Havarikommissionen
Accident Investigation Board Denmark

# BULLETIN

# Serious incident

# 15-03-2013

# involving

# PH-KZD

Certain report data are generated via the EC common aviation database

## FOREWORD

This bulletin reflects the opinion of the Danish Accident Investigation Board regarding the circumstances of the occurrence and its causes and consequences.

In accordance with the provisions of the Danish Air Navigation Act and pursuant to Annex 13 of the International Civil Aviation Convention, the investigation is of an exclusively technical and operational nature, and its objective is not the assignment of blame or liability.

The investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than that of preventing future accidents and serious incidents.

Consequently, any use of this bulletin for purposes other than preventing future accidents and serious incidents may lead to erroneous or misleading interpretations.

## BULLETIN

### General

| | |
|---|---|
| File number: | HCLJ510-2013-190 |
| UTC date: | 15-03-2013 |
| UTC time: | 05:30 |
| Occurrence class: | Serious incident |
| Location: | EKYT |
| Injury level: | None |

### Aircraft

| | |
|---|---|
| Aircraft registration: | PH-KZD |
| Aircraft make/model: | FOKKER F 70 |
| Current flight rules: | IFR |
| Operation type: | Commercial Air Transport Revenue operations Passenger |
| Flight phase: | Standing |
| Aircraft category: | Fixed wing Airplane |
| Last departure point: | Denmark EKYT (AAL): Alborg |
| Planned destination: | Netherlands EHAM (AMS): Amsterdam/Schiphol |
| Aircraft damage: | Minor |
| Engine make/model: | ROLLS-ROYCE TAY 620-15 |

### Notification

All times in this report are UTC.

The Aviation Unit of the Danish Accident Investigation Board (AIB) was notified of the serious incident by the Area Control Centre in Copenhagen Airport, Kastrup on 15-03-2013 at 05:50 hrs.

The International Civil Aviation Organization (ICAO), the European Aviation Safety Agency (EASA), the Directorate-General for Mobility and Transport (DG MOVE) and the Dutch Safety Board were notified about the serious incident 15-03-2013.

## FACTUAL INFORMATION

### History of the flight

The flight, during which the serious incident occurred, was a commercial scheduled IFR flight from Aalborg Airport (EKYT) to Amsterdam Airport (EHAM).

During the startup sequence of engine no.1, the flight crew observed a slightly later light up of the engine than normal, then a rapid increase in TGT (Turbine Gas Temperature) to 200° C. The flight crew's perception was that the engine parameters accelerated to normal stabilized idle indications.

Approximately 35 seconds later, the engine no. 2 was started and stabilized engine parameters were observed by the flight crew.

After approximately 10 seconds a "ENG 1 FAIL" warning was presented on the Multifunction Flight Display System (MFDS), which the flight crew thought was due to low idle caused by a low outside temperature ( OAT) -7°C.

The first officer called for the ENG FAIL procedures according with Emergency Checklist.

The contact with the startup ground crew was by hand signals because no ground headset was available. The commander opened left hand cockpit sliding window in order to establish contact with the ground crew and to verify the problem with the engine. The ground crew and an airport marshaller, who passed the aircraft from behind shouted that engine no.1 was on fire with smoke coming out of the rear end of the engine.

The flight crew observed that the N1 rotor speed and N2 rotor speed on engine no. 1 indicated zero, but the TGT indicated 390°C.

The first officer made a PAN call on the TWR frequency and stated that the aircraft had an engine fire.

The commander ordered the first officer to shut off engine no. 1. The first officer selected the fuel lever no.1 to shut off position and the "ENG 1 FAIL" message disappeared. At the same time, it was the flight crew's perception that the fire warning "ENG # 1 FIRE" on the MFDS and the aural fire warning went on for a short time.

The flight crew completed the ENG FAIL checklist from the Quick Reference Handbook (QRH). Thereafter it was decided to have the passengers disembark the aircraft via the main entry door. At this stage the crew did not see a reason to do an on ground emergency as this would present a higher risk for the passengers (slippery wing due to de-icing).

The engine no.2 which still was running was shut off by the first officer and in agreement with the commander.

A rapid disembarkation of the passengers was performed through the forward main entry door without any problems.

Neither passengers nor crew members were injured.

## Injuries to persons

| *Injuries* | *Crew* | *Passengers* | *Others* |
|---|---|---|---|
| Fatal | | | |
| Serious | | | |
| None | 4 | 67 | |

## Damage to aircraft

There was no damage to the aircraft.

## Personnel information

Commander

The commander was holder of valid UK Airline Transport Pilot License (ATPL). The initial issue date was 23-05-2002. The initial issue date of the validated Netherland (LN) license was 15-09-2011. The medical certificate was valid with no limitations.

Flying experience

| | Last 24 hours | Last 90 days | Total |
|---|---|---|---|
| Incident type | 1:20 | 114 | 4823 |
| All types | 1:20 | 114 | 7580 |

First officer

The first officer was holder of valid UK ATPL. The medical certificate was valid with no limitations.

Flying experience

| | Last 24 hours | Last 90 days | Total |
|---|---|---|---|
| Incident type | 1:20 | - | 1626 |
| All types | 1:20 | - | 2295 |

## Engine information

Engine Description

The Rolls-Royce Tay 620-15 is a two-shaft, axial flow, medium by-pass ratio, turbofan engine. The engine comprises a single fan assembly with a connected three-stage “intermediate” compressor, which is driven by a three-stage low pressure turbine (LPT). A 12 stage high pressure compressor (HPC) is driven by a two-stage turbine.

Located between the HPC and the high pressure turbine (HPT) are ten inter-connected tube-annular combustion chambers. Two of the combustion chambers are fitted with an igniter plug. Fuel ignition in the other eight combustion chambers is facilitated by inter-connecting tubes.

A single fuel spray nozzle is located in the front of each combustion chamber.

The fuel supply to the nozzles is mechanically controlled by the Combined Acceleration and Scheduling Controller (CASC), which is driven from the engine gearbox.

The gearbox is mounted underneath the engine and driven from the engine high pressure compressor spool via an inclined drive shaft.

The gearbox drives fuel, oil and hydraulic system pumps and other accessories.

Engine starting is facilitated by spooling up the HP system by means of Air Turbine Starter (ATS)

Engine information
Rolls Royce TAY 620-15
Installed on Aircraft 12-05-2010
S/N 17 182

| | |
|---|---|
| Time since new (TSN): | 30 745 hours |
| Cycles since new (CSN): | 28 920 cycles |
| Time since last service visit (TSLSV): | 7451 hours |
| Cycles since last service visit (CSLSV): | 7558 cycles |
| Hours before removal: | 12842 |
| Or expiry date: | 05.08.2019 |

Technical information
The engine was removed from the aircraft and sent to an approved maintenance facility for further investigation.

Engine investigation
The investigation of the engine and the associated engine components did not reveal abnormalities or discrepancies which could have led to the engine start malfunction.

Engine history
The service life of the engine since last overhaul was reviewed and no previous history of starting discrepancies was found.

Engine start system
When the engine start sequences is initiated, a hold-in circuit relay keep the starter valve open and the ATS running to starter cut-out (starter valve closed) at approximately 42 % N2. Thereafter the engine by itself normally will accelerate the idle speed.

As long as the hold-in relay is activated, start attempt of the other engine is inhibited.

Interference in the electrical start circuit during engine start can occasionally release the hold-in relay and close the starter valve. In this case the start sequences will be interrupted and a risk for hung / hot start is present.

## Communications

Recorded communications between the flight crew and Air Traffic Control (ATC) was of good quality and used in the investigation.

## Flight recorders

On the day of the serious incident the Digital Flight Data Recorder (DFDR) and the Cockpit Voice Recorder (CVR) were removed from the aircraft. The data from the DFDR and the CVR was of good quality and used in the investigation.

The DFDR operated automatically whenever either fuel lever was open and operated continuously during flight.

On the ground, and before engine start, the system could be activated by pressing the FDR/CVR GND CTL push button (p/b).

The "Before Starting Checklist" in the Aircraft Operating Manual (AOM) stated that the FDR/CVR GND CTL must be selected on. The FDR/CVR GND CTL p/b was activated by the flight crew, but recording stopped after 5 minutes. The recording started again when the fuel lever on engine no. 1 was opened.

The DFDR recorded data at intervals of one second.

DFDR read out
The first recorded data in the start sequence of engine no.1 was missing.

The first data point, recorded at 05:25:26 showed the HP (N2) system spool speed to be 11,9% from which point, the speed steadily decreased during the following over 26 seconds until a zero rotation speed was indicated. Similarly, the LP (N1) spool speed steadily decreased from 3,8% to zero during the first 28 seconds of the recorded data.

From the start of the recording, the data showed that the fuel flow to engine no.1 was 238 kg/hr. steadily decreasing to zero during the following 22 seconds, effectively corresponding to the decreasing HP spool speed. This evidence showed that engine no.1 High Pressure Shut of Valve (HPSOV) was open throughout this period. (The data showed that the engine no.2 HPSOV was closed during this period).

From the first recorded data point, the engine TGT rapidly increased from 1° C to 517° C within 13 seconds, indicating that the fuel was ignited, but the HP and LP spool systems did not accelerate in response. Following the peak at 517° C (limitation 700° C), the TGT slowly decreased until it

stabilized at approximately 390° C, indicating the TGT thermocouples were still recording an increased, but reasonably constant temperature.

41 seconds after the N2 speed was recorded to zero, the ENG 1 FAIL appeared. For a time period of 24 seconds after the ENG 1 FAIL warning was recorded, the engine no.1 HPSOV was not closed. (See appendix 1 page 10).

## System operation

Power Plant
According to the engine start procedures, the minimum N2 speed must be at 15%, along with N1 speed rising before the fuel lever is selected open position. (See appendix 2 page 11).

According to the DFDR readout the fuel lever was in open position at 11,9% N2 and was selected to shut position 66 seconds after N2 had reached zero.

## Flight crew action

According to the operators AOM Fokker 70/100 and the manufacturers engine instructions, the flight crew should monitor the start sequences until the engine parameters had stabilized at idle. Normal idle rotor speed for N2 was approximately 53% and 24% N1. If the engine for some reason during the startup did not accelerate to normal stabilized idle rotor speed, there would be risk of a hung start (N2 staggering) or a hot start.

In case of N2 staggering or a hot start, the start should be discontinued by selecting the fuel lever to shut position and motor the engine to reduce the TGT or / and extinguish a tail pipe fire.
(See appendix 3 page 12).

## Engine fire

Engine fire warnings could not be DFDR recorded. It was the flight crew's perception that the engine fire warning was trigged, but according to the CVR data the fire warning was not trigged.

## APU and anti-icing

The APU air bleed pressure and the anti-icing system were not DFDR recorded, but according to the flight crew, the APU air bleed pressure was normal and the anti-icing system was off during the engine no.1 and engine no. 2 start.

The engine start sequence on engine no.2 was normal (stabilized idle parameters).

## ANALYSIS

According to the DFDR data the engine no.1 did not accelerate to normal idle rotor speeds. The flight crew's perception of stabilized engine parameters on engine no.1, before initiating the start of the engine no.2, could not be verified.

The DFDR data was missing in the beginning of the start phase. Due to the missing data it is not possible to verify the interruption of engine no.1 start sequences or when the fuel lever no.1 was selected to open position.

Engine no.1 N2 rotor speed and N1 rotor speed was below required rotor speed with the fuel lever in open position. According to emergency procedures, the flight crew should have selected fuel lever no. 1 to shut position and motored the engine. The flight crew did not comply with the emergency procedure.

The investigation of the engine and the associated engine components on an approved maintenance facility did not reveal abnormalities or discrepancies which could have led to the hung start.

Additionally, no previous history of starting discrepancies on engine no.1 was found.

## CONCLUSIONS

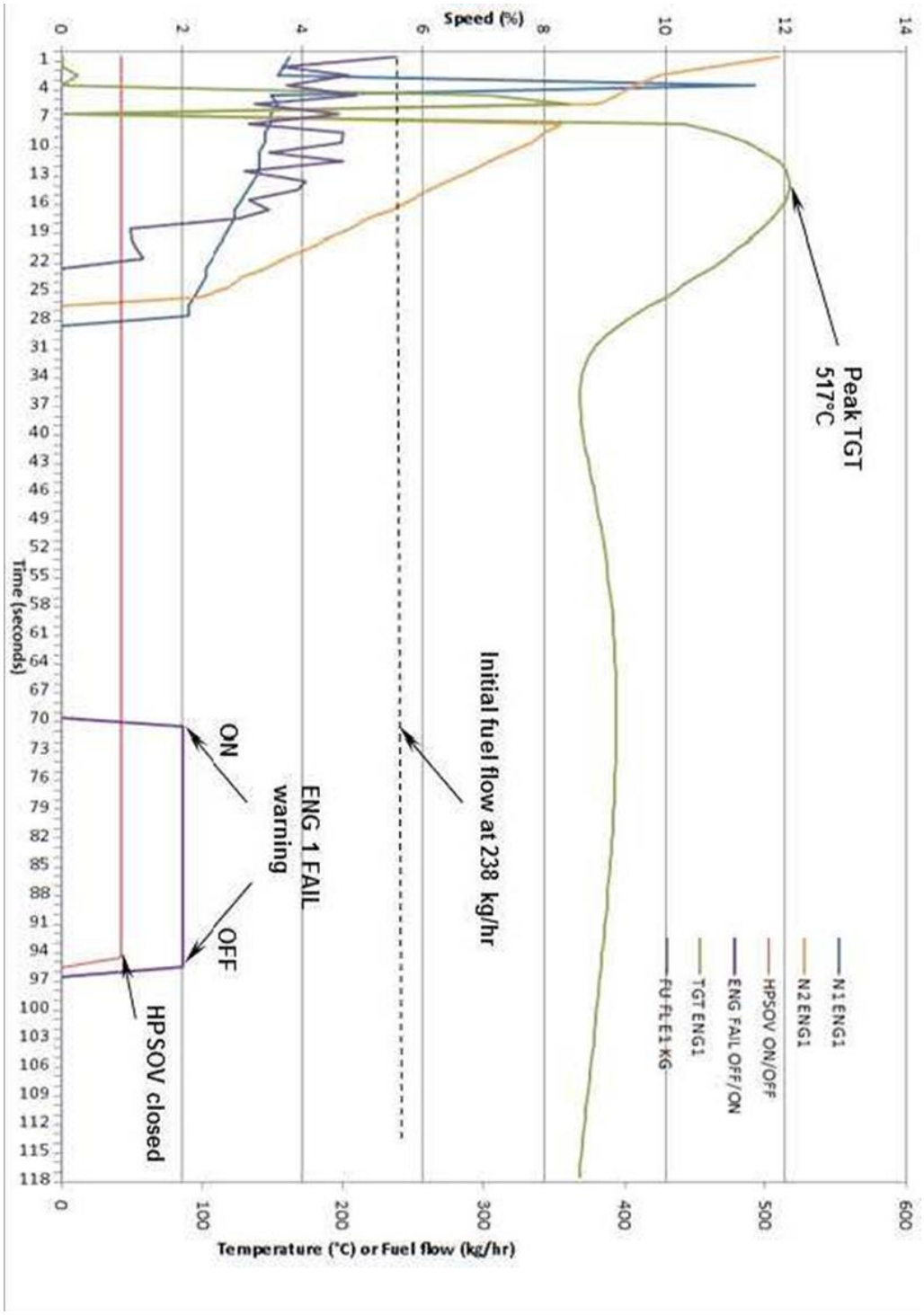
The Danish Accident Investigation Board is of the opinion that the flight crew monitoring of engine no.1 start sequence was inconsistent with the AOM starting procedures.

The staggering and decreasing N1 and N2 rotation speed resulted in a hung start which developed smoke and a standing fuel fire in the exhaust section and in the lower section of the engine.

## APPENDICES

See pages 11-12-13

**Appendix 1**


Speed (%)
Time (seconds)
Temperature (°C) or Fuel flow (kg/hr)
Peak TGT
517°C
Initial fuel flow at 238 kg/hr
ENG 1 FAIL
warning
ON
OFF
HPSOV closed
N1 ENG1
N2 ENG1
HPSOV ON/OFF
ENG FAIL OFF/ON
TGT ENG1
FU FL E1 KG

**Appendix 2**

## Operators AOM Fokker 70/100 start procedures



**1.4 Ground Start General**

The following types of ground starts are possible:

- APU supply of electrical and pneumatic power (normal start procedure).
- External electrical power and external pneumatic source.
- Battery electrical power and external pneumatic source.
- Combinations of the above.
- Crossbleed start.

Normal APU bleed air pressure required for engine starting varies between 25 and 35 psi at sea level but may be as low as 20 psi at 8000 ft elevation (also refer to subparagraph 4.5).
During engine start the APU bleed pressure drops, but should not fall below approx. 20 psi.
Start pressures below 25 psi increase the tendency to a hot or a hung start (N2 stagnation) and initial acceleration time varies inversely with starting pressure.
Optimum acceleration to idle speed and lowest TGT peak is obtained with start pressures as high as possible.
In strong tailwind the direction of N1 rotation may be reversed. If so, select the fuel lever to open when N2 RPM has stabilized.
Ground handling staff will normally maintain interphone contact during engine start.

**1.5 Engine Start Procedure**

For crew co–ordination procedure refer to AOM 2.3.2 – Ground Operation.

**Start sequence:**

- BEFORE STARTING checklist ..... COMPLETED
- START P/B. ..... ON
- Ignition Selector ..... AS REQUIRED
- Engine selector ..... AS REQUIRED
  - N2 RPM (within 10 seconds) ..... CHECK RISING
  - N1 ..... CHECK RISING
- FUEL lever at minimum 15% N2 ..... OPEN
  - TGT Indication (within 20 seconds) ..... CHECK RISING
  - TGT ..... CHECK PEAK VALUE
    TGT should not exceed: 700°C (TAY 620 engines) or 740°C (TAY 650 engines).
    If, in case of a rapidly increasing TGT, it is anticipated that the TGT start limit will be exceeded, select the fuel lever to SHUT without delay, and select the START p/b to OFF after 30 seconds.

After stabilization at ground idle:

- Engine parameters. ..... CHECK
  - EPR ..... APPROX 1.03
  - N1 ..... APPROX 24 %
  - N2 ..... APPROX 53 %
  - Secondary engine parameters. ..... NORMAL INDICATIONS
- Ignition Selector ..... NORM
- START P/B. ..... Normal

**Appendix 3**

## Emergency checklist

### NO LIGHT UP

If an engine fails to light up within approx. 20 seconds from selecting the fuel lever to OPEN:

▶ Fuel lever ..... SHUT

– After approx. 30 seconds:
  • START p/b ..... OFF

### N2 STAGNATION

If during or after starting, N2 stagnates in combination with a rising TGT:

▶ Fuel lever ..... SHUT

– START p/b ..... OFF
– After a motoring cycle perform second start attempt.
– If engine stagnates again:
  • Fuel lever ..... SHUT
  • START p/b ..... OFF

### LOW IDLING

If N2 stabilizes below a value of 48%:

– Thrust lever ..... SLOWLY ADVANCE TO OBTAIN 48% N2
– TGT ..... MONITOR

### HOT START

If there is any evidence of a rapidly rising TGT and it is anticipated that TGT start limit will be exceeded:

▶ Fuel lever ..... SHUT

– After approx. 30 seconds:
  • START p/b ..... OFF

– A second start attempt may be performed, provided TGT has not exceeded its start limit.

### EPR IND FAULT

– SEI ..... ON
– EPR ..... CHECK

### FAN ICE SHEDDING PROCEDURE

■ **On ground**

If on ground fan icing is suspected during taxiing or holding:

– Advance thrust levers to approx. 75% N1, pause momentarily and retard.

■ **In flight**

If in flight fan icing is suspected and no engine failure indications are observed:

– Quickly retard one thrust lever at a time to idle and hold it there for approx. 5 seconds.
– Advance the thrust lever momentarily to 85% N1. The thrust lever may then be returned to its original position. Repeat procedure if required.

*NOTE: An increase of N1 vibration above the alert level may be expected and ignored during this procedure. The fan will normally shed any ice formation and the vibration should diminish.*