GO BEYOND

Service Investigation

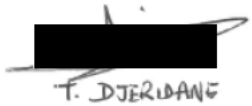
Accident / Incident Report

P&WC 8114 (2021-02)

Report No.: 21-128

Antonio L. Elias
Piper PA 46-500TP, N31062
Manteo, North Carolina, USA
July 6, 2021
PT6A-42A, RM0227

Written By: **Jeff Davis**
Service Investigation Department



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Date of Issue: **June 13, 2023**

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NTSB: **ERA21LA287**
TSB Identification: **A21F0093**
P&WC File No.: **21-128**
RFA No.: **21SIE00236**

This document has been cleared for posting on the National Transportation Safety Board Docket.

EXPORT CONTROL CLASSIFICATION		LOCATION	U.S. REGULATION	
			EAR	ITAR
		U.S.	P-ECCN NSR	P-USML NSR
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Date of marking	May 17, 2023	CANADA	EIPA (ECL)	DPA (CG)
			NSR	No

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I ANALYSIS

1.0 ACCIDENT SYNOPSIS

1.1 On July 6th 2021, a Piper PA 46-500TP, Aircraft Reg. No. N3106, reported a loss of power and performed a landing on a grassy area of the airport. The nose gear collapsed resulting in the propeller and the nose of the aircraft contacting the ground. The pilot and passenger did not report any injuries.

2.0 SUMMARY OF FINDINGS AND DISCUSSION

2.1 The scoring on the upstream side of the compressor turbine disc, the rolled over material on the 1st stage compressor rotor and centrifugal impeller indicate that the engine was producing some power during the landing/impact sequence.

2.2 The majority of the debris found in the fuel/oil heat exchanger is attributed to secondary damage from the impact sequence. The deviation noted on some of the engine controls are considered either field adjustments or minor and did not contribute to the reported loss of engine power.

2.2 The displaced material on the lockwire channels of the B nuts suggests that the P-3 tubes had been installed on their respective matting nipples on more than one occasion. In P&WC's experience, wear has been witnessed on other "B" nuts from fretting with the lockwire. The dirt buildup in the nipple threads occurs during engine operation as the "B" nut does not fully cover all the nipple threads at this location. The "B" was not properly torqued, it most likely started leaking enough P3 air during the event flight to contribute to a loss of engine power/performance. The pilot reported a loss of engine power and some recovery on several occasions indicating the P3 leak may have been intermittent initially but was most likely degrading over time.

3.0 CONCLUSION

3.1 The rubbed compressor and the compressor turbine indicate the engine was producing some power at impact.

3.2 The loose P3 tube "B" nut to the mating nipple most likely resulted in a loss of P3 air pressure to the fuel control unit. Inadequate P3 air pressure to the fuel control would result in a partial loss of engine power as reported by the pilot. The root cause for the loss of torque on the P3 tube "B" nut could not be determined.

II FACTUAL INFORMATION

1.0 INVESTIGATION PARTICIPANTS

The powerplant investigation was performed on December 14th 2021, at the Pratt & Whitney Canada's (P&WC) Service Investigation Facility at Bridgeport, West Virginia. The following individuals participated in the investigation as representatives of their respective organisations:

Heidi Kemner	NTSB
Tim McQuain	FAA
Les Doud	Hartzell Propellers
Karel Currey	P&WC
Jeff Davis	P&WC

2.0 ENGINE HISTORY

Engine Model: PT6A-42A, **Serial No.**: RM0227

Logbook Available: Yes: ☒ *No ☐
**The engine logbooks were not available at the time of the investigation.*

Time Since New (TSN): 1449.5, per an undated engine logbook entry

Cycles Since New (CSN): 1258, per an undated engine logbook entry

3.0 ENGINE EXAMINATION

All positional references are in relation to view from aft looking forward. Upstream and downstream references are in relation to gas path flow from the compressor inlet to the turbine exhaust.

3.1 External Condition

The engine was received in a sealed shipping container and was opened in the presence of the NTSB. The reduction gearbox and the exhaust duct were unremarkable (Ref. Photo No. 1 to 4, overall views of the engine). The gas generator case exhibited some buckling at 6 o'clock region forward of the inlet case mating flange. The inlet screen and areas at the bottom of the center and rear fireseals were contaminated with oil, soil, and organic material. All six of the inlet case struts were fractured (Ref. Photo No. 9). The accessory gearbox was unremarkable. One end of the fuel to oil heat exchanger mounting flange was fractured, adjacent to a bolt hole.

The engine data plate showed the engine serial number was PCE-RM0227 (Ref. Photo No. 5).

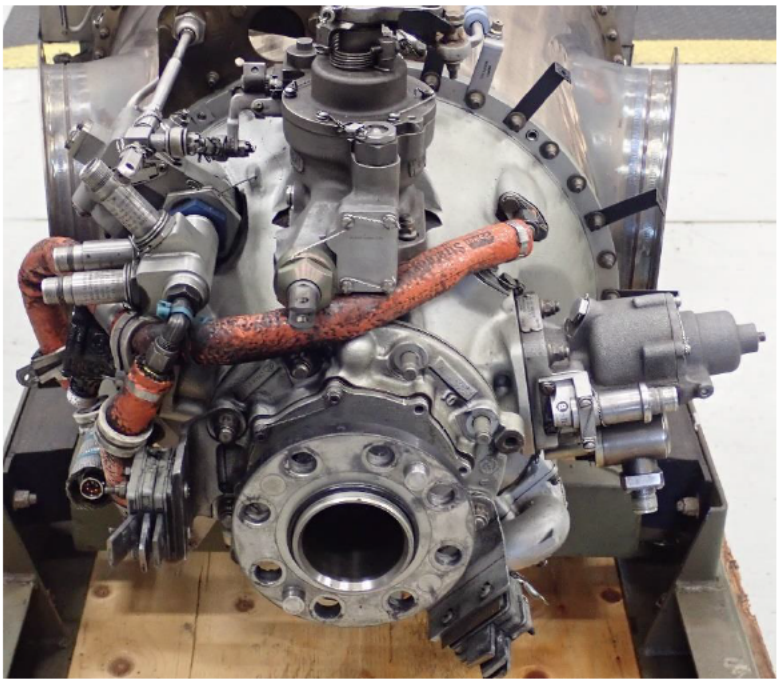


Photo No. 1, view of the front of the engine

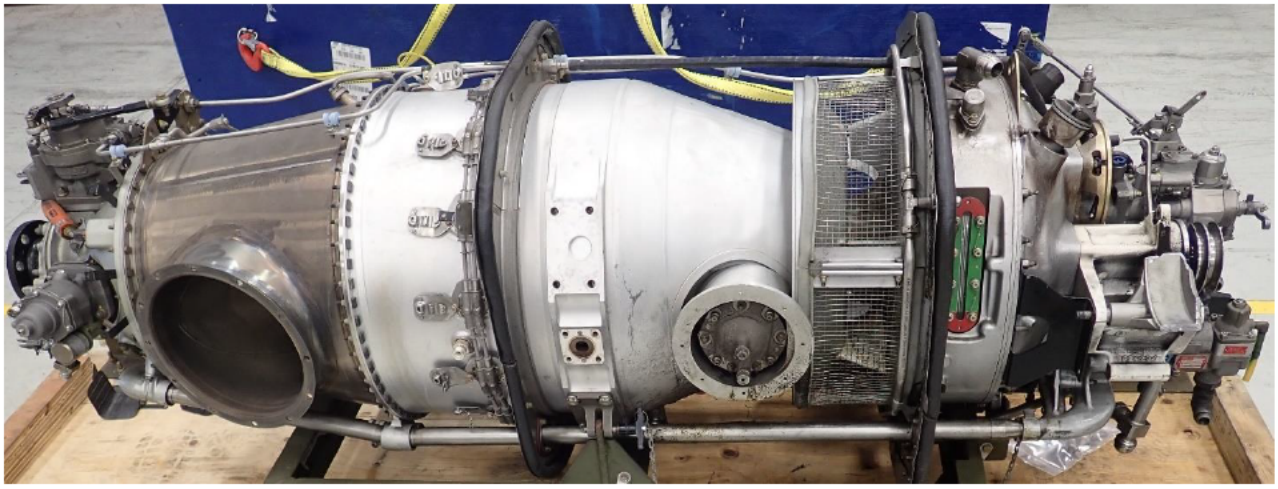


Photo No. 2, view of the left-hand side of the engine

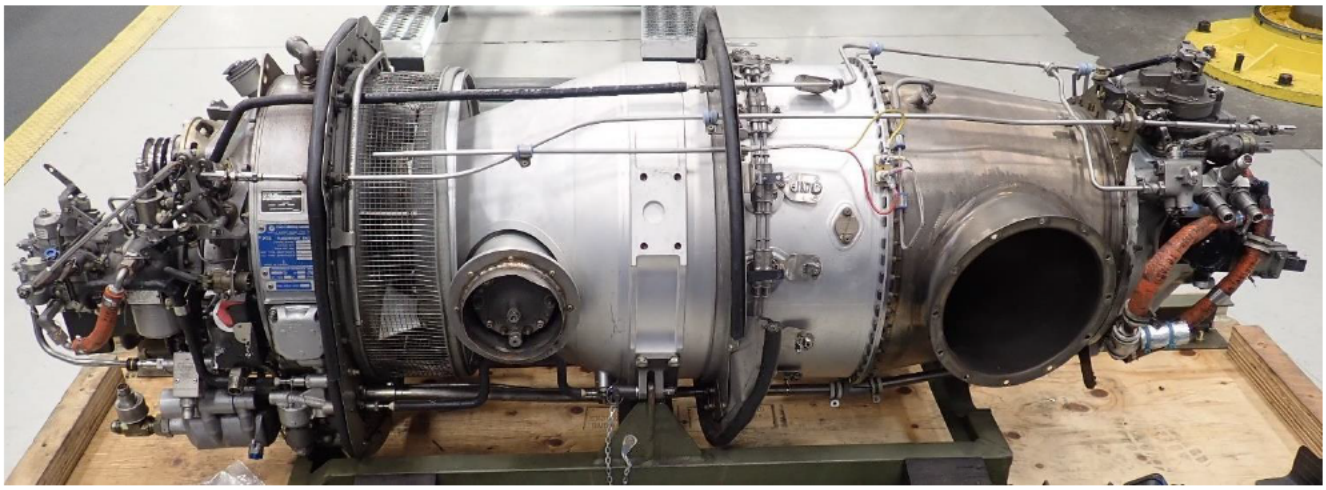


Photo No. 3, view of the right-hand side of the engine

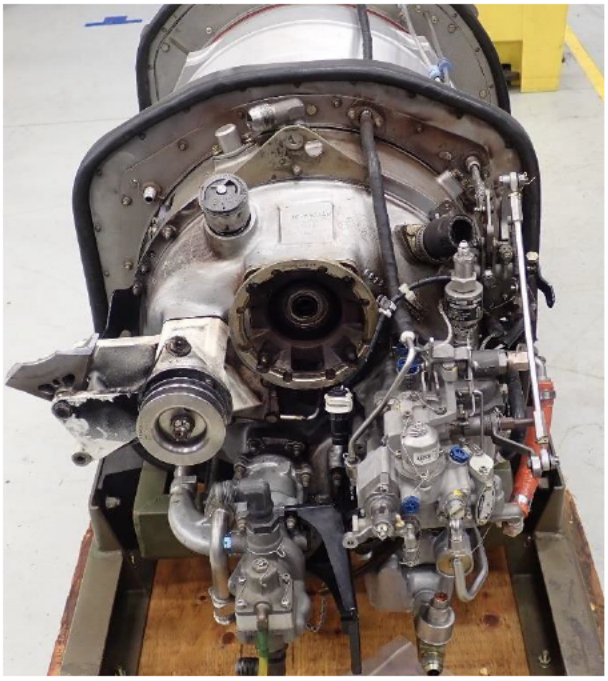


Photo No. 4, view of the rear of the engine

Photo No. 5

3.1.1 External Cases

Reduction Gearbox (RGB): The reduction gearbox was unremarkable (Ref. Photo No. 6).

Exhaust Duct: The exhaust duct was unremarkable (Ref. Photos No. 2 & 3).

Gas Generator Case (GGC): The gas generator case exhibited localized bending on the bottom section between the bleed valve bosses (Ref. Photo No. 7).

Accessory Gearbox (AGB) and Inlet Case: The gearbox was unremarkable (Ref. Photo No. 8). The inlet case struts were fractured (Ref. Photo No. 9).

Photo No. 6

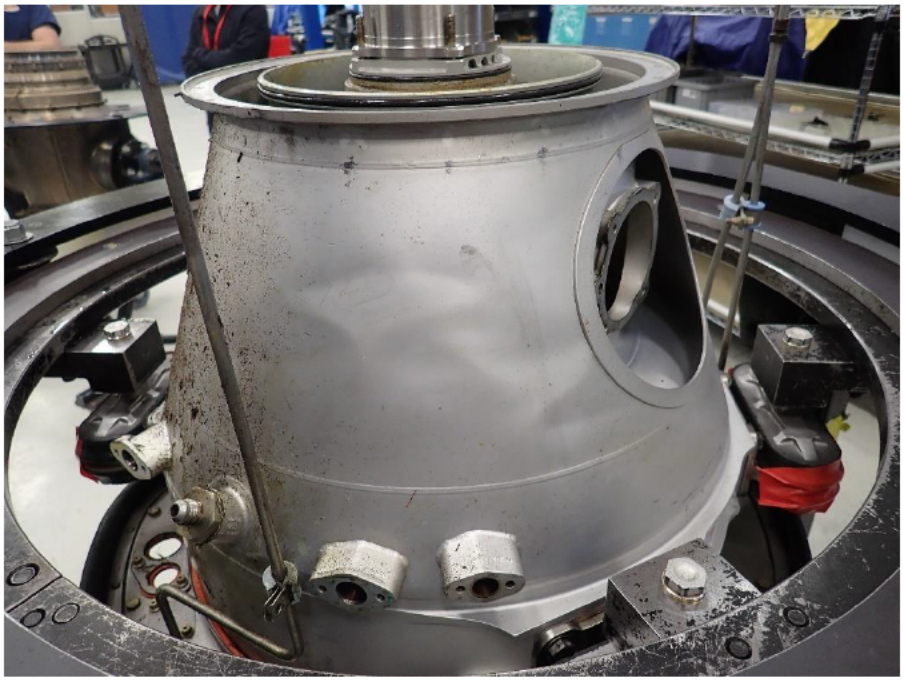


Photo No. 7

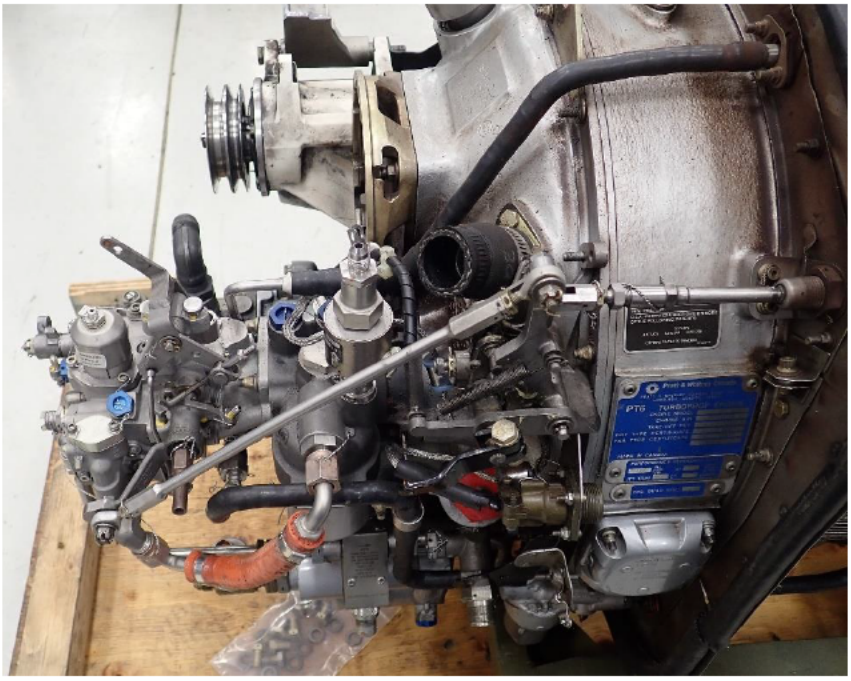


Photo No. 8

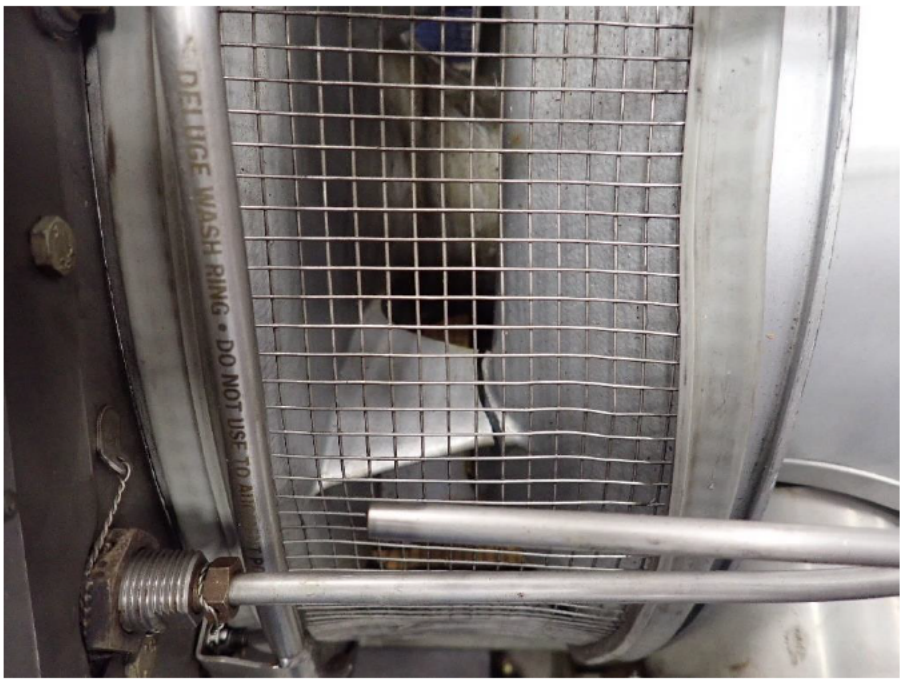


Photo No. 9

3.1.2 Power Control Linkage and Reversing Linkage

The reversing (beta) lever was not received with the engine. The front linkage was in place and secured (Ref. Photo No. 10). The propeller governor lever was secured in a fixed position with an airframe bracket/rod (Ref. Photo No. 10, red arrow).

The rear linkage was in place and secured (Ref. Photo No. 11).

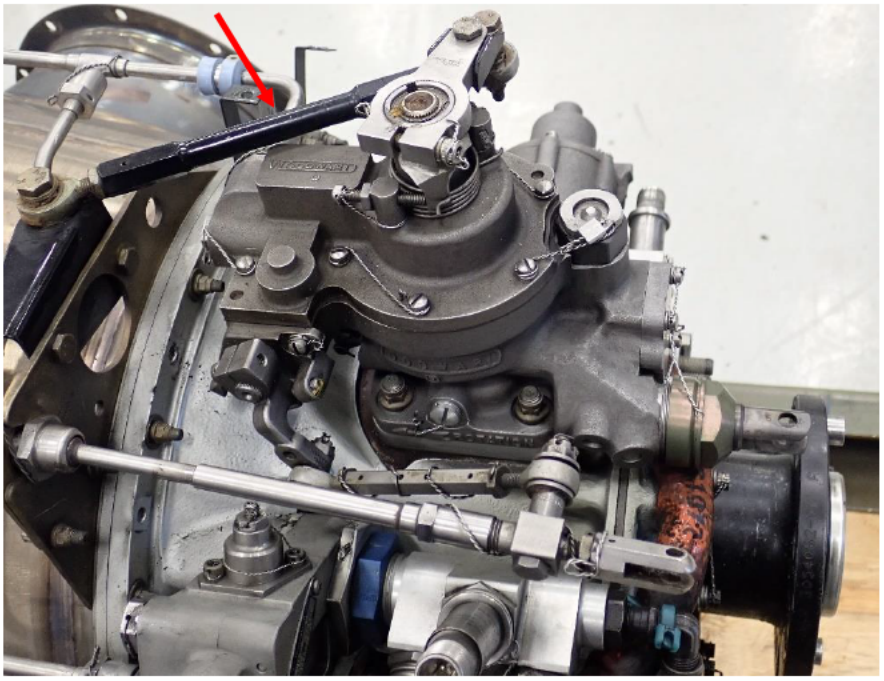


Photo No. 10

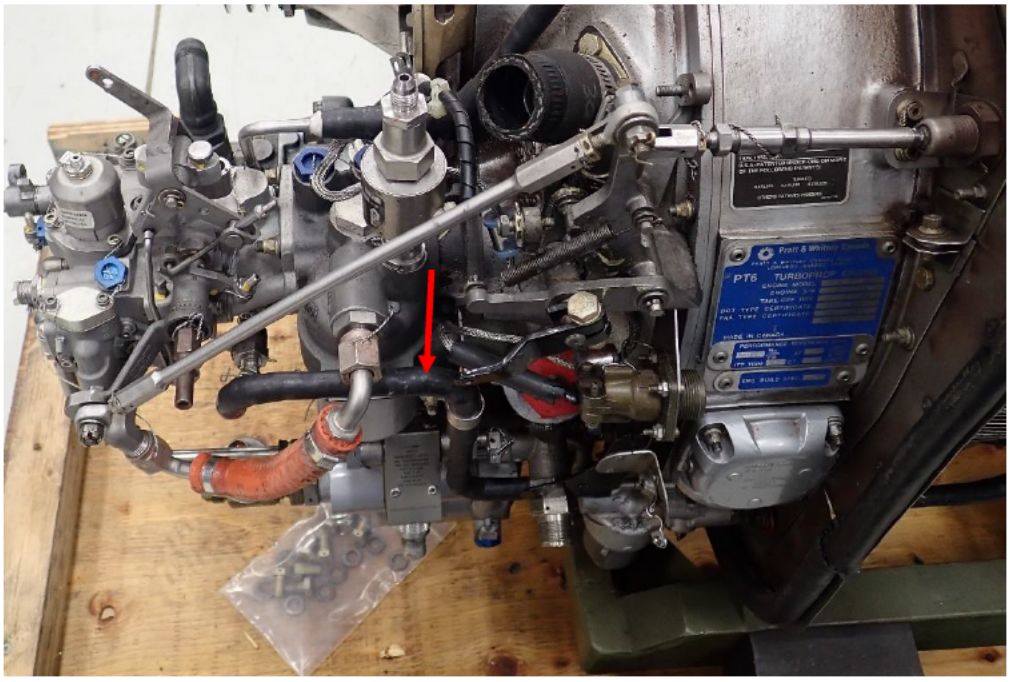


Photo No. 11

3.1.3 Pneumatic Lines

Compressor Discharge Air (P3) and P3 Filter: The front of the P3 line was secured to the gas generator case (Ref. Photo No. 12, red arrow). The rear coupling nut was lockwired to the adjacent bolt (Ref. Photo No. 12, red oval). The lockwire was removed and the coupling nut was loosely fitted (not torqued) with its respective mating tube to boss nipple. The exterior surface of the nut exhibited fretting wear from contact with the twists of the lockwire (Ref. Photo No. 13, red arrow). The nipple exhibited some polishing/fretting from contact with the mating surface of the tube (Ref. Photo No. 14, red arrow). The fittings on the rear section of the line between the compressor air filter housing and the fuel control were lockwired and secured/torqued to their respective tube to boss nipple/elbow (Ref. Photo No. 11, red arrow & 15). Both tube to boss nipples were tight in the filter housing. The P3 filter was removed from the compressor air filter housing. No visible contamination was observed in the filter (Ref. Photo No. 16).

The compressor air filter housing, tube to boss nipples, front, and rear section of the tubes were forwarded to P&WC's Material Laboratory to characterize the wear patterns on the conical surface of the tubes and nipples (Ref. Figure 1).

A view of the threads on nipple (3024606) shows a clean area indicating contact with the mating B nut (Ref. Photo No. 17). The remaining threads were filled with a blackish residue indicating these threads were not in the B nut (Ref. Photo No. 17).

Evidence of a slight change in the surface texture of the conical sealing surface at the tip of nipple 3024606 was consistent with rubbing, this is indicative of contact with the mating part (Ref. Photo No. 18a, double headed red arrow). The conical surface is 0.093" and the contact area is estimated to at approximately 0.048" (Ref. Photo No. 18a). The contact area on the conical surface for nipple MS9193-04 appears slightly more pronounced and the length of the contact is approximately 0.044" (Ref. Photo No. 18b, double ended red arrow).

The loaded flank of the threads of the nipple 3024606 shows radial chatter marks from the threads machining process (Ref. Photo No. 19a, yellow rectangles). Light superimposed circumferential marks/scratches from contacting with the mating threads (Ref. Photo No. 19a, red arrows) were observed. The loaded flank of the threads of nipple MS9193-04 did not display any evidence of chatter marks from the machining process but faint circumferential lines from the assembly with the mating (Ref. Photo No. 19b).

The threads on the non-loaded flank of nipple 3024606 show very little evidence of rubbing damage and no along the crest of the threads (Ref. Photo No. 20a). Radial orientated chatter marks from the machining process are visible (Ref. Photo No. 20a). The threads on the non-loaded flank of nipple MS9193-04 show no evidence of chatter marks from the machining process (Ref. Photo No. 20b). Faint circumferential lines from assembly with the mating nut as well as some damage to the last threads are visible (Ref. Photo No. 20b, red arrows). This type of damage was not observed on the other examined nipple and may have occurred as a result of torquing when the threads are fully engaged.

A tilted view of the conical sealing surface of the flared tube coupling of tube 3019295 mating with nipple 3024606 of the air filter housing exhibits very little evidence of contact along the surface (Ref. Photo No. 21a). A tilted view of the conical sealing surface of the flared tube coupling of tube 3027791 mating with nipple MS9193-04 shows a change of coloration and residues (Ref. Photo No. 21b, black arrows) suggesting the contact area between the two mating components (Ref. Photo No. 21b, double headed red arrow).

A view of one of the lockwire channels shows evidence of material displacement on one side of the wrenching flat (Ref. Photo No. 22, black arrow). Material displacement was evident on the lockwire channel/wrenching flat on the opposite side of the nut as well. The other two nuts on tube 3027791 exhibited damage to both lockwire channels also suggesting thse B nuts had been installed on more than once as well.

A view of the indentation as a result of fretting wear on the lateral surface of the nut corresponds to the location of the lockwire in operation (Ref. Photo No. 23, red oval). Fretting occurs under small amplitude displacements between contacting surfaces. The location of the fretting wear indentations suggests a movement of the coupling (B nut) in the counter-clockwise direction (Ref. Photo No. 23, curved orange arrow). This indicates the nut may have not been properly torqued became loose during operation.

Power Turbine Control (Py): The PY line was lockwired at all the connections and all the fittings were torqued (Ref. Photos No. 24 & 25).

Photo No. 12

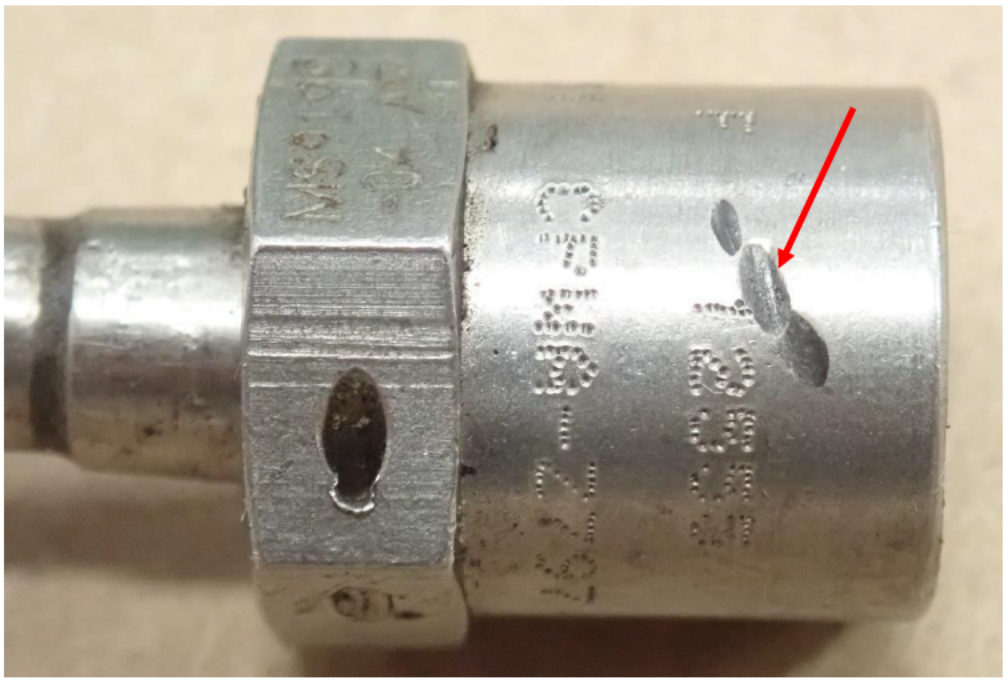


Photo No. 13

Photo No. 14

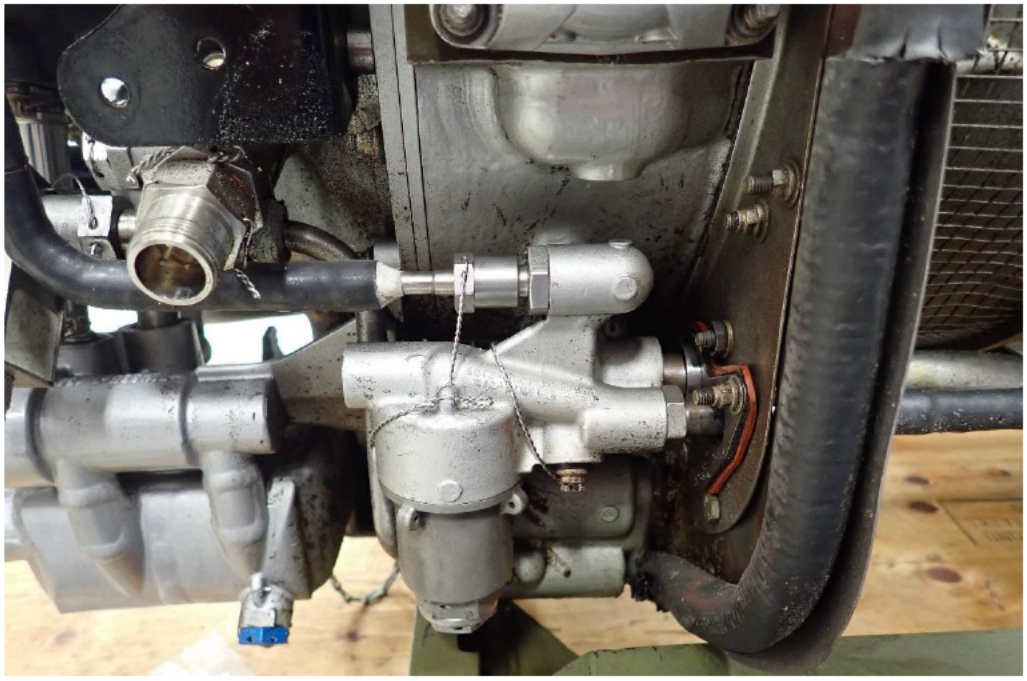


Photo No. 15

Photo No. 16

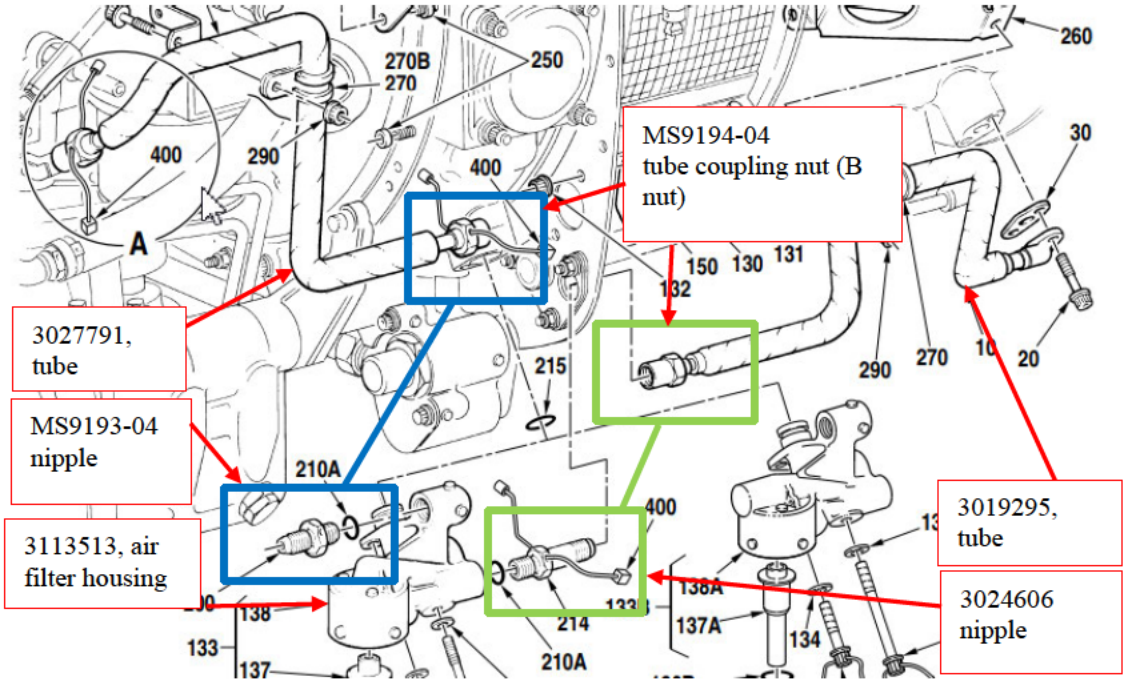


Figure 1

Photo No. 17, nipple 3024606

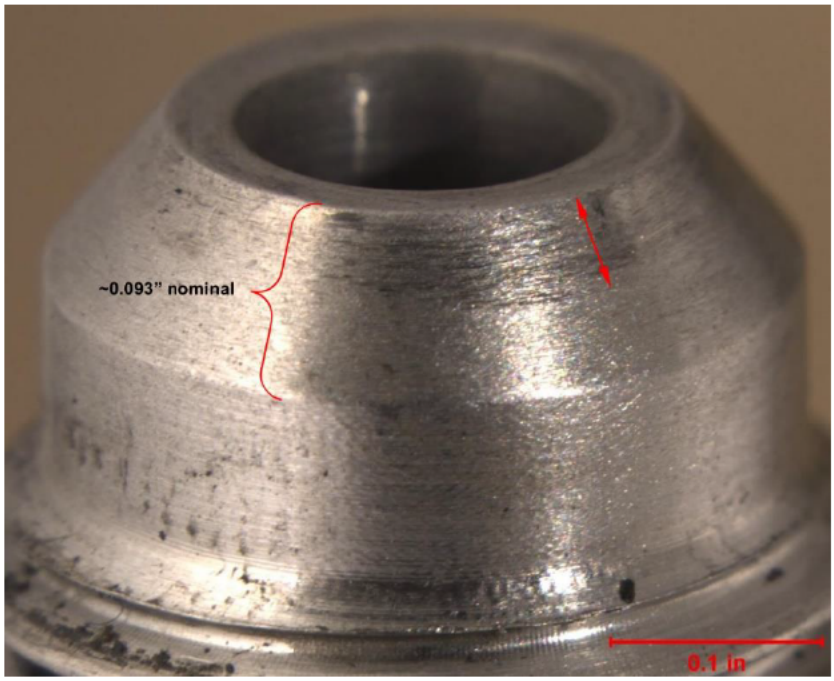


Photo No. 18a, nipple 3024606

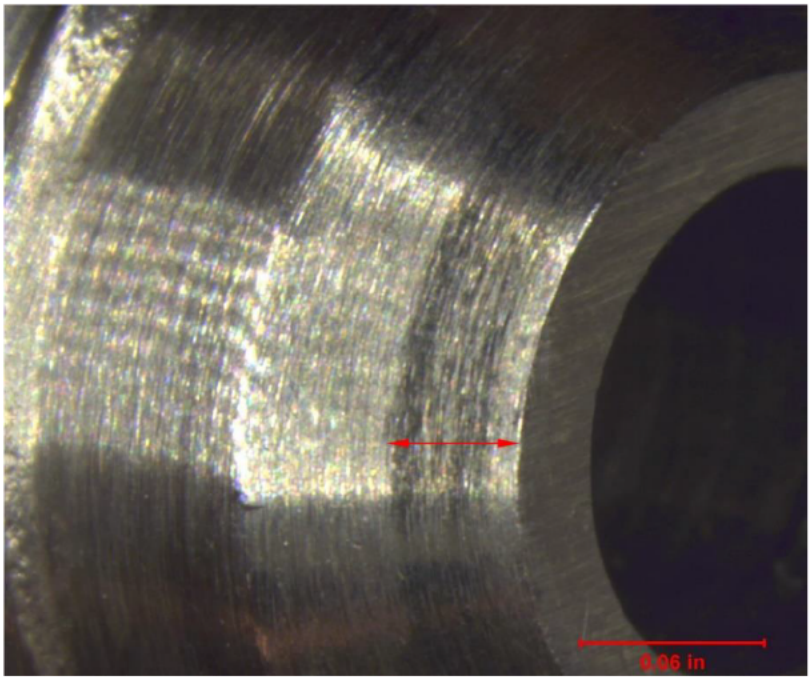


Photo No. 18b, nipple MS9193-04

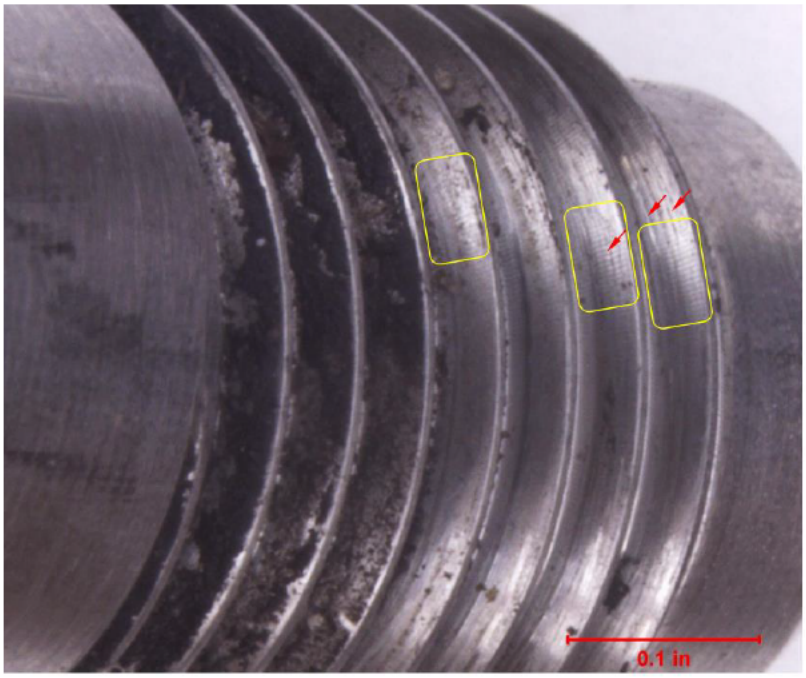


Photo No.19a, nipple 3024606

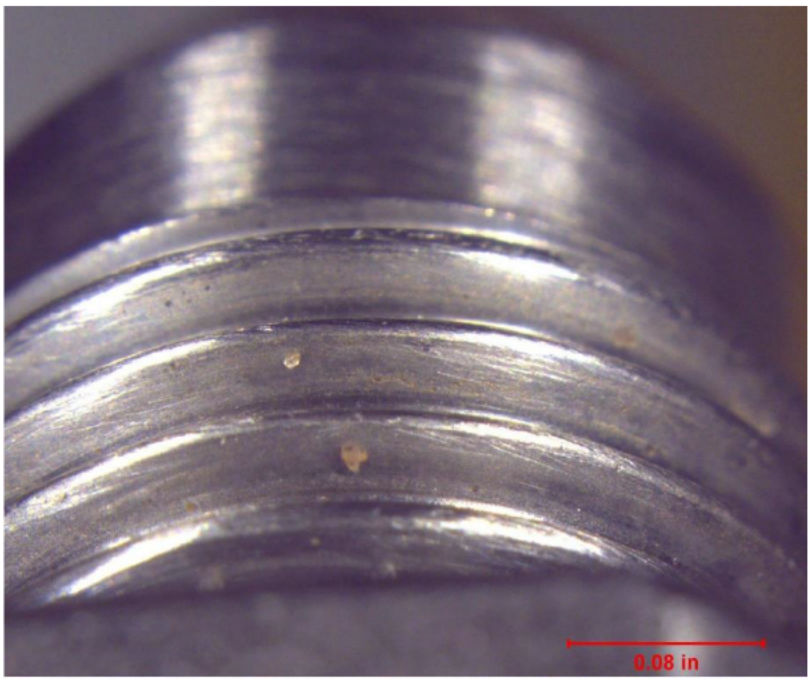


Photo No. 19b, nipple MS9193-04

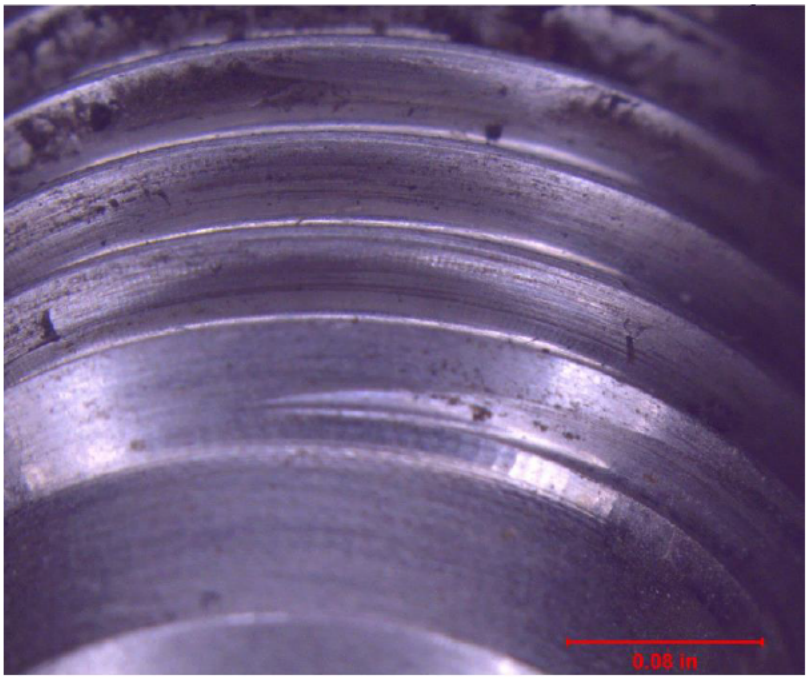


Photo No. 20a, nipple 3024606

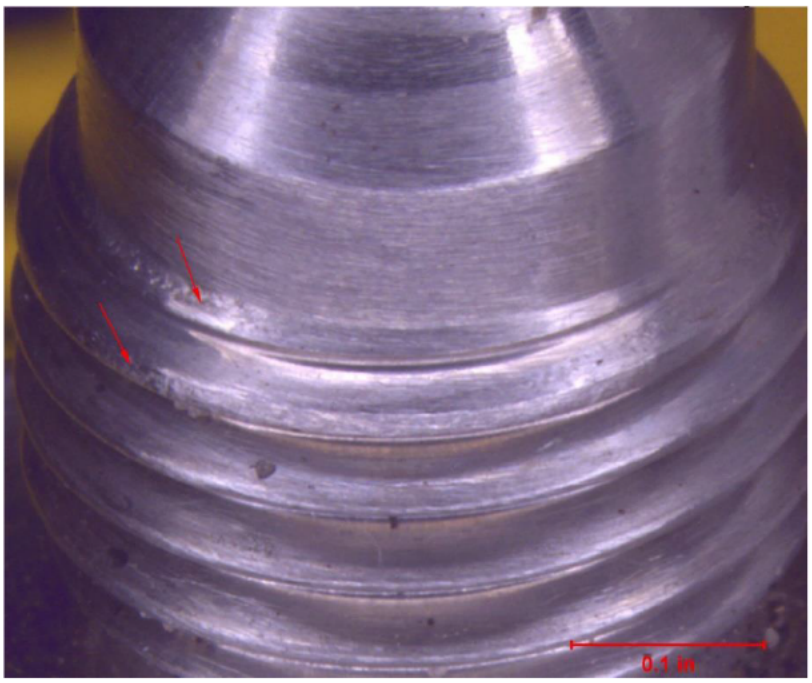


Photo No. 20b, nipple MS9193-04

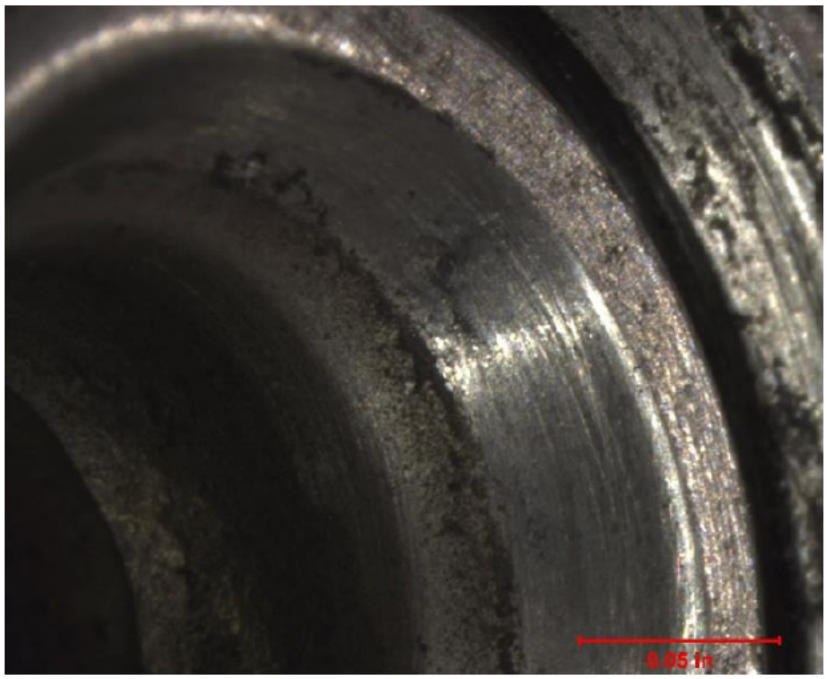


Photo No. 21a, tube 3019295

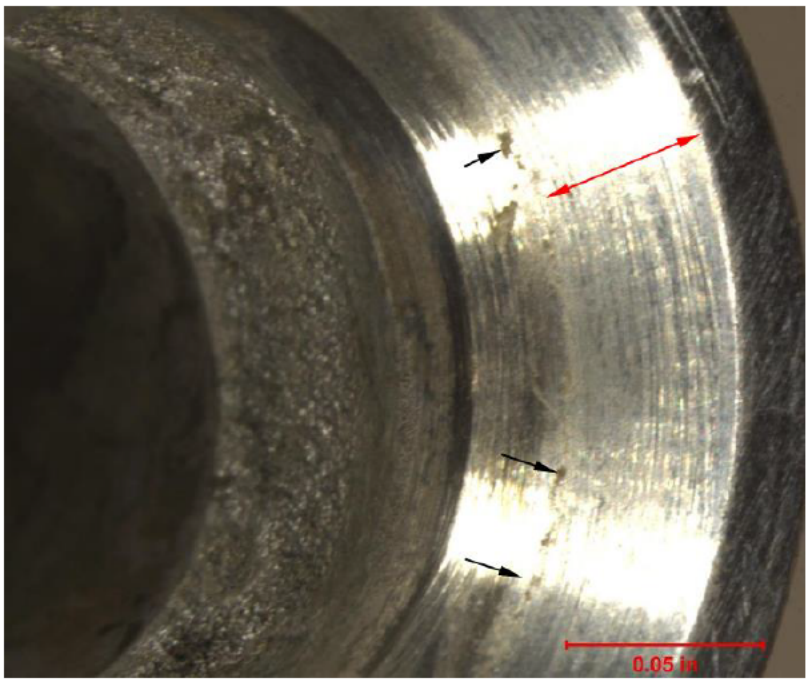


Photo No. 21b, tube 3027791

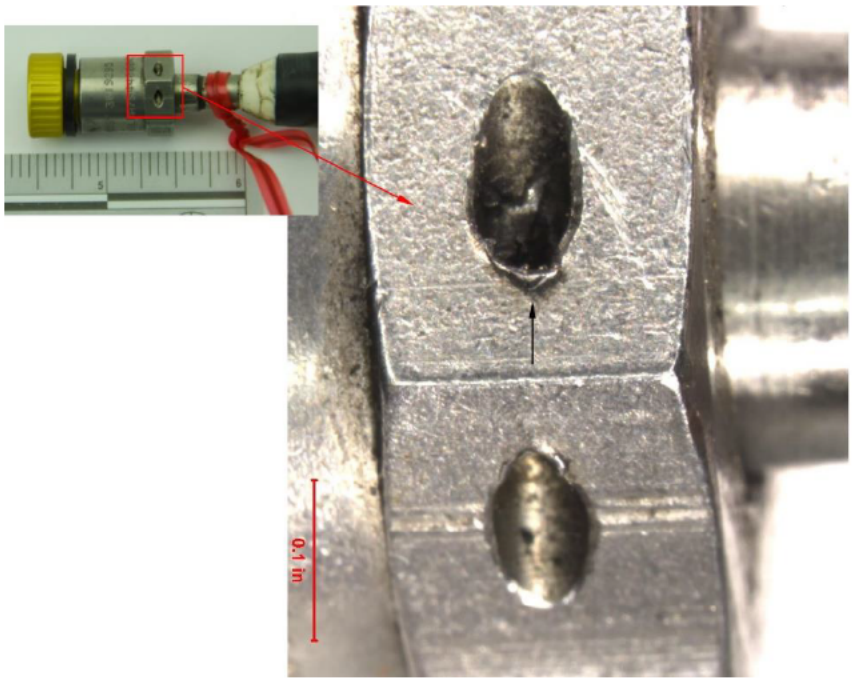


Photo No. 22

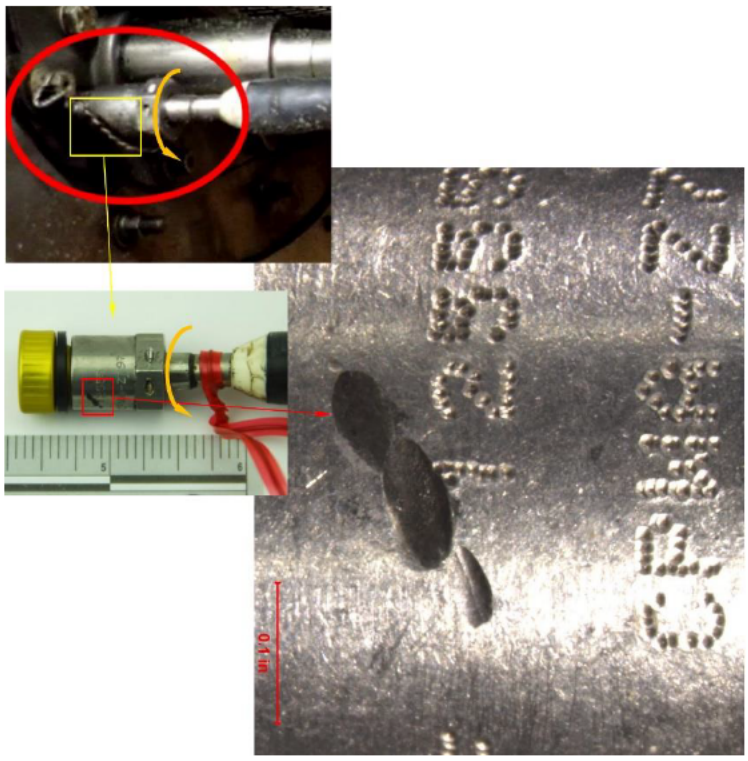


Photo No. 23

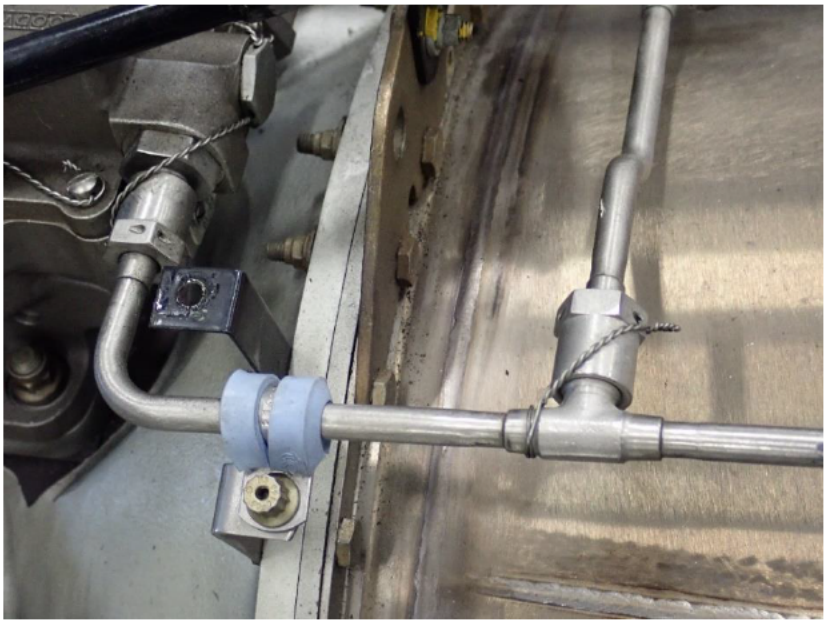


Photo No. 24

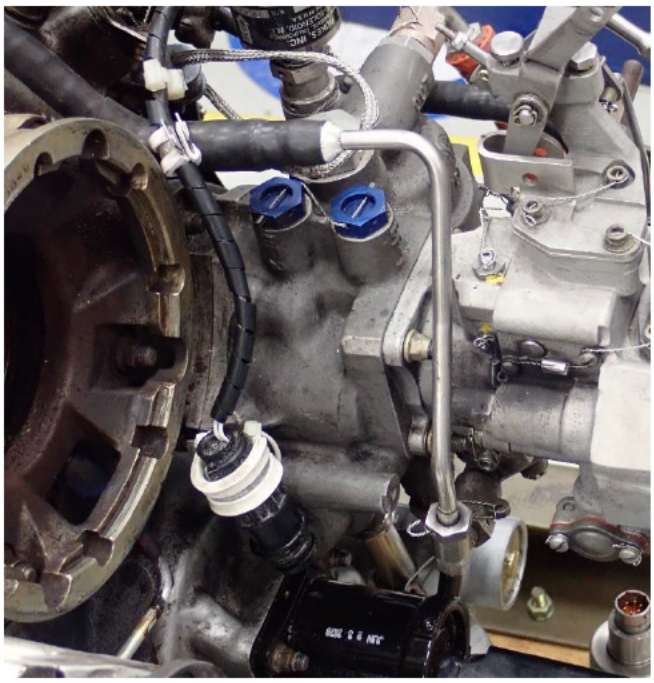


Photo No. 25

3.1.4 Chip Detectors and Filters

Chip Detectors: Some dark colored particulates build up was evident on the magnetic poles of the accessory gearbox and reduction gearbox chip detectors (Ref. Photo No. 26). The particulates was consistent with carbon.

Oil Filter: No visible contamination was observed in the filter (Ref. Photo No. 27).

Fuel Filter: No visible contamination was observed in the filter (Ref. Photo No. 28).

Photo No. 26, view of the accessory gearbox chip detector

Photo No. 27

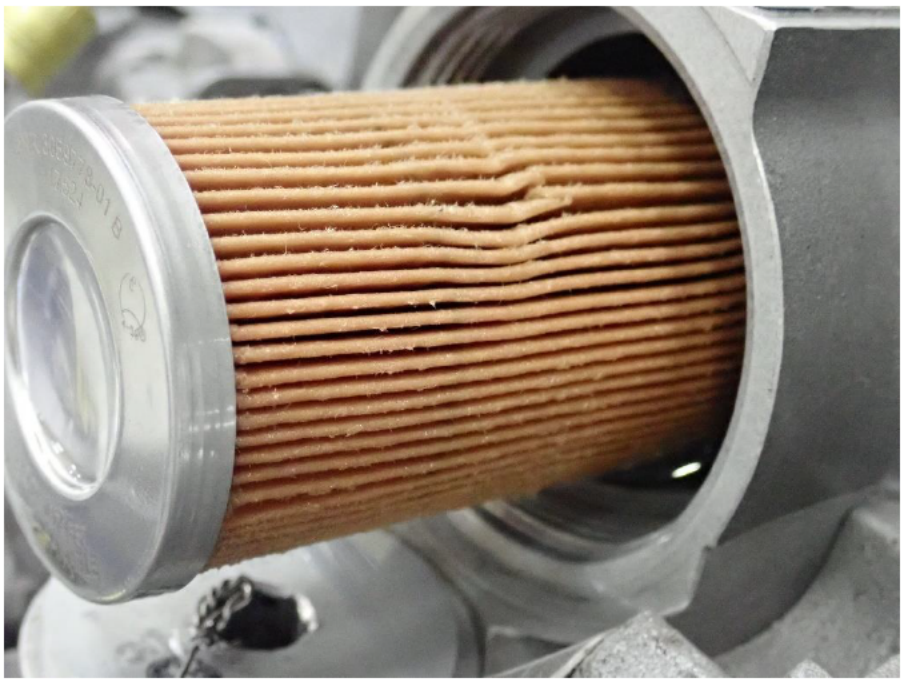


Photo No. 28

3.2 Disassembly Observations

The propeller shaft was manually rotated, and it turned freely. The gas generator case was not capable of manual rotation. The accessory gearbox was removed/ separated from the fractured inlet case (oil tank region), and the geartrain rotated freely. With the accessory gearbox and part of the inlet case removed, the front portion of the inlet case was still in place supporting the 1st stage compressor stator. The compressor was capable of manual rotation.

3.2.1 Compressor Turbine (CT) Section

The downstream side of the compressor turbine was unremarkable (Ref. Photo No. 29). The upstream side exhibited circumferential wear on the blades and rivets from contact with the bleed valve baffle (Ref. Photos No. 30 & 31). The blade tips exhibited some operational type of wear (Ref. Photo No. 32).

The bleed valve baffle was worn from contact with the compressor turbine (Ref. Photo No. 33 & 34, red arrows). The downstream side of the compressor turbine vane exhibited some soot/carbon on the surface (Ref. Photo No. 33). The shroud segments exhibited operational type wear (Ref. Photo No. 35).

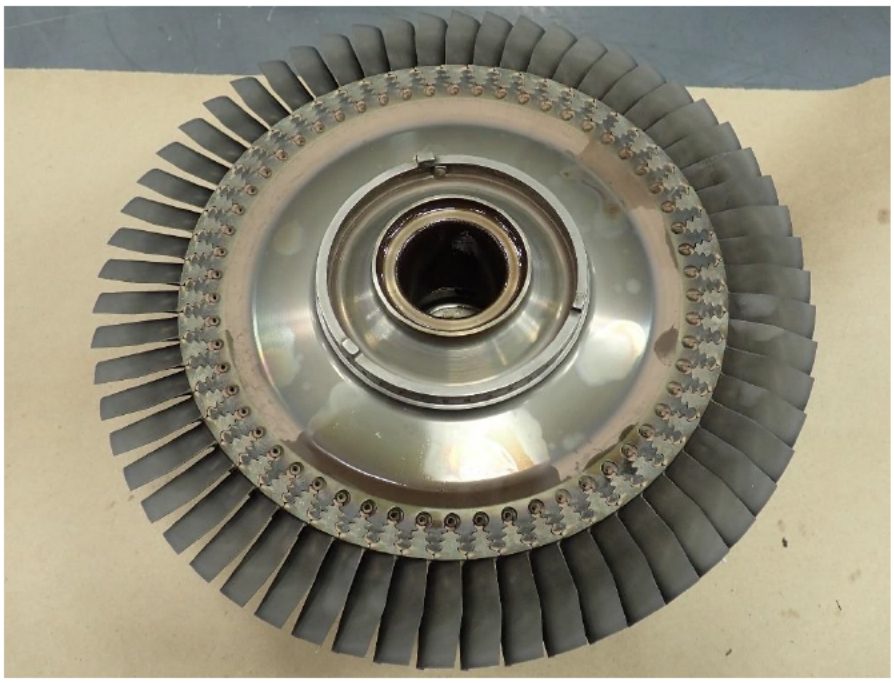


Photo No. 29, view of the downstream side

Photo No. 30, view of the upstream side

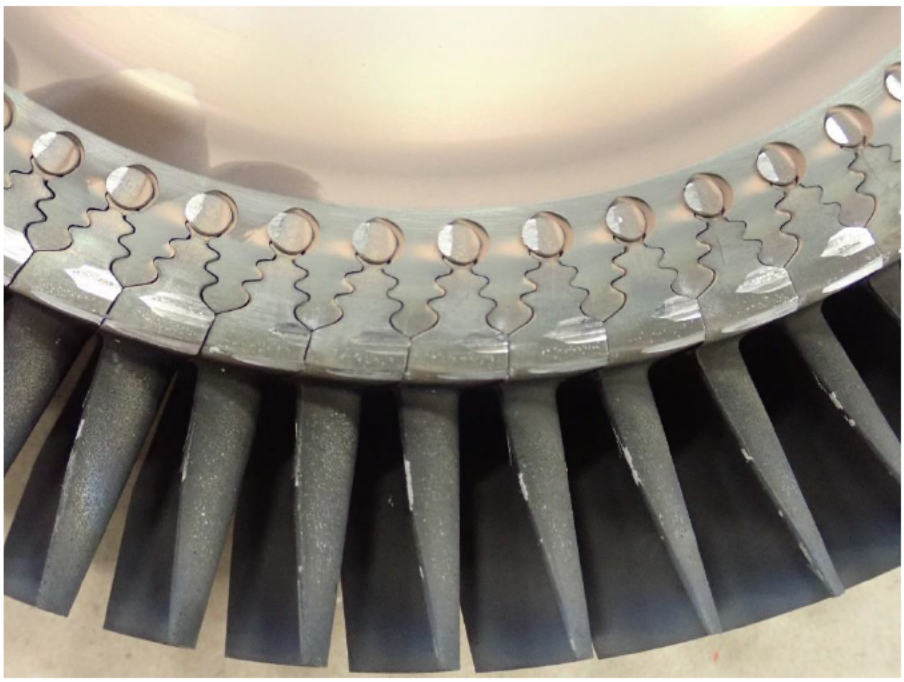


Photo No. 31, view of the upstream side

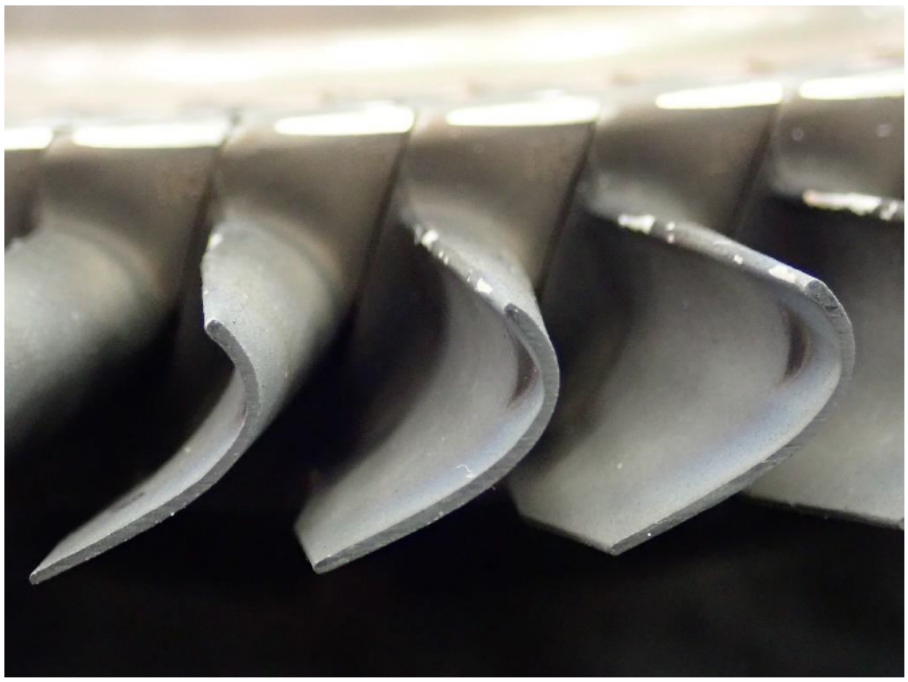


Photo No. 32

Photo No. 33, view of the downstream side

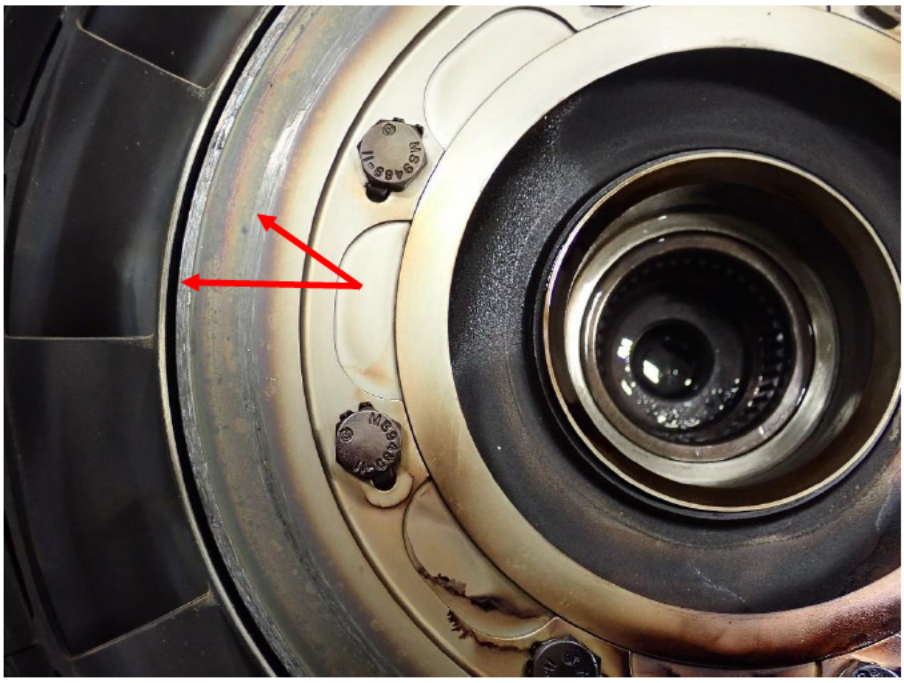


Photo No. 34

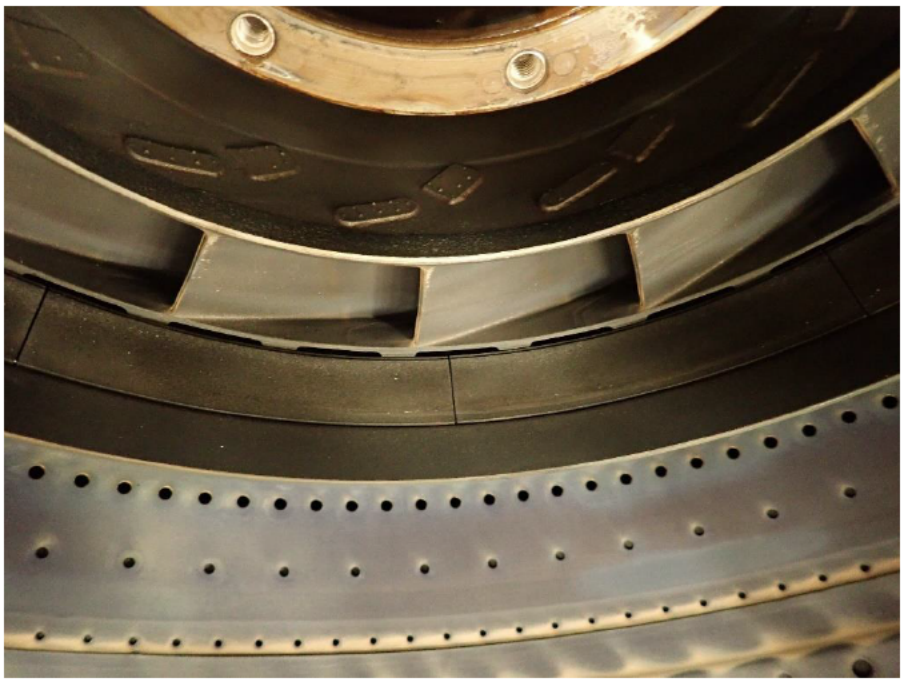


Photo No. 35

3.2.2 Combustion Section

The visible area of the inner combustion chamber liner was unremarkable (Ref. Photo No. 36). The combustion chamber liners and the small exit duct were not removed for the purpose of this investigation.

Photo No. 36

3.2.3 Power Turbine (PT) Section

The inter turbine temperature (ITT) probes, busbar, and harness, were in place and secured, no damage was evident (Ref. Photo No. 37).

The visible portion of the 1st stage power turbine vane ring was unremarkable. The 1st stage power turbine blades were viewed through the vane airfoils and the 2nd stage power turbine blades were viewed through the exhaust duct ports, no visible damage was evident. The power turbines and vanes were not removed for the purpose of this investigation.

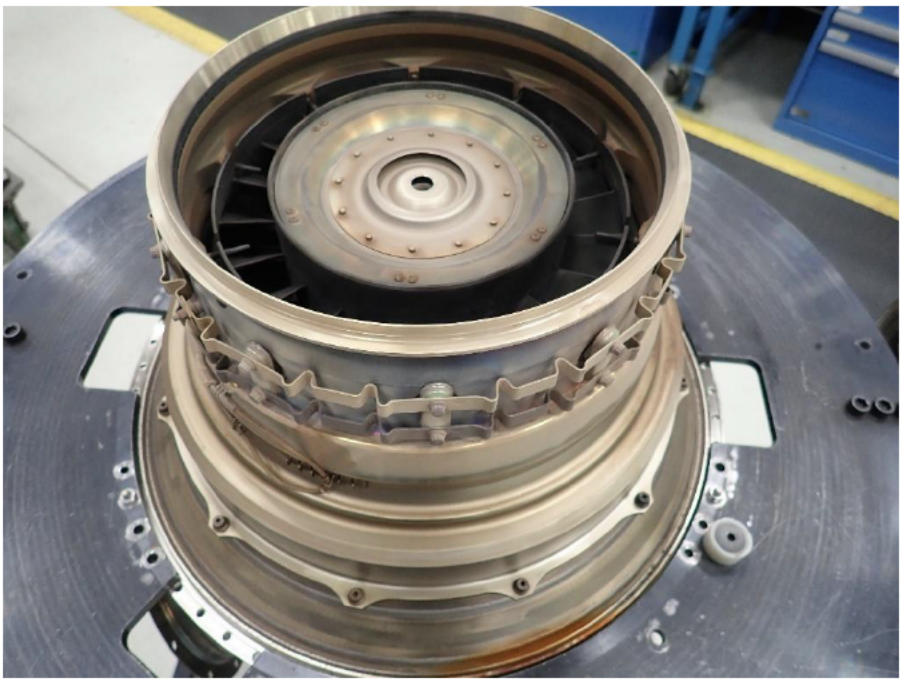


Photo No. 37

3.2.4 Compressor Section

The No. 1 & 2 bearings were in place and rotated freely (Ref. Photos No. 38 & 40). The No. 1 bearing rotor airseal and compressor rotor air seal were rubbed from contact with their respective stator airseals (Ref. Photos No. 39 & 40).

The 1st stage compressor blades had rubbed with their respective shroud (Ref. Photo No. 41). The blade tips exhibited rolled over material (Ref. Photo No. 42). The 1st stage compressor vane airfoils exhibit rolled over material on the tips from contact with the adjacent spacer. The centrifugal impeller airfoils were rubbed with rolled over material from contact with the impeller shroud (Ref. Photo No. 43). The compressor was not disassembled for the purpose of this investigation.

Photo No. 38, view of the No. 1 bearing

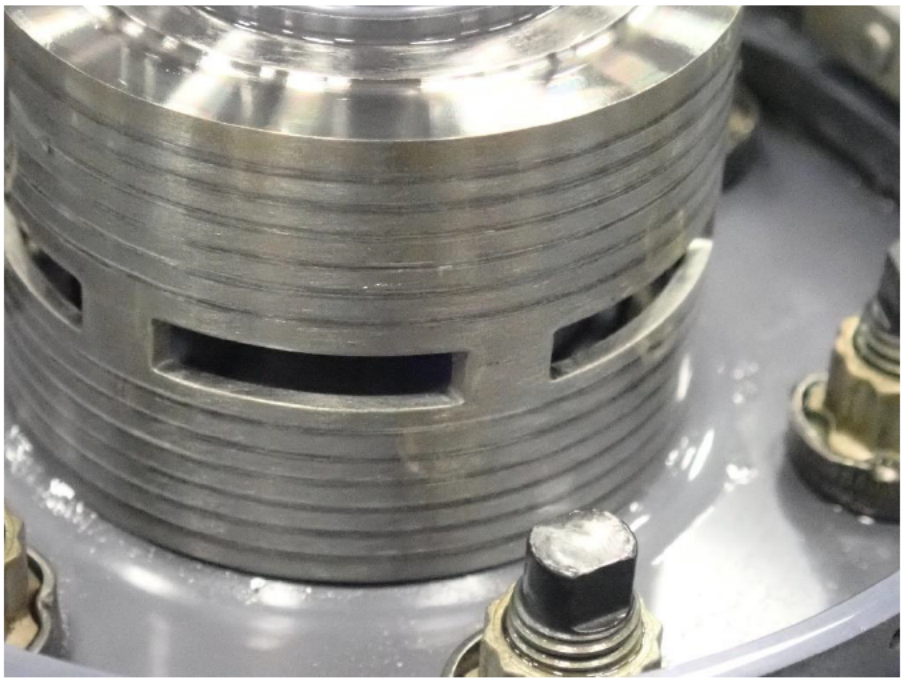


Photo No. 39, view of the No. 1 bearing rotor airseal

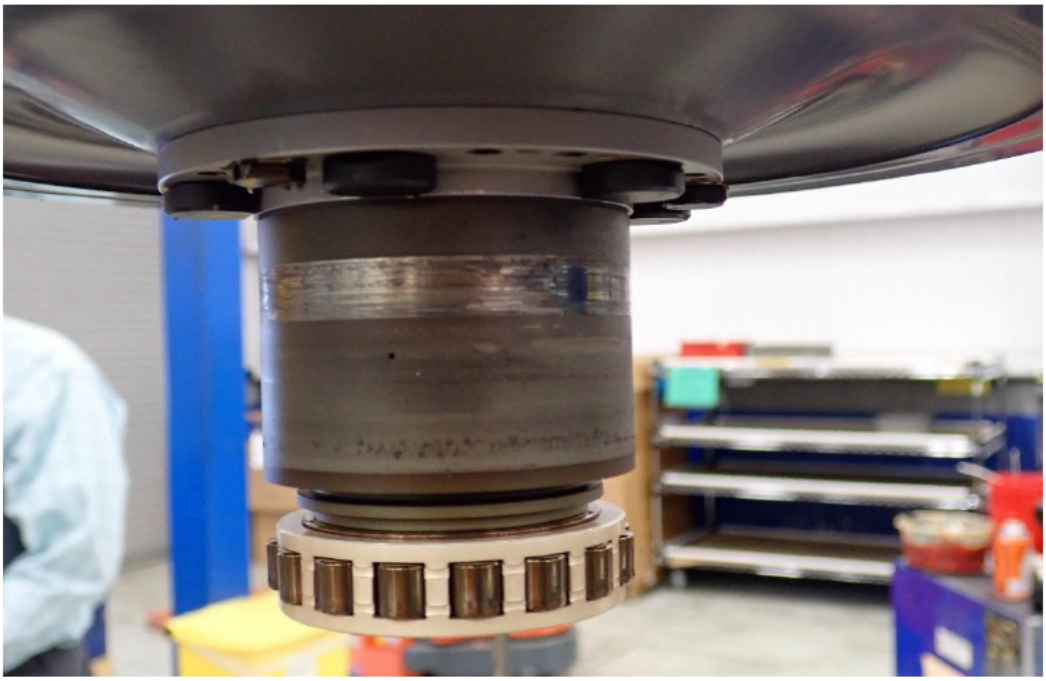


Photo No. 40, view of the compressor rotor airseal and No. 2 bearing

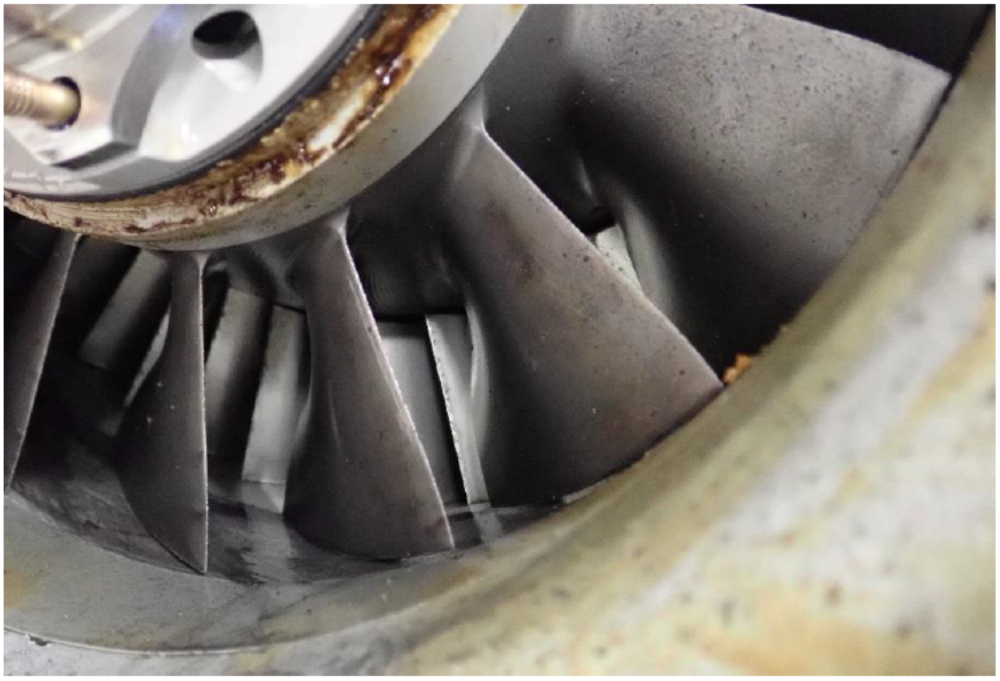


Photo No. 41

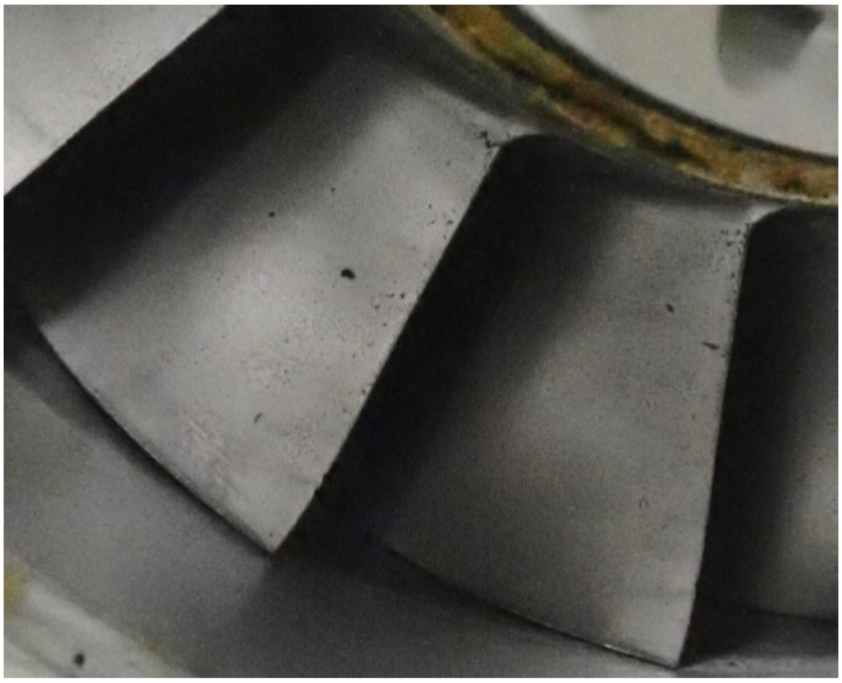


Photo No. 42

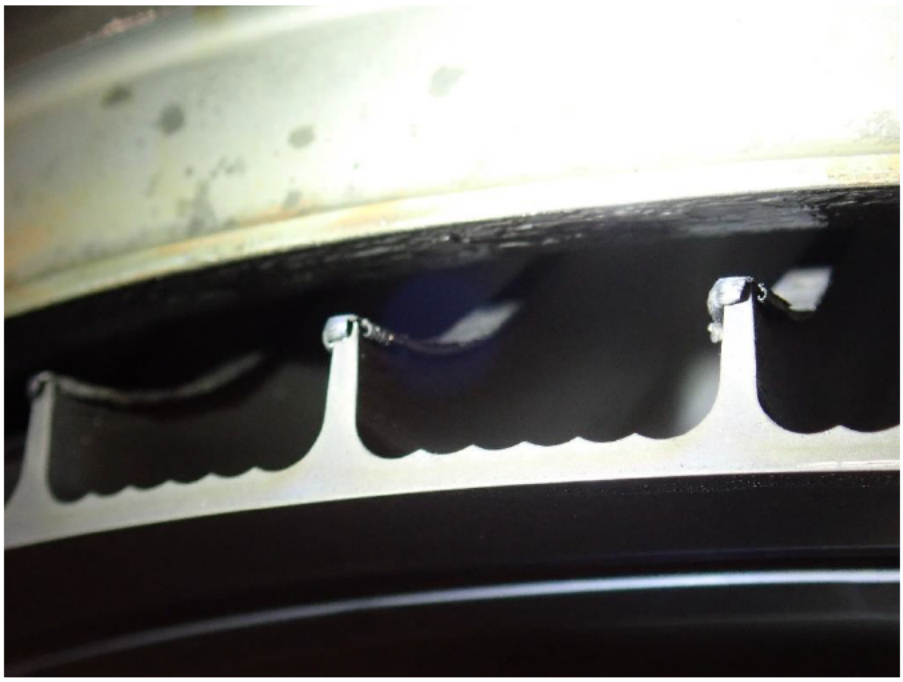


Photo No. 43

3.2.5 Reduction Gearbox (RGB)

The RGB was not disassembled for the purpose of this investigation.

3.2.6 Accessory Gearbox (AGB)

The AGB was not disassembled for the purpose of this investigation. The inlet case struts were fractured which separated the case into two sections (Ref. Photos No. 44 & 45).

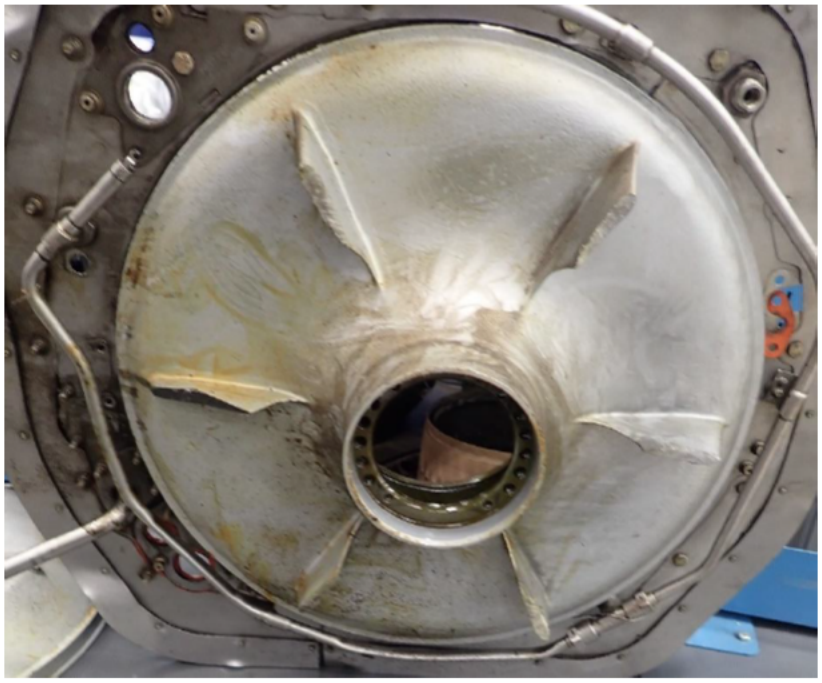


Photo No. 44

Photo No. 45

3.3 Controls and Accessories

3.3.1 Ignition System

Ignition Plugs: The igniter plugs were in place in their respective bosses on the gas generator case.

Ignition Leads: The leads were not received with the engine.

Ignition Exciter: The exciter was not received with the engine.

3.3.2 Fuel System

Fuel Oil Heat Exchanger (FOHE): One of the mounting flange bolt holes of the fuel to oil heat exchanger was fractured (Ref. Photos No. 46 & 47). The exchanger was forwarded to P&WC's Accessories Investigations for functional testing and investigation. All the bores, except for the fuel inlet were scored (Ref. Photos No. 48a to 48e). Slivers were present in the oil outlet, oil inlet, and the fuel outlet ports (Ref. Photos No. 48b, 48c, & 48e). The thermal element was functional tested in accordance with the manufacture's component maintenance manual (CMM) preassembly check method. The thermal element travel met the manual requirements.

The FOHE was forwarded to the manufacturer for additional functional testing and investigation. The unit passed the oil bypass valve function tests. The slivers of debris that were collected were forwarded to the manufacturer for analysis. The thermal element was removed, and slivers were present on the bypass valve sleeve (Ref. Photo No. 49). The outside diameter of the oil bypass valve exhibited scuff marks (Ref. Photo No. 50). A Borescope inspection revealed that slivers of debris were present further down in the oil out port and in the FOHE core, when viewed from the drain port (Ref. Photos No. 51 & 52).

The debris collected in the ports and on the oil bypass valve sleeve were analyzed using energy Dispersive X-ray Spectroscopy (EDS). The debris analysis suggests mainly three different materials: aluminum alloy, stainless steel, and a particle containing magnesium. The aluminum and stainless-steel debris in the ports were consistent with distress in the exchanger housing from contact with the stainless-steel transfer tubes, most likely during the impact sequence. The stainless-steel particle in the fuel out port had the appearance of a cut section of lockwire and measured 0.015" in diameter, consistent with lockwire used on the engine controls. The source of the magnesium could not be determined as the content did not match the alloy content of the engine components.

Fuel Pump: The fuel pump was in place and secured on its respective mounting pad on the accessory gearbox (Ref. Photo No. 53, red arrow). No visible damage was evident. The fuel pump was forwarded to P&WC's Accessories Investigation for functional testing and investigation. The driveshaft was manually rotated and moved freely. The inlet screen was removed and was found clean. The pump passed the functional test per the manufacture's CMM.

The pump was disassembled. The two drive side bearings and the driven side fixed bearing exhibited scoring marks on the face mating with the gears (Ref. Photos No. 54 & 55). The two drive side bearings showed some localized darkened area with the presence of scoring (Ref. Photos No. 54 & 55). A step groove was present in the fixed driven bearing from contact with the drive gear, as well as a step groove in the drive floating bearing from contact with the drive gear (Ref. Photos No. 54 & 55). The outside diameters of the two pressurized bearings displayed discoloration (Ref. Photo No. 56). The drive gear faces mating with the bearings were scored (Ref. Photos No. 57 & 58). Localized brown-blueish coloration was observed on the drive gear, as well as a circumferential scoring mark on the pressurized bearing side of the gear journal (Ref. Photos No. 58, red arrows & 59).

Fuel Control Unit (FCU): The fuel control was in place and secured on its respective mounting pad on the fuel pump (Ref. Photo No. 53, blue arrow). The fuel control was forwarded to P&WC's Accessories Investigation for functional testing and investigation. The throttle, manual override, and condition levers were all rotating freely by hand on their full range. The driveshaft was rotating by hand with typical resistance. There was no evidence of any blue grease remaining on the drive shaft bearings retaining plate. The power trim was in the stowed position (engine running). All of the lockwire and seals were in place and in good condition. There was yellow anti tamper paint on all adjustments.

Prior to testing the control, the air adapter was examined with a borescope. The Px orifice in the P3 fitting, the P3 port, the Py orifice, the enrichment valve, the Py fitting, and the Py bleed inlet were unremarkable. A substance similar to anti-corrosion compound was observed on the air inlet adapter fitting threads and in the Py port.

The control was installed on the test bench and the air section was pressurized to 100 psia. No leaks were observed by means of Leak-Tec fluid check. The control was set at test point (TP) 2.04 for 10 minutes. The fuel flow output was monitored, and no fluctuation was noted.

The control was tested per the manufacture's CMM and several test points were found to be deviating either above or below the tolerances. Most of the deviations were permissible field adjustments. The MOR lever angular travel test point was 2 degrees below the manual limit.

After the testing, the control adjustments were utilized to recalibrate most of the settings within the manual tolerances. The eccentric screw was adjusted to attempt to return the governing spring test points within limits. However, calibration of these test points could not be achieved. The control was disassembled to understand the why some test points could not be calibrated to the factory settings.

During the control disassembly, the throttle shaft was found bent, corroborating the inability to calibrate the governing spring test points. The bent throttle shaft was most likely secondary to the event.

Flow Divider Valve (FDV): The flow divider was in place and secured on its respective mounting pad on the fuel nozzle (Ref. Photo No. 60). The flow divider was forwarded to P&WC's Accessories Investigation for functional testing. The valve was satisfactorily tested in accordance with the manufacture's CMM.

Fuel Nozzles: The fuel nozzles were in place and secure on their respective pads on the gas generator case (Ref. Photo No. 61).

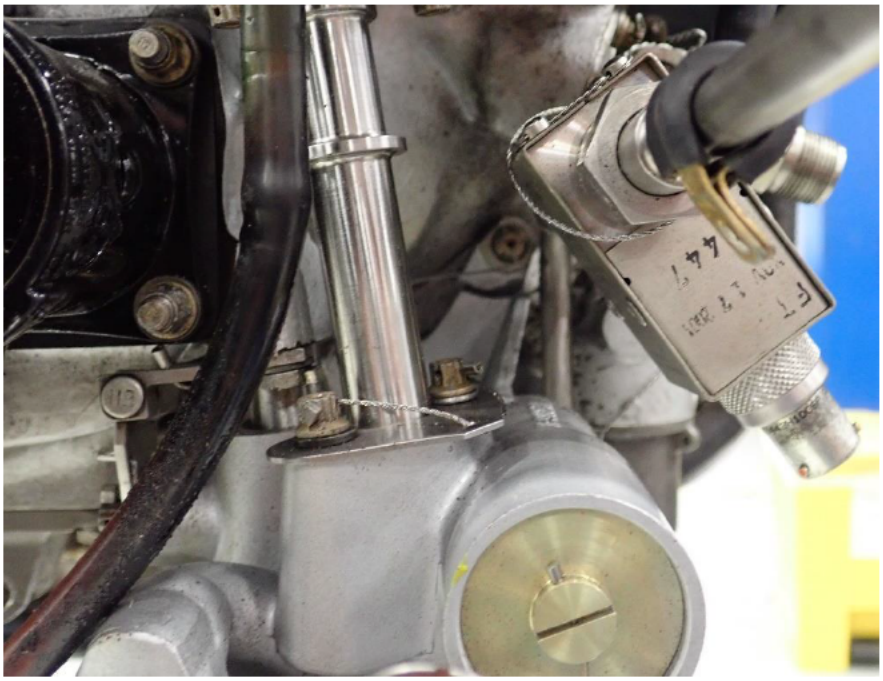


Photo No. 46

Photo No. 47

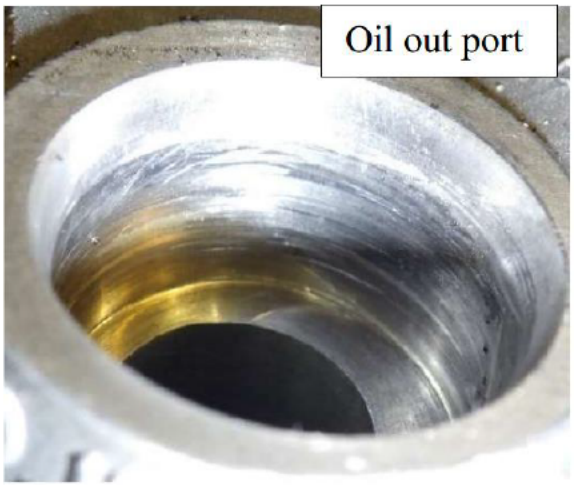


Photo No. 48a

Photo No. 48b

Photo No. 48c

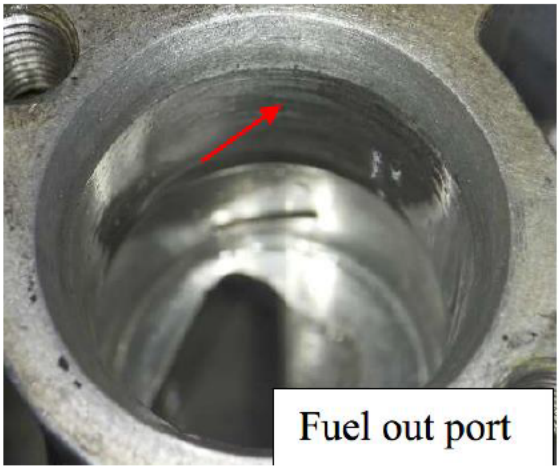


Photo No. 48d

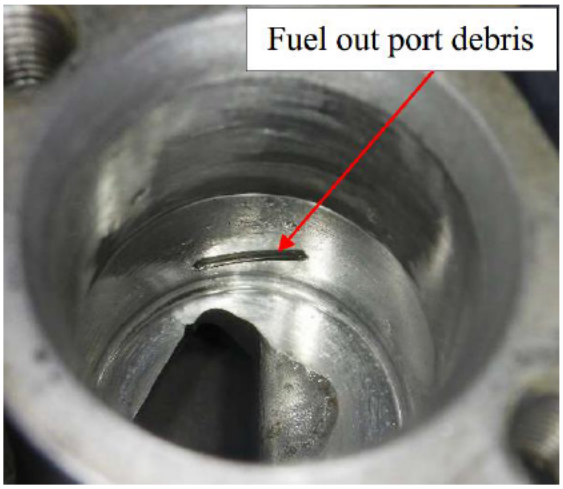


Photo No. 48e

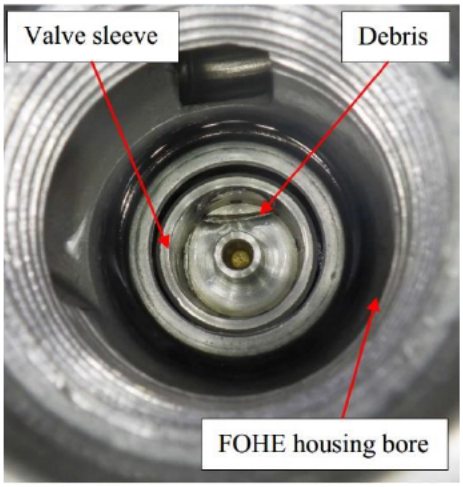


Photo No. 49

Photo No. 50

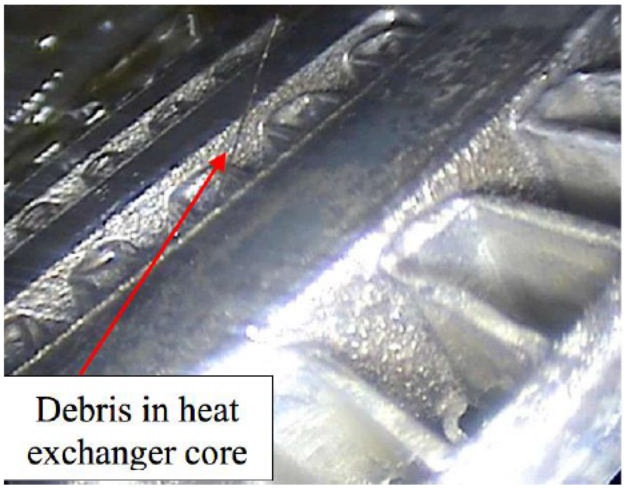


Photo No. 51

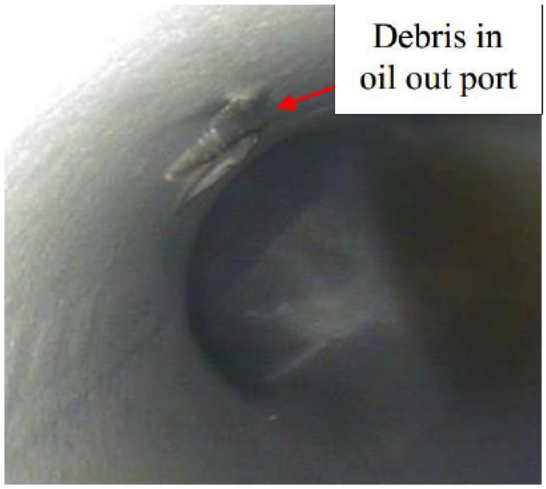


Photo No. 52

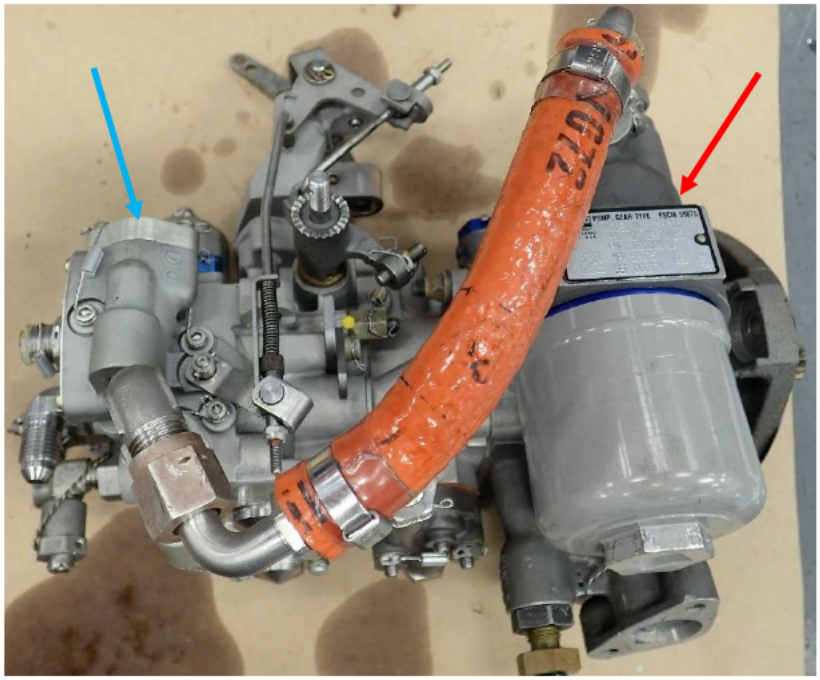


Photo No. 53

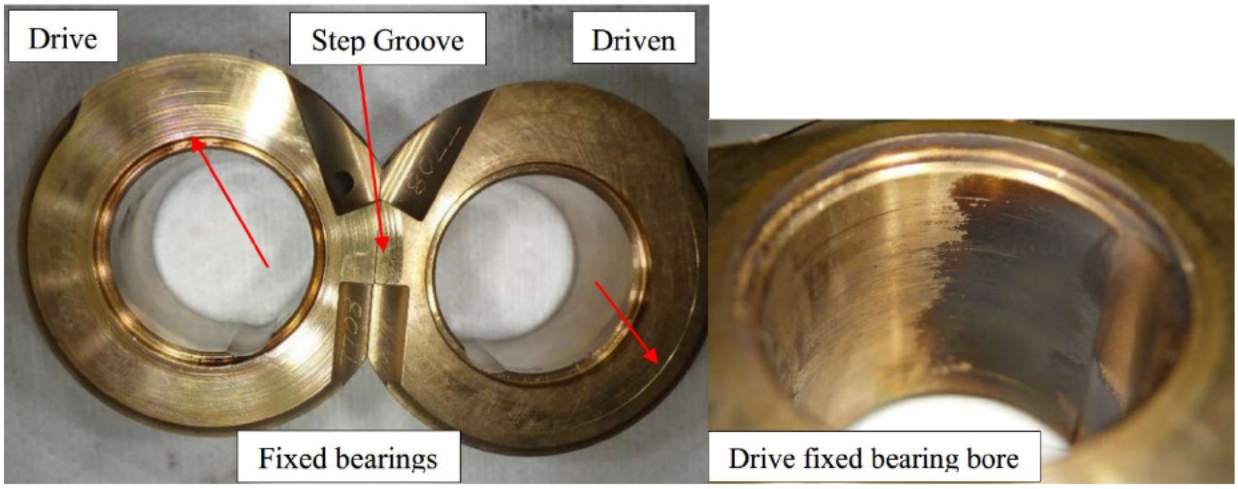


Photo No. 54

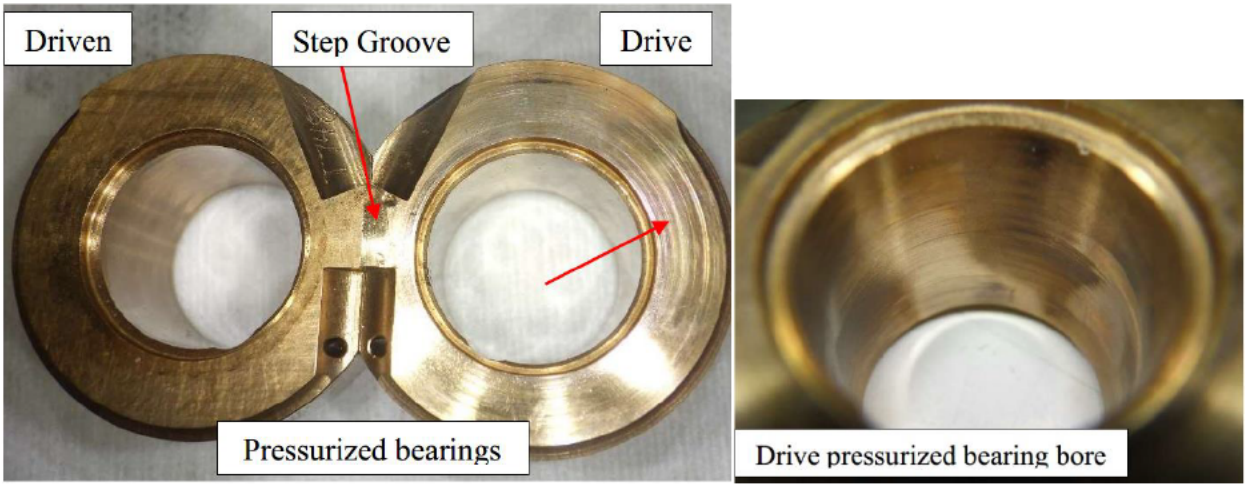


Photo No. 55

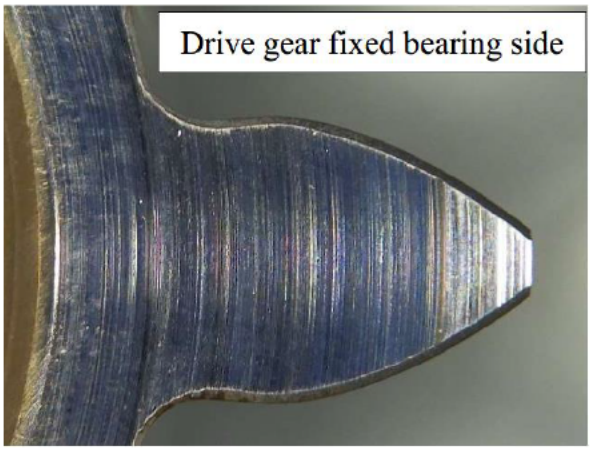


Photo No. 56

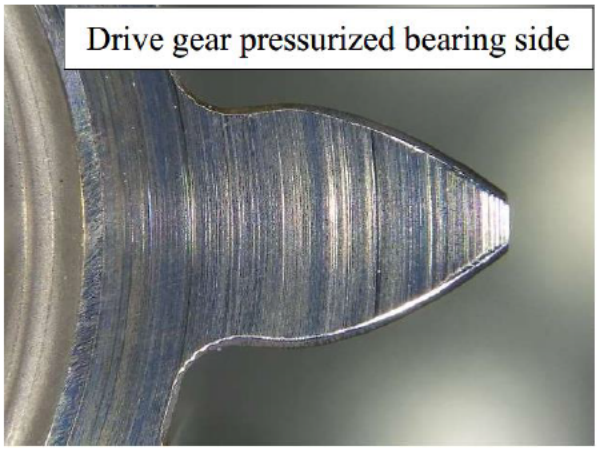


Photo No. 57

Photo No. 58

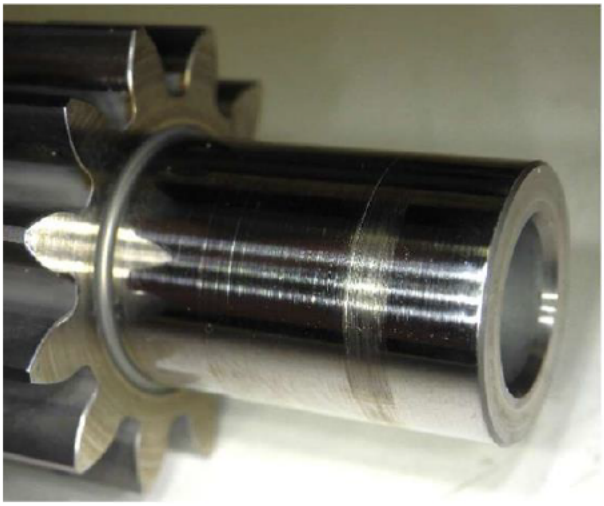
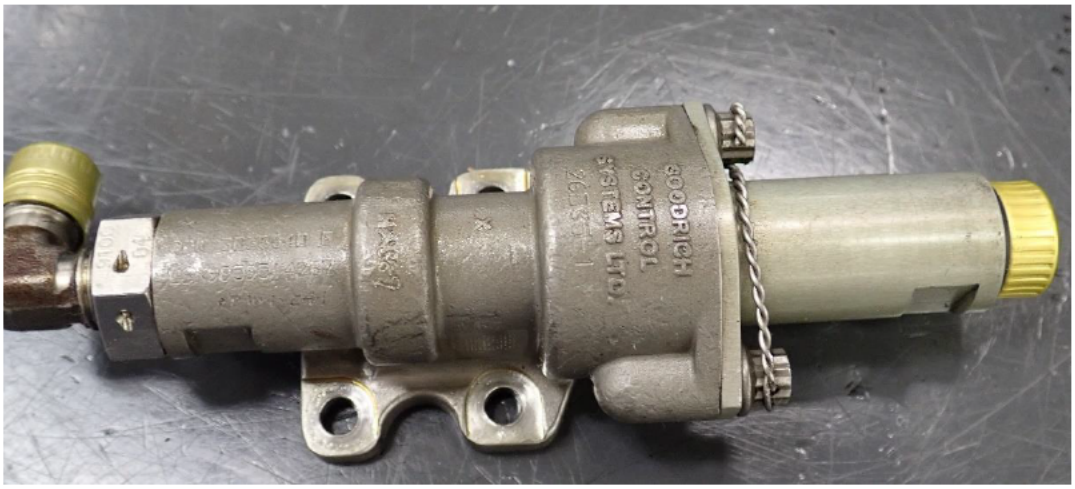


Photo No. 59



Phot No. 60

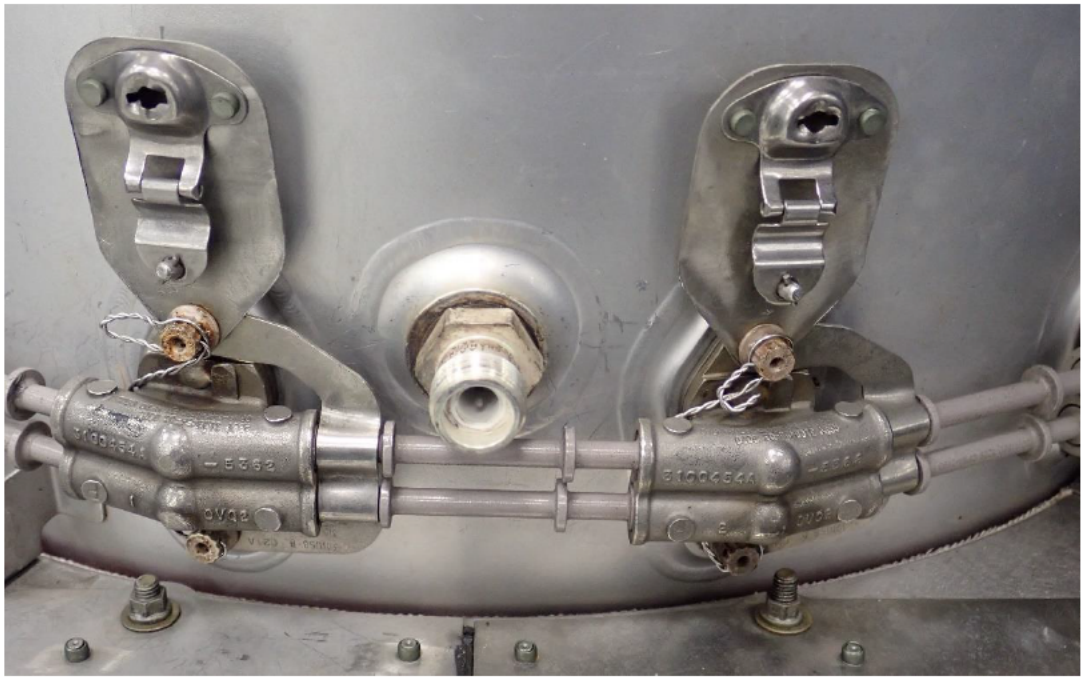


Photo No. 61

3.3.3 Air System

Compressor Bleed Valve (BOV): Both (low-pressure and high-pressure) bleed valves were in place and secured to their respective mounting pads on the gas generator case (Ref. Photos No. 62 & 63). No visible damage was evident. The bleed valves were forwarded to P&WC's Accessories Investigation for functional testing. The calibration pressure check on the low-pressure bleed valve revealed the minimum flow was below the P&WC overhaul manual tolerance. The calibration check on the high-pressure bleed valve revealed that the leakage rate was over the manual tolerance. The leak was determined to be originating from the damper set screws. The bleed valve deviations did not contribute to the event.

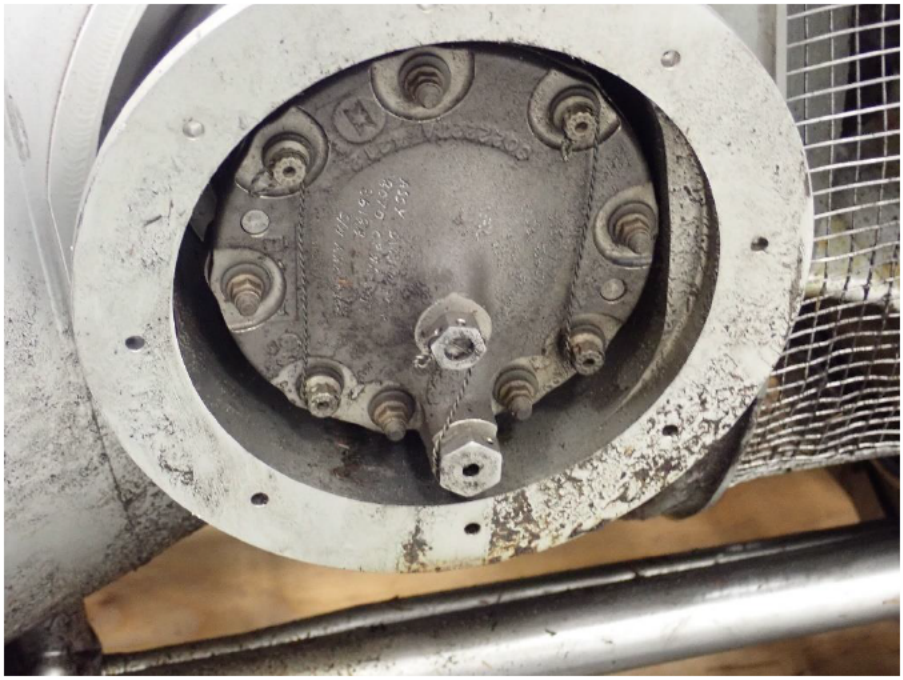


Photo No. 62, view of the low-pressure bleed valve

Photo No. 63, view of the high-pressure bleed valve

3.3.4 Oil System

Propeller Governor (CSU): The propeller governor was in place and secured to its respective mounting pad on the reduction gearbox. No visible damage was evident (Ref. Photo No. 64). The propeller governor was forwarded to P&WC's Accessories Investigation and the manufacturer for functional testing and investigation. The manufacture testing showed some deviations that were related to field adjustments. The unit was re-calibrated within the manufacture's CMM requirements.

Overspeed Governor (OSG): The overspeed governor was in place and secured to its respective mounting pad on the reduction gearbox (Ref. Photo No. 65). The overspeed governor was forwarded to P&WC's Accessories Investigation and the manufacturer for functional testing and investigation. The manufacture testing showed some deviations that were related to field adjustments. The unit was re-calibrated within the manufacture's CMM requirements.

Torque Control Unit (TCU): The torque limiter was in place and secured to its respective mounting pad on the reduction gearbox (Ref. Photo No. 66). The torque limiter was forwarded to P&WC's Accessories Investigation for functional testing. The limiter was satisfactorily tested in accordance with the manufacture's CMM.

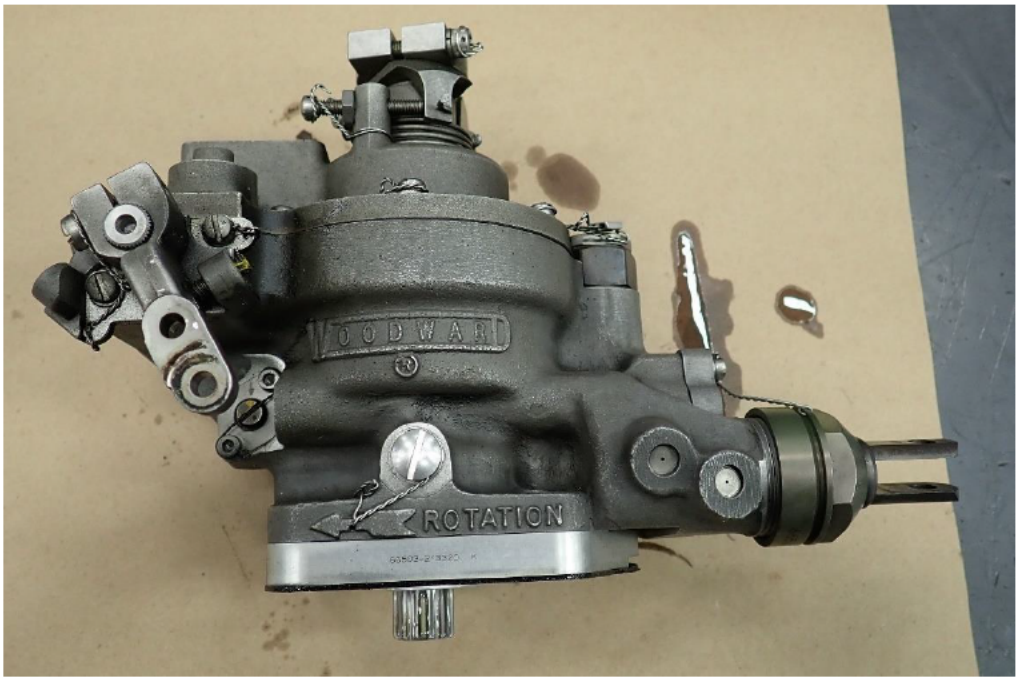


Photo No. 64

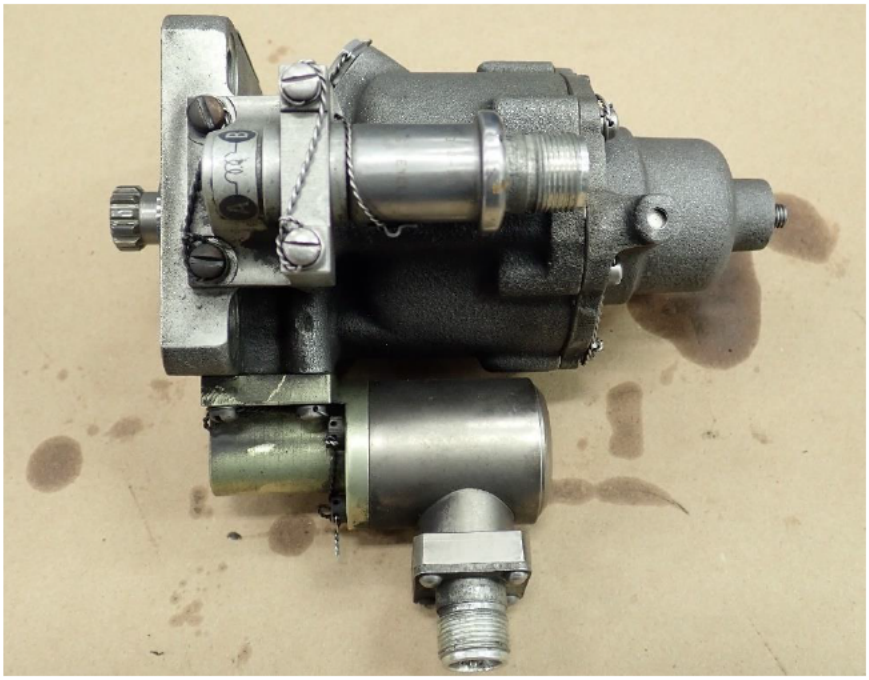


Photo No. 65

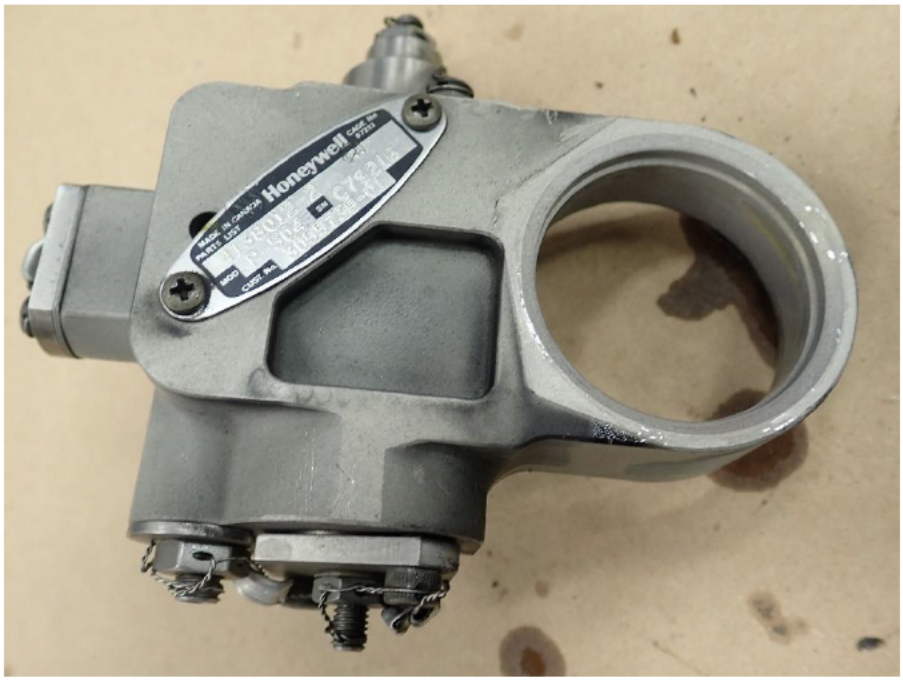


Photo No. 66