

CEN21LA237

POWERPLANTS

Group Chair's Factual Report - Attachment #1

Woodward Fuel Control Teardown Report and As Received Test Run Sheets

February 28, 2023

CUSTOMER HONEYWELL ENGINES & SYSTEMS		INVESTIGATION NO 1181324-1	
CUSTOMER ORDER Crash Investigation	WOODWARD SALES ORDER 3821494	WOODWARD WORK ORDER C106569	
CUSTOMER REJECTION DOCUMENT (CAR, QN, RFA, DMR, ETC.) N/A	WARRANTY DISPOSITION N/A	PRODUCT STATUS N/A	
PROGRAM/ENGINE TYPE GARRETT		ITEM RECEIVED 8070-166	ENGINE MFR MODEL RECEIVED N/A
PROGRAM CODE 82228	SERIAL NUMBER 893305	ITEM SHIPPED 8070-186	ENGINE MFR MODEL SHIPPED N/A
PARENT ITEM NUMBER 8070-186	PARENT ITEM SERIAL NUMBER 893305	FIRST SHIPPED	LAST SHIPPED
CUSTOMER SERIAL NUMBER N/A	APPLICATION N/A	VESSEL TYPE & VESSEL NUMBER Grumman G-164B, N8376K	SITE & LOCATION GRID ID N/A
TIME/CYCLES SINCE NEW, OVERHAUL, OR REPAIR N/A			
DATE REPORT OPENED 07-SEP-2022		DATE PART REMOVED N/A	DATE RECEIVED 23-AUG-2022

TEAM MEMBERS (D1)

Product Engineer: Brandon Bolley
 Customer QA Engineer: Jean Taylor
 Tech Advisor/Reviewer: Jeffrey T. Sympson
 Customer Account Manager: Charles J. Johnson
 Customer Service Rep: SHANNON L. COTE
 Product Integrity Coordinator: James D. Rosplock

REASON FOR INVESTIGATION (D2)

Reported Issue: On May 27, 2021, about 0750 central daylight time, a Grumman G-164B airplane, N8376K, was substantially damaged when it was involved in an accident near Celina, Ohio. The pilot sustained serious injuries. The airplane was operated as a Title 14 Code of Federal Regulations Part 137 aerial application flight. The pilot stated that he departed on the local flight with about 80 gallons of Jet-A aviation fuel and a 240-gallon mixture of fungicide and insecticide. The winds were light out of the east with a few clouds 3,000-4,000 ft above ground level. The pilot stated that shortly after takeoff from runway 8 he felt the engine lose thrust, but the engine speed remained at 100% according to the airplane's cockpit indicator. The pilot established best glide speed and began a slight right turn to avoid trees. He then jettisoned the chemical load in an attempt to maintain altitude, but the airplane descended into a waterway about 200 yards south of the departure end of runway 8. An examination of the propeller revealed it remained attached to the engine propeller shaft flange, and all three blades remained attached to the propeller assembly. All three blades exhibited leading edge gouging, chordwise/rotational scoring on both camber and face sides, bending aft and twisting towards low pitch. All three blades had 3-5 inches of the tip fractured/separated. All observed damage was consistent with impact while the propeller was rotating under power and with high impact forces.

INVESTIGATION SUMMARY (D4)

Confirmation Text: REASON FOR INVESTIGATION/RETURN NOT RELATED TO DISCREPANCY FOUND
 Discrepant Item Number: 8070-186
 Discrepancy: MECHANICAL PERFORMANCE/FUNCTION/TESTING NOT TO SPEC
 Finding: OUTSIDE FUNCTIONAL LIMITS
 Conclusion:

The unit was returned with customer fittings, power lever and speed lever linkages, pressurizing valve assembly, and the Tt2 sensor still installed. The Tt2 sensor and customer hardware was removed and a visual as-received inspection was performed. Foreign lockwire was found on the cover screws, flight idle plug, max power plug, and speed setting stop screws. Woodward lockwire was present on the power lever screws, CDP cover, Pt2 cap, and Pt2 bellows.

Minor damage was observed on the housing near the Pt2 bellows (see Figure 1) and one of the attachment screws was missing with damage to the main cover (see Figure 2). The inlet fuel filter and the inlet transfer tube that mates with the fuel pump were also missing. The power lever, speed setting lever, and drive shaft were all free to rotate normally.



Figure 1. Damage to Housing



Figure 2. Damage to Main Cover

A slave inlet filter and transfer tube were installed and the unit was installed on the test stand for as-received testing. During initial startup a steady leakage was observed from the overboard drain port at low boost pressure (approximately 5 psi). Boost pressure was increased to the normal setting of 15 psi and the leakage decreased.

The Standard Day Acceleration Schedule was run and all test points were found to be significantly high out of limits. It was observed that discharge flow and P1-P2 pressure increased with increasing speed input. Additional testing was then performed by increasing the Ps3 pressure setting in increments of 20 psi at select speed conditions and recording the P1-P2 pressure and discharge flow. Results are shown in Table 1. The data shows that the discharge flow changed in response to speed and P1-P2 pressure instead of Ps3 pressure. However, the Ps3 system was functioning normally based on Decel schedule test results. The Tt2 simulator was adjusted to the set points for the Hot Day and Cold Day Accel schedules and did not have a significant effect on discharge flow. The vacuum pump could not lower Pt2 below 11 psi due to damage on the housing near the Pt2 bellows therefore the Accel schedules at altitude conditions could not be tested.

TSP-8516	Input Speed (rpm)	Ps3 (psia)	P1-P2 (psid)	Discharge Flow (pph)
T.P. 1.5	1000	20	17	184
	1000	45	13	168
T.P. 1.6	2200	25	66	410
	2200	45	66	436
	2200	65	63	438
	2200	85	63	436
T.P. 1.7	3000	45	86	499
	3000	65	92	530
	3000	85	92	530
	3000	105	92	527
T.P. 1.8	3600	65	100	557
	3600	85	>100	558

Table 1.

The bypass valve was then removed for inspection. The purpose of the bypass valve is to maintain a constant pressure differential (P1-P2) across the metering valve and bypass excess flow back to the fuel pump. The bronze bypass plug (see Figure 3) was stuck in the valve sleeve but the plug does not move during operation, therefore it would not have affected the function of the valve. The valve piston was free to move smoothly. The o-rings on the bypass valve sleeve were found to be red fluorosilicone and were visibly compression set. Woodward began using blue fluorosilicone o-rings instead of red fluorosilicone in 1983 due to the blue o-ring material being less susceptible to compression set. The o-rings were replaced and the unit was re-tested. There was no change in performance on the Standard Day Accel schedule. The bypass valve was then replaced with a valve from an engineering house unit. The Standard Day Accel schedule was rerun and no significant change in performance was observed. Rich fuel flows on the Accel schedule would not contribute to the reported loss of thrust. The Accel schedule limits fuel flow during start and acceleration of the engine up to the required engine speed. At takeoff the engine speed is controlled by the propellor governor and fuel flow is determined by the power lever schedule.

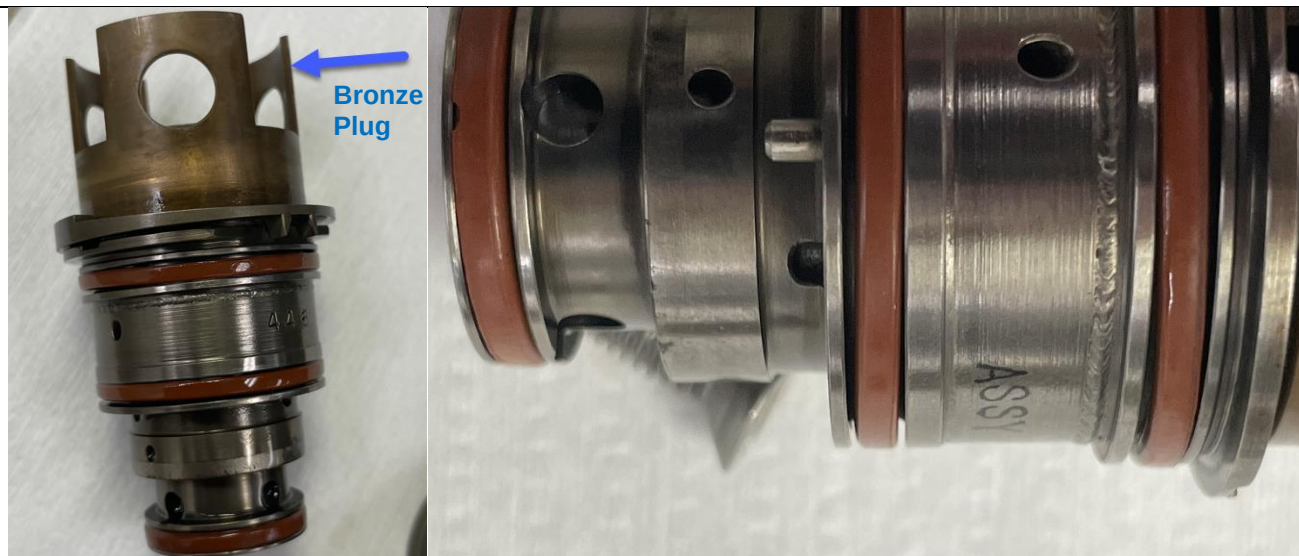


Figure 3. Bypass Valve

The original bypass valve was reinstalled and the remainder of the TSP was performed. The Underspeed Governor minimum stop setting was found to be set at 5 degrees (Limits: 3 +/- 3 degrees). At this setting the Underspeed Governor 65% Speed Schedule had rich fuel flow of 125 pph (Limits: 90 to 100 pph). The rich fuel flow at 65% speed is consistent with a higher USG min stop setting. To achieve the required fuel flow the control had to be run at 65.7% speed.

The Underspeed Governor 97% Speed schedule had lean fuel flow of 118 pph (Limits: 165 to 175 pph). To achieve the required fuel flow the control had to be run at 95.8% speed. The Overspeed Governor schedule had lean fuel flow at both 103.5% speed and 105.8% speed. At 103.5% speed the fuel flow was 180 pph (Limits: 190 to 210 pph). At 105.8% speed the fuel flow was 103 pph (Limits: 104 to 114 pph). These minor out of tolerance conditions are not considered significant.

The Decel schedule was low out of limits by up to 35%, but discharge flow did decrease as expected with decreasing Ps3 pressure. Low discharge flow on the Decel schedule would not contribute to the reported loss of thrust on takeoff.

The Power Lever schedules were out of limits with the Max Power setting at 418 pph (Limits: 450 to 470 pph) and the Flight Idle setting at 140 pph (Limits: 170 to 180 pph). These are considered normal customer adjustments and it was noted during the visual as-received inspection that there was foreign lockwire in these locations. The Tt2 Correction schedule was low out of limits consistent with the low fuel flows of the nominal Max Power and Flight Idle settings. Since Pt2 could not be lowered below 11 psia the Power Lever Pt2 Correction schedule could not be run.

The unit was then disassembled for inspection. In general, all internal parts appeared to be in good condition. All springs were intact, all bearings and levers moved freely, and no broken parts were observed. The o-rings throughout the control were red fluorosilicone and showed evidence of compression set.

No cause for the high Accel flows was found during disassembly. The Accel linkages and the fuel valve were carefully inspected and no evidence of binding, damage, or abnormal wear was observed. The Ps3 Sensor rolling diaphragm was inspected and found to be in good condition.

ROOT CAUSE (D4)

Origin of Cause: OTHER
General Cause: No Cause Found
Cause: Cause Not Isolated or Determined

CORRECTIVE ACTION PLAN (D5)

General Corrective Action: None Required
Specific Corrective Action: None Required

CORRECTIVE ACTION IMPLEMENTATION (D6)

Corrective Action Status: NO ACTION

WOODWARD GOVERNOR COMPANY
Rockford, Illinois
CAGE 66503

TSP-3516
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Rev. NEW

Case No. _____

W.G.C. Order _____

Date 08-25-2022

Customer Allied Signal

By Xavier Olson

Prod. Order _____

Allied Signal P/N 869199-14, -18, -19, -21, -25, -29

T2 Simulator _____

W.G.C. S/N 893305

Test Stand No. 184

REF. DOCUMENTS:

Allied Signal PSC No. 869199-N

W.G.C. Acceptance Test Spec. TSP-1629

For Model 8070-081, -086, -087, -116, -166

W.G.C. Acceptance Test Spec. TSP-1569

For Model 8070-170

All input settings should consistently be made while approaching set points as follows:

- PT2 Approach all inlet pressure settings from a lower pressure setting.
- TT2 Approach all inlet temperature settings from a higher temperature setting.
- PS3 Approach all compressor pressure settings from a lower pressure setting except when checking deceleration schedules or hysteresis.
- MFL Approach all manual fuel lever angular settings from a lower setting.

PRESSURE TEST

Operate unit at the underspeed governor minimum set point. Actuate fuel discharge shutoff valve. Do not shut off discharge flow for more than 2 seconds.

Checked By _____

1 STANDARD ACCELERATION SCHEDULE

Sea level start flow checking procedure: (Test pt. 1.2 only)

Start flow is to be accomplished in the following sequence:

CAUTION: At no time in this calibration procedure is PT2 to be set above PS3.

- A. Preset speed, TT2. Underspeed governor lever, main metering valve lever as specified on data sheet.
- B. Set PS3 at 20 psia Min.
- C. Set PT2 from a low pressure to the required set point without overshoot.
- D. Reset PS3 to 15 psia without undershoot.
- E. Read start fuel flow.

Hold Constant: TT2 = 59 deg. F PT2 = 14.7 psia											
Test Point	Inlet Flow pph Ref.	Req'd Lever Positions (deg.)		Input Speed RPM ± 25	PS3 psia	Pfn psig	Wf - pph			Hysteresis	
		USG	MFL				Req'd	Actual↓	Actual↑	Spec.	Act.
1.1	150	Min.	0	450	15	85	Record	5	---	---	---
1.2	350	Min.	0	1000	15	85	46 ± 2	185	---	---	---
1.3	350	Max.	0	1000	15	85	46 ± 2	185	---	---	---
1.4 **	350	Min.	0	1000	18.2 ± 1	85	46 ± 2	185	---	---	---
1.5 ***	350	Min.	0	1000	20.1 ± 1	200	70	185	---	---	---
1.6	800	Max.	0	2200	25	215	104 ± 3	409	---	---	---
1.7	1150	Max.	0	3000	45	250	189 ± 7	499	---	---	---
1.8	1400	Max.	0	3600	65	290	256 ± 10	562	---	---	---
1.9	1550	Max.	0	4000	85	335	307 ± 12	569		3	---
1.10	1550	Max.	0	4000	105	410	379 ± 14	569		6	---
1.11	1550	Max.	0	4000	116	500	452 ± 18	568	---	---	---
1.12	1550	Max.	101	4000	130	610	515 ± 10	568	---	---	---

REMARKS: ** With Wf as specified, increase PS3 until Wf starts to increase. Record PS3.

*** Adjust PS3 from a lower setting to a higher setting for exact Wf of 70 pph. Record PS3.

5 COLD DAY ACCEL SCHEDULE

Hold Constant: TT2 = -60 deg. F PT2 = 14.7 psia								
Test Point	Inlet Flow Ref.	Req'd Lever Positions (deg.)		Input Speed	PS3 psia	Pfn psig	Wf = pph	
		USG	MFL	Req'd	Req'd	Req'd	Req'd	Actual
5.1	350	Min.	0	1000	15	80	44 ± 6	
5.2	1150	Max.	0	3000	45	245	166 ± 6	
5.3	1450	Max.	0	3800	75	300	249 ± 10	
5.4	1550	Max.	0	4000	105	370	334 ± 13	
5.5	1550	Max.	0	4000	116	435	396 ± 16	

6 UNDERSPEED GOVERNOR 65% SPEED

Hold Constant: MFL = 0 deg. TT2 = 59 deg. F PT2 = 14.7 psia								
Test Point	USG Lever Positions		Input Speed ± 5	Inlet Flow	PS3 psia	Pfn psig	Wf = pph	
	Req'd deg.	Actual	Req'd	Ref.	Req'd	Req'd	Req'd	Actual
6.1	3 ± 3	5	2847 Min.	1100	45	235	145 Min.	224
6.2	3 ± 3	"	2948	1100	42	235	95 ± 5	125
6.3	3 ± 3	"	2970	1100	42	235	*	107
6.4	3 ± 3	"	2948	1100	42	235		126

REMARKS: * A Min. of 5 pph less than the fuel flow at data point 6.2.

7 UNDERSPEED GOVERNOR - 97% SPEED

Hold Constant: MFL = 0 deg. TT2 = 59 deg. F PT2 = 14.7 psia								
Test Point	USG Lever Positions		Input Speed ± 5	Inlet Flow	PS3 psia	Pfn psig	Wf = pph	
	Req'd deg.	Actual	Req'd	Ref.	Req'd	Req'd	Req'd	Actual
7.1	40 ± .25	40	4287 Min.	1650	110	400	340 Min.	274
7.2	40 ± .25	"	4400	1700	102	305	170 ± 5	4344
7.3	40 ± .25	"	4420	1700	102	305		108
7.4	40 ± .25	"	4400	1700	102	305		109
7.5	14 ± 1	14	3400**	1300	55	250	110 ± 3	69110

REMARKS: ** Set speed and fuel flow. Record speed lever angle. Req.: 14 ± 1 deg.

8 OVERSPEED GOVERNOR

Hold Constant: MFL = Max. TT2 = 59 deg. F PT2 = 14.7 psia							
Test Point	USG Lever Positions	Input Speed ± 5	Inlet Flow Ref.	PS3 psia	Pfn psig	Wf = pph	
	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Actual
8.1	Max.	4536	1800	118	510		406
8.2	Max.	4581	1800	118	510	*	401
8.3	Max.	4695	1800	118	330	200 $\pm$ 10	1800
8.4	Max.	4800	1800	118	310	109 $\pm$ 5	103
8.5	Max.	4800	1800	118	310	**	77
8.6	Max.	4695	1800	118	330	Record	183

REMARKS: *10 pph Max. drop from the actual flow of preceding data point 8.1.

** Record fuel flow with MFL at Min. position.

9 DECELERATING SCHEDULE

Hold Constant: MFL = 0 TT2 = 59 deg. F Inlet Flow = 1800 Ref. Speed = 4536 RPM USG = Min.					
Test Point	PT2 psia	PS3 psia	Pfn psig	Wf = pph	
	Req'd	Req'd	Req'd	Req'd	Actual
9.1	14.7	117	315	160 $\pm$ 5	117
9.2	14.7	75	270	108 $\pm$ 5	67
9.3	4.4	25	170	Record	

10 MAIN METERING VALVE SCHEDULE - TT2 CORRECTION

Hold Constant: Inlet Flow = 1800 pph Ref. Speed = 4536 RPM PT2 = 14.7 psia USG = Max.										
NOTE: Approach all MMV settings from a lower lever setting.										
Test Point	MFL Position ± .5 deg.	TT2 deg. F	TT2 Mike	PS3 psia	Pfn psig	Wf = pph				
						Req'd	Act. ↓	Act. ↑	Hysteresis	
									Spec.	Actual
10.1	101	130	.839	140	435	370 ± 10	326	---	---	---
10.2	101	103	.823	140	480	405 ± 10	353	360	8	7
10.3	101	59	.800	140	535	460 ± 10	418	---	---	---
10.4	101	59	.800	140	535	*	414	---	---	---
10.5	40	103	.823	75	275	164 ± 6	131	---	---	---
10.6	40	59	.800	75	280	175 ± 5	140	140	3	0
10.7	40	-60	.735	75	285	218 ± 8	192	---	---	---

REMARKS: * Record flow change when USG lever is changed from the Max. speed stop to the Min. speed stop. The change in flow must not exceed 10 pph.

11 MAIN METERING VALVE SCHEDULE - PT2 CORRECTION

Hold Constant: Inlet Flow = 1800 Ref. Speed = 4536 RPM TT2 = 59 deg. USG = Max.									
NOTE: Approach all MMV settings from a lower lever setting.									
Test Point	MFL Position ± .5 deg.	PT2 psia	PS3	Pfn psig	Wf = pph				
					Req'd	Actual ↓	Actual ↑	Hysteresis	
								Spec.	Actual
11.1	101	4.4	55	260	137 ± 6		---	---	---
11.2	101	8.8	140	380	275 ± 10		---	---	---
11.3	101	14.7	140	535	460 ± 10			7	
11.4	40	6.8	22	220	Record		---	---	---
11.5	40	8.8	30	230	105 ± 5		---	---	---
11.6 *	40	14.7	75	280	175 ± 5			3	
11.7	40	17.6	75	280	208 ± 5		---	---	---

REMARKS: * Adjustability range approximately ± 10 pph Actual + _____ - _____.