

SERIOUS INCIDENT

Aircraft Type and Registration:	Embraer ERJ 190-200 LR (Embraer 195), G-FBEH
No & Type of Engines:	2 General Electric Co CF34-10E7 turbofan engines
Year of Manufacture:	2007
Date & Time (UTC):	1 August 2008 at 1220 hrs
Location:	40 nm NW of Wallesey, en route from Manchester to Belfast City
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 90
Injuries:	Crew - 1 (Minor) Passengers - 4 (Minor)
Nature of Damage:	No 1 air cycle machine failure
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	6,500 hours (of which 410 were on type) Last 90 days - 147 hours Last 28 days - 65 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was operating a scheduled passenger transport flight with the No 2 air conditioning pack inoperative, as permitted by the Minimum Equipment List (MEL). Whilst en route, a failure of the No 1 Air Cycle Machine (ACM) occurred, releasing smoke and fumes into the aircraft. A MAYDAY was declared and an expeditious diversion was carried out. After donning oxygen masks the pilots had great difficulty communicating with each other, ATC and cabin crew, because of technical problems with the masks. During the emergency evacuation the right overwing emergency exit door became jammed and unusable. Passengers who evacuated via the left overwing exit were unaware of how to get from the wing down to the

ground. Two Safety Recommendations are made as a result of this investigation.

History of the flight

The crew reported for duty at Belfast City Airport at 0445 hrs for a four-sector day. The first sector was to London Gatwick, where the crew made a planned aircraft change onto G-FBEH for the return flight to Belfast. This aircraft had experienced a fault with the No 2 air conditioning pack on 28 July 2008. The pack had remained unserviceable since then and the defect was recorded in the aircraft technical log as an Acceptable Deferred Defect (ADD). The flight crew confirmed from the MEL that dispatch with this defect was allowed for up

to 10 days; with the limitation that the maximum altitude be restricted to FL310. After returning to Belfast they then flew the aircraft to Manchester. All three sectors were without incident.

The final sector of the day was scheduled to be from Manchester to Belfast City. The aircraft took off at 1150 hrs, with the commander operating as handling pilot. Approximately 10 minutes after takeoff, during the climb to the final cruising level of FL240, both pilots smelt a sulphurous burning smell, similar to that of a match being struck. They contacted the Senior Cabin Crew Member (SCCM) by interphone to ask if he could smell it in the cabin and asked him to check the forward toilet, which is close to the flight deck, as they considered the smell might have been due to a passenger smoking in the toilet. The SCCM and a cabin crew member from the rear of the aircraft reported that there was no evidence of anyone smoking in the toilet, but they could smell something in the cabin and a haze was visible from the rear of the cabin. When interviewed after the incident, the crew commented that the smell was unfamiliar to them, which heightened their concern.

The smell became sufficiently strong on the flight deck that the pilots decided to don their oxygen masks. The aircraft was approximately midway between Manchester and the Isle of Man and the wind direction of approximately 210° at about 15 kt made a straight-in approach to Runway 26 at Ronaldsway Airport (Isle of Man) favourable. The commander was familiar with the airport and, concerned that the smell might have been due to a fire, decided to divert there.

The co-pilot requested a descent from Manchester ATC and clearance was given to descend to FL200. He then declared a MAYDAY and informed ATC of their decision to divert to Ronaldsway. An expeditious descent was

performed, during which the co-pilot reviewed the emergency descent checklist and selected the emergency code, 7700, on the transponder. Given the absence of any flight deck warnings or visible smoke and the limited time available for planning the approach, the flight crew did not refer to any other emergency checklist.

Communication whilst wearing the oxygen masks proved very difficult due to technical problems with the masks. The co-pilot had to repeat calls to ATC to make himself understood and communications between the two pilots were rendered so poor that they had to resort to shouting.

The SCCM had tried to contact the pilots by interphone during the descent to inform them that the smell in the cabin was getting worse and that the haze was now also visible in the front of the cabin. Although both pilots could hear him, he could not hear them and the pilots activated the cabin emergency call bell. The SCCM, still unable to communicate with them by interphone, initiated the emergency access procedure and gained entry to the flight deck. The commander told the SCCM that he intended to land as soon as possible and ordered him to secure the cabin. The SCCM was advised to expect a normal landing, but was not told that they would be landing at Ronaldsway. The commander did not make an announcement to the passengers because of the communication problems experienced whilst wearing his oxygen mask and the limited time available to prepare for the approach.

Manchester ATC transferred the aircraft to Ronaldsway ATC who offered them either a Surveillance Radar Approach (SRA) or an NDB approach to Runway 26. The flight crew accepted the SRA and requested that the fire services be in attendance for the landing.

The cabin crew stated that the smell came and went during the flight. The SCCM reported that whilst on the approach to Ronaldsway the smell intensified again, becoming stronger than before and smoke was now visible in the cabin. He advised the commander, who considered that he would probably conduct an evacuation on landing. He did not communicate his intent to the SCCM or ATC as he thought that to tell them anything at this late stage of the flight might cause confusion should he decide not to order an evacuation.

The pilots continued with the SRA and became visual with the runway at an altitude of about 700 ft. The commander completed a visual approach and landing on Runway 26 and brought the aircraft to a halt at a runway intersection, turning it into wind as he did so. He then ordered the cabin crew over the Passenger Address (PA) system to stand by, and a few seconds later, gave the order to evacuate.

Aircraft evacuation

The aircraft was equipped with six emergency exits: four doors fitted with inflatable slides, two at either end of the cabin, and two 'Type III' emergency exits located

approximately midway up the cabin, over the wings. On hearing the order to evacuate, the cabin crew opened their allocated doors, the escape slides inflating automatically. The SCCM initially prevented passengers using Door 1 Left (D1L) as the slide had not fully inflated by the time the first passenger arrived there. Once it was fully inflated, the SCCM had to push himself past the flow of passengers to reach Door 1 Right (D1R) to open it. He commented that had he opened this door first, given the layout of the cabin, he would not have been able to push past passengers to get to D1L (Figure 1).

Passengers commented that they found the slides very steep and were surprised by the speed at which they slid down them. The slides also ended without any round-out at the bottom, causing passengers to slide straight onto the ground at speed. This, and attempts by passengers to slow themselves on the slides, were the principal causes of injury reported. The cabin crew became aware of the problems and tried to reduce injuries by instructing passengers to sit down as they got onto the slide and by controlling the flow of passengers down the slides. Particular attention was paid to the older and more infirm passengers.

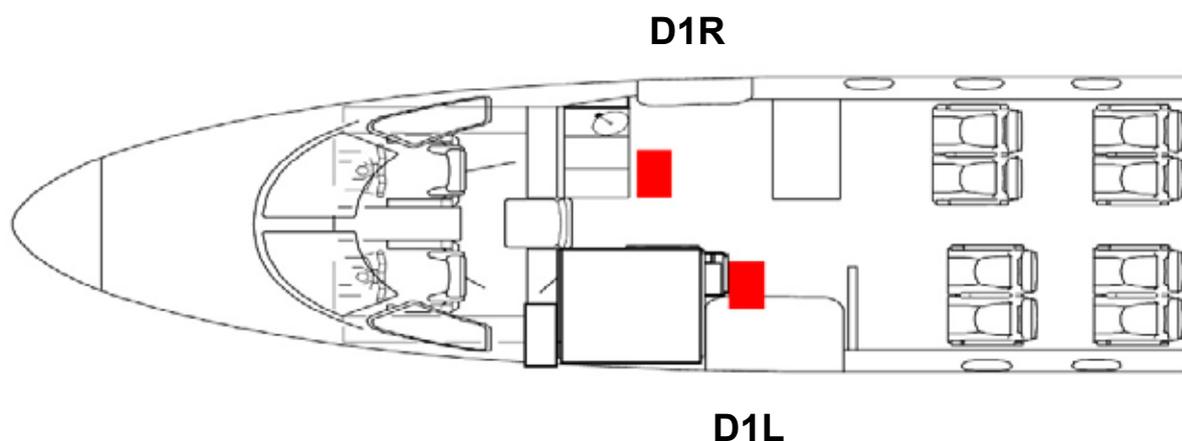


Figure 1

Forward cabin layout, showing forward exits (Doors 1 Left and Right)

When the order to evacuate was made, passengers were able to open the left overwing exit door and evacuate onto the wing. Attempts to open the right overwing exit door proved unsuccessful, as the forward upper part of the door trim had become jammed under the ceiling edge trim panel, preventing the exit from being opened (Figure 2).



Figure 2

Right overwing emergency exit showing door trim partially jammed (circled) under ceiling edge panel

Passengers evacuating via the left overwing exit reported that once out on the wing, there was confusion as to how they should get off the wing down to the ground. A 61 cm-wide walkway was demarcated at the wing root in black paint, with arrows pointing towards the trailing edge (Figure 3). This was not noticed by some passengers; one passenger thought that the markings denoted an engineers' walkway, rather than an escape route. The overriding comment from passengers who evacuated onto the wing was that it was not obvious to them that they were meant to climb off the wing via the trailing edge. Although the wing flaps were lowered in accordance with the emergency evacuation checklist, there remained a considerable drop to the ground of about 1.7 metres.

Some passengers had been queuing to use the overwing exit when they were called to the rear of the aircraft by the cabin crew to use the rear exits, once they were clear of other passengers. This included a passenger seated one seat away from the left overwing exit, who stood in the aisle and assisted passengers evacuating via that exit.

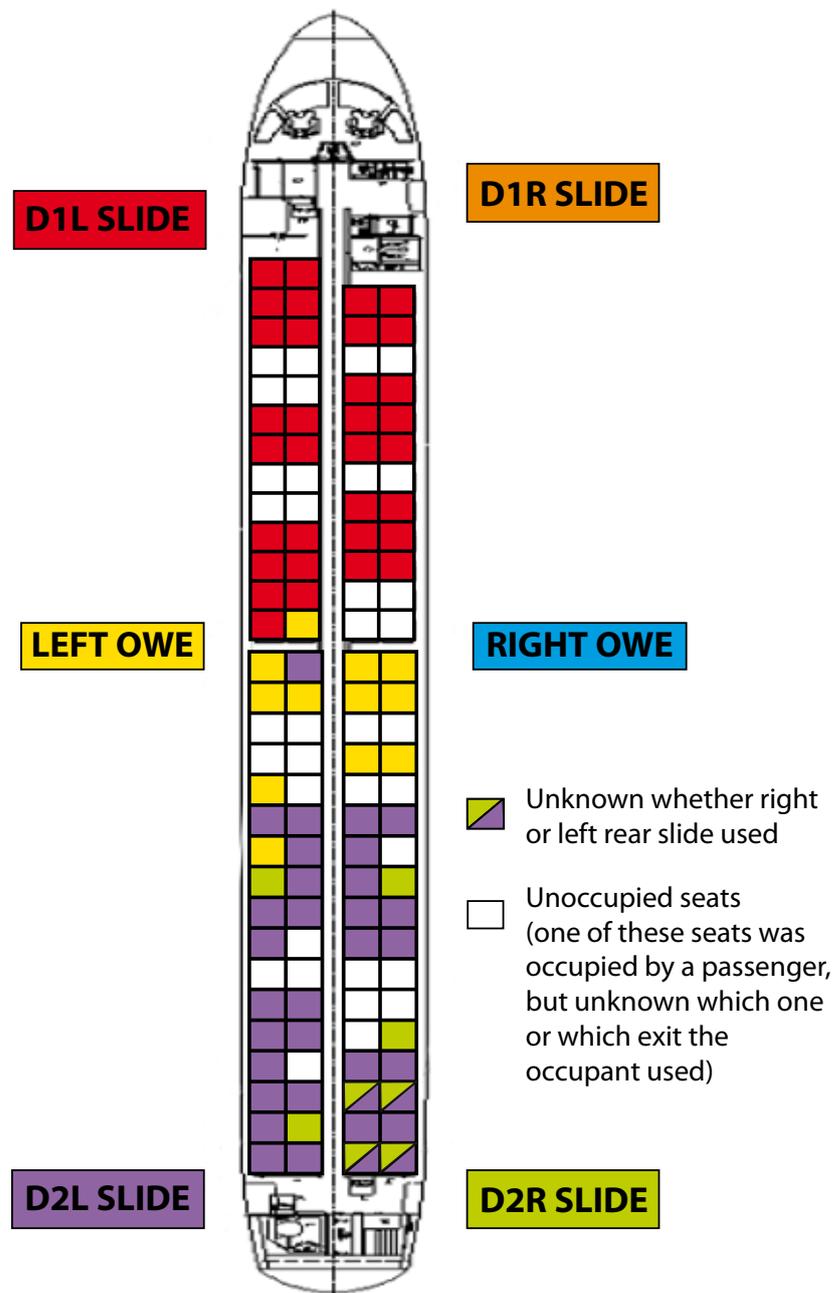
Two male passengers who evacuated via the overwing exit were able to jump down from the rear of the wing and assist other passengers to the ground. This included a mother carrying a baby. They believed that had they not been able to offer such assistance, it is likely that some of the passengers might have received serious injuries in attempting to climb off the wing. Passengers believed that the situation would have been worse had it either been raining or dark at the time of the evacuation.



Figure 3

Overwing exit evacuation route markings (left wing shown, view towards wing trailing edge)

Figure 4 illustrates the exits used by the passengers, correlated by seat position. It shows that no passengers used D1R, despite this door being open with the slide



Evacuation Routes Used

Figure 4

Evacuation routes used by passengers, correlated by seat position

The cabin crew estimated that all the passengers had exited the aircraft within one minute, following which the two cabin crew from the rear of the cabin checked that no one was still on board. They reported to the SCCM that the cabin and toilets were clear before returning

to the rear, collecting their high visibility vests and a megaphone and evacuating via Door 2 Left (D2L).

The pilots attempted to communicate with ATC and the attendant fire services by radio, but this proved difficult

because of the continuing technical problems with their oxygen masks. They eventually removed the masks and opened the window to speak to the fire services directly. On completing the emergency evacuation checklist the pilots entered the cabin, by which time only the SCCM was present. The latter had been concerned that the crew had not emerged earlier and, with no peephole to see into the flight deck, had resorted to banging on the door to attract their attention. The commander conducted a final search of the cabin and both pilots and the SCCM then evacuated via D1L.

Once outside, one of the cabin crew used the megaphone to assemble the passengers on an area of grass at the side of the runway. They also assisted passengers who were distressed or injured.

Pre-flight emergency briefing

Prior to departure, passengers seated next to the overwing exits were briefed by the cabin crew on how to operate the exit. There were also instructions attached to the seatback in front of these passengers, included in which is the depiction of an arrow apparently guiding passengers towards the trailing edge of the wing. Safety cards, provided for all passengers, included diagrams depicting passengers climbing off the trailing edge of the wing onto the ground.

Following this incident the operator revised its briefing to passengers seated next to the overwing exits to make them aware that the arrows on the wing indicate direction of evacuation, ie aft over trailing edge of the wing.

Voice and data recorders

Recorders

The aircraft was equipped with two identical Digital Voice and Data Recorders (DVDR), each recording flight and cockpit voice data. The voice recordings

were sourced from a number of microphones including each flight crew member's (headset) boom microphone, both flight crew oxygen masks, the PA system, and the Cockpit Area Microphone (CAM).

Voice and flight data

Each recorder was successfully downloaded. The data show that while climbing through FL156, the co-pilot identified a burning smell similar to that of a lit match. Around three minutes later, the commander said to the co-pilot, "OXYGEN ON MATE, OXYGEN ON". The DVDR then automatically switched to record crew speech from the microphones in the oxygen masks.

The co-pilot declared a MAYDAY and requested a further descent to FL100. This request was not acknowledged initially by ATC, and only fragmented speech was audible on the recording from the co-pilot's oxygen mask microphone.

At around the time the oxygen masks were donned, the FDR data show an unusual drop in the 'Pack 1' flow rate and compressor outlet temperature. Prior to this, the flow rate was variable about a mean value of around 70 pounds per minute (lb/min) initially, rising to 75 lb/min with peaks of 90 to 91 lb/min. (Other data provided by the operator for the same aircraft with both packs operating showed that the pack outlet temperatures and flow rates were generally lower than under single-pack operation. The mean dual-pack flow rates were generally around 50 lb/min, with transients seldom exceeding 75 lb/min during dual-pack operation).

During the descent, recorded speech from the co-pilot's microphone continued to be fragmented and was described by ATC during their communications with the aircraft as "QUITE BROKEN". Recorded speech from the commander was also fragmented, and at times could

be heard on the area microphone but not through his oxygen mask microphone. Intercom communication was also affected and the cabin crew had great difficulty understanding the flight crew. On occasions, the cockpit door had to be opened for face-to-face communication.

The aircraft landed 20 minutes after the flight crew first identified the smell. The recordings stopped when electrical power was lost after engine shutdown, so the evacuation sequence was not recorded.

Aircraft examination

Right overwing emergency exit

The right overwing emergency exit door was unlatched, but the forward upper corner of the door trim panel was partially jammed behind the outer edge of the ceiling-edge panel (Figure 2), preventing the exit from being opened.

Door retention and opening (Figure 5)

The overwing exit door is retained at its lower edge by spigots which engage in recesses in the bottom edge of the door aperture. Its top edge incorporates a locking mechanism operated by a handle at the top of the door, covered by a removable panel secured by Velcro strips. Pulling the operating handle disengages the lock at the top of the door and allows the door to pivot inwards about its lower edge. The spigots remain engaged until the door has pivoted inwards sufficiently for its top edge to clear the aperture, after which it is lifted clear of the aperture using a fixed handle near its base to support its weight. The door must then be thrown out of the aperture so that it does not cause an obstruction in the cabin to evacuating passengers. A compressible rubber bumper block limits the vertical displacement of the door during the initial phase of opening.

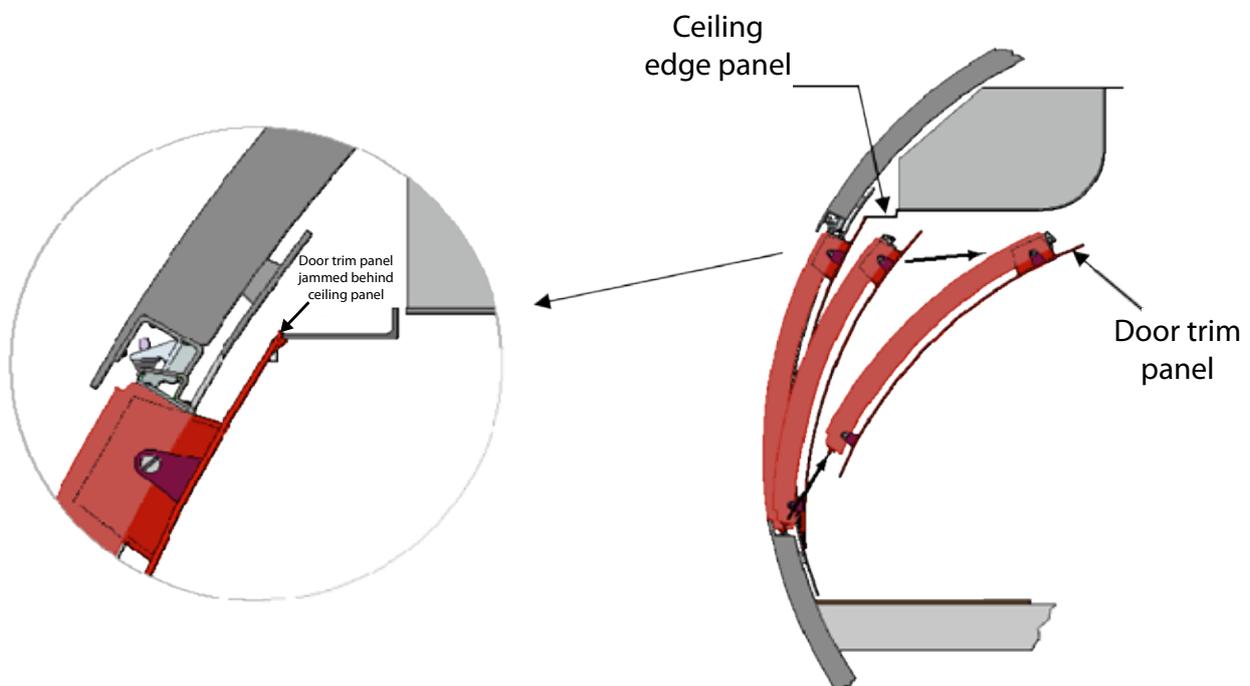


Figure 5

Overwing emergency exit opening, showing location of jam

Door opening clearances

Although the edge of the ceiling panel was cut back around the top edge of the overwing exit door, the resulting clearance between the door trim and ceiling edge panel was insufficient. Measurements of the right overwing exit showed that over most of its length the clearance was just sufficient to accommodate insertion of a credit card, but near the forward corner of the door, where the door trim had jammed, the clearance was only 0.003 inch.

Prior to this investigation, no clearance was specified at any location on or around the overwing exit door. After being alerted of this incident by the AAIB, the aircraft manufacturer issued Service Bulletin (SB) 190-25-0092. This required an inspection of the clearance between the overwing exit door trim and the ceiling edge panel, and replacement of the latter if the clearance was less than 2 mm. Additionally, a check was introduced during aircraft production to verify a minimum clearance of 2 mm between the door trim panel and the ceiling edge panel.

The efficacy of SB 190-25-0092 was subsequently assessed by the AAIB, with a representative from the aircraft manufacturer in attendance. This assessment was made on another aircraft from the operator's fleet on which the SB had just been implemented, with the rubber bumper at the top of the door correctly adjusted. It was found that the specified 2 mm clearance was insufficient to prevent the door liner from becoming jammed behind the ceiling edge panel if the door was lifted during the initial stages of opening, or if it was opened energetically, such as might be the case in an actual emergency. It was concluded that whilst the SB reduced the probability of a jam, the potential for a jam had not been eliminated.

Aircraft certification aspects

The Embraer 190 and its later derivative model the Embraer 195 were both certificated by EASA, the latter in July 2006. According to the aircraft manufacturer, the Embraer 195 was largely certified on the basis of its similarity to the Embraer 190; this approach was adopted for the overwing exits. However, during Embraer 195 development, the ceiling edge panel manufacturer introduced changes to the configuration and dimensions of the cut-outs around the overwing exit aperture, reducing the clearance between the ceiling panel and the door trim. These changes were not notified to the aircraft manufacturer.

The current aircraft certification requirements for overwing exits primarily address the issues of capacity, positioning, size and profile, but not that of potential jamming, except that there must be provisions

'to minimise the probability of jamming of emergency exits resulting from fuselage deformation in a minor crash landing.'

Source of the smoke and fumes*Background*

At the time of this incident, only the No 1 air conditioning pack was operative. The No 2 pack had been declared unserviceable after an investigation by the operator into the cause of a separate smoke in the cabin event that had occurred four days previously. It was established that the No 2 ACM rotor had seized. Examination of the No 1 pack ACM following this incident revealed that its rotor had also seized. It was later confirmed that both ACMs had suffered Stage 2 turbine blade failures. The resultant imbalance had resulted in contact between the turbine blade tips and the ACM casings, producing hot, finely divided, metallic particles that were released into

the cabin air system, creating the reported symptoms of smoke and fumes inside the aircraft.

ACM failure investigation

Both ACMs were returned to the manufacturer for disassembly and preliminary examination; the failed Stage 2 turbine wheels were then returned to the AAIB for independent metallurgical investigation. The manufacturer established that both units had suffered turbine blade fatigue failures close to the blade root in a location of high stresses associated with a known failure mode caused by turbine blade resonance.

The independent metallurgical examination confirmed this finding. No evidence of any fatigue initiating features was found near the crack origins.

Previous ACM turbine failures

Previous failures of the Stage 2 turbine have occurred and were attributed by the ACM manufacturer to fatigue failure caused by blade resonance resulting from an overspeed condition. Of those turbine failures investigated, 40% of the cases were found to have been caused by component or control system failures that could cause an overspeed. In the remaining 60% of cases, no reason for an overspeed, or any other cause of the fatigue failure, was found.

Metallurgical examination by the manufacturer of a turbine failure which occurred in 2005, after 1,279 hrs and 868 cycles, established that one blade had separated from the wheel as a result of a fatigue crack, and a further two blades exhibited partial fatigue cracks. This mode of failure was very similar to that of the failed turbine from the No 2 ACM on G-FBEH. The positions of the crack origins corresponded with a known location of high stresses induced by full-blade third-mode resonance, which the manufacturer stated occurs at 51,574 RPM +/- 3% (50,072 RPM to 53,121 RPM).

During single-pack operation, the nominal turbine speed is predicted to range from 42,500 RPM (25,000ft climb, standard conditions) to a maximum of 51,100 RPM (sea level climb, hot conditions), with an absolute maximum, taking into account sensor tolerances, of 52,100 RPM.

The manufacturer stated that an analysis of ACM removals suggested no relation between ACM failure (of any type) and single-pack operation. Following this incident the aircraft manufacturer conducted a reliability analysis of the ACM, concluding that a reduction in the current single-pack MEL operating period limit of 10 days was not warranted.

A modification to reduce the probability of Stage 2 turbine blade resonance, introducing a new Stage 2 turbine nozzle design with an increased vane count to move the blade pass frequency outside the critical range, was being developed when this incident occurred.

Crew oxygen masks

Overview

The crew oxygen masks are equipped with selector valves which give the option of 'mixed' (air/oxygen), '100%' (oxygen) and 'force-feed' (purge) modes of supply.

The microphone system installed in the masks incorporates a cut-out device that electrically isolates the microphone during the inhalation phase of breathing, and reconnects it again during exhalation. This is to prevent the 'wind-rush' sound caused by the in-flow of air/oxygen across the microphone.

The cut-out device comprises a small plastic balance beam supported on trunnion bearings in the manner of a 'seesaw', carrying a magnet that moves in proximity

to a reed switch mounted beside it. The balance beam is positioned in the gas path and is biased towards the 'microphone live' position by residual attraction between the magnet and an adjacent screw head. An asymmetry in the area presented to the gas flow on either side of the pivot creates a net force on the beam, tending to tilt it towards the 'cut-out' position in opposition to magnetic bias-force. At in-flow velocities below a certain threshold, ie during exhalation, the magnetic bias moves the beam back to its original position, restoring microphone function.

On-aircraft checks

Checks of the crew oxygen mask microphones on G-FBEH suggested that the captain's microphone was defective, but it could be made to operate by lightly tapping the face of the microphone casing.

Similar checks of the crew oxygen masks were performed on another of the operator's aircraft. The microphone on the captain's mask, like that on G-FBEH, was also initially inoperative, but became live after the mouthpiece was tapped sharply. A consistent pattern of malfunction was observed: during inhalation, the cut-out system (correctly) isolated the microphone and, thereafter, it remained isolated during the exhalation phase. Tapping the mouthpiece then restored microphone function until the cut-out mechanism isolated it again during the next inhalation phase.

During these checks it was noted that with the oxygen supply set to purge mode, the microphone cut-out mechanism tended to hunt between live and cut-out modes during speech, producing a sound similar to the garbled radio transmissions heard from the aircraft during the incident.

Oxygen mask examination and tests

The captain's and co-pilot's masks from G-FBEH, and the defective captain's mask from the other aircraft were tested and strip-examined at the manufacturer's facility in the United States, under AAIB supervision. The captain's mask from G-FBEH was found to be non-functional and could not be tested. The co-pilot's mask passed all of the test criteria. The other captain's mask operated intermittently, displaying the same characteristics as seen during the on-aircraft checks.

When demonstrated by someone who routinely performed the production acceptance tests, the microphone on a serviceable mask produced clear speech with the oxygen flow setting in all modes. However, when tried by people less familiar with mask operation, the audio output in the purge flow mode was garbled. With practice, once accustomed to speaking against the (significant) positive gas pressure in this mode, good clarity of speech was achieved. The tendency to produce garbled output when set to purge was evidently a feature of the system that required practice to overcome. The operator of G-FBEH was advised of this finding.

Strip-examination

Strip-examination of the microphone and cut-out assembly from the captain's mask from G-FBEH revealed that the magnet was fouling slightly against the side of the cut-out switch body, causing the balance beam to become stuck in the cut-out position. The cause of the foul was the incorrect positioning of the reed switch body.

Disassembly of the captain's mask from the other aircraft identified a spurious whisker projecting from the plastic housing of the cut-out switch, the free end of which contacted the underside of the flow sensor pivot. The

whisker acted as a ratchet, tending to inhibit movement of the sensor vane in the direction required to reactivate the microphone, whilst leaving its motion in the direction required to cut out the microphone unaffected. Consequently, the mechanism tended to stick in the cut-out position, leaving the microphone open circuit. The whisker or spurious material appeared to be a ‘curl’ of the switch casing material (Figure 6), probably created either in the production of the switch itself, or during its assembly into the mask.

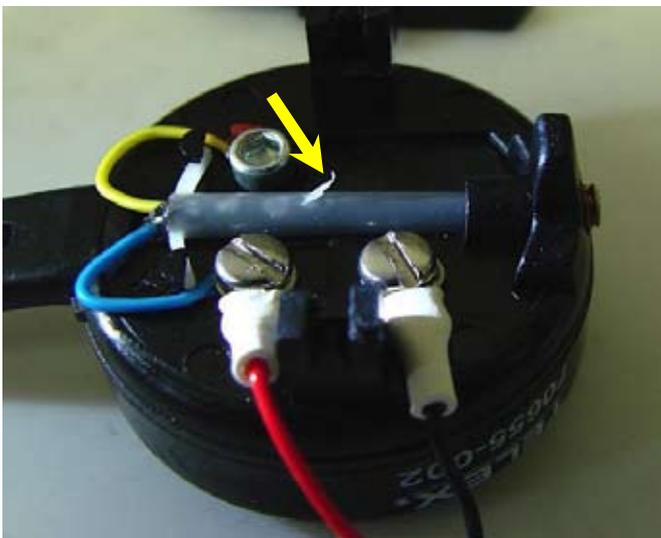


Figure 6

Whisker of plastic material on cut-out switch

In the light of these findings, the mask manufacturer undertook a detailed review of its design and manufacturing processes. This resulted in an improved physical location of the magnet at its attachment to the flow sensor vane, the use of adhesive to prevent movement of the switch body once its position has been adjusted to provide the required change-point, and the addition of quality checks to ensure that switch casings supplied to the company are free of burrs.

Additional information

Previous evacuation incident

The AAIB investigated an incident on 1 April 2002 (EW/C2002/4/1), in which the cabin of a Fokker F28 filled with smoke. An emergency evacuation was carried out, during which passengers using the overwing exits experienced similar problems getting from the wing to the ground. The report stated:

‘Having climbed out of the cabin, passengers disembarking from the left overwing exit were unsure of how to descend from the wing to the ground. A number congregated on the wing looking for a way down. Cabin crew eventually noticed the confusion and urged the passengers to get off the wing. Some passengers slid or jumped from the wing tip and leading edge (a drop of some 7 to 8 feet) instead of sliding off the wing trailing edge down the extended flaps.’

Of the report’s three recommendations, one is relevant to the incident involving G-FBEH:

Safety Recommendation 2002-42

The CAA and the JAA should review the design, contrast and conspicuity of wing surface markings associated with emergency exits on Public Transport aircraft, with the aim of ensuring that the route to be taken from wing to ground is marked unambiguously.

The Civil Aviation Authority accepted the recommendation, but no response was received from the Joint Aviation Authority. The responsibility for aircraft certification within Europe is now held by the European Aviation Safety Agency (EASA).

Analysis

Crew decision making

The commander's decision to divert to the Isle of Man was based on his concern that there might have been a fire on the aircraft. The sulphurous smell experienced by both pilots was something that they had never encountered on an aircraft before, but one which they uniquely associated with burning. Having made the decision to divert, the commander had limited time in which to achieve a straight-in approach and landing. This task was made more difficult by the communication difficulties experienced once the pilots had donned their oxygen masks. Consequently, the commander omitted to inform the SCCM that they were diverting and it also led to his decision not to attempt to speak to the passengers over the PA.

The fluctuating intensity of the smell meant that the commander did not decide to perform an emergency evacuation until late in the flight. His intentions were not communicated to the cabin crew and passengers and they were therefore surprised by the command to evacuate. However, despite the unexpected nature of the order to evacuate, this did not delay its commencement.

Door 1R & 1L configurations & passenger flow issues

None of the passengers evacuated the aircraft via D1R. This, it is considered, was influenced by the staggered layout of the front two emergency exits. In addition, there was only one crew member situated in this part of the cabin to direct and assist passengers during the evacuation and he was standing next to D1L. Passengers would have therefore had to find and use D1R at their own initiative.

Overwing escape route markings

It is apparent from this incident that the issue of ambiguous overwing escape route markings that resulted in AAIB Safety Recommendation 2002-42 still exists. It is therefore appropriate that this matter is re-examined. As responsibility for aircraft certification now lies with the EASA, the previous Safety Recommendation is therefore re-issued as follows:

Safety Recommendation 2010-007

It is recommended that the European Aviation Safety Agency review the design, contrast and conspicuity of wing surface markings associated with emergency exits on Public Transport aircraft, with the aim of ensuring that the route to be taken from wing to ground is marked unambiguously.

Overwing exit jam

The jamming of the right overwing exit door occurred because of insufficient clearance between the top edge of the door trim and the ceiling edge panel. To prevent fouling at this location, adequate clearance must be available in the initial stages of door movement until the door trim panel has passed fully beyond the ceiling panel. In the case of the right overwing exit on G-FBEH, there was effectively no clearance, such that the exit immediately jammed on attempting to open it.

The AAIB checks demonstrated that, whilst improving the situation, the 2 mm minimum clearance specified in SB 190-25-0092 was insufficient to prevent the door liner from fouling the ceiling edge panel if the door was lifted firmly as it was unlocked, or if the door was jerked open, as might occur in an emergency. The 2 mm clearance requirement is not entirely effective in eliminating the possibility of a jam. The following Safety Recommendation is therefore made:

Safety Recommendation 2010-008

It is recommended that Embraer modify the overwing emergency exits on Embraer 195 aircraft, to eliminate the possibility of the exit door jamming due to interference between the door trim panel and the ceiling edge panel.

ACM turbine failures

Examinations of the failed turbine wheels from G-FBEH showed that they had failed due to fatigue cracking originating in a location of high stresses associated with a known blade resonance condition. A new Stage 2 turbine housing was under development to address the problem.

The failure of the Stage 2 turbine on the No 1 ACM occurred after only four days out of the 10 days of single-pack operation permitted by the MEL. This suggests that the turbine speed had encroached into the resonance range during this period. It is possible that other units could be similarly vulnerable during single-pack operation. However, the aircraft manufacturer stated that this event was the only known case of the failure of an ACM Stage 2 turbine during single-pack operation on the Embraer 190/195 fleet. They also reported that the reliability of the air conditioning pack had been significantly improved through various modifications and maintenance actions, significantly reducing the probability of Stage 2 turbine failures. Therefore no Safety Recommendation is considered necessary.