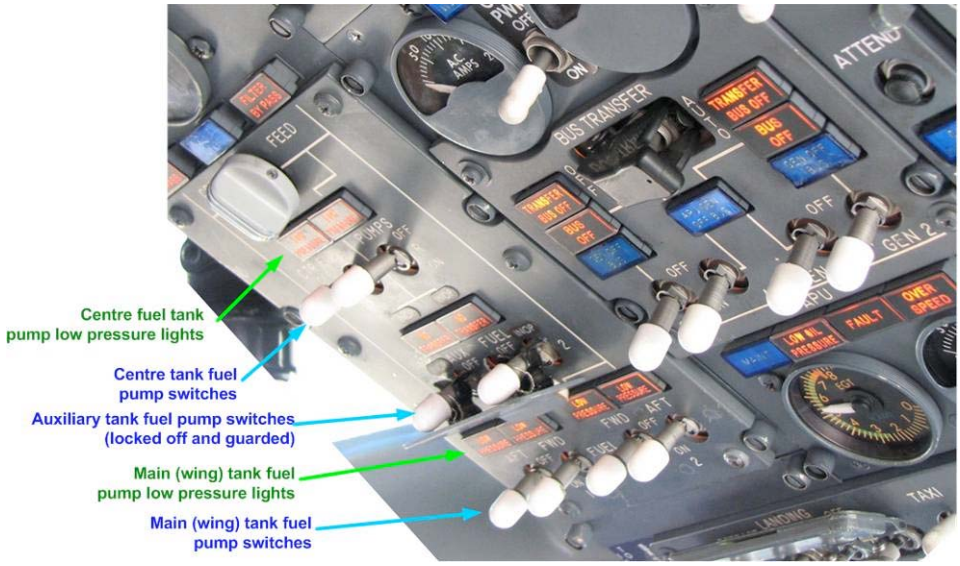
The aircraft was refuelled with the total fuel onboard being 13,660 kg. The main tanks were full with about 4,500 kg in both the left and right tanks and the centre tank was loaded with about 4,700 kg (total capacity of the centre tank was 6,900 kg). The planned fuel burn for the flight was 9,900 kg.

During the before start procedures, the pilot in command reported that he obtained approval from the despatching engineer to pressurise the aircraft hydraulic system. He then selected the hydraulic pumps, located on the forward overhead panel, to the ON position and carried out the flight controls check. The copilot believed that he probably reached over and selected the fuel pumps to ON after the pilot in command had configured the hydraulic system.

Following completion of the before start procedures, at about 5 minutes prior to push-back from the terminal, the pilot in command called for the *Before Start* checklist, which was read by the copilot. The second item required the crew to check the fuel quantity in kilograms and to check that the fuel pumps were on. The copilot reported that he called '13,000 kilograms, pumps on' and looked up at the

fuel control panel. The pilot in command reported that he was probably focussed on the fourth item on the checklist at this time (as this required his response), which was to confirm that his cockpit window was closed and locked.

Figure 3: Overhead fuel control panel of VH-TJE photographed from the copilot's seat



The crew completed the *Before Start* checklist, obtained a push back clearance from air traffic control and were cleared by the despatching engineer to start the engines. The crew completed the push back, engine start and before taxi procedures and the *Before Taxi* checklist. The aircraft then taxied and departed from runway 21.

The aircraft was climbed to flight level 310 and during the climb the sun came over the horizon. The copilot reported that he scanned the overhead panel at top of climb but did not notice that the centre tank fuel pump switches were in the OFF position. He also checked the fuel used by each engine and compared the total fuel used with the flight plan accumulated fuel burn figure. The copilot stated that he checked the total fuel quantity displayed on the flight management computer (FMC) control display unit, but he did not recall checking the amount of fuel indicated on the fuel quantity indicators for each tank.

As the flight progressed, the copilot continued to monitor the fuel burn by comparing the fuel used to the flight planned figure. The copilot continued this practice for each of the waypoints as the aircraft crossed the Great Australian Bight en route to Sydney.

The flight data recorder indicated that the master caution light illuminated at about 2 hours and 40 minutes into the flight. The pilot in command reported that he observed a flicker of the amber low pressure lights associated with the main tank aft fuel pumps. He was surprised to see that the centre tank fuel pump switches were in the OFF position and immediately selected them to ON.

Following the discovery that the centre tank fuel had not been used, the crew discussed the problem and confirmed that the total fuel remaining would not be a concern. The crew reported that they reviewed the non-normal checklist and other documentation, but did not find any relevant checklist or information about structural limitations being exceeded. The only information they found was a refuelling requirement for the main tanks to be full when the centre tank contained

more than 453 kg, and a requirement of 760 kg of fuel in the respective main tanks for the cooling of electric hydraulic pumps when the aircraft was on the ground. The crew discussed a strategy to deal with the latter requirement, which involved turning off the electric hydraulic pumps after landing.

The flight continued to Sydney and after landing the crew turned off the electric hydraulic pumps and taxied to the terminal. The receiving engineer was told by the pilot in command that there was excess fuel in the centre tank that needed to be transferred into the main (wing) tanks. The pilot reportedly advised the engineer that this transfer was necessary as the following flight was a short sector and did not require fuel in the centre tank. The investigation estimated that the centre tank had about 2,750 kg of fuel remaining, while the left and right main tanks had about 100 kg in each when the aircraft was parked at the terminal.

Aircraft fuel system

The fuel system of VH-TJE included three integral fuel tanks; the main fuel tanks in each wing and a centre fuel tank in the wing centre section for carrying additional fuel for long range flights. VH-TJE had also been originally fitted with auxiliary fuel tanks located in the rear cargo compartment but these tanks had been deactivated.

The fuel control panel was located on the forward overhead panel of the flight deck above the pilot in command's seat. The panel contained eight fuel pump switches; two pumps for each main tank, two pumps for the centre tank and two pumps for the auxiliary system. As the auxiliary fuel tanks were not used on VH-TJE, the associated fuel pump switches were covered with a small cover plate and secured with lock-wire to the OFF position (Figure 2).

Each main tank and centre tank fuel pump had an associated amber low pressure light. The low pressure light for any fuel pump would illuminate when the fuel pump output pressure was low and the fuel pump was selected to the ON position. The low pressure light for a main tank fuel pump would also illuminate if the fuel pump switch was in the OFF position and there was useable fuel in that tank. In contrast, the low pressure light for a centre tank fuel pump would not illuminate if the fuel pump switch was in the OFF position regardless of whether there was useable fuel in that tank.

Therefore, during the pre-flight phase while the fuel pump switches were selected to the OFF position, the amber low pressure lights would illuminate only for the main tank fuel pumps. When the main tank fuel pump switches were selected to the ON position, the lights would extinguish. The low pressure lights associated with the centre tank fuel pumps would remain extinguished regardless of the fuel pump switch selection.

The crew reported that the overhead fuel control panel in VH-TJE was different from some of the other 737-400 aircraft and all 737-800 aircraft used by the operator due to the fitment of auxiliary tank fuel pump switches. The centre tank fuel pump switches on these other 737 aircraft were located in a similar position to the auxiliary tank fuel pump switches on VH-TJE.

Personnel information

Experience

The pilot in command held an airline transport pilot (aeroplane) licence. His total flying experience was 19,611 hours, of which 10,705 hours were on Boeing 737 aircraft.

The copilot held an airline transport pilot (aeroplane) licence. His total flying experience was 5,026 hours, of which 2,918 hours was on Boeing 737 aircraft.

Both pilots were endorsed to operate all series of the operator's Boeing 737 aircraft. The operator's fleet consisted of 737-400 and 737-800 series aircraft.

Recent history

The incident occurred on the last day of a 4-day trip by the pilots, operating from Sydney to Perth, then to Jakarta, Indonesia, returning to Perth, and finally the Perth to Sydney sector. All previous sectors were operated in 737-800 aircraft, while the incident sector was operated in a 737-400 aircraft.

The pilot in command had spent 7 August (the day prior to the trip) at home, but had been occupied with personal matters. The copilot had spent the previous 7 days away from work with days off and sick leave while suffering from influenza. The crew duty and sleep hours during the trip (8-11 August) are shown in Table 1 and Table 2.

After arriving in Perth at 2100 WST on 8 August, both pilots slept in hotel rooms until the next morning. The copilot slept for 1 to 1.5 hours during the afternoon of 9 August, but the pilot in command, although he tried, was unable to sleep.

The flight to Jakarta departed Perth at 2105 on 9 August and the copilot acted as the handling pilot on both sectors to and from Jakarta. The pilots arrived back in Perth at 0631 WST on 10 August, after operating through the night. The copilot slept at a hotel for 3 hours that morning and then again during the night. The pilot in command, however, was involved in personal matters all of that day and did not get to sleep until 2100 that night.

Both pilots woke just before 0400 on 11 August.

Table 1: Pilot in command's 72 hour duty and sleep history

Date	Flights[3]	Departure (local time)	Arrival (local time)	Duty hours[4]	Sleep[5]
8 Aug	BNE-SYD[6] SYD-PER	1521 1801	1642 2054	8:24	7 hours
9 Aug	PER-CGK	2105	0018	10:51	Nil
10 Aug	CGK-PER	0106	0601		7 hours
11 Aug	PER-SYD SYD-BNE[6]	0544 1240	1119 1358	7:28	N/A

Table 2: Copilot's 72 hour duty and sleep history

Date	Flights	Departure (local time)	Arrival (local time)	Duty hours[4]	Sleep[5]
8 Aug	SYD-PER	1801	2054	6:14	10 hours
9 Aug	PER-CGK	2105	0018	10:51	1.5 hours
10 Aug	CGK-PER	0106	0601		3 hours (day) 6:15 (night)
11 Aug	PER-SYD	0544	1119	4:49	N/A

Operator's normal operating procedures

The operator's normal operating procedures and normal checklist operation were specified in the *737-300/400/800 Flight Crew Operations Manual*. The manual specified pre-flight and post-flight panel scan flows, including the setting of switches and controls. It also specified areas of responsibility during the various phases of flight, depending on which crew member was the handling pilot, and specified how checklists were to be executed by the crew.

The operations manual specified that prior to the aircraft taxiing for takeoff, the checking and configuring of the flight deck forward overhead panel was the copilot's responsibility. This meant that the copilot was responsible for selecting the hydraulic pump switches and fuel pump switches to the ON position during the before start procedure. These switch selections by the copilot were supposed to occur after the pilot in command had obtained approval from the despatching engineer to pressurise the hydraulic system.

The copilot reported that he was not surprised by the pilot in command's action in selecting the hydraulic pumps to the ON position during the incident flight. He also said it had occurred on a previous sector with this particular pilot in command and the practice was not uncommon throughout the operator's 737 fleet.

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3 BNE: Brisbane; SYD: Sydney; PER: Perth; CGK: Jakarta.

4 Duty hours include an allowance for the time spent on pre-flight and post-flight duties.

5 Sleep includes hours asleep that day and night, including continuous sleep into the following morning.

6 The Brisbane to Sydney and Sydney to Brisbane sectors were relocating flights as a passenger.

The normal checklists were used after the respective procedures were completed. The operations manual specified which pilot called for the appropriate checklist (either the pilot in command or the "pilot flying") and which pilot read the checklist aloud (either the copilot or the "pilot not flying"). The operations manual required that 'Both pilots visually verify that each [checklist] item is in the needed configuration or that the step is done.'

This resulted in the copilot reading the *Before Start* checklist item 'Fuel' and responding '[fuel quantity] kilograms. Pumps on' with both pilots being required to visually confirm the fuel quantity and the pump switch selection that had been carried out by the copilot during the before start procedure. The checklist did not require the copilot to specify which tanks' fuel pumps were on.

Following completion of the *Before Start* checklist, the operations manual did not contain any further procedural or checklist items relating to the 737-400 fuel system until the aircraft was shutdown after completion of a flight.

Other incidents

A search of the United States (US) National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS)[7] database was conducted for similar incidents. The search revealed six incidents in the period from1994 to 2007. involving flight crew on Boeing 737 aircraft forgetting to select the centre tank fuel pumps ON during the departure preparation and then not detecting this error during the *Before Start* checklist. In three of these incidents, the crew discovered the error after landing, while in the other three, the error was discovered late in the flight. An example of a report is as follows.[8]

> I neglected to turn on the center fuel tank pumps during the cockpit preparation flow. The main tanks were full and there was 8000 lbs [3,629 kg] in the center tank. I did not notice that the switches were off during the before start checklist. I did not catch my mistake until just before commencing my descent. I landed with 7000 lbs [3,175 kg] in the center tank and 6500 lbs [2,948 kg] in each main tank. ….. I cannot think of any contributing factors to explain my mistake, except possibly complacency caused by repetition. When I performed the checklist, I assume that I saw what I was expecting to see. Additionally, I cannot remember checking the fuel quantity gauges once during the flight. I normally check balance and consumption regularly.

7 Aviation Safety Reporting System (ASRS) database, available on the internet, is a collection of voluntarily submitted aviation safety incident/situation reports from pilots, controllers, and others in the US aviation community.

8 ASRS report ACN301703. Incident reported by the pilot in command of a US airline. Abbreviations have been written in full.

Further investigation

The investigation is continuing and will include the examination of:

- normal operating procedures
- normal operating practices
- post-flight actions
- human performance issues
- airworthiness issues.