



NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

August 1, 2019

POWERPLANT GROUP CHAIRMAN'S FACTUAL REPORT
NTSB No: ENG17IA003

A. INCIDENT

Location: Seattle-Tacoma International Airport- Seattle, Washington

Date: October 26, 2016

Time: 1550 Pacific daylight time (PDT)

Aircraft: Airbus A330-223, N855NW, Delta Air Lines Flight 17

B. POWERPLANTS GROUP

Group Chairman: Robert Hunsberger
National Transportation Safety Board
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Member: John S. Koza
Pratt & Whitney
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C. SUMMARY

On October 26, 2016, at about 1550 Pacific daylight time (PDT), a Delta Air Lines (DAL) Airbus A330-223, N855NW, equipped with two Pratt & Whitney (P&W) PW4168A-1D turbofan engines experienced a No. 1 (left) engine fire during initial climb from Seattle-Tacoma International Airport (SEA), Seattle, Washington. The crew declared an emergency, discharged both fire bottles, and returned to SEA for an uneventful overweight single engine landing. The electronic centralized aircraft monitor (ECAM) system fire indication warning remained illuminated on the cockpit display after both fire bottles were discharged. Airport rescue and firefighting (ARFF) crews met the airplane on the runway and did not observe fire or smoke coming from the engine. Water was sprayed on the airplane landing gear as a precautionary measure, but no water or fire retardants were sprayed on/into the No. 1 engine. There were no passenger or crew injuries reported. The flight was a regularly scheduled flight from SEA to Hong Kong International Airport (HKG), Chep Lap Kok, Hong Kong and was conducted under the provisions of Title 14 *Code of Federal Regulations* Part 121.

Party members from DAL, P&W, and the NTSB met at Delta TechOps in Atlanta, Georgia for an engine examination and partial disassembly from October 31-November 3, 2016. There was extensive sooting and thermal damage on the engine diffuser and low pressure turbine (LPT) cases, most concentrated at the 6 o'clock position. The engine fan rotated smoothly by hand with concurrent rotation of the LPT. The aft stages of the high pressure compressor (HPC), combustor, and forward stages of the high pressure turbine (HPT) were examined by borescope and no anomalies were visible. The electronic engine control (EEC) file from the incident flight was downloaded and reviewed and no faults were registered.

The fuel system was pressurized by porting pressurized shop air into the fuel distribution valve (FDV) and a crack was identified on the fuel manifold supply line that feeds fuel nozzle No. 1, located at the 12 o'clock position. All remaining fuel nozzles were cleaned and examined for leaks by spraying soap water solution on the fuel manifold and nozzle assemblies, but there were no additional findings.

The cracked fuel manifold supply line and fuel nozzle No. 1 were removed as an assembly and shipped to the Pratt & Whitney materials laboratory in East Hartford, Connecticut for analysis. A visual and binocular examination identified a crack that originated from the run out of the braze fillet around the toe of a ball tack weld. Scanning electron microscopy (SEM) determined that the crack surface features were consistent with high cycle fatigue. The supply line material met drawing specification and no material damage or defects were noted on the manifold supply line near the crack origin. An examination of the fuel nozzle braze joint confirmed there was sufficient braze coverage in the joint with no voids.

P&W conducted vibration testing on multiple PW4000-94 inch fan and -100-inch fan engines with TALON II combustors at Eagles Services Asia¹ (ESA) in Singapore. The testing identified a combustor tone common to all engines that excited a resonant vibratory response in the fuel manifold assembly at certain engine speeds. P&W released a service bulletin to incorporate fuel manifold clamps to dampen the vibratory response and reduce the risk of fuel manifold supply line cracking. The Federal Aviation Administration (FAA) released an airworthiness directive (AD) in March 2019 mandating installation of the fuel manifold brackets and clamps.

¹ Eagle Services Asia is a joint venture between SIA Engineering company and Pratt & Whitney, a division of United Technologies Corp.

D. DETAILS OF THE INVESTIGATION

1.0 ENGINE INFORMATION

1.1 Engine History/Maintenance

According to maintenance records, the engine had accumulated the following hours and cycles:

Engine Position	Serial Number	Time Since New (hours)	Cycles Since New	Time Since Repair (hours)	Cycles Since Repair
Left/No. 1	P733619	36,326.45	4,605	11,431.29	1,182

The last engine shop visit was in January 2014 at ESA, Singapore to repair a No. 1 bearing compartment oil leak. The front bearing compartment carbon seal was replaced, and no additional work was required. In May 2013 the engine was sent to ESA for a reported hot air leak at the 6 o'clock position, forward of the integrated drive generator (IDG). While in the shop all 24 fuel nozzles were replaced with new parts.

1.2 Engine Information

The Pratt & Whitney PW4168A-1D is a model of the PW4000-100 Inch Fan engine and part of the PW4000 family of engines. The PW4168A-1D is a de-rated version of the PW4170 (Advantage70[®]) engine.

The PW4000-100 Inch Fan engine is a high bypass ratio axial flow turbofan engine. The basic engine includes a 100-inch diameter fan with 34 shrouded fan blades coupled to a five stage low pressure compressor (LPC); both are driven by a five stage LPT (collectively the fan, LPC, and LPT are called the low, or N1, rotor). The core of the engine includes an 11 stage HPC driven by a two stage HPT (collectively, the HPC and HPT are called the high, or N2, rotor).

An intermediate case (IMC) separates the LPC from the HPC and has provisions for the front engine mount. A diffuser and full annular combustor separates the compressor sections of the engine from the turbine sections. The PW4168A-1D specifically incorporates the TALON (Technology for Advanced Low NOx) IIB combustor configuration. Aft of the LPT is a turbine exhaust case (TEC) that has provisions for the rear engine mount.

The engine is controlled by a full authority digital engine control (FADEC) that includes an electronic engine control (EEC). A fuel metering unit (FMU), mounted to the main fuel pump (MFP), meters fuel to the fuel injectors (nozzles) based on inputs from the EEC.

Pressurized fuel supplied from the MFP is metered by the FMU and flows through a fuel flow transmitter (FFT) and then to the FDV before supplying the fuel nozzles. The FDV supplies eight individual fuel supply tubes that each feed their own fuel manifold. The fuel manifolds, also known as triplets, each supply fuel to three fuel nozzles. In total there are 24 fuel nozzles that are evenly spaced and mounted around the circumference of the diffuser case.

According to the FAA type certificate data sheet No. E36NE Revision No. 7, the PW4168A-1D has a static sea level rated Take-Off thrust of 68,600 pounds and a static sea level maximum continuous thrust rating of 59,357 pounds². The PW4168A-1D was certified by the FAA on 25 November 2008.

All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made aft looking forward (ALF). A cross section of the engine is shown below in **Figure 1**. A figure identifying the fuel manifold triplet and fuel nozzle numbering is shown below in **Figure 2**.

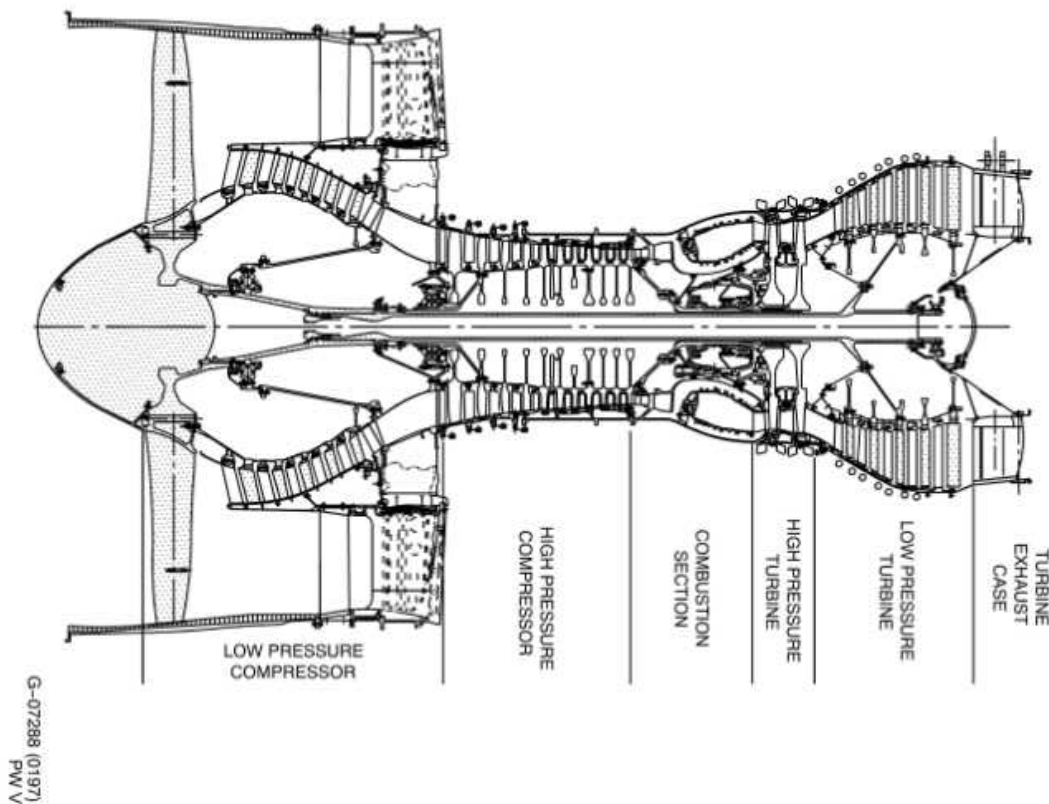


Figure 1-PW4168A-1D Engine Cross Section

² The Sea Level Static Ratings are ideal and are based on ICAO Standard Atmosphere conditions, a Pratt & Whitney hardwall bellmouth inlet, no fan or compressor air bleed or load on accessory drives, an exhaust system having no internal pressure or external scrubbing losses, and fan duct and primary nozzle velocity coefficients equal to 1.0.

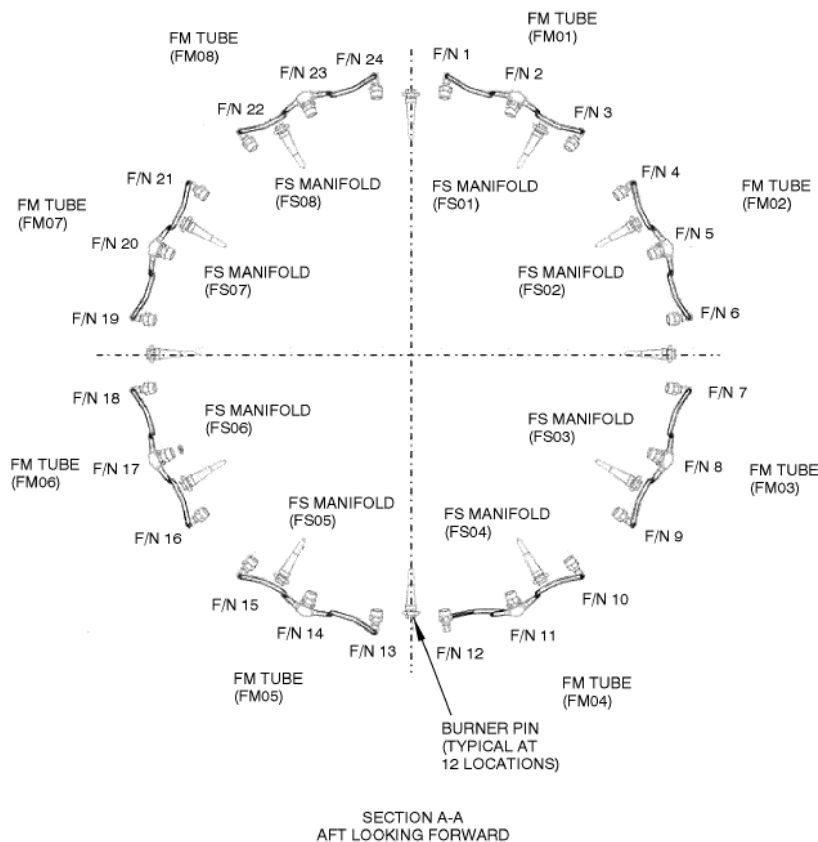


Figure 2- PW4000 Fuel Manifold Triplet Diagram

2.0 NO. 1 ENGINE EXAMINATION, ENGINE SERIAL NUMBER P733619

The No. 1 engine was removed from the airplane at SEA and prepared for shipment to Delta TechOps in Atlanta, Georgia for examination. The engine was received at Delta TechOps in an engine shipping stand and was held in the NTSB quarantine cage until the investigation team arrived. The engine was then transferred onto work pedestals to facilitate inspection and removal of external components (**Photos 1, 2, and 3**). The engine was sooted/discolored from the 5 o'clock to 12:30 positions, between the fan case and exhaust case. The soot/discoloration was most concentrated from the 6 to 9 o'clock positions from the forward flange of the HPT case to the aft flange of the diffuser case. Clamps, wiring harness cables, and the electrical power cables (feeder cables) in the area of greatest soot concentration exhibited thermal damage including charred and melted material (**Photos 4 and 5**). At the 12 o'clock position an additional area of localized soot/discoloration was noted on the diffuser case near fuel nozzle No. 1. Directly above the discoloration, the middle of three pressure regulating valve pneumatic lines had braided metal sleeve burn through and discoloration above the collar (**Photos 6 and 7**).



Photo 1- Left Side of Engine, As Received



Photo 2- Right Side of Engine, As Received

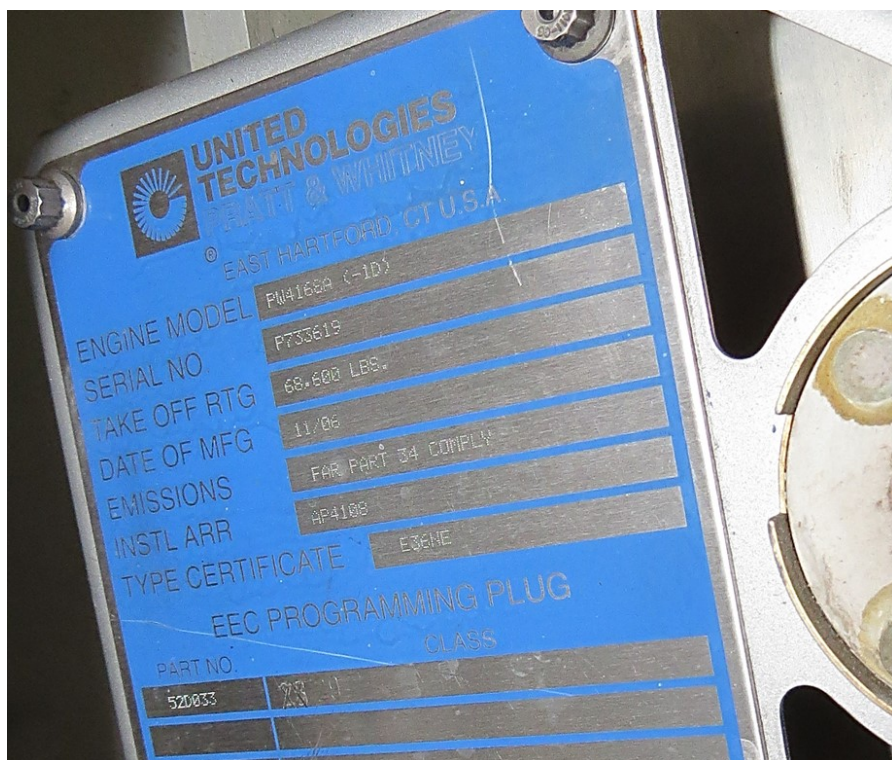


Photo 3- Engine Serial Number P733619 Data Plate



Photo 4- Soot/Discoloration and Thermal, 6 to 9 o'clock



Photo 5- Soot/Discoloration and Thermal Damage, 6 o'clock



Photo 6- Localized Soot/Discoloration, 12 o'clock



Photo 7- Pressure Regulating Line Thermal Damage, 12 o'clock as Viewed from the Right Side

All external engine components that obstructed visual access to the diffuser case and fuel manifolds were removed to perform a visual examination and leak check of the fuel manifold and fuel nozzle assemblies. The fuel system lines were not separated, and special care was taken to avoid disturbing soot/discoloration patterns on the engine cases.

The oil in the IDG and oil tank was sampled and did not appear discolored or smell acrid. The six magnetic chip detector plugs were removed and there was no metal debris accumulation.

2.1 Fuel Manifold Assembly Leak Check

Each fuel nozzle was individually numbered and photographed. All engine case openings that were exposed during removal of external engine components were covered with tape. The FFT was removed and pressurized shop air (~120 pounds per square inch (psi)) was ported into the supply side of the FDV valve in accordance with the engine maintenance manual (EMM). The fuel manifold system was pressurized, and an air leak was detected coming from the fuel manifold supply line that feeds fuel nozzle No. 1, located at the 12 o'clock position. Fuel nozzle No. 1 and the attached fuel manifold supply line were cleaned, and a fine crack was observed on the manifold supply line near the nozzle braze joint (**Photos 8 and 9**). A second pressure check was completed after each fuel manifold and nozzle assembly was cleaned with isopropyl alcohol with no additional findings.



Photo 8- Manifold Supply Line Crack, 12 o'clock as Viewed With Inspection Mirror



Photo 9- Manifold Supply Line Leak During Pressure Test

A borescope inspection of the aft stages of the HPC, combustor, and forward stages of the HPT was completed. There were no visible anomalies and the condition of all parts were consistent with service run engines.

3.0 THRUST REVERSER COWL EXAMINATION

The outboard thrust reverser (TR) cowl half exhibited thermal damage including charring of the ablative material and discoloration of the thermal blanket from the 6 to 12 o'clock positions, mostly concentrated on the forward half (**Photos 10 and 11**). No burn through was observed. The damage observed was coincident with the soot/discoloration and thermal damage documented on the engine cases. The fire loop rubber grommets were thermally consumed across a majority of the loop. A small area of thermal damage was observed on the inboard side of the TR cowl at the lower split line (6 o'clock).



Photo 10- Outboard Thrust Reverser Cowl Damage

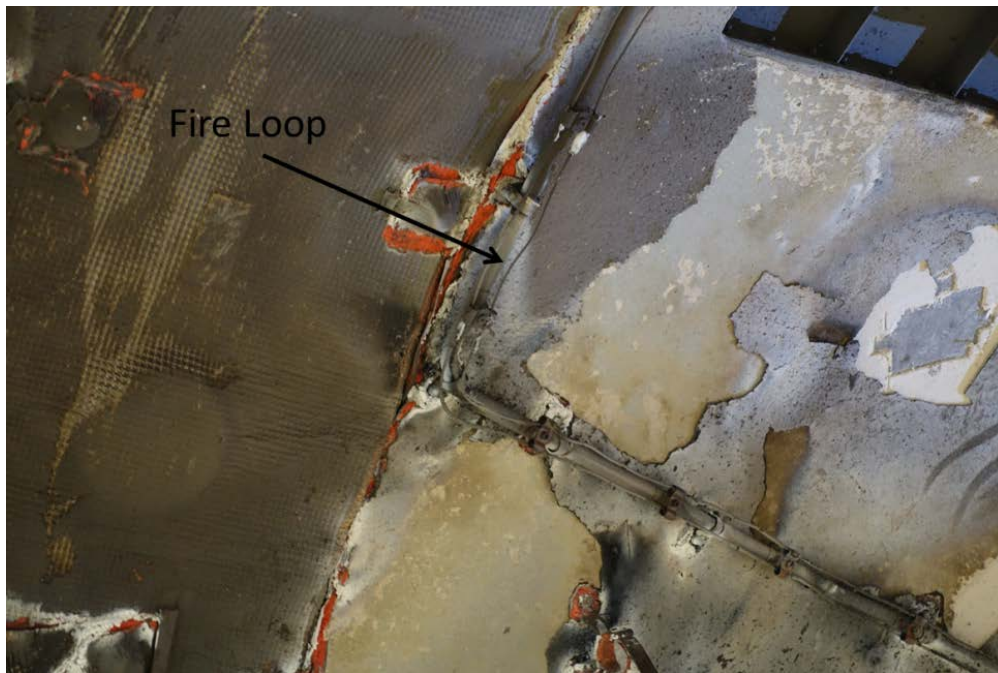


Photo 11- Thrust Reverser Ablative Coating and Fire Loop Damage, 8 o'clock

4.0 RECORDED DATA

The quick access recorder (QAR), digital flight data recorder (DFDR) and electronic engine control (EEC) data for the incident flight were downloaded and reviewed. The only anomaly observed was an increase in the exhaust gas temperature (EGT)³ reading shortly after the No. 1 engine fire warning indication. According to P&W Flight Safety there are several historical cases where EGT readings have increased due to an undercowl fire (external to the engine) in proximity to the EGT probes.

5.0 METALLURGY

The fuel manifold supply line supplying fuel nozzle No. 1 was cut several inches away from the supply line-to-nozzle elbow braze joint to facilitate removal of the nozzle from the engine case. The nozzle and manifold supply line were shipped to the P&W materials laboratory in East Hartford, Connecticut as an assembly with the fuel nozzle b-nut torqued in the same condition as when it was removed from the engine (**Photo 12**). The remaining section of the fuel manifold triplet assembly was also shipped with fuel nozzles No. 2 and No.3 removed (**Photo 13**).

³ The EGT indication system is comprised of four dual channel thermocouples that are mounted on the turbine exhaust case at the No. 1, 4, 6:30, and 10 o'clock positions. The system averages the value of the temperature recorded at each of the four thermocouples to provide a reading.

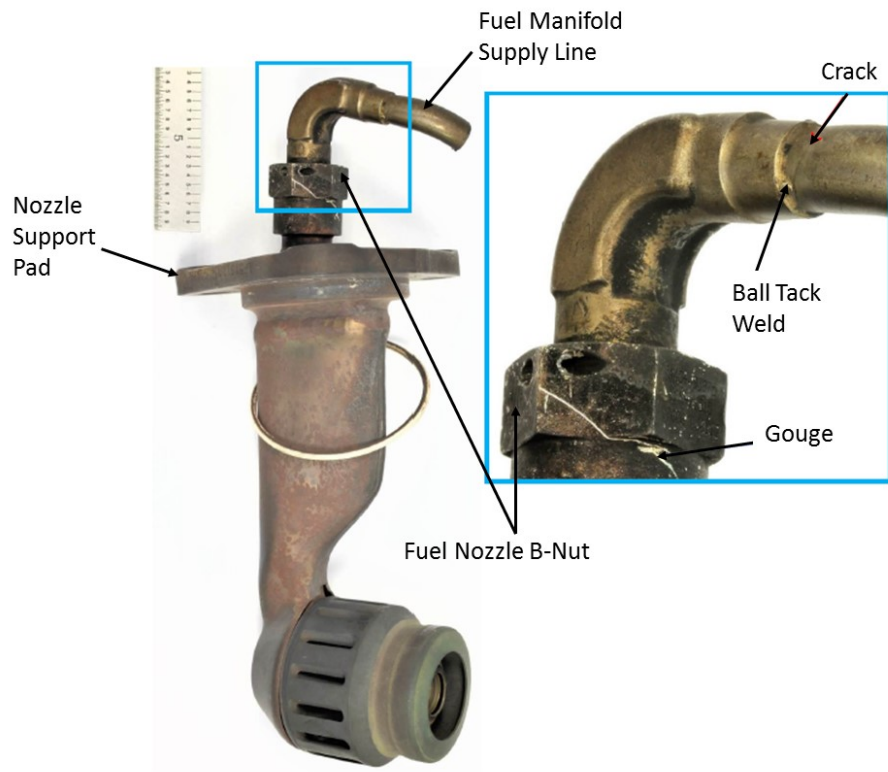


Photo 12- Fuel Nozzle No. 1 Assembly, as Removed from Engine

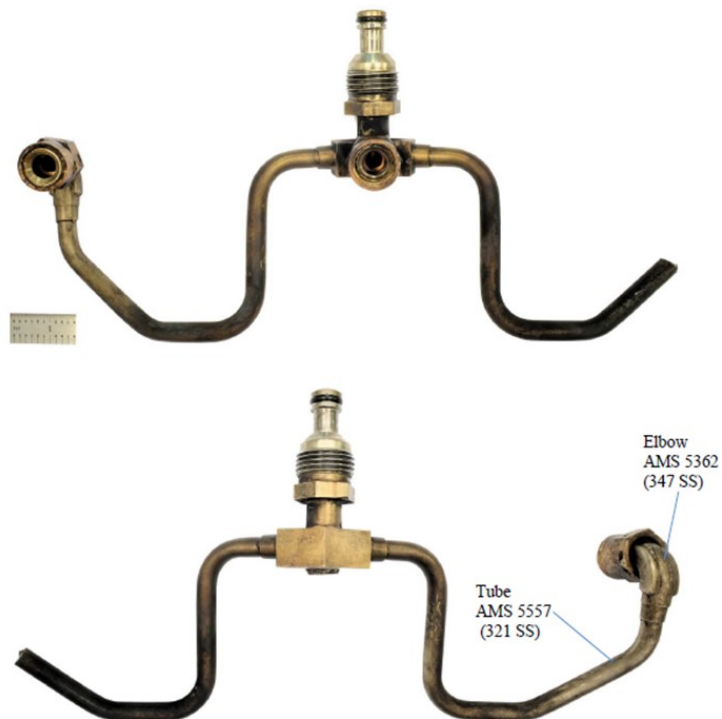


Photo 13- Fuel Manifold Triplet Assembly, Fuel Nozzles Removed

A visual and binocular examination identified a crack that originated from the run out of the braze fillet around the toe of a ball tack weld. Scanning electron microscopy (SEM) was used to examine the crack surface features and they were consistent with high cycle fatigue (HCF). There were no defects or material damage on the manifold supply line near the crack origin. A test of the manifold supply line material confirmed the material met drawing specification. The braze joint where the manifold supply line joins the elbow fitting had sufficient coverage and no voids in the braze material were observed. A complete copy of the materials laboratory report is available in the docket under the title “Pratt & Whitney Materials & Processes Engineering Metallurgical Investigation of Fuel Triplet and Fuel Nozzle from PW4168 Engine P733619.”

6.0 EAGLE SERVICES ASIA ENGINE TEARDOWN

The engine was shipped to ESA Singapore⁴ after it was released from the investigation for disassembly and parts evaluation as part of the normal repair process. The NTSB requested a copy of the engine teardown findings report. ESA did not identify any engine anomalies that may have contributed to the engine fire and the condition of all internal components, including the combustor and diffuser assemblies were consistent with similar service run engines.

7.0 PRATT & WHITNEY PW4000-94/-100 INCH FAN SERIES VIBRATION TESTING

Between July 2017 and November 2017, P&W performed vibration testing on two PW4000-100 inch fan engines and two PW4000-94 inch fan engines with TALON II (A or B) combustors at ESA Singapore. One of the PW4000-94 inch fan engines had experienced three separate fuel leak events due to fuel manifold cracks. The other three engines tested had no history of fuel leaks. The engine instrumentation package included: 12 strain gages⁵ and three tri-axial accelerometers⁶ at the fuel manifolds and nine single axis accelerometers at the fuel nozzle pads (**Figure 3**). Thermocouples were installed at fuel nozzle pad No. 1 and triplet position No. 1. A dummy igniter probe was installed in place of one of the normal igniter plugs to measure acoustic tone, and an internal combustor pressure probe was installed. Accelerometers were installed on the K flange (HPC rear case-to-diffuser case) and N flange (HPT case-to-LPT case). The testing identified an acoustic tone created by the combustor during engine operation that excites a dynamic (resonant) response in the fuel manifold assembly. The amplitude of the vibratory response at the fuel manifolds varied between engines but was present at the same frequency on all engines tested. One engine was tested to correlate the combustor tone/resonant frequency to an engine speed range. The combustor tone peaked near the end of a 5 second snap acceleration⁷ and then decreased when the engine was allowed to dwell at the higher speed. It is estimated that the tone occurred between 9,000 (86%) and 10,000 (95.6%) RPM N2.

⁴ DAL ships all PW4000 100 inch fan engines in their fleet to Eagle Services Asia for repair and overhaul.

⁵ A strain gage is sensor that measures force by converting the force into an electrical resistance.

⁶ An accelerometer is an electromechanical device that measures acceleration forces such as vibration.

⁷ A snap acceleration is a rapid increase in throttle position from idle to either maximum power or a designated high power setting.

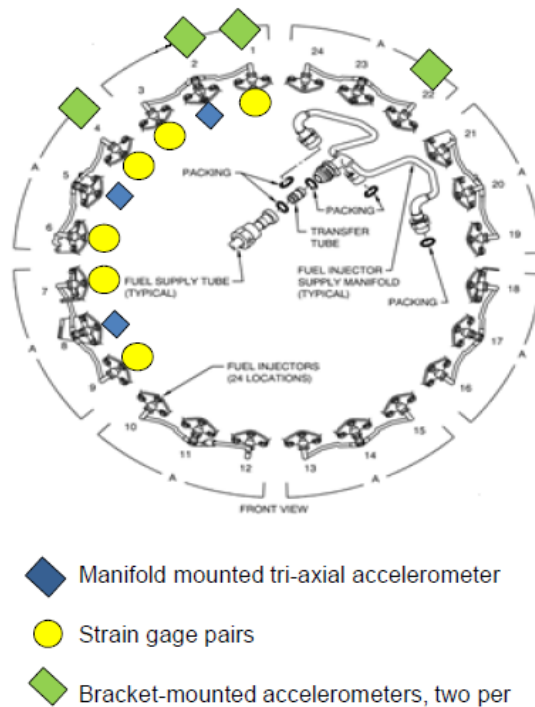


Figure 3- PW4000 Vibration Test Instrumentation

8.0 ADDITIONAL INFORMATION

8.1 Pratt & Whitney TALON IIB Combustor

The PW4000-100 inch fan fleet includes three combustor configurations: non-TALON floatwall, TALON IIA floatwall and TALON IIB floatwall. The floatwall combustor features a sheet metal shell with cast interior segments. The only difference between the non-TALON floatwall and the TALON floatwall combustors are the dilution/cooling holes locations. The change was designed to shift the combustor radial temperature distribution more towards the center of the combustor. The TALON IIB combustor can be installed per Service bulletin (SB) PW4G-100-72-214 in the pre-Advantage70[®] engines but is a requirement to be installed in the converted or production Advantage70[®] series engine per SBs PW4G-100-72-219 and PW4G-100-72-220.

The PW4000-94 inch fan fleet also features non-TALON floatwall and TALON IIA combustors. The only architecture differences between the floatwall and TALON IIA combustors installed in the -94 inch fan fleet compared to the those installed in the -100 inch fan fleet is the combustion chamber mounting pin boss.

9.0 FUEL MANIFOLD/FUEL NOZZLE LEAK HISTORY

The NTSB has investigated or acted as an accredited representative⁸ on multiple PW4000-94 inch and -100 inch fan fuel manifold/fuel nozzle leaks that have resulted in engine fires. The findings from these investigations have been supplemented with P&W field service reports from non-reportable⁹ fuel leaks to compile a summary of failure modes and an occurrence count to date. The NTSB is aware of three separate fuel manifold/fuel nozzle failure points: the fuel nozzle-to-fuel manifold interface, the fuel nozzle fitting-to-nozzle support pad braze joint, and the fuel manifold supply line (**Photos 12 and 14**).

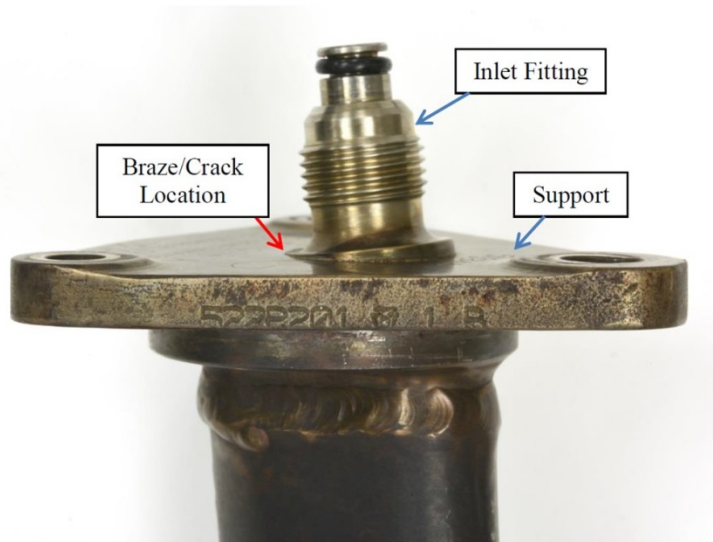


Photo 14- Fuel Nozzle Braze Crack Location

The first identified fuel leaks at the fuel nozzle-to-fuel manifold interface were attributed to a loss of fuel nozzle b-nut clamping force (loss of torque due to b-nut back off) caused by thermal gradients. These thermal gradients are specific to engines featuring the TALON II (A and B) combustor.

The fuel nozzle fitting-to-nozzle support braze cracks were also attributed to thermal gradients driven by TALON II combustors. The thermal gradients cause thermal fatigue cracks to develop and propagate until they result in a fuel leak from the braze joint. Several fuel leaks that were originally reported as b-nut related leaks were later reclassified as fuel nozzle braze cracks after the parts were retroactively examined. In addition to the thermal gradients, a tack weld that was applied during manufacture to stabilize the assembly during brazing is thought to potentially also play a role by creating stress risers that may contribute to crack formation. P&W engineering studies have not conclusively determined if the resonant combustor tone discussed in the vibration testing section of this report factors into loss of b-nut clamping or fuel nozzle braze joint crack growth. There have been 58 total fuel leaks reported due to the loss of b-nut clamping force or fuel nozzle braze cracks in the PW4000-100 inch fan

⁸ In accordance with International Civil Aviation Organization (ICAO) Annex 13 guidelines the NTSB may assign an accredited to assist a foreign ICAO member nation with the investigation of aviation hardware that is designed and/or manufactured in the United States.

⁹ According to 49 CFR Part 830, engine fuel leaks that do not result in a fire do not require NTSB notification. This regulation applies to flights operated in the United States.

fleet.¹⁰ Nine of the 58 fuel leaks resulted in an engine fire. The PW4000-94 inch fan fleet has had no reports of fuel leaks due to loss of fuel nozzle b-nut clamping, and one fuel leak that resulted in an engine fire due to a fuel nozzle braze joint crack.

Fuel manifold supply line cracks, such as the one identified on the incident engine and discussed in this report have resulted in a total of 10 fuel leak events (six different engines), resulting in two engine fires on the PW4000-100 inch fan engine fleet and eight fuel leaks (five different engines) with no resulting fires on the PW4000-94 inch fleet. All fuel manifold supply line cracks on both engine models have occurred on the top half of the engine (fuel triplets: FS01, FS02, FS07, FS08).

9.0 CORRECTIVE ACTIONS

9.1 Engine Build Audit

At the request of the NTSB, an announced¹¹ build audit of a PW4000 100-inch fan engine diffuser and combustor assembly build was conducted at ESA in March 2018. During the assembly process, there were no deviations from the engine assembly manual procedures observed and both the part numbers and condition of all parts used met manual specifications.

9.2 Pratt & Whitney Service Bulletins and FAA Airworthiness Directives

As stated in the previous section, three separate fuel leak locations have been identified on PW4000-94 inch fan and -100 inch fan engines featuring the TALON II combustor. P&W and the FAA have released corrective actions to address each of these failure modes.

On October 10, 2014, P&W released SB PW4G-100-A73-44¹² in response to the fuel leaks at the fuel nozzle to fuel manifold interface on engines featuring the TALON II combustor. The cause paragraph of the SB stated:

The Investigation of these fuel leaks has identified that the leak occurs at the B-nut connection interface between the fuel supply manifold and fuel nozzle. Temperature combined with operational loading pressures and low and high cycle stresses reduces clamping load below the minimum requirement for effective outer conical seat sealing.

The solution paragraph stated:

Perform a one-time re-torque (increased torque) of the B-nut connection interface between the fuel supply manifold and fuel nozzle per the accomplishment instructions. In the interim time frame before the increased torque procedure is accomplished; perform a visual

¹⁰ Reports of fuel leak events due to loss of b-nut clamping force and fuel nozzle braze joint cracks were combined because the probable cause assigned to both failures is the same. It is also unknown how many events originally classified as loss of b-nut clamping force may have been due to braze joint cracking.

¹¹ ESA was notified of the build audit in advance of the audit date.

¹² SB PW4G-100-A73-44 is a compliance category 3 bulletin. The inspection was to be performed at the next "A" check and every subsequent check until the torque increase had been accomplished. The recommended compliance timeframe for the torque increase was based on engine cycles. Revision No. 1 was released on February 12, 2015 to change the affected engine serial number list.

inspection within next A-check interval. Perform a repetitive visual inspection at each A-check until the increased torque is implemented.

The SB calls for the fuel nozzle b-nut torque to be increased from 200 lbf-in (pounds force-inch) to 250-270 lbf-in. The FAA released airworthiness directive (AD) 2015-17-17 effective October 2, 2015 mandating the inspection and b-nut torque increase. As of March 2019, 100 percent of the operating fleet was in compliance with the SB/AD recommendation.

On February 16, 2016, P&W released SB PW4G-100-A73-45¹³ in response to additional fuel leaks from the fuel nozzle braze joint located between the fuel nozzle inlet fitting and the nozzle support pad. The cause paragraph of the SB stated:

The investigation of these fuel leaks has identified that the leak occurs at the brazed joint interface on the fuel injector support (fuel nozzle) between the inlet fitting and the nozzle support pad. Cracks are attributed to thermal mechanical fatigue due to high thermal gradients on engines equipped with the TALON IIB Combustor.

The SB recommends a repetitive inspection of fuel nozzles for soot or coke formation at each “A” check until the fuel nozzles are replaced with either the new one piece forged design nozzle that eliminates the braze joint or zero-time brazed nozzles. A follow up SB, SB PW4G-100-A73-47 was released by P&W on March 10, 2017 recommending replacement of cast nozzles with the updated one piece forged design by April 1, 2019. The FAA mandated SB PW4G-100-A73-45 with AD 2016-22-05, effective December 6, 2016. As of March 2019, 95 percent of the operating fleet had complied with SB PW4G-A73-100-47.

On February 5, 2018, P&W released SB PW4ENG 73-223¹⁴ recommending the installation of forged fuel nozzles on the PW4000-94 inch fan engines with TALON II combustors. The repetitive inspection included in the PW4000-100 inch fan engine SB and AD does not apply to the -94 inch fan fleet. According to the FAA, the risk assessment generated for the failure mode did not support the release of an AD for the PW4000-94 inch fan fleet and the NTSB concurs with the FAA assessment. As of March 2019, no engines in the PW4000-94 inch fan fleet had complied with the SB.

On March 14, 2018, P&W released SB PW4G-A73-48¹⁵ recommending the installation of brackets and clamps on the fuel manifold assemblies to dampen the resonant vibratory response to a combustor tone on PW4000-100 inch fan engines with TALON II combustors. SB PW4G-A73-48 Revision No. 3 was released on March 26, 2019 to update the recommended SB compliance to a category 3 (within 100 cycles or one calendar month from SB revision date, whichever occurs first) for engines that had previously experienced a fuel manifold crack. Engines that have not previously experienced a fuel manifold crack and have not yet incorporated the SB were assigned a recommended compliance category 4 (do when engine or module is at a maintenance facility that can do the procedure, but before September 30, 2024). The FAA mandated the installation of the fuel manifold brackets and clamps with AD-2019-06-07 on March 28, 2019. AD 2019-06-07 replaces AD 2016-22-05 discussed above and mandates an

¹³ PW4G-100-A73-45 is a compliance category 3 bulletin for the inspection part of the SB. The inspection should be completed by the next “A” check and every subsequent A check. The fuel nozzle replacement recommendation had a category 4 compliance or when the engine or module goes to the maintenance base which is capable of performing the nozzle change regardless of the reason why the engine is in the shop.

¹⁴ PW4ENG-73-223 is a compliance category 7 bulletin, “do when supply of superseded parts is fully used”

¹⁵ PW4G-A73-48 was initially released as a category 5 bulletin. The brackets and clamps were to be installed when the engine was disassembled sufficiently to give access to the changed subassembly.

inspection of all fuel nozzles for soot or coke accumulation in accordance with SB PW4G-100-A73-45 within 800 flight hours after December 6, 2016, or before further flight, whichever occurs later. If a nozzle fails inspection it should be removed and replaced with an eligible part. At the next shop visit or within 24 months of the AD effective date (May 2, 2019), all cast nozzle assemblies should be removed and replaced with forged nozzle assemblies in accordance with SB and engine maintenance manual instructions. Finally, at the next shop visit or within 60 months of the AD effective date, whichever comes first, brackets and clamps should be installed on the fuel manifold triplets in accordance with SB PW4G-100-73-48 Revision No. 1.

On November 8, 2017, P&W released SB PW4ENG-73-224¹⁶ recommending the installation of fuel manifold brackets and clamps on PW4000-94 inch fan engines with TALON II combustors. On March 29, 2019 Revision No. 1 to the SB was released to amend the compliance recommendations. For engines that have experienced a fuel manifold crack and have not incorporated SB PW4ENG-73-224 on manifold triplets FS01, FS02, FS07, and FS08, the SB assigned a compliance category 3 (install brackets and clamps on fuel manifold triplets FS01, FS02, FS07, and FS08 within 130 cycles or two calendar months from the SB revision date, whichever occurs first. Installation of the bracket and clamps on the remaining manifold triplets (FS03, FS04, FS05, FS06) can be delayed until the next shop visit). For engines that have not experienced a cracked manifold assembly, the compliance remains a category 5. The FAA issued AD 2019-06-02 on March 26, 2019 to mandate the SB. The AD has the same compliance requirements as those recommended in the SB and the AD effective date was April 30, 2019.

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Propulsion

¹⁶ PW4ENG-A73-224 was initially released as a category 5 bulletin. The brackets and clamps were to be installed when the engine was disassembled sufficiently to give access to the changed subassembly.