Australian Government

Australian Transport Safety Bureau

# Depressurisation involving Fokker F28, VH-NHF

49 km W of Newman Airport, Western Australia, 7 June 2016

**ATSB Transport Safety Report**

Aviation Occurrence Investigation

AO-2016-057

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**Postal address:** PO Box 967, Civic Square ACT 2608
**Office:** 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
**Telephone:** 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
**Facsimile:** 02 6247 3117, from overseas +61 2 6247 3117
**Email:** atsbinfo@atsb.gov.au
**Internet:** www.atsb.gov.au




**Addendum**

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# Depressurisation involving Fokker F28, VH-NHF

## What happened

On 7 June 2016 at about 1000 Western Standard Time (WST), a Fokker F28 MK 0100 aircraft, registered VH-NHF, departed on a charter flight from Christmas Creek to Perth, Western Australia. On board were five crewmembers and 28 passengers.

The aircraft was on climb to the planned cruise altitude of FL 340[1] and the weather was generally clear and smooth with intermittent icing conditions. The first officer was the pilot flying (PF) and the captain was the pilot monitoring (PM) for this flight.[2]

As the aircraft climbed through FL 200, the flight crew heard a 'whistling' noise. They did not notice any other abnormal indications and after about one minute, the noise stopped. At about FL 305, a loud 'whooshing' noise was heard by the flight crew on the flight deck and the three cabin crewmembers who were standing in the forward galley.

The cabin crew believed the noise was coming from the forward lavatory, so one cabin crewmember inspected the lavatory, but could not identify where the noise was coming from. The PM checked the aircraft pressurisation indications located on the cockpit overhead panel and noticed that the cabin altitude[3] indicated 6,000 ft as expected, but the cabin pressure rate of climb had increased from about 200–300 ft/min to about 500 ft/min[4] (Figure 1). This indicated to the PM that they were losing cabin air faster than the pressurisation system could pressurise the aircraft.

**Figure 1: F28 cabin pressure gauges**


Source: Operator annotated by ATSB

The PM contacted air traffic control (ATC) to request a level-off at FL 320, rather than their planned level of FL 340. At about this time, the cabin manager informed the flight crew that the cabin crew had heard a 'suction' noise from the forward lavatory, but could not identify the source of the noise. The PM asked the cabin manager to cautiously inspect the forward lavatory again.

1 At altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 340 equates to 34,000 ft.

2 Pilot flying (PF) and pilot monitoring (PM) are procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances; such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and aircraft flight path.

3 Altitude corresponding to pressure inside the cabin. 6,000 ft cabin altitude corresponds to an atmospheric pressure of 6,000 ft (See *F28 pressurisation – general description* below).

4 Engine compressor bleed air is used to supply pressurised air through ducting to the two air-conditioning packs. The air-conditioning packs then deliver air at a flow rate, pressure and temperature that maintains suitable conditions in the aircraft. The pressurisation system normally operates in automatic mode, but has a manual back-up mode if required.

The flight crew then received a 'PACK 1'[5] level 2 warning[6] in the cockpit and the associated emergency procedure displayed on the multi-function display unit (MFDU). The first step of the procedure was to turn off the affected air-conditioning pack and wait two minutes for the pack to cool before attempting a reset. When the PM turned off air-conditioning pack 1, they noticed the cabin pressurisation rate of climb increase to in excess of 2,000 ft/min.

The PM contacted ATC again and requested a descent to FL 250 and received a clearance from ATC to initially descend to FL 290 due to an airspace boundary. Before the PF was able to start the descent, the flight crew received an 'auto-throttle 1'[7] level 1 warning. At about this time, the PM informed the cabin manger that they were about to activate the seat-belt sign because an 'excessive cabin altitude' warning was imminent and the emergency oxygen would deploy.

Before the two minutes passed for the air-conditioning pack reset, the 'excessive cabin altitude'[8] level 3 warning activated. The flight crew performed their initial drill,[9] which included donning their oxygen masks. The PM then checked the cabin altitude, noticed it was indicating in excess of 25,000 ft and that the passenger emergency oxygen had deployed, and made a PAN[10] call to ATC. They received a clearance for an immediate descent to 10,000 ft, and the PF initiated an emergency descent.

As the aircraft descended, the cabin crew performed their 'sit-fit-advise'[11] drills for deployment of passenger emergency oxygen and the flight crew performed their 'emergency descent procedure'. The flight crew completed their 'excessive cabin altitude' procedure during the descent and then discussed their requirements for flight at 10,000 ft, which included alternate destination options. The PF levelled the aircraft at 10,000 ft and the flight crew completed the 'emergency descent procedure', which included a public address that emergency oxygen was no longer required.

The flight crew completed the air-conditioning pack and auto-throttle emergency procedures. After air-conditioning pack 1 was selected on, the cabin altitude decreased to 1,500 ft and the PACK 1 fault did not return for the rest of the flight. The PM left the seat belt light on for the remainder of the flight, but gave permission for the cabin crew to leave their seats to check on the needs of the passengers.

The cabin crew checked on the condition of the passengers and noted that one passenger wished to continue using supplemental oxygen. The cabin crew facilitated the passenger's request and provided them with portable oxygen for the remainder of the flight.

ATC contacted the aircraft for a progress update and provided the latest weather details for Newman, Meekatharra and Perth. The flight crew diverted the aircraft to Newman Airport, which was the closest option with company ground services. The crew advised ATC that an ambulance was required on arrival.

The aircraft landed at Newman at about 1100. Paramedics were available on arrival at Newman to provide assistance, but were not required.

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5 This warning refers to the number 1 air-conditioning pack.

6 There are three levels of warning; 1, 2 and 3, level 3 being the highest level of warning. When a higher level of warning is activated the associated procedure is prioritised on the MFDU, replacing any active lower level warning procedures.

7 Auto-throttle is linked to the automatic flight control system so that engine thrust is varied automatically according to the flight profile of the aircraft.

8 The excessive cabin altitude warning activates at about 10,000 ft cabin altitude, and the passenger emergency oxygen automatically deploys at about 14,000 ft cabin altitude. The deployment of passenger emergency oxygen is indicated in the cockpit and the pilots must manually deploy the system if it fails to deploy automatically. This check is included in the 'excessive cabin altitude' procedure.

9 Immediate actions performed from memory before reference to the checklist.

10 An internationally recognised radio call announcing an urgency condition which concerns the safety of an aircraft or its occupants but where the flight crew does not require immediate assistance.

11 Sit down, fit oxygen masks and advise passengers.

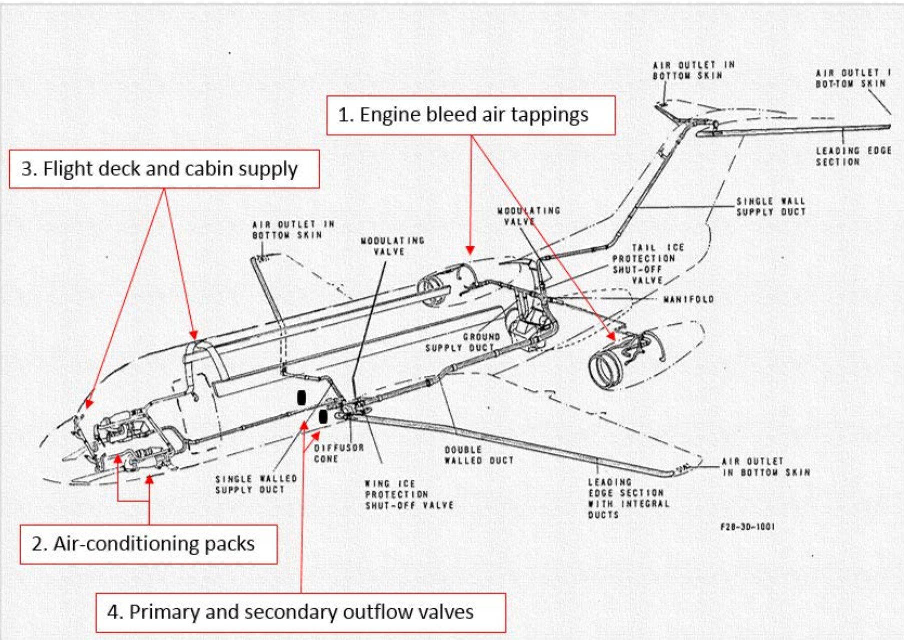
## *F28 pressurisation – general description*

Bleed air is compressed air taken from the compressor stage of the engine. Bleed air is used for several functions including pressurisation, air-conditioning and anti-icing. For pressurisation, the bleed air is supplied to the two air-conditioning packs located underneath the floor of the flight deck, which are used to control the temperature of the air prior to distribution into the flight deck and cabin (Figure 2).

Cabin pressure is regulated by the outflow valves, which control the outflow of air from the cabin in either automatic or manual mode. Controls for automatic and manual mode of operation are located on the flight deck. In automatic operation, the differential pressure[12] of 7.46 psi provides a cabin pressure altitude of 8,000 ft at an aircraft altitude of 35,000 ft (FL 350). The outflow valves will normally limit the maximum pressure differential in automatic and manual mode to 7.65 psi and the cabin pressure altitude to 12,000 ft plus or minus 1,500 ft, provided airflow from the air-conditioning pack(s) is available. An excessive cabin altitude warning is presented at 10,000 ft. The cabin is automatically depressurised upon landing and there are two negative pressure relief valves to prevent negative cabin pressure.

When one pack is selected off, the respective pack main valve shuts off bleed air supply and the other pack increases its output flow rate to 140 per cent of the normal flow rate. A single pack is capable of maintaining cabin altitude by itself at the maximum operating altitude of FL 350. Air-conditioning pack 1 is located underneath the floor of the flight deck on the left-hand side, which is just forward of the forward lavatory.

**Figure 2: F28 bleed air supply**




Source: ATSB

## *Captain (PM) comments*

The captain provided the following comments:

- No systems associated with air-conditioning/pressurisation were recorded as unserviceable before the flight.
- The emergency unfolded 'very quickly' with multiple faults and therefore knowledge of the emergency drills and procedures needed to be 'second-nature'. By the time they had

[12] Pressure difference between the external atmosphere and aircraft cabin.

performed their initial drills and checked the deployment of the passenger emergency oxygen, the cabin pressure altitude was already indicating in excess of 25,000 ft.
- The loud ‘whooshing’ noise was similar to the noise heard in the simulator during rapid decompression training.
- They did not feel any physiological effects during the loss of pressure and responded in accordance with their training.
- Their simulator training was comprehensive, allowing them to follow procedures while maintaining sufficient ‘spare mental capacity’ to deal with all the problems that unfolded in a logical and methodical manner.

### *Cabin manager comments*

The cabin manager provided the following comments:

- One passenger reported to them there was an unusual smell and the PM indicated to them that this was probably from the failed air-conditioning pack.
- Prior to the oxygen mask deployment, they felt a sensation in their ears, ‘like on a descent’. Another cabin crewmember commented to the cabin manager that they looked pale, and another cabin crewmember reported to them that they felt a loss of breath.
- After the instruction to sit down for the expected excessive cabin altitude, they were concerned that the sleeping passengers might not get their oxygen masks on when they deployed.
- About two minutes after sitting down, they heard a loud bang and the passenger emergency oxygen deployed.
- Some passengers had trouble fitting their oxygen mask, so the cabin crew used a combination of hand signals and verbal communication to assist them while remaining in their jump seats.
- They felt that the incident was managed in a ‘textbook’ manner.
- Another member of the cabin crew reported to them that they saw sticky tape covering the emergency oxygen in the forward lavatory, which prevented its deployment.

### *Maintenance findings and corrective actions*

The operator’s maintenance investigation of the incident found the following:

- There was a visual indication of duct over-temperature on air-conditioning pack 1.
- There was a controller fault on air-conditioning pack 1 and the flight deck temperature control was not working. The controller was replaced.
- A ‘heavy leak’ was found from the recirculation duct during investigation of air-conditioning pack 2. The recirculation duct was replaced.
- One of the outflow valves was found to be a ‘bit sticky’. The primary and secondary outflow valves were replaced. However, this did not have any effect on the pressurisation test results.
- There was a ‘massive leak’ from the inlet and outlet of air-conditioning pack 1. Pack 1 was removed and a large hole found in the plenum duct[13] (Figure 3). The plenum duct and primary and secondary heat exchanger were replaced on pack 1. Aircraft pressurisation was then tested and found to be serviceable (including operations with either pack 1 or pack 2 turned off).

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13 The plenum duct houses air at positive pressure (pressure higher than surroundings), and equalises pressure for a more even distribution in order to manage irregular supply or demand.

**Figure 3: Ruptured plenum duct**

Source: Operator

### *Operator comments*

The airline operator provided the following comments:

- The pack 1 fault was triggered by a compressor outlet overheat switch, which is located in the compressor outlet duct of the number 1 air-conditioning pack.
- The auto-throttle 1 fault was probably linked to the leaks in the air-conditioning ducts, which resulted in a conflict between the demands of the pressurisation computers and the operation of the auto-throttle system.
- The reason why the passenger emergency oxygen did not deploy in the forward lavatory is under investigation.
- The depressurisation can be attributed to pack 2, being the sole air supply, having a 'heavy' recirculation duct leak, which would not allow pack 2 to pressurise the aircraft.

### *Similar occurrence*

On 11 April 2016 VH-NHF suffered a number 2 bleed valve fault, which was reset once and then failed a second time. The pilots initiated a return to Perth. During the transit, the number 1 bleed valve failed. The pilots initiated their emergency drills, which included the use of emergency oxygen and a precautionary descent to FL 140. The excessive cabin altitude warning did not activate and during the descent, the number 1 bleed valve was reset. A normal approach and landing was performed at Perth.

## ATSB comment

Air-conditioning pack 1 is located on the left side of the aircraft underneath the floor of the flight deck, just aft of the left seat, which places it close to underneath the floor of the forward lavatory. The pack 1 plenum duct likely ruptured at about FL 305 to produce what the aircraft captain described as a loud 'whooshing' noise and what the cabin manager described as a 'suction' noise. According to Flight Safety Foundation *Human Factors and Aviation Medicine*, the immediate donning of oxygen masks by the flight crew, following an 'excessive cabin altitude' warning, is the essential first step to surviving a high altitude depressurisation.

The subsequent maintenance investigation found duct leaks from both air-conditioning systems. However, only the leak from air-conditioning pack 1 triggered an alert to the pilots, and that fault was associated with an overheat condition. In accordance with the operator comments, the rapid increase in the cabin pressure altitude rate of climb, which occurred when the flight crew turned pack 1 off, indicates that pack 2 alone could not supply a sufficient quantity of air to the distribution ducting to maintain cabin altitude. The systems were only able to re-pressurise the aircraft following the descent to 10,000 ft (the demands on the pressurisation system were substantially reduced) [14] and the successful reset of pack 1.

## Safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

### *Operator*

As a result of this occurrence, the operator has advised the ATSB that they are taking the following safety action:

All parts removed from the number 1 air-conditioning pack will be forwarded to the manufacturer, or authorised repair organisation, for further technical investigation to determine the cause of the failure of the plenum duct.

## Safety message

The incident started in a subtle manner as an unusual noise, then quickly escalated to a compound emergency. After some initial uncertainty regarding the noise, the flight crew quickly recognised the true nature of the emergency that was unfolding. The captain and cabin manager both commented that the emergency then unfolded in accordance with their expectations and there were several factors that assisted their emergency management. These factors included:

- their training experiences, which they felt closely matched their emergency experience
- procedural knowledge of their initial drills
- the fact that their colleagues were trained to the same level as themselves.

This incident highlights the importance and value of high-quality training for both flight crew and cabin crew. Quality training clearly assists in equipping crewmembers with the required knowledge and confidence to effectively respond to a time critical emergency. A sound understanding of emergency procedures is particularly important in ensuring that crews not only respond to an emergency appropriately, but also retain the capacity to deal effectively with other potentially complicating factors. Similarly, a sound understanding of aircraft systems supports effective crew decision making with respect to the best course of action when confronted with abnormal circumstances.

Additional information regarding how to respond to an aircraft depressurisation is provided in the following ATSB education bulletins:

- *Staying safe during an aircraft depressurisation – Passenger information bulletin* (AR-2008-075 (1))
- *Aircraft Depressurisation – Cabin crew information bulletin* (AR-2008-075 (2)).

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[14] The pressure difference between 30,500 ft aircraft altitude and 6,000 ft cabin altitude is about 7.51 psi, whereas the pressure difference between 10,000 ft aircraft altitude and 1,500 ft cabin altitude is about 3.81 psi (1 atmosphere = 14.7 psi). Therefore, at 10,000 ft, the demands on the pressurisation system were substantially reduced.

# General details

## Occurrence details

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|---|---|---|
| Date and time: | 7 June 2016 – 1020 WST | |
| Occurrence category: | Serious incident | |
| Primary occurrence type: | Depressurisation | |
| Location: | 49 km west Newman, Western Australia | |
| | Latitude: 23° 28.50' S | Longitude: 119° 19.78' E |

## Aircraft details

| | | |
|---|---|---|
| Manufacturer and model: | Fokker B.V. F28 | |
| Registration: | VH-NHF | |
| Serial number: | 11458 | |
| Type of operation: | Charter - Passenger | |
| Persons on board: | Crew – 5 | Passengers – 28 |
| Injuries: | Crew – 0 | Passengers – 0 |
| Aircraft damage: | Nil | |

# About the ATSB

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; and fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

# About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.