

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



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POWERPLANT

Group Chair's Factual Report

March 13, 2026

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A. INCIDENT

Location: Hebron, North Dakota
Date: June 17, 2024
Time: 1000 central daylight time
Airplane: Thrush Aircraft S2R-G10, Registration No. N529KC

B. POWERPLANT INVESTIGATORS

Group Chair	Harald Reichel National Transportation Safety Board Washington DC
Group Member	Jennifer McDuffie Honeywell Aerospace Technologies Phoenix, Arizona
Group Member	Mike Croye TAE Aerospace Scottsdale, Arizona

C. SUMMARY

On June 17, 2024, at about 1000 central daylight time, a Thrush Aircraft S2R-G10 airplane, N529KC, sustained substantial damage when it was involved in an accident near Hebron, North Dakota while performing aerial agricultural chemical applications. The commercial pilot was uninjured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 137 aerial application flight.

The purpose of the low-level flight was to apply liquid chemicals to a rural wheat field. The airplane departed from the Chase Airstrip (6NA5), Hebron, North Dakota. The pilot reported that shortly after completing the aerial application work and with an empty hopper, the engine began surging, with the engine power fluctuating. The pilot decided to return to 6NA5 to land the airplane. While enroute to 6NA5, the engine lost all power. The pilot performed a forced landing on a rural dirt road. During the landing, the airplane departed the road and came to rest upright in a grass ditch. The pilot was able to egress from the airplane without further incident.

The wreckage review determined the engine was in good enough condition to be tested and was subsequently shipped to Honeywell's San Tan remote test facility in Queen Creek, Arizona.

The engine was installed on a propeller test stand and successfully started and run to a partial flight power setting which replicated the reported propeller and power instability that the pilot reported during the incident flight. The propeller governor (PG) was removed from the engine and inspected at Honeywell's computerized tomography (CT) lab which revealed no internal abnormalities. The PG was then sent to Woodward Inc's facility in Loves Park, Illinois, for teardown and examination.

Visual examination of the PG revealed an unusually large offset field adjustment on the maximum and minimum stop settings of the propeller speed lever. It was also found that the speed setting lever had been re-indexed on the speed setting shaft spline from the factory setting by two spline tooth widths, an unapproved field adjustment. Bench testing of the as-received PG showed the speed limit settings were not within factory or operational limits. The PG was adjusted to factory settings and additional bench testing found it to be within operational limits. A subsequent teardown of the PG did not find any internal mechanical faults.

A review of the past engine maintenance work revealed that after a recent hot section inspection (HSI), the post maintenance test cell run showed the propeller RPM¹ was too high. The TAE technician re-indexed the PG speed setting lever to reduce the maximum speed setting. It was noted that Honeywell maintenance manual (MM) guidance prohibits the re-indexing of the speed setting lever on the speed setting shaft in the field.

Further examination of the oil passages and in-line fittings of the engine accessory gearbox was carried out. A small red colored piece of debris was found within the PG reset orifice and check valve,, an in-line flow control component in the PG oil system. The debris appeared to be the same color and consistency as the torque stripe² paint that was applied to other engine line connectors; material analysis confirmed the composition was consistent with the torque stripe paint.

Blockage of the check valve orifice can prevent engine oil from being correctly ported to the NTS system and the PG reset piston and potentially impacting the PG's governing set point.

¹ The propeller rotational speed is measured in revolutions per minute (RPM).

² Torque Stripe is an inspection paint used to visually detect torque movement due to vibratory loosening or tampering of fittings, assemblies, nuts, bolts and studs. When set, the paint is a dry and brittle material that breaks from the relative motion of the parts, providing a fast, convenient visual proof of fastener loosening or tampering.

D. DETAILS OF THE INVESTIGATION

1.0 Engine Information

1.1 Airframe Information

The incident Thrush Aircraft S2R-G10 airplane was powered by a Honeywell TPE331-10-511M turboprop engine and a Hartzell HC-B3MN-5L/LM11693N constant speed, variable pitch three-bladed aluminum propeller. At the time of the accident, the Hobbs meter showed 2,185.0 hours.

1.2 Engine Description

The accident engine was a Honeywell (formerly AlliedSignal, Garrett, and AiResearch) model number TPE331-10-511M turbo-propeller engine, part number (P/N) 3102180-2 with serial number (S/N) P-36258C. The TPE331-10 (Figure 1) is a single-shaft engine with a two-stage centrifugal compressor, an annular combustion chamber, and three-stage axial turbine that drives the compressor (gas generator section) and the reduction/accessory gearbox (AGB). The model number identification is broken down as follows:

TPE means turboprop engine
331 - is the series number assigned by Honeywell
10 - identifies the type certificate model
511- is the rating code
M - identifies this engine was originally installed in a Mitsubishi

According to the Federal Aviation Administration (FAA) Type Certificate Data Sheet (TCDS) E4WE, revision 34, dated May 22, 2014, the TPE331-10 turbo propeller engine, the engine has maximum continuous shaft horsepower power (SHP) of 900; 944 Equivalent Shaft Horsepower (ESHP); and output shaft rotation speed of 1,591 revolutions per minute (RPM). The takeoff (5 minute) limit is as follows: 940 SHP, 984 ESHP, and output shaft rotation speed of 1,591 RPM. The maximum exhaust gas temperature is 1202°F (650°C) for maximum continuous and takeoff.³ Maximum allowable propeller shaft torque as sensed by the torque sensor, in pound-feet (lb.-ft.), is 3,105 for 5-minute torque limit and 2,972 lb.-ft. for maximum continuous.

³ Engine power rating is based on the following: 1) International Standard Atmosphere (ISA), Sea Level Static Conditions; 2) fuel with lower heating value of 18,400 British Thermal Unit (BTU) per pound; 3) No bleed-air extraction; 4) No anti-icing airflow; 5) No external accessory loads; 6) Zero inlet loss; 7) Exhaust gas discharging to ambient-static pressure through the furnished turbine exhaust diffuser; and 8) Turbine gas temperature limits not exceeded. ESHP is for a static condition and is based on the following equation: $ESHP = (\text{Net Thrust (pounds)} / 2.5) + SHP$

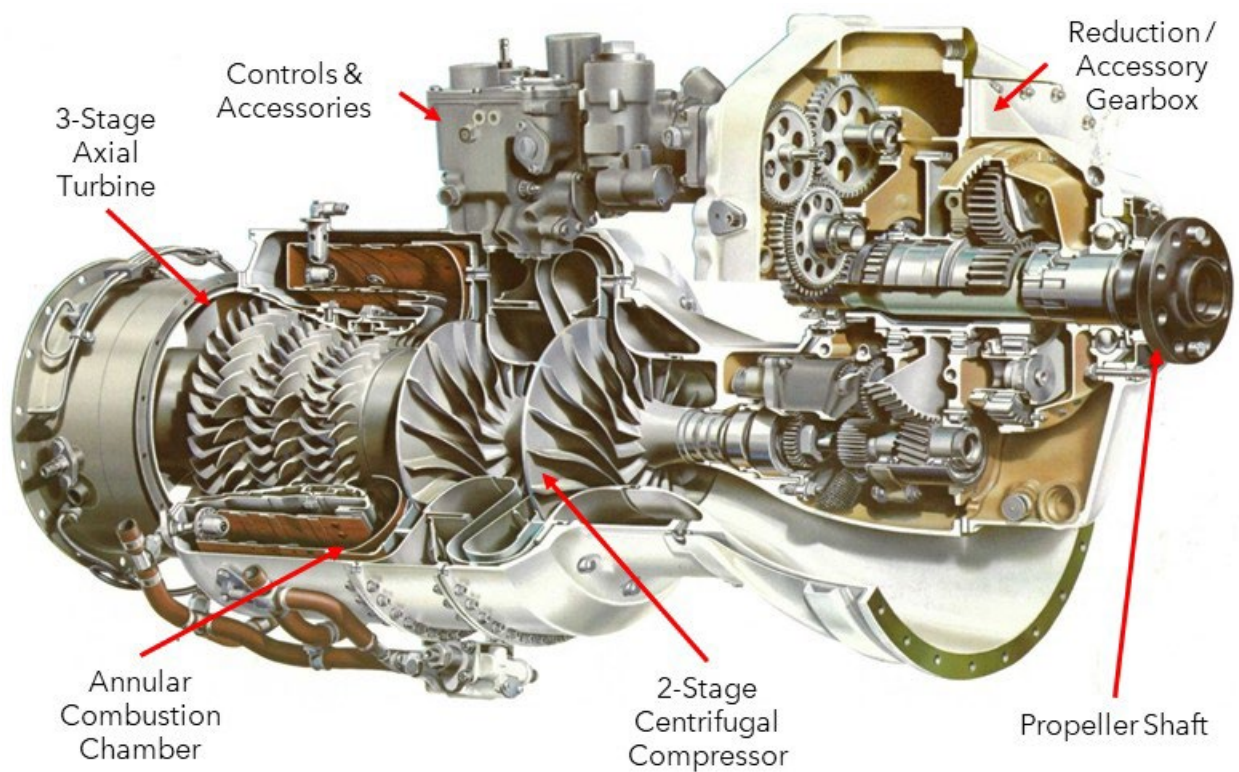


Figure 1. Generic TPE331 Engine Cross-Section

Figure Courtesy of Honeywell

The TPE331-10 is a counterclockwise rotating propeller installation⁴. The gearbox incorporates a fixed ring gear assembly and a floating planetary gear. The bull gear/sun gear assembly drives the planet gears, which drive the propeller shaft in a counterclockwise rotation. The gearbox ratio is 26.229 to 1, with a 1,591 RPM propeller speed at 100% engine speed.

1.3 Engine Maintenance and Service History

Table 1 summarizes the times and cycles during the last two overhauls that were reported in the logbook:

⁴ All directional references to front and rear, left and right, top and bottom, and clockwise and counterclockwise are made aft looking forward (ALF), as is the convention. All numbering is in the circumferential direction, starting with the No. 1 position at the 12:00 o'clock position or immediately clockwise from the 12:00 o'clock position and progressing sequentially clockwise ALF. The direction of rotation of the engine compressor and turbine is clockwise, and the propeller shaft is counterclockwise ALF.

Table 1 - Times of Last Overhauls

Date of Overhaul	Total Engine Time Since New (TSN)	Total Engine Cycles Since New (CSN)
September 13, 1999	11,544.8 hours	9,871 cycles
December 1, 2011	17,838.1 hours	15,304 cycles

A logbook record dated November 15, 2011, states the propeller governor was overhauled in accordance with Woodward manual 33170 Revision 4 and TSP-1674 Revision AC. A component maintenance logbook record dated December 1, 2011, for propeller governor, GTEC part number 897410-16 and serial number 2243813, stated the TSO was 0.0 hours.

A review of the engine maintenance records showed that on December 21, 2023, with engine TSN 20,022.3 hours, a hot section inspection (HSI), a propeller pitch control inspection, and a fuel control unit (FCU) spline inspection were performed by TAE Aerospace (a Honeywell TPE331 authorized service center) in Midvale, Idaho. According to the TAE representative, who interviewed the technician who had performed the HSI service, the FCU was removed from the engine during the inspection; however, the PG was not.

According to the TAE representative, it was noted after the hot section inspection, the maximum propeller RPM setting was too high. TAE called the operator to inquire if any operational problems had been recently reported. The operator informed him that no squawks had been reported. To troubleshoot the discrepancy, the technician swapped the PG with an available slave unit and noted the same high RPM. The technician then installed the original PG back onto the engine and re-indexed the speed setting lever by two splines to bring the angular relationship of the lever to a more neutral position. Following the PG speed setting lever adjustment, the RPM high setting remained steady at 100%, the engine was returned to the customer who installed it in the airplane, performed ground runs and then conducted a test flight with no propeller RPM issues.

The starter generator power wires were incorrectly connected when the engine was installed in the airframe following the HSI in early 2024, resulting in a high reversed electrical current being passed through the engine when the electrical power was initially applied. The engine was subsequently removed and sent to TAE Aerospace where an engine repair based on a Honeywell MM lightning strike instructions was performed in May 2024.

A logbook entry dated May 28, 2024, for corrective actions performed by TAE Aerospace states: "Disassembled engine to the extent necessary to inspect due to high-voltage current, passing through the engine. All parts identified as discrepant

were repaired or replaced at this time and reassembled engine for testing. The following parts installed at this time include, an overhauled FSOV P/N 394230-9-1 S/N 9782C, a new PPC sleeve assembly P/N 869647-5, a new 70100080-14 PPC cam assy., a new prop-shaft roller bearing P/N 358360-5 S/N 23-162370-05232, and a new bearing P/N 3101689-1 S/N 23-162370-00229." There was no entry for any repair or replacement of the PG.

On May 28, 2024, the engine was reinstalled in the airplane with TSN 20,022.3 hours.

According to the information provided by the pilot in the Pilot/Operator Aircraft Accident/Incident Report, the last annual/100hour engine inspection was performed by the operator on June 12, 2024.

2.0 Wreckage Examination Information

According to the on-scene and wreckage review field notes, the airplane sustained substantial damage to the rudder. The airplane was recovered from the accident site and was transported to the operator's hangar in Hebron, North Dakota, where it was stored in a secure location until the wreckage review occurred on July 23-24, 2024. The engine was examined by Honeywell subject matter experts and their field notes revealed in summary that:

- The engine was intact and appeared undamaged.
- The engine inlet was free of debris.
- The airframe to engine fuel lines remained connected.
- The airframe to engine oil lines remained connected.
- Oil was present in the oil tank.
- The 1st stage impeller and 3rd stage turbine were undamaged.
- The propeller was free to rotate and corresponding rotation of 1st stage impeller and 3rd stage turbine was observed.
- The engine control rigging was intact and appeared undamaged.
- The control cables continuity between the cockpit throttle quadrant and the engine were intact.
- The full sweep ranges of the power lever (PLA) and speed lever was confirmed.
- The feather valve could be actuated by hand.
- Oil was observed in the engine exhaust duct.

3.0 Initial Engine Examination

3.1 General Condition

The engine was secured in a Honeywell shipping box (Figure 2) and opened for the examination when the investigation team arrived on October 21, 2024. The engine logbook, various fuel samples from different locations of the airframe, and an oil sample from the oil tank were also found in the shipping container. The starter-generator was not returned with the engine.

The initial examination consisted of various inspections to ensure the engine was in a testable condition prior to installing the engine on the test stand.



Figure 2. TPE331-10-511M Engine - As Received

The engine was removed from the shipping box and placed into a propeller stand mount frame (Figure 3) before the visual examination was performed. The engine was generally intact and undamaged.



Figure 3. Engine Placed into the Propeller Stand Collar

The engine oil tank was empty: however, it was reported that the oil tank was nominally full during the wreckage review, and it was drained in preparation for shipping.

The 1st stage impeller as viewed through the inlet was undamaged (Figure 4).



Figure 4. 1st Stage Impeller - Undamaged

The 3rd stage turbine as viewed through the exhaust was undamaged (Figure 5). Oil was observed in the bottom of the inner surface of the exhaust duct. A small oil puddle was observed in the exhaust duct. Additionally, the turbine scavenge pump cover was oil wetted. The turbine scavenge pump cover was removed revealing oil in the outer sleeve of the turbine housing inner barrel.

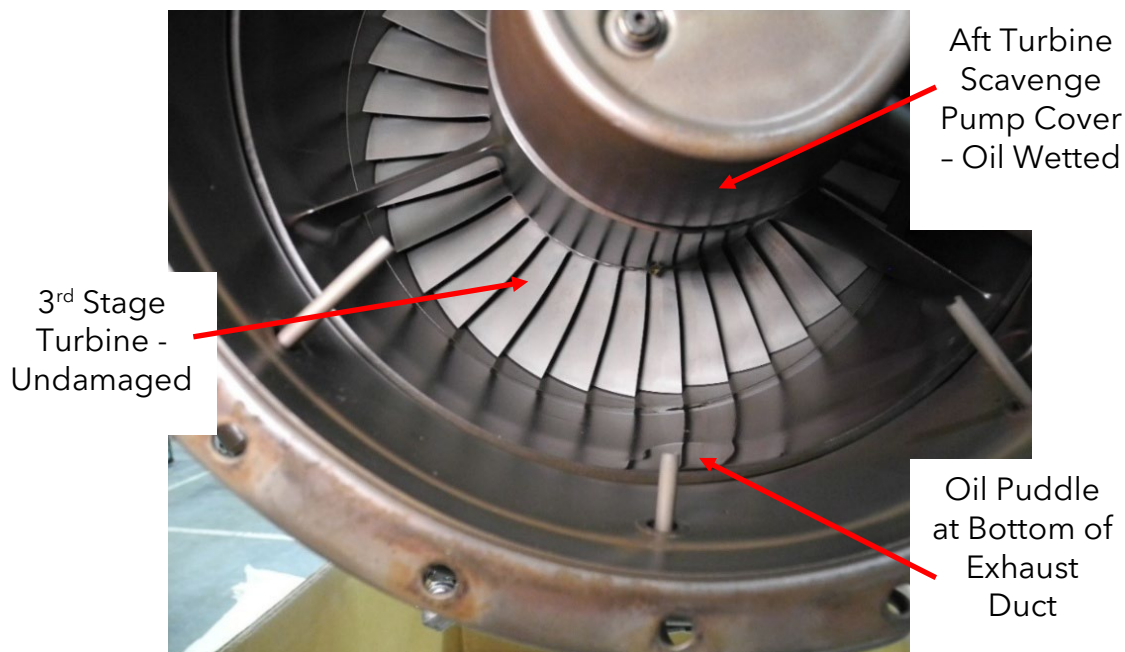


Figure 5. Exhaust Duct - Oil Puddle Observed at Bottom

The scavenge pump (Figure 6) was undamaged; however, it was nominally sooty and dry.

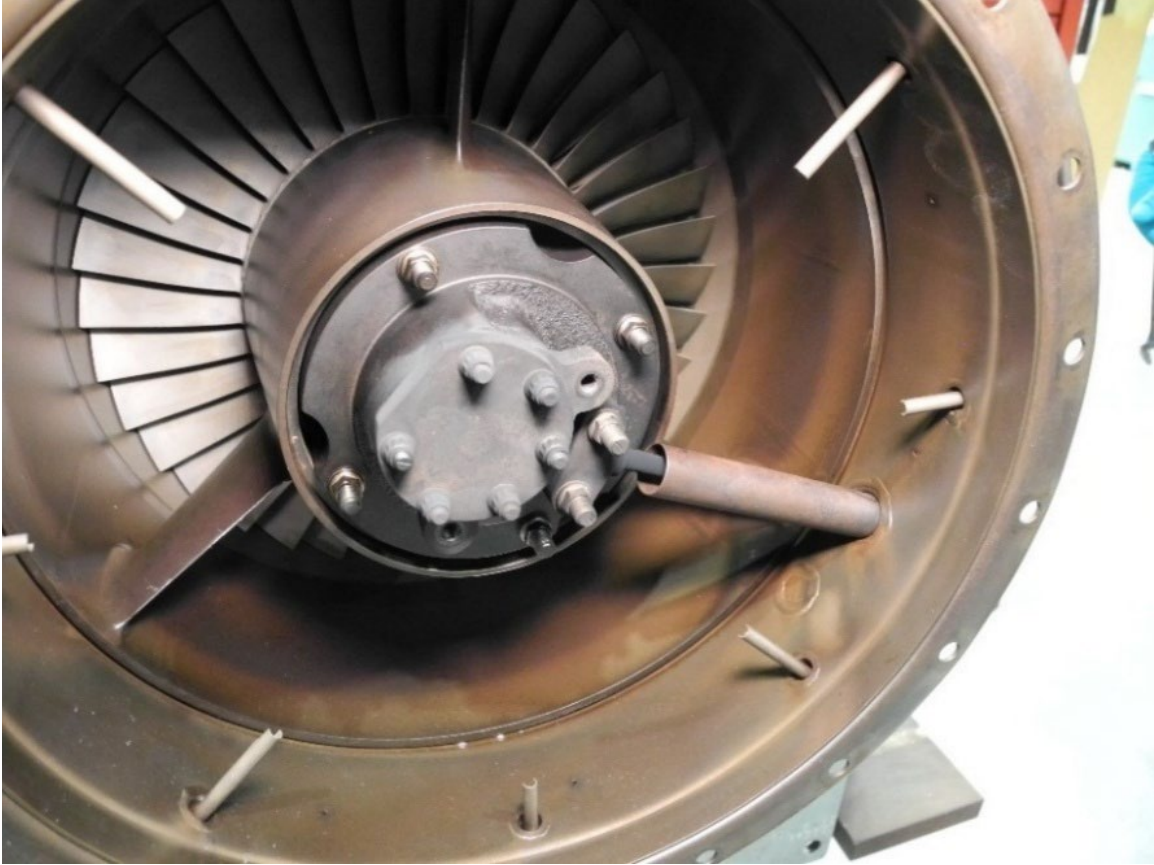


Figure 6. Turbine Scavenge Pump Housing - Cover is Removed

The turbine scavenge pump was removed, revealing undamaged oil wetted gears and splines (Figure 7) and an intact gasket.

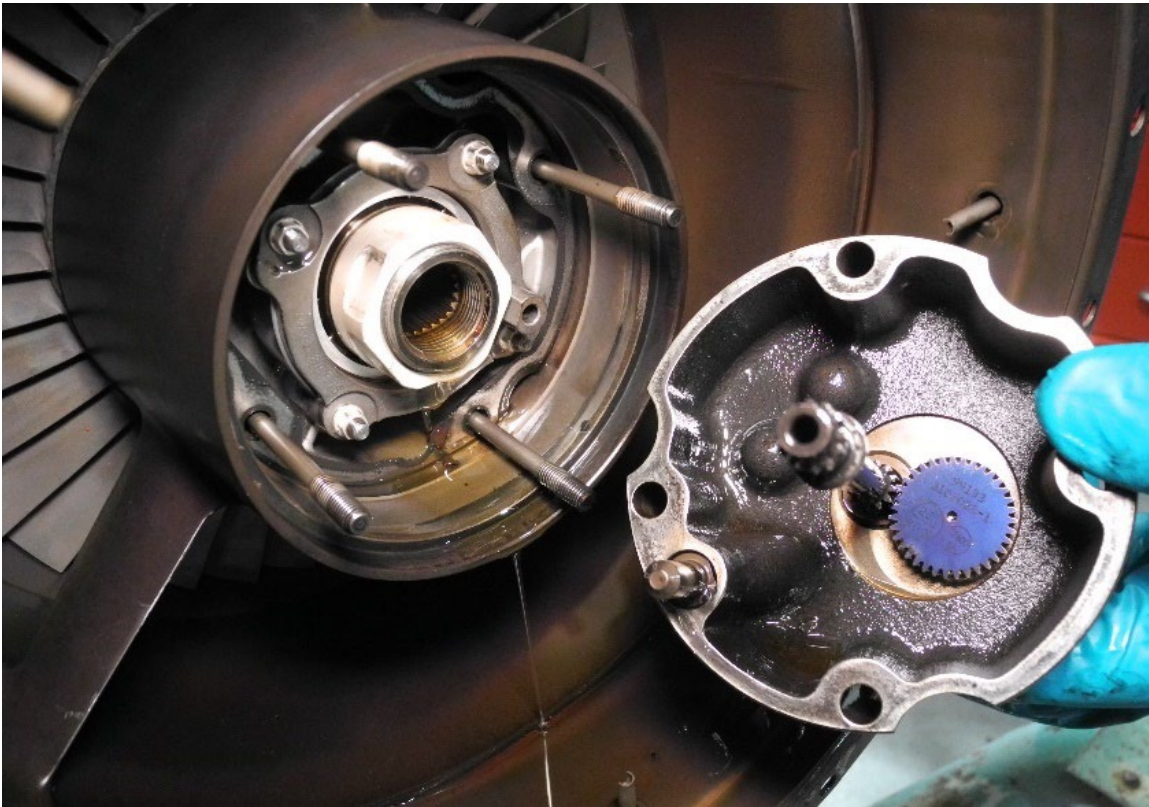


Figure 7. Turbine Scavenge Pump - Undamaged

The exhaust section was intact with no signs of external thermal damage, uncontainment, or impact damage.

3.2 Main Filters Examinations

The fuel filter was removed and examined revealing a filter cavity full of fuel and a clean filter (Figure 8). The oil filter was clean.

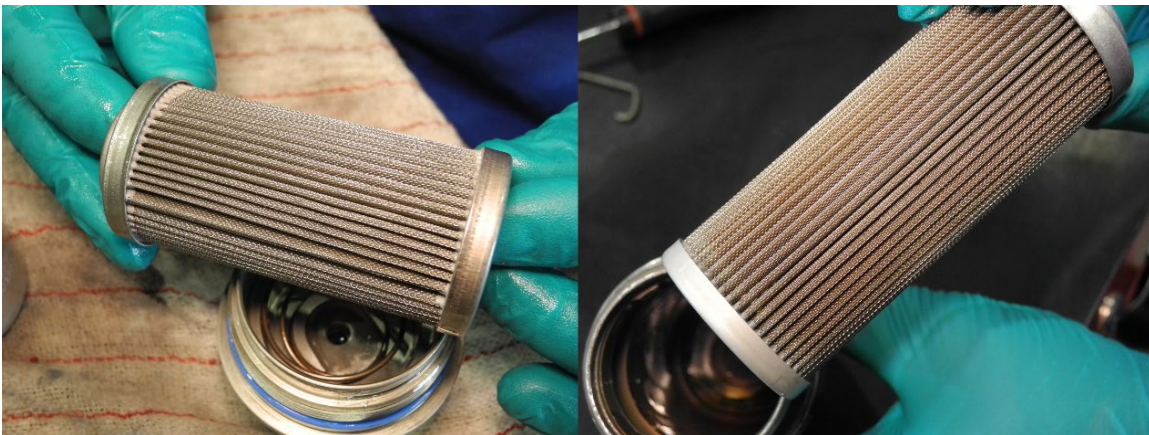


Figure 8. Fuel Filter (Left), Oil Filter (Right) - Clean

3.3 Accessory Gearbox and Torque Meter Examination

The AGB and propeller flange were undamaged. The gearbox was drained of oil and an oil sample was collected. A borescope was inserted through the vent fitting to inspect the high-speed pinion to torque sensor gear mesh. Both gears were meshed, undamaged and oil wetted (Figure 9). The AGB was not further disassembled.



Figure 9. Borescope Image of High-Speed Pinion - Torque Sensor Gear Mesh

3.4 Control Accessories Examination

All the engine control accessory components, consisting of the fuel pump, FCU, concentric shaft, PG, propeller pitch controller (PPC), and feathering valve connected to the rear flange of the AGB were in location (Figure 10), undamaged and still linked together with their respective undamaged rigging rods.

The tach generator was not installed on the engine at the time of the engine examination; however, it was removed during the wreckage examination to facilitate disconnection of a wiring harness and then stored in a container.

4.0 Propeller Stand Testing

Upon completion of the initial examination, the engine was placed onto a propeller stand at the San Tan remote facility (Figure 11). A four-bladed slave propeller was mounted on to the propeller flange.



Figure 10. TPE331 Event Engine in Propeller Stand

The engine was motored and visually inspected three times to confirm that all systems were operational.

The first start attempt of the engine was unsuccessful due to a test cell fuel delivery problem. Once this was corrected, the engine started and achieved a stable idle. With the propeller start locks still engaged, the engine speed was slowly increased via the power lever angle (PLA) potentiometer from ground idle to 96% and no anomalies were encountered.

The speed was reduced to ground idle and then the PLA was placed in reverse to disengage the start locks. The PLA potentiometer was then increased until the engine control system reached the prop governing mode. When prop governing mode was reached, the engine speed began to exhibit an abnormal speed reduction

and an exhaust gas temperature (EGT) increase. The PLA was quickly reduced, and the engine resumed stable ground idle operation.

A second power increase of PLA was performed and as the prop governing mode was reached the same abnormal behavior of a rapid decrease of speed and increase of EGT occurred. The PLA was again quickly reduced, and the engine resumed stable ground idle operation.

The third increase in PLA was performed and as the prop governing mode was reached the same abnormal behavior of a rapid decrease of speed and increase of EGT occurred. The PLA was not reduced, and the speed was seen to fluctuate between 90.2% and 95.6%, the torque pressures fluctuated between 37 and 45 pounds per square inch (psi) and the EGT fluctuated between 1,062°F and 1,189°F three times and the EGT began trending upwards before the PLA was reduced and a stable ground idle was again achieved.

The fourth attempt saw the engine respond in the same manner as the third attempt.

The engine's behavior was consistent with a problem in the propeller governing system; the PG was subsequently removed for further inspection.

5.0 Computer Tomography Scan of Propeller Governor

After the San Tan test was completed, the PG was removed from the engine, packaged and transferred to the Honeywell CT laboratory where it was scanned and analyzed. The 3-D scan images were reviewed and no anomalies were found.

The PG was then shipped to the Woodward facility in Love's Park, Illinois, for functional testing and teardown examination.

6.0 Propeller Governor Test and Teardown

6.1 Propeller Governor Description

Among the engine accessories that manage the power of the Honeywell TPE331-10, a Woodward PG is used to control the speed of the propeller. The Woodward PG is a constant speed controller used to manage hydraulic single-acting constant speed propellers (Figure 12). The PG single-acting feature makes it only capable of decreasing propeller blade angle by providing oil pressure to the piston in the dome of the propeller. To increase the propeller blade angle, the oil pressure on

the piston is reduced; however, the force to increase the propeller blade angle is provided by only the internal springs and counterweights on the propeller.

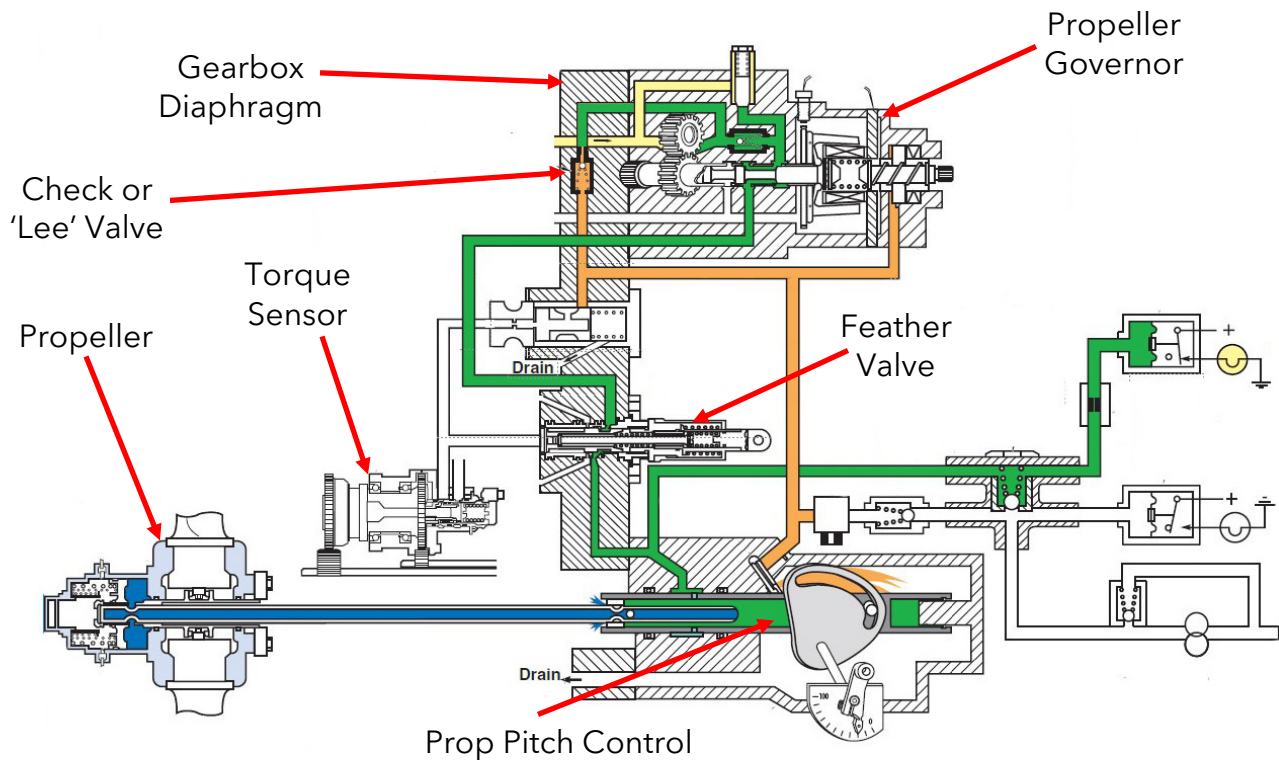


Figure 11. TPE331 Propeller Control Schematic as Installed on Engine

Figure Courtesy of Honeywell

TPE331 engines with propellers that operate at 1591 RPM (CCW) have a reset piston within the propeller governor that will reset the propeller governor to a value greater than 100% RPM when the power lever is below the flight idle gate. A rotary valve in the propeller pitch control input shaft dumps the oil from the reset piston, which resets the propeller governor to approximately 107% engine RPM, so that maximum (Beta) pressure is supplied to the propeller control system. When in propeller governing mode, oil is ported through a check valve, also called the Lee valve, to the negative torque sensing (NTS) system and the Propeller Governor Reset Piston, preventing this reset of the propeller governor to approximately 107%. The Lee valve is normally open during engine operation. If the Lee valve is plugged, oil is not ported to the reset piston.

6.2 Propeller Governor History

According to Woodward personnel, the PG was originally manufactured by Woodward and shipped on November 30, 1988, as P/N 8210-115 with S/N 2243813. The PG returned to Woodward for repair and subsequently return shipped to the customer on July 14, 1989. The PG data plate indicates P/N 8210-263 and S/N

2243813-D (Figure 13). Woodward released a Modification Revision D to PG P/N 8210-115 in 2005 that would change the PG to P/N 8210-263 and add the letter 'D' to the end of the component serial number. There was no maintenance records found that would indicate when the PG modification Revision-D was incorporated or by who.

The event PG had been operated 2,185 hours since it was last overhauled by National Flight Services on Nov. 15, 2011. The last engine maintenance, which consisted of a HSI occurred, 0.9 hours before the event. There is no report of the PG being repaired during this time. Further, it was reported that the PG was not removed from the engine at the time of the HSI.

During the engine repair for the lightning strike in May 2024, it was reported that the technician re-indexed the speed setting lever by two splines to bring the angular relationship of the lever to a more neutral position which will decrease the propeller governing speed of the engine. According to the Honeywell Maintenance Manual 72-00-27 for the TPE331-10-511M engine model, a Temporary Revision No. 72-167 was issued on February 29, 2000, that added cautionary instructions when performing the PG RPM settings, stating 'CAUTION: NEVER ATTEMPT TO MEET THE PROPELLER GOVERNOR RPM SPEED REQUIREMENT BY REPOSITIONING SERRATED LEVER ASSEMBLY ON THE PROPELLER GOVERNOR SHAFT. Further, it stated that if the relationship between the lever and the shaft is not maintained, then the PG must be returned to an authorized facility to be recalibrated.

6.3 Propeller Governor Examination

The event PG was Woodward part number (PN) 8210-263, serial number (SN) 2243813 with an assembly date of July 1989 (Figure 13).

The PG was secured in the original cardboard shipping box when the investigation team arrived for examination on December 9, 2024. The PG was inspected and documented by Woodward personnel; the PG was found to be undamaged and in a testable condition.

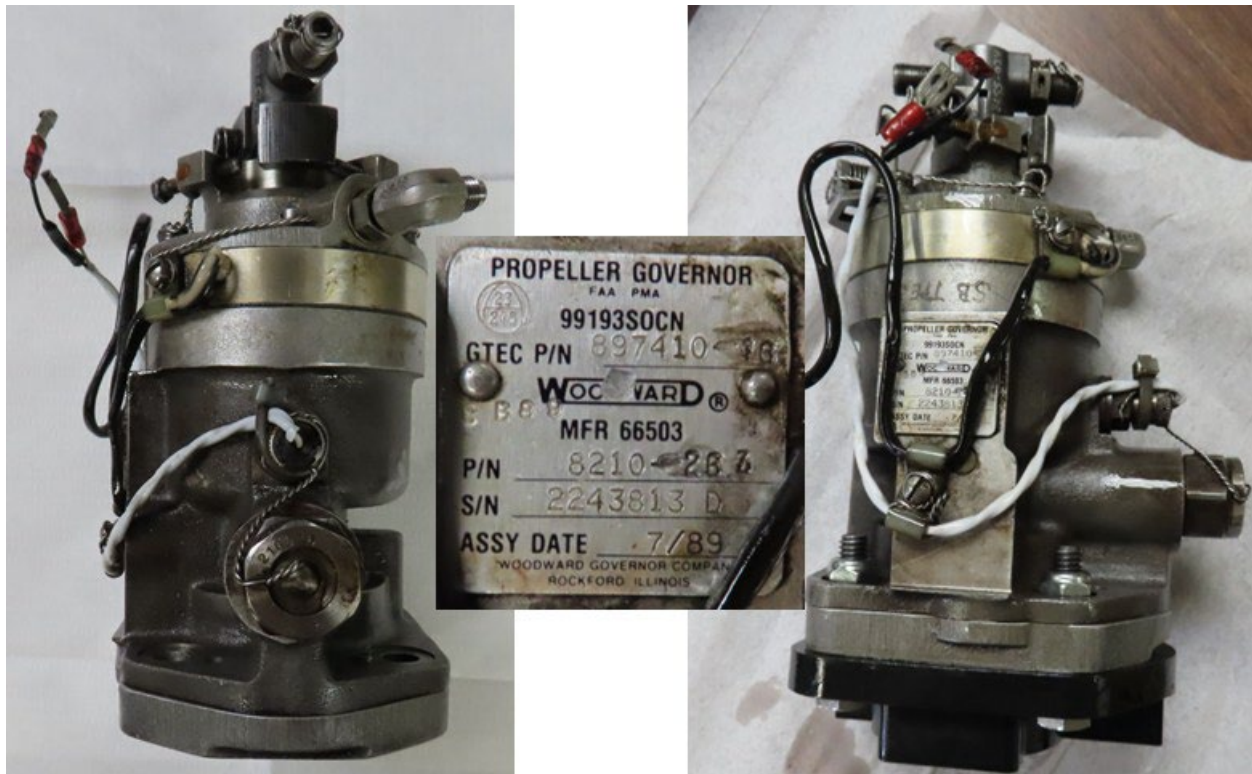


Figure 12. Woodward PG S/N 2243813 - As Received

The two electrical wire bundles were present; the black sheathed bundle is intended for propeller synchronization; however, it is not used for this single engine Thrush engine application, and the lead ends were bare wire. The white wire bundle is connected to a pickup coil on the PG and is intended for an electric speed signal, however, it is also not used in the Thrush engine application.

The maximum and minimum speed settings of the PG are established at the factory by adjusting the position of two set screws on the propeller speed setting shaft (Photo 12). Normally the extended threads of the maximum and minimum set screws are approximately even. The two set screws of the event PG were present and locked; however, they were asymmetrically positioned by approximately 20° (See dimensions A & B in Figure 14 and Figure 15). Minor adjustments of the speed set screws are allowed in the field as part of the rigging adjustment procedure; however, the Woodward technicians noted this to be an unusually large variance.

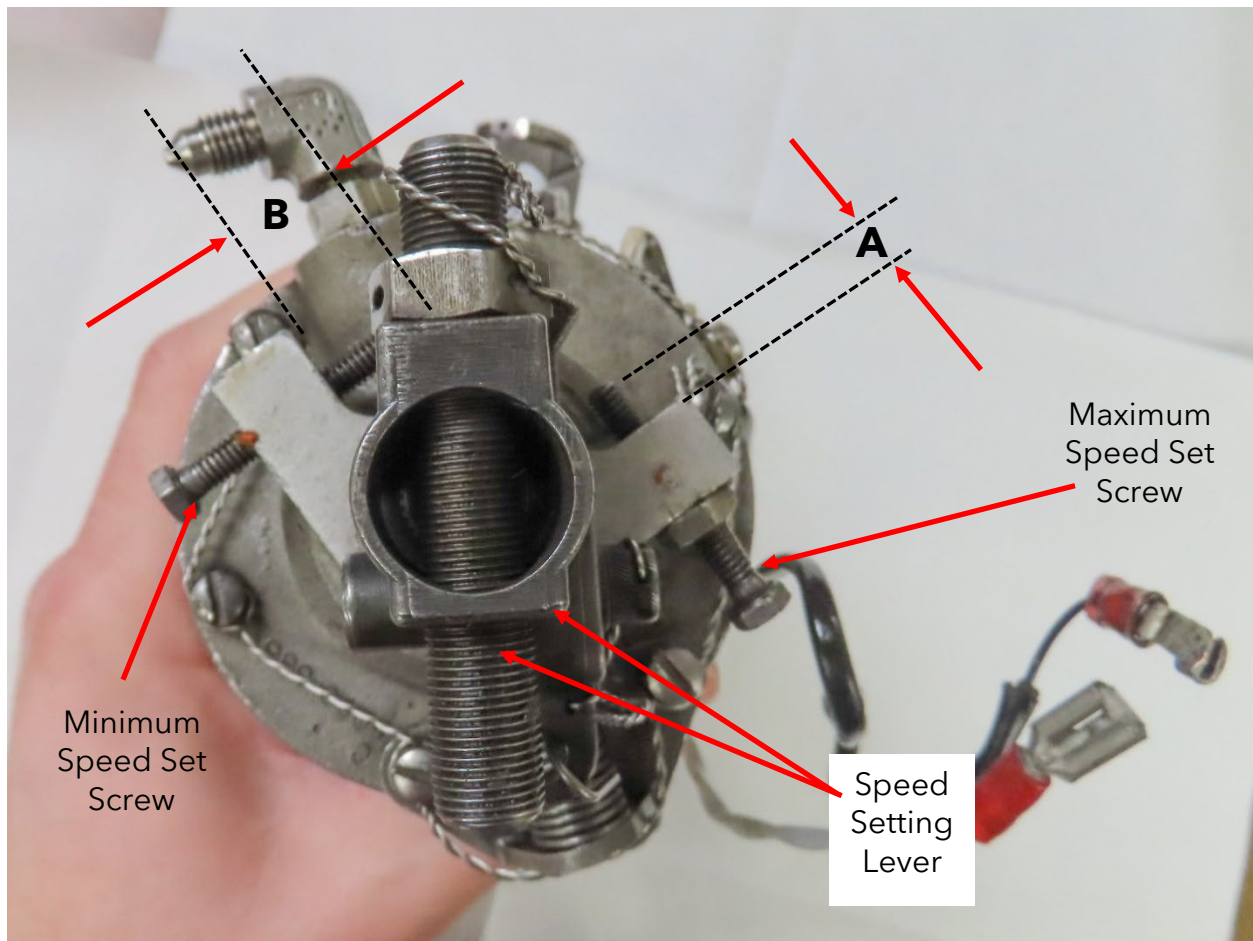


Figure 13. Details of Speed Setting Lever on Speed Setting Shaft

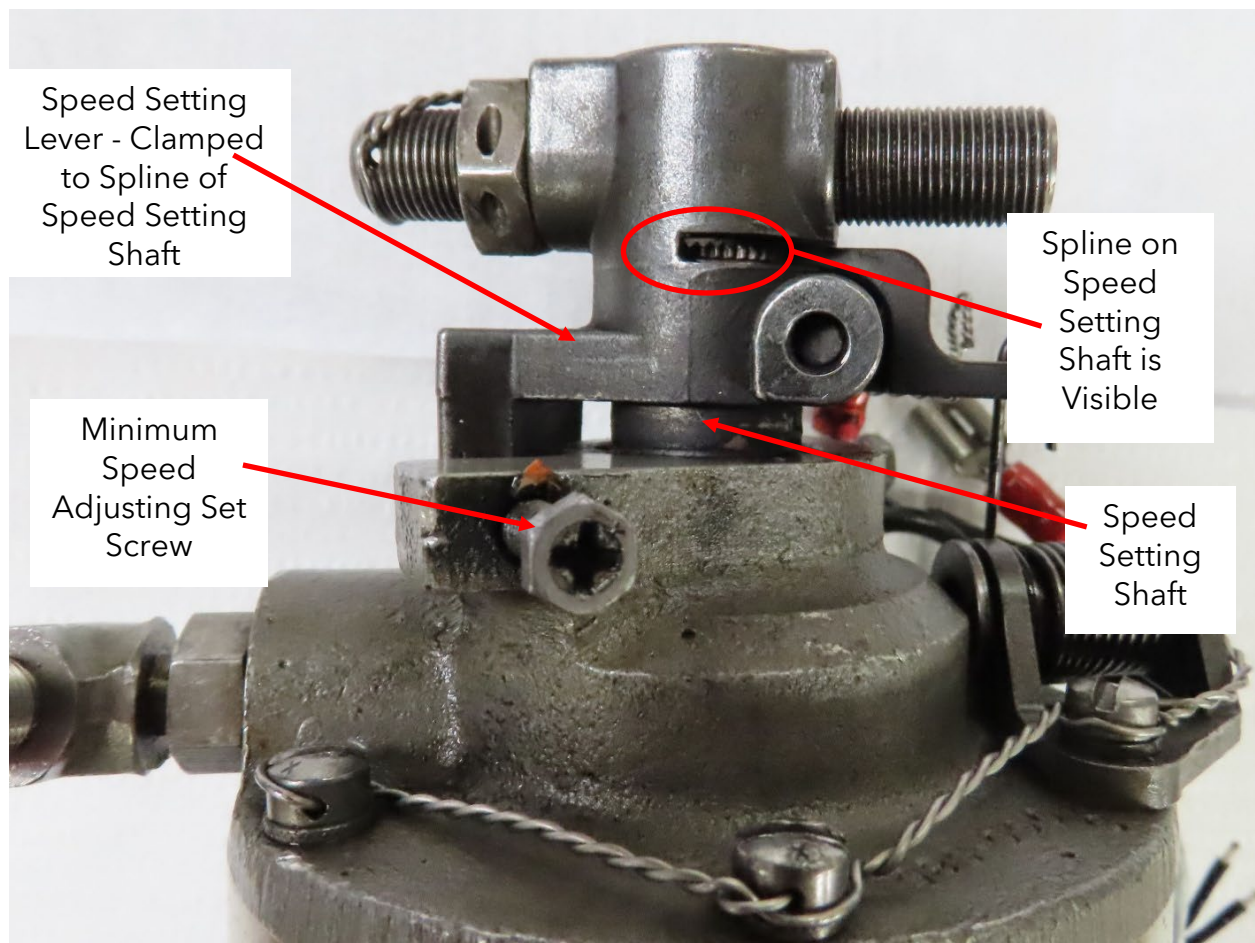


Figure 14. Detail of Speed Setting Lever on Speed Setting Shaft

6.4 Propeller Governor Testing on Test Stand

A full acceptance test procedure (Woodward document TSP-1674) was performed on the PG. The PG was mounted onto the Woodward production test stand (Figure 16) and run for approximately 10 minutes to stabilize the temperature of the unit.



Figure 15. PG Mounted onto Test Stand

A factory reference protractor was mounted on the PG (Figure 17 and Figure 18) to confirm the range of rotation of the speed setting shaft and the position of the speed setting lever on the speed setting shaft spline.

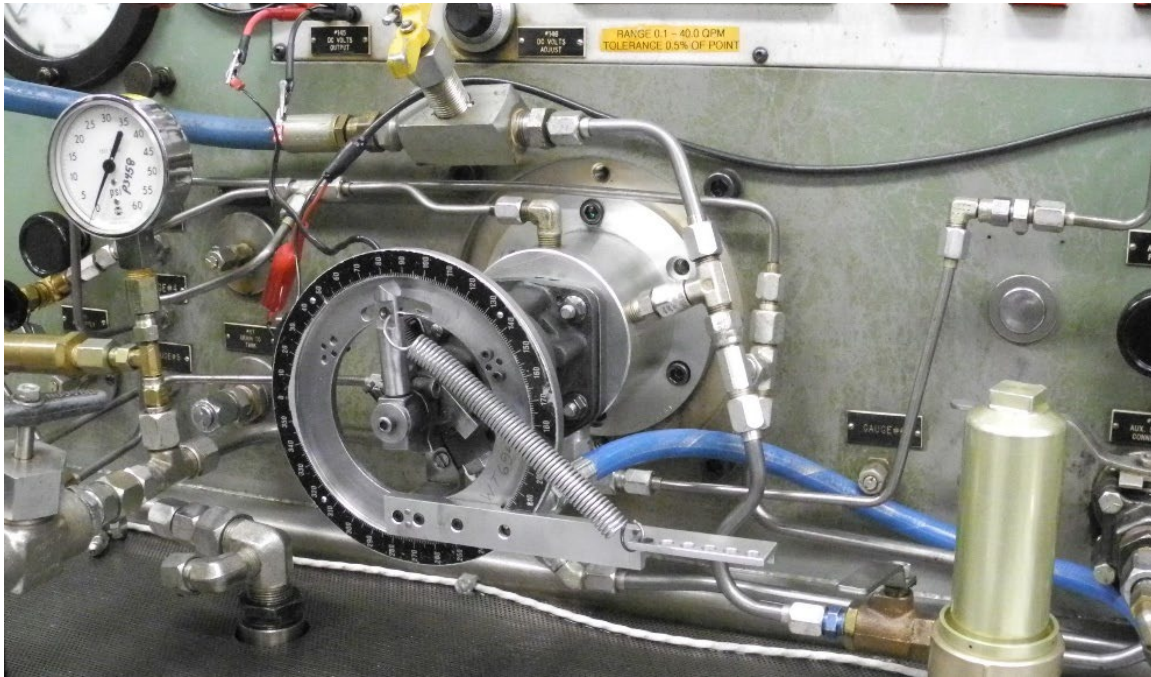


Figure 16. Factory Reference Protractor Mounted PG - Front View

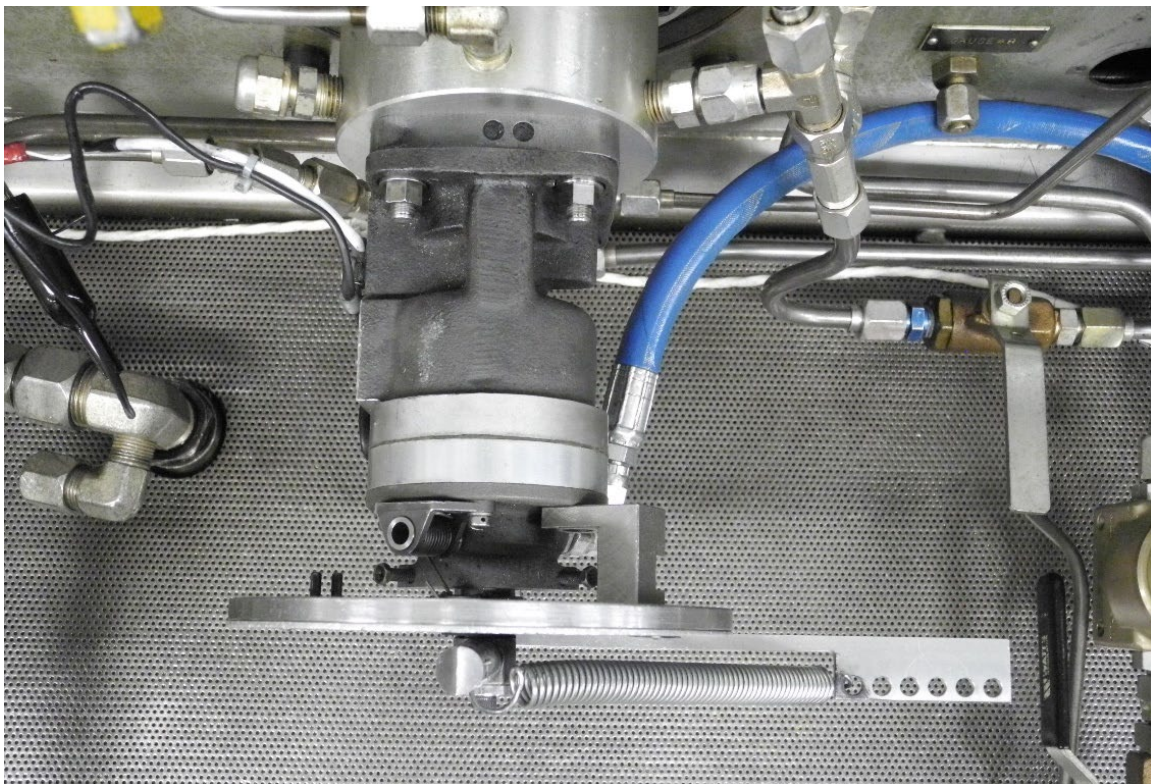


Figure 17. Factory Reference Protractor Mounted on PG - Top View

The test results were recorded in Woodward document TSP-1674 (Figure 19).

According to the Woodward test sheet, the required maximum speed of the PG is 3,754 RPM (equivalent to 100% engine RPM) and should occur at an external protractor setting of 84° + or - 5° (See PT. 6 in Figure 3) while the minimum speed of 3,604 RPM (equivalent to 96% engine RPM) should occur at an external protractor setting of 10° (+ or - 2°) below the maximum speed position.

The measured values of the speed input shaft positions were:

- Maximum 3,553 RPM or 201 RPM lower than the required 3,754 RPM (or 94% engine speed) at a protractor setting of 96°.
- Minimum 3,232 RPM or 372 RPM lower than the required 3,604 RPM (or 86% engine speed) at a protractor setting of 78°.

The minimum speed occurred 18° (96° - 78°) below the maximum speed position, which was beyond the 10° (+ or - 2°) limit.

WOODWARD, Inc.
Rockford, Illinois
CAGE 66503

TSP-1674
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TEST REPORT for 8210-115 and 8210-263

☐ Woodward I/N: 8210-115
☒ Woodward I/N: 8210-263
Woodward Sales Order No. 3981869
S/N 2243813
Oil Inlet Temp. 140 +/- 5 deg. F

Customer P/N: 897410-7, -9
Customer P/N: 897410-11, -16
Customer P.O. No. N/A
Technician [REDACTED]
Oil Inlet Pressure: 95 +/- 10 PSIG

Customer Spec. PSC 897410
Customer Spec. PSC 897410
Date 12/09/2024

PT	Section No.	DESCRIPTION	SPEED RPM		OIL PRESSURE PSIG		OIL FLOW QPM		
			REQUIRED	ACTUAL	REQUIRED	ACTUAL	REQUIRED	ACTUAL	
1	3.1	Check Valve	0	0	15 Max.	30	Start Flow	Start Flow	
2	3.2	Relief Valve	3400 +/- 15	3400	485 +/- 15	485	0	0	
3	3.2.1	Back Pressure	3400 +/- 15	3400	545 Max.	520	0	0	
4	3.3	Maximum Speed	3754 +/- 10	3553	150 +/- 5	150	Use Bleed Orifice		
5	3.4	Minimum Speed	3604 +/- 10	3232	150 +/- 5	150			
6	3.5	Control Lever at Max. 84 +/- 5 deg.			PT4 to PT5 10 +/- 2 deg.	76 at max (17)			
7	3.6	Overspeed (Check/Sec. 3.6)	4017 +/- 40	3840	150 +/- 5	150			
8	3.7	Increase Speed to Obtain		3493	350 +/- 5	350			
9	3.7	Increase Speed to Obtain		3513	50 +/- 5	50	12.6		
10	3.7	Pressure Gain = PT 9 - PT 8	60 +/- 20	60					
11	3.8	Decrease Speed to Obtain		3495	350 +/- 5	350			
12	3.8	Speed Hysteresis = PT 8 - PT 11	-15 to +40	-2			10.9 QPM Min.	4.6	
13	3.9	Pump Capacity	3400 +/- 15	3400	150 +/- 20	150	New 2.0 QPM Max. w/a Repair 2.4 QPM Max. 1.1		
14	3.10	Internal Leak	As Required	3569	150 +/- 5	150			
15	3.11	Magnetic Pickup Voltage	3700 +/- 10	3700	4.5 volts +/- 0.5 Peak to Peak		4.0	Volts	
16			375 +/- 10	375	0.4 volts Peak-to-Peak Min.		.7	Volts	
17		Frequency	3700 +/- 10	3700	925 +/- 3 Counter Reading		925	Hz	
18	3.12	Electrical Speed Change	3.12.1	N/A	3.12.3	N/A	3.12.4, 50 +/- 5 RPM	512	RPM
19		Electrical Hang-up	3.12.3	N/A	3.12.6	N/A	3.12.7, 25 RPM Max.	512	RPM
20	3.13	External Leakage	3000 +/- 50	3000	100 +/- 10	100	0	NONE	
21	3.14	Total Leak	0	0	200 +/- 10	200	0.5 QPM Max.	.4	
22	3.15	Return Spring Check	0		High to Low Speed Stop, Unassisted		Check for Pass ☒		

After adjusting & using protractor 109 max

Figure 18. PG Test Results

Woodward adjusted the maximum speed stop screw to achieve 100% (3,754 RPM) and this resulted in a protractor reading of 109°, confirming that the PG maximum speed could be returned to production calibration.

This finding was consistent with the speed setting lever having been re-positioned in the field by two spline teeth and then field-adjusting maximum and minimum stop settings on the PG.

6.5 Propeller Governor Teardown

The PG was disassembled (Figure 20) and no abnormalities were found.

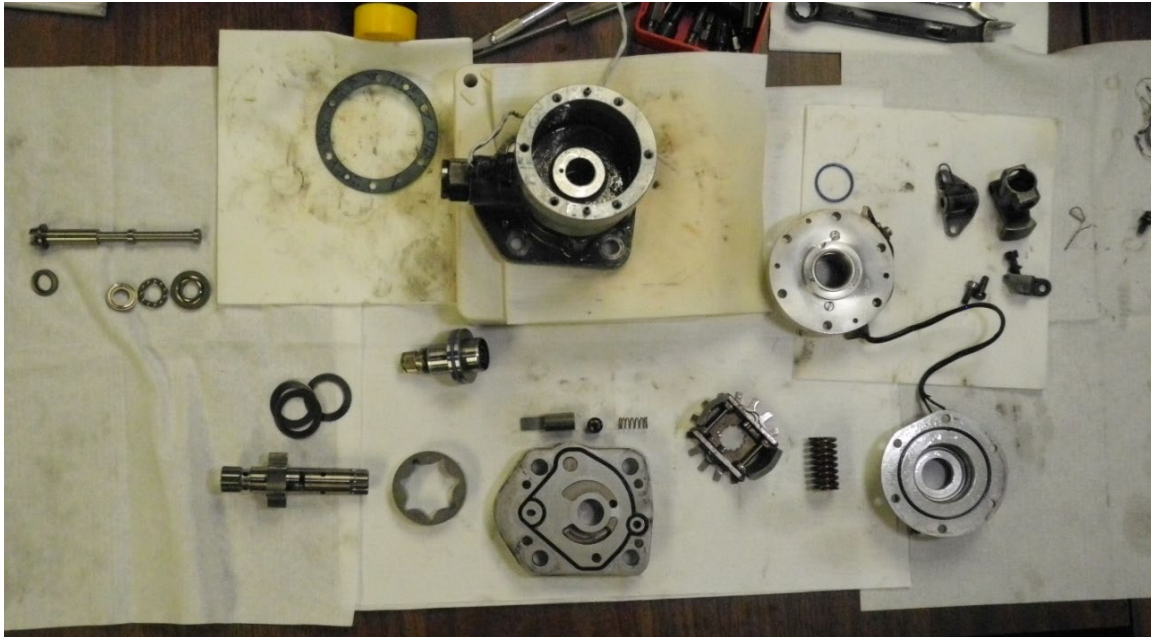


Figure 19. PG - Disassembled

7.0 Examination of the Propeller Control Oil Passages in Accessory Gearbox

The powerplant team reconvened at the Honeywell facility in Phoenix, Arizona, on February 4, 2025 to examine the propeller control system oil passages and in-line fittings of the engine AGB (Figure 21).

The engine was placed into a workstand to facilitate the examination; the PG had been previously removed for the examination performed at Woodward.

7.1 Oil Lines for Hydraulic Speed Reset and NTS Pressure Regulator

Oil from the PG pump (denoted in green) is transferred across the PG-to-AGB interface to supply the hydraulic speed reset piston and the NTS pressure regulator

(Figure 22). There is a filter screen located within the PG mounting flange at the exit of the PG oil line that is secured with a circlip.

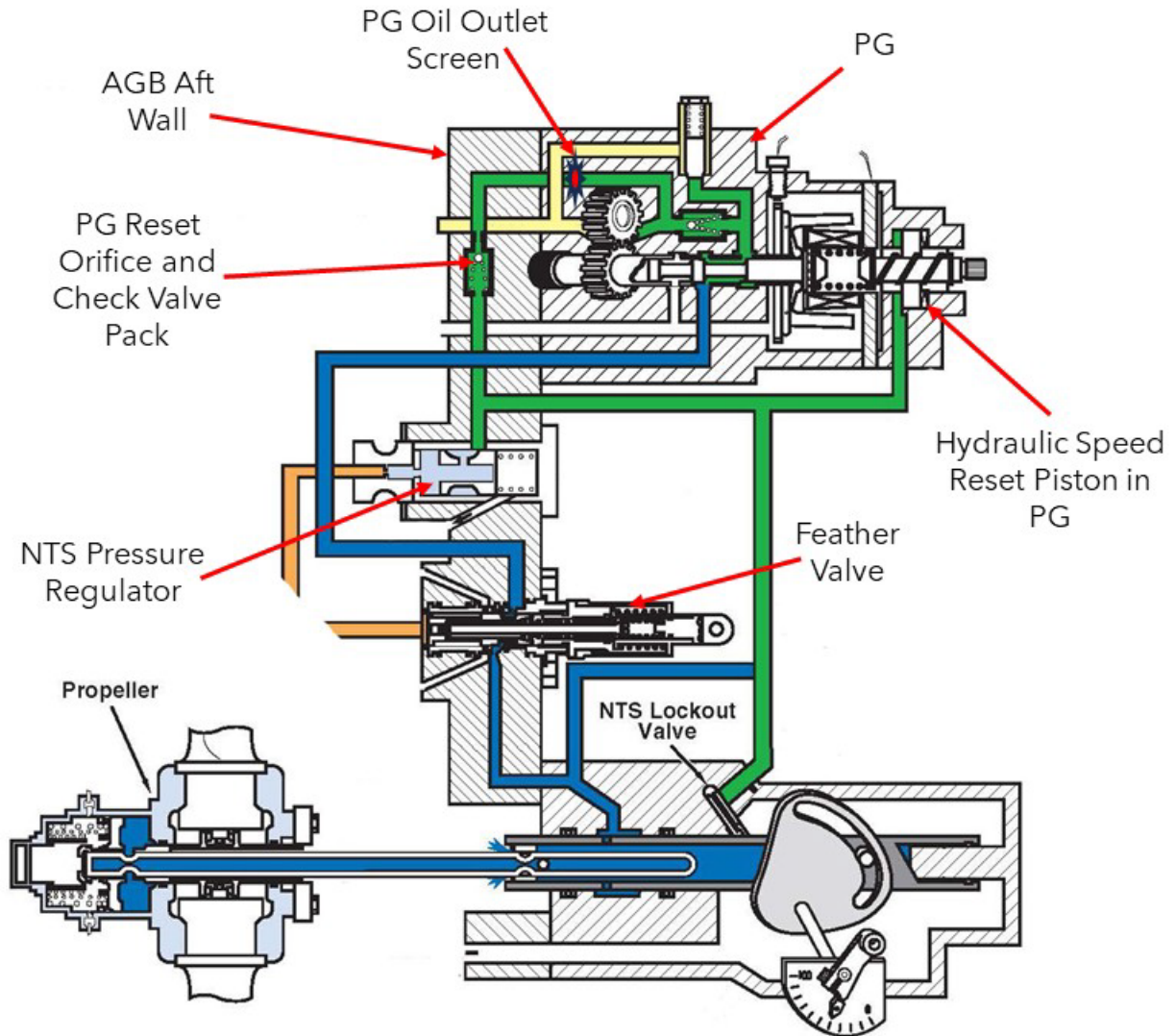


Figure 20. Schematic of PG and AGB Oil Lines

The PG reset orifice and check valve assembly consists of three parts: The Lee valve, the Lee valve expander pin and reset orifice pack. The PG reset orifice pack is manufactured by The Lee Company, Westbrook, CT.

The Lee valve is first inserted into the machined recess in the AGB aft wall after which the expander pin is inserted into the Lee valve to lock the Lee valve into the recess. Finally, the reset orifice is screwed into the AGB recess.

7.2 Examination of PG Oil Outlet Screen

Because the PG had already been disassembled at the Woodward facilities and returned to Honeywell, the PG mounting flange (Figure 23) was examined for integrity and contamination. The filter screen and its retaining clips were still present in the flange recess; the screen was removed and found to be clear of any debris.

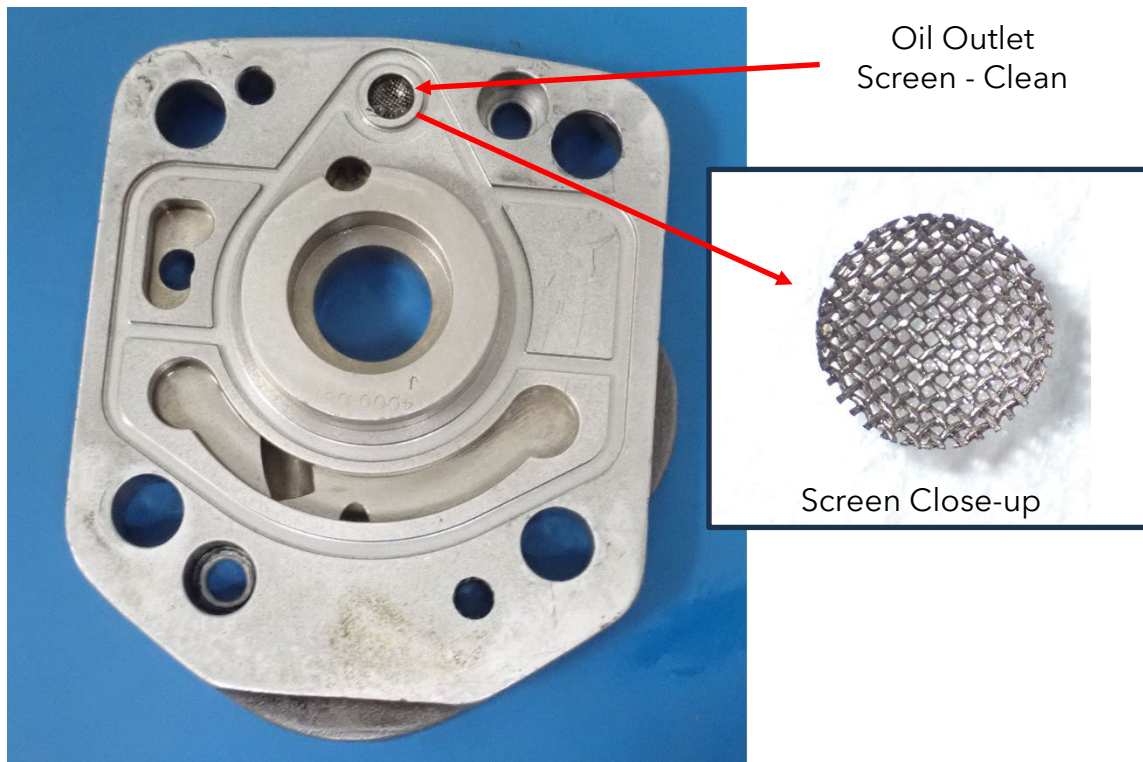


Figure 21. Oil Outlet Screen on PG Mounting Flange - Clean

7.3 Examination of the Oil Lines

The PG flange pad and surrounding area were examined and found to be clean, oil wetted and undamaged (Figure 24).

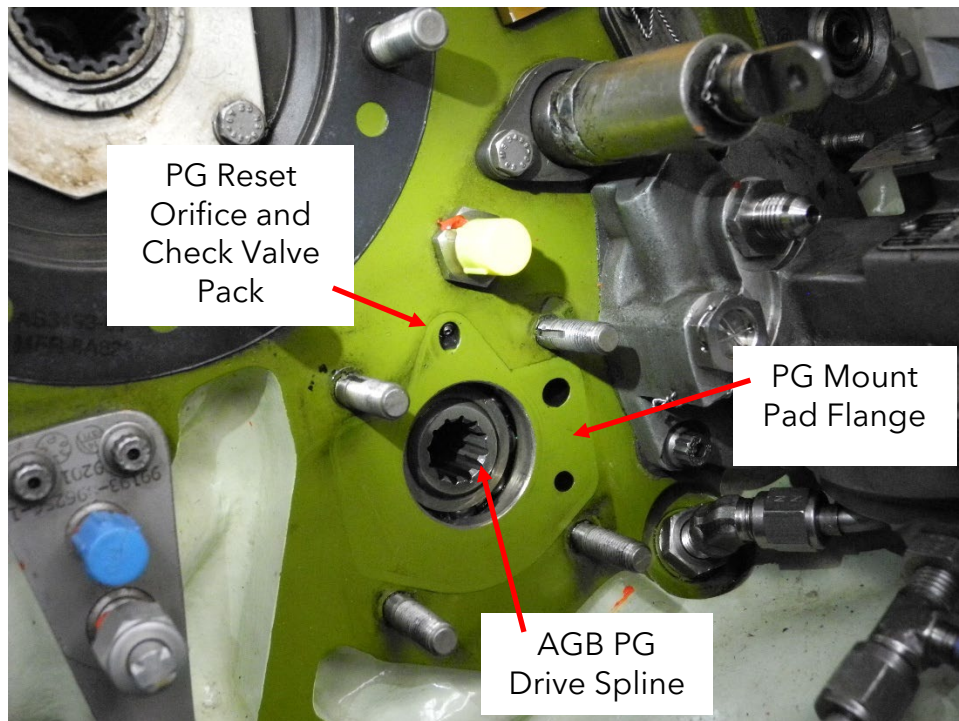


Figure 22. AGB PG Flange Area

The external entrance of the installed PG reset orifice and check valve was examined and found to be clean (Figure 25).

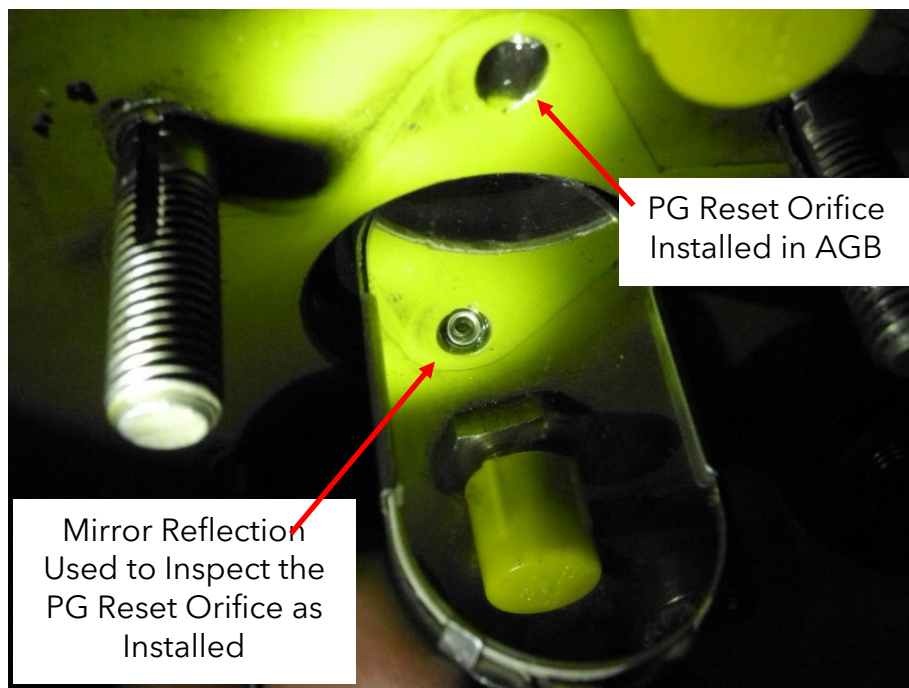


Figure 23. PG Reset Orifice in Location - Clean

The PG reset orifice (Honeywell P/N 897026-2) (Figure 27) was unscrewed and removed with no difficulty from its recess in the AGB (Figure 26) and found to be clean.

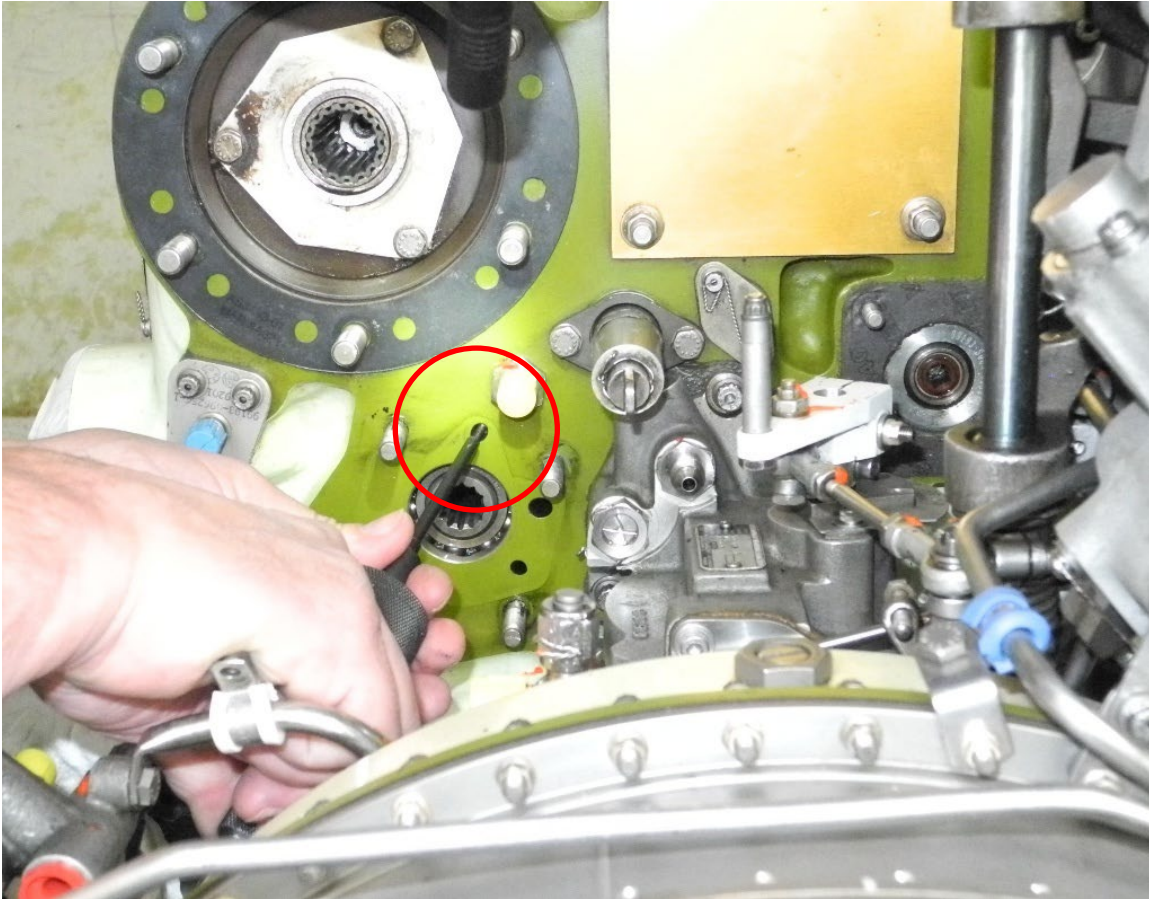


Figure 24. PG Reset Orifice Being Removed with Tool



Figure 25. PG Reset Orifice - Clean

The Lee valve expander pin (part of the PG check valve assembly - Honeywell P/N 771-590-9001) was removed in the normal manner using a small slide hammer (Figure 28) and found to be undamaged.

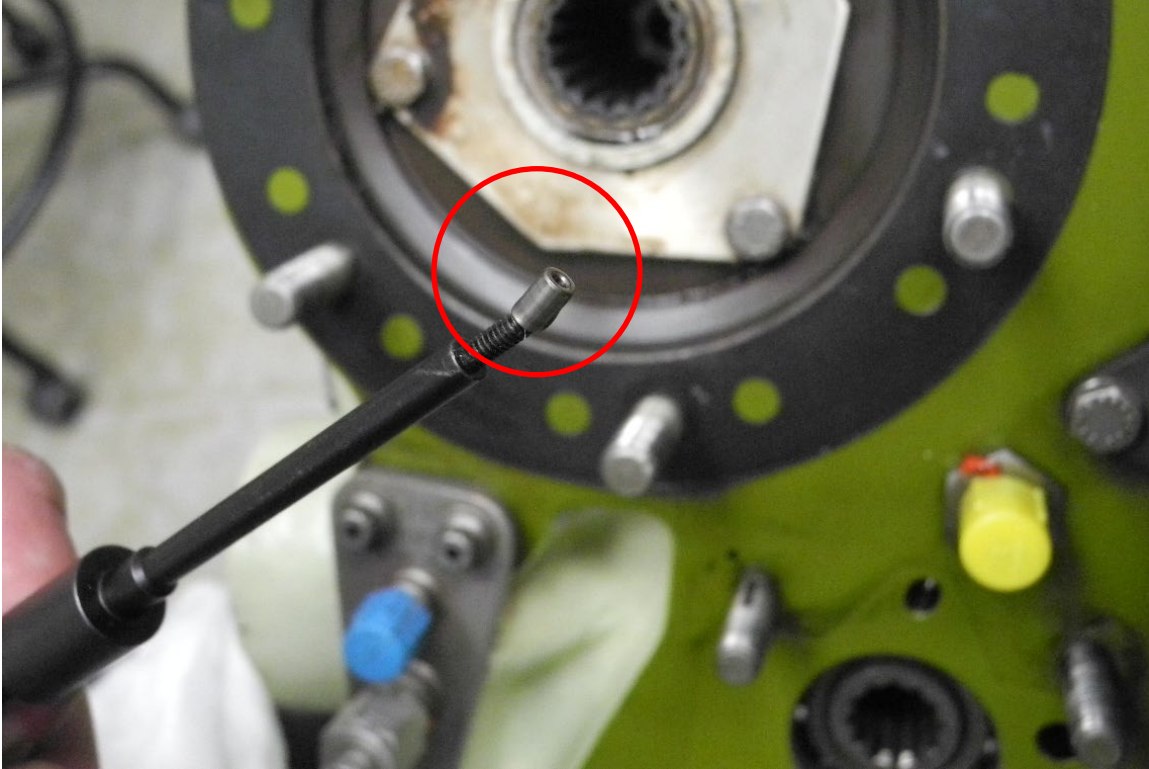


Figure 26. Lee Valve Expander Pin - Withdrawn from AGB

After the Lee valve expander pin was removed, the Lee valve was visually examined in-situ, revealing a small red-colored irregularly shaped foreign object (Figure 29).

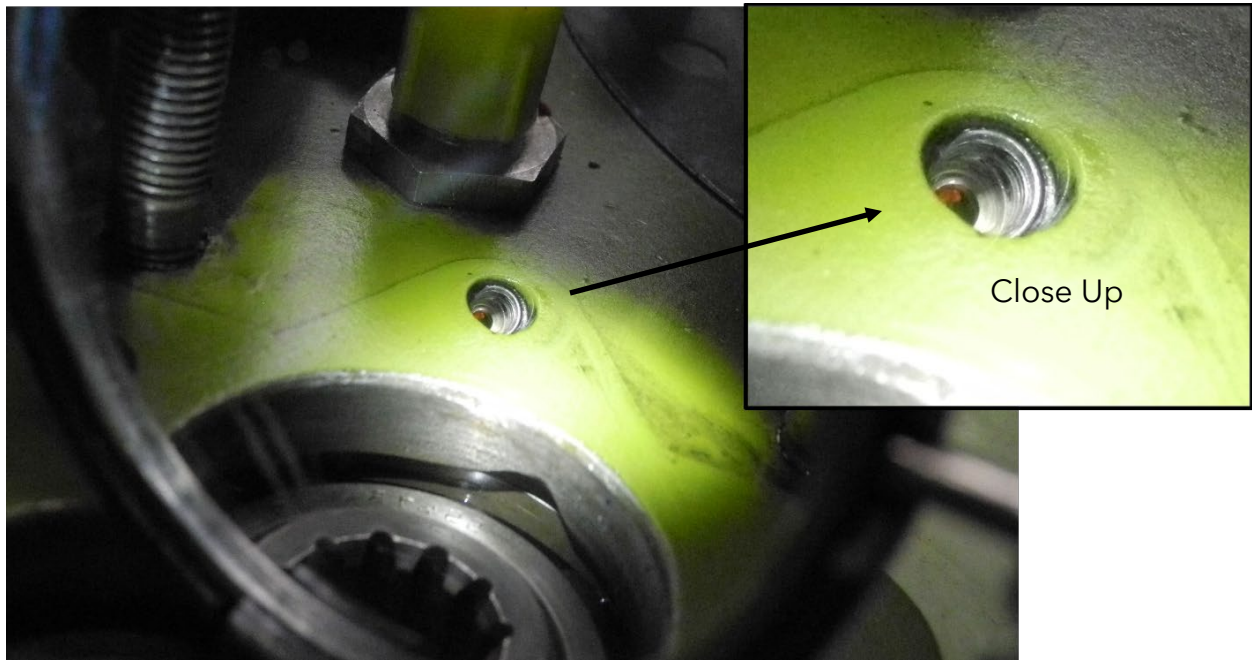


Figure 27. Lee Valve In-Situ - Note Red Foreign Object in Close Up

The Lee valve was removed from the AGB recess for further examination (Figure 30).

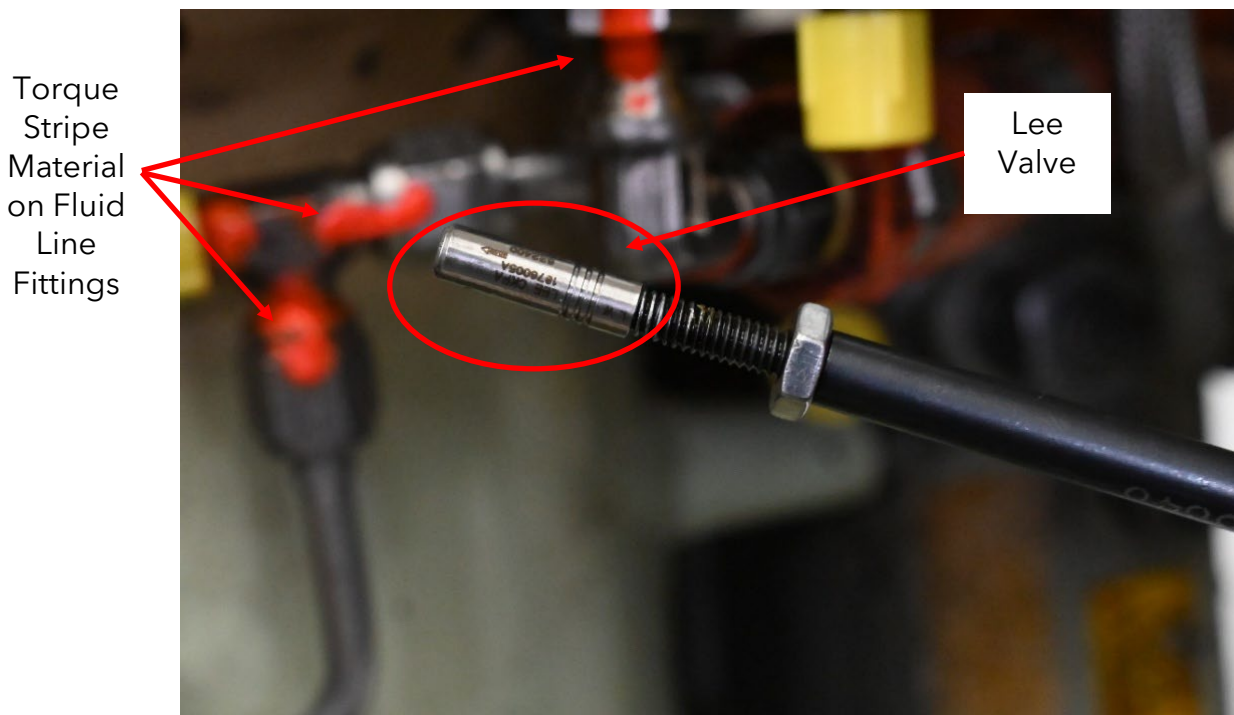


Figure 28. Lee Valve - Withdrawn from AGB

The Lee valve was examined using a microscope, which confirmed a small red-colored irregularly shaped foreign object inside the barrel of the valve that appeared to be captured between the ball and seat of the valve (Figure 31); however, because of the small size and shape of the Lee valve, it was not impossible to confirm this observation. Therefore, the Lee valve was sent to the Honeywell CT lab to confirm the location of the debris.

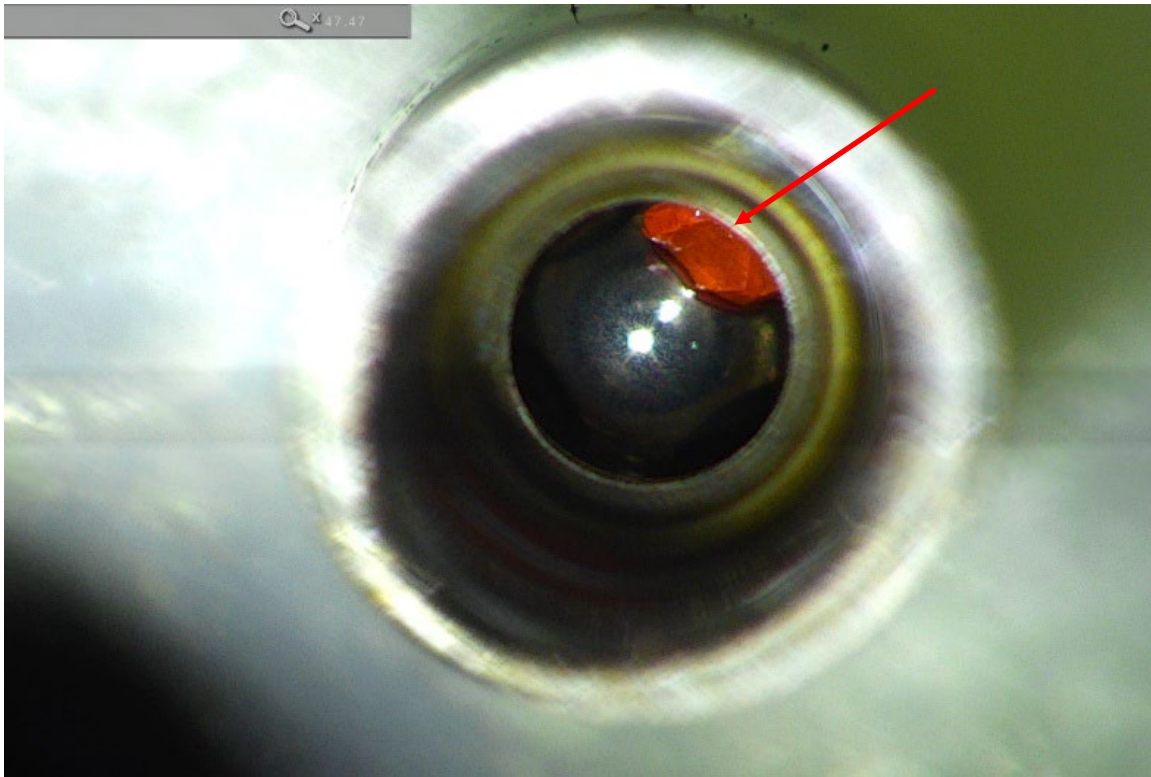


Figure 29. Red Foreign Material Inside of the Lee Valve Barrel

The CT image of the Lee valve revealed that the ball was not seated (Figure 32). The red debris could not be seen in the CT image because the debris was made of a low-density material.

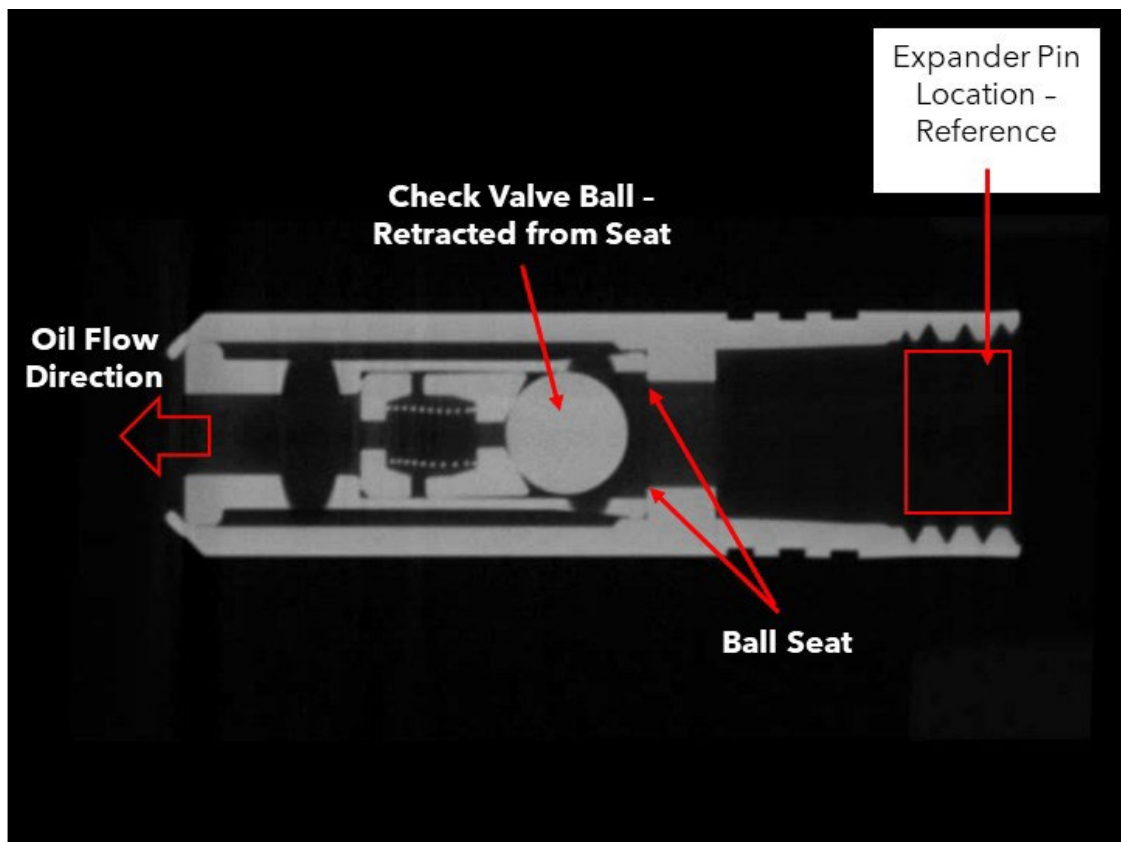


Figure 30. CT scan of Lee Valve - Ball is Not Seated

It was noted that most external fluid line connections on the engine were marked with a red colored torque stripe paint (Figure 33).

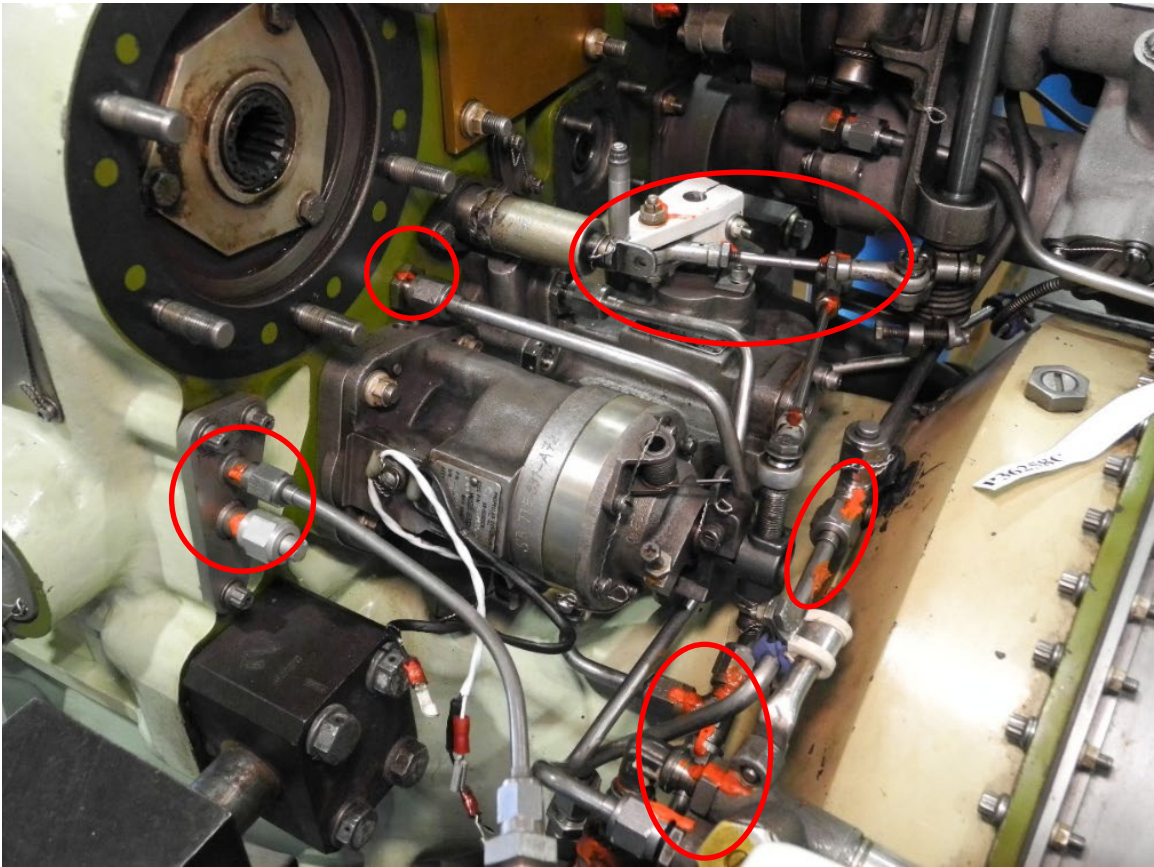


Figure 31. Engine as Received - Note Application of the Red Torque Stripe Material

8.0 Honeywell Material Analysis

The debris recovered from within the NTS valve was measured to be approximately 0.071 inches long, 0.035 inches wide and 0.025 inches thick (Figure 33).

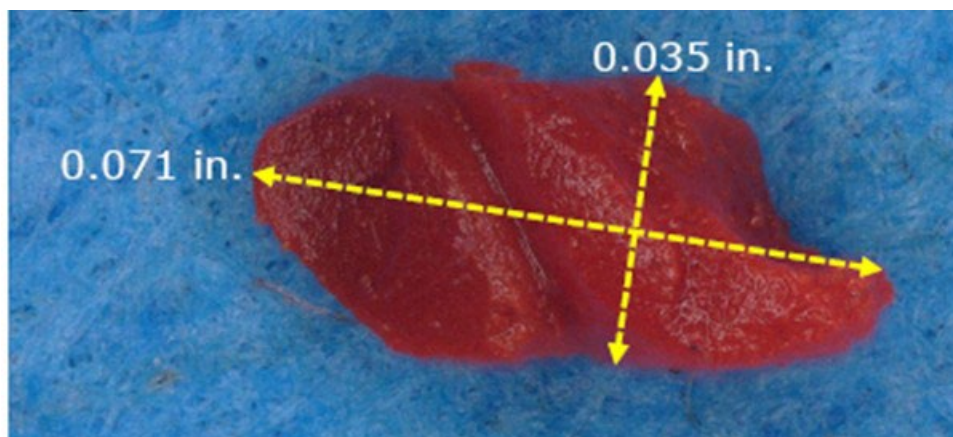


Figure 32. Dimensions of the Recovered Debris

The Lee valve with the debris and a sample of the torque stripe material from the line fittings were sent to the Honeywell materials laboratory for analysis. Fourier Transform Infrared (FTIR) analysis was performed on the debris and the torque stripe sample material which confirmed the chemical similarity between the debris and the torque stripe (Appendix 1).

9.0 Honeywell Technical Manual Information

9.1 Maintenance Manual 72-00-27 Exerts Related to Contamination

MM 72-00-27 includes a general FOD awareness note in the Standard Reassembly Procedures:

"(1) Exercise extreme care to prevent dirt, dust, and foreign particles from entering the engine. If any foreign particle is dropped into the engine during maintenance, stop work until foreign particle is located and removed, even if this may cause considerable disassembly.

(2) For added protection to the engine, cover large openings with plastic sheeting. Cap open tube ends. If the engine is to be left for even a short period in a partially disassembled state, cover or cap all openings."

MM 72-00-27 Procedure 36 in the troubleshooting guide includes instruction to check for contamination in the NTS check valve inlet (pre-SB) or replacing the NTS check valve (post-SB) as a troubleshooting step if the prop governing RPM shifts 4-8%. Additionally, the first step of PG removal instructions says "Clean area around propeller governor base to avoid introducing contaminants into orifice area under propeller governor." the PG installation instructions include a Caution statement: "THE ORIFICE AREA MUST BE CLEAN TO MAKE SURE PROPER NTS SYSTEM OPERATION."

Within the engine test section of MM 72-00-27, the following statement relative to symptoms of a clogged NTS system is included: "A PROPELLER GOVERNOR HIGH RPM SHIFT UPWARD OF 4 TO 8 PERCENT, PRIOR TO WHICH PROPELLER GOVERNOR HIGH RPM SPEED OPERATION HAS BEEN ACCEPTABLE, AND/OR FAILURE TO NTS, MAY BE INDICATIVE OF A PLUGGED NTS ORIFICE ASSEMBLY."

9.2 Service Bulletins Related to the Lee Valve

Service Bulletins (SB) TPE331-72-2164 is a Category 2 RELIABILITY service bulletin and TPE331-72-2168 is a Category 1 SAFETY service bulletin. Incorporation of

these SBs is recommended by Honeywell but not required by the FAA for continued airworthiness.

Service Bulletins TPE331-72-2164 and TPE331-72-2168, published April 13, 2010, are related to the installation of a new Lee valve. This new Lee valve contains an integral orifice, downstream of the valve's ball/seat, and an integral filter screen designed to protect the Lee valve orifice from blockage caused by oil-borne contamination. The integral filter screen within the new Lee valve (SB configuration) is contained in a flange with a diameter of 0.070 inches. For comparison, the Lee valve installed in the airplane at the time of the accident, PN 771-590-9001 (pre-SB configuration), contains an orifice with a diameter of 0.030 inches and is upstream of the valve's ball/seat.

SB TPE331-72-2168 is a Category 1, SAFETY service bulletin that provides the instructions for replacing the accessory gearbox housing assembly part numbers with the latest accessory gearbox housing assembly part number that incorporates the new NTS check valve design. The recommended compliance period is at the next hot section inspection (HSI), or at next access to the affected area with the engine removed from the aircraft, or within a period not to exceed 5 years after issue of the service bulletin (i.e. by April 13, 2015), whichever occurs first.

SB TPE331-72-2164 provides instructions to rework the accessory gearbox housing to remove the previous NTS check valve and install the new NTS check valve, which results in a part number change at the accessory gearbox housing assembly level.

These service bulletins are applicable to all TPE331-5 and -10 series turboprop model engines with a hydraulic torque sensing system and a rated propeller shaft speed of 1591 rpm at 100 percent. The event engine did not have these SBs incorporated.

Submitted by:

Harry Reichel
Aerospace Engineer - Powerplant
National Transportation Safety Board

APPENDIX 1

Testing Material

- NTSB – Lee Valve Debris. Unknown debris was removed from the check valve (PN 771-590-9001). For comparison, a piece of torque stripe from the fuel pump out fitting was submitted for testing.
 - PN 771-590-9001 Debris
 - Torque Stripe
- Request is to perform FTIR analysis on the unknown debris and compare it to the provided sample.

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Test Procedure

- Fourier Transform Infrared (FTIR) analysis was requested on the samples.
- The unknown debris was initially analyzed without any prior cleaning, using the FTIR-Attenuated Total Reflectance (ATR) technique. Its spectrum showed minor oil peaks mixed in with the debris peaks. IPA was then used to clean the sample before being re-tested. Each sample was placed over the diamond window and lightly compressed with the pressure arm before being analyzed.
- Each spectrum contains 64 scans at 4cm-1 resolution.
- The technique was performed on a Nicolet-series Spectrometer.

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APPENDIX 1

Test Results

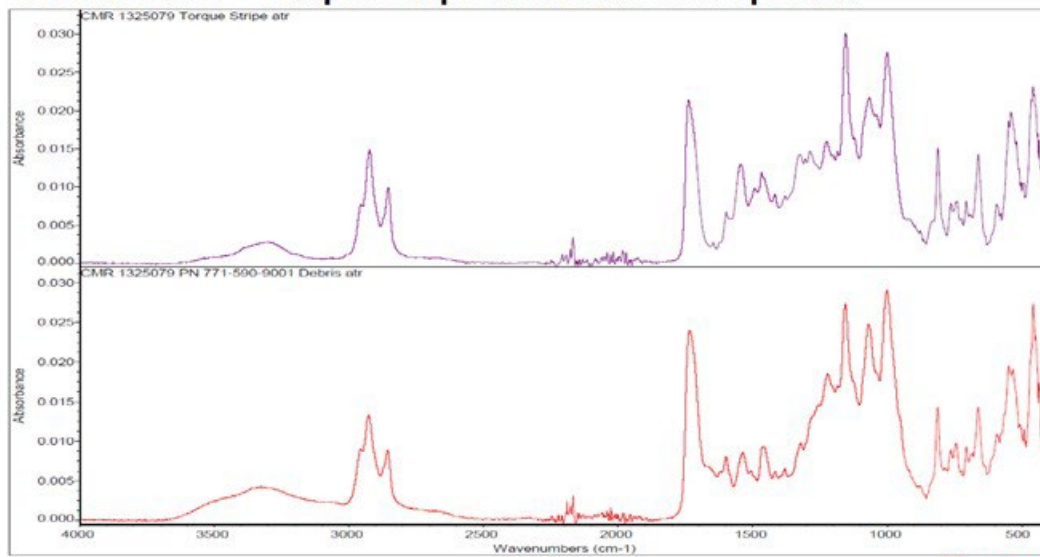
- The PN 771-590-9001 Debris atr spectrum was similar to the Torque Stripe atr spectrum.
- The Torque Stripe atr spectrum was similar to Acrylic spectra, such as an Acrylic Resin, from the KnowItAll/Wiley database.
- Both samples' atr spectra were similar to each other.

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Test Results – Torque Stripe and Debris atr spectra



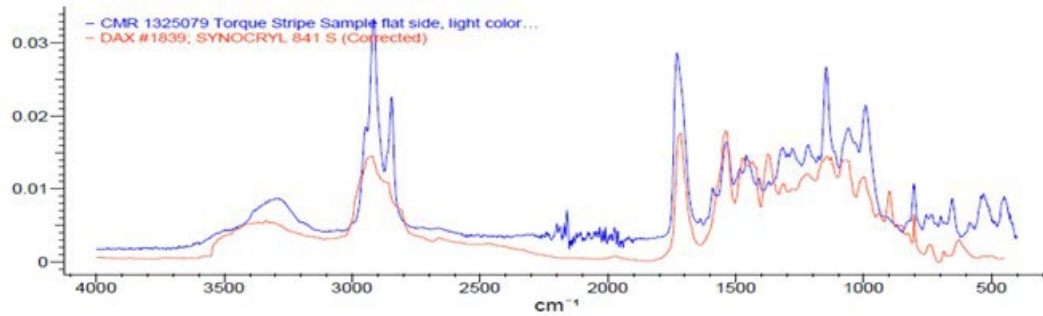
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APPENDIX 1

Test Results – Torque Stripe atr spectrum similar to an Acrylic Resin spectrum WILEY



HQI	Tag	rect	DB	ID	Name	Spectrum	Chemical Description
78.52			DAX	1839	SYNOCRYL 841 S		THERMOSETTING ACRYLIC RESIN

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