Boeing 757-236, G-BIKF, 5 April 1996

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Aircraft Type and Registration:	Boeing 757-236, G-BIKF
No & Type of Engines:	2 Rolls-Royce RB211-535C turbofan engines
Year of Manufacture:	1982
Date & Time (UTC):	5 April 1996 at 0650 hrs
Location:	Stand C49, London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 7
	Passengers - 89
Injuries:	Crew - None
	Passengers - None
Nature of Damage:	Damage to auxiliary power unit air ducting
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	12,000 hours (of which 2,500 were on type)
	Last 90 days - 55 hours
	Last 28 days - 18 hours
Information Source:	AAIB Field Investigation

The aircraft was about to push back from stand C49 on a scheduledservice from London to Zurich with 7 crew and 89 passengers onboard (6 club class, 83 economy). Passenger boarding had beenroutine, all doors were closed but not yet armed, and the boardingjetty had been removed. The ground power supply to the aircrafthad been disconnected as the auxiliary power unit (APU) was providingaircraft electrical power and air for cabin conditioning. Thetug and towbar were attached and a ground engineer was in contactwith the flight crew via the external intercom.

The commander requested, and was granted, push-back clearancefrom ATC but was told to wait for other ground traffic to clearfrom behind his aircraft before moving. He therefore selectedthe anti-collision beacon 'ON', but kept theparking brake applied. The crew, in preparation for engine start,had actioned the 'Before Start' checklist and had selected theair conditioning 'PACKS' to 'OFF'.

At this stage, the cabin service director (CSD) was making hisfinal check of the cabin and was walking to the rear of the aircraft. As he approached seat rows 19 to 20, he heard a "thud"and saw what appeared to be a shower of "confetti" riseinto the air adjacent to seat row 24 (the last row before thecentre toilets). He also noticed the cabin atmosphere becomecontaminated with a blue-grey mist. He turned and immediatelymade his way to the flight deck to inform the commander that "therehad been an explosion and that the cabin was filling with smoke". The commander, who had also heard a faint thud and felt a slightpressure surge on his ears, looked past the CSD into the cabinand was able to see a 'bluish smoke haze' to the rear.

The commander immediately instructed the first officer to callfor the airport emergency services on the ground movement frequencywhilst he called the company on the ground handling frequencyto request full ground support and for the jetty to be repositionedat door L1. He then made a public address (PA) to the passengersinstructing them to move forward. On hearing the first officertransmit that there had been an explosion on board the aircraft,the ATC watch supervisor, using the omnicrash communications system,instigated full emergency procedures by declaring an "AIRCRAFTACCIDENT". This alerted not only the airfield emergencyservices but also those from neighbouring local authorities. The fire crews were on scene within two minutes, at 0657 hrs.

Two ground dispatchers rapidly appeared in the mouth of the jettyand were hurried in their positioning of the jetty by the commandershouting through the open flight deck direct vision (DV) window. The CSD, who was standing in the flight deck doorway and listeningto updates from the rear cabin crew over the interphone, theninformed the commander that the smoke intensity was increasing. On hearing this, and seeing that the jetty was moving rapidlytowards the forward door, the commander ordered the CSD to openthe front door (door L1) and evacuate the passengers as soon asthe jetty was in position. The commander then made a furtherPA instructing the passengers to "leave the aircraft quickly,without hand baggage, by the front door". The evacuationinto the terminal lounge was fast and orderly and conducted withoutincident.

The flight crew did not action the evacuation checklist, but duringthe evacuation the first officer selected the aircraft systems(*ie* fuel, hydraulics etc) to 'off'. He suggested to thecommander that the APU should also be shut-down, but the commanderdecided against this action and put the PACKSto 'ON' in an attempt to remove or dissipatethe smoke.

At this stage, with no previous warning indications on the flightdeck, the commander noticed that one 'CARGO FIRE-BOTTLEDISCHARGE LIGHT' was 'ON' and as hewatched, the second 'DISCHARGE LIGHT' illuminated. This also brought to his attention the cargo fire bottle dischargemessages on the engine indication and crew alerting system (EICAS)display. Although there was no associated indication of a 'CARGOFIRE', the commander ordered the first officer to carryout the 'CARGO FIRE' checklist. The firstitem on the checklist is to select the 'CARGO COMPARTMENTARMING SWITCH' (for the affected cargo compartment) to'ARM'. This action, in the case of the AFTCARGO COMPARTMENT, arms the No 1 and No 2 cargo fire extinguishers,turns off the cargo heat fan and cargo heater, turns off the recirculationfan and switches the right air conditioning pack to high flow. However, as both fire-bottle discharge lights had already illuminatedthe crew believed that activation of the arming switch was irrelevantand therefore did not action this checklist item.

As the fire service arrived the commander attempted, without success,to contact the fire crew on ground frequency of 121.6 MHz. However,as the flight crew vacated the aircraft to join the passengersand cabin crew in the lounge, the fire crew arrived in the cabin. The commander reported that as he left the aircraft smoke hadreached the forward cabin and, whilst "thicker"

thanfirst observed, was not too dense and visibility was approximatelyone third to one half of the cabin length.

The APU was still running as the fire crew boarded the aircraftand, although the commander could not remember selecting the APUto OFF before he vacated the aircraft, fire crew personnel reportedthat the commander did in fact select the APU off at their request.

Once on board, the fire crew used a thermal imaging camerawhich indicated a 'hot spot' in the rear cargo hold. The rearcargo hold was subsequently emptied of luggage, but nothing unusualwas found. The panelling at the forward end of the rear cargobay was removed and, although no fire damage was found, it wasobserved that the insulation material in the exposed bay had beendisturbed. Further examination of this zone was performed afterthe arrival of AAIB and it was found that the hot air deliveryduct from the APU to the pneumatic manifold had fractured (seeillustration for location).

Use of Checklists

The company Flying Manual, 'Non-Normal Procedures' section, details'Procedures beyond the scope of the Quick Reference Handbook'(QRH). The relevant paragraphs are reproduced below:

'Procedures cannot be established for all conceivable Non Normalsituations. The degree, complexity and variety of multiple failuresis difficult to cover in the QRH. It is the responsibility ofthe crew to assess the situation and execute sound judgement todetermine the safest course of action. Thorough knowledge ofboth the aircraft systems and Technical Manuals is required toenable the correct action to be taken in the event that the situationis not covered in the QRH.

It is rare to encounter in-flight situations which are beyondthe scope of established Non Normal procedures. These eventscan arise as a result of unusual occurrences such as mid-air collision,bomb explosion of other major malfunction. In such situationsthe flight crew may be required to accomplish multiple Non Normalchecklists, selected elements of several different check lists(applied as necessary to fit the situation) and rely on theirown technical knowledge, judgement and experience.'

The commander exercised his judgement in this situation and electednot to action the evacuation checklist. The first officer, havingbeen instructed to carry out the cargo fire checklist, did notaction any of the items on that list since he believed them tobe irrelevant because both cargo fire bottles were already indicatingdischarge. The commander also retained the APU in operation inan attempt to effect smoke removal from the cabin.

The incident was dealt with in an expeditious and professionalmanner by both the flight and cabin crew. There was no formalchecklist procedure to cover this situation.

The commander always has the option to initiate a full evacuationof passengers using the aircraft emergency exits and slides. However, in this situation a full evacuation was not necessaryand may well have caused injury to some passengers. Such incidentsmay arise however, between the time that the first passenger boardsthe aircraft and the aircraft moves under its own power and theemergency slides are armed, when a rapid disembarkation of thepassengers, using the airport facilities (jetties and/or mobilesteps), is required. A suitable checklist for flight deck andcabin crew which covered this situation would formalise the proceduresto be adopted. It is therefore recommended that:

96-46**:** The CAA Flight Operations Inspectorate should promotethe introduction, by Air Operator Certificate holders, of a formalised'rapid disembarkation' checklist procedure to expedite the de-planingof passengers using normal passenger entry facilities during potentiallyserious incidents which do not require a standard evacuation andwhich occur before aircraft push-back, or movement under enginepower, and before the cabin door evacuation slides have been armed.

Engineering examination (see illustrations)

Examination of the passenger cabin some three hours after theevent showed that although there was a large quantity of fibreglassinsulation debris in the area of the centre cabin and toilet,particularly on the right side, there was neither physical evidencenor a smell to suggest that there had been any fire.

Examination of the fuselage cavity immediately forward of theaft cargo compartment and aft of the main wheelwell revealed thatthe insulating blankets which had been wrapped round the 5 inchdiameter titanium air duct from the APU to the pneumatic manifoldhad been considerably displaced and locally disrupted. The fuselagesidewall insulation had been disturbed in the floor/sidewall gap,particularly on the right side of the aircraft, and it was mainlythis type of material which had been distributed into the passengercabin.

It was observed that the transverse part of the section of APUair duct within this cavity aft of the main wheelwell was partiallyfree to move and that the duct had separated just downstream ofa bend near the left fuselage side. The duct separation had occurredat the weld which joined the bend to the transverse straight partof the duct section. At this position, the duct had been supportedby a stirrup hung from a fore and aft floor beam. The stirrupclamp band was about 1 3/4 inches wide andhad been positioned such that it had enclosed the duct weldedjoint within its width; there was evidence of relative movementbetween the straight part of the duct and the clamp liner. Itwas also found that the section of duct aft of the failed onehad kinked towards the fuselage side at the first restrainingclamp aft of the bend. The parts of the transverse duct sectionwere removed from the aircraft for metallurgical examination ofthe failed weld.

The duct section assembly consisted of four parts welded together,two bend pieces with 0.035 inch wall thickness and two straightsections with 0.020 inch wall thickness. Metallurgical examinationrevealed the failure to have been by tensile fatigue, originatingin the toe of the weld joining the upstream bend to the transversestraight section and on the edge of the weld which attached tothe straight part. The failure had progressed by a fatigue mechanismround approximately 75% of the duct periphery before final rupture. The examination showed the weld to have been of very good qualitywith no features which might have lead to premature fatigue initiation.

Inquiries revealed that, during early operation of the Boeing767 and 757 types, the titanium pneumatic ducting, which was originallyfabricated mainly from 0.020 inch thick material, was prone tocracking. As a result of this experience, the manufacturer introducedmodified ducting, by Service Bulletin (BSB 757-36-0015 for B757s),with 0.035 inch thick material at the bends and strengtheningrings. The modified ducting was made Mandatory by the CAA andit had been fitted to 'KF' in October 1987. Since that time 'KF'had completed 13,500 flights and 16,580 flight hours.

Although ducting of this specification has proved satisfactorilydurable on Boeing 757s, as a result of continuing problems onB767 aircraft, the manufacturer later produced ducting of a furtherimproved standard which had been stress relieved. Ducts of thislatest standard were

considered, for B757s, to be a product improvementonly and, although fitted from new on late build aircraft, werelisted as preferred spare parts for replacement ducts on aircraftalready in service.

Also within the same cavity, forward of the aft cargo compartment,were the two cargo bay fire bottles and the two temperature sensingelements for detecting hot air leaks running parallel to the airduct. Although there had been no indication of a 'Duct Burst'on the flight deck, the detection system tested serviceable. Since the fire bottles had indicated that they had discharged,they were removed; however, weighing them indicated that theywere still fully charged.

Enquiries of the manufacturer revealed that the discharge sensorsystem for these bottles was designed to detect a relatively smalldrop from nominal charged pressure and incorporated variationof the trigger pressure to compensate for changes of static chargedpressure with temperature. The sensors were fitted to an externalboss on the bottle so that, if the bottle material were to beheated faster than its contents, the trigger pressure could riseabove the charge pressure.

During the course of the investigation it became apparent thatthe APU duct support clamp, which was at the position at whichthe duct weld failed, was not correctly located. According tothe design, the clamp should have been attached to the floor beamcloser to the aircraft centreline (see diagram). The operatorimmediately called for a survey which revealed that this aircraftwas the only one in their fleet to have the clamp mislocated. There was no evidence that the clamp had ever been attached tothe correct floor beam, nor was there evidence that repairs ormodifications had been done to this area of the floor structure.