INVESTIGATION REPORT

Incident to the CESSNA - 182 - P registered N609PC

on 28 February 2018
at Yonval (Somme)

[1] Except where otherwise indicated, the times in this report are in local time.

Time	Around 09:40[1]
Operator	Private
Type of flight	Cross country
Persons on board	Pilot, passenger
Consequences and damage	Aeroplane damaged
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in July 2021. As accurate as the translation may be, the original text in French is the work of reference.	

Vibrations and smell of smoke en route, commanded engine shut-down, off-field forced landing

1 - HISTORY OF THE FLIGHT

Note: the following information is principally based on the pilots' statements and the parameters from the aeroplane's onboard GPS.

The pilot, accompanied by a passenger in the right front seat, took off at around 09:10 from Touquet-Côte d'Opale aerodrome (Pas-de-Calais) for an IFR cross-country flight to Lognes-Émerainville aerodrome (Seine-et-Marne).

At the end of the climb and arriving at FL 70, the pilot and his passenger detected a smell of smoke, vibrations and an abnormal engine noise. The pilot shut down the engine and then tried to restart it, without success. The passenger in the right seat who had more flight experience[2] then took the controls, made an emergency call and tried to divert and glide to Abbeville aerodrome (Somme). He realised quite quickly that he would not be able to reach the aerodrome. He chose a field and made an off-field forced landing at around 09:40.

[2] He held an Airline Transport Pilot License (ATPL) and was also an IFR and twin-engine instructor.

Once on the ground, the two pilots inspected the plane and observed that the crankcase was perforated.

Source: pilot

Figure 1: Aircraft on forced landing site (left) and perforation of crankcase (right)

2 - ADDITIONAL INFORMATION

2.1 Meteorological information

The data from the Touquet-Côte d'Opale aerodrome 08:00 UTC and 08:30 UTC METARS gave meteorological information compatible with a VFR flight, the situation being CAVOK with an easterly wind of around 10 kt and gusts of up to 25 kt.

2.2 Pilots' statements

In addition to the information given in the history of the flight, the pilots indicated that at the time when they identified the failure, the oil temperatures were in the green, the cylinder temperatures were also normal, the maximum cylinder temperature was 415 °F, and the oil pressure was low.

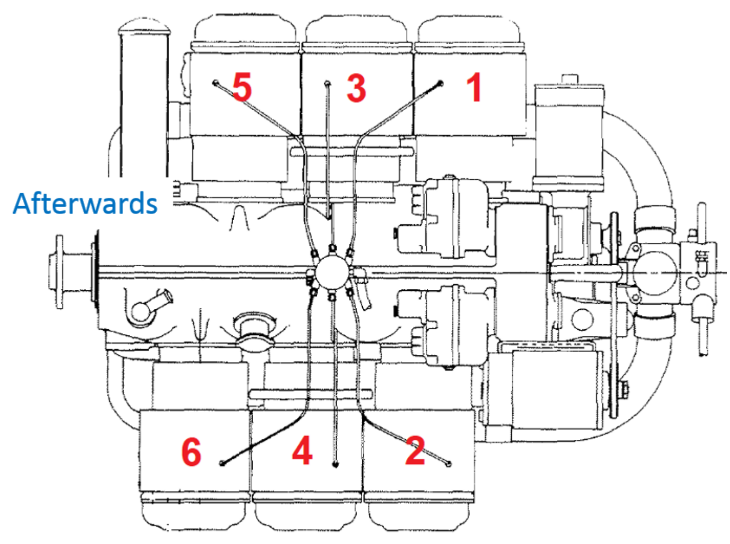
The pilots also indicated that the engine warm-up time at departure had been complied with.

The pilot in the right seat indicated that he had flown with the plane the day before without having a problem and that the plane had then remained in a hangar up until the accident flight.

2.3 Aircraft and engine information

The aeroplane is equipped with a Continental O-470-R engine whose certificate of airworthiness was issued on 20 July 2004.

The propulsion system is an air-cooled, flat six-cylinder engine. The cylinders are numbered 1 to 6 as shown in the diagram below.



Source: Continental

Figure 2: Top view of engine, identification of cylinders

Each cylinder is equipped with a rod attached to the crankshaft by the rod cap and to the piston pin by the rod small end. Two rod bearings are positioned between the rod and the crankpin (see Figures 3 and 4). A lubrication system lubricates this zone with oil.

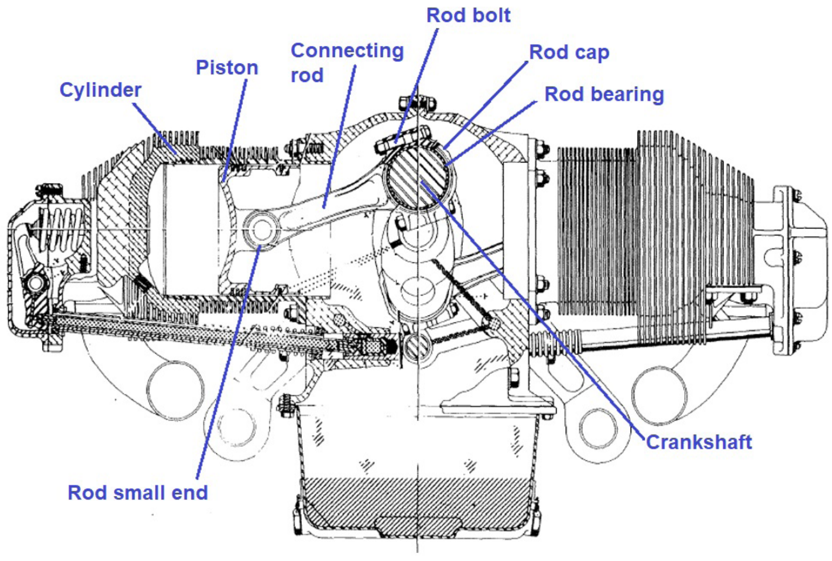


Figure 3: Cross-section view of engine

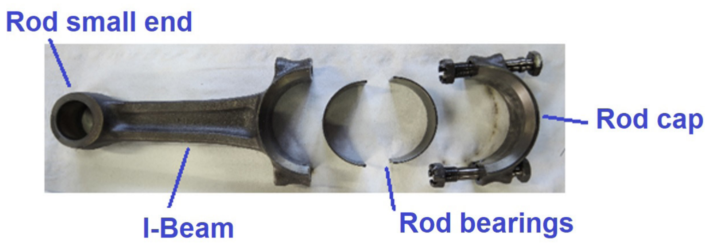


Figure 4: Composition of a connecting rod

The last maintenance operation was carried out on the engine on 13 February 2018, i.e. 15 days before the accident. At this date, the engine had logged 756 operating hours since new (TSN[3]) with a calendar age of around 14 years. The operating time between this maintenance operation and the event is estimated at five or six hours.

(3) Time Since New.

The maintenance operation of 13 February had consisted in the replacement of cylinder No 2. According to the statement made by the mechanic who carried out this operation, this cylinder had been replaced after the pilots had reported vibrations. The troubleshooting carried out had brought to light that a valve of this cylinder had blocked, resulting in an absence of compression.

On the landing site, the day of the incident, the aeroplane's cowlings were removed by the members of the company which maintains the aircraft. The perforation of the crankcase in line with cylinder No 1 and the separation of the right magneto were observed. The BEA did not visit the aircraft landing site.

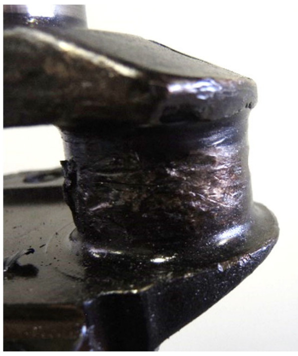
2.4 Examination of engine

The company which maintained this aircraft removed the engine around 15 days after the incident.

The engine was examined by the BEA on its premises. This examination showed that the damage was concentrated in the environment of the cylinder No 1 rod. The other significant damage concerned the rod bearings of the crankshaft front bearing.

The damage in the environment of cylinder No 1 was the following:

- ❒ sudden failure of crankcases;
- ❒ rod broken into multiple fragments;
- ❒ partial destruction of piston;
- ❒ damage to crankpin associated with rod, with signs of intense heating.



Source: BEA

Figure 5: Rod debris

Figure 6: Partially destroyed piston blocked in cylinder

Figure 7: Crankpin

The I-beam had broken at each end. Amongst the analysable debris, signs of fatigue cracking were identified, very locally over a small depth, on the rod cap fragments (see Figure 8), which had initiated on the inner side of the rod (crankshaft end).

Source: BEA

Figure 8: Rod No 1 fracture surface

This cracking zone was associated with abnormally high hardness of the material composing the rod. Despite exchanges with the manufacturer, Continental Motors, it was not possible to determine if this high hardness could have contributed to the occurrence or was generated during the failure by local heating.

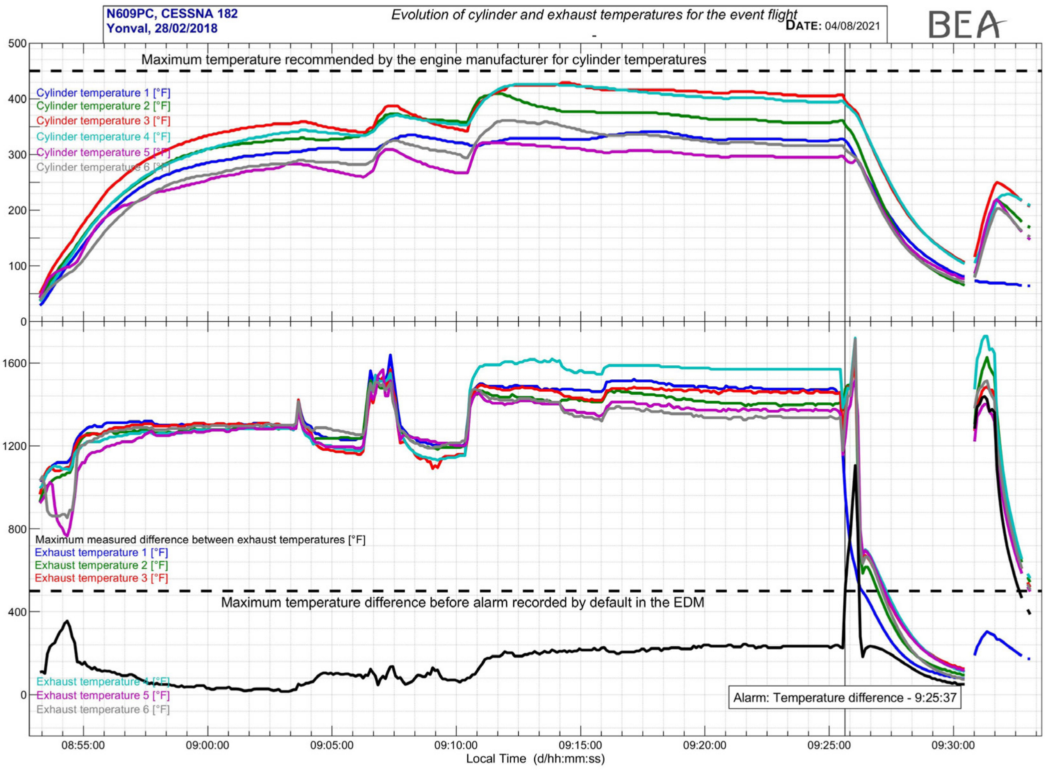
Debris from the rod bearings associated with this rod was recovered at the bottom of the oil sump in the form of strips.

2.5 Examination of EDM computer

[4] Engine Data Management.

An EDM[4] computer was installed on board the aircraft. This equipment displays in the cockpit, the main engine parameters and notably, the cylinder (1 to 6) and exhaust gas (1 to 6) temperatures. It also records these different parameters in a non-volatile memory and can save up to 30 hours of data.

The occurrence flight was recorded in this computer making it possible to analyse the evolution of the different cylinder and exhaust gas temperatures (see Figure 9).



Source: BEA

Figure 9: Engine cylinder and exhaust gas temperatures read out from EDM

In particular, it can be observed that during the flight, the temperature of the six cylinders was below the activation threshold of the EDM warning at 450 °F.

The exhaust gas temperatures were in a normal range, between 1,350°F and 1,550°F for all the cylinders, except for cylinder No 4 whose temperature was slightly higher. The EDM does not activate a warning simply based on the value of the exhaust gas temperature, but there is a warning if the measured difference between the various exhaust gas temperatures exceeds 500°F.

Around 09:25, this difference suddenly increased, exceeded the warning activation threshold and reached around 1,100°F. This was due to a substantial drop in the exhaust gas temperature for cylinder No 1 while the temperatures for all the other cylinders showed a high peak before a sudden drop. This is consistent with a perforation of the crankcase in line with cylinder No 1. The attempt to restart the engine shortly after, followed by its definitive shutdown, was also recorded.

2.6 Similarities and differences with accident to Cessna U206F registered F-HNCM

[5] https://bea.aero/en/investigation-reports/notified-events/detail/accident-to-the-cessna-u206f-registered-f-hncm-on-09-04-2017-at-sainte-marie-au-bosc/

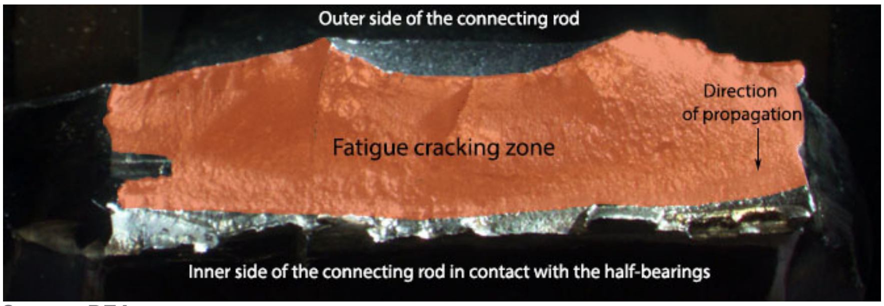
The Cessna U206F registered F-HNCM[5] was involved in an accident on 9 April 2017 following an off-field forced landing. The latter was the consequence of the engine in-flight shutdown with perforation of the crankcase (IO-520-F engine similar to O-470-R of N609PC).

The examinations of the engine had shown that the engine shutdown was due to the failure of rod No 4. The laboratory examination of this rod had shown that the fatigue crack had initially started on the outer surface of the rod cap. The growth of this crack had then resulted in a sudden failure and the rod's separation from the crankshaft.

The identical findings in both cases concern the damaged state of the crankpin associated with the given rod (with signs of intense heating), the rod bearings reduced to small strips and the perforation of the crankcase. This is ordinary damage resulting from the failure of a rod on the type of given engine.

The failure initiated on N609PC is different to that initiated on F-HNCM in terms of the following:

- ❐ The position of the incipient crack zone; respectively on the inner side of the rod in contact with the rod bearings (see Figure 8) and on the outer side of the rod (see Figure 10).
- ❐ The extent of the fatigue cracking zone; very local (a few *µm*) on N609PC (see Figure 8) and to a much wider extent (a few cm) on F-HNCM (see Figure 10).
- ❐ The modification of the mechanical characteristics of the material (hardness) in the vicinity of the incipient crack zone on N609PC and without modification on F-HNCM.



Source: BEA

Figure 10: Fracture surface on F-HNCM

The comparison of the two cases seems to show a different fatigue crack initiation process but with equivalent consequences.

3 - CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation. They are not intended to apportion blame or liability.

After identifying an engine malfunction in cruise, the passenger in the right seat who had more experience than the pilot, took the controls and carried out a successful off-field forced landing.

The BEA's examinations of the engine showed that a fatigue failure of rod No 1 was behind the engine shutdown.

A fatigue failure of a rod on a similar engine was found by the BEA in a previous accident. The fatigue crack initiation process was different in these two occurrences. It was not possible to determine the cause of the fatigue failure of these two rods.