DHC-8-311, G-JEDD

AAIB Bulletin No: 1/2002	**Ref: EW/C2001/3/4**	**Category: 1.1**
INCIDENT		
Aircraft Type and Registration:	DHC-8-311, G-JEDD	
No & Type of Engines:	2 Pratt & Whitney PW-123 turboprop engines	
Year of Manufacture:	1999	
Date & Time (UTC):	20 March 2001 at 1545 hrs	
Location:	Bristol International Airport, Avon	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 4	Passengers - 25
Injuries:	Crew - None	Passengers - None
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	38 years	
Commander's Flying Experience:	3,900 hours (of which 3,000 were on type)	
	Last 90 days - 150 hours	
	Last 28 days - 50 hours	
Information Source:	AAIB Field Investigation	

History of the flight

The commander was a company line training captain who was carrying out line training for a new first officer. The first two sectors of the day's duty had been uneventful and the aircraft landed at Bristol at 1314 hrs. At that time, the weather produced a surface wind from 080° at 25 gusting 36 kt, visibility 2,000 metres in light snow, scattered cloud base 500 feet, temperature 0°C. The aircraft parked normally on stand 5, heading east (into wind). After the passengers had deplaned, the crew went into the airport terminal, as the next planned departure was at 1510 hrs. The crew did not fit the engine intake blanking plugs during the turnround.

During the intervening period, the weather conditions worsened. The snow fall became heavier with a progressive deterioration in visibility and the strong, gusty easterly wind continued. During its time on the ground, the aircraft began to accumulate a covering of snow.

The crew returned to the aircraft in time to prepare for the next planned departure. The commander arranged for the aircraft to be deiced using heated type II fluid. This was carried out and the commander completed a pre-flight external inspection, which included a visual inspection from the ground of each engine intake lip and a tactile inspection of the rear of each intake through the open bypass doors. The commander assessed that there was no build up of snow or slush in these areas and considered that the engine intakes were clear of ice and snow.

The runway in use was Runway 09 which had been closed for a period of time to enable snow clearance operations to take place. Meanwhile, the passengers had been embarked. Once the runway had re-opened, the crew performed a normal engine start and the aircraft began to taxy out for departure at 1535 hrs.

On reaching the holding point for Runway 09, ATC requested that the aircraft hold position in order to allow a stream of inbound aircraft to land. While holding, with the aircraft's tail into wind, the right engine suddenly ran down, for no apparent reason. The crew carried out the Engine Failure procedure from the aircraft's Quick Reference Handbook (QRH), but did not select Ignition to Manual (ON) for the left engine. About 2.25 minutes after the right engine failure had occurred, the left engine also failed without warning. The weather at the time was a surface wind from 080° at 24 kt, visibility 1,000 metres in moderate snow, scattered cloud base 300 feet, temperature 0°C.

The aircraft was thus left on the taxiway with only aircraft battery power. The commander advised ATC of the occurrence and requested provision of a bus to deplane the passengers and a tug and towbar to reposition the aircraft to the parking ramp.

The passengers were duly deplaned, having been carefully advised by the cabin crew to avoid the left propeller which was still windmilling quite fast adjacent to the forward exit door. The aircraft was then towed to a parking stand. On arrival, the aircraft was quarantined and the engine intake blanks were fitted. Fortunately, the outside air temperature remained at freezing until the AAIB inspection of the aircraft was carried out.

Engine intake arrangement

Air is fed to the centrifugal first stage of the compressor by a chin-mounted intake (see Fig.1). The lip of the intake has a rubber de-ice 'boot' and, as the air flow turns upward towards the compressor inlet, it passes through a heated seal forming part of the engine itself. In icing or heavy precipitation conditions, selection of the by-pass door to 'open' means that, in forward flight, some of the ram-air and particles of ice or heavy droplets of water should pass by the compressor inlet, into the plenum and out through the by-pass aperture.

Engineering inspection

The aircraft was examined on the ramp at Bristol Airport. As found, both engines had intake blanks fitted, the intake by-pass doors were open and both propellers were unfeathered. The wet snow had recently ceased and the temperature was between 0° and +1°C. An initial 'feel' by hand inside the by-pass door exit duct suggested that there was no snow/ice present in the duct but when the blanks were removed and a stepladder and torch obtained, it was possible to discern accumulations of wet slush behind the intake lip and further down in the by-pass plenum (see Figs. 2 & 3)

These deposits were similar in both engine nacelles and, in the case of the plenum, were about 25-40 mm deep, mainly around the edges of the cavity and forward of the by-pass door (see Fig 2). It was for this reason that they had not been detected by the tactile check earlier.

The snow/slush was removed, the engines were started and the aircraft taxied to a ground-running apron, where the engines and propellers were exercised throughout their operating range without any anomalies being discovered. The engines were further inspected before the aircraft was returned to service.

Engineering analysis

In the absence of any defects or malfunctions associated with the engines it is concluded that they both probably 'flamed-out' due to sudden ingestion of wet snow/slush which had accumulated in the intake and/or by-pass plenum whilst the aircraft was parked. The deposits which were observed were probably the residue of larger accumulations which had been ingested during the incident.

Flight Recorders

The two solid state recorders fitted to the aircraft (two-hour CVR and 25 hour FDR) retained a record of the entire event. Both engine shutdowns had occurred approximately 35 minutes before power to the CVR was removed and hence were recorded in the area of CVR memory where the three (crew audio) channels were summed together. The FDR was operational, by design, whenever the anti-collision light switch was selected to 'red' or 'white'.

The aircraft had been parked on stand 5 on a heading of 087°M prior to engine start. Pre-flight checks having been carried out, the crew started both engines; right engine first. Both starts appeared to be normal. The auto-feather system was selected and airframe de-ice pressure was observed to be 22psi on both the left and right systems. Static air temperature was recorded as being +1.6°C on the FDR.

The aircraft was taxied to holding point 'Golf Two' during which the taxi checklist was carried out and the commander requested for all the ice protection to be put on for departure. The aircraft stopped at the hold and had been stationary for a period of five minutes with both propellers at 800 rpm. As the first officer was reading back the departure clearance to ATC the right engine ran down. Simultaneous reductions towards zero of propeller speed and torque, high pressure compressor speed, low pressure compressor speed and inter-turbine temperature were recorded from the right engine. Fuel flow reduced from 275 lb/hr to 107 lb/hr. As this engine ran down, fuel flow and ITT increased slightly on the left engine.

The commander informed ATC of the problem and then carried out the engine failure checklist memory items. The right hand propeller had stopped rotating by the time that the first two items (power lever to flight idle and condition lever to fuel off) were actioned and there was no oil pressure available to start to feather the propeller. Following a public address announcement to the passengers, he requested the engine fail / fire / shutdown checklist from the QRH. The first officer read out the items in sequence and the commander responded with the required settings. The checklist item for ignition required that the operating engine was set to MANUAL and the affected engine set to OFF. However, there was no differentiation made between the two engines during the 'Ignition?' challenge made by the first officer. The commander's response was only to acknowledge that the ignition of the affected engine was set to OFF. As a consequence, the ignition on the then

unaffected (left) engine was not selected to MANUAL, a setting which would have enabled continuous igniter operation on that engine.

As the penultimate checklist item was being addressed, the left engine failed in a similar manner to that of the right engine. From the BETA range and feather discrete parameters recorded, it can be inferred that the power lever on the left engine was set to flight idle (to be followed by condition lever to fuel off) as the propeller speed reduced through 400 rpm. However, there was insufficient oil pressure to completely feather the propeller and it continued to windmill at speeds of between 70 rpm and 130 rpm for the remainder of the DFDR recording.

The crew were aware of the windmilling propeller and discussed de-planing the passengers through the rear exit, in preference to the normal exit door, which was situated on the left side of the aircraft just forward of the propeller. Ultimately the passengers were disembarked through the normal exit after the cabin staff had made an announcement alerting them to the still-rotating propeller.

Previous occurrences

The phenomenon of in-flight, ice induced engine flameouts had been experienced on previous occasions on other DHC-8 aircraft belonging to overseas operators. In response to these events, the manufacturer issued a Safety of Flight Supplement, number 4, on 28 July 1994.

In each occurrence, the aircraft had been parked in heavy precipitation in temperatures near freezing, without having the engine intake plugs fitted. Investigation of these occurrences concluded that quantities of ice/slush/snow had been deposited within the engine intake nacelles. The sudden breaking loose of this build up could disturb the intake airflow sufficiently to cause an engine flameout.

The Supplement stressed the importance of an engine intake inspection prior to flight. It also recommended that the first take-off after such exposure should be conducted with the Bypass Doors open and the Ignition selected to Manual (on).

Operator's Procedures

The manufacturer's Safety of Flight Supplement had been encompassed into this operator's procedures in the Operations Manual Part B4 and in a Notice to Aircrew 48/00 dated 13 October 2000, entitled Winter Operations - Dash 8. Page 4 of the Notice contained the following advice:

'Through the icing experience of one operator it has been discovered that ice can build in the engine air intake, immediately ahead of the bypass door. If this ice accumulation is not removed it can build forward of the nacelle plenum and potentially cause an engine power interruption. As a result of these events, (operator's name) has implemented the following procedure:

Tactile inspections of the engine intakes must be completed during all station stops when icing conditions exist. If icing conditions are encountered in-flight or icing conditions exist or have existed on the ground, an inspection to ensure that the air intakes are clear, must be performed. A visual inspection of the intake may NOT identify ice that has formed in the nacelle plenum. With the intake bypass doors 'OPEN', reaching inside the plenum chamber will identify any ice, slush or 'other' contaminant build-up. This area MUST be clear before flight.'

The engine intakes of the DHC-8 are located below the propeller spinners. As such, they are significantly higher than even the tallest pilot. Thorough visual inspection of the inside of the intake without the aid of some form of elevated platform is not physically possible. In order to perform the visual check, it was usually necessary for the pilot to obtain some steps from a ground handling agency. These were not necessarily readily available.

As a consequence of this incident, the operator has equipped each aircraft in the fleet with its own set of foldaway steps to facilitate the intake inspections. These steps can be stowed in the baggage hold of each aircraft and are readily accessible to the pilots.

Operator's Checklist

The Operator's Normal Checklist that was current at the time of the incident indicated that the Ice Protection/Ignition should be selected 'as required' during the Line Up checks. Additional advice contained in their Dash 8 Operational Notice 48/00 dated 13th October 2000, valid until 13 April 2001, indicated that 'During icing conditions, open by-pass doors and select ignition to MANUAL immediately after engine start (series 100,200 and 300 not incorporating Auto Relight System MODSUM 8Q100813/Service Bulletin 8-74-02)'

After this incident, the operator revised the aircraft checklist to provide an additional check of ice protection prior to taxi. Had the ignition been selected manually to ON at this stage, then it is unlikely that the engine flameouts would have occurred.

Manufacturer's Service Bulletin

When operating in icing conditions, it is an Aircraft Flight Manual Limitation requirement that engine ignition be selected to Manual. This was not complied with in this incident. The commander had briefed to use Manual Ignition for take-off, however, the Line Up checks (where Ice Protection/Ignition was specifically listed) had not been completed prior to the engine flameouts.

Experience from a previous incident has shown that should a temporary interruption of the intake air flow occur due to ice breakaway, then having the engine ignition selected to Manual (on) is sufficient to enable the engine to recover to normal operation after a transient power loss.

The aircraft manufacturer produced a modification Service Bulletin (SB), No. 8-74-02, Installation of an Auto Relight System, which linked igniter operation to engine HP spool speed (Nh). With this modification embodied, when the condition levers are selected above FUEL OFF, the igniters automatically operate if Nh falls below a threshold value. Whilst the 'Reason' paragraph of the SB implies that the modification is intended to enhance economic operation and compliance is 'at operator's discretion', there is clearly an additional safety benefit because the engines are protected against transient 'flameout' conditions at any phase of flight. The SB was incorporated at build from Aircraft Serial Number 541 and above: G-JEDD (serial number 533) did not have this modification at the time of the incident.

Because of the possibility of a repeat of this type of incident, AAIB proposed that the incorporation of Service Bulletin (SB) No. 8-74-02 be mandated on all aircraft by the Canadian airworthiness authority (Transport Canada). However, Transport Canada responded negatively to this proposal, citing that the current maintenance and operational procedures afforded an equivalent level of protection to that offered by the SB. They considered that the choice of which of the two alternative

ways of achieving the intent of the recommendation was a business decision which was best left to the operators.

Within the United Kingdom, all operators of the Dash 8 have elected to modify their aircraft in accordance with the SB to afford maximum protection from this type of event.

The manufacturer also indicated that it would revise and reissue DHC-8 Service Letters DH8-SL-12-006E (100/200/300 series aircraft) and DH8-12-001C (Q400 series) to highlight the importance of ensuring that the engine intakes are clear of frozen contaminant prior to departure.