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Faulty procedures were partly to blame for the failure to reinstall the center wing fuel tank purge door in a Boeing 777 after maintenance, the U.K. AAIB says.



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The failure by maintenance personnel to reattach a fuel tank purge door inside the left main landing gear bay of a British Airways Boeing 777-200 was a causal factor in an incident in which a vapor trail of fuel streamed from the center wing tank after takeoff, the U.K. Air Accidents Investigation Branch (AAIB) said.

In its final report on the June 10, 2004, incident, which occurred on departure from London Heathrow Airport, the AAIB said that, after being

told that a crew waiting at the runway holding point had seen a trail of smoke coming from their airplane, the flight crew of the Zimbabwe-bound 777 declared an emergency, determined that the “smoke” actually was leaking fuel, jettisoned enough fuel to reduce the airplane to maximum landing weight and returned to Heathrow for a normal landing. Although the report noted that the leak created “potential for a wheel-well fire,” the airplane was not damaged and none of its 166 occupants was injured.

When a maintenance technician inspected the airplane after its arrival at the gate, he “noticed a few drips of fuel on the left main landing gear but none on the ground,” the report said. “After opening the left inboard main gear door, he detected a distinct smell of fuel. An inspection inside the gear bay revealed that the center fuel tank purge door was not in place [Figure 1, page 44]. The purge door was hanging on a lanyard inside the fuel tank, and a plastic bag was attached to the purge door opening. The bag contained fuel

and the screws that would normally hold the purge door in place.”

The report said that the plastic bag was the same type that was used at the British Airways maintenance facility at Heathrow and at British Airways Maintenance Cardiff (BAMC), the operator’s subcontracted maintenance organization in Wales, where the airplane had undergone maintenance between May 2 and May 10, 2004.

The maintenance was a 2C check — conducted on British Airways 777s every 1,500 days or 8,000 cycles or 24,000 flight hours, whichever occurs first — that included two tasks requiring access to the center wing fuel tank: an internal inspection of the rear spar and a check of the bonding of the tank’s float switches (Figure 2, page 45). Safe entry into a center wing fuel tank requires that all fuel first be removed and fuel vapors be purged.

The maintenance organization used a purging procedure discussed in the aircraft maintenance manual (AMM) that required removal of seven fuel tank access doors — but not the purge door.

A separate AMM entry — not cross-referenced in the discussion of the purging procedure — said

that the purge door should be opened by attaching a lanyard to the door; unfastening the bolts, washers and clamp ring that hold the door in place; and using the lanyard to lower the door into the tank. Later, after a maintenance technician enters the fuel tank, he or she should remove the purge door from the airplane, the entry said.

The maintenance organization used job cards — also called certification cards — that contained instructions on how to complete specific maintenance procedures, such as draining the center wing tank. Each job card listed the tasks involved in the procedure; for each task listed, one box was stamped when the task was completed and a second box was stamped to certify that it had been completed correctly. The stamps were numbers that were assigned to each member of the maintenance staff to identify which one had performed a particular task. If any nonroutine action was taken — such as removal of the purge door as part of the job of purging fuel vapors from the center wing fuel tank — a licensed aircraft engineer (LAE) was required to produce relevant “defect cards” — such as one card for removal



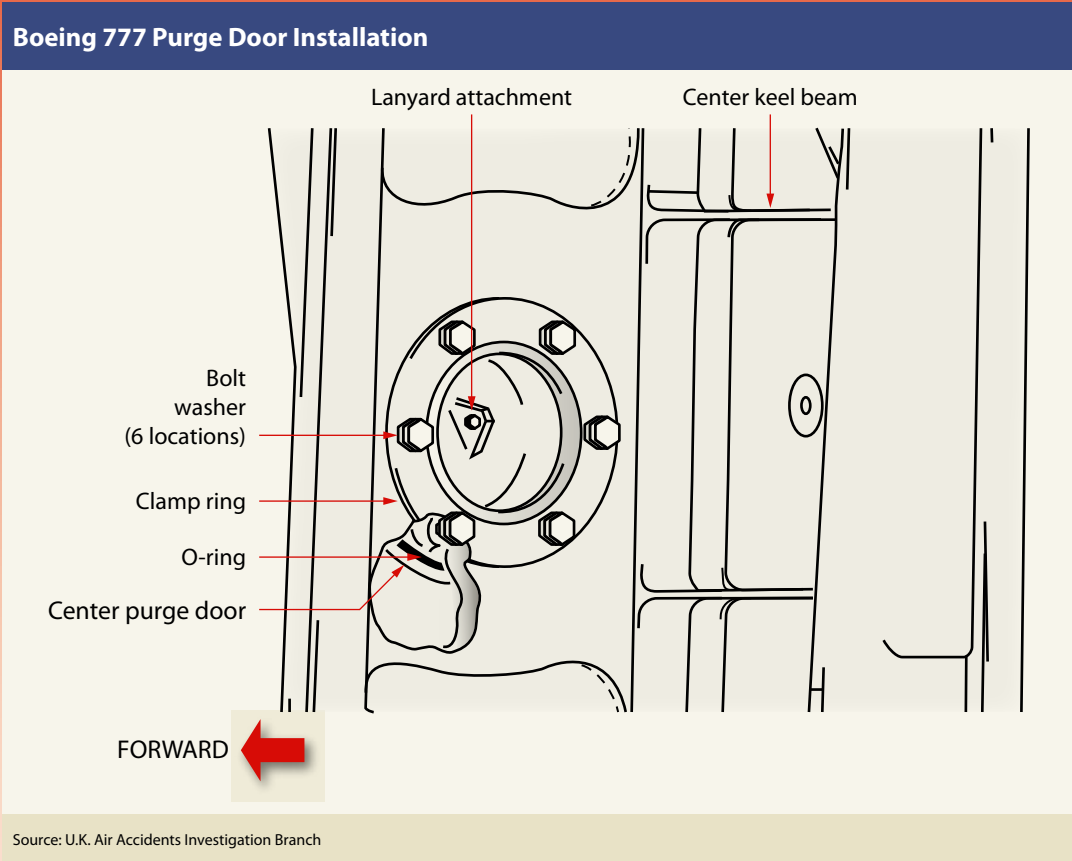
# OPEN DOOR

BY LINDA WERFELMAN



Leaking fuel trails the British Airways Boeing 777 after takeoff from London Heathrow Airport.

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Source: U.K. Air Accidents Investigation Branch

Figure 1

of the purge door and a second card for its reinstallation.

In this instance, removal of the purge door was not recorded on a defect card, and there was no card for the door’s reinstallation.

**Unaware of the Purge Door**

During the investigation, interviews with 10 maintenance personnel who had been working near the center wing tank revealed no one who remembered having removed the purge door or who was aware that anyone else had removed it. Seven of the 10 were even unaware that 777s have a purge door.

The technical team leader (TTL) who certified the completion of the draining and purging of the center wing tank had been promoted to TTL one month before the work was performed on the incident airplane. He had undergone training for the 777 technical type rating about 18 months before the incident but worked primarily on 747s, in which purge-

door-removal procedures allowed for the purge door to remain hanging on a lanyard inside the tank and to be reinstalled by using the lanyard to pull it back into position. His team of two technicians and one mechanic also worked primarily on 747s.

A review of maintenance records revealed a previous instance in which a purge door was removed from the center wing tank of a 777 without an accompanying defect job card. In that instance, in February 2004, an experienced TTL observed the open purge door while he was conducting the rear spar inspection and ordered a defect card for its reinstallation.

**‘Confusing Diagram’**

He also wrote a “query for engineering advice note” (QEAN), in which he questioned the rear spar inspection procedure outlined in the AMM and requested “clarification as to whether it was the front spar or the rear spar that needed inspecting,” the report said.

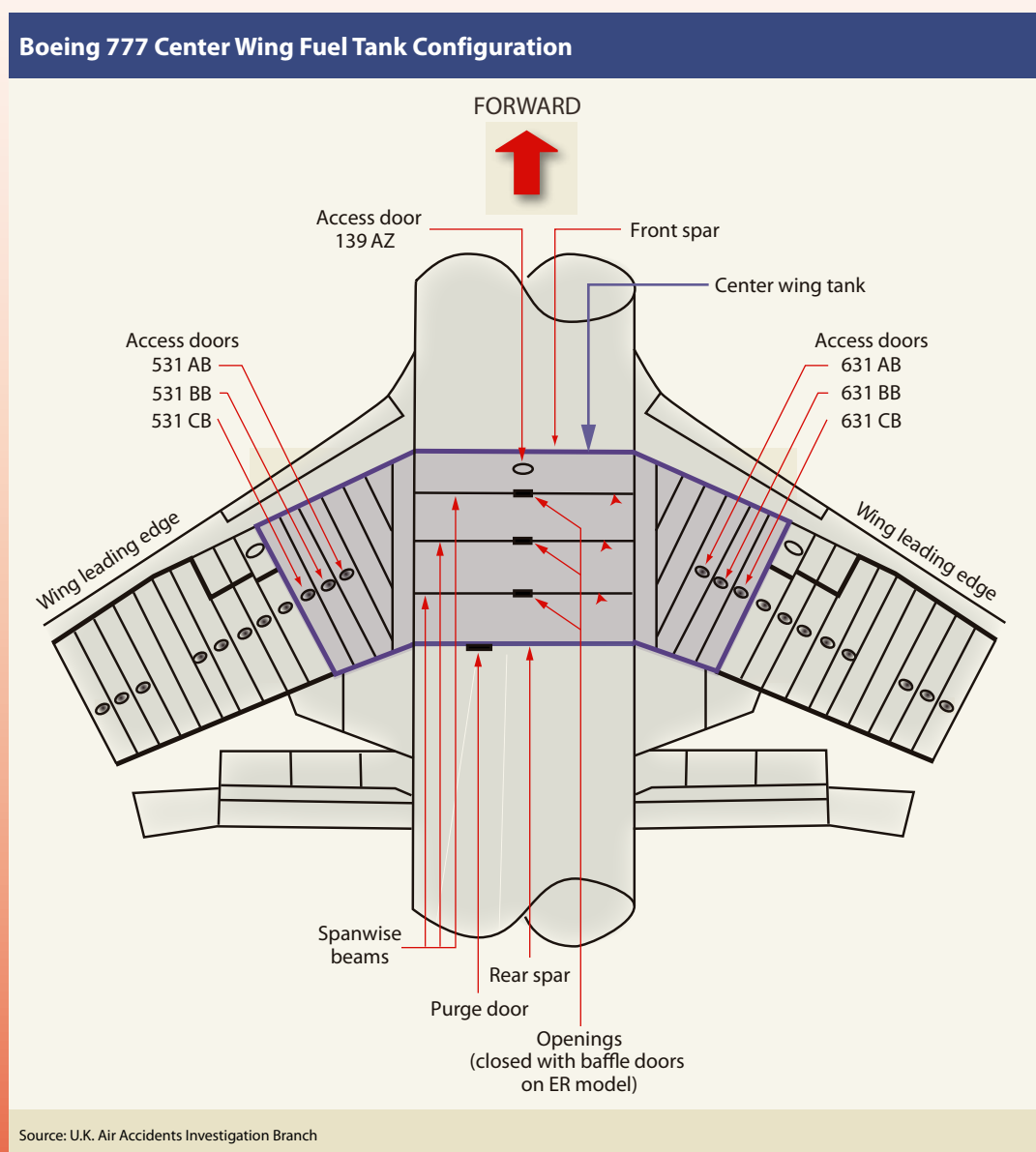
A technical services engineer responded the next day, saying that the rear spar required inspection and that he would contact Boeing to question a diagram on the Boeing task card, which “incorrectly showed the front spar ... as the area to be inspected,” the report said.

“No action was taken to withdraw the confusing diagram or to highlight its errors to other maintenance staff,” the report said. “Also, no action was taken to determine if rear spar inspections on previous aircraft had been carried out correctly.”

The technical services engineer sent a fax to the manufacturer on March 16, 2004, outlining

problems with the rear spar inspection diagram; Boeing’s first response, sent March 23, was lost and was sent again April 15, after a second query from the maintenance organization. The response confirmed that the rear spar was the area to be inspected and said that a corrected diagram would be issued. The correction was included in the May 5 revision of the AMM and the Boeing task cards, which were received by the operator on June 8 — one month after maintenance was performed on the incident airplane.

The maintenance technician who conducted the inspection on the incident airplane had



**“No action was taken to withdraw the confusing diagram or to highlight its errors to other maintenance staff.”**

Figure 2

never conducted a similar inspection and had never been inside a 777 center wing fuel tank. He complied with the incorrect illustration on the job card, and, as a result, he did not enter the rear section of the center wing tank where the purge door was located or remove three baffle doors, which were designed to limit rapid fuel movement within sections of the center wing fuel tank as a result of changes in the airplane's attitude and which should have been removed to perform the inspection.

"A potential opportunity to detect the open purge door was lost when the rear spar inspection was carried out in the wrong location because of an error in a diagram in the ... AMM," the report said. "The maintenance organization was aware of the error in the AMM diagram and had notified the aircraft manufacturer, but no action was taken to communicate this fact to production staff."

In his query to Boeing, the technical services engineer also noted that the rear spar inspection procedure did not mention the need to remove the baffle doors, but he did not specifically ask for advice on what to do with them; the reply from Boeing did not mention the baffle door issue.

### Recurring Question

The issue had been raised at the maintenance organization before — about two years before the incident, when a production engineer requested that routine job cards be produced for the removal and reinstallation of center wing tank baffle doors. A planning engineer prepared a QEAN about the absence of any reference to the baffle doors in the AMM; the response from Boeing indicated that the question had been misunderstood, but "technical services [at the maintenance organization] appeared to overlook this discrepancy and no further action was taken," the report said.

In June 2003, the planning engineer wrote another QEAN, restating his question. The report said that a technical services engineer responded that the question had been raised with the manufacturer and that "these changes will come, but at this present time, they are slow

and we unfortunately cannot pressurize Boeing to speed up."

This response was incorrect, the report said. Boeing had closed the issue after responding to the question the previous year, and the maintenance organization had never resubmitted its question.

Although the maintenance organization had been aware of the missing baffle-door reference, routine job cards had never been created for removal and reinstallation of the baffle doors, the report said.

As a result, defect cards were required each time baffle doors were removed. On several occasions, however, they were removed but there were no corresponding defect cards; the report characterized this as "an unacceptable practice that may have contributed to the unrecorded removal of the purge door."

After the center wing fuel tank was closed, leak checks were conducted. The TTL who conducted the checks could not remember the specific amount of fuel used for the check, but the report said that it probably was the 40,000 kg (88,184 lb) "catch-all" amount that maintenance personnel typically used to ensure that all access doors were secure.

The AMM said that 30,900 kg (68,122 lb) of fuel was sufficient for a leak check of all center wing fuel tank access doors, but the "Fuel Leak Detection" procedure did not discuss the purge door. The separate purge door-removal procedure said that refueling the center wing fuel tank with at least 32,000 kg (70,547 lb) of fuel was required for a leak check of the purge door. However, after the incident, it was determined that 32,000 kg was not sufficient to reach the base of the purge door opening. The AMM subsequently was revised to include the correct figure — 52,163 kg (114,999 lb).

The report said, "Several routine procedures should have revealed the open purge door, but they all failed. Firstly, the paperwork failed because no defect card was raised indicating that the purge door had been opened. Secondly, tank inspection before its closure failed because the rear spar inspection was carried out in the wrong location and because



**"Several routine procedures should have revealed the open purge door, but they all failed."**

the engineers closing the tank did not know the purge door existed. Thirdly, the ‘safety net’ leak checks failed because the job cards and the AMM [center wing tank] leak check procedure did not refer to the purge door. Moreover, the purge door leak check fuel quantity was incorrect, and the engineer carrying out the leak checks did not know about the purge door.”

After the maintenance check, the airplane was flown 53 sectors before the incident flight. During that time, the highest recorded fuel load was 26,800 kg (59,083 lb) — about half the amount that would have been necessary for fuel to leak because of the missing purge door, the report said.<sup>1</sup>

There was no record of any maintenance that would have required opening the left main inboard gear door after the 2C check and before the incident flight. Without such maintenance, there was no opportunity to observe the missing purge door; the area where the door was located could not be seen from the ground when the left inboard main landing gear door was closed, the report said.

The maintenance organization had a system for the reporting of maintenance errors, but such errors were not routinely reported, the report said (see “Defining the Blame Boundary”). Since the incident, analysis of maintenance

## Defining the Blame Boundary

A six-month review of British Airways Maintenance Cardiff (BAMC) quality discrepancy reports (QDRs) — which concerned items “of an airworthiness nature relating to aircraft maintenance operations/procedures” — revealed no reports of internal maintenance errors, the U.K. Air Accidents Investigation Branch (AAIB) said.

“However, it is known that maintenance errors were occurring because they were being reported by the operator once aircraft had returned to service,” the AAIB said in its report on the incident involving the Boeing 777-200 fuel leak.

“The extent of the lack of internal maintenance error reporting could not be determined, but it was discovered that on at least one previous occasion [in February 2004], the purge door had been removed but not recorded as removed. This event was not reported at the time but was revealed during the investigation. Had it been reported and thoroughly investigated, the lessons learned could have prevented [this subsequent] incident.”

The report cited several possible reasons that maintenance errors were not being reported under the QDR system, which required reporters to identify themselves. These reasons included the would-be reporter’s fear of being blamed or fear that a colleague would be blamed, or a belief that “no effective action

would be taken to prevent a recurrence,” the report said.

The maintenance organization had a disciplinary policy designed to deal with cases of “misconduct” and “gross misconduct,” but the policy did not discuss what types of maintenance errors would fall into each category, or what types of disciplinary action might be taken in case of a self-reported maintenance error, the report said. In addition, for some employees, it was unclear where the “blame boundary” lay.

“The company’s disciplinary policy did not set clear boundaries, and it did not encourage uninhibited reporting,” the report said. “The company did not have investigators who had been pre-identified ... and the investigators, including the investigator of [this incident], did not receive any formal maintenance error investigation training. There was no formal feedback process following an incident investigation, and in cases where disciplinary action was taken, very limited information was made available.”

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### Further Reading From FSF Publications

McKenna, James T. “Maintenance Resource Management Programs Provide Tools for Reducing Human Error.” *Flight Safety Digest* Volume 21 (October 2002).

error data has begun in an effort to identify and prevent future errors.

### Causal Factors

The investigation identified four causal factors:

- “The center wing tank was closed without ensuring that the purge door was in place;
- “When the purge door was removed, defect job cards should have been raised for removal and refitting of the door, but no such cards were raised;
- “The center wing tank leak check did not reveal the open purge door because the purge door was not mentioned within the AMM procedures for purging and leak-checking the center wing fuel tank; with no record of the purge door removal, the visual inspection for leaks did not include the purge door; [and] the fuel quantity required to leak check the purge door was incorrectly stated in the AMM; [and,]
- “Awareness of the existence of a purge door on the Boeing 777 was low among the production staff working on [the incident airplane,] due in part to an absence of cross references within the AMM.”

As a result of the investigation, the AAIB issued safety recommendations calling on BAMC to — among other things — “actively encourage” personnel to inform managers of problems with procedures discussed in job cards and AMMs and promptly remedy the problems, and to “identify and publish clear disciplinary policies and boundaries relating to maintenance errors to encourage uninhibited internal reporting of maintenance errors.” Other recommendations called for BAMC to ensure that its maintenance error management

system complies with elements recommended by the CAA and to ensure that its TTLs adequately disseminate information from TTL meetings to personnel on their teams. Another recommendation said that British Airways should conduct a safety audit of BAMC after the maintenance organization had addressed other safety recommendations.

After the incident, both BAMC and Boeing took “significant safety action” to address the issues identified during the investigation, the AAIB said. BAMC, after an internal investigation, delivered presentations to employees on the risks of unrecorded work, developed new procedures for the identification and storage of temporarily removed parts, revised the job cards used for work involving center wing tanks and upgraded the QEAN system to ensure that issues would not be closed or forgotten before they were addressed.

Boeing published several documents discussing the purge door, including an all-operator message, and revised several sections of the AMM — including discussions of purge door removal and reinstallation, and rear spar inspection — and related task cards.

In addition, British Airways took several related actions, including an audit of BAMC job cards. Of 2,200 cards for a maintenance D check, 61 were identified with “highest-risk” deficiencies and about 500 with lower deficiencies; all were addressed by BAMC, the report said. ●

*This article is based on AAIB accident report no. 2/2007, “Report on the Serious Incident to Boeing 777-236, G-YMME, on Departure From London Heathrow Airport on June 10, 2004.”*

### Note

1. Fuel records showed that the last time before the incident that the center wing fuel tank contained more than 52,163 kg (114,999 lb) was on Feb. 10, 2003 — an indication that the purge door was in place on that date. Maintenance records showed no maintenance between Feb. 10, 2003, and the 2C check in May 2004.