AAIB Bulletin No: 2/96 **Ref: EW/A95/12/1** **Category: 1.1**

Aircraft Type and Registration:	Boeing 747-436, G-BNLT	
No & Type of Engines:	4 Rolls-Royce RB-211-524G2-19 turbofan engines	
Year of Manufacture:	1991	
Date & Time (UTC):	26 December 1995 at 2032 hrs	
Location:	Rio de Janeiro, Brazil	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 19	Passengers - 322
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to APU and surrounding structure	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	N/A	
Commander's Flying Experience:	N/A	
Information Source:	AAIB Field Investigation	

With the Auxiliary Power Unit (APU) in operation[1], the aircraft was in the process of being pushed back from the stand and the crew were starting the engines when, as the No 2 air conditioning pack was reportedly selected on, an explosion occurred in the APU bay at the tail of the fuselage. A (caution) message was noticed by the crew on the EICAS (engine indication crew alerting system) screen relating to the APU and, although there was no APU fire warning, the APU fire drill was carried out in accordance with the QRH (quick reference handbook). This, however, did not extinguish the fire due to the APU bay doors having been 'blown open' thus rendering the fire suppression and fire detection systems in this bay ineffective. At about this time the crew were advised by the ground movements controller that flames were visible from the area of the APU. The

[1]The operation of the APU on this airline's Boeing 747-400 aircraft is not restricted to 'ground use only', and may be run upto 15,000 feet after takeoff, It is quite a common occurrence to takeoff with the APU supplying one air-conditioning pack such that maximum advantage is taken to de-rate the main engines. Once climb power is selected, air conditioning usually reverts to main engine supply and the APU is shut down.

fire was extinguished by ramp personnel, operating from an elevated mobile platform, using hand-held dry powder extinguishers.

Examination of the aircraft by engineering personnel from the operator revealed that although the level of fire/heat damage was relatively low, structural damage had occurred to the tailcone/APU bay, bay doors and intake ducting (Figure 1), with evidence to show that the tailcone had 'sprung' in excess of 4 inches to the right to make contact with the inboard end of the inner elevator. Inspection of the APU itself, type P&WC 901A, revealed that a pipe nut on the secondary fuel manifold was apparently loose where it connected to the No 1 (12 o'clock position) fuel nozzle. Figure 2 shows this nut, as found, and it may be seen that several turns of the thread on the nozzle assembly are exposed when compared to the primary connection, which was found tight. After a temporary repair had been made to the damaged structure the aircraft was flown, without passengers, to the operator's base at Heathrow where a full examination was carried out and rectification work instituted.

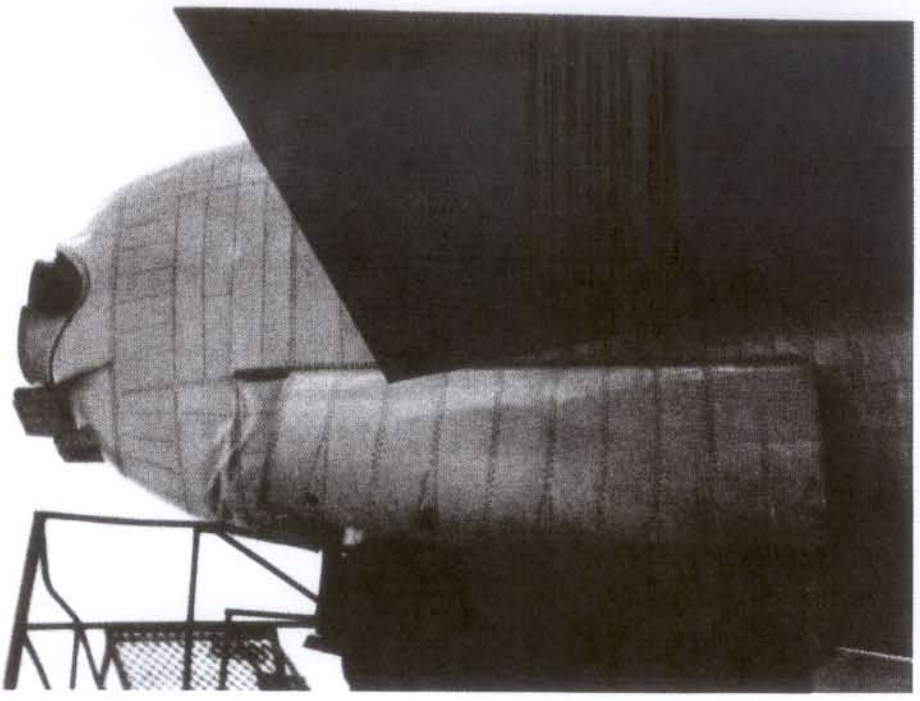
After removal, the APU was taken to an overhaul facility in the UK where it was examined in detail by representatives of the manufacturer, the aircraft constructor, the CAA and the AAIB. It was established that the nut in question was the only one loose out of a total of 28 relating to the primary and secondary manifolds, none of the others exhibiting any significant reduction from their tightened torque values. With reference to Figure 3, the nut was removed completely from the nozzle, which exposed one end of the internal transfer tube. This tube is fitted with an 'O' ring seal at each end, and it was evident that the exposed item had failed. The design of this connection is such that for fuel to escape from the manifold, the seal must be ineffective and the nut must be loose, but it is not known if one defect could have precipitated the other. Thus it was evident that fuel had escaped, probably in the form of a 'mist', into the hot environment of the APU bay, which had been in operation for a period of time prior to pushback, until the fuel/air ratio in the bay was capable of supporting combustion. The ignition source for this mixture was likely to have been various hot external surfaces at the rear of the engine which, although mostly insulated, had small areas that were not, for example, at the support strut attachment points.

Examination of the components from the loose connection revealed the presence of brown coloured deposits over most of the thread forms, particularly on the pressure faces, and the conical sealing surfaces of the pipe flare and nozzle fitting. This was not typical of other manifold connections, all others examined exhibiting bright, relatively polished, surfaces. This comparison is shown in Figure 4 and indicates that the pipe nut may have been loose for a period of time.

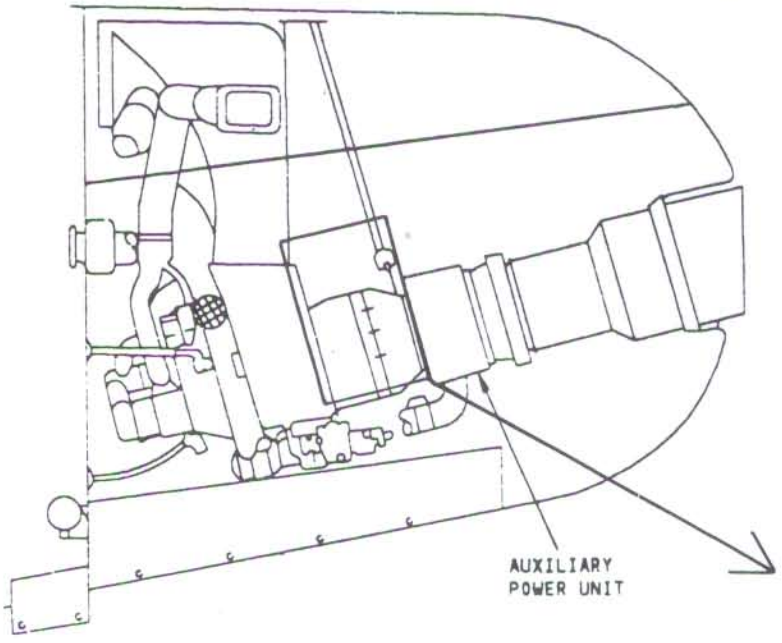
As a result of a previous occurrence of a fuel leak from a manifold connection in which, with the APU running, the nut was found to be engaged by just one turn of the thread, the manufacturer issued a Service Bulletin in March 1993 (SB No 16157R1) requiring a once off check of all APUs in service.

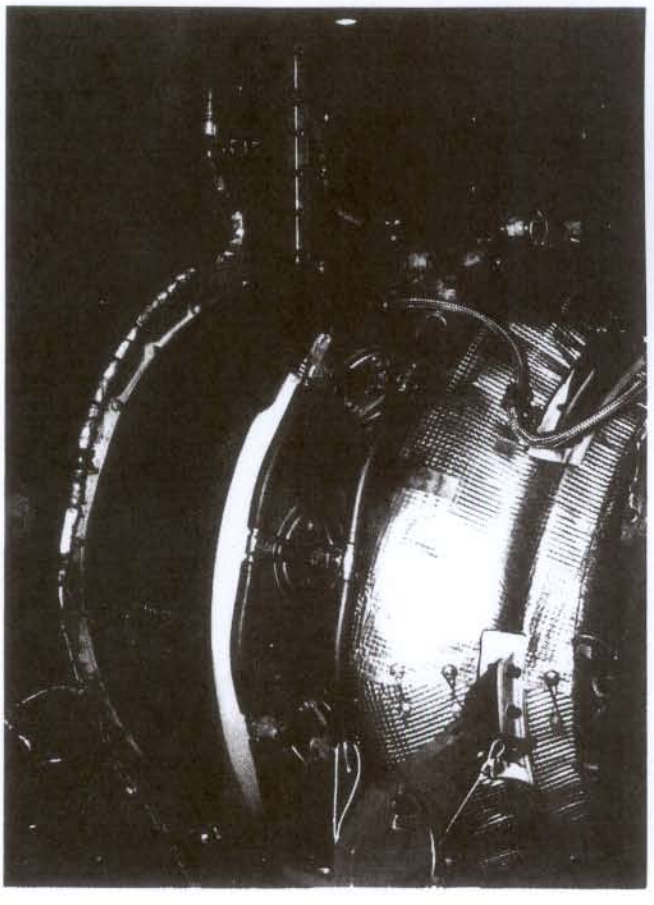
The Bulletin stated that the manufacturer did not understand how the nut had become untorqued as no maintenance had been carried out in that area and the unit had run for 827 hours. A check of the airline's fleet in accordance with this Bulletin in 1993 revealed several pipe nuts to be undertorqued.

Although the APU fitted to 'LT' was manufactured in 1989, it was installed in August 1994 as a zero-timed overhauled unit, since when it had run for some 2,000 hours, 1,640 cycles, upto the time of the accident. On assembly, the manifold pipe nuts are required to be torque tightened to values between 310 and 400 lbf.ins, depending on the location of the nozzle. No means of secondary locking is employed. At the overhaul agency concerned, assurance that these pipe nuts were correctly torqued rested with the same person who actually installed the manifolds and tightened the nuts. However since this event, this agency intend to institute an independent check of the torque loading on these nuts. The secondary manifold and the No 1 fuel nozzle, together with all the transfer tube 'O' ring seals, have been returned to the manufacturer for a detailed examination and check on quality of manufacture. Any findings of significance will be reported upon in a future AAIB Bulletin.



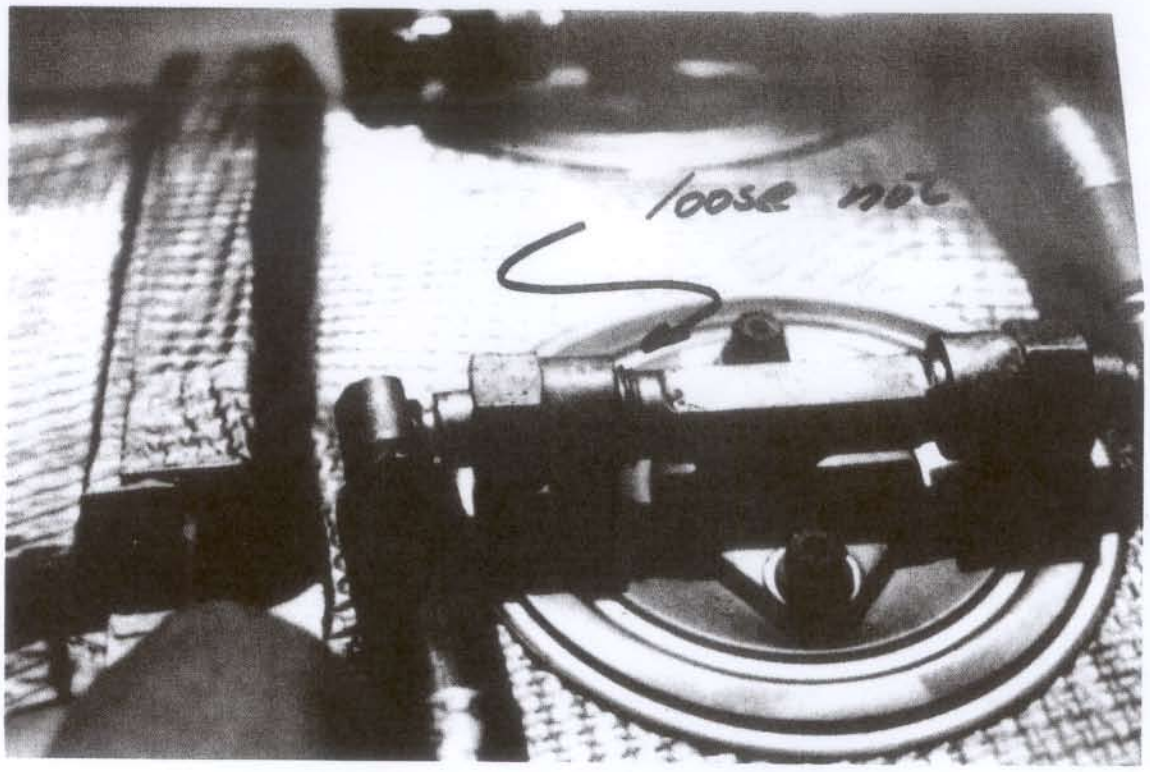
Damage to tailcone. Internal damage included broken/deformed frames and bent APU support struts





Sooting/heat damage to APU

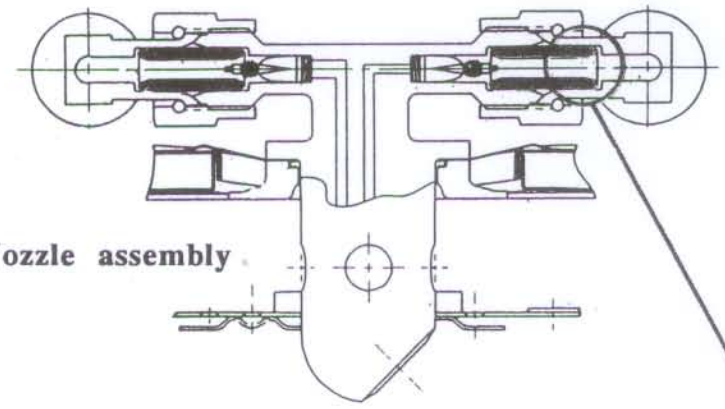
Figure 1



Loose pipe nut as originally found

Figure 2

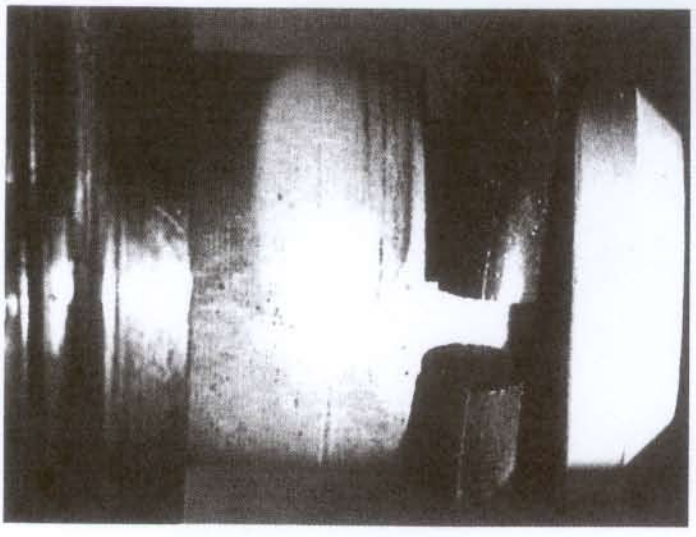
Primary connection



Secondary connection

Nozzle assembly

Mechanical and rubber witness marks



Transfer tube details

Broken O ring seal

Figure 3