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SAFETY INVESTIGATION REPORT

Accident to the CESSNA – 401 B registered N517HC on 30 October 2020 close to Toussus-le-Noble aerodrome

Time	Around 17:25[1]
Operator	Private
Type of flight	Local
Persons on board	Pilot and two passengers
Consequences and damage	Aeroplane substantially damaged
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.	

Fire in left engine during approach, forced landing in a field

1 HISTORY OF THE FLIGHT

Note: the following information is principally based on statements and the data from the aircraft's engine computer (CGR-30).

The pilot, accompanied by a passenger who was also a pilot, sat in the right seat and a mechanic sat in the rear, took off at 17:10 from Toussus-le-Noble aerodrome for a local flight expected to last around 30 min. This was the first time that the aeroplane had been flown after being in storage for more than twelve years followed by around eight months of work to return it to an airworthy condition after its acquisition by the new owner. The purpose of the flight was to check for the overall correct operation of the aeroplane.

Just after taking off, the temperature of cylinder No. 4 on the left engine exceeded 460°F (around 238°C) which led to this temperature being displayed in red on the engine computer screen and activated the illumination of an alert light on the instrument panel. The mechanic-passenger considered that it was probably a false alert due to a fault on the temperature probe and verbalised this. The pilot and the passenger in the right seat nevertheless carried out actions to reduce the engine temperature, notably by reducing power and stabilising the aeroplane in level flight at 1,500 ft. After these actions, the temperature of cylinder No. 4 decreased and the light went out. Based on the opinion expressed by the mechanic-passenger, the pilot-in-command decided to continue the flight.

At approximately 17:20, on the return leg of the flight, the alert light came on again and the pilot, the passenger in the right seat and the mechanic-passenger observed that a fire had broken out in the left engine. The pilot, assisted by the passenger in the right seat, cut off the fuel supply to the left engine without this having a noticeable effect on the fire and then made an input on the control to feather the propeller.

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

The passenger in the right seat then declared a MAYDAY on the Toussus-le-Noble control tower frequency and the pilot-in-command decided to directly head for runway 25.

Shortly after this, as he was not sure that he would be able to reach the runway safely, he decided to carry out an emergency landing in a ploughed field. The emergency landing was carried out without any particular incident with the landing gear retracted and the flaps completely extended. As soon as the aeroplane came to a halt on the ground, the occupants evacuated without difficulty.

The fire fighters, alerted by the Toussus-le-Noble controller, rapidly intervened and put out the fire which had remained confined to the left engine.

2 ADDITIONAL INFORMATION

2.1 Persons on board information

The 47-year-old pilot in the front left seat held an aeroplane Commercial Pilot Licence (CPL (A)) obtained in 2018 along with a valid Instrument Rating Multi-Engine (IR-ME). He had logged approximately 650 flight hours including 183 hours on twin-engine aeroplanes. During the previous month, he had flown 3 hours on twin-engine aeroplanes and 6 hours 10 minutes on single-engine aeroplanes.

He indicated that no particular check-out programme had been planned, the purpose was solely to carry out a local flight to check the behaviour of the aeroplane and its correct operation in normal conditions[2]. He added that he had carried out a reinforced safety briefing before the flight, placing particular emphasis on the evacuation procedures and the presence of the onboard fire extinguishers. He justified his decision to carry out an emergency landing in a field by the fact that the fire seemed to be particularly fierce and that he was not sure that he would be able to keep the aeroplane in flight until reaching the aerodrome runway. He also observed that the propeller of the left engine had not feathered despite the input on the control which degraded the aeroplane's lift-to-drag ratio.

The 51-year-old passenger in the front right seat held an Airline Transport Pilot Licence (ATPL (A)). He had logged 4,450 aeroplane flight hours, including 23 hours in the previous month. He had not carried out a flight on a Cessna 401 during the previous three months.

The maintenance workshop managers indicated that they had recommended to the owner to call on professional pilots for the aeroplane's first flight which he had accepted.

Note: The owner of the aeroplane was himself a pilot and held an aeroplane Private Pilot Licence (PPL(A)) along with instrument and multi-engine piston ratings; he did not have previous experience on this model of aeroplane.

The passenger sat in the rear was the head of the workshop which had carried out the work to return N517HC to an airworthy condition. He held a Part-65 FAA[3] mechanics licence and was thus approved to carry out maintenance operations on aircraft registered in the USA. He declared that

[2] The flight did not therefore come under the scope of a Maintenance Control Flight (MCF) and the applicable regulations were those of a general aviation flight (NCO).

[3] Federal Aviation Administration: American civil aviation authority.

he had had no particular role on board and was simply a passenger, the pilots having offered to take him for the ride.

2.2 Meteorological information

The 17:30 automatic METAR for Toussus-le-Noble aerodrome gave the following information:

- wind from 220°, 8 kt;
- visibility greater than 10 km;
- few clouds at 1,700 ft, covered at 3,400 ft;
- temperature 14°C, dew point 11°C;
- QNH 1024.

The weather situation described by the witnesses the day of the accident was suitable for a VFR flight with a clear sky and no turbulence.

2.3 Aircraft information

2.3.1 General information

N517HC is a Cessna 401B, twin-engine aeroplane equipped with two 300-hp Continental TSIO-520-E piston engines.

Up until February 2020, the aeroplane was owned by the maintenance workshop and had not been in service since 2006. It had not been subject to any particular preservation measures during this period and was simply stored in a workshop hangar.

Engine manufacturers have developed specific procedures to preserve engines when the latter are to undergo a long period of not being used. Continental describes in its Maintenance Manual[4], the storage procedures for an indefinite period and the procedures for returning an engine to service after storage along with the associated checklist. These procedures include an oil change, replacing the spark plugs with cylinder dehydrators, inserting desiccant bags in the exhaust pipe and applying preservation oil inside the cylinders. The manufacturer also recommends regular inspections, replacing the desiccant products as required and applying preservation oil every 90 days.

The aeroplane was purchased by the current owner at the beginning of 2020 for a low price plus the estimate for returning the aeroplane to service which included 300 man hours.

The left engine rolled out of the factory in 2000, the same year in which it was installed on the aeroplane. In 2020, the maintenance documents showed a total operating time for this engine of 408 hours.

2.3.2 Regulatory framework of continuing airworthiness

As the aeroplane was registered in the USA, it was covered by Part 91 of Title 14 of the American Code of Federal Regulations[5]. For the maintenance aspects, Part 91 refers the operator to Part 43[6].

[4] Edition M-0 of January 2017.

[5] Part 91 of Title 14 of the Code of Federal Regulations (14 CFR Part 91 - GENERAL OPERATING AND FLIGHT RULES).

[6] 14 CFR Part 43 - MAINTENANCE, PREVENTIVE MAINTENANCE, REBUILDING, AND ALTERATION.

The latter indicates that for an aircraft such as N517HC, the only maintenance obligation is to carry out a 100-hour or annual inspection for the renewal of the certificate of airworthiness.

The 100-hour or annual inspection must at least include:

- the content of Appendix D of Part 43 which contains simple maintenance tasks (check of compression ratio, borescope inspection of cylinders, visual inspections, etc.). The principle of this inspection is based on "on-condition" maintenance[7];
- compliance with all the applicable airworthiness directives;
- compliance with the Airworthiness Limitation Items (ALI) and Certification Maintenance Requirements (CMR) defined in the manufacturer's Aircraft Maintenance Manual (AMM).

The 100-hour or annual inspection actions must be carried out by a mechanic holding a Part 65 licence[8]. A non-approved mechanic can however carry out work under the supervision of an approved mechanic, the latter then assumes responsibility for the associated actions.

The Approval for the Return to Service (APRS) of the aeroplane after the 100-hour or annual inspection cannot be signed by a mechanic who only holds the Part 65 licence if there have been major modifications or alterations. The signatory of the APRS must have obtained an Inspection Authorization (IA) from the FAA[9]. In France, around ten people hold this IA.

It should be noted that the engine manufacturer also provides, in a Service Information Letter[10], calendar limits before the engine's general overhaul. However, FAA regulations do not make the validity of the certificate of airworthiness conditional on compliance with these limits. In the case of the engines on N517HC, the manufacturer recommended a maximum time between two overhauls of twelve years, including any periods of storage or inactivity. The calendar limit recommended by Continental had therefore been exceeded by around eight years in 2020.

2.3.3 Returning aeroplane to airworthy condition

The work to return the aeroplane to an airworthy condition was carried out under the supervision of a French IA inspector, contracted for this purpose by the owner. It was the workshop who presented the inspector to the owner. It was the IA's responsibility to determine the precise list of maintenance operations required by regulations for the renewal of the N517HC's certificate of airworthiness and to ensure that these operations were carried out correctly.

The managers of the maintenance workshop stated that, prior to the sale of the N517HC, a borescope inspection of the cylinders in the presence of the owner and his IA inspector had been carried out with satisfactory results. For his part, the owner stated that he had not attended the borescope inspection and had not received the photographs of the inspection, but that the workshop managers had assured him that the examinations had shown that the two engines were "healthy", with no signs of wear, damage or corrosion.

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[7] *"Examination of those aspects of an installation that are predictive of pending failure, followed by performance of preventative maintenance activities before occurrence of total failure."* (Source: McGraw-Hill Dictionary of Scientific & Technical Terms).

[8] 14 CFR Part 65 - CERTIFICATION: AIRMEN OTHER THAN FLIGHT CREWMEMBERS.

[9] In the remainder of this report, the IA holder will be referred to as the IA inspector.

[10] Continental SIL 98-9C.

Neither the workshop nor the IA inspector who signed the APRS after the 100-hour inspection were able to provide the BEA with these images[11].

The owner stated that this assessment that the engines were in good condition and the possibility given by the workshop and validated by the IA inspector, not to carry out the engine overhaul contributed to his decision to make the purchase[12].

Most of the programme followed by the maintenance workshop to return the aeroplane to an airworthy condition was very similar to that of a 100-hour or annual inspection, as defined in Appendix D of Part 43. In addition to these continuing airworthiness items, the following work was carried out:

- installation of a new avionics suite, carried out by the owner. The IA inspector took responsibility for the work and relied on the owner's electrical engineering skills to ensure that this modification was carried out correctly;
- painting of the aeroplane on the workshop premises by a specialist company at the owner's expense;
- furnishing of cabin.

During the maintenance work on the aircraft, engine ground tests were carried out between 7 August 2020 and 30 October 2020. The data recorded by the CGRs (see paragraph 2.5) during these tests was not shared with the workshop or IA inspector. The investigation was unable to determine the precise nature and conditions of these tests nor who carried them out.

2.4 Site and wreckage

The damaged aeroplane was located 900 m south of runway 07R of Toussus-Le-Noble aerodrome, in an obstacle-free field close to a road.

[11] The saving and archiving of images obtained during borescope inspections is not a regulatory requirement.
[12] According to the mechanics questioned, the general overhaul of an engine costs at least 70,000 €.

Figure 1: overview of wreckage on site

The aircraft suffered little damage during its emergency landing. The on-site examination focused on the left engine, which was removed and taken to the BEA for further examinations. Neither of the two propellers was found feathered.

The compartment aft of the left engine nacelle was severely damaged by the fire. The engine support spars were also almost completely destroyed by the fire.

When the engine was examined around three weeks after the accident, signs of significant overheating were observed, particularly in the area of cylinders No. 2 and No. 4. The liners of all the cylinders in this engine were found to be heavily marked by corrosion and friction (see **Figure 2**). Given the extent of this corrosion and the piston wear marks that were observed, it is highly unlikely that the corrosion appeared after the accident.

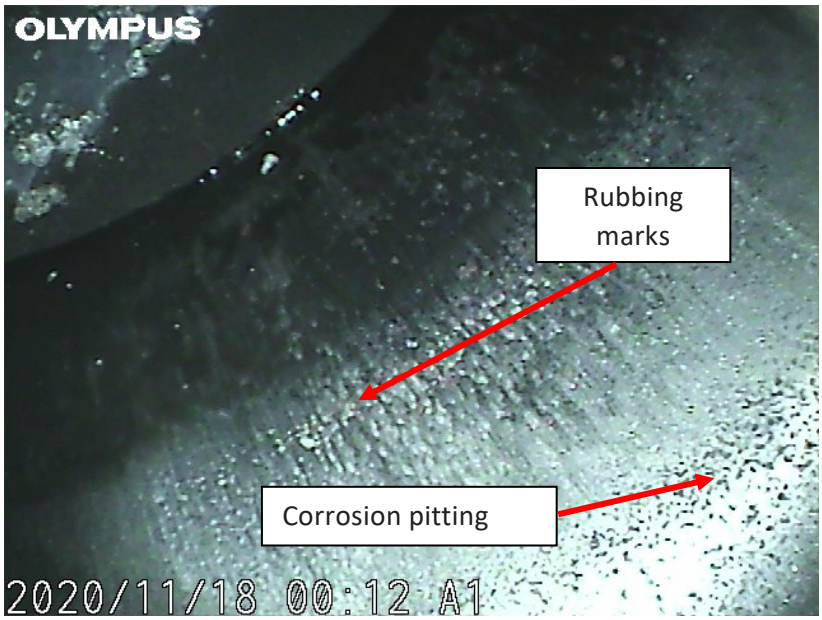

Figure 2: borescope inspection of cylinder No. 4 (source: BEA)

The examinations were not able to determine where the fire broke out or the exact path of its propagation.

The examinations were not able to explain why the propeller of the left engine had not feathered.

2.5 Read-out of recorded data

The CGR 30 is a computer installed in the cockpit and displays in real time, information relating to the operation of the engine. This computer also records data for maintenance purposes.

Figure 3: CGR-30 display
(source: CGR-30P Instructions Manual, page 1)

On analysing the recorded data, it was observed that certain ground tests showed that the temperature of the cylinder No. 2 and 4 heads of the left engine tended to significantly exceed that of the other cylinders of the left and right engines without, however, reaching the limit defined by the manufacturer (460°F)[13]. However, given the uncertainty about the conditions in which these tests were carried out, it was not possible to reach a definite conclusion about the existence of an engine malfunction prior to the accident flight. The other recorded parameters did not show a significant deviation from the norm.

The maintenance workshop managers indicated that the owner had informed them that these tests had been carried out but had not authorised them to read out the CGR to analyse their results. The owner of the aeroplane declared that he had not received a request from the workshop to do this.

The accident flight data was also read out. The data shows that as soon as power was increased on the ground, there was a rapid increase in the temperature of cylinder No. 4 and to a lesser extent, cylinder No. 2. The temperature of the cylinder No. 4 head reached 536°F[14] which is in excess of the maximum temperature limit defined in the manufacturer's manual. According to the CGR 30 manual, this would have led to the corresponding CHT[15] parameter being displayed in red on the screen of the CGR 30 and the illumination of the red light on the instrument panel. The temperature then decreased before increasing and exceeding the critical threshold again a few minutes later.

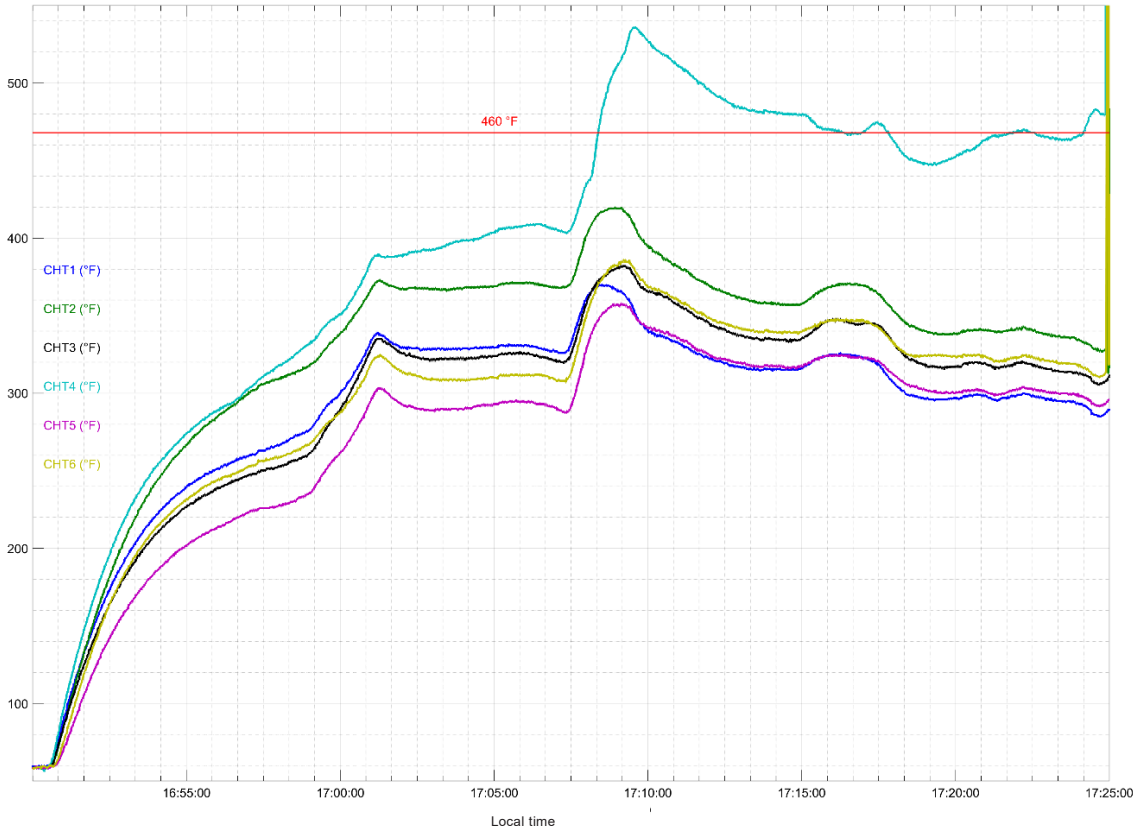

Figure 4: temperature of cylinder heads on left engine during flight of 30 October 2020 (source: BEA)

[13] i.e. around 238°C.

[14] 280°C.

[15] Cylinder Heat Temperature.

3 CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation.

Scenario

N517HC had remained unused in a hangar for around 14 years without any particular storage precautions being taken. The engine calendar time to overhaul limit recommended by the manufacturer had been exceeded by eight years and the aeroplane was sold for a reduced price by the maintenance workshop who owned it. For probably economic reasons and in accordance with the possibilities offered by the American regulations, the engine overhaul was not carried out.

It is very probable that the left engine had internal corrosion, the small amount of operating time over a long period being conducive to this damage, without this being detected during the inspections prior to the sale.

During the return to service process, various operations and inspections were carried out in parallel on the aeroplane by the maintenance workshop, the owner and the inspector awarding the Inspection Authorization. The latter then approved the aeroplane's return to service.

During the flight, abnormal parameters were detected on the left engine and a warning was activated. The pilot-in-command initially continued the flight, the mechanic-passenger having indicated to him that it was probably a false alarm.

During the return leg, the warning was activated again and a fire broke out in the left engine. The pilot-in-command, believing that he would not be able to reach the runway, decided to carry out an emergency landing in a field.

The investigation was not able to determine the cause of the fire. However, it is probable that the fire broke out level with cylinder No. 4 of the left engine.

Contributing factors

The following factors may have contributed to the in-flight fire in the left engine:

- the very long term storage of the aeroplane without any particular engine preservation or return to service procedure being implemented, contrary to the recommendations of the engine manufacturer;
- the non-performance of the engine overhaul although it was recommended by the manufacturer, without any precaution or alternative inspection to this overhaul. The American regulations permit this;
- the insufficient sharing of information between the maintenance workshop and the new owner during the return to airworthy condition operations;
- the continuation of the flight after the appearance of a warning associated with the temperature of cylinder No. 4 on the left engine in the context of a first flight after a long period of being on the ground and substantial maintenance operations.

The following factor may have contributed to attenuating the consequences of the fire after it broke out:

- the emergency landing in a field rather than trying to reach the runway at a distance of around 900 m given the strength of the fire and the urgency of the situation.

Safety lessons

Maintenance of aeroplanes registered in the United States

American regulations give the owners of aeroplanes registered in the United States alternatives notably with respect to continuing airworthiness, compared to the European equivalent.

This American framework sets out the minimum requirements applicable in the general case of aircraft in operation. However, particular situations - notably very long term storage - should lead to additional checks and precautions which are not explicitly mentioned in the regulations.

It is therefore the responsibility of the owner of the aircraft, the maintenance workshop and the IA inspector to each show adaptability and discernment with respect to these atypical cases, to ensure that flight safety is correctly taken into consideration in the face of economic constraints.

Long-term storage of general aviation aircraft

Keeping an aircraft on the ground for a long period can have important consequences on its airworthiness. It is generally accepted that the most effective preventive maintenance for an aircraft expected to be inactive for a long period is for it to be flown at least once a month. It should be noted that simply running the engine while on the ground does not constitute a satisfactory alternative measure and may, in reality, prove to be harmful for the engine.

Certain situations - the health crisis linked to the COVID-19 pandemic is a recent example - may however mean that these good practices cannot always be complied with. In this case, preservation measures should be implemented to prevent or at least slow down, the deterioration of the aircraft's state.

In the scope of measures taken following the COVID-19 pandemic, the European Aviation Safety Agency (EASA) published a guide, "Return to service of aircraft after storage" for CAMOs[16] and AMOs[17].

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.

[16] Continuing Airworthiness Management Organisation.

[17] Approved Maintenance Organisation.