**INCIDENT**

| | | |
|---|---|---|
| **Aircraft Type and Registration:** | Airbus A319-111, G-EZIM | |
| **No & Type of Engines:** | 2 CFM56-5B5/P turbofan engines | |
| **Year of Manufacture:** | 2005 (Serial no: 2495) | |
| **Date & Time (UTC):** | 31 March 2017 at 1723 hrs | |
| **Location:** | Isle of Man Airport, Isle of Man | |
| **Type of Flight:** | Commercial Air Transport (Passenger) | |
| **Persons on Board:** | Crew - 6 | Passengers - 124 |
| **Injuries:** | Crew - None | Passengers - None |
| **Nature of Damage:** | None | |
| **Commander's Licence:** | Airline Transport Pilot's Licence | |
| **Commander's Age:** | 34 years | |
| **Commander's Flying Experience:** | 7,800 hours (of which 7,543 were on type)<br>Last 90 days - 164 hours<br>Last 28 days - 76 hours | |
| **Information Source:** | AAIB Field Investigation | |

## Synopsis

Shortly after takeoff the flight crew experienced a smell and smoke/mist in the cockpit. The cabin crew also reported smoke in the cabin. The commander decided to return to land and while approaching the end of the downwind leg the smoke began to dissipate. The landing was uneventful. The aircraft had been dispatched with a seized Air Cycle Machine (ACM) in Pack 1, and in accordance with the Minimum Equipment List it had been activated in 'heat exchanger mode' after takeoff. It is probable that, in this mode, the air flowing through the damaged ACM produced the smell and smoke/mist.

## Background to the flight

On 26 March 2017 an overheat defect was reported in G-EZIM for Air Conditioning Pack 1 (AIR PACK 1 OVHT). The pack was made inoperative and a FL370 altitude restriction was applied. The following day, troubleshooting maintenance activity resulted in new sensor parts being ordered and on 31 March, the morning of the incident, further maintenance resulted in the determination that the Air Cycle Machine[1] (ACM) in Pack 1 had seized. This was based on there being no airflow at the Pack 1 ram-air outlet. A new ACM was ordered and Pack 1 was reinstated for in-flight use only in 'heat exchanger mode', in accordance with the aircraft manufacturer's Minimum Equipment List (MEL) 21-52-01G '*Air cycle machine failed*'. 'Heat exchanger mode' means only operating the pack in flight when the total air

**Footnote**

[1] An ACM consists of a turbine-driven compressor and fan.

temperature (TAT) is less than, or equal to, 12°C. This results in the pack using cool ram air but the air still passes through the ACM.

**History of the flight**

The aircraft departed from Bristol Airport for the Isle of Man Airport and the flight crew operated Pack 1 in accordance with MEL 21-52-01G. The flight was uneventful. On the return flight, about 90 seconds after takeoff from Runway 26 at Isle of Man Airport, the commander noticed what looked like mist coming from the vent above his windshield. He described it as being light grey and that it was followed almost immediately by an "acrid burning smell much akin to a match just being struck." He turned to the co-pilot to ask if he could smell anything and noticed that the mist behind his seat was dense enough to highlight rays of sunshine entering the cockpit.

The cabin manager (CM) reported that, about 30 seconds after liftoff, he and another cabin crew member seated at the front of the aircraft noticed that the cabin smelt of burning and seconds later the cabin began to fill with "grey/hazy smoke".

The commander asked the co-pilot to transmit a MAYDAY call to ATC of "smoke in the cockpit" and requested a level-off at FL50. The commander then handed control to the co-pilot and noticed that the cabin attendant light was flashing on the Audio Control Panel on the centre pedestal, indicating that the cabin crew were trying to call them. The buzzer had probably been drowned out during the initial radio exchange with ATC. He gave the "Attention crew at stations" call over the public address (PA) which is a standard call to indicate to cabin crew that the flight crew are aware of a potential emergency situation but are unable to respond immediately due to cockpit workload.

The flight crew discussed their options but the density of the mist was sufficient to convince the commander that an ECAM warning, most likely for 'AVIONICS SMOKE', was almost inevitable. They advised ATC that they intended to return to the Isle of Man and were given a downwind heading. The co-pilot retained control while the commander spoke to the CM over the interphone, who confirmed that smoke was present in the cabin and that the passengers were anxious. The commander gave the CM a NITS[2] briefing, including that there might be a slim possibility of an evacuation should the situation worsen. He then made a similar announcement to the passengers over the PA stating than an evacuation was unlikely.

While approaching the end of the downwind leg for a tight base turn the smoke began to dissipate but the smell remained so the crew elected to continue with the MAYDAY instead of downgrading to a PAN. The commander resumed control at about 2,000 ft and an uneventful landing was made to a full stop on the runway. He made contact with the fire service who stated that they could not see anything unusual so they escorted the aircraft to the stand. The total flight time was about 11 minutes.

**Footnote**

[2] The NITS briefing is an emergency briefing given to cabin crew; it stands for Nature, Intention, Time, Special Instructions.

### Commander's comments

The commander stated that the co-pilot had selected Pack 1 on after reaching 1,000 ft aal and Pack 2 about 10 seconds later. The occurrence of the smoke was not soon enough after selecting the packs ON for him to associate this as being a possible cause. The smoke visually dispersed after about 2 to 3 minutes but the acrid smell remained. He commented that his main concern was the possibility of receiving an avionics smoke message on the ECAM which would have resulted in needing to consider setting the emergency electrical configuration. This would have increased the landing distance required while the landing distance available at the Isle of Man was only 1,613 m. He said they had insufficient time to troubleshoot or consult the Quick Reference Handbook and he was surprised at how quickly the 11 minutes passed. It was only after landing that the flight crew discussed the faulty pack as being a possible cause.

### Description of the Air Cycle Machine

The ACM is installed between the fan plenum and the condenser of the air conditioning pack (Figure 1). The ACM contains a rotary body which is composed of three wheels connected by a tie-rod (Figure 2). The three wheels are a fan, a compressor and a turbine, which are encased in a fibreglass plenum diffuser. The shaft of the rotary body is supported by two self-acting foil-air bearings and a double self-acting air-thrust bearing. These bearings are located in closed chambers which are supplied with cool and pressurized air from the turbine stage. In the case of a significant air leakage to or from those chambers, or an increase of temperature of the cooling air, the air bearing can fail which eventually leads to ACM seizure.

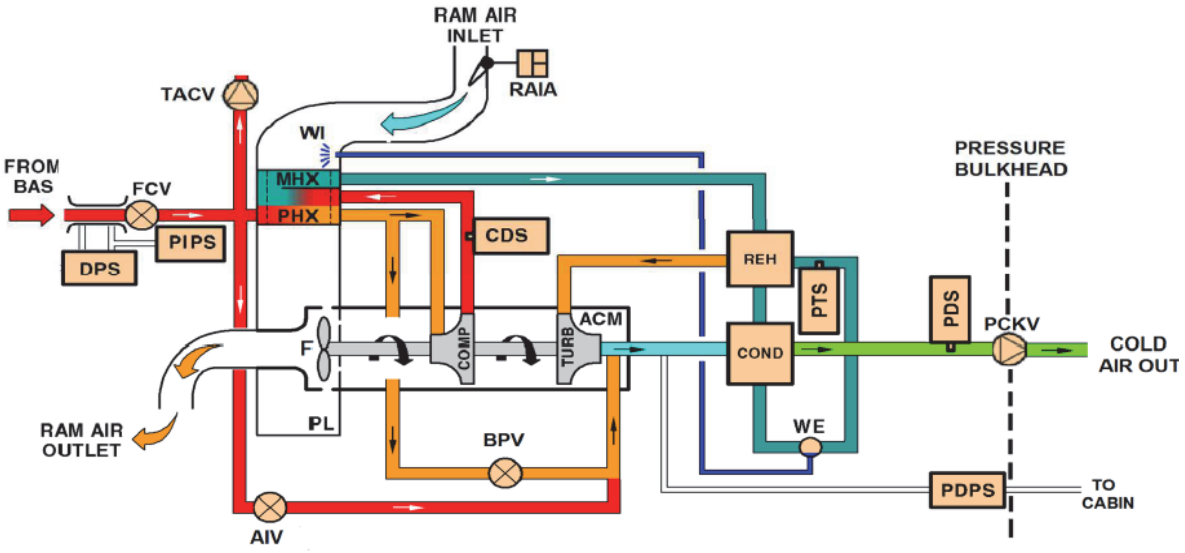


**Figure 1**

Schematic of the air flow through the Pack. ACM shown in the centre

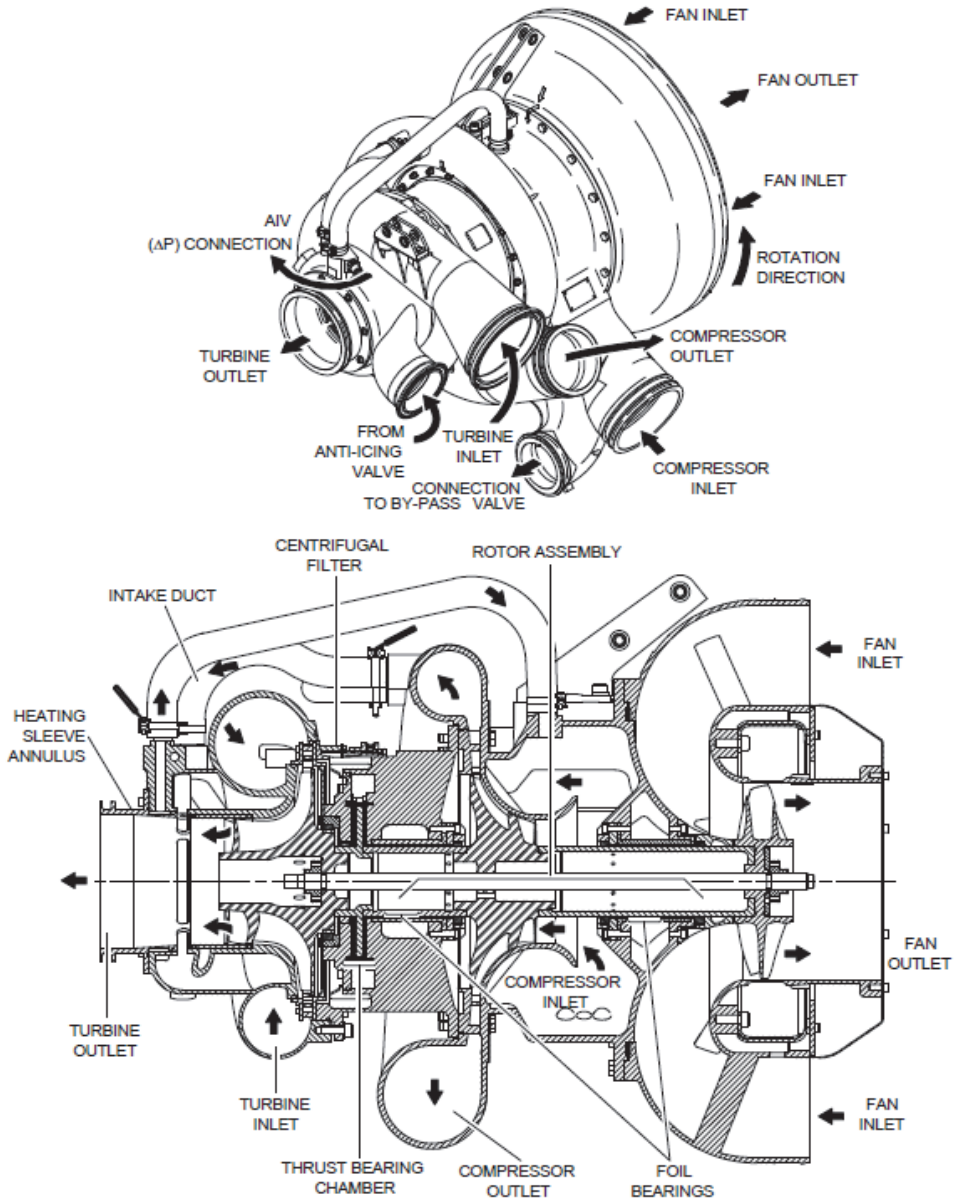


**Figure 2**

Schematic of ACM

## Aircraft examination

During the aircraft troubleshooting process, Pack 1 ACM was suspected to be the cause of the smoke so Pack 1 was deactivated (by closing the pack flow control valve) and an operational test of Pack 2 was performed using bleed air from engines 1, 2 and the APU in turn, with no apparent smoke or smells. The ACM from Pack 1 was replaced and the aircraft returned to service. As of 29 June 2017 the aircraft had accumulated a further 903 hours and 541 cycles without any reports of further smoke or smells.

The ACM was sent to a repair and overhaul organisation but it was not tagged as being the subject of an air safety investigation; therefore, no detailed report or photographs of its examination were available. However, the overhaul organisation stated that '*the machine*

*was tested faulty with rotary body seized*'. The repair documentation revealed that the turbine wheel was found damaged by friction on the turbine scroll and the rotary tie rod was also found damaged by friction, so the whole rotary body was replaced. The fan housing was not replaced, which indicates that the fan wheel had probably not touched the housing, and so the fan wheel had probably not been damaged.

The ACM had accumulated 25,000 flying hours. The ACM does not have a life limit but there is a repair scheme that is dependent on flying hours and cycles. It had previously been in a workshop for repair in April 2014 at 7,885 flying hours.

**Aircraft manufacturer's MEL procedures**

The aircraft manufacturer's Minimum Equipment List (MEL) contained the following entry for a failed ACM. The procedure allowed for the pack with the failed ACM to be operated in '*Heat Exchanger Cooling Mode only'* providing certain alerts were not present, which were not present in the case of G-EZIM. This mode allows the pack to be operated in flight when the TAT is less than or equal to 12°C.

**21-52-01G Air cycle machine failed**

| Repair Interval | Nbr Installed | Nbr Required | Placard |
|---|---|---|---|
| C | 2 | 1 | No |

(o) One may be operated on heat exchanger cooling only (air cycle machine failure) provided that:

1. The following alerts:
   AIR COND CTL 1(2)-A FAULT
   AIR COND CTL 1(2)-B FAULT
   associated with the operative pack are not displayed on the EWD, and
2. The affected pack outlet temperature indication is operative on the BLEED SD page .

Reference(s)

(o) *Refer to OpsProc 21-52-01G Air Conditioning Pack (One Air Conditioning Pack in Heat Exchanger Cooling Mode only)*

The aircraft manufacturer confirmed that it was the intention of MEL 21-52-01G to allow the pack to be operated in the air when the ACM had seized. They did not have any records from other customers reporting that a seized ACM had started turning again in flight. Based on the findings from this investigation the manufacturer stated:

> *'In the absence of evidence further to the ACM examination, it was not possible to determine the root cause of the ACM failure and its condition at the time of the event. Therefore, the aircraft manufacturer is not in position to propose any safety action at this stage.'*

**Aircraft operator comment**

The aircraft operator had stated that it had applied MEL 21-52-01G to three other A320 series aircraft following inoperative ACMs in the previous 12 months, with no adverse effects. However, it was not known if any of these involved ACM seizures.

The operator is reviewing what action should be taken in the future when an ACM is found to be seized. The aircraft manufacturer's manuals do not provide the option of dispatching with one pack turned off. The pack either has to be disabled, which means that the flight crew cannot turn it on if the other pack fails, or they have to operate the pack in 'heat exchanger mode'.

**Analysis**

In this event on G-EZIM, the smells and smoke/mist experienced by the flight crew and cabin crew occurred after Pack 1 was turned on, which was believed to contain a seized ACM. Turning the pack on in 'heat exchanger mode' results in air flowing through the ACM and it is possible that this airflow caused the ACM to turn, but due to a problem with the air bearings there was friction which generated heat and smells. This scenario does not explain why the symptoms did not occur on the earlier flight. However, the ACM in Pack 1 was found to be damaged and replacing it has resulted in no further occurrences of smells or smoke/mist, which increases the likelihood that the ACM was the cause.

The manufacturer's manuals permit an air-conditioning pack to be operated in 'heat exchanger mode' when the ACM has seized. Operating a pack in 'heat exchanger mode' with an ACM in such a condition could result in the airflow being sufficient to turn what was considered to be a seized ACM. The friction from this operation could then produce undesirable smells and potential smoke/mist into the cabin and cockpit air systems. The aircraft operator is reviewing what action should be taken in the future when an ACM is determined to be seized.