SERIOUS INCIDENT

Aircraft Type and Registration:	Dornier 328-100, D-CIRT
No & Type of Engines:	2 Pratt & Whitney Canada PW119B turboprop engines
Year of Manufacture:	1997
Date & Time (UTC):	23 September 2009 at 1410 hrs
Location:	Dundee, Fife
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to air-switching valve in both engines
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	8,100 hours (of which 400 were on type) Last 90 days - 120 hours Last 28 days - 42 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft had not been in regular use for almost two years and was being repositioned from Dundee to a maintenance facility in Germany, in preparation for sale. The crew experienced a variety of system malfunctions during the takeoff and initial climb, followed by a loss of oil pressure on the left engine. The crew declared an emergency with Leuchars ATC and were receiving radar vectors to return to Dundee when the oil pressure on the right engine also began to fluctuate. The crew advised ATC that they were experiencing problems with both engines and manoeuvred the aircraft to land at RAF Leuchars, an airfield with which they were not familiar.

After landing there was no external evidence of an oil leak, but the left and right engines had lost approximately seven and four quarts of oil respectively. The subsequent engineering investigation revealed that in both engines the air-switching valve had seized due to the presence of corrosion, which allowed the oil system to become over pressurised and caused oil to be vented overboard.

One Safety Recommendation is made.

History of the flight

The aircraft was to fly from Dundee to Oberpfaffenhofen, Germany, on a Permit to Fly, where further maintenance would be carried out to make the aircraft serviceable for a potential sale.

The two pilots, native Russian speakers, worked for a German company that had been contracted by the aircraft owners to reposition the aircraft. The pilots travelled to Dundee the evening before the flight and the maintenance organisation collected them from their hotel at 0800 hrs.

The aircraft had not flown for some time, and so the pre-flight procedures included an extensive inspection of the aircraft documentation, an external inspection, during which the commander noted that both engines oil levels were just below full, and a ground run. After the ground run, a paperwork issue was resolved and at approximately 1330 hrs the crew declared that they were ready to fly the aircraft to Germany. The weather conditions were good, with scattered clouds around 3,000 ft agl and a strong south-westerly wind.

The start-up and taxi were described by the crew as normal, and at 1406 hrs D-CIRT commenced its takeoff from Runway 27. Shortly after getting airborne the commander saw an amber caution warning light illuminate, but it then disappeared. The co-pilot believed this was the ELEVATOR DISC LOAD HIGH caption, but as it self-extinguished no action was required. At 1,500 ft the aircraft was accelerated to 'clean' airspeed, the flaps were retracted and the propeller rpm and torque were adjusted to the climb settings. Passing 3,000 ft, the RH ALT caption illuminated (referring to the alternator on the right-hand engine), along with associated messages on the EICAS. The crew completed their 'after takeoff' checks and were about to commence the abnormal checklist for the RH ALT caption when the commander noticed the left engine oil pressure was fluctuating. While the crew were discussing the fluctuating oil pressure the red left engine oil pressure warning illuminated with the associated audio attention-getter. The crew initially levelled the aircraft at FL 60, advised Leuchars Radar that they would like to return to Dundee and, after a prompt from ATC, declared an emergency.

ATC at Dundee observed the takeoff, and noticed some grey smoke coming from both engines, but as the aircraft had not flown since December they thought that it was probably not unusual. An engineer from the maintenance organisation, who had been working with the crew, observed the takeoff, and saw what he described as a trail of white smoke from the left engine. He considered that this was not normal and when the aircraft had disappeared from view he decided to call ATC to ask them to advise the crew. On his way to a phone he turned on a radio that monitored VHF ATC frequencies and heard the aircraft report it was returning to Dundee with an emergency.

The commander considered the implications of shutting down the left engine with a right engine alternator failure, and the implications of the associated loss of electrically-driven hydraulics, and decided that he would shut down the left engine, in accordance with the QRH drills for low engine oil pressure. The co-pilot had identified the left power lever, and was about to retard it, in accordance with the drill, when the commander noticed the right engine oil pressure start to fluctuate. The crew stopped the left engine shutdown drills and the commander asked the co-pilot to request radar vectors to the nearest suitable airfield. The co-pilot thought that he had communicated this to ATC when he said, "WE ARE HAVING PROBLEMS WITH TWO ENGINES RT AND IT'S THE SHORTEST WAY TO THE FIELD." As the aircraft had already requested a return back to Dundee, ATC understood that the aircraft was asking for vectors direct to Dundee.

The commander was now concerned that at any time either engine, or both, might stop without further

warning and so he manoeuvred the aircraft to remain in visual conditions whilst following the general direction of the ATC vectors. The crew saw an airfield, which they believed was the one to which ATC were vectoring them, and called visual with the field. ATC advised them that the field they were visual with was Leuchars and that they still had 10 miles to run to Dundee; they then asked the crew if they required to land at Leuchars. The crew were not familiar with Leuchars and thought the controller was offering them an alternative to the airfield that was ahead of them, and so replied *"*NEGATIVE*"*.

The crew completed their landing checks and positioned the aircraft onto finals for Runway 28 at Leuchars; with the engines at low power the oil pressure fluctuations had reduced in severity. ATC again advised the crew that they were flying towards Leuchars, not Dundee, to which the crew replied "ROGER". The Leuchars controller judged from the position and attitude of the aircraft that it was the crew's intention to land at Leuchars, and so cleared the runway. He then confirmed that the landing gear was down, and gave D-CIRT clearance to land.

D-CIRT landed safely at 1418 hrs and vacated the runway. ATC advised the crew that they were on the ground at RAF Leuchars, and the crew then realised where Leuchars was. The airfield was not in the aircraft's FMC database, nor did the crew carry its approach plates.

Maintenance history

The aircraft had previously been operated by City Star Airlines, which had ceased trading in January 2008, and the aircraft had latterly been used as a source of serviceable spares to support the airline's other aircraft. The aircraft remained in open storage at Aberdeen until it was purchased by an aircraft asset management company who had the aircraft made serviceable and had it flown to Dundee, in December 2008, where it was once again placed in storage. During its time at Dundee, maintenance was carried out in accordance with the aircraft manufacturer's storage programme, which included routine low power (idle) engine runs, by an approved engineering organisation. In September 2009, the owners contracted the engineering organisation to carry out a package of work, in order to allow the aircraft to undertake a ferry flight to Oberpfaffnhofen. This included the rectification of outstanding defects, power assurance runs on both engines and a review of the status of the aircraft's compliance with current mandatory requirements. The results of this activity were passed to the Luftfahrt Bundesamt (LBA) who, after review, issued the aircraft with an EASA 'Permit to Fly'.

Flight Recorders and Maintenance Computer

The aircraft was fitted with a 25-hour Flight Data Recorder (FDR) and 2-hour Cockpit Voice Recorder (CVR). These were both removed from the aircraft following the serious incident to be downloaded and then analysed by the AAIB.

The CVR recording did not include the incident as it had been recorded over with recent information while engine tests were carried out on the aircraft post-incident. A time history of salient parameters from the FDR for the incident flight is shown at Figure 1. The engine parameters recorded on the FDR were engine torque and propeller speed However, many more engine parameters were recorded by the maintenance computer during any out-of-limit condition of engine parameters, plus 10 seconds of data prior to the out-of-limit condition being detected. A number of these conditions were detected and recorded for the oil

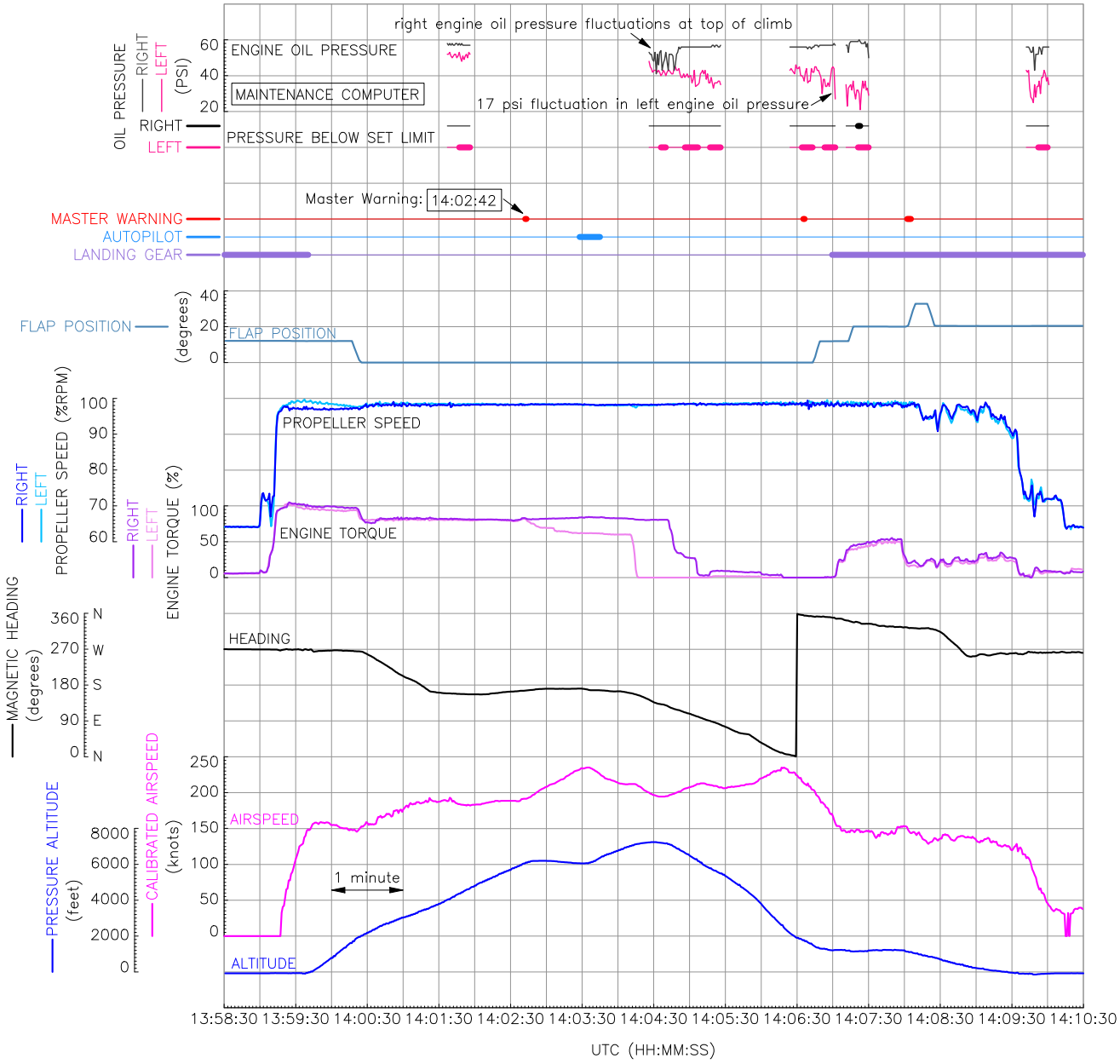

Figure 1

Salient FDR parameters and maintenance computer recordings for the serious incident to D-CIRT

pressure of both engines during the incident flight: these are also presented in Figure 1.

The figure shows that the maintenance computer detected an oil pressure 'below-limit' state for the left engine during the climb, lasting 10 seconds as the aircraft passed through 4,500 ft pressure altitude. A nominal difference of about 6 psi in oil pressure was recorded between the left and right engines (left engine lower, at around 52 psi) for similar levels in engine torque and propeller speed. As the aircraft levelled off at approximately FL60, there was a master warning associated with the left engine oil pressure[1]

Footnote

[1] The FDR records when the master warning is active but does not record the reason for the warning. In this case, however, the crew reported that the left-engine oil pressure warning light also came on.

(time 14:02:42). This was followed by a reduction in engine torque on the left engine (as the crew started to shut it down), reducing from 84% to 62% before the shutdown was cancelled. The autopilot was then engaged for about 20 seconds, during which the aircraft started to climb again.

The 'top of climb' was at just above FL70 before the torque on the left engine was reduced to near zero, followed by a stepped reduction in torque on the right engine for the descent. From top of climb, throughout the descent and landing, the maintenance computer detected a further 13 left engine oil pressure 'below-limit' conditions and one on the right engine. The associated extracts of engine oil pressures recorded by the computer show that the oil pressure difference between the engines grew as the left engine pressure fell to about 30 psi (ie a 50% reduction), although it fluctuated as much as 17 psi. Fluctuations were also recorded in the right engine oil pressure at top of climb, but stopped once the torque was reduced for the descent.

The master warning also alerted a further three times during the flight but, these were coincident with changes in aircraft configuration for landing.

Initial investigation of the engines

Due to a delay in the notification of this event to the AAIB, some troubleshooting of the reported defects had been carried out before the aircraft was inspected. A review of the post-incident maintenance actions confirmed that no abnormalities had been found with either of the engines' oil systems and that there was no evidence of external oil leaks, although the left engine had lost approximately seven quarts of oil and the right engine had lost approximately four quarts. Borescope inspection of the engines did not identify any obstruction of the bearing oil vents or any evidence of damage to the high pressure and power turbines. However, a small amount of oil splatter was observed on the left engine power turbine.

After replenishing the oil systems, both engines were operated at idle power for 20 minutes, with no observed oil pressure fluctuations. The power of the right engine was increased to 100% torque for five minutes with no observed abnormalities. The power of the left engine was then increased to 85% torque for several minutes without any observed defects, but when the torque was increased further the engine oil pressure began to fluctuate wildly. After reducing the torque to below 85% the oil pressure stabilised again. After shutdown, the right engine had consumed one and a half quarts of oil and the left engine three quarts, with no evidence of an external oil leak or of 'venting'.

This aircraft's equipment included a fault reporting system which, on detecting a parameter exceedence, records the event as well as ten seconds of data preceding and ten seconds after the exceedence, into the aircraft's Central Alerting System (CAS) to aid troubleshooting by maintenance personnel. A download of the CAS showed that there were 11 'low oil pressure' events recorded for the left engine between 14:01 and 14:14. The lowest recorded pressure was 21 psi. For the right engine the system recorded only one event at 14:04, when the engine oil pressure decreased to 41 psi. After discussion with the engine manufacturer, the decision was made to remove both engines for detailed inspection at an engine overhaul facility.

Engine oil system - description

The turbo-machinery of the PW119 engine is supported by seven bearings which are located in four separate sumps or cavities. Each cavity is provided with a

pressurised supply of oil from the lubrication system. The oil is contained within these sumps by the use of labyrinth seals which require a flow of air passing from the outer face of the seal into the cavity to be effective. The air in each cavity is then vented overboard through a breather in the accessory gearbox.

At low power, below 40% Nh (high pressure impeller/ turbine speed), sealing air is provided by air bled from the output of the high pressure impeller (P3). Above 40% Nh the pressure and temperature of the P3 air is too high and air bled from immediately upstream of the high pressure impeller (P2.5) is used for seal pressurisation. The source of bleed air is controlled by the air-switching valve, which is spring-loaded to supply P3 bleed air. As engine rpm increases beyond 40% Nh, the increase in P2.5 allows the valve piston to move against the spring force, blocking the supply of P3 air and allowing P2.5 air to flow to the bearing cavities. This should change before the engine reaches its stable ground idle speed of 66% Nh. Failure of the air-switching valve to move from the P3 bleed air position to the P2.5 position, as the engine speed increases, will cause the engine oil cavities and gearboxes to become over-pressurised, forcing oil into the breather system before it is discharged overboard.

Further investigation

The engines were removed in March 2010 and dispatched to an approved overhaul facility for further investigation under the supervision of the Bundesstelle für Flugunfalluntersuchung (BFU), the German Federal Bureau of Aircraft Accident Investigation.

Both engines were subject to an 'as received' test to determine whether the cause of the abnormal engine behaviour observed by the flight crew could be identified prior to disassembly. During the tests, when operating above idle speed, both engines exhibited high oil consumption with vapour observed venting from the oil system breather. Both engines exhibited oil pressures in the reduction and accessory gearboxes that were at or above the maximum allowable pressure, together with oil vent pressures greater than the P2.5 bleed pressure.

The P2.5/P3 air-switching valves were replaced with new units and the runs repeated, with no abnormalities observed on either engine. The P2.5/P3 air-switching valves were partially disassembled and both valves were found to be seized in their housings. They were then dispatched to the engine manufacturer for further investigation, which showed that the pistons of both air-switching valves were seized in their respective housings and a hydraulic press had to be used to remove them. After removal it was found that both pistons, the piston rings and the inner surface of the valve housings were corroded.

Analysis

The high oil consumption on both engines experienced by the flight crew was entirely consistent with the failure of the engine air-switching valves to operate correctly as power was increased. The storage of the aircraft at both Aberdeen and Dundee, where it was exposed to the effects of saline moisture, would have increased the rate of formation of corrosion products within the valves. However, although the air-switching valves should have operated before the engines reached stable ground idle speed, the increased oil consumption, resulting from the over-pressurisation of the oil system was not apparent prior to dispatch of the aircraft. Therefore:

Safety Recommendation 2010-094

It is recommended that Pratt and Whitney Canada amend the maintenance requirements for the PW100 series of engines, to ensure the continued serviceability of the air-switching valve on engines installed on aircraft in storage.

The engine manufacturer has subsequently confirmed that they will review the de-preservation requirements for these engines and amend them as necessary. Transport Canada has confirmed that they will monitor this activity.

Conclusion

The cause of this serious incident was the failure of both engine air-switching valves to operate normally. This resulted in the over-pressurisation of the engine oil cavities and the purging of oil overboard through the engine vent system. The presence of corrosion on the pistons, piston rings and the inner bore of the valves, caused as a result of the prolonged storage of the aircraft, prevented the valves from operating normally.

The crew were faced with a series of malfunctions resulting in their decision to land at the nearest suitable airfield. However, these intentions were not communicated effectively to ATC and it was the decisive action of the Leuchars controllers which prevented an escalation of an already difficult situation.