STATE COMMISSION ON AIRCRAFT ACCIDENTS INVESTIGATION

Warsaw, **7 January 2015**

Reference number of air occurrence

1804/14

FINAL REPORT

on investigation into air occurrence to aircraft of a maximum takeoff weight equal to or below 2 250 kg*

This Report is a document presenting the position of the State Commission on Aircraft Accidents Investigation concerning circumstances of the air occurrence, its causes and safety recommendations. The Report is the result of the investigation carried out in accordance with the applicable domestic and international legal provisions for prevention purposes only. The investigation was conducted without the need of application of the legal evidential procedure. In connection with the provisions of the Regulation (EU) No 996/2010 of the European Parliament and of the Council on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC (EU Journal of Laws L.2010.295.35), the wording used in this Report may not be considered as an indication of a person guilty or responsible for the occurrence. The Commission does not apportion blame or liability.

In connection with the above, any form of use of this Report for any purpose other than air accidents and serious incidents prevention can lead to wrong conclusions and interpretations. This Report was drawn up in the Polish language. Other language versions may be drawn up for information purposes only.

1. Type of occurrence:

serious incident.

2. Investigation was conducted by:

SCAAI Investigating Team.

3. Date and local time of the occurrence:

5 October 2014, 12:30 hrs LMT. All times throughout the Report are expressed in LMT.

4. Place of take off and intended landing:

Pobiednik Wielki (EPKP) aerodrome near Kraków.

5. Place of the occurrence:

Kraków TMA, EPKP ATZ.

6. Category, type, registration marks, owner of the aircraft, user:

airplane, Cessna U 206F, registration marks: HA-ERA, owner: AVIA-Rent Ltd., user: Seven Rights Sp. z o.o.

* Form and scope of this report do not meet all the guidelines contained in Appendix "Form of the Final Report" of Annex 13 to the Convention on International Civil Aviation

Damage: cracked two through bolts fixing cylinders No. 2 and No. 3, cracked engine block, damaged cooling fin on cylinder No.2, fuel line feeding cylinder No.2 broken before fuel injector, cracked exhaust manifold on cylinder No. 6, substantial engine damage caused by repeated thermal loads. Due to the extent of damage the engine was qualified to withdrawal from service.

7. Type of operation:

a flight for skydiving operations.

8. Phase of flight:

climb.

9. Flight conditions:

according to VFR, in VMC conditions, daylight.

10. Weather factors:

weather had no impact on the occurrence.

11. Flight organizer:

Seven Rights Sp. z o. o.

12. Pilot-in-Command data:

male, aged 35. His total flight time on airplanes – 429 hrs 54 min, over the last 30 days: 16 hrs 21 min, on Cessna U 206 F: about 100 hrs. Holder of CPL(A) valid until 29 August 2016. SEP(L) rating valid until 30 April 2016, MEP(L) and IR valid until 16 July 2015. Holder of valid General Radiotelephone Operator's Certificate, Class 1 Aero-Medical Certificate valid until 7 May 2015 and Class 2 Aero-Medical Certificate and LAPL valid until 5 May 2019 without limitations. Theoretical Knowledge Exam valid until 12 April 2015, Operator Proficiency Check valid until 15 July 2015.

13. Injuries to the crew and passengers:

no injuries.

14. Course and analysis of the occurrence:

On 5 October 2014, at Pobiednik Wielki aerodrome (EPKP) near Kraków CESSNA U-206F flights for skydiving operations were conducted. Before the fifth lift, around 12:00 hrs, the airplane was refueled and the oil level in the engine was checked (the quantity approximately 8,5 qts). That flight was planned for FL 110 (3350 m). The airplane took off from Runway 09. At the proper altitude the pilot retracted flaps, reduced engine boost to 25 inches of Hg and the engine speed to 2500 rev/min. During the climb the pilot maintained the exhaust temperature at 1400° F (1300°F is recommended). At the altitude of 1600 ft the pilot established communication with Kraków Approach (KK APP) and received clearance to climb to FL 110.

After about 20-minute flight the pilot noticed the decreasing temperature of cylinder No. 2 (UBG-16 instrument). The pilot turned the plane in the direction of the take-off aerodrome and continued the climb monitoring the temperature indicator. The temperature of cylinder No. 2 was slowly but continuously decreasing. Approximately at FL 80 the pilot and the skydivers clearly smelled fuel in the cabin. The pilot decided to make a precautionary landing at the aerodrome, reduced engine boost and enriched mixture. Heading towards the aerodrome the pilot declared his intention of dropping the sakydivers at FL-70. At this moment the engine started running roughly and lost power. The pilot reduced the engine boost to 14 inches of Hg and reached the aerodrome where at FL 70 the skydivers exited the aircraft (landing at a designated place). The pilot started the descent, the engine still was running roughly. Without changing the flight parameters the pilot executed the aerodrome traffic circuit and landed on Runway 09. After landing he taxied in front of a hangar. After leaving the cockpit the pilot found a significant oil leak from the engine (Figure 1), and duing an initial inspection it turned out that the engine block was cracked in two places.

Figure 1. Lower surface of the fuselage covered with the leaking oil.

During a detailed visual examination of the *Continental* six-cylinder injection engine executed in a hangar in the presence of the SCAAI representative the following damages were found: fatigue crack of the two through bolts fixing cylinders No. 2 and No. 3 (Figure 2), crack of the engine block in the area of cylinders No. 2 and No. 3 and rupture of the fuel line before fuel injector of cylinder No. 2 (Figures 3 and 4).

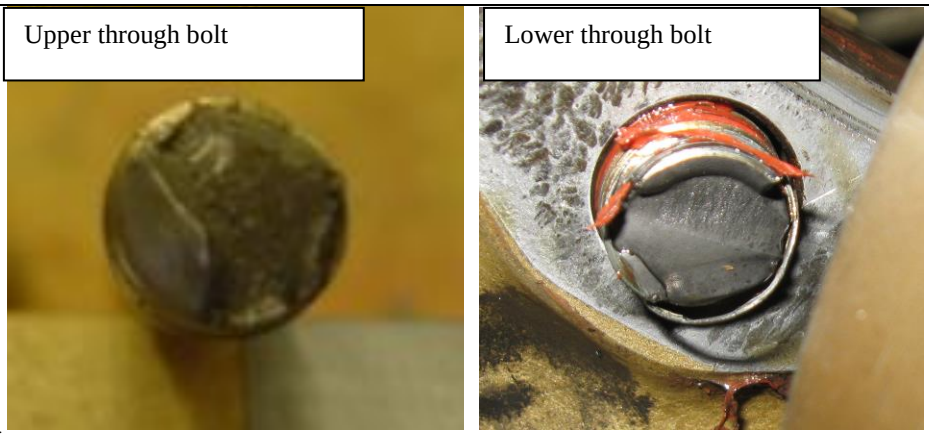

**Figure 2. Fracture surfaces of the through bolts fixing cylinders No. 2 and No. 3.

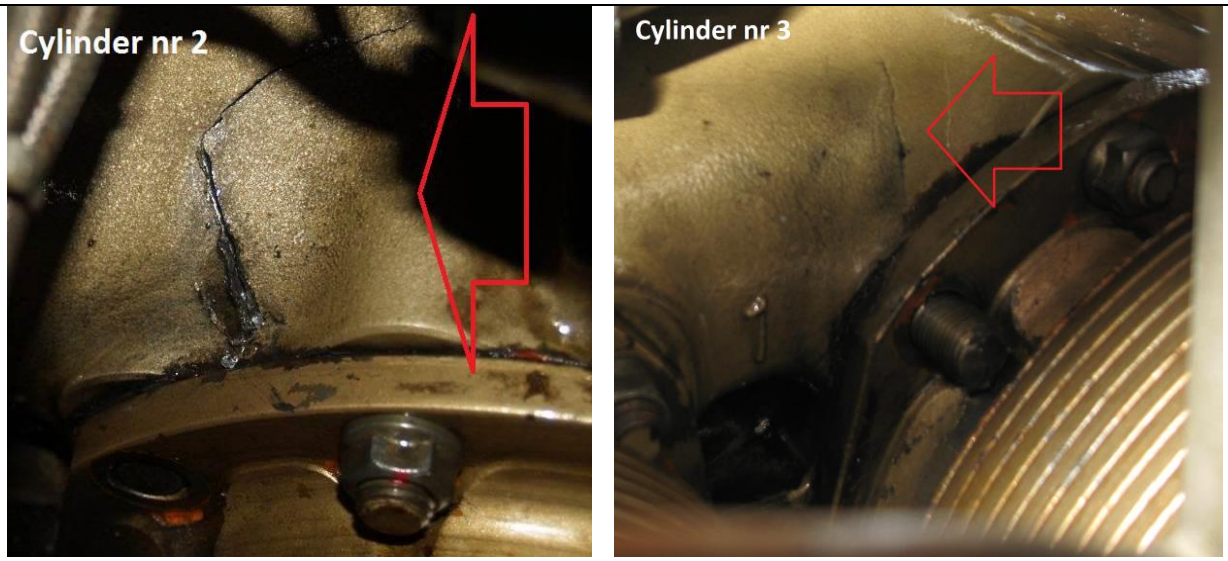

**Figure 3. Cracks of the engine block.

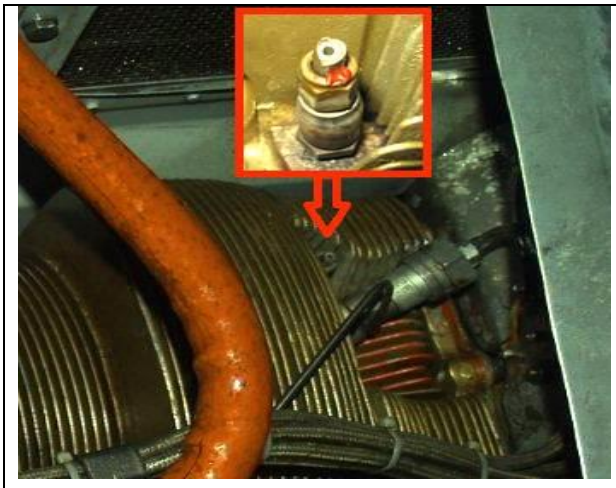

**Figure 4.

Ruptured fuel line.

**Photo taken by SCAAI

Cracks of the engine block on both sides originated in the holes, through which the top through bolt goes. After analyzing the nature of the bolts fractures, the Commission concluded that the cracking process started at the threaded portion and progressed gradually (numerous beach marks visible in Figure 2). The fracture of the final phase of the cracking process has a sudden nature.

Analysis

The table below presents the history of sealings replacements in the engine (according to the owner statement).

History of replacements of seals in the engine	Engine work time
Transfer of the airplane to the user.	2206,4 h
Replacement of seals of the valves tappets tubes.	2312,1 h
Replacement of a gasket under a cylinder and seals of the valves tappets tubes.	2337,0 h
Replacement of a gasket under a cylinder and sealings of the valves tappets „tubes”.	2410,1 h
Engine damage.	2468.5 h

In the Commission opinion, the frequent replacement of damaged seals resulted from the engine overheating and was associated with oil leaks. The Commission found that in the Aeroplane Technical Log there were no records documenting the engine failures.

According to the Commission, when mounting the cylinder after replacement of sealing, the nuts on the through bolts were not tightened to the proper torque, which initiated their process of cracking. The resultant backlash, combined with cyclic thermal loading, caused the bending forces on the screw joint, which initiated the development of cracks of the through bolts. It was found that there was no nut at the upper through bolt of cylinder No.2. This shows that the crack of this bolt occurred earlier than the crack of the lower one. Due to a longer period of vibration and rotation of the bolt in the hole the nut unscrewed and fell away. On the lower bolt, on the same side, the nut remained on the threaded portion.

The rupture of the fuel line before fuel injector of cylinder No.2 occurred due to the vibration of the cylinder which resulted from the cracking of the second through bolt.

Visual examination of the engine during disassembly additionally showed the crack of the exhaust manifold on cylinder No. 6 (Figure 5) and local discoloration of heat-resistant paint on all cylinders.

**Figure 5.
Cylinder No. 6. Visible blowthrough from the cracked exhaust manifold.

After removal of cylinder No. 3 it was found that the whole surface of the cylinder barrel showed microcracks. In the Commission opinion, such a damage occurs after exceeding of the compressive stress in a nitrided surface layer. Those damages existed on the whole perimeter of the cylinder barrel, and not only in the areas of the side pressure from the piston, so they could only be caused by the cyclic thermal loads. In addition, the surface of the cylinder barrel in the area of mating with the piston rings was dark, which proved its overheating. Due to high temperature (which significantly deteriorated lubrication conditions) the honing in this area had been almost completely worn, which further deteriorated lubrication conditions of the cylinder barrel (longitudinal scratches from the piston rings) and its further overheating (Figure 6 below).

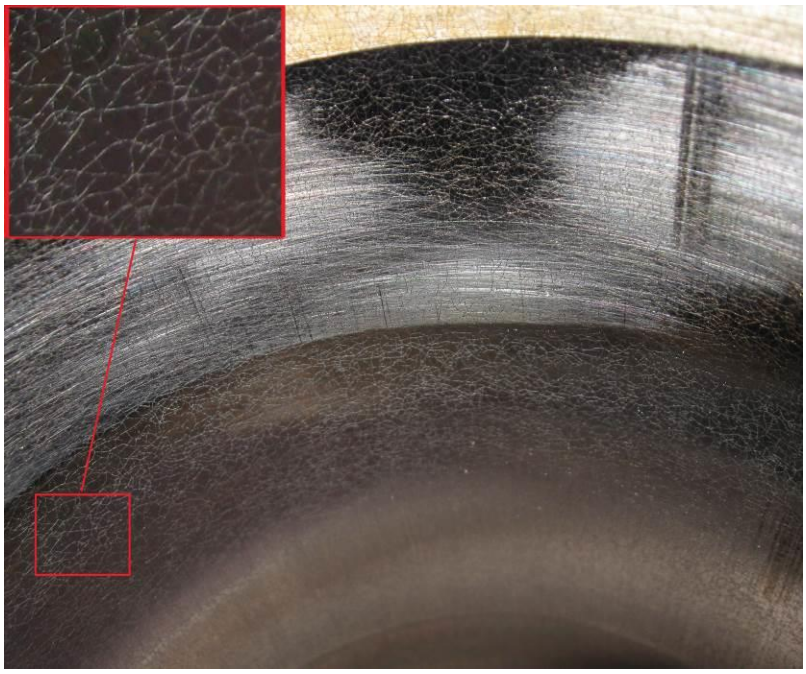

**Figure 6.
Microcracks on the cylinder surface. Visible longitudinal scratches caused by poor lubrication of the engine.

A ring of light purple color was visible on the head of the exhaust valve. It indicated a slight overheating, while a small amount of carbon deposit indicated a good combustion (Figure 7).

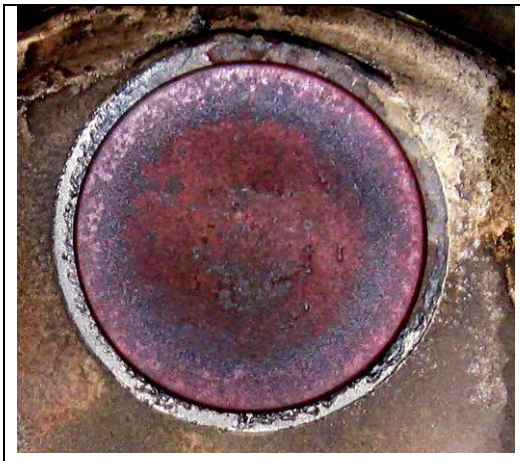

**Figure 7. Exhaust valve.

In addition, during the analysis of photos attached to the Notification of Air Occurrence, the Commission noted incorrect position of one of the cooling fins of cylinder No. 2. This proved its crack due to overheating (Figure 8 below).

Figure 8. Section of the photo showing change of the position of cylinder No. 2 cooling fin.

This damage is more visible in the photo taken during the disassembly of the engine (Figure 9).

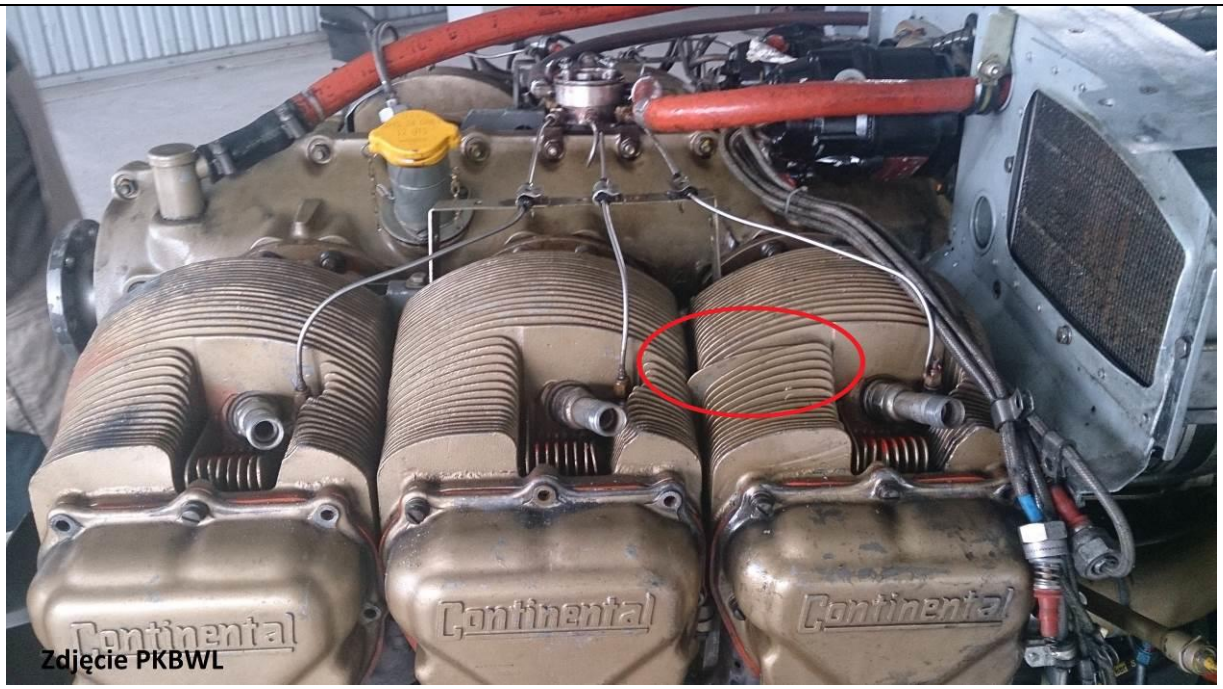

Figure 9.
Damaged cooling fin of cylinder No. 2.
Photo taken during the disassembly of the engine.

15. Causes of the occurrence:

- incorrect usage of the engine in flight;
- probably too weak tightening torque of the two through bolts fixing cylinders No.2 and No.3, which led to the cracks of the bolts and the engine block and to the breaking of the fuel line feeding the fuel injector of cylinder No.2.

16. Commission comment:

The distinct smell of fuel, the temperature drop in cylinder No. 2 and rough engine operation clearly indicated a leakage in the fuel system, which could had led to the airplane fire.

In the Commission opinion, in this situation the pilot should shut off the fuel valve, increase the engine boost (to burn quickly the fuel remaining in the fuel lines) and after stopping the engine switch off the magnetos and perform an emergency landing on the aerodrome.

Continuation of the flight with the damaged engine running until landing, and taxiing to the hangar could had caused a fire or even an explosion of the aircraft.

According to the Commission, the described engine damages proved that it was poorly operated.

The Commission notes that in a short period of time it is another case of engine damage due to its improper usage in the operations of skydivers lifting. In the Commission opinion this fact may indicate that pilots are not fully aware of the temperature gradient (cylinders cooling) in such operations and importance of maintaining the recommended engine parameters.

Due to change in categorization of the occurrence from "incident" to "serious incident" in the meantime the owner disassembled the damaged engine without the participation of a representative of SCAAI. The above circumstances caused that condition of the engine has not been fully investigated.

The Commission acquainted with the user comments on the Draft Final Report, but they were not relevant to the cause of the serious incident.

A representative of the aircraft owner for Poland did not make any comments on the Draft Final Report.

17. Safety recommendations: none

18. Annexes: none

Composition of the Investigating Team:

Investigator-in-Charge: Jacek Bogatko, instructor pilot, MSc (Eng.)

Team member: Stanisław Żurkowski, PhD, Eur Ing

Team member: Ryszard Rutkowski, instructor pilot, MSc (Eng.)

….....*signature on the original Report*.....

(Stamp and signature of the Investigator-in-Charge)