Department of Transport

Bureau of Air Safety Investigation

INVESTIGATION REPORT

B/921/1032

# Boeing 727-277 VH-ANA
# Brisbane Qld
# 4 July 1992

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under the provisions of Air Navigation Regulation 283

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ABBREVIATIONS

| | |
|---|---|
| AA | Arithmetical Average |
| ATC | Air Traffic Control |
| CAA | Civil Aviation Authority |
| CAR | Civil Aviation Regulation |
| CCC | Common Crash Call |
| CVR | Cockpit Voice Recorder |
| EPR | Engine Pressure Ratio |
| FAC | Federal Airports Corporation |
| ICAO | International Civil Aviation Organisation |
| OIC | Officer In Charge |
| P/N | Part Number |
| RFFS | Rescue Fire-fighting Service |
| RIV | Rapid Intervention Vehicle |
| RPA | Rules and Practices for Aerodromes |
| SMC | Surface Movement Control |
| S/N | Serial Number |
| ULFV | Ultra-large Fire Vehicle |

Unless otherwise indicated, all times are Australian Eastern Standard Time (Co-ordinated Universal Time + 10 h).

## SYNOPSIS

At 0707 hours, on 4 July 1992, Boeing 727-277 aircraft VH-ANA took off from runway 01 at Brisbane Airport on a regular public transport flight to Sydney. As the landing gear was retracting, the crew heard a loud bang emanate from the rear of the aircraft. This was followed by cockpit indications of a fire in, and a loss of thrust from, the no. 2 (centre) engine. Ground witnesses saw large flames streaming from the rear of the aircraft. The crew shut down the engine, completed the engine-fire checklist, and flew a circuit for a landing on runway 01.

During the landing roll, the crew were advised that there were still signs of fire around the centre engine, so a decision was taken by the aircraft captain to evacuate the aircraft. After clearing the runway and stopping the aircraft, the evacuation of passengers and crew was carried out from the two front doors and the forward left overwing exit. During the evacuation, two passengers received minor injuries. The fire was extinguished quickly by airport fire personnel.

The investigation revealed that a fatigue failure had occurred in the first-stage compressor fan disc of the no. 2 engine leading to disruption of the engine. The fire resulted when a section of engine disc severed the main fuel line to the engine. Deficiencies were also revealed in the Brisbane Airport emergency plan and in some aspects of the training of rescue and fire-fighting personnel.

# 1. FACTUAL INFORMATION

## 1.1 History of the flight

Boeing 727-277 VH-ANA was scheduled to operate a regular public transport flight from Brisbane to Sydney on 4 July 1992. There were nine crew members and 96 passengers on board. At 0702 hours the aircraft taxied for a taxiway A7 intersection departure from runway 01. The first officer was the handling pilot for the sector, and the aircraft commenced the take-off roll at 0706 hours.

The crew reported that all engine parameters were normal during the take-off sequence. However, as the landing gear was retracting, with the aircraft about 100 ft above the ground, they heard a loud bang which emanated from the rear of the aircraft. The no. 2 (centre) engine thrust lever drove fully forward, the fire warning light illuminated and the fire bell sounded. Almost immediately afterwards, the Brisbane tower controller advised that there was a large fire at the rear of the aircraft.

The crew initiated the emergency checklist actions. As the no. 2 engine thrust lever could not be moved and the start lever was jammed in the open position, the crew pulled the no. 2 engine fire switch, which closed the engine fuel shut-off valve. The no. 1 fire extinguisher bottle was then discharged, whereupon the warning light went out. At this time the tower controller advised that there was still a glow at the rear of the aircraft, coupled with slight smoke. The crew requested a 1,500 ft right-hand circuit to return for landing on runway 01, and continued to manage the flight on the basis that the fire had been successfully extinguished. At this time the captain assumed the role of handling pilot. Meanwhile, the emergency services had been activated, with rescue and fire-fighting vehicles moving into position.

All the cabin crew members had heard the loud noise associated with the engine failure. The purser undid her harness and then heard the sound of the fire bell. She was called to the flight deck and told by the first officer that there was a fire in the no. 2 engine, that the flight was returning for landing, and that there would be no requirement for an evacuation. The purser duly briefed the other flight attendants and then informed the passengers that the aircraft was returning to Brisbane.

While the aircraft was manoeuvring onto the downwind leg, Boeing 737 VH-TAG was lined up for takeoff at the threshold of runway 01. The controller cleared VH-TAG to takeoff, then returned his attention to VH-ANA. Approximately 3 minutes 30 seconds had elapsed since VH-ANA had become airborne. It was turning onto the base leg of its landing pattern when the controller advised that there was still 'a small flame at the back of the centre engine'. The crew then discharged the second fire bottle.

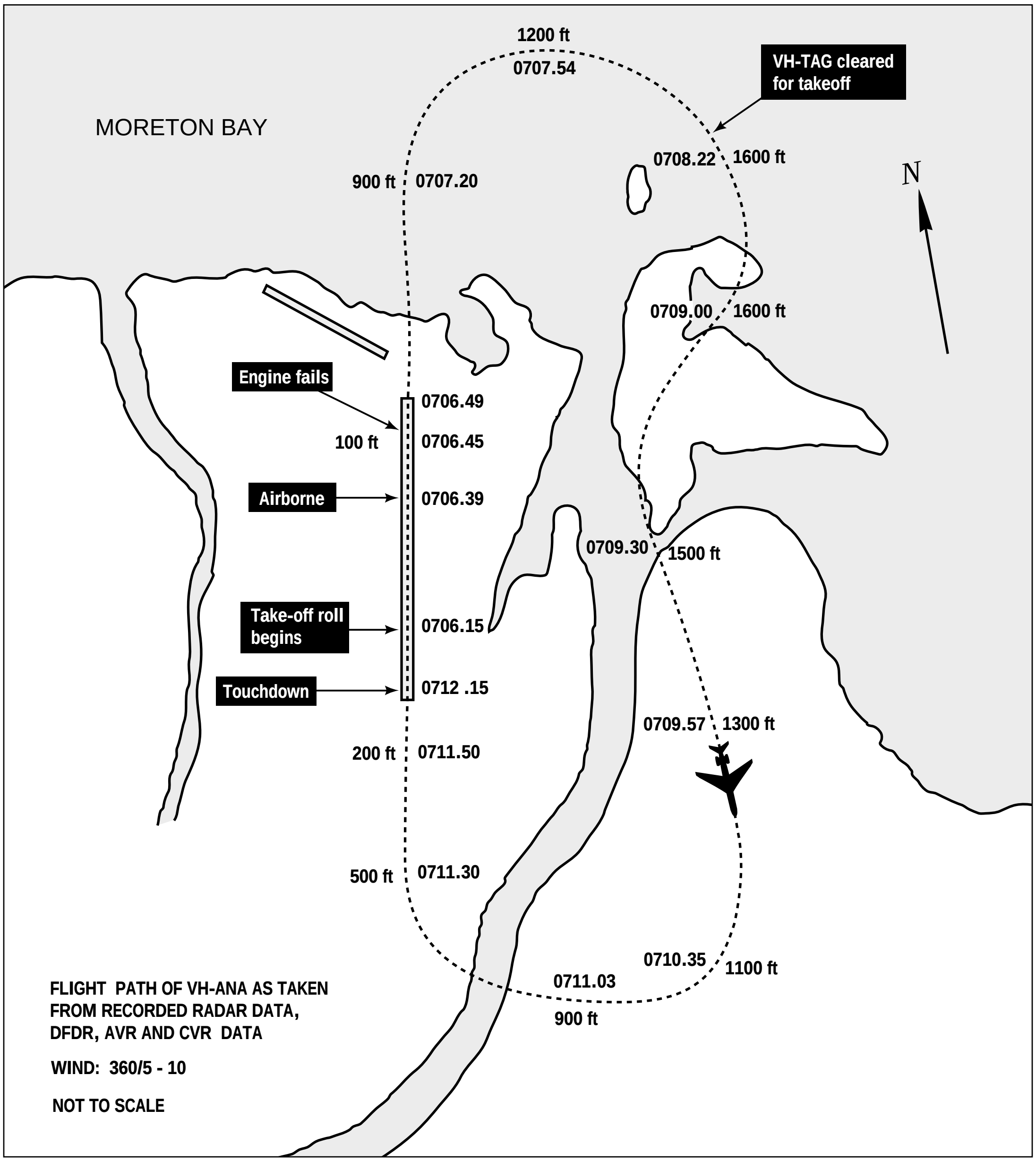



**Figure 1**

The aircraft landed normally, less than 6 min after the engine failure. About 20 seconds after touchdown, the crew asked the tower controller whether any fire was still visible. On being informed that there were some small flames around the front of the centre engine, the crew advised that they would stop the aircraft adjacent to the fire vehicles positioned on taxiway A4S. Figure 1 shows the flight path of the aircraft from takeoff at 0706.15 to touchdown at 0712.15 following the inflight emergency.

Towards the end of the landing roll, the crew advised the purser that an evacuation would be necessary, and that the three rear exits were not to be used. The flight attendants were then briefed accordingly.

The aircraft was brought to a stop 1 minute 15 seconds after touchdown. The crew then advised the tower that the engines were being shut down and that the aircraft would be evacuated from all exits except the three at the rear of the aircraft. As soon as the engines were shut down, the fire crews extinguished the residual fire around the engine.

The evacuation was orderly and rapid, although two passengers sustained minor injuries during the process.

## 1.2 Injuries to persons

| | Crew | Passengers | Others |
|---|---|---|---|
| Fatal | – | – | – |
| Serious | – | – | – |
| Minor/None | 9 | 96 | – |

## 1.3 Damage to aircraft

The aircraft was substantially damaged by liberation of the no. 2 engine's second and third-stage fan discs. The damage was confined to the area of the no. 2 engine installation.

## 1.4 Other damage

Minor damage was caused to the runway surface by the liberated engine components.

## 1.5 Personnel information

### 1.5.1 Flight crew

The aircraft captain was aged 54 years and held a valid Airline Transport Pilot Licence. He had completed his last medical check on 5 February 1992 and was appropriately endorsed to fly B727 aircraft. His total flying experience was 13,642 h, of which 2,700 were on B727 aircraft.

The first officer was aged 33 years and held a valid Airline Transport Pilot Licence. He had completed his last medical check on 24 February 1992 and was appropriately endorsed to fly B727 aircraft. His total flying experience was 5,800 h, of which 2,000 were on B727 aircraft.

The flight engineer was aged 31 years and held a valid Flight Engineer Licence. He had completed his last medical check on 24 April 1992 and was appropriately endorsed on B727 aircraft. His total flying experience was 3,200 h, of which 2,700 were on B727 aircraft.

### 1.5.2 Cabin crew

The cabin crew consisted of a purser and five flight attendants. All members of the cabin crew had been trained in accordance with the regulations and had had their proficiency checked within the previous year.

### 1.5.3 Other personnel

All Air Traffic Services and firefighting officers were appropriately licensed and trained for the positions they occupied at the time of the occurrence.

## 1.6 Aircraft information

The aircraft, S/N 22641, was manufactured by the Boeing Aircraft Company in 1981. It was powered by three Pratt & Whitney JT8D-15 engines, and had a maximum take-off weight of 89,358 kg.

The Certificate of Registration and Certificate of Airworthiness were current and the aircraft was serviceable for the proposed flight.

The aircraft weight at the time of the accident was 70,000 kg and the centre of gravity was within limits.

## 1.7 Meteorological information

The weather at Brisbane Airport at 0707 hours was fine and clear with a temperature of 18°C and a northerly wind at 5–10 kts. The atmospheric pressure was 1,008 hPa.

## 1.8 Aids to navigation

Not relevant.

## 1.9 Communications

The Brisbane Air Traffic Control (ATC) frequencies relevant to this accident were: Brisbane Ground (SMC)—121.7 MHz; and Brisbane Tower—120.5 MHz.

During the emergency, communications between the aircraft crew and ATC were conducted on frequency 120.5 MHz. On receiving landing clearance, the flight crew requested that they remain on the tower frequency and this request was granted by the tower controller.

Communications between ATC and the emergency response vehicles were conducted on frequency 121.7 MHz. The emergency response vehicles were fitted with radios that allowed them to communicate on both tower and SMC frequencies. However, they could only monitor one frequency at a time. Procedures for the vehicles involve their monitoring the tower frequency while the aircraft is on the runway and then the SMC frequency when the aircraft moves off the runway. On this occasion the emergency vehicles switched to the SMC frequency as the aircraft had moved onto a taxiway. As a result, the emergency response vehicles did not monitor or communicate with the aircraft flight crew while the B727 was on Brisbane tower frequency.

The automatic voice recording of communications between both these agencies and the aircraft, as well as the various emergency response vehicles, indicated that all transmissions were of satisfactory clarity.

## 1.10 Aerodrome information

Brisbane Airport is owned and operated by the Federal Airports Corporation (FAC). It has two non-intersecting runways—runway 01/19 and runway 14/32. Runway 01/19 (see figure 2), which was the runway relevant to this occurrence, is 3,500 m long, 45 m wide and constructed of asphaltic concrete.

### 1.10.1 Aerodrome drainage ditches

There are a significant number of drainage ditches on the Brisbane aerodrome surface adjacent to taxiways but outside the taxiway strips. The ditches vary in size from about 4 m wide and 1.5 m deep to 2 m wide and 0.5 m deep and have grasses and reeds growing in them. These characteristics make the ditches difficult to distinguish from their surrounds in daylight conditions and more so in reduced visibility conditions. There are no markings along the ditches or at their extremities.

The position of the ditches meets International Civil Aviation Organisation (ICAO) aerodrome standards. These standards contain no requirement for such ditches to be marked.

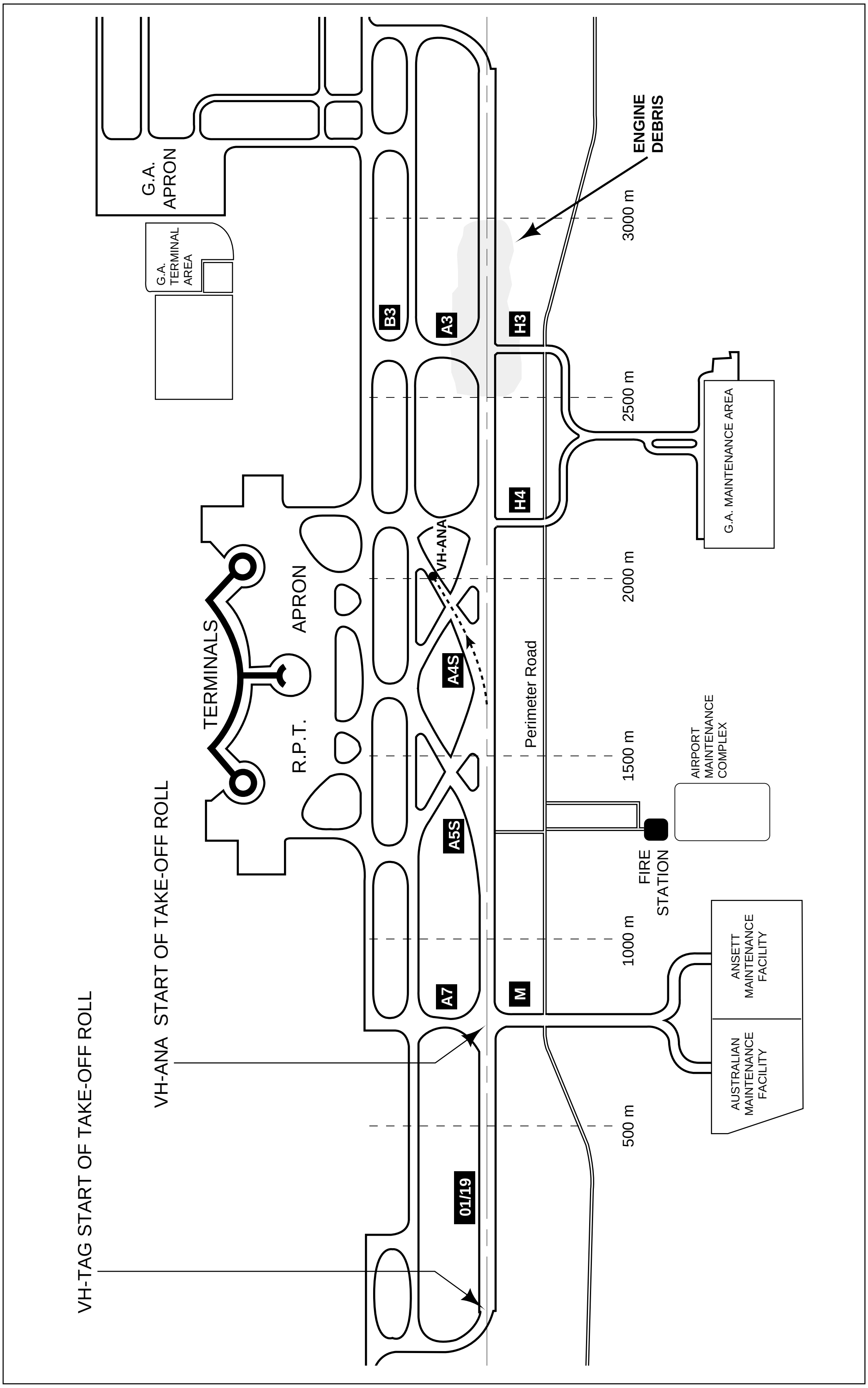



**Figure 2**

### 1.11 Flight recorders

#### 1.11.1 Flight data recorder

The aircraft was fitted with a Lockheed Aircraft Services 209 digital flight data recorder with a recording duration of 25 h on magnetic tape and a Teledyne Controls flight data acquisition unit. A total of 19 parameters and 45 discrete events were recorded, which included only one engine parameter—engine pressure ratio (EPR). The readout of the recording showed that the failure of the no. 2 engine occurred 7 seconds after lift-off when the aircraft was about 30 m (100 ft) above ground level, at an airspeed of 156 kts. At that point, the EPR for the no. 2 engine fell from the take-off setting of approximately 2.1 to zero over a period of 2–3 seconds. There were no indications on the recorded parameters to indicate an impending failure.

#### 1.11.2 Cockpit voice recorder

The aircraft was fitted with a Sunstrand model AV557C cockpit voice recorder (CVR) with a recording duration of 30 min. The recording was replayed and was of good quality throughout. An analysis of recorded frequencies up to the time of engine failure did not reveal any abnormalities.

The CVR tape was examined and indicated that the crew had reacted to the emergency as a well co-ordinated team in evaluating the problem and completing the various checklists.

### 1.12 Wreckage information

Recovery and examination of the first stage fan disc revealed that the failure of a blade retention post resulted in the release of two fan blades. A further three blade retention posts and four fan blades were released as a result of abnormal loading. The release of the six blades created an out-of-balance situation which led to the separation of the first, second and third discs from the engine.

The engine failure occurred as the aircraft was overflying the intersection of taxiway A3 after lift-off from runway 01. Engine debris and the no. 2 engine cowls were scattered along the runway and associated flight strip for about 500 m after the point of the engine failure.

Substantial mechanical and fire damage was caused to the vertical and horizontal firewalls of the no. 2 engine bay and to the no. 2 engine. The intake ‘S’-duct for the engine also received puncture damage from engine debris.

### 1.13 Medical and pathological information

Not relevant.

### 1.14 Fire

When the engine failed, some of the liberated particles struck and ruptured the main fuel line to the engine fuel pump, and severed the throttle and engine start lever cables. The leaking fuel was ignited when it came into contact with hot engine parts. Fuel continued to flow through the open fuel line until the crew pulled the no. 2 engine fire switch which closed the fuel shut-off switch. Extensive scorching and other fire damage was caused to the forward firewall in the area immediately surrounding the main fuel-line connection, and to the entire right side of the engine.

### 1.15 Survival aspects

#### 1.15.1 Evacuation

As the aircraft slowed to taxi speed, the flight attendants moved to their respective stations to control the evacuation.

The aircraft was fitted with nine exits (see figure 3). Four of these exits—the forward left and right doors, and the rear left and right doors—were equipped with emergency evacuation slides. The overwing exits on B727 aircraft are not fitted with evacuation slides and following egress from the aircraft via these exits, passengers are supposed to follow markings on the aircraft wing and slide off the trailing edge of the wing to the ground.

The company training and operations manuals for the flight attendants implied that all slide-equipped doors were fitted with escape slides which would automatically inflate. In fact, on company B727 aircraft, only the right-hand rear emergency exit door is always fitted with an automatic inflation slide. The remaining three slide-equipped doors can be equipped with either an automatic or manual inflation escape slide.

The two forward doors on VH-ANA were fitted with manual slides. The flight attendants expected the slides to deploy automatically but quickly pulled the manual inflation handle when it became obvious that the slides were not going to deploy automatically.

Flight attendants opened both forward overwing exits. After the flight attendant responsible for the right overwing exit opened the exit, she noticed a 'dark, greasy patch which was surrounding a vent'. She was unaware of the function of the vent and as four firefighters were standing in the area to the rear of the wing, she assumed the discolouration may have been associated with the fire. She therefore blocked this exit from use.

The right forward escape slide was damaged during the evacuation. Damage consisted of a split in the fabric covering the inflation tubes, although the tubes themselves remained intact. The split ran for most of the length of the slide. It was later learned that a passenger had lost the heel from one of his shoes during the evacuation, thereby exposing a number of small tacks on the base of the shoe.

The passengers exited the aircraft in an orderly manner with only a small number attempting to retrieve hand baggage. There was little congestion at the exits. Flight attendants at the forward exits told passengers to 'jump and sit', whilst the flight attendant at the left overwing exit was required to modify his command to include the instruction to 'follow the arrows' when passengers ran along the wing towards the wingtip instead of moving towards the trailing edge of the wing. On the forward exits, the flight attendants did not designate passengers to stabilise the bottom of the slides and assist other passengers. This instruction is not required by company procedures. Figure 3 shows the exits used and the arrows show the direction of evacuation.

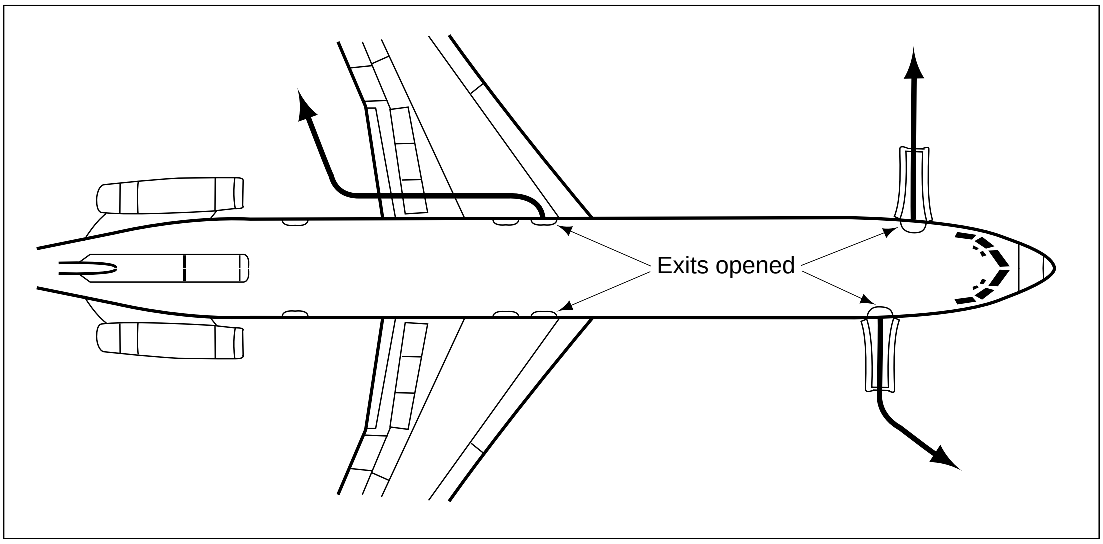



**Figure 3**

### 1.15.2 Passenger survey

A questionnaire concerning the events which occurred before, during, and after the evacuation was distributed to 74 of the 96 passengers from the aircraft. The names of the other 22 passengers were not available as they had not been retained in the operator's reservations system after completion of the flight. Responses were received from 34 passengers and a study of these revealed the following:

- Fifteen indicated that they recalled receiving instructions from the cabin crew before landing.
- Thirty indicated that their choice of exit was dictated by the proximity of the exit to their seat.
- Seven exited via the left overwing exit, and 27 through the forward exits (18 right and nine left).
- Of those passengers who used the forward exits, six stated that they experienced difficulty using the exit slide—one became entangled in the tear in the slide, four complained of being thrown forward on contacting the ground at the end of the slide and the other struck his head on the door sill.
- Of the seven passengers who used the overwing exit, five had difficulty getting from the wing to the ground.

## 1.16 Tests and research

No special tests or research were undertaken in addition to the normal process of investigation.

## 1.17 Additional information

### 1.17.1 Engine installation and history

The Pratt & Whitney JT8D-15 turbofan engine is an axial-flow, twin-spool design of moderate bypass ratio utilising a six-stage low-pressure compressor, driven by a single turbine through concentric shafting. The serial number of the no. 2 engine on VH-ANA was P695237. It had completed a total of 26,599 cycles since new and 1,026 cycles since it was last inspected in a maintenance facility. (One takeoff and landing is one cycle.)

The first-stage fan disc fitted to the no. 2 engine was P/N 817401C, S/N K32280. At the time of the failure, the disc had completed 20,540 h and 15,605 cycles since new. It was delivered to the operator from the manufacturer on 23 October 1981. The disc first entered service on 5 December 1981 and prior to failure, had been removed from service on three occasions: in 1984 to have an anti-galling compound on the surface of the blade slots restored; in 1987 when no work was carried out on the disc; and on 29 November 1991 when the disc was inspected by the approved fluorescent penetrant process. During this inspection, no faults were found with the disc, which by then had completed 19,152 h and 14,579 cycles since new.

A search of the maintenance records for the disc found that it had been maintained in accordance with the manufacturer's specifications and that there was no record of any foreign-object damage being sustained by the engine to which the disc had been fitted. Moreover, when compared to other engines owned by the same operator, the engine to which this disc was fitted was the subject of a lower than normal number of compressor stalls, engine surges and vibration reports. Inspections following these reports did not find any fault with, or damage to, the particular engine or its components.

### 1.17.2 Engine intake duct

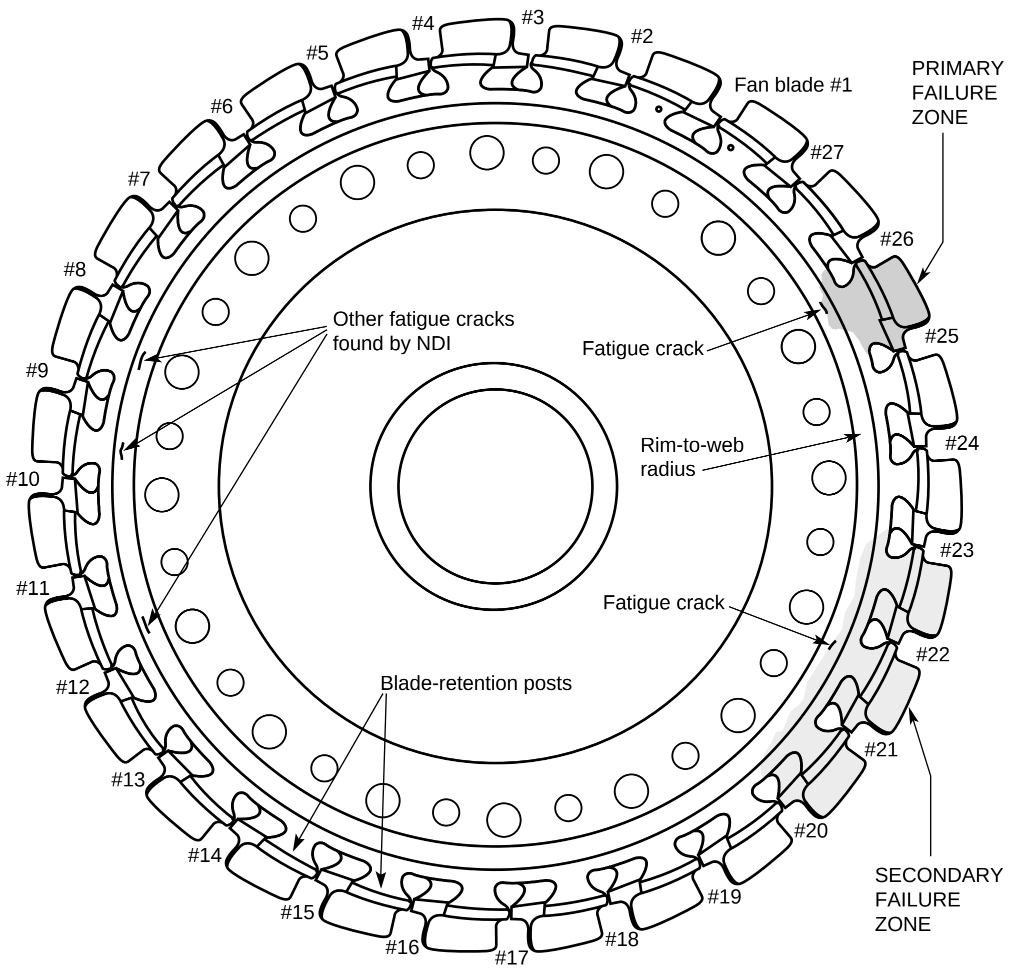
The no. 2 engine intake duct was inspected following the accident and no evidence of any out-of-tolerance mismatch between adjoining sections of the duct was found. There was no evidence of repairs, dents or erosion within the duct or any of the mating surfaces which might have been likely to affect the performance of the engine. All the vortex generators within the duct were accounted for. All damage in the duct area was caused by engine debris.

### 1.17.3 Engine compressor fan-disc examination

The failed first-stage fan disc was subjected to metallurgical examination. The examination revealed that fatigue cracking had occurred in the rim-to-web radius of the forward side of the disc which resulted in the release of a blade-retention post and two fan blades (primary failure zone, figure 4). Crack growth at the site of the primary fracture occurred over a period of approximately 700–800 engine cycles. A further three blade-retention posts and four fan blades were released as a result of a fracture under abnormal loading conditions and in the presence of a smaller pre-existing crack on the forward rim-to-surface radius under the blade-retention posts between blade numbers 21 and 22 (see figure 4 below). Non-destructive inspection of both the forward and aft rim-to-web radii found another three cracks in the forward radius.

The forward radius was then subjected to a detailed examination which revealed that the fatigue cracking initiation was associated with surface damage resulting from abrasive hand machining which attempted to polish the radius. Evidence of the abrasive process included sharp bottomed scratches formed by abrasive particles ploughing and tearing the surface, and embedded silicon carbide particles at the ends of the scratches.

It was apparent that the abrasive hand machining process had not been as a result of any rework during the operational life of the disc, but had occurred during manufacture.




First-stage low-pressure compressor disc fatigue crack and failure zones

**Figure 4**

### 1.17.4 Examination of other fan discs

Ten first-stage fan discs from the operator of VH-ANA were examined in order to assess the condition of the rim-to-web radius. It was apparent that a variety of machining processes had been employed to form and finish the radius. Five of the discs inspected were found to have abrasive polishing marks in the area of the forward rim-to-web radius. However, none displayed evidence of the scratches associated with ploughing and tearing, and the presence of embedded silicon particles, which were present on the failed disc.

### 1.17.5 Other failed discs

On 12 September 1981, a first-stage fan disc of a JT8D engine, which was fitted to a Douglas DC-9 aircraft operated by a Japanese airline, failed. The failure of the disc involved fatigue cracking from the forward rim-to-web radius. Although the cause of the failure was not determined, it was reported that the failure was similar to that which occurred to the disc in VH-ANA. The disc fitted to the DC-9 had completed 9,467 cycles at the time of failure.

On 18 August 1992, a Boeing 727 operated by a North American airline suffered a failure of the first-stage fan disc of its no. 2 engine during takeoff. The failure of the disc involved fatigue cracking from the forward rim-to-web radius. The nature of the failure was reported to be similar to that experienced by the disc in VH-ANA. The disc had completed 15,699 cycles at the time of failure.

Inspections of JT8D engines have revealed three additional cases of cracked discs.

### 1.17.6 Disc manufacturing and quality assurance

The disc was manufactured by the engine manufacturer at its plant in North Haven, Connecticut, USA. All failed and cracked discs identified to date were manufactured prior to 1986 by the same process at this facility.

The arithmetically averaged (AA) value of surface roughness specified by the manufacturer for the rim-to-web radius was 32 microinches. The surface roughness on the failed disc averaged 40 microinches.

The manufacturer could not provide details of the quality assurance procedures used to ensure compliance of the finish of the rim-to-web radius with specification.

Since 1986, the manufacturer has produced fan discs at a different facility. At that time the procedures used during manufacture were altered to allow for the inspection of each component at the end of each stage throughout its production. The manufacturer believes that by this method, any fault will be discovered earlier in the process. As a result of an increase in the number of inspections carried out by different persons during the manufacturing process, faults are more likely to be detected.

### 1.17.7 Emergency response plan

The FAC was issued with a licence by the Civil Aviation Authority (CAA) to operate Brisbane Airport. One of the requirements under the terms of this licence is that the airport proprietor issue an airport operations manual. At Brisbane, this manual is issued by the airport's general manager. The CAA, as the issuer of the licence, is responsible for auditing compliance with the requirements of the licence. The licence had last been renewed in December 1991 and compliance checks were carried prior to the renewal. However, details of these checks were not available.

Brisbane Airport's Operations Manual part 2, section 1.1 contains the airport's emergency plan while section 1.2 deals with aircraft accidents and incidents. The plan is agreed to by the Airport Emergency Committee and describes the strategies and procedures to alert and marshal all available airport and community resources following an emergency at Brisbane Airport. The plan aims to ensure that appropriate priorities are afforded to preserve life and property during or following an emergency.

The Airport Emergency Committee is chaired by an officer of the FAC. The members are representatives of the CAA, airlines operating into the airport, various Commonwealth and State government departments (including the emergency services) and welfare organisations.

The CAA publication *Rules and Practices for Aerodromes (RPA)* specifies a minimum frequency of once every two years for a full-scale exercise of the aerodrome emergency plan. However, it recommends that this exercise should be conducted annually. The new part IXA of the Civil Aviation Regulations (CARs) was introduced in December 1992 and, along with new Civil Aviation Orders, will ultimately replace *RPA*. The new CARs do not specify a minimum frequency for full-scale emergency exercises. Regulation 89ZA of CARs specifies the requirements for aerodrome safety inspections and reports. Although there is a requirement to report on the implementation of the aerodrome emergency plan, there is no requirement within the existing regulations to ensure that the plan is exercised, or that if it is exercised, it is effective.

An examination of the aerodrome emergency plan current at the time of the accident revealed that it was incorrect and out of date in some areas with respect to terminology, names of key personnel, and telephone numbers. It was also established that the plan had not been exercised for 19 months.

### 1.17.8 Emergency notification and response

The effectiveness of the notification of, and response to, the emergency by the various agencies was examined. The examination revealed that:

- The tower controllers activated the common crash call (CCC) at 0708 hours.
- The alert and notification of the emergency to the various emergency response agencies varied in effectiveness. Although the police answered the call, the officer hung up before receiving the emergency briefing. Moreover, the FAC security office at Gate 1 was not advised of the emergency, and advice to the airline was delayed. This was partly because established procedures—particularly a CCC read-back check—had not been correctly followed. As a result, the police response was delayed by 8 min.
- The Airport Security Office was not connected to the common call system and, although notified of the emergency, was not aware of its full nature and extent.
- The common call was correctly acknowledged by the ambulance, fire brigade, and hospital.
- The response by some participants was not fully in accordance with the airport emergency procedures, causing some confusion as to who was in command of the on-site proceedings following the evacuation of the aircraft. As a result, those procedures which set out the post-evacuation handling of passengers were not fully completed, while information on the number of persons on board and the nature of the cargo carried was not made available to the airport's rescue fire-fighting service (RFFS).
- On-site supervisors indicated that the airport emergency plan was not implemented in its entirety as their judgement at the time was that the circumstances did not warrant it.

The response by the RFFS was rapid; however, one of the RFFS vehicles was rendered ineffective when it became stuck in a drainage ditch.

### 1.17.9 Fire-fighting response

The RFFS response consisted of four ultra-large fire vehicles (ULFVs), and one rapid intervention vehicle (RIV) with the officer in charge (OIC) on board. By the time the aircraft landed, two ULFVs were positioned at taxiway H4, one at taxiway M, and the fourth at taxiway A4 along with the RIV. The ULFV positioned at taxiway M (call sign Tender 3) followed the aircraft along the runway and reported that there were still flames around the centre engine. As the aircraft turned off the runway at taxiway A4S, the OIC requested the tower to ask the aircraft to stop and shut down the engines. The fire was then quickly extinguished.

In accordance with the RFFS tactical plans, the driver of Tender 3 intended to position his vehicle at the nose of the aircraft. Because of the large turning circle of the ULFV, he elected to leave the runway at taxiway A5S to allow a more favourable approach to the aircraft via a grass verge. As the vehicle manoeuvred across the grass at about 20 km/h, the driver's attention was directed to the aircraft and the evacuating passengers. Neither the driver nor the other occupant of the vehicle noticed the presence of a ditch until the vehicle was about 5 m from it. At that late stage a collision with the ditch could not be avoided (see figure 5).

Investigation revealed the level of RFFS knowledge of the drainage system on the airport to be superficial. All on-airport driver training was limited to sealed surfaces, and topography training focused mainly on the location of buildings and hardstandings. Knowledge of the airport drainage system was limited mainly to an awareness of its general layout with little knowledge of the exact position of spoon, finger, or lateral drains.

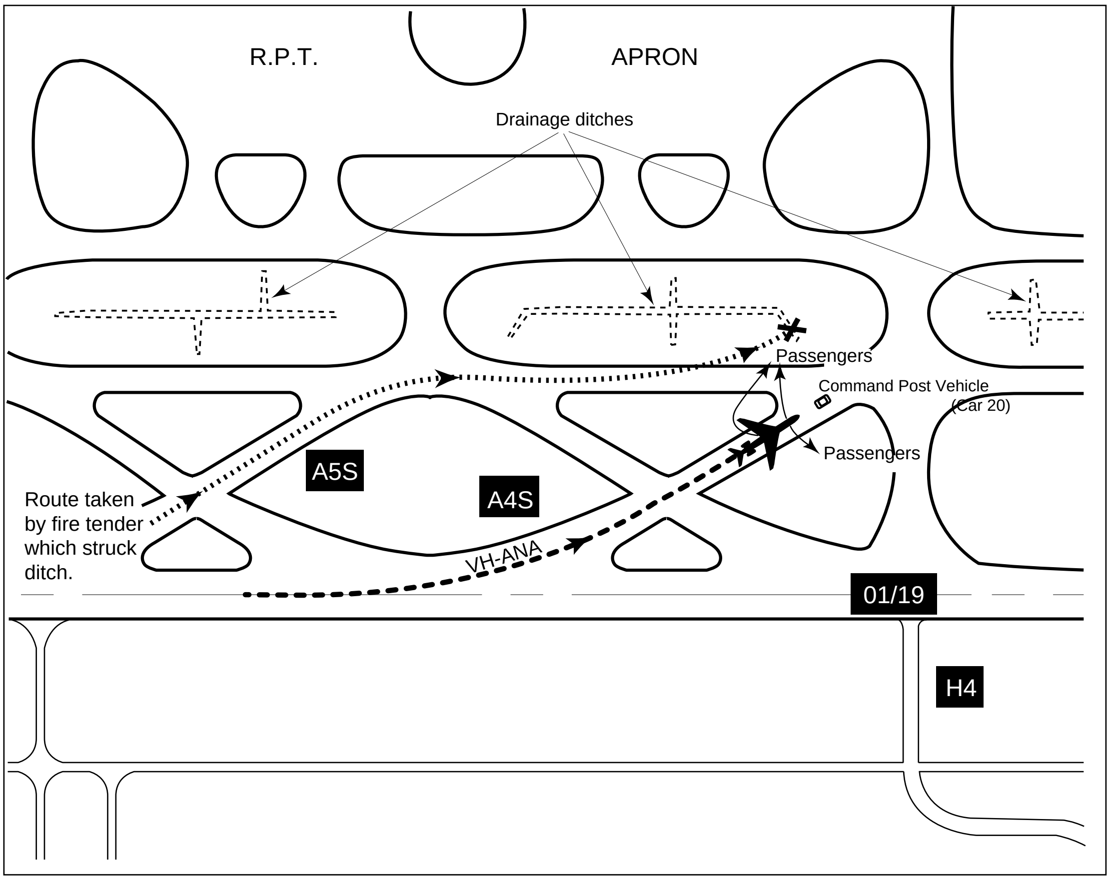



**Figure 5**

The RFFS did not have direct radio contact with the flight crew of VH-ANA. The former were on the SMC frequency and the aircraft had requested and was approved to remain on the aerodrome control frequency. Consequently, information requested by the flight crew after landing concerning the fire was not available directly from the RFFS.

### 1.17.10 Departure of VH-TAG

By the time VH-ANA had become airborne, VH-TAG was lined up at the threshold of runway 01 ready for takeoff. The tower controller indicated that, from his perspective in the control tower, no fire was evident from VH-ANA until it was beyond the end of the runway. Further, he did not see any debris falling from the aircraft. He decided to clear the runway in preparation for the emergency landing by VH-ANA by instructing VH-TAG to take off. It was not until the airport safety officer began a runway inspection after VH-ANA had landed that debris was found on the runway.

The crew of VH-TAG were aware of the problem with VH-ANA but, like the tower controllers, had no reason to believe that there was any debris on the runway.

Post-flight reconstruction of events revealed that VH-TAG was airborne prior to reaching the area of debris.

# 2. ANALYSIS

## 2.1 Introduction

The investigation determined that successful recovery of the aircraft and its occupants depended on (1) the nature of the failure of the engine turbine disc and subsequent fire; (2) the response to the emergency by the flight-deck and cabin-crew members; (3) radio communications between the aircraft crew, tower controllers and the fire-rescue personnel; and (4) the response of the airport fire-rescue services.

As is common to all occurrences where an evacuation of an aircraft takes place, the evacuation procedures were reviewed and an evaluation of the evacuation was undertaken.

## 2.2 The engine

### 2.2.1 Engine-disc failure

The metallurgical examination concluded that the engine failed as a result of the failure of the first-stage fan disc. The failure of the disc was the result of a fatigue crack initiated at a 'V'-bottomed scratch in the forward rim-to-web radius. It is probable that this scratch was caused during the finishing process of manufacture. Any inspection carried out following this process did not find a fault in the surface finish.

The disc was last in-service inspected 1,026 cycles prior to failure. The fatigue crack was calculated to have propagated over a period of 700–800 cycles and was therefore either not present or not detectable when the last inspection was carried out. There was no evidence found of any contributory influence which might have been a factor in the propagation of the fatigue crack.

### 2.2.2 Fire

The fire-warning light and aural alarm were activated when the fire-detection system sensed an overheat condition in the no. 2 engine bay. It is probable that the fire warning ceased as a result of a reduction in the heat in the engine bay when the fuel supply was exhausted after the crew shut the fuel off.

The activation of the fire bottles would not have been effective in extinguishing the fire as the engine cowls had been torn off and the extinguishing agent would have been dissipated by the airflow in the open engine bay.

The residual fire present when the aircraft landed was a result of metal and electrical wiring burning in the forward engine-bay area.

## 2.3 Actions of the aircraft crew

### 2.3.1 Flight deck crew

During the flight and in response to the in-flight emergency, the flight crew carried out their tasks in a co-ordinated manner. The flight-deck emergency response was in accordance with recommended procedures. Cabin crew were kept informed of the situation as it developed. Considering the limited information available to the crew from the aircraft instrumentation, the control tower and the RFFS, the decision by the captain to evacuate the aircraft would appear to have been the correct course of action. However, the decision taken by the crew to taxi the aircraft to the position of the fire vehicles delayed the evacuation, and was therefore questionable given the information available to the pilots.

### 2.3.2 Cabin crew

A number of factors were identified during the investigation which related to activities within the cabin. Indications are that company procedures were adopted by the flight attendants and that these procedures worked well in this occurrence. However, the purser's removal of her restraint system prior to her call to the cockpit is contrary to procedures which dictate that flight attendants remain seated until advised by the flight-deck crew that it is safe to remove their seat restraints.

Passenger assistance at the base of the slides or in aiding passengers sliding down the wing was not sought by the flight attendants at the forward doors. Such assistance can reduce the incidence of injury and the briefing required is minimal, e.g. 'Hold the slide once you're on the ground'. However, due to the short time between the decision to evacuate the aircraft and the commencement of the evacuation, a detailed briefing of the passengers was not possible.

A flight attendant ruled the right overwing exit unusable, mainly because of the discolouration around an auxiliary power unit exhaust vent. Some flight attendants had a limited knowledge of the aircraft beyond the cabin.

## 2.4 Communications

Communications between flight-deck crew and the tower controller were adequate and effective, as were the intra-aircraft communications.

The fire-rescue vehicles monitored the SMC frequency and had effective communications with the personnel in the control tower and between vehicles. However, they were not able to communicate with the aircraft crew, which had requested to remain on tower frequency. The RFFS had the facility to communicate on the tower frequency, but, for reasons not determined, remained on the SMC frequency. Thus the fire-rescue crew were required to relay vital information concerning the state of the fire and the operating status of the aircraft to the aircraft crew through the tower controller.

The need for direct communications between aircraft flight crew and the emergency response team can be critical to the safety of persons and property in an emergency. However, on this occasion, the lack of direct communications did not affect the decision to evacuate the aircraft.

## 2.5 Airport emergency response

The implementation of the airport emergency plan was flawed in several areas. The plan had not been fully exercised for 19 months. Had it been exercised more regularly it is probable that the shortcomings that emerged during this occurrence would have been detected and corrected. The training of the RFFS officers was deficient in the area of their knowledge of the aerodrome. Fortunately, on this occasion, none of the shortcomings had an effect on the safe landing of the aircraft or the evacuation of the passengers and crew.

## 2.6 Evacuation

The company training and operations manual in use at the time of the occurrence incorrectly implied that all exits with slide capability were fitted with slides which would deploy automatically. This discrepancy was detected by the investigation shortly after the event and was rectified by the operator with an amendment to the B727 operating manual.

Given the limited time available for the cabin crew to prepare for the evacuation of the aircraft, their response was efficient and accorded with company procedures.

# 3. CONCLUSIONS

## 3.1 Findings

1. The flight crew were correctly licensed and qualified to undertake the flight.
2. The cabin crew had been trained and checked as proficient in accordance with CAA requirements.
3. The aircraft was serviceable prior to the commencement of the flight.
4. The failure of the no. 2 engine resulted from the failure of the first-stage fan disc.
5. Fatigue cracking in the first-stage fan disc initiated at ‘V’-bottomed scratches in the forward rim-to-web radius and propagated under the blade posts.
6. The scratches were created during the initial rough polishing of the rim-to-web radius during manufacture.
7. Subsequent finish polishing of the radius had not removed all the surface damage created during the initial rough polishing process.
8. The disc failed after completing 15,605 cycles.
9. The out-of-balance situation caused by the release of six blades from the disc led to the separation of the first, second and third discs from the engine.
10. Two other first-stage fan discs have failed in service, both at the forward rim-to-web radius. Their failure modes are reported to be similar to that of VH-ANA.
11. A further three cracked discs have been found during special inspections. The cracks in all three are reported to be similar in nature to that of VH-ANA.
12. There was an organisational failure in that the Brisbane Airport emergency plan was out of date and had not been exercised for 19 months.
13. The training of the RFFS firefighters placed insufficient emphasis on the location of airfield drainage ditches.
14. The drainage ditches associated with Brisbane Airport comply with ICAO requirements. However, they are difficult to see.

## 3.2 Significant factors

1. The final finishing process used in the manufacture of the first-stage compressor fan disc did not adequately remove scratches caused by the initial rough polishing process.
2. The inspection of the finished product was inadequate in that it did not detect ‘V’-bottomed scratches in the forward rim-to-web radius.
3. During the takeoff, the disc failed, resulting in a sudden and complete loss of engine power.
4. Liberated engine components severed the main engine fuel line.

# 4. RECOMMENDATIONS

## 4.1 Interim recommendations

The following interim recommendations were made on 31 July 1992. Responses to these interim recommendations received from the CAA on 10 August 1992 and the FAC on 14 August 1992 are summarised below.

Interim recommendation 1

That the FAC consider methods of ditch marking, by day and by night, which will allow the drivers of emergency vehicles to identify and avoid open drainage ditches.

Response

The FAC advised that:

- Brisbane Airport complied with the requirements of ICAO Annex 14;
- the installation of drainage-ditch marking could lead to confusion with airfield lighting and other markings;
- it doubted that the drainage ditches constituted an impediment to safe movement, provided drivers have airside familiarisation training and exercise reasonable care in the operation of their vehicles.

Interim recommendation 2

That the CAA, in consultation with the US Federal Aviation Administration, the engine manufacturer and the operator,

(i) determine the source and history of the defective component, and others supplied at the same time;

(ii) evaluate the manufacturing process (which includes grinding);

(iii) consider the implications if other discs from a similar source and/or in a similar condition are currently in service; and

(iv) take the necessary action to prevent other failures from similar defective discs.

Response

The CAA advised that it was actively pursuing all of the points raised, and subsequently issued Airworthiness Directive AD/JT8D/27, effective 24 December 1992.

## 4.2 Safety actions taken

Subsequent to the presentation of BASI's interim recommendations and the drafting of the final recommendations of this report, the CAA and the FAC advised that the following actions were being taken to address deficiencies identified:

Actions taken by the CAA

(a) Airworthiness directive AD/JT8D/27, dated December 1992 has been issued, requiring mandatory inspection of all JT8D-9 through 17AR engines in the Australian fleet [see final recommendation 2].

(b) A review of auditing and surveillance procedures for all airports is being carried out, taking into account the problems identified at Brisbane Airport.

(c) Further emphasis is being placed on the requirements in relation to airport topography training at all airports as part of the competency based standards for all fire service operational training programs [see final recommendation 8].

(d) Air traffic services and fire service procedures have been reviewed to ensure that both pilots and the RFFS are aware of the radio frequency being used which would allow direct radio contact between the aircraft crew and the RFFS officer-in-charge [see recommendation 4].

(e) An aerodrome emergency procedures workshop was conducted on 16 and 17 June 1993 to discuss with industry and the FAC the aerodrome emergency procedures, communications and other issues associated with those procedures. The significant outcomes from this workshop were:

- the acceptance of an agreed framework for aerodrome emergency procedures manuals;
- the adoption of the FAC/Emergency Management Australia proposal for three levels of classification for aircraft in emergency by seating capacity;
- the adoption of clear and unambiguous terminology to describe requirements for standby of the local RFFS or to require a full emergency services turnout;
- agreement to upgrade training and checking of tower staff in handling aerodrome emergencies; and
- agreed amendments to AIP and the Manual of Air Traffic Services to ensure 'ground' frequency is the frequency to be used by the aircraft and emergency vehicles.

Actions taken by the FAC

(a) FAC local procedures have been put in place for regular review of names of key personnel and telephone numbers and correction/amendment where necessary.

(b) A table top exercise involving all responsible agencies, which re-enacted the VH-ANA incident and trialled amendments to the airport emergency plan was undertaken. The integrity of the plan was confirmed. A further two table-top exercises have since been undertaken and an additional table-top and a major field exercise are planned before the end of July 1993 [see final recommendation 7].

(c) Each FAC Safety Officer vehicle has been fitted with permanent blue beacons to identify it as the Mobile Command Post when appropriate. A loud hailer in each vehicle will facilitate marshalling of evacuated passengers.

(d) The airport emergency plan has been amended requiring the tower controller to advise the FAC Security Officer of emergencies at the same time as the police and other emergency services are advised.

(e) In consultation with all responsible agencies the FAC has formulated the draft of a new airport emergency plan for the Brisbane Airport.

## 4.3 Final recommendations

The following final recommendations are made regarding the investigation of this accident after considering the responses to the interim recommendations identified in para. 4.1 and interested party comments on the draft report. The Bureau recommends that:

1. The CAA liaise with and encourage Pratt & Whitney, the engine manufacturer, to publish a service bulletin identifying by part and serial number those compressor hubs which may exhibit a surface finish where deep scratches from rough polishing have not been eliminated by subsequent polishing processes.
2. The CAA amend AD/JT8D/27 to introduce a requirement which recognises that those hubs which have a rougher than specified surface finish and/or deep scratches should either be retired from service or be re-inspected at intervals advised by the engine manufacturer.
3. The FAC, regardless of the ICAO Annex 14 standard in respect to marking of ditches, further consider the introduction of ditch and hazard marking for Australian domestic and international airports.
4. The CAA examine the organisation and procedures covering communications during an emergency to ensure that appropriate communications are available between the RFFS and the flight crew of an aircraft to which they have been directed to attend.
5. The CAA amend CAR 89I 1(b) part 2 of schedule 10 to include specific direction on the frequency of aerodrome emergency plan exercises.
6. The CAA examine its procedures for surveillance of the implementation of aerodrome emergency plan requirements, to ensure that the procedures provide adequate confidence that the standards specified in the regulations are actually being met in practice and that the legal responsibility for this is clearly defined.
7. The FAC review and update the Brisbane Airport emergency plan to conform with the requirements of the CARs.
8. The CAA review its emergency/rescue vehicle driver training syllabus to include a segment which specifically identifies the location of airfield hazards.
9. The CAA ensure that airline flight attendant training syllabuses include familiarisation with those areas of technical terminology and characteristics specific to the aircraft on which they operate that are necessary for them to perform their cabin safety functions most effectively.

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