NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594

March 21, 2016

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT
NTSB ID: CEN16MA036

A. ACCIDENT

Location:	Akron, Ohio
Date:	November 10, 2015
Time:	1452 eastern standard time
Aircraft:	British Aerospace HS 125-700A, Reg. No. N237WR

B. POWERPLANTS GROUP

Chairman:	Carol M. Horgan National Transportation Safety Board Washington, DC
Member:	Henry Soderlund Textron Aviation Wichita, Kansas
Member:	John (Jay) Eller Honeywell Phoenix, Arizona
Member:	James P. Chambers Honeywell Phoenix, Arizona
Member:	Bobby E. Boyd Honeywell Phoenix, Arizona

C. SUMMARY

On November 10, 2015, about 1452 eastern standard time (EST), Execuflight flight 1526, a British Aerospace HS 125-700A, N237WR, departed controlled flight while on approach to landing at Akron Fulton International Airport (AKR) and struck a 4-plex apartment building in Akron, Ohio. The pilot, copilot, and seven passengers died; no ground injuries were reported. The airplane was destroyed by impact forces and postcrash fire. The airplane was registered to Rais Group International NC LLC and operated by Execuflight under the provisions of 14 Code of Federal Regulations Part 135 as an on demand charter flight. Instrument meteorological conditions prevailed and an instrument flight rules flight plan was filed. The flight departed from Dayton-Wright Brothers Airport (MGY), Dayton, Ohio, about 1413 EST and was destined for AKR.

D. DETAILS OF THE INVESTIGATION

1.0 Powerplant information

The airplane was equipped with two Honeywell TFE-731 engines.

1.1 Engine description

The Honeywell TFE731-3 is a medium bypass turbofan engine featuring a one-stage geared fan, a four-stage axial flow low pressure compressor (LPC), a one-stage centrifugal high pressure compressor (HPC), an annular combustor, a one-stage high pressure turbine (HPT), and a three-stage low pressure turbine (LPT). The engine power system controls engine thrust by governing low pressure rotor speed. The TFE731-3 is thrust rated at 3,700 lbs (sea level).

1.2 Service history

Review of the Execuflight airplane records found that the left engine[1], a model TFE731-3R-1H, had operated 11,541.2 hours and 8055 cycles since manufacture in May 1987 and 1153.6 hours and 719 cycles since its last major periodic inspection (MPI).[2] The right engine, a model TFE-731-3DR-1H, was manufactured in April 1979 and was modified from a model TFE731-3R-1H to a model TFE-731-3DR-1H in January 2004 in accordance with Honeywell Service Bulletin 72-3568R3. It had operated 14,099.3 hours and 9,763 cycles since new and 1,782.9 hours and 1,097 cycles since a July 2008 MPI.[3] See Table 1.

position	model	serial number (S/N)	time since new (TSN)	cycles since new (CSN)	time since last MPI	cycles since last MPI
No. 1 (left)	TFE731-3R-1H	P84521	11,541.2	8,055	1,153.6	719
No. 2 (right)	TFE731-3DR-1H	P84169	14,099.3	9,763	1,782.9	1,097

Table 1. Engine data

1.3 Engine data

The engine data plates were not recovered. During engine teardown, the engine found attached to the left pylon was confirmed as engine serial number (S/N) P-84521 and the engine found attached to the right pylon was confirmed as engine S/N P-84169 by a match of several engine component S/Ns to engine logbook entries.

[1] All references to position are aft looking forward unless otherwise noted.

[2] The manufacturer-recommended MPI interval for the TFE731-3R-1H is 1400 operating hours.

[3] The manufacturer-recommended MPI interval for the TFE731-3DR-1H is 2100 operating hours.

2.0 Left engine examination

2.1 External condition

The engine was substantially fire damaged. The spinner and portions of the fan inlet were thermally consumed. Much of the accessory drive section was thermally destroyed and the fuel control unit (FCU), fuel pump, and fuel heater, also fire damaged, remained attached to the engine by tubing. A package of material recovered from the vicinity of the engine included steel accessory drive train and accessory parts including the bevel takeoff gear, fuel control and oil pump components and the fuel and oil filter elements. The steel components were examined with no anomalies noted. Thermal damage prevented assessment of the fuel filter and oil filter elements.

The air/oil cooler was slightly deformed between 9 and 3 o'clock[4], thermally damaged with substantial portions missing between 3 and 6 o'clock, and missing between 6 and 9 o'clock. The engine casings were structurally intact with no evidence of uncontainment or burn-through. Terrain debris, resolidified metal, and building material fragments were present in the fan gas path. The fan blade leading edges (LEs) were torn and battered consistent with foreign object damage (FOD). Viewed through the exhaust, the LPT S3 showed no obvious damage. The engine low pressure rotor would not rotate by hand either at the fan or at the LPT. See Figure 1.

Figure 1. Right side view of P-84521

[4] O'clock refers to circumferential position in a clockwise direction as viewed from the rear of the engine looking forward.

2.2 Disassembly observations

2.2.1 Fan bypass/air inlet section

2.2.1.1 Spinner

The spinner was thermally destroyed.

2.2.1.2 Spinner support

The spinner support was intact and displayed light circumferentially-oriented scraping damage.

2.2.1.3 Fan rotor assembly

The fan blades, which are of titanium alloy construction, displayed tip damage and multiple LE nicks and tears. One blade was bent. The bent blade and the LE tears were deformed in the direction opposite of fan rotation. See Figure 2.

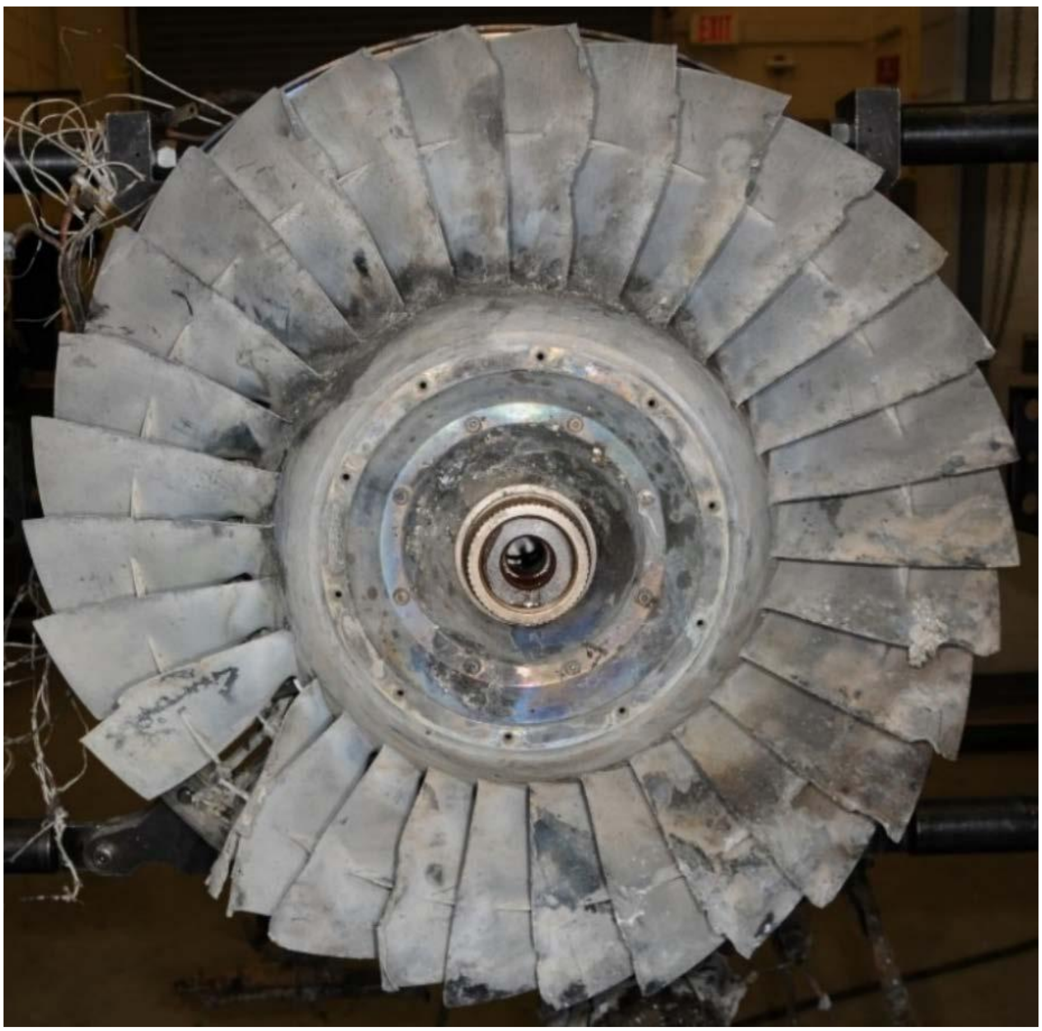

Figure 2. Forward face of fan showing blade damage

The midspan dampers of the bent blade and an adjacent blade were deformed and the bent blade had displaced aft in the disk retention slot. See Figure 3. The aft platform edge of the displaced blade was radially deformed and exhibited heavy scoring damage. See Figure 4.

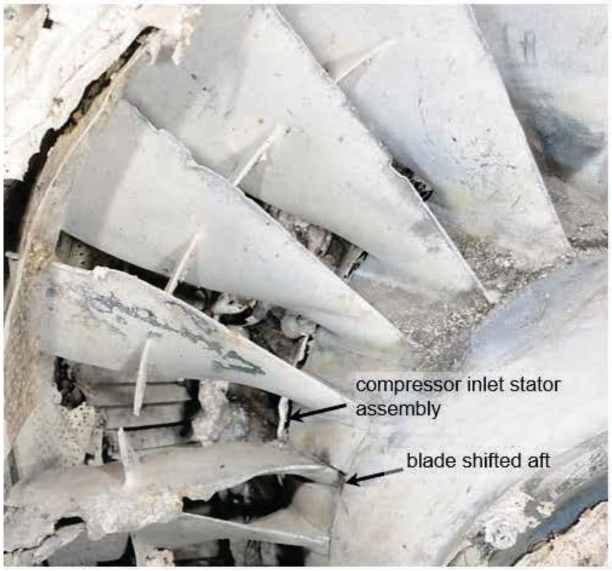

Figure 3. Detail of fan forward face showing displaced blade Figure 4. Deformed aft platform edge of displaced fan blade

2.2.1.4 Compressor inlet stator assembly

The compressor inlet stator assembly exhibited heavy 360° scoring along its inner shroud forward edge. See Figure 5. Several compressor inlet stator vanes displayed impact marks characteristic of FOD. Twelve vanes were bulged/deformed.

(a) (b)

Figure 5. Forward side of the compressor inlet stator assembly showing overall (a) and detail (b) views of 360° inner shroud scoring damage

2.2.1.5 Fan support assembly

The fan support assembly was intact. The fan shaft and ring gear rotated freely after removal from the engine. The No. 1 and No. 2 bearings were not disassembled.

2.2.1.6 Fan inlet housing and bypass stator assembly

The fan inlet housing and bypass stator assembly was fragmented and was thermally consumed between 2 and 9 o'clock. The fan bypass stator vanes were randomly displaced.

2.2.1.7 Engine support housing and intermediate case

The engine support housing and the intermediate case were intact. The planetary gear train was continuous and appeared in good condition. The planetary gear train was not disassembled. The No. 3 bearing was not disassembled.

2.2.2 Compressor section

The low pressure rotor remained seized following fan removal. It loosened slightly after chunks of resolidified aluminum-like material were removed from between the case and the Sl compressor blades.

2.2.2.1 LPC

The LPC first stage (S1) blades, which are of titanium construction, exhibited light LE damage consistent with FOD. See Figure 6. The LPC was not disassembled.

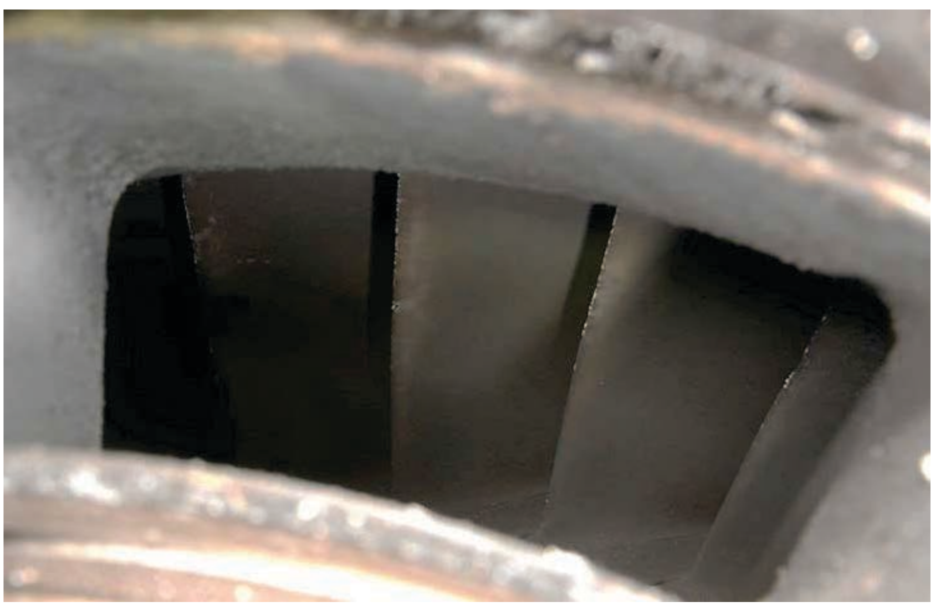

Figure 6. LPC S1 LE damage

2.2.2.2 HPC

The HPC was not disassembled.

2.2.3 Combustion section

2.2.3.1 Combustion plenum

The combustion plenum was structurally intact.

2.2.3.2 Combustion liners

The inner and outer transition liners and deswirl vane appeared structurally intact. There was a heavy soot deposit on the combustor outside surface between 10 and 2 o'clock. An off-white fibrous substance resembling insulation fiberglass was present at most of the combustion liner air cooling/dilution holes. See Figure 7.

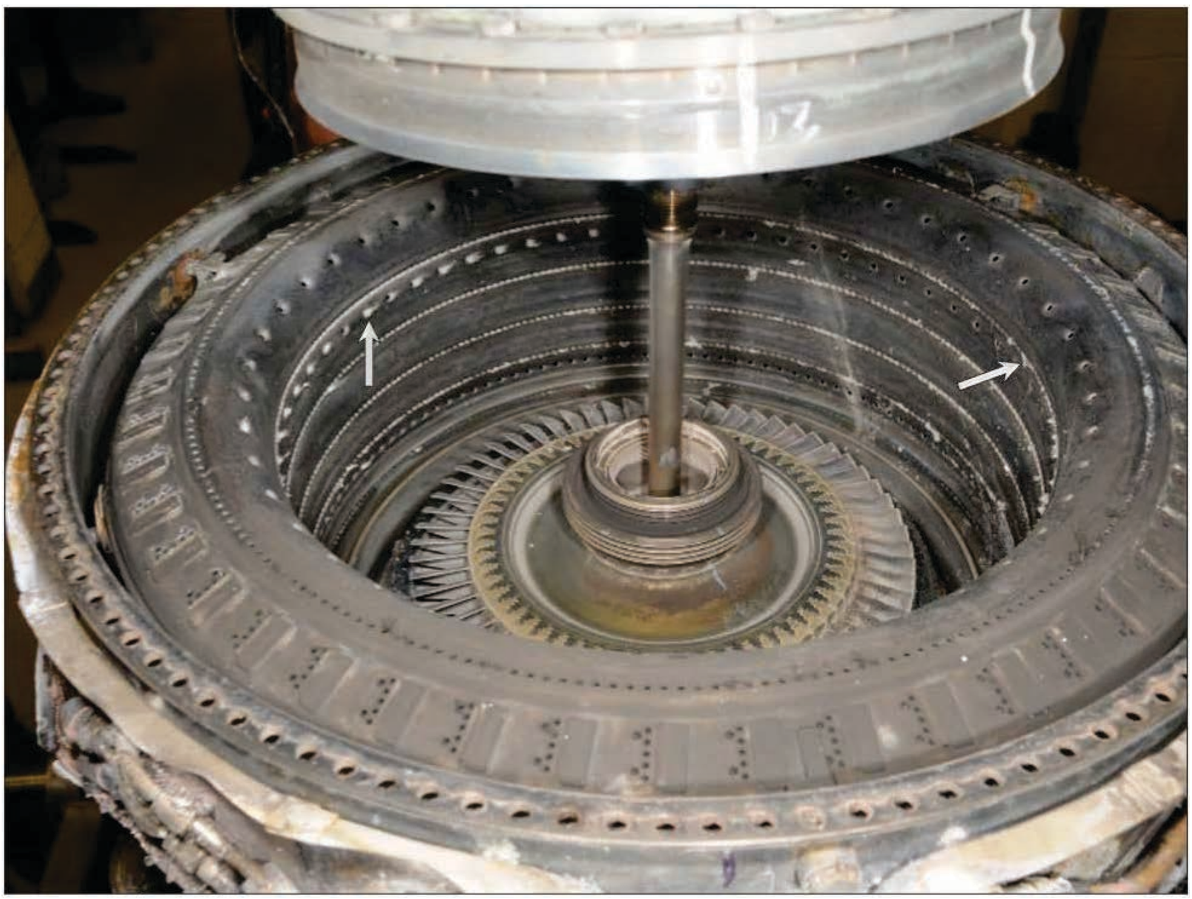

Figure 7. Fibrous debris lodged in combustion liner air holes

The fibrous debris protruded into the combustion chamber consistent with being carried through the engine in pressurized engine airflow. The debris was uncharred. See Figure 8.

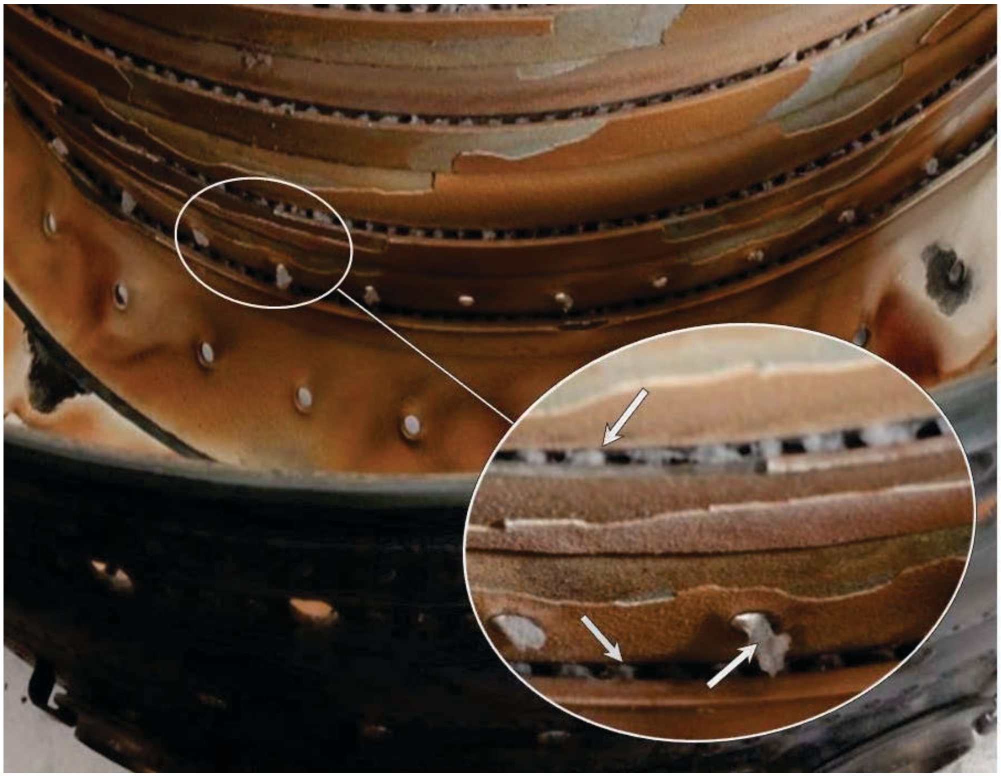

Figure 8. Fibrous debris inside combustor

2.2.3.3 Fuel nozzles

A similar off-white fibrous substance protruded from the fuel nozzle air shroud orifices. The fuel nozzles exhibited light corrosion and the nozzles installed between 10 and 2 o'clock (nozzles 11, 12 and 1) were heavily sooted. See Figure 9.

Figure 9. Fibrous debris protruding from fuel nozzle air shroud orifices

A sample of the fibrous substance was submitted to a Honeywell materials lab for examination. Energy-dispersive X-ray spectroscopy (EDS) of the fiber component revealed a spectrum high in silicon and oxygen. The chemical analysis and general macroscopic examination of the fibers strongly suggested that the substance was fiberglass consistent with building insulation material. See Figures 10 and 11.

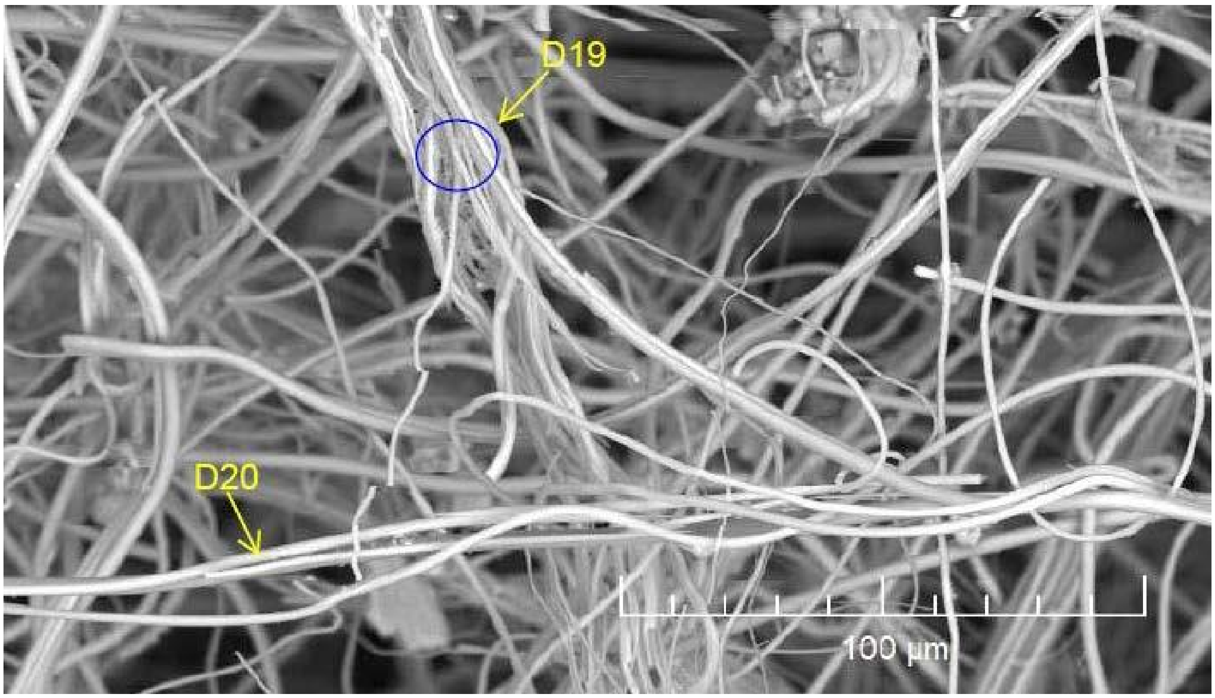

Figure 10. Scanning electron microscope image of fibrous substance found in P-84521 combustor

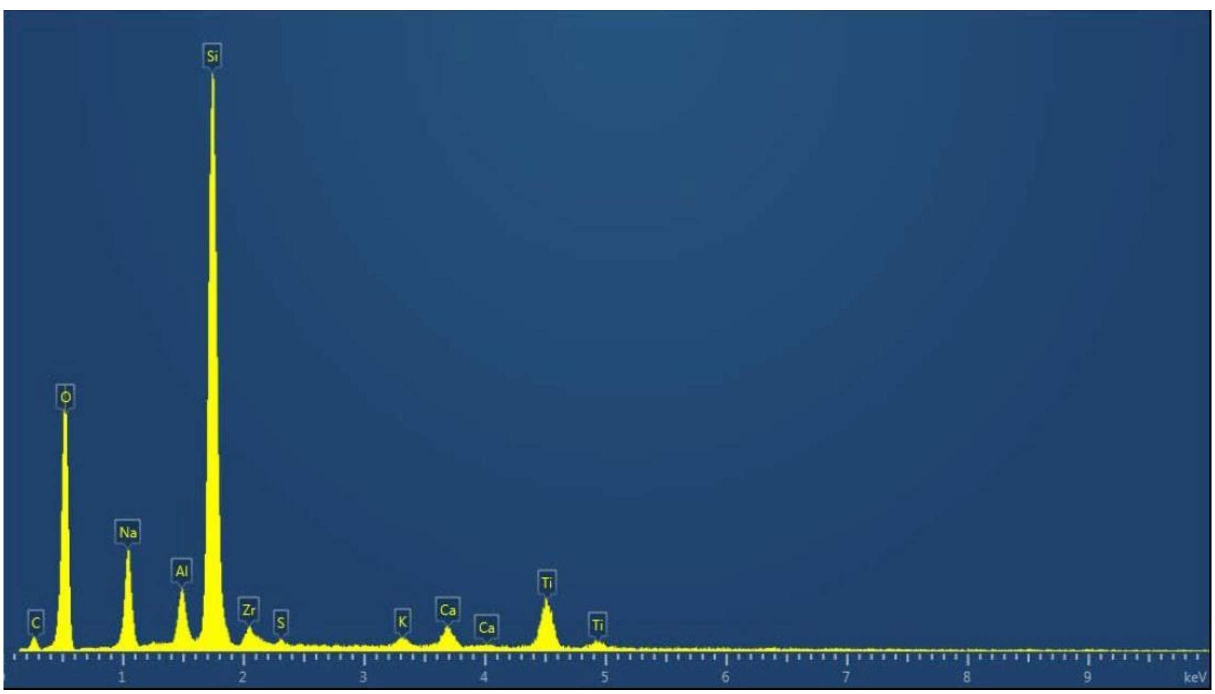

Figure 11. EDS of fibrous substance showing a spectrum rich in silicon and oxygen

2.2.4 HPT section

The HPT rotor turned freely after the LPT was removed.

2.2.4.1 HPT nozzle

The HPT blade tip shroud segments were rotationally scored. See Figure 12.

2.2.4.2 HPT rotor

The HPT rotor blades exhibited LE tip erosion damage.[5] The blade tips were also circumferentially scored. See Figure 13. The circumferential scoring was consistent with the scoring observed on the HPT tip shroud segments. Both the erosion and the tip rub had further exposed the blade cooling passages.

Figure 12. HPT blade path scoring

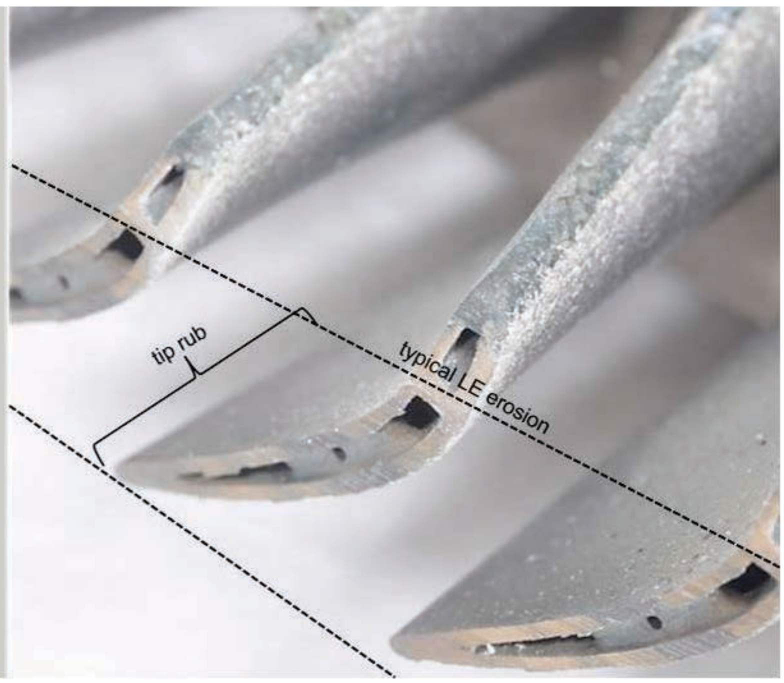

Figure 13. HPT blade tip scoring damage

A light spray of shiny, silver-colored deposits was observed on the suction side of several HPT rotor blade airfoils. See Figure 14. The deposits were smooth, spread out, and appeared fused to the blade material. See Figure 15 for an exemplar deposit microphotograph.

[5] Honeywell considers the HPT S1 LE tip erosion normal in-service wear.

Figure 14. HPT rotor showing silver-colored deposits

Figure 15. Exemplar microphotograph of silver-colored deposit (P-84169 LPT S1)

A light-colored substance was observed at the blade platform mating edges/secondary air flow exits. See Figure 16. The HPT forward curvic coupler and seal were undamaged. The HPT aft curvic coupler was undamaged.

Figure 16. HPT blade platform deposits

2.2.5 LPT section

2.2.5.1 Interstage transition duct

The internal surfaces of the interstage transition duct were coated with debris; the duct was otherwise unremarkable. The thermocouple probes were intact and the interturbine temperature (ITT) harness were unremarkable.

2.2.5.2 LPT shaft and seal assembly

The LPT shaft and seal assembly exhibited a 270° arc of light rub adjacent to the shaft radius.

2.2.5.3 LPT S1 nozzle

There was a light spray of shiny, silver-colored deposits on the suction sides of several of the LPT S1 nozzle vanes that appeared fused to the airfoil surfaces. The LPT S1 blade path was moderately rubbed.

2.2.5.4 LPT S1 rotor

The LPT S1 rotor blade tip shrouds were scored. One blade was separated mid-span and four blades exhibited mid-span TE cracks. Several adjacent blades were lightly dented. The blade separation fracture surface was dark-colored. No blade/shroud tip section fragments were found. See Figure 17.

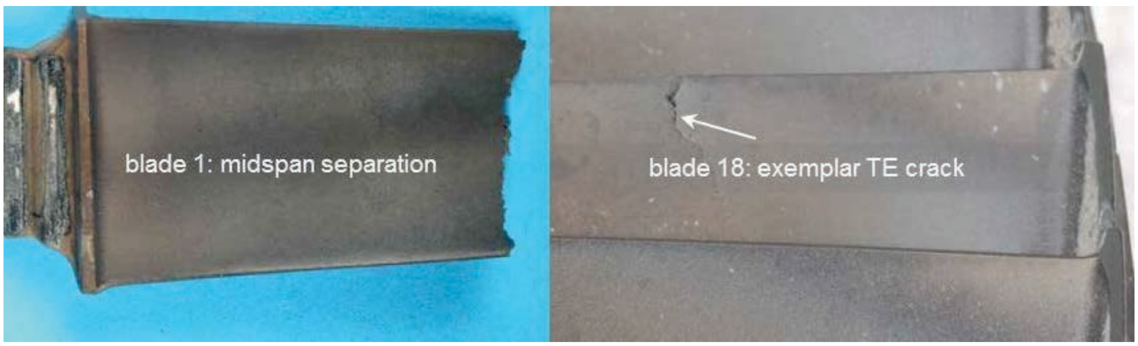

Figure 17. LPT S1 blade separation (blade 1); exemplar TE crack (blade 18)

The LPT S1 rotor blades were examined at a Honeywell materials lab. Examination of the separated blade fracture surface found no evidence of fatigue. The finer fracture features were obscured by oxidation. Secondary intergranular cracks were observed below the fracture surface at some locations. Cross-sections of the fracture revealed oxidation and alloy depletion along the fracture surface consistent with a creep/stress rupture fracture mechanism. EDS of the blade determined that the base material was as specified. Examination of TE cracks revealed similar oxidation and alloy depletion consistent with creep/stress rupture.

There was a light spray of shiny, silver-colored deposits on the suction sides and LEs of several LPT S1 blades that appeared fused to the airfoil surfaces. See Figure 18.

Figure 18. Silver-colored blade deposits

EDS analysis of the silver-colored deposits produced spectra rich in aluminum. See Figure 19.

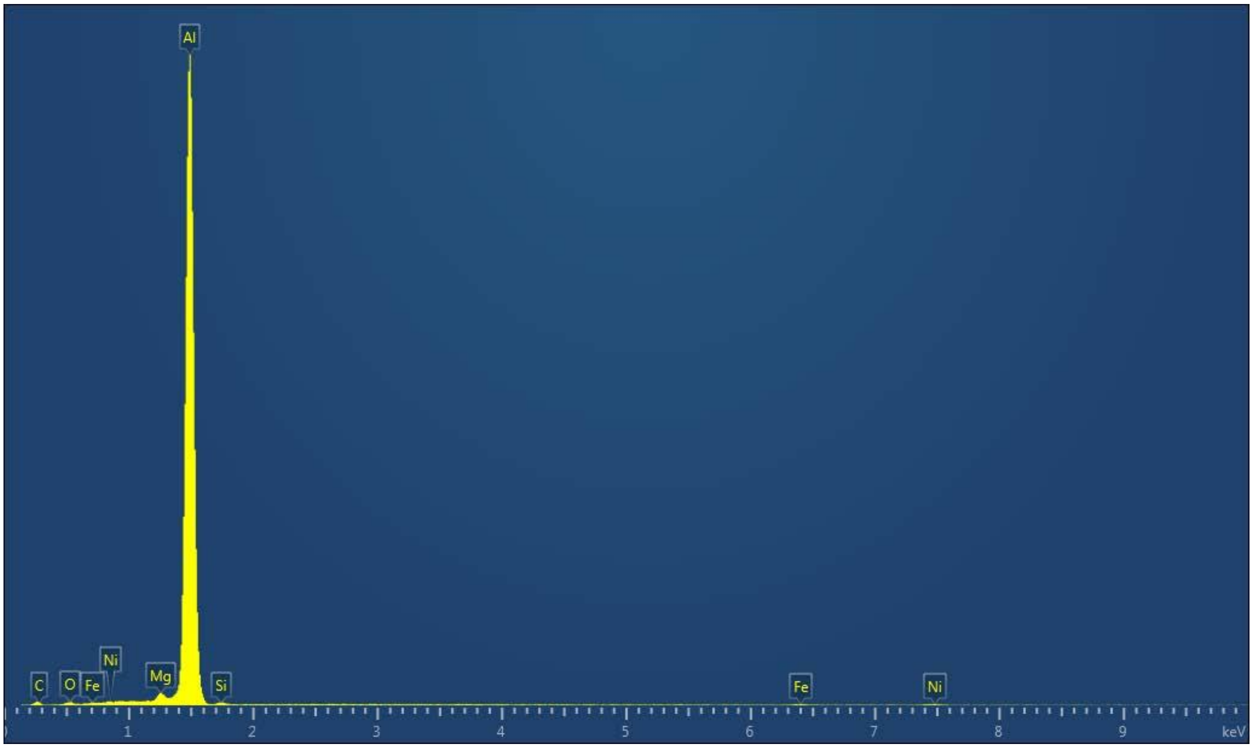

Figure 19. EDS spectrum of LPT S1 rotor blade deposits showing a spectrum rich in aluminum with lesser concentrations of magnesium, silicon, iron, nickel, and oxygen

The EDS result indicated that aluminide particles entered the engine gas stream while combustion was occurring.

2.2.6 LPT S2 nozzle

The suction sides of several LPT S2 nozzle vanes exhibited a light spray of shiny, silver-colored deposits that appeared fused to the airfoil surfaces. The forward and aft curvic coupling teeth and knife edge seals were undamaged.

2.2.6.1 LPT S2 rotor

The suctions sides of several LPT S2 rotor blades exhibited a light spray of shiny, silver-colored deposits that appeared fused to the airfoil surfaces. Accumulations of a white, powdery substance were adhered to the inner LPT S2 rotor blade tip shroud surfaces. The forward and aft curvic teeth were undamaged.

2.2.6.2 LPT S3 nozzle

The LPT S3 nozzle blade path was scored.

2.2.6.3 LPT S3 rotor

Accumulations of a white, powdery substance were adhered to the inside surfaces of the LPT S3 rotor blade tip shrouds.

2.2.7 Thrust and exhaust nozzle

The thrust and exhaust nozzle was unremarkable.

3.0 Right engine

3.1 External condition

The engine was substantially fire damaged. The forward portion of the spinner and the left side of the accessory gearbox housing were thermally consumed. The inside of the oil filter housing was dry and varnished with no obvious contaminants. The oil filter element was clean. The chip detector tip was corroded. No ferrous slivers or buildup were found on the chip detector. The right engine cases appeared structurally intact with no evidence of uncontainment or burn-through. The air/oil cooler was fractured and partially missing between 6 and 9 o'clock. See Figure 20.

Figure 20. Left side view of P-84169

The LEs and tips of the fan blades were torn and battered with material breakouts and curling opposite the direction of fan rotation. A large quantity of terrain debris and some resolidified metal were present in the inlet and between the fan blades. See Figure 21.

Figure 21. Front view of P-84169 assembly (fan housing removed)   Figure 22. Fan bypass stator exit

The air path between the aft side of the fan and the forward side of the fan bypass duct stator vanes was packed with terrain debris and apparent building materials, including large soil clods and brick fragments. See Figure 22.

The underside of the LPC surge bleed valve was coated with a thick layer of a spongy, soil-like substance. See Figure 23. Similar contamination was noted at the customer LPC bleed port.

3.2 Disassembly observations

3.2.1 Fan bypass/air inlet section

3.2.1.1 Spinner

The spinner tip was destroyed by fire and the forward section had collapsed. Circumferentially-oriented scoring was observed on the aft spinner section. See Figure 23.

3.2.1.2 Spinner support

The spinner support was intact. Its outside surface was heat-roughened and displayed circumferentially-oriented scoring. See Figure 24.

Figure 23. Debris coating bleed valve stem

Figure 24. Circumferential spinner and spinner support scoring

3.2.1.3 Fan rotor assembly

All of the fan blades, which are of titanium construction, displayed full-span LE nicks, tears and curling opposite the direction of fan rotation, consistent with FOD. The TEs displayed outer span dents and scrapes. Three consecutive blade tip TEs were bent opposite the direction of fan rotation. An arc of six blades exhibited bent midspan dampers; several other dampers were slightly deformed.

3.2.1.4 Fan support assembly

The fan support housing was intact. The fan shaft and ring gear rotated freely. LP rotor continuity was established from the LPT to the planetary gears. The Nos. 1 and 2 bearings were not inspected.

3.2.1.5 Fan inlet housing and bypass stator assembly

The fan inlet housing was coated with carbon and scorched between 3 and 6 o'clock. Between 6 and 9 o'clock, the exterior wall was missing and the exposed honeycomb material was charred but the containment ring was intact.

3.2.1.6 Compressor inlet stator assembly

The compressor inlet stator was packed with soil/debris. All of the stator vanes were intact. After removal of loose soil/debris, soil-like deposits remained adhered to all of the vanes. The deposits were concentrated at the outboard ends. The vanes displayed LE damage consistent with FOD.

3.2.1.7 Engine support housing and intermediate case

The engine support housing and the intermediate case were intact. The planetary gear train was continuous and appeared in good condition. The No. 3 bearing was not disassembled.

3.2.2 Compressor section

3.2.2.1 LPC

The LPC S1 blade LEs displayed significant dents, nicks, and tears consistent with FOD. The blades were thickly coated with a substance similar to the debris found on the underside of the bleed valve stem. See Figure 25. The LPC was not disassembled.

Figure 25. LPC S1 airfoils thickly coated with debris and showing severe LE damage

3.2.2.2 HPC

The HPC was not disassembled. A borescope probe inserted at the 12 o'clock bleed port revealed an accumulation of debris at the impeller exducers. Another static borescope inspection at the aft side of the LPC S4 (through the surge bleed valve opening) found a buildup of debris at the inner diameter flow path. No obvious vane damage was noted.

3.2.3 Combustion section

3.2.3.1 Combustor

A large annular mound of debris had formed between the combustor and plenum wall. See Figure 26. The debris was soil-like with a fine-tilth consistency and was hosting fungus/mold growth, but it appeared "puffed up" and was adhered together.

Figure 26. Combustor showing soil-like debris formation. Detached air shrouds and debris can be seen inside several fuel nozzle ferrules

Portions of the mound remained with the interstage transition duct when it was separated from the engine. See Figure 27. The combustion liner was not removed from the plenum.

(a) (b)

Figure 27. Showing annular formation of debris adhering to plenum at (a) combustor and (b) interstage transition duct following flange separation

3.2.3.2 Fuel nozzles

The fuel nozzle tips were corroded. Fibrous deposits were found protruding from the fuel nozzle air orifices. See Figure 28.

Figure 28. Foreign debris blocking and protruding from fuel nozzle air orifices

The air shrouds of several nozzles detached during removal and remained inserted in the plenum case ferrules. The nozzles with detached air shrouds appeared scorched and displayed formations of fibrous/soil debris that appeared to have filled the space underneath the air shrouds. See Figure 29. Sections of these debris formations had displaced and collected at the base of the fuel nozzles or remained inside the plenum ferrule. See Figure 26.

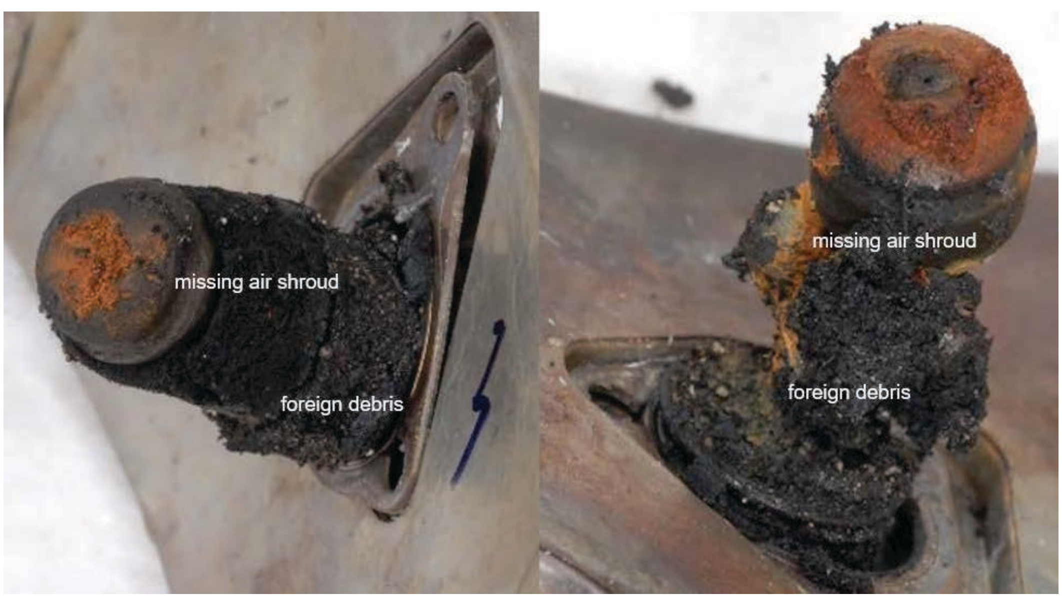

Figure 29. Fuel nozzles with separated air shrouds showing intact and displaced debris formation

3.2.4 HPT section

The HPT rotor was inspected as installed. The blades were covered with soot. There was no obvious tip rub. The high pressure rotating group was not disassembled.

3.2.5 LPT section

3.2.5.1 Interstage transition duct

Foreign debris adhered to the inside surface of the interstage transition duct; it was otherwise unremarkable. The ITT probes were intact and the ITT harness was unremarkable.

3.2.5.2 LPT shaft and seal assembly

The LPT shaft and seal assembly was unremarkable.

3.2.5.3 LPT S1 nozzle

There was a light spray of shiny, silver-colored deposits on the suction side of several LPT S1 nozzle vanes that appeared fused to the airfoil surfaces. No other anomalies were noted.

3.2.5.4 LPT S1 rotor

There was a light spray of shiny, silver-colored deposits on the suction side of several LPT S1 blades that appeared fused to the airfoil surfaces. A white powdery debris was collected between the blades at the tip shrouds. The forward and aft curvic teeth were undamaged.

3.2.5.5 LPT S2 nozzle

There was a light spray of shiny, silver-colored deposits on the suction side of several LPT S2 nozzle vanes that appeared fused to the airfoil surfaces. The seal and blade path were in good condition.

3.2.5.6 LPT S2 rotor

There was a light spray of shiny, silver-colored deposits on the suction side of the blades that appeared fused to the airfoil surfaces. Accumulations of a white, powdery substance were adhered to the inner LPT S2 blade tip shroud surfaces. The forward and aft curvic teeth were undamaged.

3.2.5.7 LPT S3 nozzle

The LPT S3 nozzle blade path showed no marks. The honeycomb seal was in normal condition.

3.2.5.8 LPT S3 rotor

The LPT S3 rotor was heavily sooted. A white powdery debris was collected between the blades at the tip shrouds. The forward and aft curvic teeth were undamaged.

3.2.5.9 LPT tie rod

No tie rod anomalies were noted.

3.2.6 Thrust and exhaust nozzle

The thrust and exhaust nozzle was unremarkable.