Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A08C0145

ENGINE FAILURE – FORCED LANDING

GOGAL AIR SERVICES LIMITED
NOORDUYN NORSEMAN MK V C-FECG
SNOW LAKE, MANITOBA, 15 nm N
06 JULY 2008

Canada

Aviation Investigation Report

Engine Failure – Forced Landing

Gogal Air Services Limited
Noorduyn Norseman MK V C-FECG
Snow Lake, Manitoba 15 nm N
06 July 2008

Report Number A08C0145

Summary

The float-equipped Gogal Air Services Limited Noorduyn Norseman Mark V (registration C-FECG, serial number N29-43) departed Burntwood Lake Lodge, Manitoba, on a 20-minute flight to Snow Lake. Approximately 10 minutes into the flight, the engine began to sputter and lose power. The pilot attempted but was unable to restore engine power. At 0900 central daylight time, the pilot made a forced landing 15 nautical miles north of Snow Lake into a sparsely-wooded marshy area. The pilot and seven passengers exited the aircraft without injury. The aircraft sustained substantial damage; however, the impact forces were low and the emergency locator transmitter did not activate. The pilot radioed another company aircraft that was flying in the area and informed the other pilot of the accident. A company helicopter was dispatched to the site and the pilot and passengers were flown to Snow Lake.

Ce rapport est également disponible en français.

Other Factual Information

The nearest weather reporting station is Flin Flon, Manitoba, situated approximately 40 nautical miles (nm) to the west of Snow Lake. The 0900 central daylight time [1] aviation weather report for Flin Flon was as follows: wind 360° true at 6 knots, visibility 15 statue miles, sky clear, temperature 12° C, and the dew point was 8°C. The Flin Flon weather was consistent with the conditions in Snow Lake on the morning of the occurrence. These weather conditions are conducive to the formation of carburetor ice under certain conditions. No carburetor ice was noted by the pilot during the flights on the day of the accident. The company is certified to operate under day visual flight rules (VFR) conditions, which existed at the time of the flight.

The pilot held a commercial pilot licence – aeroplane and helicopter. The licences were validated by a category 1 medical certificate valid until 01 September 2008. The pilot held a pilot competency check on the Norseman valid until 31 May 2009.

The aircraft was to be flown from the company's Snow Lake water base to the Burntwood Lake Lodge situated 37 nm to the north and return with seven passengers and their baggage. The pilot completed the pre-flight inspection and added 100 litres (159 pounds) of fuel to the left tank, bringing the total fuel on board to approximately 500 pounds. The planned fuel usage for the 40-minute round trip was 150 pounds. The flight to Burntwood Lake was uneventful and the aircraft performed normally. At Snow Lake, the passengers and baggage were loaded. The aircraft's total weight was estimated to be at or near its maximum authorized gross weight of 7540 pounds.

The aircraft took off from Burntwood Lake and the pilot levelled the aircraft at 1000 feet above ground level. Approximately 10 minutes into the flight, the engine began to sputter and lose power. The pilot pushed the engine mixture control to the full rich position, applied carburetor heat, and switched fuel tanks. Engine performance did not improve and the aircraft began to lose altitude. The pilot attempted to reach a lake situated approximately three miles away. Approximately one mile from the lake, the pilot realized that he would not be able to reach it and aligned the aircraft with a marshy area that lay below. The aircraft touched down on the marsh grass, travelled approximately 200 yards through the reeds before entering a stand of trees at about 30 mph. The wings and floats absorbed the brunt of the impact and the aircraft came to a gradual stop. The right float ended up beneath the fuselage, causing the aircraft to tilt to the right. The pilot exited through the left door and assisted the passengers out of the cabin. No injuries were reported.

The aircraft was examined on site and a clean and bright flow of fuel was found present at the main airframe fuel strainer. The engine cowling was removed and an initial examination of the Pratt & Whitney (P&W) R1340 AN-1 engine (serial number 18620) revealed that the exhaust ear on the number 2 engine cylinder had cracked and split open. The engine was removed from the site and taken to the TSB Central Region wreckage facility for further examination.

Ce rapport est également disponible en français.

---

1 All times are central daylight time (Coordinated Universal Time minus five hours).

This examination found some minor chafing in several areas, but identified no major discrepancies other than the failure of the number 2 cylinder. The engine was rotated and it was observed that the number 2 cylinder exhaust valve did not move from the closed position. It was determined that the separation of the ear caused an increase in clearance between the exhaust valve push rod and the valve rocker arm to the point where the valve would not open. During engine operation, a closed exhaust valve can result in the hot pressurized exhaust gases being forced back into the common induction system through the normal opening of the intake valve. Small glowing carbon deposits in the hot exhaust gases can induce pre-ignition of the fuel/air mixture in the induction system and result in a disruption in the normal air/fuel mixture to the remaining cylinders. This, in turn, can lead to engine roughness and loss of engine power.

The cylinder was removed from the engine and sent to the TSB Engineering Laboratory for analysis. The valve operating mechanism, bearing clearances, and valve pushrods were examined and found to be within acceptable serviceability limits. The crack on the number 2 cylinder was found to extend from the oil drain hole on the inboard side through to the oil drain hole on the outboard side and up into the valve cap flange area (See Photo set 1).

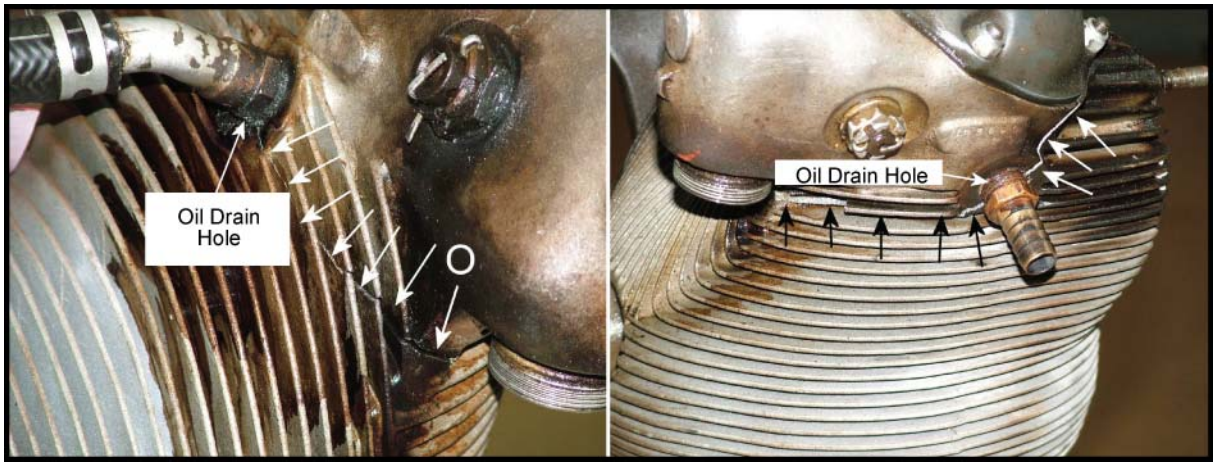

Figure 1. Extent of exhaust ear failure; the "O" points to the area of crack origin

The cylinder fracture was examined under a scanning electron microscope (SEM). Casting porosity and heavy oxidation were found in several areas of the fracture surface and in the origin area of the failure. Beach marks were found that indicated that the fracture and failure occurred as a result of fatigue. The origin of the fatigue was co-located in an area of geometric stress concentration, at the corner where the cooling fin attaches to the cylinder (see Photo set 2).

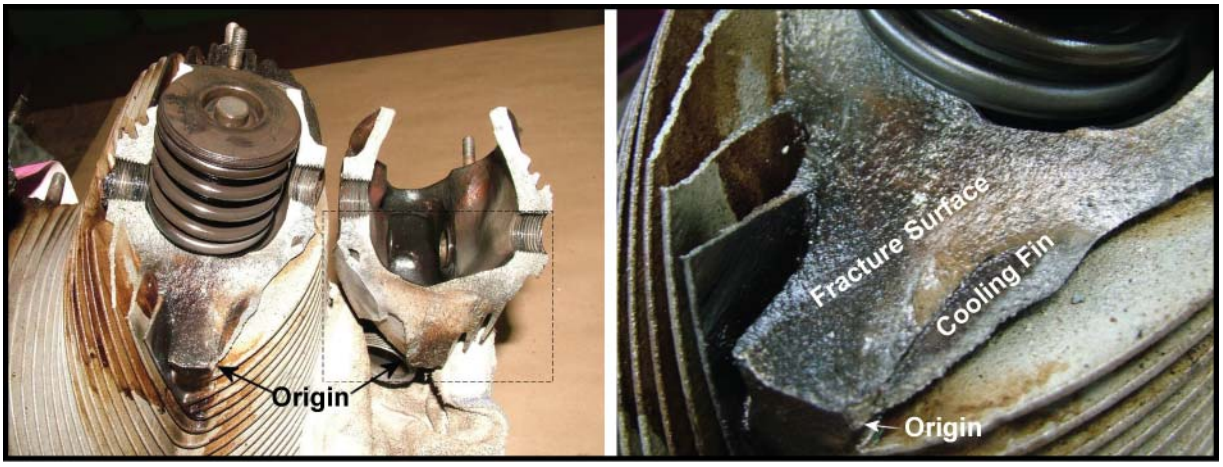

Figure 2. Origin of crack located on a sharp radius corner of the cooling fin

The normal operation of the pushrod provided the cyclic tension load needed to promote the growth of the fatigue crack. The cluster of casting porosities at the corner of the cooling fin was most probably present since the cylinder was first cast, indicating that the fatigue process started when the cylinder was first put into service. The majority of the crack's fatigue lifetime occurred at lengths below the threshold of detectability and did not reach detectability until late in the fatigue lifetime. The severe extent of the corrosion, staining, and rub on the fracture surface indicated that the fatigue crack had been present for a considerable time prior to failure. Due to pounding of the surfaces nearest to the origin, however, it was not possible to quantify the time it took to grow from detectability to failure.

An examination of the aircraft technical records indicated that the aircraft had been maintained in accordance with the Gogal Air Services-approved maintenance schedule. The aircraft last underwent a 100-hour inspection on 07 August 2007, 51 hours prior to the occurrence. The engine had accumulated 1031 hours time-in-service since its last overhaul. The engine overhaul life is 1200 hours with a 50-hour tolerance. The engine received a top overhaul on 16 August 2002 at 436 hours time since overhaul (TSO). Nine overhauled chrome-barrelled P&W cylinders were installed. On 26 July 2003 at 555 hours TSO or 119 hours since top overhaul, the number 1 cylinder was replaced due to a cracked exhaust ear. On 14 June 2008 at 992 hours TSO or 556 hours since top overhaul, the number 3 cylinder was replaced due to a failure of the intake valve seat. On 06 July 2008 at 1031 hours TSO or 595 hours since top overhaul, the number 2 cylinder failed on the occurrence flight due to a cracked exhaust ear.

The cylinders are not subject to an overhaul time limit and tracking of cylinder life and overhaul cycles is not maintained. The cylinders are overhauled when the engine is overhauled or when the cylinders are removed prematurely due to a cylinder problem. During overhaul, the cylinders are subjected to an inspection, including liquid penetrant inspection of the head area and, in some cases, ultrasonic testing on the barrel threads. Some overhaul facilities mark the cylinder skirt with the overhaul date and coding particular to the facility or put a serial number on the valve ear for tracking purposes. There are no requirements to track cylinder life or repair information. Some cylinders have accumulated high-time usage while others have not.

High-time usage can lead to material failure under certain conditions. While the complete history or total time in service of the failed number 2 cylinder could not be established, numerous and overlapping overhaul shop markings were noted on the cylinder skirt and both valve ears.

P&W manufactured the R1340-series engine between 1925 and 1960. After 1960, no new cylinders were made, but a large quantity of unused spare stock remained in the civil and military markets. A prototype heavy head cylinder was produced by a vendor in the late 1990s that was supposed to be stronger across the dome, on the sides, and in the rocker box area. Production of these cylinders was stopped due to technical difficulties, which are being addressed by the vendor.

The P&W R1340 is used extensively in the Norseman and DHC-3 Otter aircraft, which are still in common use today. The P&W R1340, like many piston engines, has a history of cylinder failures. Most cylinder failures are rectified during engine overhaul or routine maintenance. Cylinder failures occurring in-flight do not always result in a loss of engine power necessitating a forced landing.

A review of the aircraft's history revealed two documented forced landings. On 12 September 1989, the aircraft was forced to land on Mawdesley Lake (15 nm east of the The Pas, Manitoba) due to a failure of the number 3 exhaust valve. The cylinder had accumulated 586 hours TSO. On 14 June 1990, the aircraft was forced to land on Emerald Lake (25 nm northeast of Flin Flon, Manitoba) due to a failure of the number 2 cylinder exhaust valve. That cylinder had accumulated 625 hours TSO. The major factor in a successful forced landing is the availability of a suitable landing area. These forced landings occurred in an area of extensive open water and neither of the forced landings resulted in an accident or aircraft damage.

Transport Canada issued Service Difficulty Advisory AV-2007-02 that discussed concerns regarding cylinder head and cylinder flange failures on the Pratt & Whitney R985-series engine. The advisory contains inspection information that may be useful or interchangeable with the R1340-series engine cylinders.

Analysis

The number 2 engine cylinder exhaust ear failed under fatigue in an area of casting porosity and geometric stress concentration. The casting porosity was likely introduced during manufacture of the cylinder some 50 to 80 years prior. The time in service of the cylinder could not be established because there is no requirement to track the cylinder's total accumulated usage. Numerous repair shop markings on the cylinder skirt and ear area suggest that the cylinder had high-time hours in service. The area of fatigue was subject to normal operational loading that took years to initiate and manifest the crack. The severe extent of the corrosion, staining, and rub on the fracture surface indicated that the fatigue crack had been present for a considerable time prior to failure. Because the crack was not detected by liquid penetrant inspection during cylinder overhaul 595 hours prior to the occurrence flight, the development of the crack to the detectable stage likely occurred after that time. The casting porosity, age of the cylinder, and its high time in service were major contributing factors in its eventual failure.

The failure and separation of the number 2 cylinder exhaust ear prevented the exhaust valve from opening. The hot exhaust gases migrated back into the induction system through the opening of the intake valve, causing a disruption in the fuel/air mixture to the remaining cylinders and resulting in a loss of engine power.

Records indicated that three of the engine's nine cylinders failed within 600 hours of cylinder overhaul or within one-half of the engine's overhaul life. The number 1 cylinder failed at the exhaust ear less than 120 hours after cylinder overhaul. The three failed cylinders were all located near the top of the engine which could indicate a thermal stress problem associated with airflow, but this was not proven. The last cylinder failure resulted in a forced landing and the occurrence accident. Past cylinder failures on this aircraft have also occurred in the top cylinder positions and have resulted in two documented forced landings. These forced landings, however, did not result in an accident or aircraft damage. On the occurrence flight, the engine power loss occurred in an area where a successful damage-free landing was improbable. The pilot controlled the landing and put the aircraft down in an area where damage to the aircraft and injury to the occupants would be minimized.

The following TSB Engineering Laboratory report was completed:

LP 148/2008 – Cylinder Failure, Noorduyn Norseman MK V, C-FECG

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

Findings as to Causes and Contributing Factors

1. The number 2 engine cylinder exhaust ear failed in fatigue in an area of casting porosity and geometric stress concentration. The casting porosity was likely introduced during manufacture of the cylinder some 50 to 80 years before the occurrence.

2. The failure of the number 2 cylinder exhaust ear prevented the exhaust valve from opening. The hot exhaust gases migrated back into the induction system through the intake valve, causing a disruption in the fuel/air mixture to the remaining cylinders, resulting in a loss of engine power.

3. The engine power loss occurred in an area of flight in which a damage-free forced landing was improbable.

Finding as to Risk

1. The growing age and time in service of some of the originally manufactured P&W R1340-series cylinders has increased the risk of material fatigue leading to a premature failure of the cylinder. Some cylinder failures can then put the aircraft at risk of an engine power loss resulting in a forced landing or accident.

Other Finding

1. Transport Canada Service Difficulty Advisory AV-2007-02 discusses concerns regarding cylinder head and cylinder flange failures on the Pratt & Whitney R985-series engine. The advisory contains inspection information that may be useful or interchangeable with the R1340-series engine cylinders.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 07 April 2009.

*Visit the Transportation Safety Board's Web site (**www.tsb.gc.ca**) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.*