LIMITED OCCURRENCE INVESTIGATION REPORT – FINAL

Reference Number	CA18/3/2/1405						
Classification	Serious Incident		**Date**	13 February 2023		**Time**	0838Z
Type of Operation	Private (Part 91)						
Location							
Place of Departure	Delta 200 Airfield (FADX), Western Cape Province		Place of Intended Landing	Delta 200 Airfield (FADX), Western Cape Province			
Place of Occurrence	On a private road, approximately 2 nautical miles (nm) north of FADX, Western Cape Province.						
GPS Co-ordinates	Latitude	33°36' 46.91" S	Longitude	018°27' 33.33" E		Elevation	220 ft
Aircraft Information							
Registration	ZS-ZGZ						
Make; Model; S/N	Cessna U206C Super Skywagon (Serial Number: U206-1003)						
Damage to Aircraft	None		Total Aircraft Hours	11 342.8			
Pilot-in-command							
Licence Type	Commercial Pilot Licence (CPL)		Gender	Male		Age	21
Licence Valid	Yes	Total Hours	266.9	Total Hours on Type			130.9
Total Hours Past 30 Days	17		Total Flying Hours on Type Past 90 Days	124.5			
People On-board	1 + 6	**Injuries** 0	**Fatalities**	0	**Other (on ground)**		0

What Happened

On Monday morning, 13 February 2023, a pilot reported at Delta 200 Airfield (FADX) situated on Brakkefontein Road in Koeberg, Western Cape province, to prepare for the sport parachuting drop flight abeam the same airfield. The Cessna U206C Super Skywagon aircraft with registration ZS-ZGZ was to be used for this flight. Upon arrival at the operator's facility at FADX, the aircraft was pushed out of the hangar, and the pilot carried out a pre-flight inspection; nothing abnormal was detected. The pilot stated that the aircraft had 160 litres (l) of Avgas LL100 fuel and the engine oil level indicated 8.5 quarts on the dip stick.

Once the aircraft was ready, the pilot informed the skydiving team (which consisted of three tandem parachute instructors and three passengers they each intended to jump with). Visual meteorological conditions (VMC) by day prevailed at the time of the flight which was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

The pilot stated that before embarkation, one of the tandem parachute instructors presented a safety briefing. The tandem parachute instructors later performed the pre-jump inspection on the gear in accordance with (IAW) the Parachute Association of South Africa (PASA) standard operating procedures (SOP) to ensure that the parachutes were all fitted with serviceable automatic activation devices (AAD), and that the altimeters were serviceable. The pilot started the engine and allowed it

to warm up until the indications were within the green arch. Later, the pilot taxied the aircraft to the threshold of Runway 20 and performed the pre-departure run-up checks. The pilot called the Cape Town International Airport (FACT) tower on very high frequency (VHF) 118.10-Megahertz (MHz) before take-off to inform them of his flight plan to climb to flight level (FL) 090 whilst in the Terminal Manoeuvring Area (TMA) before he could return to FADX, from where the skydivers drop would commence. Thereafter, the pilot opened the throttle lever to 2 550 revolutions per minute (RPM) with the manifold air pressure (MAP) set at 25 inches. He then commenced with the take-off run. The pilot reported that the aircraft rotated at 89 knots indicated ground speed and, after reaching 400 feet (ft) above ground level (AGL), he made a left turn to the west towards the sea.

As the aircraft reached 4 500 feet (ft) above ground level (AGL) whilst manoeuvring in the TMA area, one of the passengers reported feeling ill. The pilot instantly called FACT approach on frequency 120.05 MHz to inform them of their emergency, as well as to request permission to descend to a lower height and return to FADX. The pilot advised the tandem instructors to remain on-board as he considered that to be the safest option.

Approximately after exiting the TMA at 3 000 AGL, the pilot heard a loud bang coming from the engine. This was followed by oil splashing on the windscreen. The pilot followed the engine failure procedure as outlined in the Pilot's Operating Handbook (POH) and switched off the engine. He then broadcasted a Mayday call on the TIBA (uncontrolled airspace traffic information broadcasts by aircraft) on frequency 124.80 MHz whilst preparing for a forced landing. Through the limited visual on the left side of the windscreen, the pilot spotted a road passing through the industrial area. He then glided the aircraft towards the road and performed a successful forced landing approximately 2 nautical miles (nm) north of FADX. The pilot and the passengers were uninjured; they exited the aircraft without assistance.

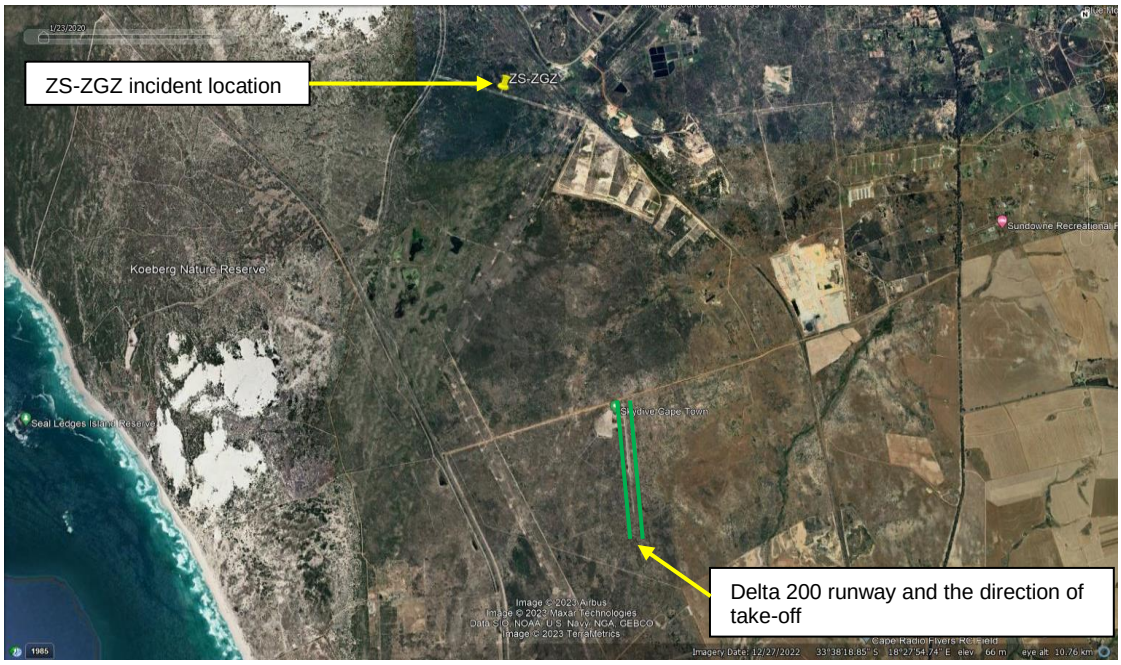

Figure 1: View of the airfield and the area where the aircraft landed. (Source: Google Earth).

Figure 2: The aircraft on the public road after the forced landing. (Source: Operator)

Delta 200 Airfield (FADX)

FADX is a small unlicensed airfield situated in Koeberg in the Western Cape province. It accommodates private aircraft operators on arrangement, and it is known for skydiving operations by both the Stellenbosch and the Cape Town skydivers club. The airfield has no air traffic control (ATC) services and has a single asphalt runway orientated 02/20 that is 734 metres (m) long and 9m wide. The airfield elevation is 220ft. The runway surface is relatively flat and smooth. The pilot described it as being in good condition and well maintained.

The Pilot

The pilot was issued a Commercial Pilot Licence (CPL) by the SACAA on 20 September 2022 with an expiry date of 30 September 2023. The pilot's logbook was examined, and it was found that at the time of the incident, the pilot had flown a total of 266.9 hours, of which 130.9 hours were on the aircraft type. The pilot had the aircraft type endorsed on his licence. The pilot had a valid Class 1 aviation medical certificate which was issued on 24 August 2022 with an expiry date of 12 August 2023. The pilot had no restrictions listed on his licence.

The Aircraft (Pilot's Operating Handbook)

The Cessna C206 Super Skywagon is a six-seat, high wing monoplane aircraft of all metal, semi-monocoque construction, equipped with a fixed tricycle tabular spring steel main gear struts and a steerable nose wheel with an air / hydraulic fluid shock strut. The aircraft had an entry door on the left side of the cabin at the pilot's seat position and a double cargo door on the right side of the cabin, but for parachuting operations, the cargo door was removed.

The aircraft is powered by a six-cylinder, horizontally opposed, air cooled Continental IO-550-F27B fuel injected engine (Serial number 1031203) with a wet sump oil system. The engine has a power output of 300 brake horsepower (BHP) at 2 850 RPM, and maximum continuous is 285 BHP at 2 700 RPM. The engine cylinders are numbered as follows: 1, 3 and 5 on the right-hand side, back to front and 2, 4 and 6 on the left-hand side (Figure 3 below). The engine was fitted with a Hartzell three-blade constant speed propeller.

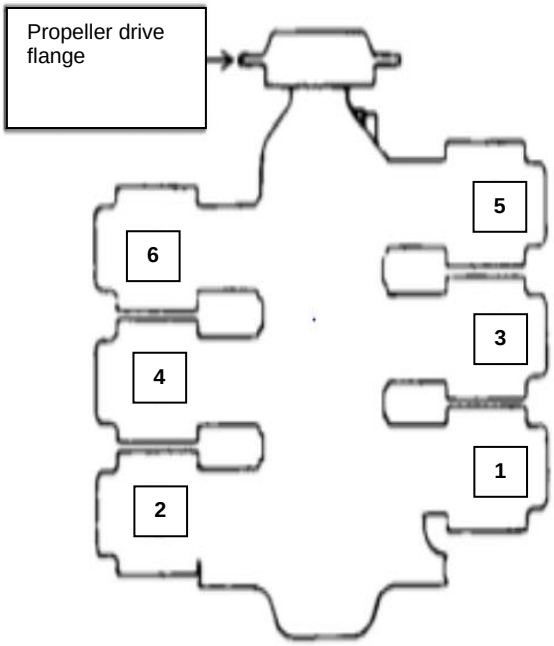

Illustration 1: Continental engine cylinder numbering (view from the top).
(Source: Continental operator's manual)

The engine comprised 2 crankcase halves with 3 cylinders fitted to each half. Each cylinder is retained by 8 nuts, with are tightened onto studs in the crankcase halves. 4 of the studs has a larger thread diameter than the other 4 studs. 2 of the larger diameter studs at each cylinder are classified by the engine manufactures as "thru studs", in that they pass through both crankcase halves and are used to secure the 2 crankcase halves together in addition to securing 2 opposing cylinders. The remaining six studs at each cylinder are shorter and do not pass through both crankcase halves but are screwed into threaded holes in each crankcase half.

According to Continental operator's manual, oil is drawn from a sump through the suction tube to the intake side of the engine driven gear type oil pump. From the outlet side of the pump, oil is directed to the integral oil filter screen chamber. An oil by-pass valve is incorporated in the oil pump housing in the event that the filter becomes clogged. An oil pressure relief valve is incorporated in the oil pump housing. The pressure relief valve opens when pump pressures exceed the adjusted/specified limit. When the pressure relief valve opens, oil is directed back to the intake side of the oil pump gear.

From the oil discharge port, oil is directed through a crankcase passage to the right crankcase oil gallery. Right side tappet, tappet guides and valve mechanisms are lubricated by passages leading off this gallery. An oil temperature control valve is located at the front end of the right oil gallery to regulate oil temperature within limits. When oil reaches a temperature high enough to require cooling, the oil temperature control valve expands and blocks the passage, directing oil flow through the oil cooler. From the oil temperature control valve cavity, oil is directed to the camshaft passage. A groove around the front of the camshaft directs oil to the front camshaft bearing and left crankcase oil gallery. Left side tappets, tappet guides and valve mechanism are lubricated by passages leading off this gallery.

Hydraulic valve tappets transfer oil from the main oil galleries to the cylinder overhead. Oil flows through the hollow push rods to a drilled oil passage in the rocker arms. Oil that flows through and exits the rocker arms lubricate the valve stems, springs, roto coils and retainers. The oil then falls to the lower rocker cavity returning to the crankcase and sump through the push rod housing. Lubricating oil is directed to the governor drive gear and propeller governor through passages off the left main gallery. Oil is channelled through a discharge port to the crankshaft oil transfer collar and crankshaft interior.

Oil then travels through a transfer plug installed in the middle diameter of the crankshaft and flows to the propeller. Oil from the left main crankcase is also directed upward through crankcase oil passage to the crankshaft main bearing. Oil flow from the rear crankshaft main bearing to the starter shaft gear bushing and idler gear bushing. Oil is directed upward from the idler gear bushing to both accessory drive bushings.

Oil lubricating the crankshaft main journals is directed through the upper main bearing oil spurt holes, through the crankcase passages to oil squirt nozzles that spray oil onto the underside of the pistons. This oil spray aids in lubrication and heat dissipation. Oil falls from the pistons through the crankcase cavity back to the oil sump.

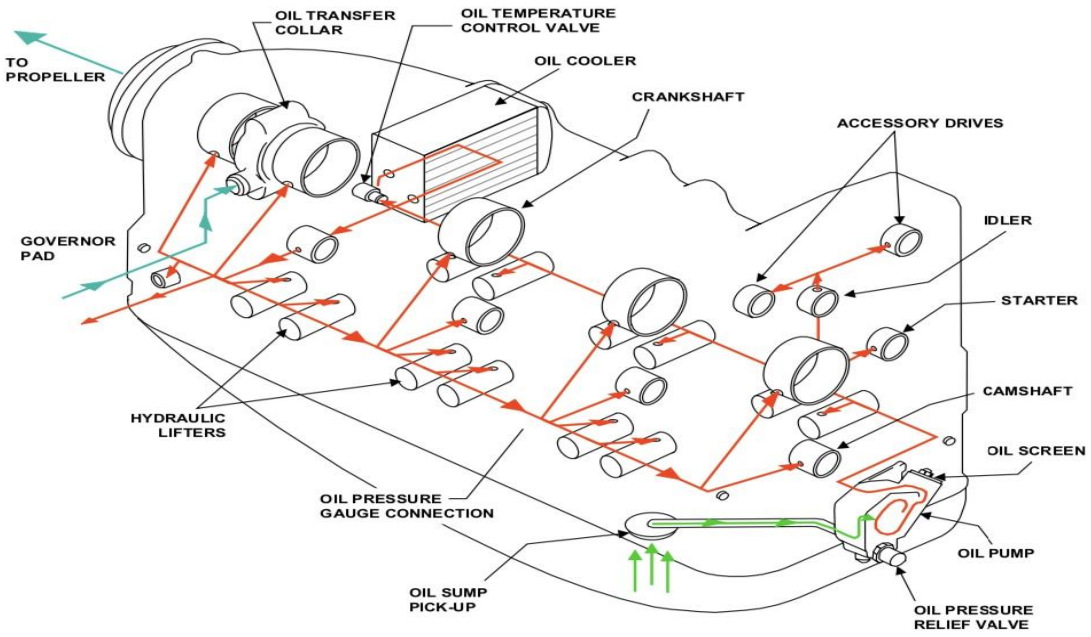

Illustration 2: Oil system schematic for IO-550 model engine. (Source: Continental Operator's Manual)

According to the Continental Motors (TCM) service instruction letter (SIL) 98-9C dated 17 July 2023, time between overhaul (TBO) period for IO-550-F27B engine model fitted on ZS-ZGZ is 1 900 hours or 12 years. Scrutiny into the engine logbook and flight folio revealed that the engine was installed as new on ZS-ZGZ on 8 December 2015. The engine has recorded 1 556.7 total hours in service since installation. Scrutiny into the aircraft engine logbook indicated no evidence of the engine being removed from the aircraft or disassembled since the original date of installation. There was no evidence of modification/s performed on the engine from its original type design and no trace/s of major repairs.

The aircraft's maintenance work pack indicated that the last 100-hour mandatory periodic inspection (MPI) prior to the incident flight was certified on 27 January 2023 at 11 299.0 total airframe hours. The aircraft had accumulated 11 342.8 total hours at the time of the incident, meaning that it had flown a further 43.8 hours since the last inspection. Records showed that the operator complied with all the available Airworthiness Directives (ADs) and Service Bulletins (SBs). The aircraft maintenance organisation (AMO) that certified the maintenance task was in possession of an approval certificate issued by the SACAA on 28 February 2022 with an expiry date of 28 February 2023.

The aircraft's Certificate of Airworthiness (C of A) was issued on 17 December 1997 with an expiry date of 31 December 2023. The Certificate of Registration (C of R) was issued to the current owner on 13 June 2011. The Certificate of Release to Service (CRS) was issued on 27 January 2023 with an expiry date of 26 January 2024 or at 11 399.0 hours, whichever occurs first.

The weather report for FADX obtained from FACT on 13 February 2023 at 0700Z stated the following:

Wind Direction	130°	Wind Speed	3 knots	Visibility	> 10km
Temperature	21°C	Cloud Cover	Nil	Cloud Base	Nil
Dew Point	18°C	QNH	1013		

Post-incident examination of the aircraft/engine:

The engine was inspected before the aircraft was recovered to Stellenbosch Aerodrome (FASH) in the Western Cape province. The engine oil filler cap remained in place. The engine-driven oil pump and oil supply lines were intact. The crankcase had a hole at the top-right side in line with the No.5 piston area (right front). It was evident from the outside view that the hole at the top-right side of the crankcase was caused by the No.5 connecting rod inside the crankcase. The connecting rod shaft was 'spotted' inside the engine, adjacent to the hole. Oil was forced out of the crankcase and it escaped through the gaps in the engine cowling and contaminated the aircraft's windscreen. Some fragments of the connecting rod were ejected through the hole and were strewn on the cooling baffles between the cylinders. There was a significant amount of oil remaining in the sump; a sample of the oil was taken for analysis.

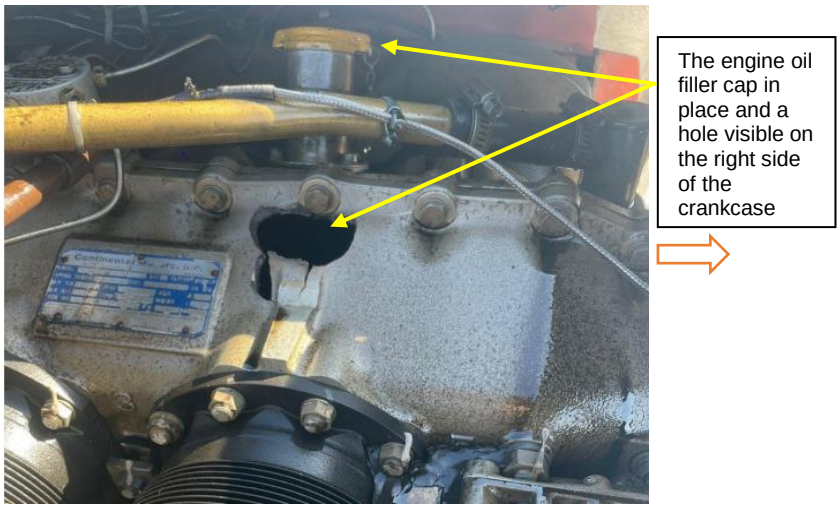

Figure 3: A hole on the right crankcase and the oil filler cap. (Source: AMO)

The engine was removed from the firewall/airframe and placed on a stand to enable a teardown inspection by the SACAA-approved AMO. Engineers documented the exterior condition of the engine before it was dismantled. The engine was reported to be in good condition and none of its exterior components was missing. All 6-cylinder base nuts and through bolts torque values were checked and found to be at the correct value as recommended in the operator's manual.

After the oil sump was removed, a large amount of metallic debris was found in the sump, but no significant debris was found that could have originated from external components of the engine. A significant quantity of oil remained in the engine sump and the oil sump pick-up was free of metal particles and/or other contamination. The engine-driven oil pump did not show any signs of abnormal wear.

Figures 4 and 5: A picture of the engine oil sump pick up (left). The engine-driven oil pump (right).

The crankcase halves were in good condition with no cracks or corrosion noted on them. The through bolts holding the two crankcase halves together were inspected, and no anomalies were noted on them. The crankshaft, counterweights, counterweight bushings, counterweight pins and plates dimensions were checked; they were within the engine manufacturer's limits, which indicated an exceptional engine balance during assembly at the manufacturer's facility. Hydraulic lifters and the camshaft were in good condition.

A detailed examination of the engine components revealed that the steel backed copper/lead alloy lined big-end (main) bearing for the No.5 connecting rod had failed, dislodging the connecting rod. This resulted in severe localised damage in the engine. Fragments of a failed connecting rod big-end cap, bearing shells and bolts were found inside the engine. Evidence showed that the No.5 connecting rod fractured near the big-end area. Fragments of the No.5 piston, bushings, piston pin and associated snap rings were found in the oil sump, an indication that the piston skirt was knocked (several times) by the failing No.5 connecting rod until the piston pin separated from the small end. The torque values for all other connecting rods big-end cap nuts were checked and found to be at the required figures as recommended in the operator's manual.

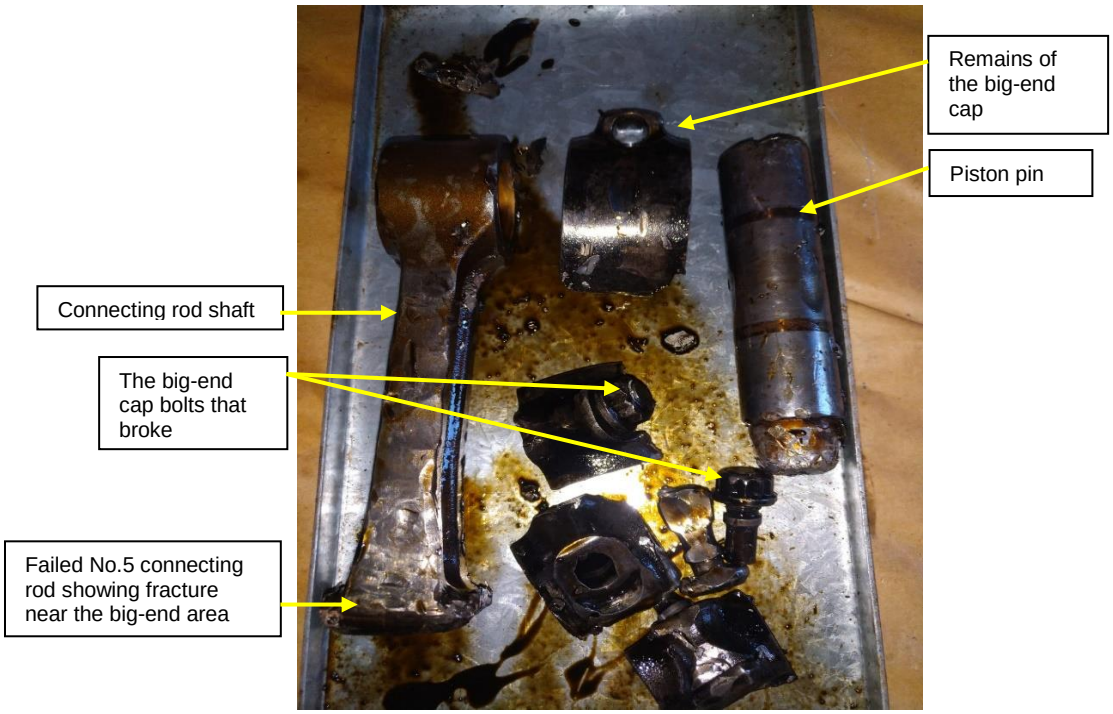

Figure 6: Damaged No.5 piston connecting rod. (Source: AMO)

There was evidence of severe heat damage (discolouration) on the No.5 big-end bearing (main) which resulted from a lack of lubrication in the region of the No.5 connecting rod journal surface area. Examination of the engine crankshaft journal revealed a blocked oil supply hole to the No.5 big-end main bearing which contributed to oil starvation and lack of lubrication. This blockage of the pressurised oil flow seemed to have been caused by a failed big-end bearing (main) which further initiated a progressive loosening of the clearance at the journal area, which allowed a gradual increase in piston stroke and increased the contact between the piston and valves. This looseness caused repeated reaction forces on the No.5 big-end bearing, pounding them until the fatigue crack extended to the shells, and breaking them. The journal surface then continued to overheat and to elongate until the connecting rod end cap bolts broke. The material that blocked the oil passage was non-metal and seemed to have originated from the soft bearing lining material (copper lead). Measurements of the engine journal diameters were consistent with the correct bearings having been used or installed on all six big-ends during assembly.

*NOTE: The bearing shells design starts out with a semi-circular steel backing which is bonded, and an intermediate layer of copper/lead alloy designed to provide the necessary cushioning, fatigue strength and temperature transmission.

Figures 7 and 8: The crankshaft journal surface showing a blocked oil supply hole (red circle) and discolouration (left picture). The non-metal debris extracted from the hole (right picture). (Source: AMO)

According to the engine manufacturer, the engine model fitted on ZS-ZGZ had a 12 quarts capacity oil sump. The aircraft maintenance records indicated that the operator complied with the oil change intervals as recommended by the engine manufacturer. Scrutiny into the aircraft technical records revealed no history of abnormal oil consumption since the engine was fitted to the aircraft on 8 December 2015.

Records indicated that 10 quarts of aviation Aeroshell W100 plus mineral oil was poured into the engine during the last MPI which was performed on 27 January 2023. With the engine oil filter that was replaced, the oil level settled at about 9 quarts after the engine ground run. The upliftment of oil between the flights after the last MPI was consistent. It should be noted that most of the flights were flown by the incident pilot. The aircraft had flown a further 43.8 hours since the last MPI. The calculated oil upliftment between the flights since the last MPI indicated that the engine oil level was between 8 and 9 quarts during the pre-flight inspection.

Examination of the aircraft's technical records indicated that the aircraft was properly certificated and maintained IAW the SACAA regulations. There were no open or differed maintenance items listed in the aircraft flight folio before the serious incident flight.

Oil Analysis

The analysis of the oil sample from the sump by the AMO showed that it was consistent with Aeroshell W100 plus oil. The results of the analysis were considered normal with no evidence of water content.

ENGINE FAILURE DURING FLIGHT

1. Airspeed -- 75 KIAS.
2. Fuel Selector Valve and Quantity -- CHECK.
3. Mixture -- RICH.
4. Auxiliary Fuel Pump -- ON for 3-5 seconds with throttle 1/2 open; then OFF.
5. Ignition Switch -- BOTH (or START if propeller is stopped).
6. Throttle -- ADVANCE slowly.

FORCED LANDINGS

EMERGENCY LANDING WITHOUT ENGINE POWER

1. Airspeed -- 80 KIAS (flaps UP).
   70 KIAS (flaps DOWN).
2. Mixture -- IDLE CUT-OFF.
3. Fuel Selector Valve -- OFF.
4. Ignition Switch -- OFF.
5. Wing Flaps -- AS REQUIRED (40° recommended).
6. Master Switch -- OFF.
7. Doors -- UNLATCH PRIOR TO TOUCHDOWN.
8. Touchdown -- SLIGHTLY TAIL LOW.
9. Brakes -- APPLY HEAVILY.

Findings

(i) The pilot was issued a CPL by the SACAA on 20 September 2022 with an expiry date of 30 September 2023.

(ii) The pilot's logbook was examined, and it was found that at the time of the incident, the pilot had flown a total of 266.9 hours, of which 130.9 hours were on the aircraft type.

(iii) The pilot had a valid Class 1 aviation medical certificate which was issued on 24 August 2022 with an expiry date of 12 August 2023.

(iv) The pilot had no restrictions listed on his licence.

(v) The flight was conducted under the provisions of Part 91 of the CAR 2011 as amended.

(vi) The last 100-hour MPI prior to the incident flight was certified on 27 January 2023 at 11 299.0 total airframe hours. The aircraft had logged 11 342.8 total hours at the time of the incident, meaning that it had been flown a further 43.8 hours since the last inspection.

(vii) The AMO that certified the last maintenance task had an approval certificate issued on 28 February 2022 with an expiry date of 28 February 2023.

(viii) The aircraft's Certificate of Airworthiness (C of A) was issued on 17 December 1997. The reissued C of A had an expiry date of 31 December 2023.

(ix) The Certificate of Registration (C of R) was issued to the current owner on 13 June 2011.

(x) The Certificate of Release to Service (CRS) was issued on 27 January 2023 with an expiry date of 26 January 2024 or at 11 399.0 hours, whichever occurs first.

(xi) The engine teardown inspection revealed a blocked oil supply channel/oil on the No.5 connecting rod journal surface area.

(xii) Examination of the engine components revealed that the steel backed copper/lead alloy lined big-end (main) bearing for the No.5 connecting rod had failed. The connecting rod detached which resulted in severe localised damage in the engine.

(xiii) No person was injured during the serious incident sequence.

Probable Cause

Successful forced landing on a road after an engine failure that seemed to have been initiated by the failed No.5 big-end bearing, which produced debris that blocked the pressurised oil supply line on the journal area; this led to lack of lubrication.

Contributing Factor

Unknown.

Safety Action(s)

None.

Safety Message and/or Safety Recommendation/s

None.

About this Report

The decision to conduct a limited investigation is based on factors including whether the cause is known and the evidence supporting the cause is clear, the level of safety benefit likely to be obtained from an investigation and that will determine the scope of an investigation. For this occurrence, a limited investigation has been conducted, and the Accident and Incident Investigations Division (AIID) has relied on the information submitted by the affected person/s and organisation/s to compile this limited report. The report has been compiled using information supplied in the initial notification, as well as from follow-up desk top enquiries to bring awareness of potential safety issues to the industry in respect of this occurrence, as well as possible safety action/s that the industry might want to consider in preventing a recurrence of a similar occurrence.

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011 and ICAO Annex 13, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and not to apportion blame or liability.

Disclaimer

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This report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa