

SERIOUS INCIDENT

Aircraft Type and Registration:	DHC-8-402 Dash 8, G-ECOF	
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines	
Year of Manufacture:	2008 (Serial no: 4216)	
Date & Time (UTC):	30 October 2016 at 1340 hrs	
Location:	Belfast City Airport	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 4	Passengers - 77
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Heat damage to tail cone	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	35 years	
Commander's Flying Experience:	6,370 hours (of which 6,190 were on type) Last 90 days - 211 hours Last 28 days - 68 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB inquiries	

Synopsis

During preparations for takeoff the flight crew were made aware that smoke could be seen emanating from the rear of the aircraft around the APU. The commander initiated a precautionary disembarkation and the APU, which had been running, shut itself down. It was apparent that the tail cone of the aircraft had become very hot, resulting in discolouration of the external surfaces. It was subsequently found that the APU exhaust duct liner had partially disintegrated, resulting in hot exhaust gases being directed outside the liner. Two days prior to this event, a piece of the liner had been ejected from the APU exhaust whilst the aircraft was on stand at Birmingham. However it was incorrectly identified as originating from an airport vehicle and the aircraft was allowed to continue in service.

History of the flight

The aircraft was boarded, the passenger doors were closed and the crew was preparing for departure. The APU was running, with the intention of using it for engine start during pushback. One of the ground handlers informed the crew that smoke was emanating from the rear of the aircraft around the APU. The absence of flight deck indications of an APU fault and the calm demeanour of the ground handler led to the commander not being overly concerned at this stage. He asked the No 1 cabin attendant to open the forward door, with the intention of investigating the problem himself. Meanwhile the co-pilot contacted ATC and asked if they could see anything unusual. After a short delay a reply was received stating that

smoke could be seen around the rear of the aircraft. At this point the commander decided to initiate a precautionary disembarkation and briefed the cabin crew over the intercom. Only the forward main passenger door was used as the rear airstairs were unserviceable. He also asked the co-pilot to put out a PAN call to ATC, informing them of the situation. At around this time the APU shut down, generating a FAIL caption. At no time were any fire or smoke warnings received on the flight deck, nor were any fumes or smoke observed inside the aircraft, although a burning odour became apparent as the incident progressed.

All the passengers had disembarked by the time the airfield fire service had reached the aircraft and, after consultation with the fire chief, the crew pulled the FDR and CVR circuit breakers, shut down the electrical systems and vacated the aircraft.

The fire crew used thermal imaging equipment to determine that the temperature in the APU area was around 158°C, which reduced to 40°C at the rear pressure bulkhead. The heat had resulted in discolouration of the external surfaces of the tail cone.

Earlier incident

Two days before the APU incident, on 28 October 2016, the same aircraft, with a different crew, was on stand at Birmingham and had received pushback clearance with the APU running. The pushback tug driver then noticed a piece of debris lying approximately 10 m behind the aircraft; it was hot when he picked it up. The commander examined the object and conducted a walk-round inspection of the aircraft. There was no obvious aircraft damage and the object bore no markings, such as a part or serial number. He discussed the matter with the co-pilot, who confirmed that nothing abnormal was observed during his walk-round some 30 minutes earlier. Photographs were taken of the debris item (Figure 1), which was then disposed of in a FOD (foreign object damage) bin. The engines were started on stand and were noted to operate normally. In the absence of any evidence to indicate that the object was associated with the aircraft the pilots assumed that it had come from a passing truck on the roadway behind the aircraft.

The aircraft had been parked at the stand for approximately 50 minutes, during which time a ground power unit had been used until the doors were closed. The object was found after the walk-round had been conducted; the APU had been running for about five minutes.

Following the incident two days later, attempts were made to locate the debris item, but without success.



Figure 1

Debris item photographed by crew after discovery

Aircraft examination

The APU is located within a bay in the tail cone on this aircraft type. An exhaust duct, fabricated from titanium, is installed within the aft section of the tail cone. Within this is a duct liner made from a fibre-metal acoustic material; it is elliptical in section, supported on frames within the duct and bolted to it at its forward end (Figure 2).

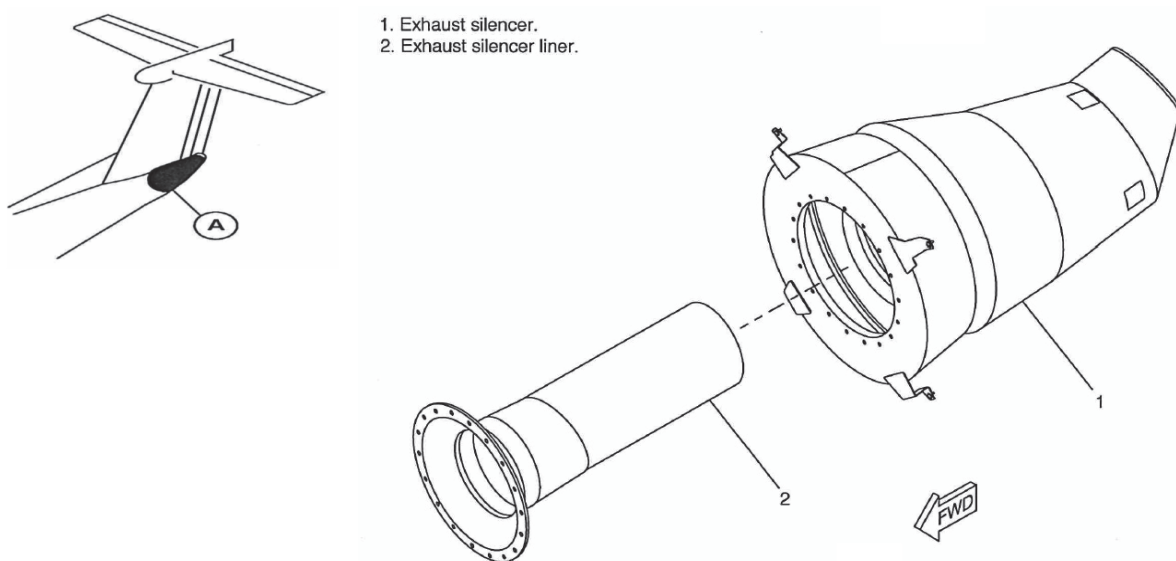


Figure 2

APU exhaust duct and liner

It was apparent that the front half of the liner had partially disintegrated and that the item discovered on the ground at Birmingham was a circumferential section from the front end, having separated both at the junction with the bolted ring and several inches aft. The portion of the liner that remained within the duct was removed, possibly causing some additional distortion (Figure 3).



Figure 3

Recovered part of the exhaust duct liner

The operator commented that they had observed instances of the liner cracking close to the first frame (furthest forward).

Although the ejected piece of liner was not available for examination, Figure 1 shows what appears to be fretting or abrasion damage on the outer surface.

The internal surfaces of the tail cone were discoloured as a result of high temperatures causing the paint to blister, and electrical cables in the area had sustained visible heat damage. A subsequent download of the APU data memory module by the operator confirmed that the APU had shut down as a result of an open circuit condition and that this was probably associated with the cable damage.

Other information

An examination of the recent maintenance history revealed that the APU had been changed by a contracted company on 13 October, approximately two weeks prior to the incident. This followed a FAIL caption followed by an auto shut-down. Removal and installation of the APU does not in itself involve disturbing the exhaust duct liner, although the Aircraft Maintenance Manual calls for an 'Opportunity Inspection' of it, using Maintenance Task 49-80-04-210-801. The company stated they had a contract with G-ECOF's operator to deliver 250 man hours per 24 hour period spread over three aircraft. Their hangar

is modern and well lit, and they were familiar with conducting APU changes on Q400 aircraft. A general visual inspection was duly carried out and the appropriate worksheet signed off. There is no scheduled inspection of this component. The subject duct liner had been installed in the aircraft at initial build.

On 18 October the APU failed to start and this was logged as a deferred defect until it was cleared on 26 October after replacing a thermocouple. This was only two days prior to the piece of exhaust duct liner being ejected whilst on the stand at Birmingham.

The aircraft manufacturer disclosed that, in addition to the subject event, they were aware of 17 reported events of duct liner cracks since September 2003. Most of the failures were cracks or separation along the weld lines and occurred on aircraft that had achieved between 2,355 and 25,063 flight hours. G-ECOF had achieved 16,703 flight hours. Two of these incidents involved pieces that were missing from the liner and a third suffered a 'collapsed' liner, causing exhaust gas to enter the tail cone in a similar manner to the subject event. Smoke, but no fire, was also reported and there was heat damage to electrical wiring and paint blistering on the tail cone structure. Many of the incidents were associated with the APU either failing to start or shutting down unexpectedly.

It should be noted that the APU on this aircraft type is certificated for ground use only and, in the event it is not shut down by the crew prior to takeoff, it is turned off by a weight-off-wheels signal.

Discussion

It was concluded that the disintegration of the APU exhaust duct liner allowed hot exhaust gases into the exhaust duct volume outside the liner and into the tail cone itself.

The duct liner is located within a jet efflux and as such is exposed to a severe thermal and acoustic environment. Whilst no calendar or flight hours limit, or regular inspection period, is specified, it is reasonable to expect the liner to deteriorate in service. However, the 17 prior events logged by the aircraft manufacturer covered a wide range of time in service. The duct's location in the airframe means it is difficult to inspect effectively unless the APU is removed. Such removals, and consequent 'opportunity' inspections, seem to occur at relatively frequent, although necessarily irregular, intervals. Indeed, the subject duct had been inspected only two weeks prior to ejecting a substantial piece of the liner; it was also found that the APU itself had been unserviceable for eight days out of the two weeks. It is therefore likely that some aspect of the failure was present at the time of the last inspection, despite the good working environment of the hangar in which the APU change had been carried out.

The nature of the failure was not determined, although chances of obtaining more information may have been improved had the ejected piece of the duct liner been correctly identified and retained. There were some marks visible in photographs taken of this item, although it could not be concluded if they were the result of in-service fretting or abrasion during installation.

No flames were observed during the incident although the temperature clearly was sufficiently high to cause blistering and charring of the paint, thus generating smoke. The electrical harnesses in the area were also damaged, leading to the APU shutting down, thus removing the heat source. Had this not occurred, it is possible that an actual fire may have developed, although this might have been accompanied by flight deck warnings or indications from the ground handlers, which should have prompted the flight deck crew to shut down the APU. It was found however that none of the previously reported incidents had resulted in a fire. In addition, it is considered that there is little likelihood of a duct liner failure resulting in an airborne fire as the APU is not capable of being used in the air.