AIRCRAFT INCIDENT SHORT REPORT

CA18/3/2/1292: Uncontained engine failure during flight as a result of separation of the No. 4 connecting rod big end bearing cap.

Date and time	:	29 November 2019 at 1246Z
Location	:	En route to Port Elizabeth Aerodrome (FAPE)
Aircraft registration	:	ZS-EZK
Aircraft manufacturer and model	:	Cessna 206C
Last point of departure	:	Port Elizabeth Aerodrome (FAPE)
Next point of intended landing	:	Port Elizabeth Aerodrome (FAPE)
Location of incident site with reference to easily defined geographical points (GPS readings if possible)	:	S33°59'24.0" E026°36'.37.0" at an elevation of 226 ft AMSL
Meteorological information	:	Temperature: 24°C, Visibility: 10km CAVOK
Type of operation	:	Aerial Work (Part 137)
Persons on-board	:	1 + 1
Injuries	:	None
Damage to aircraft	:	Damage limited to engine

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 of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (2011), 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:

Figure 1*:* A photograph of the aircraft.
(Source https://www.avcom.co.za/phpBB3/viewtopic.php?t=13285&start=1740)

1. SYNOPSIS

1.1 On Friday 29 November 2019, a Cessna 206C aircraft departed Port Elizabeth Aerodrome (FAPE) on a survey flight over Port Alfred area with the intention to return to FAPE. Fine weather conditions prevailed at the time of flight. On-board the aircraft were the pilot and a photographer. Pre-flight inspection showed nothing abnormal with the aircraft. The engine started without fault and the aircraft took off without any incident. The survey task took about three hours, and all went as planned. On completion of the survey whilst en route back to FAPE, a loud bang was heard from the engine compartment. Thereafter, the engine started to vibrate, making an abnormal sound and a small cloud of white smoke emanated from the front section. The pilot instantly cross-checked the engine instruments and noticed the low oil pressure indication, but the engine continued to run. The pilot broadcasted a MAYDAY call to the air traffic control (ATC) requesting to land on Runway 26. The pilot managed to keep control of the aircraft and used the available engine power to perform a safe landing. No injuries were reported. Post-incident inspection of the engine revealed a hole on the top left side of the crankcase. The investigation revealed that the No.4 connecting rod had failed due to excessive heat that was concentrated on the No. 4 camshaft journal area as a result of oil starvation.

2. FACTUAL INFORMATION

2.1 On Friday 29 November 2019, a Cessna 206C aircraft with registration mark ZS-EZK departed Port Elizabeth Aerodrome (FAPE) on an aerial survey flight over Port Alfred area with the intention to return to FAPE. The survey was conducted at approximately 250 kilometres per hour (km/h) and at 20 000 feet (ft) above ground level (AGL) using a hand-held video camera. Fine weather conditions prevailed at the time of the flight.

2.2 On-board the aircraft were the pilot and a photographer (who was seated on the right-hand seat). The pilot reported that the inspection of the aircraft flight folio indicated no defects and that the engine oil level in the sump following the dipstick reading was at 8 quarts. Water check of the fuel sample was taken from the aircraft's underwing purging areas using a beaker. The fuel sample came out clear and bright, free from contaminants. Fuel (Avgas LL100) quantity on departure was 300 litres, which is 216 kilograms (kg). The aircraft's maximum take-off weight is 1632.93kg. Both occupants and fuel together weighed 375.6kg and the actual calculated take-off weight was 1388.4kg, meaning that the aircraft was below its maximum weight limit. The pilot completed a walk-around pre-flight inspection before boarding the aircraft with no identified abnormalities. The two occupants had a short briefing inside the aircraft before starting the engine.

2.3 The engine started without fault and was left to run for a few minutes until the engine instruments had stabilised before taxiing to Runway 26 holding point. Pre-departure system checks were completed. The pilot noted no challenges during the initial departure and had observed a positive rate of climb at 125 knots (kt) indicated airspeed (IAS). All engine instruments were within normal parameters from take-off to cruise at 20 000ft AGL. The survey took about 3 hours, and all went as planned. En route to FAPE, the air traffic control (ATC) cleared the pilot for visual approach on Runway 26 and was instructed to position the aircraft on final approach, about 4 nautical miles (NM) from the east. Whilst on approach phase at 12300ft AGL, a loud bang was heard from the engine compartment. The engine started to vibrate, making an abnormal sound. A small cloud of white smoke emanated from the front section. The pilot instantly commenced the memory items from the emergency checklist and cross-checked the engine instruments to identify the problem. At that moment, the only incorrect indication he could identify was the oil pressure indication, which was low.

2.4 The engine continued to run, and the pilot reduced the power to avoid further damage. The pilot broadcasted a MAYDAY call to the ATC informing them of the situation and requested to proceed straight for Runway 26. The aircraft was cleared to land, and the Aircraft Rescue and Firefighting (ARFF) service was alerted by the ATC. About 3 minutes later, another loud bang was heard from the engine. Oil leaked to the cowlings, followed by loss of engine power which was indicated by a drop in manifold pressure. The pilot reported that he managed to keep control of the aircraft and used the available engine power to perform a safe landing on Runway 26. No injuries were reported, and the aircraft damage was limited to the engine. The aircraft was operated under the provisions of Part 137 of the South African Civil Aviation Regulations of 2011 as amended.

2.5 The incident occurred during daylight conditions at a geographical position determined to be S33°59’24.0” E025°36’.37.0” at an elevation of 226 feet (ft) above mean sea level (AMSL).

Figure 2: The aircraft post-incident. (Source: Operator)

3. Post-incident Engine Examination

3.1 The aircraft was fitted with a Continental TSIO-520-C six-cylinder, horizontally opposed fuel injected turbocharged engine, serial number 103412 rated at 285 horsepower (hp). The engine comprises 12-quart capacity oil sump. Oil is drawn from the sump through the suction tube to the intake side of the engine-driven gear type oil pump. Oil entering the engine is directed to the hollow camshaft, which serves as the engine's main oil gallery. Grooves and drilled holes in the camshaft are located so as to afford proper lubrication through a system of orifices to the main bearings, lifters, idler gear bushing, accessory drive gear bushings and the starter drive gear bearing. Oil leaving the camshaft interior at the front of the crankcase is directed to the left main crankcase gallery. From there, it is directed to the main thrust bearing and the governor drive gear, and then to the crankshaft oil transfer collar, which in turn directs oil to the interior of the crankshaft.

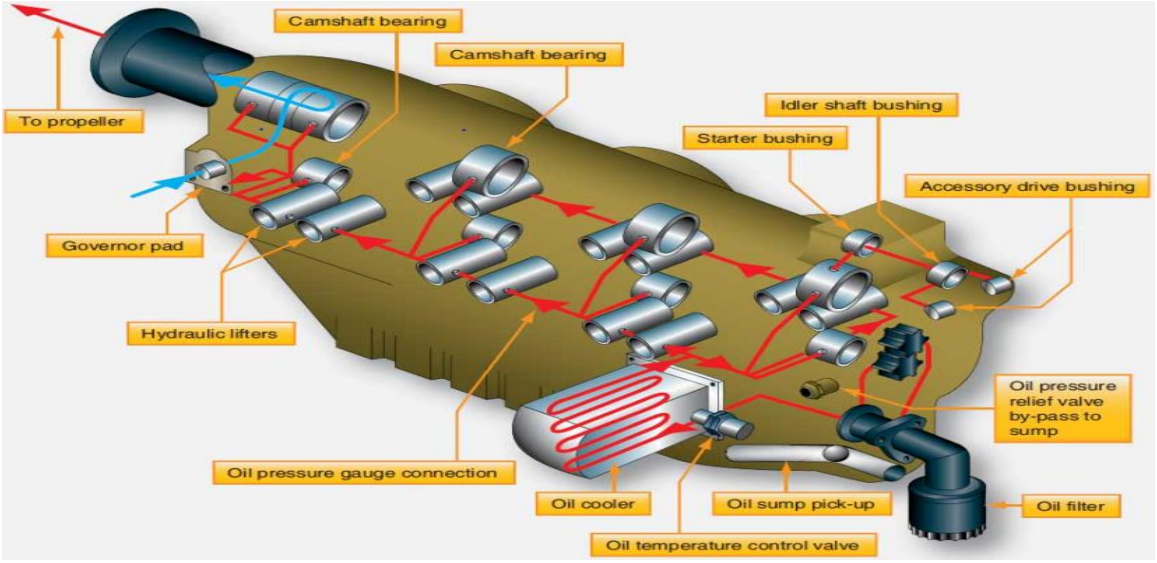
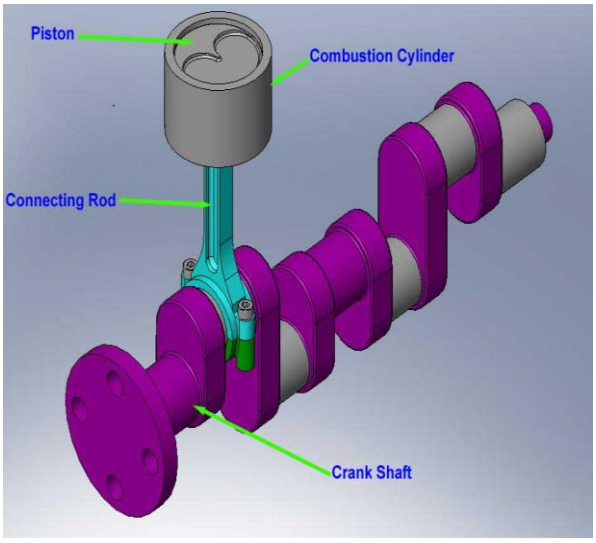
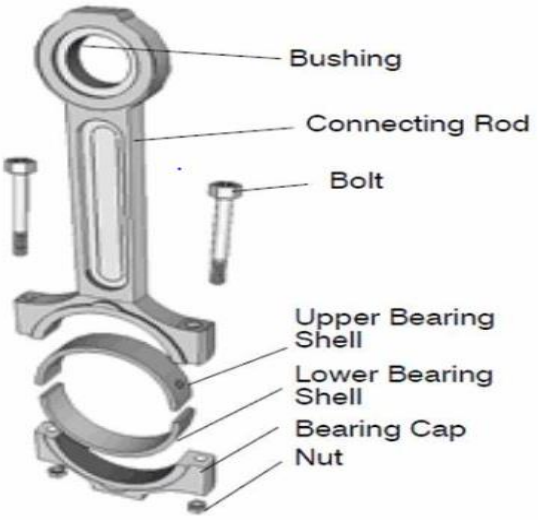


Figure 3: Aircraft engine oil system schematic diagram. (Source: Aircraft Maintenance Manual)

3.2 The engine was installed on the aircraft at zero hours (new) on 20 July 2017 at 18993.95 recorded tachometer hours. The aircraft had accumulated a total of 19735.04 tachometer hours at the time of the incident and the engine had accumulated 741.09 hours. The engine time between overhaul (TBO) is 1600 hours or 12 years, whichever occurs first. The engine was examined after the incident and a hole was noted on the top left side of the crankcase; it was apparent that it was caused by the No. 4 connecting rod. Oil was forced out of the crankcase and had escaped through the gaps of the engine cowlings and had spread onto the windscreen. Licensed engineers from the supporting aircraft maintenance organisation (AMO) at FAPE were ordered to remove the engine, which was later transported to an independent engine overhaul facility at Springs Aerodrome (FASI) for a teardown examination. The teardown examination revealed that the No. 4 connecting rod and piston had disconnected from the crankshaft journal. The connecting rod shaft was found fractured. Cylinders No.1, 2, 3, 5 and 6 were not compromised.

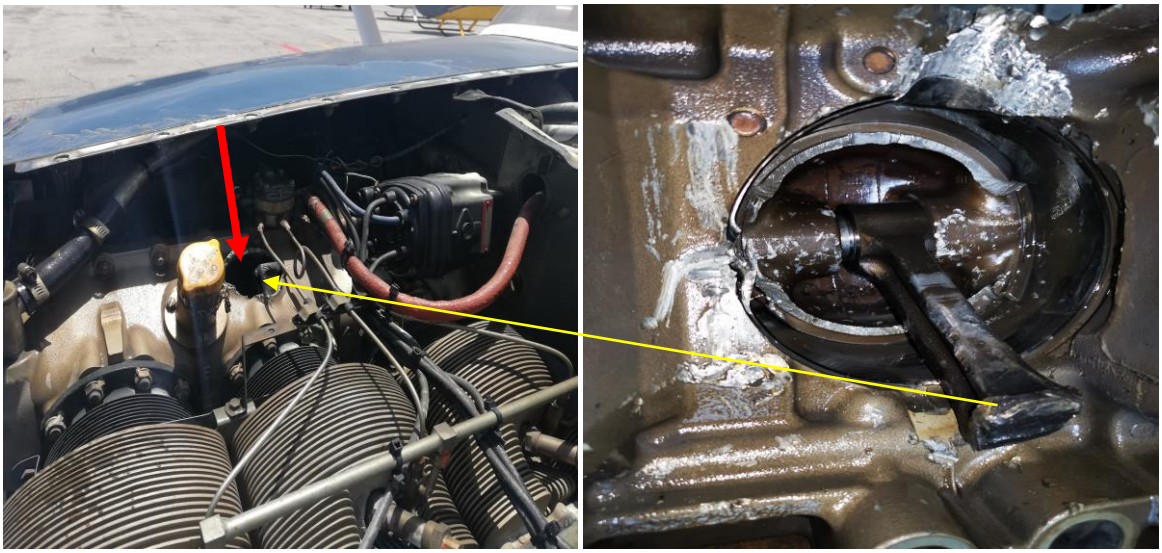
3.3 *NOTE: The connecting rod connects the piston to the crankshaft whilst transmitting power of the combustion from the combustion chamber to rotate the crankshaft. Each connecting rod is attached to the crankshaft by a split, plain bearing retained by a bearing cap. The assembly is secured by two bolts, each passing through integral bolt hole formed on the connecting rod and the cap and retained by a nut. The nuts are not split-pined or otherwise positively locked but are meant to be retained by correct torque loading. Failure of a connecting rod, usually called “throwing a rod”, is one of the most common causes of catastrophic engine failures, frequently putting the broken rod through the crankcase and, thereby, rendering the engine irreparable; it can result from fatigue near a physical defect in the rod, lubrication failure in a bearing due to faulty maintenance or from failure of the rod bolts from a defect, improper tightening, or re-use of already used bolts where not recommended.





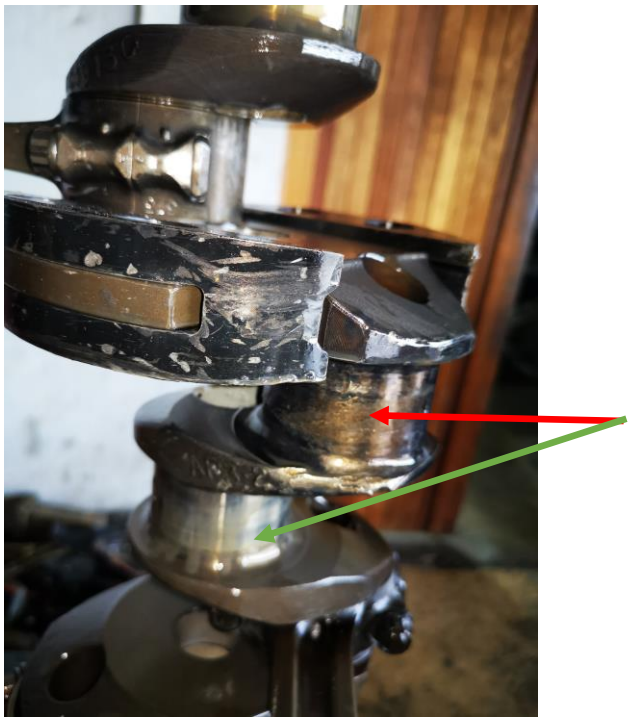
Figures 4/5: An illustration of how a connecting rod connects to the engine crankshaft and the connecting rod. (Source: https://images.app.goo.gi/wCecfG4Q6Y9pgjBQ9 and http://confident-instruments.com)

3.4 The overall condition of the overhauled engine oil sump showed no defects and there was a small amount of oil remaining, which is consistent with Standard Aerospace Equipment (SAE) 100 Grade mineral oil. Some metallic debris, which was found in the oil sump, was examined and it was discovered that it originated from the connecting rod shaft and the aluminium crankcase.



Figures 6/7: A hole on the crankcase top left area (left) and the No.4 piston showing a fractured connecting rod shaft (right).

3.5 Evidence of heat discolouration was noted on the No.4 connecting rod journal area (see Figure 7). Oil to the connecting rod bearings is supplied via drilled holes on the crankshaft journal. The holes were inspected and were found to be free from obstruction. This suggested that there was no restriction of oil supply to the crankshaft and that oil starvation was limited to the No.4 connecting rod journal area.



Figures 8: Heat discolouration noted on the connecting rod No. 4 crankshaft journal area.

3.6 The connecting rod bolts, bearings and nuts were not found during the teardown inspection. Engineers who removed the engine at FAPE indicated that nothing originating from the connecting rod was found in the engine compartment. Most of the debris appeared to have been ejected through the hole on the crankcase. The engine oil filter element was examined, and it showed evidence of significant deposits of a material with copper and

bronze colour. The overhaul of the engine indicated no evidence which may suggest incorrect or poor maintenance. The oil system showed no evidence of internal oil leakage (oil exiting through the breather or oil getting into the combustion chamber of one or more cylinders and being consumed) or external leak. The oil pump was examined and was found to be operational at the time of the incident. There was evidence of oil throughout the pump body and accessory housing oil galleries. The operator kept an oil filling log to monitor changes in oil consumption. According to data logged a month prior to the occurrence of this incident, the aircraft's oil consumption had remained the same in relation to flight time.

3.7 Examination of maintenance records revealed no anomalies and there were no reported defects with the engine prior to the incident. A 100-hour Mandatory Periodic Inspection (MPI) was completed on 10 July 2019 at 19645.97 recorded tachometer hours and 652.02 engine hours. According to the flight folio's most recent entries, two uplifts of 1 quart of oil each were recorded prior to the incident flight. The first quart was uplifted in Grahamstown Aerodrome (FAGT) on 6 November 2019 at 19688.3 recorded tachometer hours and after 8.46 hours flight time. Another quart of oil was uplifted in Queenstown Aerodrome (FAQT) on 8 November 2019 at 19695.5 tachometer hours, after 7.2 hours flight time. On 13 November 2019, a 50-hour engine oil change was carried out at 709.58c engine hours and 9 quarts of SAE 100 grade mineral oil with corrosion preventatives was uplifted in the 12 quarts oil sump.

3.8 The oil sump is equipped with an oil level dipstick or gauge notched and stamped with numerals representing quarts. According to the Continental Engine Operation and Installation Manual (page 12-00-03), the engine requires a minimum of 6 quarts of useable oil in the sump, including the one in the oil filter so it can function properly in all flight attitudes and atmospheric conditions in which the aircraft is expected to operate. The engine oil consumption, in accordance with (IAW) Lycoming's Service Instruction No - 1427C dated 29 December 2010, was calculated to be 0.9 quarts per hour (0,006 x 285BHP x 4 ÷ 7.4 = 0.92 quarts per hour), meaning that an uplift of 1 quart of oil was required for every 6 hours of operation. Between 17 and 22 November 2019, a total of 31.51 hours was flown in six sorties with no oil upliftment recorded. The incident happened during the last flight at 741.09 total engine hours, at which point the No.4 connecting rod detached from the crankshaft journal. The 31.51 hours flown after the 50-hour oil change showed that the engine had consumed about 5.25 quarts of oil from the initial 9 quarts that was uplifted on 13 November 2019. Heat discolouration was noted on the camshaft of the No.4 journal area.

3.9 This was an indication that the engine was operated with less than the minimum required quantity (below 6 quarts) of oil in the sump, which contributed to inadequate oil film or lubrication that caused excessive heat concentration on the No.4 connecting rod big end journal area. This suggested that the pilot did not confirm the oil level using the dipstick prior to the incident flight. The absence of adequate oil film between the bearing and the

journal created metal-to-metal contact, thus, causing the metal to expand, either compressing the aluminium of the connecting rod bearing cap or stretching the steel bolts, causing them to lose their pre-load, at which point they started backing out. The engine continued to run with the loose bearing cap until the bolts became completely loose as the connecting rod was stretched and compressed at every stroke.

4. CONCLUSION

4.1 Findings

4.1.1 Fine weather conditions prevailed at the time of the flight and this was considered not to have a bearing on the incident.

4.1.2 The flight was conducted under the provisions of Part 137 of the South African Civil Aviation Regulations 2011 as amended.

4.1.3 The pilot was issued a medical certificate on 15 November 2019 with an expiry date of 30 November 2020.

4.1.4 The pilot was issued a Commercial Pilot Licence (CPL) on 30 April 2019 with an expiry date of 31 March 2020, and with no restrictions.

4.1.5 The pilot had accrued 64.2 total flight time on the aircraft type and had 1223.2 total flight time.

4.1.6 The aircraft's certificate of registration was issued on 29 October 2019.

4.1.7 The aircraft's certificate of airworthiness was issued on 29 April 2019 with an expiry date of 30 April 2020.

4.1.8 Examination of the aircraft logbooks showed that a 100-hour MPI was carried out on 10 July 2019 at 19645.97 recorded tachometer hours and 652.02 engine hours.

4.1.9 Examination of the maintenance records revealed no anomalies of the aircraft and there were no reported defects with the engine at the time of the incident.

4.1.10 The overall condition of the engine indicated that it was correctly assembled; no evidence was observed which suggested incorrect or poor maintenance.

4.1.11 The No.4 connecting rod separated from the camshaft journal due to excessive heat caused by oil starvation.

4.1.12 The aircraft had accrued a total of 19735.04 tachometer hours at the time of the incident.

4.1.13 The aircraft had about 300 litres of Avgas LL 100 aviation fuel on departure.

5. PROBABLE CAUSE/S

5.1 The No.4 connecting rod had failed due to excessive heat that was concentrated on the No. 4 camshaft journal area as a result of oil starvation.

6. Contributing factor/s

6.1 Inadequate pre-flight inspection.

7. SAFETY MESSAGE

7.1 None.

This report is issued by:

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