DEFENCE FLIGHT SAFETY BUREAU

ADF Propulsion Symposium

Defence Aviation Safety Authority
PC9 Engine Failure near Beermullah, WA – 2 Nov 17
Event Sortie

Perth region

PC-9A
Engine control

Power Control Lever

EFCU Toggle
### Event Description

<table>
<thead>
<tr>
<th>Role</th>
<th>Action/Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>“Convert excess speed to height”</td>
</tr>
<tr>
<td></td>
<td>“Check for primary mechanical failure”</td>
</tr>
<tr>
<td>QFI</td>
<td>“No signs.”</td>
</tr>
<tr>
<td>Student</td>
<td>“Check Ng”</td>
</tr>
<tr>
<td>QFI</td>
<td>“62% stable”</td>
</tr>
<tr>
<td>Student</td>
<td>“Simulate ELS isolate emergency fuel switch”</td>
</tr>
<tr>
<td>QFI</td>
<td>“Select”</td>
</tr>
<tr>
<td>Aircraft tone</td>
<td>Discreet beep</td>
</tr>
</tbody>
</table>

- **Student:** “Does it respond?”
- **QFI:** “No response”
- **Student:** “… simulate select …”
- **QFI:** “Select.”

- **Student:** “1 banana 2 banana 3 banana 4”

- **Student:** “1 banana”
- **QFI:** “Yeah, taking over”
- **Student:** “Handing over”

- **Student:** “We’ve got a bit of, firing happening.”

- **Mechanical noise:** Knock, knock, knock, and a ratchet sound.  

**Approximately 9 seconds**
Overhead Beermullah Airstrip
Touch down and roll
On-site investigation

A23-001 at Beermullah
PT6A-62 Engine

Propeller Shaft (NG)
- Power Turbine Blades

Gas Generator Shaft (NG)
- Compressor
- Turbine Blades
- Centrifugal Compressor Blades
- Axial Compressor Blades

FWD
Engine tear-down

Vector Aerospace, Brisbane
Compressor Turbine Blades

Metallic spatter
Example CT blade
Thermocouples
Power Turbine 2 Blades
Analysis

PT2 Blades
PT2 Blade with delaminating metallic spatter
Fuel Control Unit (FCU)
Manual OverRide (MOR) Lever

MOR Mechanism

Stain line around the circumference
Same pattern
## Cockpit Voice Recorder

<table>
<thead>
<tr>
<th>Label</th>
<th>Start (sec)</th>
<th>End (sec)</th>
<th>Event Description</th>
</tr>
</thead>
</table>
| A     | -13.50      | -2.00     | Student: “Convert excess speed to height”  
QFI:  
Student: “Check for primary mechanical failure”  
QFI:  
Student: “No signs.”  
QFI:  
Student: “Check Ng”  
QFI:  
Student: “62% stable”  
QFI:  
Student: “Simulate ELS isolate emergency fuel switch isol/arm.”  
QFI:  
Student: “Select” |
| B     | -0.25       | 0.25      | Aircraft tone: Discreet beep |
| C     | 6.00        | 11.00     | Student: “Does it respond?”  
QFI:  
Student: “No response”  
QFI:  
Student: “… simulate select …”  
QFI:  
Student: “Select.” |
| D     | 12.00       | 16.00     | Student: “1 banana 2 banana 3 banana 4” |
| E     | 18.00       | 20.50     | Student: “1 banana”  
QFI:  
Student: “Yeah, taking over”  
QFI:  
Student: “Handing over” |
| F     | 22.00       | 24.00     | Student: “We’ve got a bit of, firing happening.” |
| G     | 23.50       | 26.50     | Mechanical noise: Knock, knock, knock, and a ratchet sound |
CVR, FDR and ELU Sync
“Snapback”

MOR Lever (Brown), EFCU Actuator (Blue), Mounting Rod (Yellow)
Fast Actuator

~13% exceedance
Supplied Fuel (at incident temperature and pressure conditions)

MOR Lever position (at incident direction and rate of movement)

Fuel Flow

Incident Actuator (5.08 mm/sec)

Max Wf value ~ 45 pph higher

~13% exceedance
Delivered Fuel (quantity and rate)

P1 (inlet pressure, based on altitude and airspeed)
# Surge and Stall Identification

<table>
<thead>
<tr>
<th>SURGE/STALL Criteria</th>
<th>Incident under Investigation Criteria-met?</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine banging</td>
<td>Yes</td>
<td>As per aircrew recollection</td>
</tr>
<tr>
<td>Smoke and/or Flames from exhaust</td>
<td>Yes</td>
<td>Flames</td>
</tr>
<tr>
<td>Decreasing torque</td>
<td>No</td>
<td>Torque was already at minimum</td>
</tr>
<tr>
<td>Increasing ITT</td>
<td>Yes</td>
<td>~ 450 °C increase</td>
</tr>
<tr>
<td>High Altitude</td>
<td>No</td>
<td>~ 9,500 ft(^{24})</td>
</tr>
<tr>
<td>Low Airspeed (below 150 KIAS)</td>
<td>Yes</td>
<td>~ 106 KIAS(^{25})</td>
</tr>
<tr>
<td>High sideslip</td>
<td>Unlikely</td>
<td>Roll ~ 1°</td>
</tr>
<tr>
<td>High Angle of Attack</td>
<td>Unlikely</td>
<td>Pitch ~ -6°</td>
</tr>
<tr>
<td>Environmental Control System (ECS) in OFF/LOW position</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>PCL transients (especially chop/re-advance)</td>
<td>Yes (for EFCU) See comment</td>
<td>No PCL transients. However, EFCU was commanding engine speed increase (advance)</td>
</tr>
</tbody>
</table>

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<tr>
<th>SURGE Criteria</th>
<th>Criteria-met?</th>
<th>Comment</th>
</tr>
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<tbody>
<tr>
<td>Failure of engine Ng and torque to increase normally in response to PCL movement</td>
<td>Yes (for EFCU) See comment</td>
<td>Failure of engine Ng and torque to increase as expected to EFCU Toggle movement</td>
</tr>
<tr>
<td>Very rapid increase in ITT</td>
<td>Yes</td>
<td>~ 450°C increase in ~ 4 sec</td>
</tr>
<tr>
<td>Total Engine Failure</td>
<td>Yes</td>
<td>CT tip melt, PT2 failure</td>
</tr>
</tbody>
</table>
Interplay of factors

- Use of EFCU
- Fast EFCU Actuator
- Low mass flow (airspeed/altitude)
<table>
<thead>
<tr>
<th>Year</th>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td><strong>OEM Letter:</strong> Recommends against routine use of the EFCU.</td>
<td>Nil</td>
</tr>
<tr>
<td>2005</td>
<td><strong>ASOR Recommendation:</strong> investigate the frequency with this emergency system is used in every day training flights, whether it was designed for such a purpose and if so what sort of maintenance schedule is appropriate</td>
<td>Rejected</td>
</tr>
<tr>
<td>2010</td>
<td><strong>ASOR:</strong> The use of airborne EFCU for training at 2 FTS be reviewed for compliance with DI (AF) OPS 3-1, which states that Airborne Emergency Training is to be conducted only where there is a clear benefit and minimum risk</td>
<td>WASO is developing an EE500 template for recording EFCU use.</td>
</tr>
<tr>
<td>2010</td>
<td><strong>SPO Investigation:</strong> 70% of failures world wide occurred with RAAF aircraft. Feedback from Pilatus was that the EFCU should only be for emergency use and not training.</td>
<td>Log use of the EFCU for training purposes, to assist in determining the number of failures</td>
</tr>
<tr>
<td>2014</td>
<td><strong>OEM Letter:</strong> Recommends against routine use of the EFCU.</td>
<td>Nil</td>
</tr>
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</table>
Recommendations

- Beermullah airstrip maintenance (enduring)
- Other emergency airstrip maintenance (enduring)
- Use of airstrips in planning
- 2FTS SI update (airstrip layout)

- EFCU Actuators, ensure within specification

- Non-emergency use of EFCU Toggle

- Awareness regarding surge ‘risk-factors’
- Awareness regarding EFCU Toggle + Surge scenarios
Key learning outcomes

- ASRs: Actions must address recommendation
- Using equipment outside of intended use. Make sure the risk has been assessed and accepted
- Question organisational norms
Questions

Comments