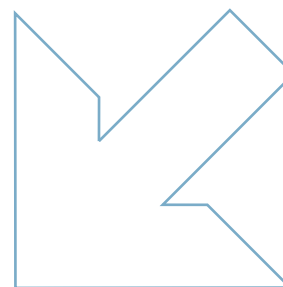




Fuel pumps left in OFF position



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1 | Introduction

An A320 encountered a dual engine rollback, after the aircraft levelled off at Flight Level 380, as a result of fuel starvation.

The aircraft was dispatched with the center tank empty. Both wing tank fuel pushbutton switches had been left in the OFF position from engine start. Interesting lessons may be learned from this event.

2 | Investigation

An official investigation was conducted with the concerned Investigations Board, the airline, engine supplier and Airbus.

Five different hypothesis have been examined:

- Adverse weather conditions
- Fuel contamination
- Aircraft fuel system anomaly
- Engine misbehaviour
- Fuel pumps left in the OFF position.

The following data have been investigated:

- Engines Full Authority Digital Engine Control (FADEC) Non Volatile Memories
- Digital Flight data Recorder (DFDR) engine main parameters
- Post Flight Report (PFR).

Analysis of all the available data allowed to rule out the first four hypothesis.

Indeed:

- There was no indication that inclement weather condition could have contributed to the event
- The fuel sampling analysis confirmed that the fuel was not contaminated
- The data recorded within the engine computer allowed to rule out any control system/engine issue
- The aircraft's recorded data and troubleshooting performed on the aircraft, did not highlight any evidence of failure in the following systems:
 - Fuel
 - Electrical generation and distribution
 - Autoflight.

The only remaining scenario was therefore that all fuel pumps had remained switched-off from the engine start until the time of the dual engine rollback.

The available data allowed to confirm the following:

- 1) During the engine start sequence all fuel pumps were left in the OFF position, leading to the triggering of the following ECAM Cautions:

FUEL L TK PUMP 1+2 LO PR
FUEL R TK PUMP 1+2 LO PR

The crew cleared both Cautions but left the fuel pumps in the OFF position.

As a consequence, both engines were being gravity fed during the engine start, take-off and climb phases of the flight.

- 2) The behaviour of the engines was normal until the aircraft reached FL380, some 23 minutes after take-off. At that point, both engines rolled back, leading to:
 - The Mach Number to decrease from M0.78 to M0.63
 - The disconnection of the Electrical Generators 1&2 (Engines 1&2 N2 being below 53%)
 - The Ram Air Turbine deployment (Emergency Electrical Configuration).
- 3) The aircraft started to descend and the crew declared an Emergency.
At FL 320, the engines were recovered leading to an automatic re-connection of both Electrical Generators. The crew then decided to turn back to the departure airport where an uneventful landing was performed.
This scenario was confirmed through a flight test done on an Airbus A320 production aircraft.

3 | Analysis of the event

Operations Engineering Bulletin 178 “OPERATION OF CENTER TANK PUMPS”

The OEB was applicable to the aircraft concerned by this event. During the refuelling, all fuel pumps were set to OFF, in accordance with OEB 178.

This OEB was issued to avoid having the center tank pump in operation if not fully immersed.

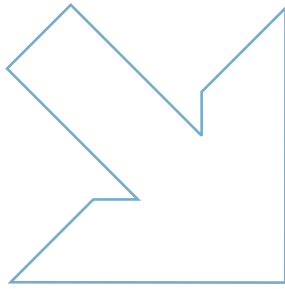
It calls for:

- All fuel pumps to be in the OFF position before and during the refuelling
- The wing tank pumps to be set ON after the refuelling
- The center tank pumps to be left OFF, if the total fuel on board is less or equal than 12 000 kg.

Note: 1. OEB 178 is applicable to some A318/A319/A320 aircraft with a center tank.

2. OEB 180 “OPERATION OF FUEL PUMPS”, applicable to some A321 aircraft, was also issued to avoid having wing fuel pumps running if not fully immersed during fuel loading operation: It notably calls for all wing fuel pumps to be turned OFF before refuelling.





A318
A319
A320
A321

OEB PROC N° 178/1

FEB 08

6.00

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OPERATION OF CENTER TANK PUMPS (cont'd)

PROCEDURE A (CONT'D)

CENTER TANK PUMPS OPERATION

WARNING

Do not turn on the center tank pumps, if the center tank contains less than 2 000 kg (4 500 lb) of fuel, even if it is requested by another procedure.

Before and during refueling:

ALL TK PUMPS OFF

■ **IF THE TOTAL FOB AFTER REFUELING IS LESS THAN OR EQUAL TO 12 000 KG (26 500 LB)**

After refueling:

- CTR TK CHECK EMPTY

It fuel remains in the center tank, it must be considered unusable

- L and R TK PUMP 1 and 2 ON

- CTR TK PUMP 1 and 2 MAINTAIN OFF

- FUEL MODE SEL MAN

Note : The QRH OEB PROC N° 178 gives a quick access to the OEB procedure, which is also covered in AFM TR - 4.03.00/28 issue 2.

Limitations of fuel gravity feed

The altitude limitations linked to gravity feed are due to the application of Henry's law. The law states that the concentration of a solute gas in a liquid is directly proportional to the partial pressure of that gas.

Therefore, as the airplane climbs and as the atmospheric pressure decreases, so does the amount of air dissolved in the aircraft's fuel.

The excess air vents into the fuel tanks and engine fuel lines.

At some point, the quantity of vapour present in the fuel, when it reaches the engine, may exceed the engine inlet maximum allowable vapour / liquid ratio and the operation of the engines is compromised. In the example illustrated in this article, the airplane was able to reach FL380 before the engines eventually rolled back.

However, the precise altitude at which engines will experience fuel starvation depends on a number of factors, including saturation level of air in the fuel, temperature and rate of climb.

Considering the worst case operating conditions, the A320 FCOM 3.02.28/QRH 2.09 paper procedure has retained three different scenarios:

- The airplane is on gravity feed shortly after take-off, in which case the gravity fuel feed ceiling is limited to FL150 or 7 000 feet above the airport
- The airplane switches to gravity feed with a Flight time above FL300 being less than 30 minutes, in which case the ceiling is limited to FL300
- The airplane switches to gravity feed with a Flight time above FL300 exceeding 30 minutes, in which case the ceiling is the current FL.

4 | Standard Operating Procedures

ECAM task sharing rules

This event serves to highlight the importance of adhering to the ECAM operational philosophy. The first pilot, who notices an ECAM Caution or Warning, announces the title of the failure. The Pilot Flying (PF) then orders "ECAM Action", and the Pilot Non Flying (PNF) confirms the action.

This process ensures that both crew members are aware of the failure, and that they share a common understanding of the actions to be undertaken.

The PNF then performs the action and requests permission to clear the failure.

The PF will first check to ensure that the action has been completed, then announce, "Clear ECAM".

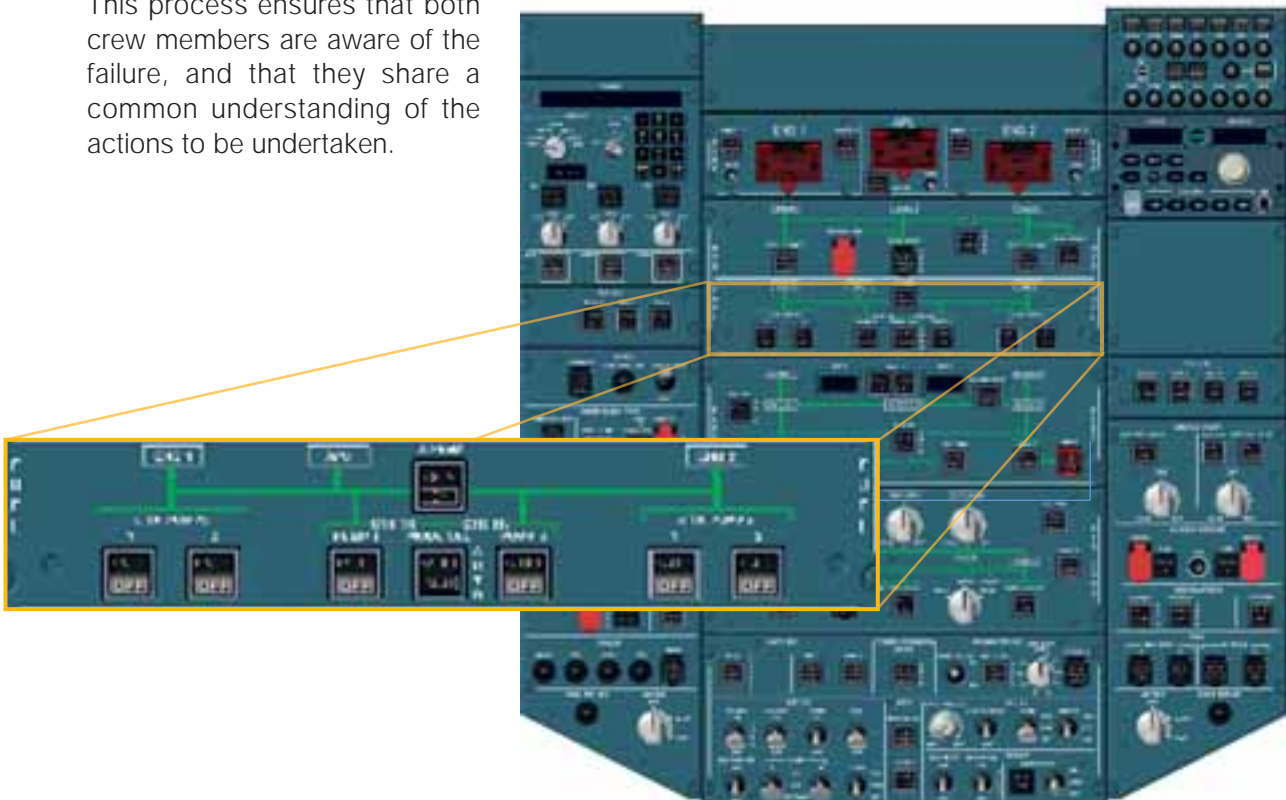
Fuel pumps left in OFF position

The following three barriers were available to alert the crew of the abnormal configuration they were flying in:

- First barrier:

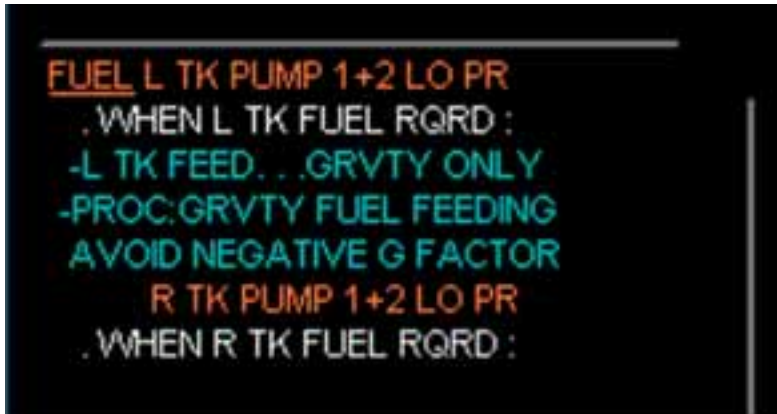
At the beginning of the Cockpit Preparation checklist for the Overhead Panel, the SOPs request the crew to extinguish all white lights (pushbutton switches) on the overhead panel, as applicable during the scan sequence. This ensures that both the center tank and wing tank pushbutton switches are selected to the ON position prior to flight, except for the center tank if OEB 178 applies.

With the center tank and wing tank fuel pumps I in the OFF position, this is how the overhead panel would look like; notice the six illuminated white pushbutton lights:



- Second barrier:
30 seconds after the first engine start (flight phase 2), if the wing tank fuel pumps are still

in the OFF position, the dedicated ECAM Caution will trigger, and the FUEL page will be displayed:



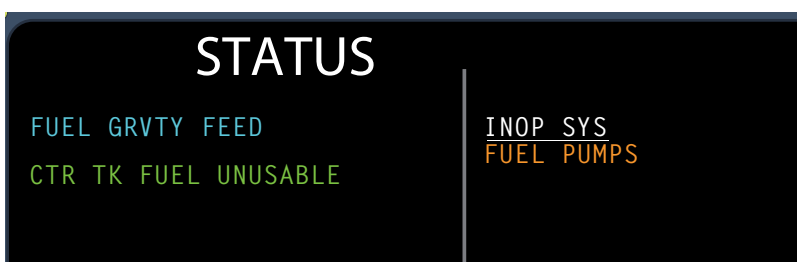
(ECAM upper display – E/WD – Warning part)



Symbol  means:
PUMPS OFF

(ECAM lower display SD)

- Third barrier:
Clearance of an ECAM Caution leads to the display of the STATUS page:



5 | Enhancements

Flight warning Computer (FWC)

Airbus is working on future enhancements in the next FWC standard H2F5 (certification planned by mid 2009). Indeed, the TAKE OFF CONFIG will be improved to monitor as well the fuel pumps, hydraulic pressure, IDG disconnection, and electrical generators.

For example, if the fuel pumps are left in the OFF position, this new FWC standard will recall the following ECAM Caution :

FUEL L TK PUMP 1+2 LO PR
FUEL R TK PUMP 1+2 LO PR

Information concerning OEB 178 and OEB 180:

Operators for which OEB 178 and/or OEB 180 apply, may cancel them by the accomplishment of the mandated Service Bulletin 28-1159-00 (this SB involves only 2 hours of elapsed time).

6 | Conclusion

Existing barriers (white lights on the overhead panel, ECAM Caution, audio warning, status page display on the System Display) were available to prevent the crew overlooking the fuel pumps in the OFF position.

Further barriers will be included with the proposed enhancements:

- Addition of some system monitoring within FWC standard H2F5
- Cancellation of OEB 178 and OEB 180 with the implementation of the modification referenced in SB 28-1159-00.

Additionally, the following more general lessons may be learned from this event:

- ECAM task sharing rules should be followed before clearing Cautions or Warnings
- Design features are not meant, and never will, to replace effective briefings.





Safety First

The Airbus Safety Magazine
For the enhancement of safe flight through
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Safety First
07 February 2009

Safety First is published
by Airbus S.A.S
1, rond point Maurice Bellonte
31707 Blagnac Cedex / France

Editor:
Yannick Malinge,
Vice President Flight Safety

Concept Design by
MULTI MEDIA SUPPORT 20090053

Computer Graphic by Quat'coul

Copyright: GSE 420 0046/09

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Printed in France by AMADIO

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