Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AMENDED REPORT

AVIATION OCCURRENCE REPORT

ENGINE FAILURE ON INITIAL CLIMB

AMPHIBEC (ULTRALIGHT) C-FPXF
RIVIÈRE-DU-LOUP, QUEBEC
11 JANUARY 1994

REPORT NUMBER A94Q0003

Canada

MANDATE OF THE TSB

The Canadian Transportation Accident Investigation and Safety Board Act provides the legal framework governing the TSB's activities. Basically, the TSB has a mandate to advance safety in the marine, pipeline, rail, and aviation modes of transportation by:

- conducting independent investigations and, if necessary, public inquiries into transportation occurrences in order to make findings as to their causes and contributing factors;
- reporting publicly on its investigations and public inquiries and on the related findings;
- identifying safety deficiencies as evidenced by transportation occurrences;
- making recommendations designed to eliminate or reduce any such safety deficiencies; and
- conducting special studies and special investigations on transportation safety matters.

It is not the function of the Board to assign fault or determine civil or criminal liability. However, the Board must not refrain from fully reporting on the causes and contributing factors merely because fault or liability might be inferred from the Board's findings.

INDEPENDENCE

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Engine Failure on Initial Climb

Amphibec (Ultralight) C-FPXF
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Synopsis

The pilot and passenger took off from the Rivière-du-Loup Airport, Quebec, for a local flight in the advanced ultralight. The engine stopped during the initial climb, and the aircraft entered a steep left turn and spun to the ground. The pilot and passenger were fatally injured.

The Board determined that the engine stopped when the rear piston seized. The aircraft then stalled at an altitude insufficient for a recovery. Factors contributing to the piston seizure were the defective crankshaft seal, the very low ambient temperature, the use of an oversized radiator, incorrect installation of the cooling system, and the use of type 165 (warm weather) carburettor jets.

Ce rapport est également disponible en français.

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5.0 Appendices

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1.0 Factual Information

1.1 History of the Flight

Around 1350 eastern daylight saving time (EDT), the pilot and passenger readied the advanced ultralight for a local pleasure flight. At approximately 1430 EDT, the pilot operated the engine at high rpm on the ground, then taxied the aircraft to the take-off area.

Around 1500 EDT, the ultralight took off from the Rivière-du-Loup Airport, and turned slightly to the right. The engine failed when the aircraft was just past the runway end at an estimated altitude of 200 feet above ground level (agl). The aircraft turned quickly to the left before crashing on the snow-covered ground.

The pilot and passenger were fatally injured in the crash. The aircraft was substantially damaged.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	1	-	2
Serious	-	-	-	-
Minor/None	-	-	-	-
Total	1	1	-	2

1.3 Damage to Aircraft

The aircraft wings and forward fuselage were substantially damaged. The fibreglass fuel tank situated in the nose of the aircraft was destroyed on impact; its contents spilled out on the snow.

The engine was mounted over the high wing and was not damaged. One of the three blades of the pusher propeller was severed. The blades showed no signs of rotational impact damage.

1.3.1 Wreckage and Impact Information

The aircraft struck the snow-covered ground in a nose-down attitude and remained in that position. Damage to the wings and forward fuselage suggests a left rotation at low speed at the time of impact.

The flight controls were damaged in the crash. Examination of the flight controls did not reveal which occupant was flying the aircraft at the time of impact.

1.4 Personnel Information

	Pilot-in-command
Age	50
Pilot Licence	Private - Aeroplane

	Pilot-in-command
Medical Expiry Date	01 Nov 94
Total Flying Hours	1,298
Hours on Type	16
Hours Last 90 Days	20
Hours on Type Last 90 Days	14
Hours on Duty Prior to Occurrence	-
Hours Off Duty Prior to Work Period	7

1.4.1 *Pilot*

The pilot-in-command was occupying the right-hand seat. He held a private pilot (aeroplane) licence and a private pilot (ultralight) licence. Both licences were valid, and they authorized him to act as pilot-in-command and to carry a passenger.

1.4.2 *Passenger*

The passenger was occupying the left-hand seat. He was the builder and owner of the aircraft, and he held a student pilot (ultralight) permit. His permit did not authorize him to act as pilot-in-command or to carry a passenger. He had passed the pre-solo examination but had not yet written the examination for a private pilot (ultralight) licence.

The passenger had logged 16.3 flying hours on an RX-550 ultralight with a flying school. He had also flown about 16 hours in C-FPXF with the pilot who accompanied him on the accident flight.

1.4.3 *Conduct of Flight*

The flight was conducted in accordance with Transport Canada standards and procedures for advanced ultralight operations.

1.5 *Aircraft Information*

The owner built the amphibious advanced ultralight using the designer's plans and tools. The controls in this side-by-side two-seat aircraft are configured to allow it to be flown by the occupant of either seat.

The aircraft was equipped with skis for winter operation. The weight on take-off was about 400 kilograms, which is the maximum allowable take-off weight for this type.

Manufacturer	Amphibec MFG
Type	Advanced ultralight

Year of Manufacture	1993
Serial Number	RA-582-08
Certificate of Airworthiness (Flight Permit)	Statement of conformity
Total Airframe Time	33 hr
Engine Type (number of)	Rotax 582UL (1)
Propeller/Rotor Type (number of)	GSC International (1)
Maximum Allowable Take-off Weight	400 kg
Recommended Fuel Type(s)	Automotive
Fuel Type Used	Automotive

1.5.1 Stall Characteristics

With two occupants and a full fuel tank, the stall speed of the Amphibec is approximately 45 miles per hour (mph), and its climb speed is about 55 mph.

Because of their low weight, ultralight aircraft have very low inertia and lose speed rapidly if the engine fails. In addition, with the engine mounted over the high wing, this aircraft pitches up if the engine fails in the climb; the angle of attack increases and speed decreases very rapidly.

During a climbing turn, an aircraft describes an upward spiral; in this manoeuvre, the outside wing in the turn is at a greater angle of attack than the inside wing. Consequently, in a climbing turn, the outside wing is the first to stall and drop when speed decreases or the angle of attack increases.

1.5.2 Engine

The Amphibec is powered by a Rotax 582UL engine mounted with the cylinder heads down and the propeller aft. The engine is cooled by liquid circulating through cooling jackets around the two cylinders and cylinder head. The crankshaft bearings are lubricated by an atomized mixture of air/fuel/oil, which enters the engine crankcase before being drawn into the cylinder for combustion.

Examination of the engine which had 33 hours total time since new revealed grooves on the rear piston skirt and rear cylinder wall. These marks on the piston were found mainly on the surface adjacent to the gas intake port and exhaust port. The rear cylinder spark plugs and exhaust manifold were greyish, indicating a high combustion temperature.

The ball-type bearing supporting the crankshaft at the propeller reduction gear end (rear) showed signs of overheating. The ball bearing cage had melted and had become lodged against the seal. The ball bearings and races bore marks indicating insufficient lubrication. The parallel ball-type bearing exhibited no abnormal marks.

No grooves were observed on the front piston or cylinder. The front cylinder spark plugs were a brownish colour and the exhaust manifold was black, indicating normal combustion temperature.

Combustion temperature is directly related to the ratio of air/fuel/oil in the mixture drawn into the cylinder; the leaner the mixture, the higher the combustion temperature. The Rotax engine manufacturer recommends replacing the type 165 warm-weather main carburettor jets with type 175 jets for cold weather operation. This modification produces a richer mixture and lower combustion temperature, which reduces thermal expansion of the piston.

The first page of the engine operator's manual from the manufacturer contains the following warning: [TRANSLATION] "Because of its design, the Rotax 582UL engine is subject to sudden failure, possibly requiring an emergency landing. Emergency landings can result in severe injury or loss of life." The aircraft builder stated that he was aware of this information when he bought the engine.

1.5.3 Cooling System

The builder installed a thermostat-equipped cooling system manufactured by Aviation Normand Dubé Inc. The thermostat (C), located near the cylinder head, regulates the coolant temperature at about 160 degrees Fahrenheit.

The installation diagram[1] normally supplied by Aviation Normand Dubé Inc. with its cooling system components (see figure 1) shows a bypass hose (E) returning coolant to the water pump (D). This reduces the temperature differential of the coolant between the cylinder head outlet and the hose returning to the engine.

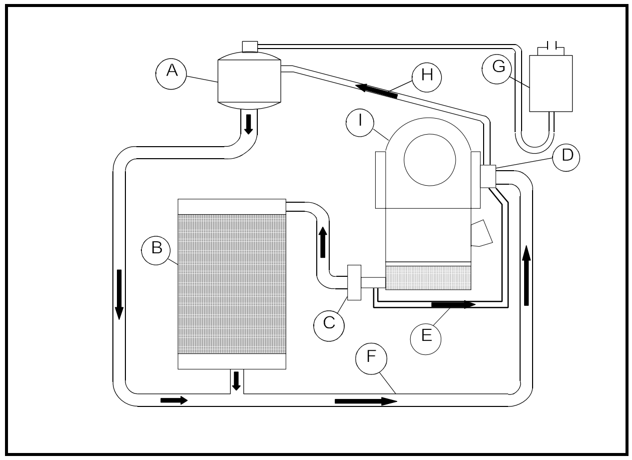

Figure 1 - Aviation Normand Dubé Inc. cooling system

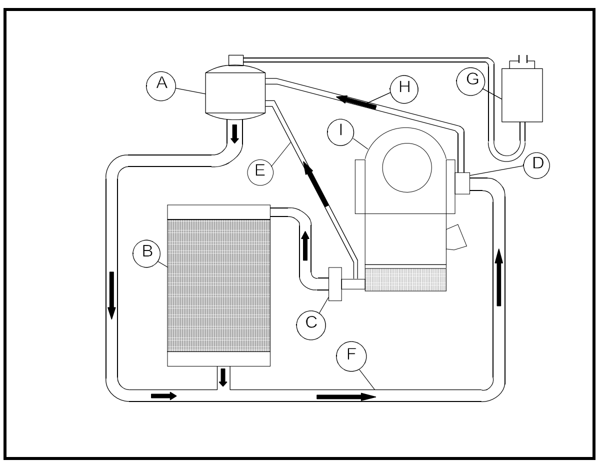

Figure 2 - Cooling system as installed on the aircraft

However, the cylinder head (I) on the aircraft (see figure 2) was not designed to be fitted with an integrated thermostat. The bypass hose (E) was not installed in accordance with the installation diagram supplied by Aviation Normand Dubé Inc. Instead, the bypass ran back to the expansion tank (A), which increased the temperature differential of the coolant between the engine outlet and pump return (D).

[1] Legend: A- radiator expansion tank; B- radiator; C- thermostat; D- water pump; E- bypass hose; F- cooled liquid; G- overflow reservoir; H- system venting tube; I- engine.

In addition, the aircraft was fitted with an oversized radiator (B). With a cooling surface 20 to 50 per cent greater than that of the radiators built and recommended by the engine manufacturer, the oversized radiator contributed to excessive engine cooling.

The rear cylinder spark plugs and exhaust manifold were greyish, indicating a higher combustion temperature.

1.5.4 Distribution of Rotax Service Bulletins

The exclusive distributor receives service bulletins from the engine manufacturer and forwards them to the authorized distributors, who normally send them to their customers. However, new engine owners receive only the service bulletins issued by the engine manufacturer after their date of purchase; previously issued bulletins are not normally provided at the time of purchase.

1.5.5 Installation Instructions and Service Bulletins

It could not be confirmed whether or not the builder had all the instructions and information required to install the cooling system, either according to the diagram of the thermostat-equipped system supplied by Aviation Normand Dubé Inc. or according to the system recommended by Rotax.

There was no indication that the owner-builder was informed of the Rotax service bulletin issued in November 1991 before he purchased the engine. That service bulletin related to the cooling system for 582UL engines, and it specified a maximum coolant temperature differential of 11 degrees Fahrenheit between the engine outlet and the water pump return. Aircraft maintenance engineers receiving training on this type of Rotax engine, however, are informed that this temperature differential can be up to a maximum of 40 degrees Fahrenheit.

1.5.6 Indication of Exhaust Gas Temperature

The engine was equipped with two sensors and a dual temperature gauge indicating the exhaust gas temperature for each cylinder. The gauge shows when one cylinder is running too hot in comparison with the other. This temperature differential indicates whether the fuel mixture is correct so as to avoid excessive combustion temperatures, which can cause piston overheating and seizure in the cylinder. Interpretation of the gauge reading is reliable only when the engine is at full power, as during take-off.

1.6 Meteorological Information

Weather conditions at the time of the accident were favourable for visual flight. The winds were from the west at 5 mph and the temperature was around minus 14 degrees Celsius.

1.7 Aerodrome Information

The aircraft took off from a hard snow surface to the south of and parallel to airport runway 23. The area beyond the end of runway 23 is cleared for about 1,000 feet and then terminates in a wooded area.

The ultralight crashed on the extended centre line of runway 23 about 500 feet past the end of the runway.

1.8 Medical Information

The passenger sustained fatal head injuries during the impact, and the pilot was asphyxiated. It was not possible to determine which occupant was flying the aircraft.

There was no evidence that incapacitation or physiological factors affected the performance of either occupant. Toxicological test results were negative.

1.9 Survival Aspects

The structural wing spar runs through the cockpit at the ceiling. The passenger, who occupied the left-hand seat, sustained severe head injuries caused by striking this spar. The pilot, who occupied the right-hand seat, was pinned between the spar and the snow.

The aircraft was not equipped with shoulder harnesses, nor were they required equipment on this type of aircraft under the existing regulations. Occupants of advanced ultralight aircraft are not required to wear helmets.

2.0 Analysis

2.1 Pilot Flying

It could not be determined who was flying the aircraft. The pilot-in-command was qualified for the flight, and was capable of flying the aircraft even if he was in the right-hand seat.

2.2 Survival Aspects

The cockpit structure provided little protection for the occupants in the event of a nose-down impact. The use of shoulder harnesses and helmets probably would have resulted in less severe injuries to the occupants. Also, the pilot in the right-hand seat probably would not have been pinned between the ground and the spar.

2.3 Engine Failure

2.3.1 Engine Cooling System

The incorrect installation of the bypass hose and the oversized radiator resulted in a decrease in the temperature of the coolant being returned to the engine.

The builder's intention, when installing the cooling system, was to prevent the engine from overheating during manoeuvres on the ground on hot summer days.

Nevertheless, the result was that coolant was returned to the engine at a lower temperature, and the temperature differential of the coolant between the engine outlet and the pump return became greater. During operations at very low ambient temperatures, this cooling system, with its increased efficiency, would lower the temperature of the coolant by more than 40 degrees Fahrenheit before the coolant returned to the engine block.

The colder liquid returning to the pump and circulating through the jackets around the two cylinders and the cylinder head reduced thermal expansion of the cylinders and cylinder head.

2.3.2 Combustion Temperature

The carburettor for each of the two cylinders was fitted with one main jet with a setting of 165 (for warm weather), rather than 175 (for cold weather) as recommended by the engine manufacturer. Consequently, the very low ambient temperature of minus 14 degrees Celsius produced a leaner air/fuel mixture, which resulted in higher combustion temperatures and greater thermal expansion of the pistons.

The colour of the spark plugs, piston surfaces, and exhaust manifolds indicated a higher combustion temperature in the rear cylinder than in the front. The cause of the difference in combustion temperatures can be traced to the seal at the rear of the engine block near the reduction gear. Only the bearing adjacent to this seal was damaged and showed signs of overheating. The damage to and overheating of the bearing apparently originated with air being drawn in at each engine cycle, which led to degradation of the lubrication to the bearing. The cause of the seal failure could not be determined due to a lack of evidence. However, bearings rarely deteriorate to that point after only 33 hours of service; this implies a defect in the seal. Air sucked in through the defective seal caused thinning of the air/fuel/oil mixture aspirated into the rear cylinder, producing a higher combustion temperature in the cylinder during take-off.

2.3.3 Loss of Piston/Cylinder Clearance

The grooves on the piston and on the rear cylinder indicate that the engine stopped because of a loss of clearance (seizure). The piston seizure was caused in part by increased thermal expansion of the piston due to the higher combustion temperature resulting from air being drawn in through the defective seal. Additionally, the seizure was also caused by reduced thermal expansion of the cylinder due to excessive engine cooling.

2.3.4 Engine Manufacturer Service Bulletins

Because of this engine's particular susceptibility to stopping, the engine manufacturer posted a warning on the first page of the manual and issued service bulletins to that effect.

The service bulletin on the engine cooling system was issued before the aircraft builder purchased the engine. The builder, therefore, probably did not have all the information regarding the installation of the cooling system and engine operation, because purchasers normally do not receive bulletins issued previous to their date of purchase.

2.4 Aircraft Behaviour

During the engine warm-up on the ground, the pilot could not have raised the engine power level to the point where he would have obtained a reliable exhaust gas temperature reading, as the ski-equipped aircraft would have slid on the hard snow-covered surface. During the take-off run, full engine power was applied. The increase in the exhaust gas temperature reading was almost instantaneous, but more time was required for the instruments to show a decrease in coolant temperature. However, during the take-off, it is possible that neither of the occupants observed this situation on the instruments.

During the climb-out to 200 feet agl, the rear piston continued to expand, while cooling of the cylinder was more effective; both events contributed to the piston seizure.

Before the engine stopped, the aircraft was turning slowly to the right during the initial climb. When the engine stopped, the ultralight pitched nose up and lost speed very quickly. The stall speed for this aircraft is close to the climb speed; the angle of attack of the left wing, which is the outside wing in the turn, exceeded that of the right wing, and the left wing stalled first.

The stall occurred at an altitude insufficient for the pilot to regain control of the aircraft and make an emergency landing on the cleared area straight ahead. The aircraft entered a left-hand spin before it struck the ground.

3.0 Conclusions

3.1 Findings

1. The pilot was qualified for the flight.

2. It could not be determined which of the two occupants was flying the aircraft.

3. The stall speed for the Amphibec is close to the climb speed.

4. The ultralight stalled at an altitude insufficient for the pilot to make a recovery and regain control of the aircraft.

5. The cooling system installation was not in accordance with the diagram provided by the cooling system manufacturer, nor did the installation conform with the recommendations of the engine manufacturer.

6. The oversized radiator and ambient temperature of minus 14 degrees Celsius were conducive to excessive cooling of the cylinders.

7. The type 165 (warm weather) carburettor jets and the temperature of minus 14 degrees Celsius caused higher combustion temperatures and increased thermal expansion of the pistons.

8. The engine stopped because of a lack of clearance (seizure) between the rear piston and cylinder.

9. There was no indication that the builder had all the documentation concerning the installation of the cooling system and the operation of the engine.

10. The aircraft was not equipped with shoulder harnesses, and the occupants were not wearing helmets; such equipment was not required by regulations.

11. Only the crankshaft bearing near the propeller reduction gearbox showed signs of overheating and insufficient lubrication.

12. The crankshaft bearing rear seal allowed air to leak in and thin the air/fuel/oil mixture.

13. Only the rear piston lost clearance with the cylinder.

3.2 Causes

The engine stopped when the rear piston seized. The aircraft then stalled at an altitude insufficient for a recovery. Factors contributing to the piston seizure were the defective crankshaft seal, the very low ambient temperature, the use of an oversized radiator, incorrect installation of the cooling system, and the use of type 165 (warm weather) carburettor jets.

4.0 Safety Action

The Board has no aviation safety recommendations to issue at this time.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson John W. Stants, and members Zita Brunet and Maurice Harquail, authorized the release of this report on 07 February 1996.

Appendix A - List of Supporting Reports

The following TSB Engineering Branch laboratory report was completed:

LP 9/94 - Fuel Sample Analysis.

This report is available upon request from the Transportation Safety Board of Canada.

Appendix B - Glossary

agl	above ground level
EDT	eastern daylight saving time
hr	hour(s)
kg	kilograms
mph	miles per hour
rpm	revolutions per minute
TSB	Transportation Safety Board of Canada

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