Report 06-009

Boeing 767-319
ZK-NCK

fuel leak and engine fire

Auckland International Airport

30 December 2006

Abstract

On 30 December 2006, a fire occurred in the left General Electric CF6-80C2 engine nacelle of a Boeing 767 aircraft as it taxied clear of the runway after landing at Auckland International Airport. The fire was promptly extinguished and the minor damage was confined within the nacelle.

The air traffic controller offered to have the aerodrome fire service check that the fire had been extinguished prior to the aircraft continuing to the terminal, but because of miscommunication, uncertainty about the severity of the situation and unfamiliarity with the aerodrome emergency plan, there was a 9-minute delay before the fire service arrived at the aircraft.

The fire was caused by a leak in the engine fuel manifold, which had been chafed by a manifold loop clamp that was missing some cushion material. Chafing was a known service issue that had been addressed by a service bulletin, but the bulletin instructions were found to be ineffective. The incident engine had been inspected 450 flight hours prior to the fire, and twice within the prescribed inspection interval, without any damaged clamps or chafing being found.

The engine manufacturer revised the service bulletin to require the replacement of all of the manifold loop clamps at each inspection.

The air traffic control provider and the Auckland Airport company clarified their emergency instructions to staff and amended their procedures for responding to flight crew requests for rescue fire assistance.

Safety recommendations were made to the Director of Civil Aviation regarding a direct communication link between aerodrome control towers and rescue fire service stations, and a programme of education on emergency communications.

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Abbreviations

AEP	aerodrome emergency plan
Airways	Airways New Zealand
ATC	air traffic control
^{o}C	degree(s) Celsius
^{o}F	degree(s) Fahrenheit
mm	millimetre(s)
RFS	rescue fire service
UTC	coordinated universal time

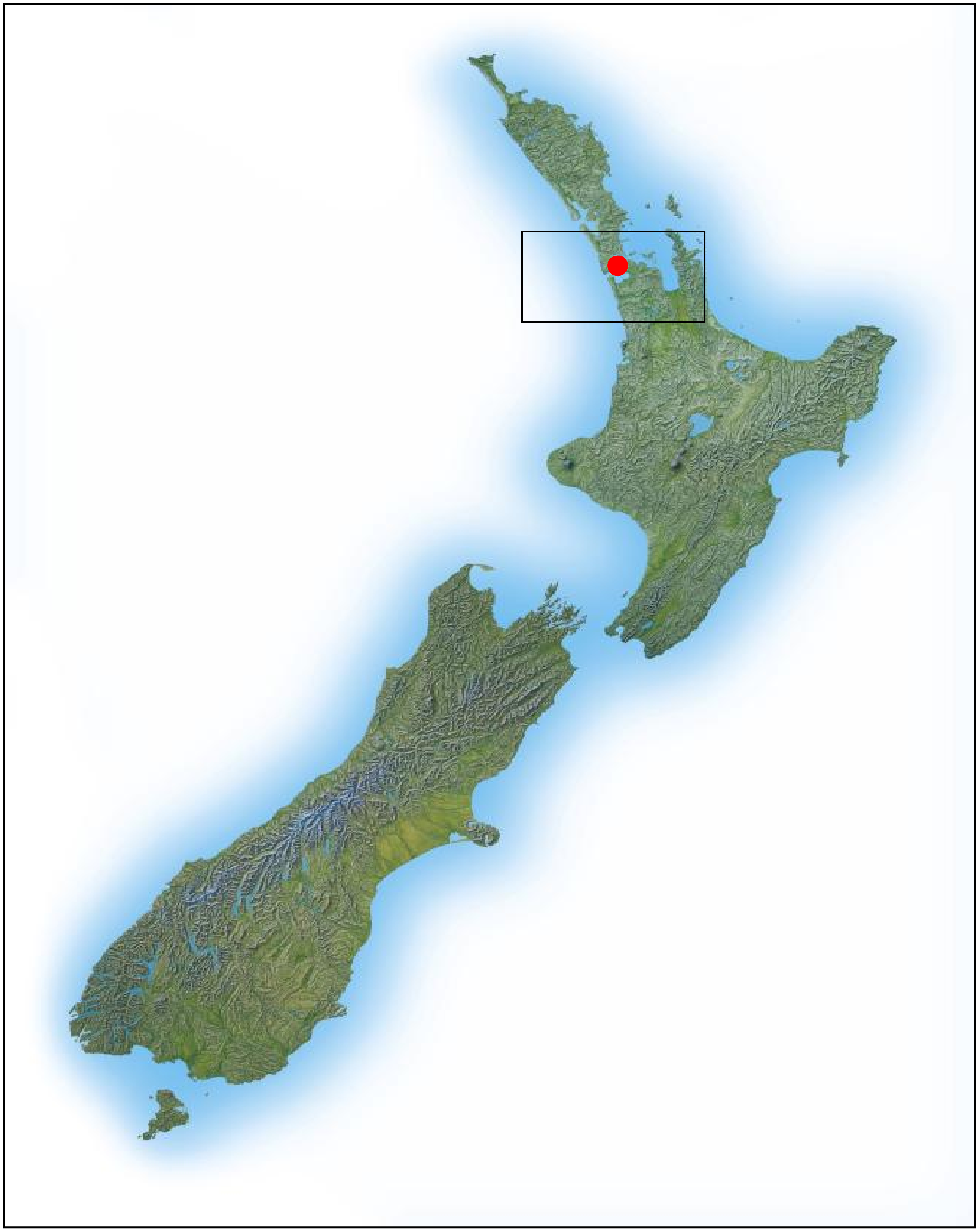
Glossary

apron	a defined area on an aerodrome, intended to accommodate aircraft for the purposes of loading or unloading passengers and cargo, refuelling, parking or maintenance
Apron	the radio and telephone call sign for the Auckland Airport Apron Information Service that was responsible for coordinating movements around the terminal and on the apron. The service was separate from air traffic control's Ground Control function that controlled movements between the apron and runways
distress	a condition of being threatened by serious and/or imminent danger and requiring immediate assistance. The spoken distress signal is "MAYDAY"
urgency	a condition concerning the safety of an aircraft, or of some person on board or within sight, but which does not require immediate assistance. The spoken urgency signal "PAN, PAN", preferably said 3 times, was meant to attract attention and assert priority in communications

Data Summary

Aircraft registration:	ZK-NCK
Type and serial number:	Boeing 767-319, 26971
Number and type of engines:	2 General Electric CF6-80C2-B6F turbofans
Year of manufacture:	1997
Operator:	Air New Zealand Limited
Date and time:	30 December 2006, 0706[1]
Location:	Auckland International Airport latitude: 37° 00.5´S longitude: 174° 47.5´E
Type of flight:	air transport
Persons on board:	crew: 12 passengers: 135
Injuries:	crew: nil passengers: nil
Nature of damage:	minor
Pilot's licence:	airline transport pilot licence
Pilot's age:	49
Pilot's total flying experience:	12 000+ hours, including 1077 hours on Boeing 767
Investigator-in-charge:	P R Williams

[1] Times in this report are in New Zealand Daylight Time (UTC+13 hours), and expressed in the 24-hour mode.



General area of the incident

1 Factual Information

1.1 History of the flight

Aircraft landing and fire warning

1.1.1 On the night of 29 December 2006, ZK-NCK, a Boeing 767-319 aircraft, flew from Auckland, New Zealand to Apia, Samoa and returned the next morning as flight NZ61 with 135 passengers on board. The same 3 pilots, a captain, a first officer and a second officer operated both flights, but the cabin crew was changed at Apia. A line engineer was carried to perform the servicing at Apia, and neither he nor the pilots noted anything unusual with the aircraft. There were no relevant deferred defects when ZK-NCK departed Apia.

1.1.2 At 0705 on 30 December 2006, the first officer landed the aircraft on runway 23L at Auckland under visual meteorological conditions. He used full reverse thrust, which was cancelled at approximately 60 knots prior to turning off the runway at taxiway A8 (see Figure 1).

1.1.3 Three seconds after the thrust reversers were stowed, a fire warning annunciated for the left engine. The first officer stopped the aircraft and the pilots carried out the engine fire checklist, which included shutting down the left engine. The fire warning remained after the initial actions had been taken, so an engine fire extinguisher was discharged. All fire indications had ceased 27 seconds after the first warning. The captain then took control of the aircraft.

1.1.4 At 0706, the first officer advised the air traffic control (ATC) ground controller, "We have had a fire indication on the left engine" and asked if there was any sign of a fire. The controller saw no sign of fire, but asked if the pilots wanted the "fire department out for a look". The first officer said they did. The ground controller then said, "There is a possibility you've got something there, so I'll get you to roll ahead, right at [taxiway] Bravo 10 onto Bravo to hold."

1.1.5 The captain said that the urgency signal[2] was not used with any of these communications because the fire warning had ceased after the flight crew took the required action, and the rescue fire service (RFS) was requested only to conduct an external inspection of the left engine to confirm the status of the engine. The ground controller did not specifically ask whether the pilots were declaring an emergency.

1.1.6 The captain informed the cabin crew and passengers of an engine problem, reviewed the emergency checklists with the crew and urged them to remain alert for a possible ground evacuation. The aircraft stopped on taxiway B shortly before 0710, some 4 minutes after the initial fire warning.

1.1.7 Shortly before 0714, the second officer tried to call the RFS crew chief on the ground control frequency, but the ground controller intervened and said that the RFS had been requested but had not yet responded. The controller said he had no direct contact with the RFS unless he was to use the "crash" button in the tower, which he thought was not warranted. The captain said that the flight crew had agreed with that decision and that no urgency situation existed.

1.1.8 The captain then shut down the right engine and advised the airline's control centre of the delay. The airline's line maintenance team overheard that call and dispatched a tug and engineers to assist. ATC cleared the tug to drive to the aircraft, where the engineers found no sign of fire.

1.1.9 At 0715, the RFS crew chief called the ground controller to say they were responding to the "hot brakes" incident. The ground controller said, "It was a fire indication" and that the pilots just wanted a visual inspection and probably didn't need all the trucks.

1.1.10 Shortly after 0718, the captain advised the airline that the RFS crew chief had cleared the aircraft of any fire hazard. The aircraft was towed to the terminal gate at 0727. Engineers then confirmed that there had been a fire inside the left engine nacelle and that there was a leak from the fuel manifold.

[2] The signal "PAN, PAN". See paragraph 1.5.8.

1.1.11 No one was injured.

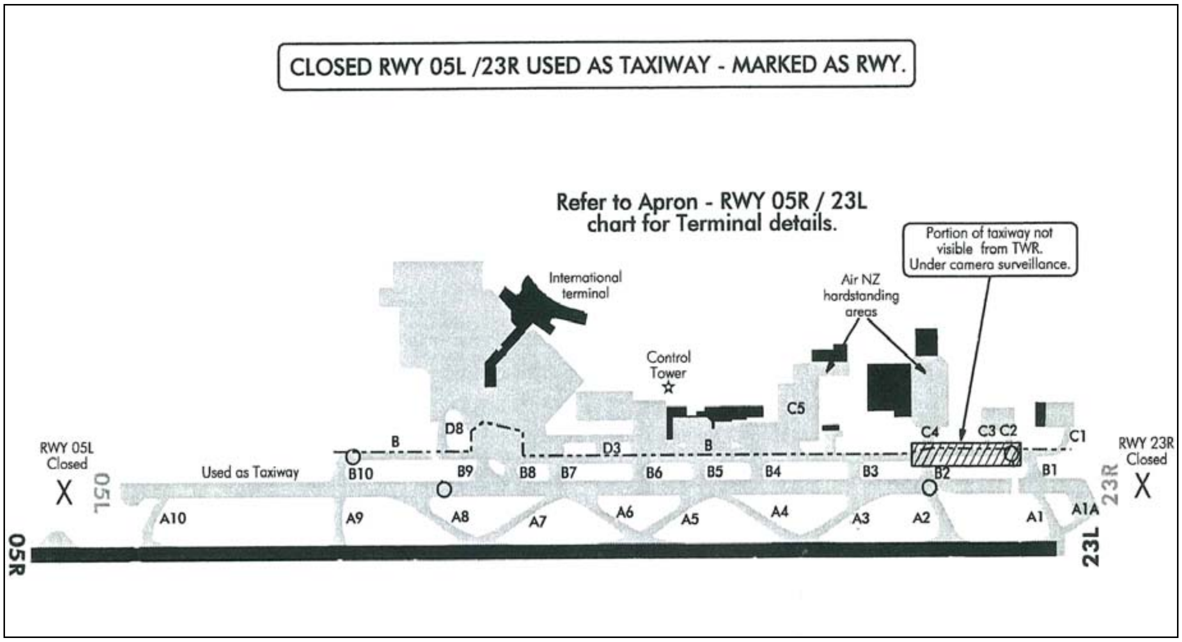


Figure 1
Auckland International Airport plan
(Diagram adapted from Aeronautical Information Publication of New Zealand, courtesy of Airways New Zealand.)

Response of air traffic control and the airport company

1.1.12 The ATC staff in the tower comprised: an aerodrome controller and a flight data assistant; a ground controller, responsible for aircraft and vehicles on the manoeuvring area other than the runway; and a delivery controller, who issued route clearances to aircraft and was also the shift manager. The air and ground traffic situation was busy, and the ground and delivery controllers continued to manage other movements while dealing with the NZ61 incident.

1.1.13 The ground controller said that he advised the others in the tower of the situation immediately after the initial advice from the aircraft. He said that because no emergency had been declared by the pilots of NZ61, he considered there was no need to activate the aerodrome emergency plan (AEP).

1.1.14 The ground controller could not recall whether he had asked the delivery controller to call the RFS or the delivery controller had offered to do so, but he considered that once the delivery controller had got involved, the delivery controller was then responsible for coordinating the subsequent assistance to the aircraft. Both controllers said that they had felt a full RFS response was not required and could have been hazardous with the number of other ground movements.

1.1.15 Three minutes after the ground controller offered to request a fire truck, staff of the airport company's Apron Information Service ("Apron") overheard the crew of NZ61 asking on the ground control frequency if the RFS was on the way. Apron then telephoned the airport company's incident control room to ask whether ATC had requested the RFS. The incident control room staff were not aware of an incident and said they would check with ATC, but there was no record that they did so.

1.1.16 Around the same time, another Apron staff member telephoned the ground controller and asked if the RFS was required. The ground controller said yes and indicated that, other than using the crash alarm, which he did not want to do, he had no direct line with the RFS.

1.1.17 Apron then called the incident control room again and asked for a fire truck to attend to NZ61 and suggested that the problem could be "brakes".

1.1.18 The delivery controller said that he was not immediately aware of the incident. He said that he was not specifically asked to call the RFS and he had thought that the ground controller was expecting an RFS vehicle that Apron had arranged.

1.1.19 At 0711, the delivery controller telephoned Apron and asked when the fire truck would be dispatched. The ground controller recalled that the delivery controller and flight data assistant discussed how to call the RFS directly and he advised them that as the RFS station was not always manned, they should telephone extension 98777, which he knew would be answered in the incident control room.

1.1.20 At 0712, about 6 minutes after the pilots had accepted the offer of assistance, ATC made the first telephone call to the incident control room to request the RFS. The delivery controller dialled 98777, which he thought would connect with the RFS station. Incident control room staff answered and said the RFS was on the way, but the delivery controller could see from the tower that no truck had left the station. The alarm rang in the RFS station at 0713.

1.1.21 The delivery controller thought that the only direct link between ATC and the RFS was via the crash alarm buttons, although he knew that the "emergency" telephone on the controllers' consoles went to the incident control room and was heard by other parties, including the RFS.

1.1.22 At about 0714, the delivery controller again rang the incident control room to ask where the RFS was. The RFS crew chief reported being at the aircraft just after 0715.

1.2 Damage to aircraft and preliminary defect determination

1.2.1 The aircraft was fitted with 2 General Electric Aircraft Engines Limited (General Electric) CF6-80C2-B6F[3] turbofan engines. Further engine information is in section 1.4. Damage was confined within the left engine nacelle. The rubberised thermal protective coating of the thrust reverser inner diameters had patches of heat damage from the 5 o'clock to 6 o'clock positions[4] below the fuel manifold (see Figure 2).

Figure 2
Damage to left engine cowls, ZK-NCK
Left: thrust reverser inner diameter. Right: damage at 5-6 o'clock position.

[3] The suffix B6F signified the specific thrust rating and installation on the Boeing 767 type.
[4] Clock positions were as seen from the rear of the engine, looking forward, the top of the engine being 12 o'clock.

1.2.2 Soot was present on the compressor rear frame, except at the one o'clock position of the fuel manifold, by the #3 loop clamp (see Figure 3). General Electric advised that soot does not adhere to surfaces hotter than 700°F (370°C).

1.2.3 Once the engine had cooled, it was motored and a fuel leak was found at the #3 clamp location.

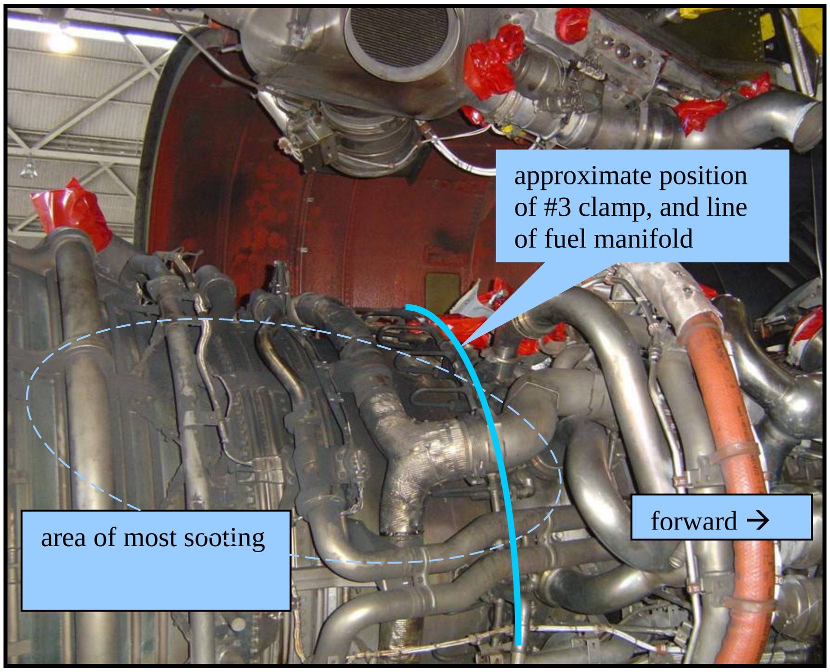


Figure 3
Area affected by fire, left engine of ZK-NCK

1.2.4 The #3 clamp was removed in the presence of the Commission's investigator. The clamp was loose on the manifold, but the attachment bolt break-out torque exceeded that specified. There was residue of a fibreglass tape, used to help achieve the required torque, under the clamp. Some cushion material was missing from inside the clamp and there were signs of metal-to-metal wear (see Figure 4). A pinhole was found in the fuel manifold where the clamp had been located.

1.2.5 Subsequent handling of the clamp caused further damage to the cushion material.

1.2.6 Chafing under fuel manifold clamps was a known problem with the CF6-80C2 engine series and had been addressed by General Electric service bulletin number CF6-80C2 SB73-0326, which required fuel manifolds and the 24 clamps on each engine to be inspected every 4500 flight hours. Both engines on ZK-NCK had been last inspected on 19 November 2006, 450 flight hours and 102 cycles[5] prior to this event, with no manifold chafing found.

1.2.7 The left engine, serial number 704518, was replaced and the left engine thrust reverser halves required minor repairs before ZK-NCK was returned to service.

1.2.8 Examination of the fuel manifold found 5 other clamps with excessive sideways movement, although the torque on 4 of them met the requirement. The exception had a torque value just below that specified and was the only clamp without tape under it. The tape was abraded at all loose clamp locations, and through to the manifold at 4 of these.

[5] An aircraft cycle was one take-off and one landing.

1.2.9 The cushion material was intact on all of the clamps, apart from #3, but the material was compressed and polished, although noticeably less so on the clamps from the left manifold half that had been replaced in November 2005.

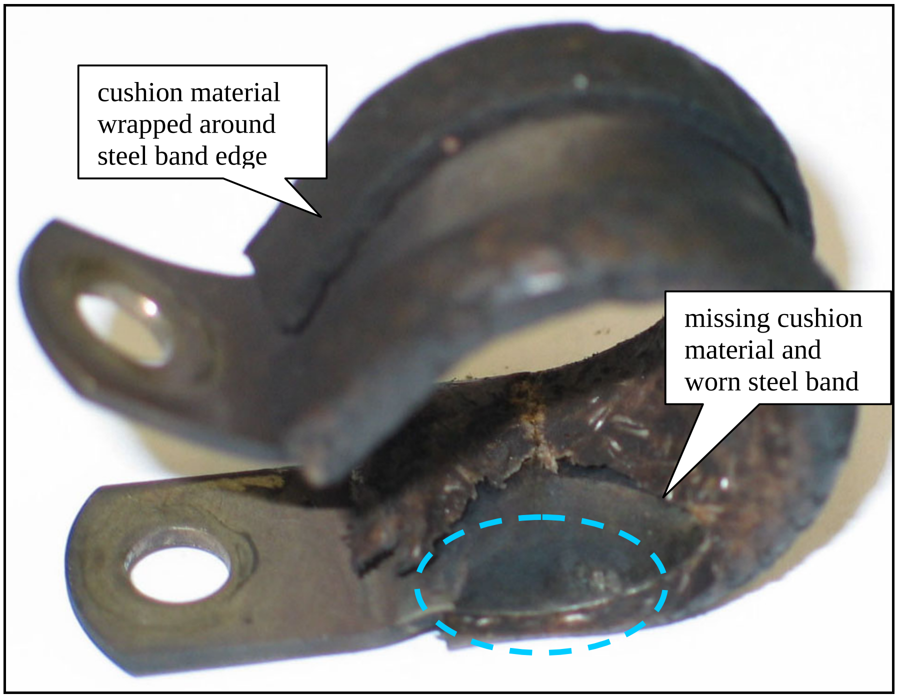


Figure 4
#3 loop clamp from engine serial number 704518
Showing missing cushion material and metal wear.

1.2.10 All but one clamp position was taped and the tape condition was generally poor. In addition, remains of 4 different types of approved tape, of apparently varying ages, were present.

1.2.11 The fuel nozzles were connected to the manifold by “pigtails” (see Figure 5). Those at positions 7 and 12, or approximately the 3 o’clock and 5 o’clock manifold positions, were seen to be bent before the manifold was removed. The operator suggested that the “pigtails” could have been inadvertently bent during the replacement of their adjacent engine igniters some time previously.

1.2.12 The fuel manifold and clamps were sent to General Electric for further examination and the engine was sent to an overhaul facility.

1.2.13 The aircraft manufacturer reviewed the incident and concluded that no changes to the aircraft systems or flight crew procedures were necessary.

1.3 Personnel information

Aircraft crew

1.3.1 Each pilot held a current airline transport pilot licence with more than 1000 flight hours on the B767 and over 10 000 total flight hours. Each pilot had completed a simulator check within the previous 3 months, and the captain and the first officer had crewed a simulator session that included engine fire drills a week prior to the incident. The captain and first officer had completed operational line checks in August 2006.

1.3.2 None of the pilots had accrued more than 15 hours of flight time over the previous 7 days or more than 48 hours in the previous 30 days. Prior to reporting for flight NZ60 to Apia on

29 December 2006, the captain had had more than 3 days free of duty, the first officer nearly 30 hours, and the second officer 9 days. The cabin crew had had 44 hours free of duty prior to joining NZ61.

1.3.3 The flight crew had been on duty for about 10 hours when NZ61 landed at Auckland. Appropriate in-flight rest had been taken to preserve their alertness for the arrival.

1.3.4 The pilots and flight service manager had all completed annual safety and emergency procedures training within the previous 9 months.

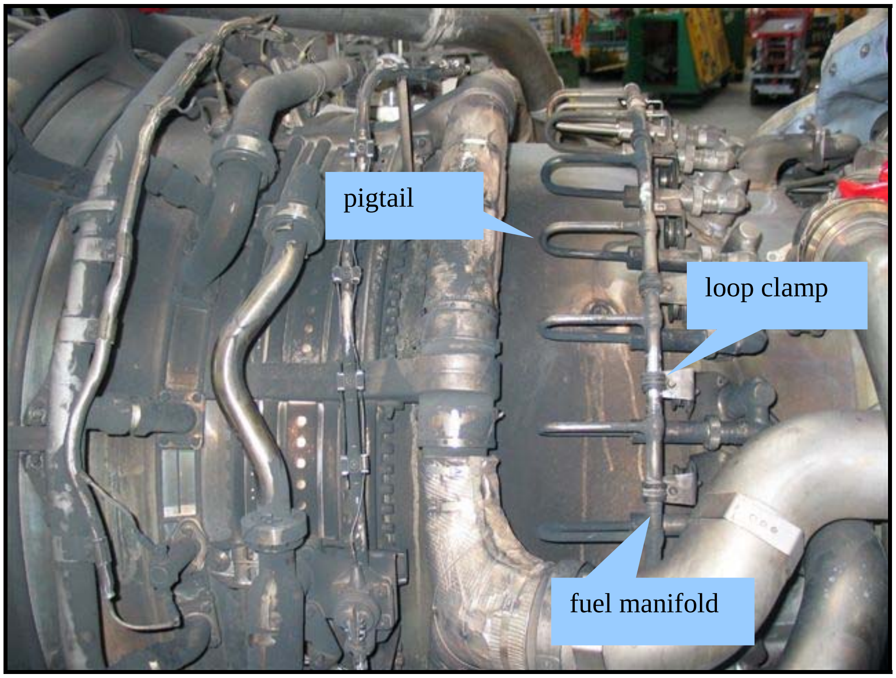


Figure 5
Fuel manifold and clamp locations, engine 704518

Air traffic controllers

1.3.5 Airways New Zealand (Airways) provided ATC services at controlled aerodromes and employed the controllers. At Auckland, the delivery controller was in charge of the tower when 2 or more controllers were on duty, and was responsible for coordinating with other parties during non-standard events[6].

1.3.6 The ground controller's responsibilities included: providing an ATC service to arriving aircraft taxiing after landing until, in the case of international flights, the aircraft were passed to Apron; answering the direct telephone line with Apron; and activating the AEP in the event of an aircraft emergency.

1.3.7 The delivery controller started his duty on 30 December 2006 at 0630, having completed his previous shift at 1500 the day before. In the 3 days prior to 30 December, he had worked 14.25 hours' duty, including breaks, and had one day free of duty.

1.3.8 The ground controller also started his duty on 30 December 2006 at 0630, having completed his previous shift at 2045 the day before. The minimum break between shifts in a roster was 9.5 hours. In the 3 days prior to 30 December, he had worked 17.75 hours' duty.

[6] Controllers' responsibilities were taken from Airways' Auckland Tower Main Trunk Procedures manual.

1.3.9 Each controller had held an ATC licence for at least 25 years, was rated for all tower controller positions at Auckland, and had passed a proficiency check within the previous 4 months.

Airport company incident staff

1.3.10 The incident control room was a unit of the airport operator, Auckland International Airport Limited, and had been established to receive notifications of all airport incidents and emergencies and to manage the company's initial response to them. The incident control room staff used a computer program to help them choose the appropriate checklist and response to an incident or a request for assistance.

1.3.11 The airport's Response Unit fulfilled the traditional RFS role, but more than 90% of the Unit's call-outs were to non-operational events elsewhere at the airport, such as building fires and medical emergencies[7].

1.3.12 Most of the training of incident control room and RFS staff was done in-house. The airport company said that at the time of the NZ61 incident, the incident control room was manned by the required 4 staff, and the RFS was fully manned to the required standard.

Maintenance technician

1.3.13 The technician who had most recently completed the fuel manifold inspection on ZK-NCK had trained for one year at the Air New Zealand Technical Training School in Christchurch, then spent a year in other employment before joining Air New Zealand Engineering Services[8] at Auckland in 2002 as an apprentice. He had completed his apprenticeship in January 2006 and on 30 December 2006 he held a Level 4 Certificate in Aeronautical Engineering.

1.3.14 The technician said that he could recall quite well performing the inspection on 19 November 2006 and that apart from asking someone to get a replacement anchor nut from the store, he had worked alone on the left engine, without difficulty or interruption. He had accomplished the service bulletin 3 or 4 times previously on Boeing 767 and Boeing 747 aircraft.

1.3.15 He said that the leading hand who assigned him the task had signed off the work after a check of all clamps for security. The leading hand had left the company prior to the engine fire incident and was not available for comment.

1.4 Aircraft and engine information

1.4.1 ZK-NCK was a Boeing 767-319 manufactured in the United States in 1997 and delivered to the operator in June that year. The aircraft was fitted with 2 General Electric CF6-80C2 turbofan engines manufactured by General Electric Aircraft Engines Limited. The CF6-80C2 model engine was used on at least 5 other aircraft types, including some of the operator's Boeing 747-400 aircraft.

1.4.2 Engine serial number 704518 (the engine) was delivered new to the operator in June 1997, and installed on the left wing of ZK-NCK on 19 April 2002. At the time of the incident, the engine had accumulated 26 056 hours and 4171 cycles since installation on ZK-NCK and 42 789 flight hours and 6740 cycles since new.

1.4.3 Fuel was supplied to the CF6-80C2 engine combustion module through 30 evenly spaced nozzles. Each nozzle was connected by a "pigtail" to the fuel supply manifold (see Figure 5).

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[7] Although operational incidents were a minor part of the Response Unit's work, it is referred to as the RFS in this report. On 1 February 2008, the Unit's name was changed to Airport Emergency Services.
[8] Air New Zealand Engineering Services was a maintenance, repair and overhaul company within the Air New Zealand group. As a certificated design organisation, it could design changes for aircraft and engines and their components.

1.4.4 The incident engine was fitted with a drain-less type fuel manifold, comprising 2 independent halves. The right half, which developed the pinhole leak, had General Electric part number 1303M32G12 and operator's serial number ANZ0030.

1.4.5 The manifold tubing was constructed of stainless steel with a nominal outside diameter of 0.675 inch (17.15 millimetres (mm)) and a nominal wall thickness of 0.035 inch (0.89 mm). The typical operating fuel pressure was 1000 pounds per square inch.

1.4.6 The manifolds were held in place by 24 cushioned loop clamps, or "P" clamps, General Electric part number J1220G10, which were bolted to friction brackets. The clamps were made of a stainless steel band sheathed in a composite cushion material reinforced with braided glass fibres. The cushion material was wrapped around the edge of the steel band. The acceptable cushion thickness was 0.042 to 0.062 inch (1.07 to 1.57 mm). The manifolds were further supported by 2 brackets on the lower half and by the "pigtails".

1.4.7 The manifolds and all clamps on the engine were new items at installation, in accordance with assembly instructions.

1.4.8 The right manifold half had not been replaced since the engine was installed on ZK-NCK, but the left half had been replaced in November 2005 after a leak was discovered during scheduled maintenance. That leak was caused by chafing, but not at a clamp location. Replacement of the manifold half would have required the removal of all of the clamps, but there was no record on whether any clamps were replaced.

1.4.9 General Electric advised that there had been 12 reported fuel manifold leak events worldwide on CF6 engines between the issue of the service bulletin in March 2003 and October 2007, with 9 of the events having occurred since 2006. The 30 December 2006 event was the first to be reported by flight crew and the first time that clamp chafing had led to a fire.

1.4.10 Another 10 leaks and 2 fires had been caused by failures of "pigtails", a problem that had been addressed by a separate service bulletin.

1.4.11 Air New Zealand Engineering Services had no record of any other maintenance to the manifolds or nozzles since the previous scheduled major inspection, and the operator had not had any recent reports of abnormal fuel usage on ZK-NCK.

General Electric service bulletin CF6-80C2 SB73-0326

1.4.12 General Electric service bulletin CF6-80C2 SB73-0326, issued on 5 March 2003, prescribed an inspection of the fuel supply manifolds for chafing caused by loose or worn cushioned clamps. Extracts from the accomplishment instructions of the service bulletin are in the Appendix. No specific training was provided for the inspection as it required basic trade skills only.

1.4.13 After initial compliance, repeat inspections were required every 4500 flight hours, which, for Boeing 767 line operations with this operator, were achieved every 9 to 10 months. Air New Zealand Engineering Services said that it had conducted more than 190 of these inspections, and found only 3 examples of chafing, none of which resulted in metal-to-metal wear.

1.4.14 Previous inspections of engine 704518 in accordance with the service bulletin were as follows:

Inspection	Date	TSPI	Notes
1	20 Mar 03	-	2 clamps replaced
2	6 Jan 04	4396	20 clamps replaced
3	13 Sep 04	4175	24 clamps replaced
4	19 May 05	3964	Nil clamps replaced
5	6 Feb 06	4002	Nil clamps replaced
6	19 Nov 06	3869	Nil clamps replaced
Removal	31 Dec 06	450	Leak and engine fire

TSPI = time (flight hours) since previous service bulletin inspection.

1.4.15 The number of clamps noted was the number ordered from stores against the relevant job number. There was no record of how many clamps were actually replaced and, being low-cost consumable items, none was required. Clamps could have been requisitioned for a job and not used and others could have been obtained from elsewhere.

1.4.16 The technician who had completed the most recent service bulletin inspection said the task had been time consuming but not difficult. He said he always read the task cards and any associated service bulletin first. He recalled that the task on 19 November 2006 was done in the afternoon in the main hangar at Auckland, and he did not think that he would have been fatigued. Access to the components, lighting and equipment were all acceptable. He could not recall any time pressure.

1.4.17 He said that for such repetitive tasks he marked a reference point and worked on one clamp at a time. At the finish, he checked the first component again to be sure all were done. He said he first checked for clamp looseness and, after moving a clamp aside, he checked any tape for chafing before removing that. He checked the manifold using a torch and a mirror, and by touch. If a clamp appeared to be worn, he would remove it from the manifold for inspection. He was alert to the possibility of cushion edges splitting and exposing the band of the clamp.

1.4.18 The technician said he could not recall particular clamps that were loose or replaced during the most recent inspection, but he remembered not many clamps were replaced. He said that on previous occasions he had found manifold chafing that was within limits and clamps that had to be replaced, but he could not recall a damaged clamp and chafed tube together. He said that re-fitting the clamp and the use of tape to get the required torque was a trial and error process, but he had never had to use more than 2 winds of tape to get it right. He said that unless a tape roll ran out, it was unlikely that he would have to use more than one type of tape.

1.4.19 Four other technicians familiar with the service bulletin were interviewed. All said that when they had done the inspection, lighting, tooling and access to the engine were acceptable. They noted that some clamps were difficult to reach and you had to persevere to inspect them properly, because unless a clamp was removed from the manifold, the inside face of the clamp could not be fully seen. None of the technicians had seen damaged clamp cushion material.

1.4.20 While all those interviewed seemed to understand correctly the intent of the service bulletin, there were 2 schools of thought as to whether the clamp should be removed completely from the manifold. Some felt the clamp had to be removed, even though the instructions said it was not necessary, because the cushion material could not be properly inspected if the clamp remained around the manifold.

1.4.21 There were also opposing views on whether clamps that were loose before the inspection could be re-used, and whether tape could be used with existing clamps to get the required tightness.

1.4.22 In spite of the 4500 flight hours' inspection interval, General Electric's data indicated that the longest time achieved since the last inspection for an engine that had a manifold leak caused by clamp chafing was 2672 hours.

1.4.23 The Air New Zealand Engineering Services internal investigation of the 30 December 2006 event concluded that the #3 clamp was already damaged, and its condition should have been detected at the time of the previous inspection 450 flight hours earlier. However, the company considered that the service bulletin content may have contributed to an ineffective inspection, and it recommended that General Electric review the service bulletin.

1.4.24 The service bulletin did not instruct the removal of old tape from under clamps, did not address the difficulty of inspecting the cushion material while the clamps remained on the manifold, and allowed the re-use of clamps.

1.4.25 Subsequent action taken by Air New Zealand Engineering Services and General Electric, including a revision of the service bulletin, is shown in section 4 of this report.

1.5 Communications

1.5.1 All communications between NZ61 and ATC during the incident were on the ground control frequency, 121.9 megahertz. Communications between ATC, Apron and the incident control room were by telephone, and those between the incident control room and the RFS were by telephone and ultra high frequency radio.

1.5.2 In the ATC tower, there was a prominent crash alarm button at each controller's console. Pushing the button activated a klaxon in the RFS station and an alarm in the incident control room and in the Apron observation room.

1.5.3 Separate "emergency" telephone switches at each console connected controllers directly to the incident control room only. However, the conversation was automatically transmitted to Apron and the RFS station and over RFS radios. The airport company expected controllers to report all aircraft emergencies via the "emergency" line, because the company trained its incident control room staff to give priority to that communication channel.

1.5.4 The airport company said that anyone, including a controller, who observed an emergency or hazard not involving an aircraft should call extension 98777, which was answered in the incident control room. Calls on that extension were not re-broadcast.

1.5.5 Above the ATC controllers' consoles were notices that read:

> For all emergencies…phone 256 8777 or ext 98777.

Other notices in the tower stated "Dial ext 98777 (Rescue Fire)". Controllers spoken with on 2 visits to the tower during this investigation said that they would report an aircraft emergency by dialling 98777, as the notices directed. Some controllers thought the direct emergency line should also be used but none of those asked was sure which calls the RFS could hear directly.

1.5.6 The International Civil Aviation Organisation recommended[9] that a control tower be linked directly with its RFS station:

> ***Communication and alerting systems***
> 9.2.31 *Recommendation – A discrete communication system should be provided linking a fire station with the control tower, any other fire station on the aerodrome and the rescue and fire fighting vehicles.*

1.5.7 The RFS staff at Auckland did not monitor ATC frequencies or watch aircraft movements, although some staff were always in the RFS station. If the crash alarm activated or the incident

[9] International Civil Aviation Organisation, Annex 14, Volume 1, Aerodromes, 4th edition, July 2004. Note that this was a recommendation, not a standard.

control room initiated a call-out, relevant telephone calls were simultaneously broadcast to the RFS station loudspeakers and to radios in the rescue vehicles. The responding RFS crew chief could communicate from a vehicle directly to aircraft pilots on the ground control frequency.

1.5.8 Distress[10] was defined as "a condition of being threatened by serious and/or imminent danger and requiring immediate assistance". Urgency was defined as "a condition concerning the safety of an aircraft, or of some person on board or within sight, but which does not require immediate assistance". The definitions did not imply that their use was restricted to in-flight situations. The pilot of an aircraft with a distress or urgency condition should transmit the spoken signal "MAYDAY" or "PAN PAN" as appropriate, followed by the nature of the condition, the crew's intentions and their position.

1.6 Aerodrome emergency plan

1.6.1 An aerodrome operator was required[11] to have an AEP that described how the operator and assisting agencies would respond to emergencies occurring on or in the vicinity of the aerodrome.

1.6.2 Civil Aviation Rule Part 172, Air Traffic Service Organisations – Certification, stated in part:

> **172.109 Aircraft emergencies and irregular operation**
> (a) Each applicant for the grant of an air traffic service certificate shall establish procedures to ensure maximum assistance and priority is given to an aircraft known, or believed to be, in a state of emergency.

1.6.3 The Aeronautical Information Publication New Zealand stated in part[12]:

> The [air traffic service] unit on the aerodrome is responsible for alerting the emergency services, following a request from a pilot or when an aircraft was considered to be in any of the following emergency phases:
>
> (a) Local Standby Phase: when an aircraft approaching the aerodrome is known, or suspected, to have developed some defect, but trouble is not such as would normally prevent carrying out a safe landing…will bring all aerodrome-based emergency services to a state of readiness...
> (b) Full Emergency Phase: when an aircraft approaching the aerodrome is, or is suspected to be, in such trouble that there is danger of an accident…will bring all facilities, both on the aerodrome and in the city…to a rendezvous point on the aerodrome. It will also alert the hospital…
> (c) Aircraft Accident Phase: when an aircraft accident has occurred on or in the vicinity of the airport.
>
> When an emergency occurs in flight and adequate communications exist, the pilot is responsible for advising [ATC] accordingly and for nominating the desired state of readiness of the aerodrome emergency services.

1.6.4 Airways commented that the Local Standby and Full Emergency phases were defined for "an aircraft approaching the aerodrome", not for an aircraft at an aerodrome.

1.6.5 The Airways Auckland Tower Main Trunk Procedures amplified sections of the airport company's AEP. In particular, the Alerting System was to be activated "when an aircraft emergency occurs within the jurisdiction of the Auckland airport Aerodrome Emergency Plan". The Airways procedure noted that the tower crash alarm sounded in the RFS station, but did not show that an alarm also sounded in the incident control room and at the Apron observation room. The procedure correctly stated that the dedicated emergency telephone was answered in the incident control room.

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[10] Aeronautical Information Publication New Zealand, section ENR 1.15.
[11] Civil Aviation Rule Part 139.57, Aerodrome Emergency Plan.
[12] Aeronautical Information Publication New Zealand, ENR 1.15-12.

1.6.6 The Airways procedure for passing a Local Standby or Full Emergency message to the incident control room if time was short was:

1. Pass ATC Immediate Action List details to ICR[13].
   Add Nature of Trouble. [Emphasis in original.]
2. Advise ICR to "Standby Readback".
3. Clear Rescue Fire vehicles onto manoeuvring area using [frequency] 121.9 [megahertz].
4. Request readback of ATC Immediate Action List details from ICR.
5. Pass remainder of "Emergency Message" to ICR.
6. Request readback of "Emergency Message".

1.6.7 The AEP Local Standby procedure listed, in part, the following actions for Airways staff:

- When communication is difficult or pilot's requirements are unclear, the following shall be used as a guide:
  - If a fire warning light is showing but there is no apparent sign of fire;
  -…
  - Any other situation when the Surface Movements Controller [ground controller] estimates that the condition does not require full emergency action.
- Sound the crash alarm.
- Pass Emergency Message as per the proforma on Emergency Line…
- After the aircraft has landed and when considered necessary, instruct the pilot to change frequency to 121.9 MHz [megahertz] to allow direct communication with Rescue Fire Control…

Note
1. It is the pilot's responsibility to nominate activation of Local Standby…

1.6.8 The "ATC Immediate Action List" was included on the Emergency Message proforma, which was readily available to controllers in the tower.

1.6.9 The Aeronautical Information Publication New Zealand had no reference, as it once did, to any facility for a pilot with an emergency or operational problem to speak directly to the responding RFS unit at the aerodrome of landing. However, the RFS crew chief had to be on the ATC ground control frequency in order for RFS vehicles to be cleared onto the manoeuvring area.

1.6.10 If a pilot reported a condition or requested assistance without using the urgency or distress signal or stating the desired level of aerodrome emergency services response, ATC could determine an appropriate response. However, the airport company advised that experience had taught it to not send a sole vehicle to any aircraft incident, and all Local Standby situations at Auckland were met with a full turn-out of available RFS crews. Some off-airport agencies, such as the ambulance service, would also be notified.

1.6.11 The airport company said that its "Local response – no emergency declared" procedure covered incidents that did not have Local Standby or Full Emergency status, but the procedure and the incident control room checklist, titled "Local standby – no emergency declared", were not published in the AEP.

1.6.12 Auckland ATC had a corresponding local procedure "Rescue Fire Assistance Requested – No Declared Emergency" that read in part:

1. Confirm that pilot does not wish to declare an emergency
2. Select EMG [emergency] phone line
3. Pass the following details:
   - LOCAL RESPONSE – NO EMERGENCY DECLARED
   - Type of aircraft
   - Aircraft call sign
   - Nature of trouble
   - Type of assistance requested

[13] Incident control room.

1.6.13 That procedure had been amended, on an unknown date, by "Aircraft Requesting Rescue Fire assistance – No Emergency Declared", a copy of which was in an "Emergency Folder" in the tower. The significant differences were:

> 1. Sound the crash alarm…
> 4. When 'Rescue Fire Control' calls on 121.9 [megahertz], issue clearance for response vehicles to enter the manoeuvring area...
> 6. Restrict all aircraft movements as necessary.

1.6.14 Following a review of procedures immediately after the incident, Airways removed the "Aircraft Requesting Rescue Fire assistance – No Emergency Declared" procedure and reinstated the previous "Rescue Fire Assistance Requested – No Declared Emergency".

1.6.15 Having reviewed the incident, the airport company considered that the RFS had acted appropriately and responded promptly once alerted. It said the delay in alerting the RFS was due to the following:

- ATC did not call the ICR on the direct "emergency" line, as required in the AEP
- The request for one fire truck did not fit the ICR predetermined responses
- Information came to the ICR from various uncoordinated sources and was unclear.

1.6.16 As required by Civil Aviation Rules, the airport company conducted aircraft emergency exercises and "table-top" exercises on alternate years to test the AEP. The exercise instruction for the most recent aircraft emergency exercise, conducted on 8 November 2006, had stated, in part, that the first strategic objective was to "test and assess notification systems for an aircraft emergency".

1.6.17 Airways was not listed as a participant in the most recent AEP exercise. Its involvement was usually limited to starting an exercise with a simulated emergency message to the incident control room. The exercise debriefs and umpires' reports had not noted any deficiency with communications between ATC and the incident control room.

1.7 Flight recorders

1.7.1 The aircraft was fitted with an Allied Signal (now Honeywell) digital flight data recorder. Relevant data for the incident flight was provided to General Electric and is commented on in section 1.9 of this report.

1.7.2 The aircraft was fitted with a cockpit voice recorder, which was not downloaded because adequate information was obtained from the pilots and other sources.

1.8 Fire

1.8.1 Inspection of the engine after the event found no sign of an abnormal ignition source, and no bleed air leaks. General Electric advised that the typical engine case temperature in the vicinity of the fuel manifold during thrust reversal was over 950^{o}F (510^{o}C), reducing to 450^{o}F (230^{o}C) at ground idle thrust. The highest case temperatures were approximately 300 mm aft of the fuel manifold.

1.8.2 General Electric said that the air flow through the nacelle in flight and when maximum reverse thrust was selected on the ground was too great to form a combustible fuel-air mixture in the presence of a fuel leak. The mixture would become critical after thrust reverser stowage, when the air flow was about one-seventh of that during maximum reverse thrust and the engine case was still very hot.

1.8.3 General Electric noted that the fuel auto-ignition temperature was especially dependent on the air velocity in the engine nacelle, which determined the fuel contact time in the heated environment. Test data for conditions similar to those present during the landing of NZ61 showed that the fuel auto-ignition temperature was 990°F (530°C), compared with 435°F (225°C) in still air. Ignition of the fuel-air mixture would have occurred after about half a second of contact with the hot case.

1.8.4 Once the leaking fuel had ignited, the nacelle air flow would have moved the flames aft and downwards and triggered the fire detector. The flight crew response to the fire warning stopped the fuel flow, and the fire could have ceased before the extinguisher was discharged.

1.8.5 The light-to-moderate coating of soot on, and minor heat damage to, a few fire detection loop isolators, which melt or are consumed at temperatures of 1100-1200°F (595-650°C), suggested that the fire was of short duration and no hotter than about 1000°F (540°C).

1.9 Tests and research

1.9.1 The vibration characteristics of the engine over the 3 months prior to the fire event were analysed by Air New Zealand Engineering Services, and the flight data recorder data reviewed by General Electric. No abnormality was detected and General Electric considered that the vibration values, at approximately 25% of the maximum acceptable values, were normal. Subsequent examination of the engine at the overhaul facility found no evidence of vibration damage or incorrect assembly that could have caused vibration.

1.9.2 On 6 August 2007, General Electric, in consultation with an accredited representative of the United States National Transportation Safety Board, completed an examination of both halves of the fuel manifold and all of the clamps from the engine.

1.9.3 The manifold pinhole was 0.014 by 0.031 inch (0.36 by 0.79 mm) in area and had originated in the region of missing cushion material on the #3 clamp. Some of the stainless steel band of the clamp had also worn away.

1.9.4 General Electric believed that foreign abrasive material could accumulate in the cushions of worn clamps and accelerate fretting of the manifold tubing. Residue of fibreglass tape was found outside the fretted area.

1.9.5 The report concluded that there were no material anomalies with the unworn clamp cushion material or the stainless steel used in the clamp and the manifold tubing.

1.9.6 As part of its investigation of this incident, General Electric reviewed the effectiveness of the service bulletin and the inspection interval. Following vibration analysis of the fuel manifold system and clamps, the engine manufacturer concluded that an increased inspection interval would be justified if all clamps were replaced at each inspection.

1.10 Other information

1.10.1 On 5 October 2007, the pilots of a foreign-registered Boeing 777 aircraft taxiing for departure at Auckland advised Apron that they had a cargo compartment fire warning and were returning to the terminal. The pilots added that they thought the warning could be false. The pilots did not declare an emergency, but did ask for the RFS to check the aircraft.

1.10.2 The comment that the warning could be false created uncertainty in Apron as to what response was required. Subsequently, there was confused communications between Apron, the incident control room and the RFS that led to a delay in the RFS responding.

2 Analysis

2.1 The incident involved 2 main safety issues. The fuel leak and subsequent fire in the left engine of ZK-NCK occurred in spite of periodic engine inspections intended to detect fuel manifold chafing before a leak developed. The delay in getting the RFS to inspect the aircraft exposed some unfamiliarity with and weaknesses in the AEP and procedures.

Fuel leak and fire

2.2 The engine fire was a serious incident that arose during operating conditions that were typical and encountered by identical engines many hundreds of times each day worldwide. While General Electric's analysis of nacelle air flow and case temperatures suggested that the risk of an in-flight fire from an event of this cause was low, there was a risk that a fire on the ground could have more serious consequences.

2.3 As nothing untoward was noticed during the turnaround at Apia, it was probable that the leak developed in the manifold during the flight to Auckland. The leak was small enough that the pilots did not notice any unusual fuel usage en route.

2.4 After NZ61 landed, the engine nacelle conditions were conducive to a flammable fuel-air mixture that ignited almost immediately upon contact with the hot engine case. The flight crew response to the fire warning was deliberate and familiar as a result of their recent training.

2.5 The fire warning was still present after the engine was shut down and the fire handle for the left engine was pulled, and remained until after an engine fire extinguisher was operated. That sequence of indications should have suggested to the pilots that the fire warning was genuine.

2.6 The fuel leak was in the manifold below the #3 clamp on the right manifold half, at approximately the one o'clock position on the engine. Although the clamp was properly bolted to the attachment bracket, it was missing some cushion material and metal-to-metal fretting had occurred between the manifold and the clamp.

2.7 The most recent inspection of the engine in accordance with service bulletin 73-0326 was on 19 November 2006 and the one before that was completed on 6 February 2006. Both inspections were completed inside 4500 flight hours from the prior inspection on 19 May 2005. That suggested that the earlier inspections had not been performed well, or that the service bulletin itself was not effective for detecting manifold chafing before it progressed to a leak. The latter was more likely, as discussed below.

2.8 The #3 clamp was located near the top of the engine and was not obstructed by other engine components. The technician who had performed the most recent inspection considered that he had had adequate access, lighting and tools to perform the task, and his description of his work method suggested he was knowledgeable and conscientious.

2.9 The original service bulletin stated that the manifold was to be inspected to detect "…chafing caused by worn cushioned loop clamps". A technician complying with the accomplishment instructions might see that the cushion material on a clamp edge was in good condition but not notice material missing from the inside of the clamp. The only way to inspect the inside of a clamp properly was to remove it from the manifold. For that reason, the initial service bulletin was deficient and was a factor in the damaged #3 clamp not being detected before a leak occurred.

2.10 The original service bulletin instructions did not refer to the possibility of tape being under clamps, which could have been the case if it had been used after a prior inspection. The Air New Zealand Engineering Services investigation suggested that the age and condition of the tape and clamps removed from the fuel manifold meant that the inspection on 19 November 2006 had not met the required standard. Its view was that there would have been obvious damage that had not been detected and which led to a fuel leak only 450 hours later. That conclusion could have been influenced by the condition of the #3 clamp cushion material, which was further damaged during removal and later handling, and might not have looked as it did at the previous inspection.

2.11 The discovery of remnants of tape of different widths on the manifold, and the condition of much of that tape, raised some doubt about the accuracy of the technician's recollection of his inspection on 19 November 2006. The presence of tapes of different type and age could be explained by a technician reasoning that because previously applied tape was not worn, the manifold tubing underneath would not be chafed, so the existing tape could remain. Such logic could have been followed at more than one inspection. The associated clamp was also likely to receive less scrutiny if the tape was undamaged.

2.12 Although the standard of the technician's work on 19 November 2006 was closely reviewed after the engine fire event, that of the person who performed the inspection of 6 February 2006 was not. Because both inspections took place within a 4500-hour period, chafing could have been present throughout that period and not found. Whether the performance of any of the involved technicians did not meet the expected standard could not be conclusively shown.

2.13 The technician said that not many clamps had been replaced on 19 November 2006, but the record of store issues showed that none had been requisitioned for that job and no record had been kept of clamp replacements per specific engine. As there was no record that any clamps had been replaced on the 2 previous inspections, totalling nearly 8000 flight hours, the technician's criteria for assessing the condition of tape and clamps on 19 November 2006 were possibly no different from those of some of his fellow workers. Regardless, clear and effective accomplishment instructions from the engine manufacturer would have reduced the likelihood of ineffective inspection.

2.14 Following an examination of the chafed manifold from the engine, General Electric revised its description of the damage process to say that foreign material could enter damaged cushion material and accelerate wear. The presence of worn tape at 5 loose clamp locations on the manifold supported the conclusion that worn, and not necessarily damaged, clamps could lead to chafing. The service bulletin was revised in August 2007 to require the replacement of all clamps at each inspection. The removal of clamps also permitted better cleaning and inspection of the manifold.

2.15 The revised service bulletin added a requirement for tape residue to be removed prior to manifold inspection, but also removed the earlier option of using tape to get the required tightness of clamp bolts. Air New Zealand Engineering Services advised that it intended to continue applying low-friction tape under loop clamps, a practice that other operators had shown was successful in reducing manifold chafing.

2.16 Although the engine had no unusual vibration characteristics that could have caused chafing, the clamp and bracket assembly configuration was such that a tight clamp could loosen during normal engine operation, with potential for wear and chafing.

2.17 The original service bulletin had required a check for loose clamps after the manifold had been inspected but before the procedural step to re-bolt the clamps to the bracket assemblies. It was not clear whether the service bulletin had been issued with a step missing, but within Air New Zealand Engineering Services an individual variation had developed to check for tightness first. That action had been useful for identifying clamps that could need replacement and locations where chafing could be present. The reissued service bulletin removed the tightness check, probably as a result of new clamps being fitted each time.

2.18 General Electric advised Air New Zealand Engineering Services that the original 4500 flight hours interval was primarily for maintenance convenience rather than based on empirical wear rates of clamps. The interval appeared optimistic, given that General Electric's data showed that 2672 hours was the longest time recorded between an inspection and a subsequent manifold leak caused by clamp chafing. However, no data was given regarding the age of clamps or how many times they had been re-used before they had chafed and caused a leak.

2.19 After this incident, General Electric re-examined the vibration characteristics of the clamp and manifold assembly and determined that an increased inspection interval of 7500 hours could be substantiated if clamps were replaced at each inspection. Air New Zealand Engineering Services said that it would replace all clamps at each inspection and retain a 4500 hours interval.

2.20 Because the service bulletin was revised and Air New Zealand Engineering Services adopted a more stringent inspection schedule, no safety recommendation was made in relation to the fuel manifold chafing issue.

Delay in rescue fire service response

2.21 The pilots of NZ61 advised the ground controller that they had had an engine fire warning but gave no indication of any urgency. The controller recognised that the RFS could assist, but there was no advice from ATC to either the RFS or the incident control room for more than 6 minutes. A further 3 minutes elapsed before the RFS attended.

2.22 The following factors contributed to the delay in the RFS attending to NZ61:

- the pilots did not convey any sense of an emergency when advising ATC
- the ground controller decided that the AEP did not apply
- communication between the ground and delivery controllers was imprecise and led to neither taking prompt action to initiate an RFS response
- the controllers were not fully familiar with the emergency notification procedures
- erroneous notices in the tower misled the controllers when selecting an emergency communication channel
- further delay occurred within the incident control room while the appropriate scenario and response were selected.

2.23 The flight crew had a strong indication that there had probably been an engine fire, because the warning persisted until after an engine fire extinguisher had been discharged. Their acceptance of the offer to get an RFS inspection was prudent, as there could have been an unseen problem or a risk of the fire re-igniting. The crew of NZ61 was ready for a possible ground evacuation of the aircraft, but the urgency implied by that readiness was not conveyed to ATC.

2.24 The decision on whether to use the urgency signal was for the captain to make. He chose not to do so, even though the sequence of warning indications suggested they were genuine. The decision might have seemed appropriate to the pilots because the aircraft was on the ground, the fire indications had ceased and the crew could see no sign of fire. In addition, it was sometimes unclear whether an urgency situation was warranted if a pilot only wanted to know whether their previous action had been effective, as here, or confirmation of the aircraft serviceability.

2.25 If a fire warning and engine shutdown had occurred at any time prior to landing, the reaction of most flight crews would likely have been to declare urgency and request the aerodrome emergency services to be placed on Local Standby. Reluctance among pilots to declare urgency for incidents was not uncommon. Various reasons for that reluctance have been cited anecdotally, such as confidence that the situation was under control, uncertainty as to the actual aircraft status, or avoidance of adverse publicity.

2.26 Clear communication by the flight crew of the nature of the problem and the assistance required was the key to ensuring an appropriate response to an on-board emergency or abnormal situation, whether airborne or not. Because the pilots of NZ61 did not express urgency, the response of ATC and the incident control room also lacked urgency. The incident of

5 October 2007 was another example of the aerodrome emergency response to a potentially critical situation being disjointed and slower than expected after urgency had not been declared by the flight crew.

2.27 The Commission is concerned that established procedures that expedite assistance and reduce risk might be avoided unnecessarily and could jeopardise the safety of aircraft and their occupants. A safety recommendation was made to the Director of Civil Aviation to address this concern.

2.28 The ground controller's offer to call the RFS showed that he realised the situation was potentially serious. If he had recalled and initiated the relevant ATC procedure "Aircraft Requesting Rescue Fire assistance – No Emergency Declared", the delay might have been avoided. Although the first item of that procedure was to confirm that the pilot did not wish to declare an emergency, controllers next had to contact the incident control room via the direct emergency line. The Airways variation to the procedure added "Sound the crash alarm". Knowing of these apparently contradictory terms and procedures was possibly a factor in the ground controller being reluctant to initiate the procedure, to avoid generating an emergency response when the pilot himself had not declared an emergency.

2.29 The ground controller explained that the procedure was not followed, in part, to avoid having a large fleet of RFS vehicles interrupt a busy period of aircraft movements. The delivery controller concurred with that decision, but as he was in charge of the tower team, he ought to have ensured that the reported fire indication was given priority as an emergency and the relevant procedure followed. That did not happen because the 2 controllers did not have a clear, mutual understanding of the situation and intended action.

2.30 The observation that the aerodrome emergency phases, apart from the Aircraft Accident phase, were defined for aircraft approaching an aerodrome, rather than at the aerodrome, should not normally affect a controller's response, because the local ATC procedures stated that the Alerting System was to be activated "when an aircraft emergency occurs within the jurisdiction of the Auckland airport Aerodrome Emergency Plan". NZ61 was clearly within the AEP coverage. However, the activation of the Alerting System relied upon a pilot declaring an emergency or a controller deciding that an incident was an emergency.

2.31 The most appropriate way to trigger the desired response was for a pilot to use the urgency signal with the initial advice, which in this case should have prompted the ground controller to follow an emergency procedure. Scaling back an unnecessary response was preferable to trying to increase resources after the initial response had been found inadequate. As the delay in getting an RFS response to NZ61 extended, the captain might have reconsidered whether to declare urgency in order to prompt immediate action.

2.32 Because the situation was not clearly understood by the 2 controllers and no specific emergency procedure was followed, their subsequent actions were not coordinated. The ground controller assumed that the delivery controller understood the request and would make and coordinate the RFS request in accordance with controller responsibilities shown in the Airways local procedures manual; and the delivery controller thought that Apron had already been asked to call the RFS. The procedures for handling emergencies and incidents were reiterated to Airways staff following the December 2006 incident and further simplified after the October 2007 incident by treating all aircraft requests for RFS assistance as Local Standby situations.

2.33 Approximately 3 minutes after the fire warning, Apron attempted to assist in getting the RFS to attend to NZ61. However, its well intentioned act was questioned by incident control room staff, whose processes were dependent on all parties complying with the strict AEP emergency communication procedure. By erroneously suggesting that NZ61 had a brake problem, Apron may also have created a perception of non-urgency.

2.34 The direct emergency telephone line from ATC to the incident control room was not used at any time during the incident response, although the Airways written procedures stated that the incident control room was to be contacted. The controllers' uncertainty as to which line to use was compounded by the notices that stated that internal extension 98777 was to be used for all emergency calls, including to the RFS. In the event, extension 98777 was the line used.

2.35 The misleading notices and the potential for misunderstanding the AEP communication channels had not been recognised earlier, perhaps because of the low rate of actual emergencies at Auckland, and Airways' limited involvement in AEP exercises. After this incident, the misleading notices were removed and ATC staff were reminded of the correct AEP procedures.

2.36 Occasionally, situations arise that flight crew feel could be resolved by a quick external check of the aircraft, and which clearly do not warrant a large-scale RFS turnout. In such a situation, a direct explanatory call from ATC to the RFS might suffice. If the RFS routinely responded with all available trucks, even when they were not needed, pilots could be discouraged from declaring urgency or requesting a Local Standby at times when that would be appropriate.

2.37 In spite of no urgency being declared by NZ61, the RFS response might have been faster if ATC had had a direct communication link with the RFS station, as the International Civil Aviation Organisation recommended. The incident details could be passed to the incident control room at a later stage, but the key requirement was to get an RFS response underway. A safety recommendation was made to the Director of Civil Aviation regarding that issue.

2.38 Once ATC did call the incident control room directly, the situation was clarified, although there was a further delay until the RFS was alerted while incident control room staff searched for an appropriate scenario and its "predetermined response". Although a list of scenarios and responses should have helped incident control room staff to deal effectively with the majority of non-airside incidents, operational incidents were not as easily characterised in their nature and requirements. The delay in the incident control room, and the inflexible RFS response, were barriers to the simple request of the flight crew and ATC - one truck for a visual inspection.

2.39 The level of misunderstanding of AEP procedures was shown by the 3 different courses of action expected by different parties in this incident: the airport company expected that in the event of an aircraft incident, controllers would use the direct emergency line only; controllers thought they should dial 98777; and the Airways local procedure, at the time, required controllers to use the crash button for RFS assistance. Some of that confusion might have been caused by the local ATC amendment to the procedure "Aircraft Requesting Rescue Fire assistance – No Emergency Declared". The procedure was corrected following the ZK-NCK incident, then removed after the 5 October 2007 incident.

2.40 Although AEPs were subject to annual audits and exercises, inconsistencies between the expected actions of participating organisations might not be found unless the organisations were involved to a realistic operational level. In the case of Airways, that suggested greater involvement than a controller sending a mock emergency message to initiate a simulated major accident. In practice, however, the required ATC involvement was indeed minimal once the emergency message had been sent, so there was little opportunity to observe potential misunderstandings.

2.41 The most recent Auckland Airport emergency exercise prior to this incident was held on 8 November 2006. The first strategic objective was to "test and assess notification systems for an aircraft emergency", and was considered to have been achieved. However, notification of a large-scale emergency, where there was no doubt as to the nature of the situation, was probably less likely to fail than that for a lower-level incident, such as with NZ61. In those cases where no urgency was declared and the pilots appeared to have the situation under control, controllers might find choosing the correct responses more difficult. Occasional AEP exercises with low-level scenarios, such as that involving NZ61, might be better at identifying inconsistencies in plans.

3 Findings

Findings are listed in order of development and not in order of priority.

3.1 The fire was a result of a fuel leak in the fuel manifold, caused by chafing of the manifold by the stainless steel band of the #3 loop clamp that was missing some cushion material.

3.2 The fuel leak probably developed during the flight between Apia and Auckland, but the fuel-air mixture under the nacelle was unfavourable for ignition until after landing.

3.3 Chafing of the fuel manifold was a known problem addressed by General Electric service bulletin CF6-80C2 SB73-0326, but the service bulletin instructions were not effective for identifying damaged cushion material on clamps, and had not previously recognised that undamaged but worn clamps could accelerate chafing.

3.4 The damaged cushion material on the #3 clamp was probably present at the inspection that was completed 450 hours before the incident flight. As the service bulletin then did not require clamps to be removed from the manifold, the #3 clamp condition could have appeared acceptable.

3.5 Although the revised service bulletin increased the inspection interval, the engine manufacturer's vibration analysis showed that the replacement of all the clamps at each inspection would minimise the risk of undetected chafing leading to a leak.

3.6 The flight crew responded to the left engine fire warning in accordance with the flight manual procedure and gave appropriate consideration to a possible ground evacuation of the aircraft.

3.7 If the captain had made an urgency call to ATC, the ground controller would have been more likely to follow a published AEP emergency procedure that would have generated a faster RFS response.

3.8 The controllers should have treated the reported fire incident as their priority task, even though there was no urgency signal or sign of fire, and handled the incident as an emergency.

3.9 The 6-minute delay before the controllers directly contacted the incident control room was caused by some unfamiliarity with the communication procedures in the AEP.

3.10 Some of the controllers' misunderstanding about AEP procedures was due to an undated and independent variation by Airways of the procedure for "Local response – no emergency declared" and by notices in the tower that gave incorrect information.

3.11 Further delay was caused in the incident control room because an unexpected communication channel was used, and while an appropriate incident scenario and response was searched for.

3.12 The different organisational interpretations of, and personnel unfamiliarity with, some of the aerodrome emergency procedures probably were a result of undemanding exercises of the AEP and previously undetected procedural inconsistencies.

4 Safety Actions

Air New Zealand Limited

4.1 On 30 December 2006, Air New Zealand Engineering Services initiated inspections of the fuel manifolds and clamps on all of the CF6-80C2 engines of the operator's Boeing 767 and Boeing 747 aircraft as the aircraft next transited Auckland. The inspections were limited to a security check of clamps, replacement of any found to be loose and close inspection of the manifold at locations with loose clamps.

4.2 The inspection of the Boeing 767 fleet was completed by 2 January 2007 and that of the Boeing 747 fleet by 10 January 2007. On the Boeing 747 fleet, an average of 9 clamps was replaced per engine, with 15 the maximum number replaced on any engine. On the Boeing 767 fleet, an average of 5 clamps was replaced per engine, with 11 the maximum number replaced on any engine.

4.3 On 25 January 2007, Air New Zealand Engineering Services issued Engineering Order CF6-7310-00001 REV 00 "Engine (CF6-80C2); Fuel Manifold; Chafing Inspection" to supersede service bulletin CF6-80C2 SB73-0326. The order retained the 4500 flight hours' inspection interval but corrected perceived deficiencies with the service bulletin by requiring the replacement of all the clamps at each inspection, the use of tape under each clamp to further minimise wear, and detailed reporting of inspection findings.

General Electric Aircraft Engines Limited

4.4 On 22 August 2007, General Electric revised service bulletin CF6-80C2 SB73-0326 and a further minor revision led to service bulletin CF6-80C2 SB73-0326 R2 being issued on 30 August 2007. A separate service bulletin was issued for the CF6-80E1 variant of the engine.

4.5 The revised service bulletin called for an inspection of the fuel manifold and the replacement of all 24 fuel manifold loop clamps within 4500 hours of the most recent inspection or overhaul, for engines with used clamps installed at the most recent inspection or overhaul; and within 7500 hours of the most recent inspection or overhaul for new engines or engines with new clamps installed at the most recent inspection or overhaul. After the initial inspection and replacement of clamps, further inspections and clamp replacements were to take place at intervals not exceeding 7500 hours.

4.6 The service bulletin addressed the removal of tape that could be present on the manifold prior to an inspection, but removed the original option of applying tape to achieve the required clamp tightness.

4.7 On 10 September 2007, General Electric advised all operators of CF6-80C2 and CF6-80E1 engines to adopt the service bulletin recommendations ahead of an anticipated airworthiness directive from the United States Federal Aviation Administration.

4.8 On the date this report was approved, Air New Zealand Engineering Services Engineering Order CF6-7310-00001 was current and the company had indicated that it did not intend to follow the increased inspection interval of the revised service bulletin. It believed that the use of an appropriate tape under clamps, as well as clamp replacement at each inspection, was necessary to prevent manifold chafing.

Federal Aviation Administration

4.9 On 7 September 2007, the United States Federal Aviation Administration registered Notice of Proposed Rule Making, document number FAA-2007-28413-1, which advised of an intention to mandate the requirements of the above revised service bulletins.

Auckland International Airport Limited

4.10 On 8 January 2006, Auckland International Airport Limited advised of various proposed corrective actions, including the following:

- Review, with Airways, aircraft emergency notification procedures in relation to similar types of incidents
- Reconfirm with Airways that ICR receive direct line emergency messages simultaneously with the fire station.

4.11 On 15 October 2007, following a review of the 5 October 2007 incident, Auckland International Airport Limited and Airways withdrew their respective procedures for "RFS assistance requested – no emergency declared". In their place, both parties introduced automatic initiation of the Local Standby phase for such situations.

Airways New Zealand

4.12 On 13 July 2007, the Airways Air Traffic Services Manager at Auckland advised that the following actions had been or would be taken:

> 1. All the documentation in the tower will be amended to reflect the fact that for all emergencies the appropriate phone call will be made on the Emergency Line (EMG) which goes direct to the Incident Control Room (ICR). All references to call 98777 for aircraft emergencies will be deleted.
>
> 2. At Cyclical Training it will be reinforced to staff that in the event of any sort of emergency the checklists that are provided, are to be followed.
>
> 3. Initiate discussion with AIAL to remove the [Local Standby – No Emergency Declared] procedure from the Tower instructions. This was expected to be discussed at an airport Ground Safety meeting in early September 2007.
>
> 4. Consult with the airline industry regarding [pilots'] calls to Tower staff asking for Fire vehicles without actually wanting to declare an emergency.

4.13 On 14 February 2008, Airways confirmed that the procedure for initiating a Local Standby required the controller to activate the crash alarm and use the direct emergency line to pass details of the incident to the incident control room.

5 Safety Recommendations

Safety recommendations are listed in order of development and not in order of priority.

5.1 On 22 May 2007, the Commission recommended to the Director of Civil Aviation that he:

019/08 Require operators of aerodromes that provide air traffic and rescue fire services to have a discrete communication system linking a fire station with the control tower, any other fire station on the aerodrome and the rescue and fire fighting vehicles.

020/08 Conduct a programme of education for aircraft operators, airport operators, and pilots to increase their familiarity with emergency communications and their understanding of the need for a prompt declaration if assistance was required, particularly if the actual status of the aircraft was in doubt.

5.2 On 6 June 2008, the Director of Civil Aviation replied:

019/08 There is no general provision within the Part 139 aerodrome operating rules that enables me to require operators of aerodromes to install a discrete communications system. Rule Part 139 contains requirements for notification of aerodrome RFS in an emergency. I will consider recommending amendments to Rule Part 139 to adopt relevant wording used in Annex 14, when the Rule Part is next amended.

020/08 There are in existence a number of programmes focussing on emergency procedures for aircraft operators, airport operators and pilots. I will consider whether additional programmes, or revision of existing programmes, can be undertaken to further heighten awareness of emergency procedures.

Approved for Publication 22 May 2008

Hon W P Jeffries
Chief Commissioner

Appendix

Edited extracts from General Electric service bulletin CF6-80C2 SB73-0326

(initial issue 5 March 2003)

Accomplishment instructions (drainless fuel manifolds);

1. Remove the clamp bolts (24 places). It is not necessary to remove the clamps from the manifold.
2. Move the clamps approximately 1.0 inch (25.4 mm) away from the original clamping locations.
3. Visually inspect the manifold for signs of chafing. Permitted wear is 10% of the tubing wall thickness, which equals 0.0035 inch (0.089 mm) in depth. A manifold with wear more than that must be replaced, although if the wear is less than 0.010 inch (0.254 mm), replacement may be deferred for up to 50 cycles.
4. Inspect the clamps for damaged or missing cushion material. Defective clamps must be replaced.
5. Clamps that are loose and can move more than +/- 0.10 inch (2.54 mm) along the tube centerline must be replaced. If a new clamp is still loose and can move more than +/- 0.10 inch (2.54 mm), wind glass cloth tape around the manifold to get a tighter fit.
6. Reinstall the clamp bolts (24 places). Tighten to 33-37 lb-in (3.7-4.2 Nm).
7. Report the details of any chafing found.

Recent Aviation Occurrence Reports published by the Transport Accident Investigation Commission (most recent at top of list)

07-003	Piper PA 32 ZK-DOJ, departed grass vector on landing, Elfin Bay airstrip near Glenorchy, 5 April 2007
07-005 Incorporating	Raytheon 1900D, ZK-EAN and Saab-Scania SAAB SF340A, critical runway incursion, Auckland International Airport, 29 May 2007 incorporating:
07-009	Raytheon 1900D, ZK-EAH and Raytheon 1900D, ZK-EAG, critical runway incursion, Auckland International Airport, 1 August 2007
07-004	Boeing 737-300, aircraft filled with smoke, north of Ohakea, en route Wlg-Akl, 3 May 2007
06-003	Boeing 737-319, ZK-NGJ, electrical malfunction and subsequent ground evacuation, Auckland, 12 September 2006
06-008	Piper PA23-250-E Aztec ZK-PIW, , landing gear collapse, Ardmore Aerodrome, 21 December 2006
07-001	Boeing 777 A6-EBC, incorrect power and configuration for take-off, Auckland International Airport, 22 March 2007
06-006	ZK-MYF, Partenavia P68B, loss of engine power, Takapau, 2 December 2006
06-004	Robinson R44 *Raven* ZK-HUC, wire strike, Motukutuku Point, near Punakaiki, Westland, 9 November 2006
06-002	Piper PA 23-250 Aztec, ZK-FMU, wheels-up landing, Napier Aerodrome, 13 April 2006
05-006	Fairchild-Swearingen SA227-AC Metro III ZK-POA, Loss of control and in-flight break-up, near Stratford, Taranaki province, 3 May 2005
05-008	Cessna U206G, ZK-WWH, loss of control on take-off, Queenstown Aerodrome, 10 August 2005
01-005R	Bell UH-1H Iroquois ZK-HJH, in-flight break-up, Taumarunui, 4 June 2001
05-010	Aerospatiale-Alenia ATR 72-500, ZK-MCJ, runway excursion, Queenstown Aerodrome, 5 October 2005
05-003	Piper PA34-200T Seneca II, ZK-FMW, controlled flight into terrain, 8 km north-east of Taupo Aerodrome, 2 February 2005

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