On the evening of 31 May 2000, Piper Chieftain, VH-MZK, was being operated by Whyalla Airlines as Flight WW904 on a regular public transport service from Adelaide to Whyalla, South Australia. One pilot and seven passengers were on board. The aircraft departed at 1823 central Standard Time (CST) and, after being radar vectored a short distance to the west of Adelaide for traffic separation purposes, the pilot was cleared to track direct to Whyalla at 6,000 ft. A significant proportion of the track from Adelaide to Whyalla passed over the waters of Gulf St Vincent and Spencer Gulf. The entire flight was conducted in darkness.

The aircraft reached 6,000 ft and proceeded apparently normally at that altitude on the direct track to Whyalla. At 1856 CST, the pilot reported to Adelaide Flight Information Service (FIS) that the aircraft was 35 NM south-south-east of Whyalla, commencing descent from 6,000 ft. Five minutes later the pilot transmitted a MAYDAY report to FIS. He indicated that both engines of the aircraft had failed, that there were eight persons on board and that he was going to have to ditch the aircraft, but was trying to reach Whyalla. He requested that assistance be arranged and that his company be advised of the situation. About three minutes later, the pilot reported his position as about 15 NM off the coast from Whyalla. FIS advised the pilot to communicate through another aircraft that was in the area if he lost contact with FIS. The pilot's acknowledgment was the last transmission heard from the aircraft. A few minutes later, the crew of another aircraft heard an emergency locater transmitter (ELT) signal for 10-20 seconds. Early the following morning, a search and rescue operation located two deceased persons and a small amount of wreckage in Spencer Gulf, near the last reported position of the aircraft. The aircraft, together with five deceased occupants, was located several days later on the sea-bed. One passenger remained missing.

On 9 June 2000, the wreckage of the aircraft was recovered for examination. Aside from the engines, no fault was found in the aircraft that might have contributed to the accident. Both engines had malfunctioned due to the failure of components of the engines.

The crankshaft of the left engine fractured at the Number 6 connecting rod journal. Fatigue cracking was initiated by the presence of a planar discontinuity in the journal surface. It was evident that the discontinuity had been caused by localised thermal expansion of the nitrided journal surface following contact with the edge of the Number 6 connecting rod big end bearing insert. The crankshaft failed approximately 50 flights after fatigue crack initiation.

The Number 6 bearing insert was damaged during engine operation through the combined effect of:

- high bearing loads created by lead oxybromide deposit induced preignition, and
- lowered bearing insert retention forces associated with the inclusion of an anti-galling compound between the bearing inserts and the housings.

Fatigue cracking in the Number 6 connecting rod big end housing had developed following the gradual destruction of the bearing insert. The left engine probably continued to operate for 8-10 minutes after the final fracture of the Number 6 connecting rod housing before the final disconnection of the Number 6 journal of the crankshaft. It is likely that the engine would have displayed signs of rough running and some power loss during this time. The final disconnection of the crankshaft resulted in a loss of drive to the magnetos, fuel pump, camshaft and, consequently, the sudden stoppage of the engine. The left propeller was in the feathered position when the aircraft struck the water, confirming that the engine was not operating at that time.

The physical damage sustained by the right engine was restricted to the localised melting of the Number 6 cylinder head and piston. The piston damage had allowed combustion gases to bypass the piston rings. The overheating of the right engine combustion chamber components was a result of changes in heat transfer to cylinder head and piston surfaces created by combustion end-gas detonation. The carbonaceous nature of the residual deposits on the piston crowns indicated that detonation had occurred under a rich fuel-air mixture setting. Rich mixture settings are used with high engine power settings.

The damaged piston would have caused a loss of engine oil and erratic engine operation, particularly at higher power settings. Engine lubrication was still effective at impact, indicating that oil loss was incomplete and that the piston holing occurred at a late stage of the flight. Examination of the right propeller indicated that the blades were in a normal operating pitch range (i.e. not feathered) when the aircraft struck the water. It could not be confirmed that the right engine was operating when the aircraft struck the water, although it most probably was operating when radar contact was lost as the aircraft descended through 4,260 ft when 25.8 NM from Whyalla.

The aircraft was not fitted with a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR), nor was it required to be. Analysis of recorded radar data confirmed that the aircraft performed normally during the flight until the latter stages of the cruise segment when the speed gradually decreased. Speed variations, accompanied by track irregularities, then became more pronounced. Analysis of recorded voice transmissions revealed that propeller (and engine) RPM during the climb from Adelaide was 2,400. The RPM was 2,200 after the aircraft levelled at 6,000 ft. These were normal climb and cruise engine settings used by the company and the performance achieved by the aircraft during these segments was consistent with normal engine performance. Just prior to the commencement of descent, an RPM of 2,400 was identified. That was not a normal engine power setting for that stage of the flight.

The aircraft speed and propeller RPM information, coupled with the engine failure analysis, was consistent with the following likely sequence of events:

- The power output from the left engine deteriorated during the first third of the cruise segment of the flight after the Number 6 connecting rod big end housing had fractured. The engine ceased operating completely 8-10 minutes later.
- In response to the failure of the left engine, the pilot increased the power setting of the right engine.
- Increased combustion chamber component temperatures via detonation within the right engine led to the Number 6 piston being holed. That resulted in the erratic operation of the right engine with reduced power and controllability and left the pilot with little alternative but to ditch the aircraft.
- The double engine failure was a dependent failure.

Examination of eight failures of Textron Lycoming engines from a number of operators that had occurred over the period January 2000 to November 2001 revealed that deposits of lead oxybromide on combustion chamber surfaces were not restricted to the engines from MZK; seven other engines had such deposits. The inclusion of a copper-based anti-galling compound between the bearing insert and big end housing was noted in three of the engines examined. The quantity of anti-galling compound present varied between those engines.

Lead oxybromide deposits and anti-galling compounds act in different ways to weaken the defences for reliable engine operation. The relative contribution to engine failure of the factors cannot be predicted easily because of variations in the extent of each effect and the complexity inherent in engine assembly and operation. It is likely that the formation of lead oxybromides that cause deposit induced preignition is linked to the temperature of the fuel-air charge temperature in the combustion chamber just prior to the passing of the flame front. Leaning the mixture during climb, and using near "best economy" cruise power settings appeared to favour the formation of lead oxybromide deposits that resulted in deposit induced preignition. Mixture settings of "full rich" mixture during climb and "best power" cruise settings appeared to favour reactions that resulted in less extensive and different deposits being formed. The Whyalla Airlines procedure was to lean the mixture during climb, and to use a cruise power setting close to "best economy". Those procedures were in accordance with the US Federal Aviation Administration (FAA) approved Pilot's Operating Handbook for the Piper Chieftain aircraft. The combination of the use of leaded aviation gasoline, mixture leaning during climb, and leaning for best economy during cruise was not restricted to Lycoming engines. The ATSB also found evidence of high combustion loads and lead oxybromide deposits during the examination of components from two Teledyne Continental TIO-520 engines that were defective.

Anecdotal reports indicated that there were fewer engine problems (including component failures) in engines that were operated full rich during climb, and "best power" during cruise, compared with those where the mixture was leaned during climb and "best economy" cruise power was used. A comparison of the engine operating procedures of twelve other operators of Piper Chieftain aircraft revealed considerable disparity in procedures, particularly for climb and cruise. In fact, no two operators used the same procedure.

The incidence of lead oxybromide deposits in engines that had experienced defects, coupled with the range of fuel leaning techniques used, indicated a deficiency in the operation and maintenance of those engines, at least among some of the operators of high-powered piston engine aircraft in Australia.

On 30 October 2000, the ATSB issued a recommendation that the Civil Aviation Safety Authority alert operators regarding the risks of detonation, and encourage the adoption of conservative fuel leaning practices. The report included further recommendations addressing the following:

- the engine operating conditions under which combustion chamber deposits that may cause preignition are formed (addressed to the US Federal Aviation Administration);
- the effect on engine reliability of the use of anti-galling compounds between connecting rod bearing inserts and housings (addressed to the US Federal Aviation Administration and the engine manufacturer); and
- the reliability of high-powered aircraft piston engines operated in Australia (addressed to CASA).

This accident was the first recorded ditching involving a Piper Chieftain aircraft in Australia. Available records world-wide of previous Piper Chieftain engine failure/ditching events illustrate that, in most instances, successful night ditchings occurred in better visibility and weather conditions than those confronting the pilot of MZK. The relatively minor injuries suffered by the occupants of the aircraft indicated that the pilot demonstrated a high level of skill in ditching the aircraft. The report includes a recommendation to CASA regarding guidance material for pilots on ditching.

It is likely that the survival prospects of the occupants would have been enhanced had the passenger seats been fitted with upper body restraints, and life jackets or equivalent flotation devices had been available to the occupants. As a result of a separate investigation, the Bureau issued a recommendation concerning upper body restraints on 31 March 1999. On 30 October 2000, arising from the Whyalla investigation, the ATSB issued recommendations to the Civil Aviation Safety Authority concerning the provision of adequate emergency and life saving equipment for the protection of fare-paying passengers in smaller aircraft during over-water flights.

The investigation included a detailed examination of the regulatory history of Whyalla Airlines from June 1997 to June 2000. In common with the published findings of other reports on CASA surveillance activities, there was a significant under-achievement of surveillance of the company against CASA's planned levels during that period. However, there was insufficient information to conclude that the level of surveillance achieved was of significance with respect to the accident.

With regard to Whyalla Airlines itself, issues were identified in the company that had the potential to adversely influence safety. There was insufficient information to conclude that any of these issues were of significance with respect to the accident.

As a result of the accident and ATSB's investigation, improved refuelling procedures were introduced nationally by the refuelling organisation to reduce the chance of error.

The full report is available on the ATSB website www.atsb.gov.au or from the bureau on request.