Partenavia P68TC, N33PV

AAIB Bulletin No: 5/2002	**Ref: EW/C2001/6/02**	**Category: 1.3**
Aircraft Type and Registration:	Partenavia P68TC, N33PV	
No & Type of Engines:	2 Lycoming IO-360-A1B6 piston engines	
Year of Manufacture:	1984	
Date & Time (UTC):	3 June 2001 at 1317 hrs	
Location:	Gratwich near Uttoxeter, Staffordshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 4
Injuries:	Crew 1 Serious	Passengers 3 Serious, 1 Minor
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	CAA Private Pilots Licence with FAA validation and CAA IMC Rating	
Commander's Age:	57 years	
Commander's Flying Experience:	695 hours (of which 159 were on type)	
	Last 90 days 19 hours	
	Last 28 days 16 hours	
Information Source:	AAIB Field Investigation	

Background

The privately owned aircraft was imported into the UK in December 1998 by the owner who maintained it on the USA register. It was based at Henstridge and flown almost exclusively by the owner and a trusted friend who had a Commercial Pilot's Licence and Instrument Rating. The owner made frequent trips to France and in late May she planned a family holiday in France at two different locations.

On 24 May her CPL friend partially refuelled the aircraft at Henstridge with 60 litres of AVGAS. He believed that afterwards, both tanks had equal quantities of fuel and that the level in each was about 11/2 inches below the filler neck. The next morning he flew the aircraft alone to a landing strip near Liverpool to collect three members of the owner's family. He then flew back to

Henstridge and later stated that the aircraft's behaviour and fuel consumption were normal on both flights. He could not remember the fuel quantity on landing at Henstridge but he was unaware of any serious fuel imbalance. He believed the aircraft was fully serviceable apart from a minor problem with the autopilot which he knew the owner seldom used. After lunch the owner departed with her family for Guernsey where she had the aircraft refuelled to 'full tanks'. She could not remember the fuel quantity indications on arriving or on leaving Guernsey but she assumed the tanks had been refuelled to within 11/2 inches of the filler necks. She often refuelled at Guernsey and had confidence in the airport's refuelling operators so she did not dip the tanks after refuelling.

P68 refuelling procedure

The P68's integral fuel tanks are outboard of the engines and the filler caps are at the outboard ends of the tanks about 15 feet from the aircraft's centreline. Each tank has a theoretical capacity of 71 USG (269 litres) but refuelling to that capacity is laborious. This is because the aircraft has a narrow-track landing gear attached to the fuselage so, as the first tank is replenished, the increasing weight of fuel in one wing tilts the aircraft towards the tank being filled. There is very little dihedral so before the sloping tank is full, the fuel level reaches the filler neck. At this point the refueller must change to the opposite tank and fill that to return the aircraft towards a wings-level attitude. This tank will be able to hold more fuel than the first tank to be replenished because the asymmetry will be less when the fuel level reaches the filler neck. In theory, more fuel could be loaded into both tanks by alternately topping up each tank but this is seldom done for practical reasons. The owner stated that she, and most P68 pilots she knew, have the first tank filled to the filler neck and the second filled to about 11/2 inches from the filler neck. Both tanks then hold similar amounts. Calculations showed that with the fuel level 11/2 inches below the filler neck, the likely quantity in each tank was 230 litres.

History of the accident flight

The five occupants left Guernsey on 24 May and flew direct to Vannes in Normandy. The pilot routinely cruised at power settings of 2,350 RPM and 32 inches Manifold Pressure giving a speed of 140 KIAS. The flight to Vannes would have taken some 44 minutes in still air and records recovered from the aircraft indicated that it lasted 50 minutes. The aircraft was parked at Vannes for a few days on level ground. No fuel was uplifted before leaving Vannes and the aircraft departed on 31 May to fly to Meaux on the eastern outskirts of Paris. The records indicate that this 254 nm flight lasted 2 hours 5 minutes.

The aircraft was parked on level ground at Meaux for a few days. On the morning of 3 June, the day of the accident, the owner taxied the aircraft to the aero club's fuel pumps at Meaux to have the fuel tanks replenished. She believes she may have dipped the tanks before refuelling began but she could not remember the resultant quantities. Whilst the aircraft was being refuelled, the pilot left its vicinity and went into the club premises to file her flight plan, check the weather and pay the fuel and airport charges. The fuel receipt was completed for 157 litres of 100LL AVGAS

When the refuelling operator had finished filling the left wing tank he moved towards the right wing but received instructions from a member of the pilot's family that there was no need to refuel the right wing tank. A different member of the family stated, soon after the accident, that this was because the right fuel tank gauge was indicating 2/3 full. Shortly afterwards the pilot returned to the aircraft. She did not dip the tanks after refuelling. On leaving Meaux the pilot recalled that the right tank gauge indicated "almost full" whilst the left tank gauge indicated "a bit less". Her intentions were to fly from Meaux to the airstrip near Liverpool where three persons would disembark and she

would then return to Henstridge. There were no refuelling facilities at the Liverpool landing strip and she planned to complete both legs without refuelling. She did so on the basis that the aircraft's endurance on full tanks was about 6 hours and she planned to be airborne for less than this. (The still air flight time was later calculated to be 41/4 hours and the prevailing winds were westerly).

The aircraft departed Meaux at 1020 hrs and was flown uneventfully and in VMC conditions towards Liverpool via Compiegne, Abbeville, Lydd, Clacton and Cambridge. The autopilot was disengaged throughout the flight and the pilot could not recall using abnormal amounts of rudder or roll control (the aircraft had no aileron trim). Specifically, she was not aware of any marked imbalance in roll or any abnormal fuel gauge readings.

At 1246 hrs when the aircraft was at 3,500 feet altitude and south of Leicester the pilot contacted East Midlands Approach and requested a Flight Information Service en-route to the Lichfield NDB. At 1312 hrs she transmitted a Mayday message on the East Midlands frequency stating that she had "lost" the right engine. The controller responded with information that the nearest airfield was Tatenhill in her six o'clock at about 10 miles range. The pilot turned to the right and took-up a south-westerly track towards Tatenhill. About one minute later, when asked to confirm her altitude, the pilot reported "I HAVE NO ENGINES NOW" followed by "TO DO A FORCED LANDING PAPA VICTOR, OH NO ITS GOING AGAIN". The controller continued providing vectors to Tatenhill whilst his assistant briefed Tatenhill's radio operator and West Drayton's Distress and Diversion cell on the developing situation. At 1315:40 hrs, when the aircraft was 10 miles north-west of Tatenhill at 2,800 feet altitude, the pilot reported "NO ENGINES ... W'ELL HAVE TO FIND A FIELD". The last recorded RTF message from the pilot at 1316:50 hrs was "I HAVE A HI... HILL ERM A FIELD ON A".

The pilot was heavily sedated in hospital for some time after the accident and she could remember little of the final stages of the glide approach. The aircraft passed low beside a farmhouse and crash-landed in a field of soft earth with a significant up-slope in the landing direction.

Rescue aspects

The East Midlands Approach controller vectored another light aircraft to the last known radar position and its pilot reported that the aircraft was substantially damaged. The accident was also reported via a 999 telephone call at 1321 hrs by a resident of the nearby farmhouse. The police arrived at the scene at 1332 hrs. Four of the five occupants were seriously injured and three were trapped in the wreckage. The fifth occupant, a young boy, received minor injuries and was able to extricate himself through the emergency exit which he had jettisoned before the crash in accordance with the pilot's pre-flight briefing on emergency procedures. The three trapped occupants were cut free by the local fire service and two were airlifted to hospital by helicopters. Three adult occupants had sustained debilitating spinal injuries consistent with a high, vertical speed component at impact.

Flight Data

Radar data obtained from National Air Traffic Services' Claxby antenna were used to reconstruct the latter part of the flight. The data showed that at the time the right engine lost power, the aircraft was cruising at 125 kt groundspeed on a north-westerly track at about 3,500 feet. Approaching the outskirts of Stoke on Trent, the aircraft turned to the right and took up a south-westerly track towards Tatenhill, losing some 500 feet altitude during the turn. Completion of the turn coincided with the first loss of power from the left engine. The aircraft then descended at an erratic rate to

1,300 feet altitude before turning onto a south-westerly heading towards the field where it subsequently force landed. After that turn, the rate of descent was more consistent at about 1,000 feet per minute; the ground speed was between 90 and 100 kt. The final radar contact was at 1317 hrs when the aircraft was at 540 feet amsl over terrain which rose to 460 feet amsl. When plotted on an Ordnance Survey map, the last radar return was some 500 metres north of the crash position.

Examination of the crash site

The aircraft had come to rest in a ploughed field in a relatively short distance for a forced landing, on a ground track of about 230 degrees (magnetic). The landing gear had been broken away during the first part of the ground roll, and the vertical speed had been high enough to cause the wing to fail at the centre section. As a result, there had been considerable disruption of the passenger cabin due to the inertia loads and the collapse of the fuselage structure. There was no fire and the fuel tanks remained intact with little evidence of spilt fuel, although the fire services had put down a small amount of foam at the left wing, where they advised some fuel had been seen. The right hand propeller was feathered at impact and the damage indicated that the engine had stopped. The left hand propeller showed evidence of slow rotation at impact, and was not feathered. On the accident site the aircraft was found to have about 15 gallons of fuel in the left tank whilst the right tank was empty.

Examination of the wreckage

Detailed examination of the aircraft at Farnborough found that the right hand engine fuel selector valve, which is mounted in the right wing, was in an abnormal position. Both fuel selector valves had been set from the cockpit control knobs to configure the fuel system so that the left wing tank fed the left engine and the right tank fed the right engine. In this 'tank-to-engine' configuration, the left and right systems should have been effectively isolated. A schematic diagram of the P68 fuel system is shown at figure 1 *(jpg 120kb)* at the end of this report.

Examination of the right fuel valve revealed that it was in an intermediate position which permitted all the ports of the valve to be open, or partly open, simultaneously. This had the effect of eliminating the isolation of the two sides of the fuel system. The valves, one in each wing, were operated by 'teleflex' cables from the cockpit. There was little or no 'feel' transmitted from the valve itself to the cockpit and the only indication the pilot had of valve position was the visual position of the control knob. The correct operation of the valve was therefore dependent upon the correct adjustment and operation of the teleflex cable and the care with which the pilot operated the control knob.

Testing by the AAIB at Farnborough showed that with either valve incorrectly positioned (as the right valve was found), fuel could transfer from one tank to the other either during flight or on the ground. The investigation determined that the aircraft type has a history of unequal usage of fuel from the left and right wing tanks. According to anecdotal evidence, Partenavia P68s of various marques have experienced such fuel transfer from time to time. Fuel has transferred overnight while parked, and unexplained fuel imbalances have occurred in flight. Testing also showed that with the right fuel valve as found, when the right tank ran dry the supply to the right engine was immediately interrupted, and shortly afterwards air was entrained into the left engine supply line from the right tank. The testing at the AAIB seemed closely to identify the sequence of events that occurred in this accident.

Once this possibility was confirmed, the AAIB considered it prudent to make immediate safety recommendations. On 5 September 2001 the AAIB made the following safety recommendations to the UK Civil Aviation Authority (CAA), the type certificate holder (Vulcanair) and the Italian civil aviation authority, the Registro Aeronautico Italiano (RAI):

Safety recommendation 2001-73

It is recommended that the CAA, in conjunction with the Registro Aeronautico Italiano (RAI) and Vulcanair, take early action to warn pilots of Partenavia P68 aircraft of the possibility of inadvertent fuel transfer and engine supply problems arising from a lack of correct synchronisation between cockpit fuel selectors and fuel selector valves; and take early action to require in-service inspection of these fuel selector circuits to ensure correct operation.

Safety recommendation 2001-74

It is recommended that Vulcanair, in conjunction with the RAI and the CAA, conducts an early review of the operation and airworthiness of the fuel valve selector system on all Partenavia P68 models, with a view to corrective actions to prevent inadvertent mis-positioning of fuel selector valves and resultant inadvertent fuel transfer and engine supply problems.

Responses to safety recommendations

In response to recommendation 2001-73, the CAA advised the AAIB that the P68 Maintenance Manual requires a check on the condition and operation of the fuel selector valves at 100 hour intervals. It was not apparent from the maintenance records of N33PV that this had been done. The type certificate holder had previously issued Service Bulletin No. 52 and Service Instruction No. 13 to replace the fuel selector valve control cable stop tube. The stop tube was not a factor in the accident. The CAA considers that sufficient information is contained in the existing publications to require inspections of the fuel selector circuits. However, the CAA intends to bring details of the maintenance task to the attention of owners and operators early in 2002.

In response to recommendation 2001-74, the CAA responded that it has conducted a review of the operation and airworthiness of the fuel valve selector system on P68 models operating in the UK and is satisfied that there is adequate published service information. It has stated that it will assist RAI and the type certificate holder with a review of other P68 models.

On 1 March 2002 Vulcanair informed the AAIB of the forthcoming issue of a Service Bulletin. The Bulletin would advise all P68 owners and operators of the possibility of inadvertent fuel transfer from one tank to another and consequential engine problems, due to a lack of correct synchronisation between the fuel selector knob in the cockpit and the fuel selector valve in the wing. It would also include further details of how to perform checks on the rigging of the fuel control system to obtain perfect synchronisation between the fuel selector knob in the cockpit and the fuel selector valve.

Fuel quantity indicator system

The main components of the fuel quantity indicator system were a dual fuel quantity indicator gauge mounted on the instrument panel, and two fuel quantity transmitters, one in each fuel tank. The electrical wiring from the fuel quantity transmitters to the indicator gauge passed through the wings and forward fuselage, and had been severed in a number of places. The indicator gauge and

transmitters were individually tested and found to operate correctly. During the course of this testing it was found that the information contained in the Maintenance Manual concerning the wiring of the dual fuel quantity indicator gauge, was incorrect. The connections to pins B and C of the gauge were reversed in the Maintenance Manual. This, if followed, would have had the effect of crossing the fuel tank indications over so that the contents of the left tank would be indicated as being in the right tank, and vice versa. Because of the damage to the aircraft it was not possible to establish if N33PV had been correctly wired or not. There was no evidence found during the investigation that this had been a problem at any time before the accident.

The type certificate holder has confirmed that the pin connections given in the Maintenance Manual are reversed due to a typographical error. On 15 January 2002 the company informed the AAIB that a temporary revision to the P68 Maintenance Manual would be issued as soon as practicable. On 1 March 2002 the type certificate holder stated that temporary revisions TR-001to both the P68C and the P68 Observer 2 Maintenance Manuals were being distributed.

Fuel system anomalies

The pilot stated that she had once replenished the tanks to full at Cardiff Airport and then flew to Coventry where the aircraft was parked on gently sloping ground with one wing 'higher' than the other. Overnight, fuel transferred from the higher tank to the lower and then onto the grass through the overflow vent. The pilot believed this was caused by fuel expansion in the tanks leading to syphoning through the vent pipe. This was probably a mistaken assumption since, although the fuel valve selectors may have been indicating the correct tank to engine selections, an incorrectly adjusted valve can allow fuel to transfer by gravity from one wing to the other on sloping ground.

Consequently, the fuel levels in each tank could have changed during the long intervals between arrival and departure at Vannes, and between arrival and refuelling at Meaux. The transfer rate after refuelling at Meaux would have been lower than the refuelling rate so the aircraft would probably have been left wing heavy on departure. Subsequently, with the engines running, the transfer of fuel between tanks would have been less predictable because of the effects of the fuel pumps on the pressures within the various pipes.

If the fuel selectors had not been operated for some time, it is possible that the right engine had been drawing some of its fuel supply fuel from the left tank. This could explain why the aircraft had a history of using more fuel from the left side than the right.

When asked if she moved the fuel selectors at any time during the accident flight, the pilot replied that she had never ever moved the selectors because she had never needed to do so.

Fuel planning and consumption

At the pilot's habitual cruise power settings of 2,350 RPM and 32 inches Manifold Pressure, the P68 Flight Manual fuel consumption figure is 20.4 USG/hour at best economy mixture which equates to 77.5 litres per hour. By her own admission, the pilot was not particularly skilful at leaning the mixture. She deliberately tended to err on the rich side of best economy mixture so a fuel consumption rate of 80 litres per hour was used to explore the likely fuel consumption.

The P68's engines would burn fuel at a higher rate than 80 litres per hour on take-off and climb, and at a lower rate during descent and landing. However, because the aircraft was used for sectors of about an hour's duration or more at low altitudes, this rate was considered a valid block

consumption rate for all the flights undertaken since the aircraft left Guernsey. Using that rate, the 460 litres in the tanks at Guernsey was sufficient for 5 hours 45 minutes flight. The 157 litres loaded at Meaux should have extended this endurance to about 7 hours 40 minutes flight to dry tanks if the fuel had been available to both engines.

Since leaving Guernsey the aircraft was on its third flight and it had been airborne for a total of 5 hours 49 minutes when the right engine lost power. Had it been able to continue the planned flights, it would have been airborne for at least another 1 hour 25 minutes. The total flight time for the day would then have been not less than 7 hours 14 minutes in which case the aircraft would have arrived at Henstridge with about 30 minutes of cruise fuel remaining.

Apparent fuel loss

If no fuel had transferred between the tanks, then when the right tank was empty the left tank should have contained more than 100 litres but the post accident indications were of a lower quantity in the order of 70 litres. The integrity of the left tank was not breached by impact damage but the tank's post-accident orientation was such that the wing tip was lower than the root and the level of the fuel remaining reached the tank filler neck. Consequently, between the time of the accident and the arrival of the investigators eight hours later, fuel may have leaked out from around the filler cap or from the overflow pipe onto the soil and evaporated. Evidence that this had probably occurred was the fire service's report of seeing fuel leaking from the left wing prompting them to deposit foam in that area.

Conclusions

The accident arose partly through significantly asymmetric fuel quantities in the two wing tanks before the aircraft took off. The pilot was critically injured in the accident and heavily sedated for some time afterwards, which may explain why she could remember few details of the refuelling process at Meaux. Because she left the aircraft during the refuelling operation, she may have been unaware that only the left tank had been replenished.

A representative of the flying club at Meaux stated that the club accepted payment for fuel only by French cheque or in cash, and that the pilot paid in cash and appeared to spend all her remaining French currency. However, after paying all the charges at Meaux, the pilot's family had several hundred Francs and some French currency cheques with them and consequently, the inability to pay for more fuel was not an issue. Moreover, no explanation was offered as to how a pilot could pay for 157 litres of fuel before it had been delivered without the refueller receiving instructions to deliver that quantity.

The pilot could not remember her instructions to the refueller but her instructions to a family member who remained with the aircraft were that if the left tank was between one half and two thirds full, the right tank was to be filled to within two inches of the filler neck. The pilot now believes that there may have been some confusion between the identification of 'left' and 'right' tanks. Nevertheless, if the fuel tank quantities were similar before the refuelling, it is surprising that the pilot was unaware of any tendency to roll towards the heavier left wing after take-off. Moreover, it is also surprising that the fuel gauges, which worked correctly when tested, did not give early warning of low fuel contents in one tank.

The loss of power from the right engine was consistent with exhaustion of the fuel supply from the right wing tank which had not been replenished since the aircraft left Guernsey. Had it not been for

the mis-positioned fuel selector valve, the pilot should have had ample fuel to land safely at Tatenhill on one engine, a procedure which she had been adequately trained to accomplish. This option was thwarted when air from the empty right tank reached the left engine. At that moment the left engine began to run intermittently and ultimately the pilot had no option but to execute a forced landing.

The pilot chose a brown field in which to land because she feared the aircraft might turn over if she landed in a field of standing crop. The upward slope of the field, the soft earth and the 'clean' wing configuration all contributed to a very heavy forced landing. The pilot did not remember feathering the right propeller (it had been feathered) and she could not explain why she had touched down with the flaps retracted. Nevertheless, the tone of the pilot's voice on the radio suggested that she was coping well with an unpleasant and unforeseen situation. The East Midlands air traffic controller's performance was exemplary.