# Fokker F28 Mark 0100 (Fokker 100), G-UKFI

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| **AAIB Bulletin No: 3/2003** | **Ref: EW/C2002/4/1** | **Category: 1.1** |
| **Aircraft Type and Registration:** | Fokker F28 Mark 0100 (Fokker 100), G-UKFI | |
| **No & Type of Engines:** | 2 Rolls-Royce Tay 620-15 turbofan engines | |
| **Year of Manufacture:** | 1989 | |
| **Date & Time (UTC):** | 1 April 2002 at 0516 hrs | |
| **Location:** | Manchester International Airport | |
| **Type of Flight:** | Public Transport | |
| **Persons on Board:** | Crew - 5 | Passengers - 89 |
| **Injuries:** | Crew - Nil | Passengers - 6 (Minor) |
| **Nature of Damage:** | Damage to Auxiliary Power Unit | |
| **Commander's Licence:** | Airline Transport Pilots Licence | |
| **Commander's Age:** | 41 years | |
| **Commander's Flying Experience:** | 11,960 hours (of which 3,690 were on type) | |
| | Last 90 days - 95 hours | |
| | Last 28 days - 41 hours | |
| **Information Source:** | AAIB Field Investigation | |

## Synopsis

During taxi for takeoff at Manchester International Airport, the aircraft passenger cabin filled with smoke and an emergency evacuation of the aircraft was carried out. The evacuation was carried out expeditiously, but the cabin crew had difficulty opening the Galley Service Door and some passengers using the overwing escape hatches were unsure of how to descend to the ground. The smoke had originated from a damaged Auxiliary Power Unit (APU), which had allowed oil from the unit to leak into the bleed air system.

## History of the event

The aircraft was taxiing for takeoff from Runway 24R at Manchester International Airport on a scheduled passenger service to Amsterdam, the Netherlands. The weather was dry with a light southerly breeze. Sunrise was due at 0543 hrs and the sky was just becoming light.

Shortly after passing holding point J4, the flight deck crew became aware of a burning smell in the cockpit which was becoming stronger and which they described as smelling like hot light oil. The commander brought the aircraft to a halt and instructed the first officer to set the APU, which was supplying bleed air to the air conditioning packs, to OFF.

At about the same time, cabin crew member No 3 (CC3), who was situated in the middle of the aircraft at seat row 15, became aware of smoke in the cabin. There was no intercom handset at CC3s position. She therefore walked to the front of the cabin to inform the In-Flight Supervisor (IFS) who was in the forward galley with cabin crew member No 2 (CC2). As CC3 approached the forward galley, she was passed by CC2 returning to his normal crew position at the rear of the aircraft.

On being advised of the smoke, the IFS entered the cockpit and informed the flight deck crew. Very soon after this exchange, both cabin toilet smoke alarms activated and the cockpit crew received a Master Caution alert and TOILET SMOKE message. CC2 was passing seat row 15 at the time the toilet smoke alarms activated, and he continued to the rear of the aircraft and inspected both toilets for any signs of fire. Having found none, he advised the IFS via the intercom, who relayed the information to the commander, together with the fact that the smoke was continuing to move forward and was getting thicker.

Meanwhile the flight deck crew had closed the engine bleed air switches, thereby cutting off all possible sources of conditioned air. Both pilots looked back along the cabin through the open cockpit door and both remember having difficulty seeing as far as the rear of the passenger cabin. Realising that the smoke showed no sign of dissipating, the commander decided to carry out an emergency evacuation. He told the IFS to standby for his evacuation order, whilst he and the first officer carried out the On Ground Emergency/Evacuation checklist, which involved lowering full flap and shutting down the engines. The Cockpit Voice Recorder (CVR) indicated that one minute forty seconds had elapsed between the cockpit crew first smelling burning in the cockpit and the engines being shutdown.

## Doors and Emergency Exit locations

The Fokker 100 is fitted with a Main Passenger Door located on the forward left side, behind the cockpit, and a smaller Galley Service Door on the forward right side, opposite the Main Passenger Door. In addition, there are four overwing escape hatches, two on either side of the aircraft, located at seat rows 14 and 15, for use only in an emergency. There is no exit to the rear of the aircraft. In an emergency evacuation on the ground, all doors and hatches are designated as primary exits.

Interior emergency lights illuminate all cabin exit areas and escape slides. Exterior emergency lights are located above the overwing escape hatches and just aft of the exits in the wing fillet. Floor level guidance to cabin exits is provided by luminous strips. The emergency lights are switched ON in the course of carrying out the emergency evacuation checklist.

## Evacuation

By the time the commander gave the EVACUATE order on the passenger address system, some passengers were already becoming concerned at the smoke and some had started to release their seat belts. The rapid development of events meant that CC3 did not have time to return to her normal station at seat row 15. Thus at the point that the evacuation was ordered, IFS and CC3 were at the front of the aircraft and CC2 was at his normal station at the rear of the cabin.

When the EVACUATE order was given, the IFS opened the Main Passenger Door and CC3 attempted to open the Galley Service Door. CC2 carried out his normal evacuation duty, which was to urge passengers seated in rows 16 to 22 to move forward towards the overwing escape hatches. CC3 managed to initiate the opening of the Galley Service Door, but was unable to open the door fully. Once the IFS had confirmed that the Main Passenger Door was open, the slide had correctly deployed and the passenger evacuation was underway, she changed positions with CC3 and attempted to fully open the Galley Service Door. After some difficulty, the IFS managed to kick open the Galley Service Door, and passengers were then able to leave the aircraft through both forward doors. Some passengers hesitated at the front exits and needed encouragement to use the evacuation slides. Some other passengers started to collect hand baggage before departing the aircraft. The IFS made use of a megaphone to hasten the disembarkation of the latter.

Passengers seated at rows 14 and 15 had been briefed on the operation of the overwing escape hatches prior to departure. However, as CC3 was unable to return to her emergency station at seat 15D, these passengers had to open the hatches without further guidance. The row 15 right side hatch and both left side hatches were opened successfully, but the hatch next to seat 14F, on the right of the aircraft, was not used and thus only three of the four overwing escape hatches were opened.

Having climbed out of the cabin onto the wing, passengers disembarking from the left overwing exit were unsure of how to descend from the wing to the ground. A number congregated on the wing looking for a way down. Cabin crew eventually noticed the confusion and urged the passengers to get off the wing. Some passengers slid or jumped from the wing tip and leading edge (a drop of some 7 to 8 feet) instead of sliding off the wing trailing edge down the extended flaps.

Once all the passengers had disembarked, the crew carried out a check of the cabin to ensure that all the passengers were off the aircraft. They then made their own egress and organised the passengers on the ground. The commander was the last to leave the aircraft after advising both ATC and the emergency services that the evacuation was complete. A tape recording of the ATC frequency indicated that the commander advised of the evacuation at 0516 hrs and called to indicate that the evacuation was complete at 0519 hrs. The emergency services arrived on the scene within one minute of being alerted by ATC and advised that all passengers had disembarked by the time they arrived at the aircraft.

## Engineering investigation

G-UKFI is fitted with a type GTCP36-150R APU, which provides bleed air primarily for the air conditioning system, engine starting and anti-icing systems during ground operation. The APU is mounted in the rear of the fuselage and draws air from outside the aircraft, which is fed into a sheet-metal plenum chamber and then into the APU compressor.

Bleed air from the APU compressor is fed via the APU air supply duct, into the No 2 engine bleed air supply duct. Downstream of this junction, the No 1 and No 2 engine air supply ducts join the main bleed air supply manifold, which feeds bleed air to the consumer systems. There is a check valve in the APU bleed air supply duct, which closes when the air pressure in the No 2 engine bleed air supply duct rises above the pressure of the bleed air from the APU compressor.

When the engines are running at low speed, the APU check valve remains open and the APU continues to supply bleed air, as under these conditions the APU air pressure is higher than that of the engine bleed air. As engine speed increases and the engine bleed air pressure rises above that of

the air in the APU supply duct, then the APU check valve closes, thus isolating the APU bleed air. The APU is normally switched off either shortly before, or shortly after take-off.

From the symptoms described by the crew, it was apparent that the smoke in the air conditioning system was most probably associated with the APU. The APU bay was examined for evidence of a failure, but nothing obvious was found. The APU was then started and allowed to run for several minutes under no load. On selecting the APU bleed air switch ON, an APU bleed fault indication light illuminated. It was necessary to select the bleed switch four times before the APU bleed air could be obtained. The No 1 air conditioning pack was then selected ON, to provide conditioned air to the flight deck and cabin. Within two to three seconds, thick white smoke was seen to emanate from the flight deck air vents and the passenger cabin quickly began to fill with an oily-smelling white smoke.

The APU, part number 3800270-4, serial number P-117C, was removed and sent to the APU manufacturers overhaul and repair facility in Germany. Strip examination of the unit revealed that the compressor inlet plenum had cracked and collapsed and areas of the plenum wall were missing. The rotating assemblies exhibited foreign object impact damage and were rough in operation. This and the presence of metal particles in the gearbox oil sump, indicated that bearing damage had occurred.

The primary cause of the APU failure was the cracking and collapse of the sheet-metal constructed compressor inlet plenum, which is prone to oil canning and cracking. Pieces of sheet metal had broken away from the plenum and had been ingested by the compressor, causing secondary damage to the compressor impeller blades and the rotating assemblies further downstream. The APU had continued to run in an out-of-balance condition, causing the compressor bearing to be damaged and the compressor oil seal to fail.

The manufacturer confirmed that the smoke in the cabin had been caused by the failure of the APU compressor oil seal, which had allowed APU oil to leak into the APU bleed air supply and thus to enter the air conditioning system.

The problem of APU compressor plenum cracking due to oil canning is addressed by replacement of the plenum with a new, stiffer plenum which is hydro-formed, in accordance with Allied Signal Service Bulletin (SB) GTCP36-49-6959. This SB had not yet been incorporated on the failed APU. A search of accident and incident databases did not identify any history of similar incidents on the Fokker 100 type due to APU plenum failures.

## Crew emergency procedures

The operators Operations Manual outlines the duties to be carried out by flight crew during an emergency evacuation and details which exits passengers are expected to use. Passengers seated forward of the overwing exits (forward of seat row 14) are expected to go forwards and leave via the two forward doors. Passengers seated at rows 14 and 15 and to the rear are expected to use the overwing exits.

The three cabin crewmembers have designated stations within the cabin. The IFS is seated at the Main Passenger Door, CC3 is seated in the middle of the cabin at seat number 15D and CC2 is seated at the rear of the cabin. In an emergency evacuation, the IFS is responsible for opening the Main Passenger Door and then the Galley Service Door. The CC3 is responsible for monitoring the opening of the overwing exits and providing advice on how the passengers should climb out of the

escape hatches. If the flow of passengers through the forward doors dries up, CC3 is responsible for directing passengers forward. CC2 is required to move behind the rear seated passengers urging them forward towards the overwing exits.

## Doors and exits

*Galley Service Door operation*

The Galley Service Door is a Type 1 door, 51 inches high and 24 inches wide. It is hinged at its forward edge and is fitted with a single lane slide. The door may be operated from the inside in manual or automatic modes. The mode is determined by a door selector, which controls a girt bar arrangement. In normal operation, the door is operated in manual mode and the slide does not deploy. Automatic mode is used in an emergency and the slide should deploy and inflate automatically.

The bottom of the door is level with the galley floor and an individual of average height needs to stoop to exit. The door handle is located about two thirds of the way up the door from the floor and is used as an unlocking device and a point at which to exert force to open the door. The relatively low height of the door requires anyone of average height to adopt a stooped posture when opening the door. The Galley Service Door is not fitted with a power assist system and all opening forces must be provided manually.

On most flights, the IFS opens the door to allow access by catering staff, but it is not unusual for the CC2 or CC3 to open the door if the need arises. All three cabin crew on the incident flight were familiar with opening the door in manual mode, but only the IFS had previously operated the door in automatic mode. The forces required to open the door during normal operations were described as 'very light'.

Initial examination of the Galley Service Door did not reveal any malfunction that might have caused difficulty opening the door in the automatic mode. The operator refitted a slide to the aircrafts Galley Service Door and carried out a test opening, which was filmed. The film was then made available to the investigation. During the test, the door was opened by an experienced cabin crew member of similar stature to the crew member involved in the incident.

The door opened successfully and the slide deployed normally, but analysis of the film revealed that the door stopped briefly during the early stages of opening. Indeed, frame by frame analysis revealed that the door actually moved toward the closed position before continuing to open. The door operator confirmed that she needed to push the door a second time to keep the door opening. She also noted that the posture required to open the door was awkward and that the opening forces and method required were quite different from those required to open the Main Passenger Door.

The increase in force required to open the door in automatic mode is caused by the resistance of removing the slide from its housing. It appeared from the test that the door opened a small amount (approximately 10-15°) before this resistance was felt. On reflection, CC3 remembered that she initially applied a force, which opened the door slightly, but then she released pressure on the door and had to reapply force in an attempt to open the door further.

Cabin crew were given annual training in the opening of normal and emergency exits, concentrating on the Main Passenger Door and the overwing exits, but no specific training was provided in the operation of the Galley Service Door.

*Main Passenger Door*

The Main Passenger Door is very similar to the Galley Service Door, but it is larger and, significantly, has a different hinge arrangement. The Galley Service Door opens in a manner similar to any vertically hinged domestic door, but the Main Passenger Door is fitted with an offset hinge device. Movement of the door during opening is first out, away from the fuselage, and then forward to rest in the fully open position with the inside of the door facing the fuselage.

*Overwing exits*

The overwing escape hatches are located centrally over the wing. During an emergency evacuation, passengers are expected to climb out of the cabin and move aft along the wing root and slide to the ground down the fully extended flaps. A wing trailing edge slide is not fitted.

This escape route is depicted on the Passenger Safety Card and is shown at Figure 1. The route is shown in a diagram of the entire aircraft and is quite small and not easy to discern. Red arrows on the card are intended to depict the direction that passengers should leave the aircraft once they have reached the ground.

To assist passengers once they have climbed onto the wing, the route is marked on the upper wing surface with a black line and three black arrows showing the exit direction. The wing surface is light grey in colour and the black lines are prominent. However, there are other black lines of the same size outlining the no step area running along the wing span just aft of the leading edge and just forward of the trailing edge. When viewed from the escape hatches, these lines appear to point to the wing tip.

In a passenger survey, conducted after the incident, it was clear that many passengers had expected a slide at the wing trailing edge. Some passengers thought that the absence of a slide was a result of a system failure.

A brief study of overwing exit markings on other aircraft showed that markings varied considerably. Current regulations for exit markings are contained in Joint Airworthiness Regulations (JAR) 25. There is no requirement for a specific design, but markings must have a 5 to 1 contrast ratio with the surrounding area.

## Evacuation data

A passenger survey form, which was sent to all passengers, received a 75% response. Forty eight passengers were seated forward of row 14, and 41 passengers were seated in, and aft of, row 14. The 25% of passengers who did not respond to the survey were seated randomly throughout the cabin and were distributed evenly fore and aft of row 14.

Of 31 passengers who vacated the aircraft through the forward doors, 17 departed through the Main Passenger Door and 12 through the Galley Service Door (two passengers were unsure of which door they had used). This bias toward the Main Passenger Door may reflect the delay in opening the Galley Service Door or simply greater passenger familiarity with the Main Passenger Door.

No attempt was made to open the overwing escape hatch at seat 14F. Thirty six passengers vacated the aircraft through the overwing escape hatches, 22 through the two left wing hatches and 13 through the single right hatch (one passenger was unsure which hatch was used). Six passengers

seated forward of row 14 moved rearwards and vacated the aircraft through the overwing escape hatches.

The main topic of concern amongst the surveyed passengers was the confusion over the exit route from the left wing, and several passengers commented that the cabin crews continuous calls of *Evacuate* had tended to cause some panic.

## Analysis

The manufacturer confirmed that the smoke in the cabin had been caused by the failure of the APU compressor oil seal, which had allowed APU oil to leak into the APU bleed air supply and thus to enter the air conditioning system.

Very little time elapsed between the discovery of the smoke and the commanders decision to evacuate the aircraft. Consequently, not all of the cabin crew were able to take up their appointed emergency stations. In particular, CC3 was unable to return to her emergency station at seat 15D. There was no time for extra briefing of the passengers, as would be the case in a pre-planned evacuation, and the cabin crew therefore had to improvise and rely on the pre-departure cabin safety briefing.

The requirement for a cabin crew station at the overwing exits was imposed by the CAA when the aircraft was brought into UK service. It reflects the importance of these exits, given the lack of any exit at the rear of the cabin. The passengers sitting next to the escape hatches were briefed, before departure, on their responsibility to open the hatches in an emergency. With no further guidance available from CC3, it was not surprising that only three of the four exits were opened.

It is normally the CC3s responsibility to encourage the passengers disembarking at the overwing exits to slide down the flaps at the back of the wing. The absence of this encouragement may partly explain why the passengers became confused about the correct route down from the wing. However, the passenger survey revealed that a number of passengers expected an inflatable slide to be available and none of the passengers questioned recalled seeing the wing markings. The passenger safety card *(jpg 253kb)* is not clear on the route to be taken and, whilst the wing markings meet current Airworthiness Regulations, they are the same colour as other markings on the wing and are ambiguous. A brief survey of overwing exit markings on other aircraft types showed that the standard of markings varied considerably.

The difficulty in opening the Galley Service Door appears to be due to the need to keep pushing the door until the slide has been extracted from its housing in the door. This technique is different from that required to open the Main Passenger Door, and cabin crew need to be trained in the technique.

## Safety Recommendations

The following Safety Recommendations are made:

**Recommendation 2002-42**

The CAA and the JAA should review the design, contrast and conspicuity of wing surface markings associated with overwing emergency exits on all relevant Public Transport aircraft, with the aim of ensuring that the route to be taken from the wing to the ground is marked unambiguously.

**Recommendation 2002- 43**

The CAA and JAA should review the requirements for passenger safety cards to ensure that, for aircraft with overwing exits, the safety card is required to clearly depict the emergency escape route(s) from the cabin, via the wing, to the ground.

**Recommendation 2002-44**

The CAA and JAA should review the requirements for flight and cabin crew training in respect of the operation of all available exits, to ensure that crew members are familiar with the operating procedures, and opening characteristics, in both the normal and emergency modes of operation.