

INVESTIGATION/8D REPORT

Class 1 Published: 4-APR-2014

CUSTOMER				INVESTIGATIO	N NO
HONEYWELL ENGINE	S & SYSTE	MS			
CUSTOMER ORDER		WOODWARD SALES ORDER		WOODWARD V	VORK ORDER
NONE					
CUSTOMER REJECTION DOCUMENT (CAR,QN	,RFA,DMR,ETC.)	WARRANTY DISPOSITION		PRODUCT STA	TUS
N/A		N/A		N/A	
PROGRAM/ENGINE TYPE		•	ITEM RECEIVED	•	ENGINE MFR MODEL RECEIVED
GARRETT			8070-604		N/A
PROGRAM CODE	SERIAL NUMBI	ER	ITEM SHIPPED		ENGINE MFR MODEL SHIPPED
82228	1440	0734	8070-604		897800-4
PARENT ITEM NUMBER		SERIAL NUMBER	FIRST SHIPPED		LAST SHIPPED
8070-604	1440	0734	23-NOV-1984		23-NOV-1984
CUSTOMER SERIAL NUMBER	APPLICATION		VESSEL TYPE & VESSEL NUMB	ER	SITE & LOCATION GRID ID
306	TPE	331	MU-2B-25, N8	56JT	N/A
TIME/CYCLES SINCE NEW, OVERHAUL, OR RE	PAIR				·
N/A					
DATE REPORT OPENED		DATE PART REMOVED		DATE RECEIVE	ED
24-JAN-2014		N/A		14-J	AN-2014

TEAM MEMBERS (D1)



PROBLEM DESCRIPTION (D2)

Reported Problem: UNIT WAS REPORTEDLY INVOLVED IN AN INCIDENT IN OWASSA, OK ON NOVEMBER 10, 2013

CONTAINMENT/IMMEDIATE ACTIONS (D3)

N/A



INVESTIGATION SUMMARY (D4)

The unit was inspected upon removal from the shipping container. The investigation was under the oversight of the NTSB and FAA. Unit had impact and fire damage. The unit cover was dented in the cover and cracked due to impact damage. The housing around the Pt2 bellows was dented inward. The unit had lock wire which indicate the unit was not last worked on by Woodward as the lock wire did not have Woodward marked seals on it.

Initial Testing

The unit was installed on a test stand and the acceptance test was run. The test run results are shown in Appendix 1.

Acceleration Schedule

The data showed the sea level acceleration schedule had a Pt2 bias. (This was later determined due to the Pt2 bellows having a leak caused by fire damage). The altitude acceleration was not run due to the leak in the cover. The test stand could not depressurize the control due to the leakage of the cover and the lack of capacity of the vacuum pump. The hot and cold day acceleration schedules were run and the results showed the acceleration schedule was biased by the same Pt2 pressure shift due to the bellows. The flows matched the cam profile at station 0 which is at a 0 psia Pt2 pressure condition.

The acceleration schedule showed a high level of hysteresis. Test point 3.7 indicated the flow hysteresis was 54 pph. This is normally 5 pph. This was caused by the friction in the P3 (Compressor discharge pressure (CDP)) sensor. When the bellows lost its evacuation, the bellows drives the acceleration cam against the wall of the housing. The cam rubbing against the housing causes the CDP sensor to have drag and not schedule consistently and to have high hysteresis. This corresponds to about 7 psi to 10 psi. (This was not evident in test point 3.9 for this test point is on a flat of the cam at the Pt2 bias of the leaking bellows so the hysteresis cannot be measured with fuel flow.)

Decel Schedule

The decel schedule was high above the overhaul test point limits throughout the schedule. This is most likely due to the hysteresis in the CDP sensor. The flows are on average 10 pph above the high limit of the overhaul test point limits. With the 10 psi shift high in CDP sensor this would account for 9 pph of the shift.

Underspeed Governor Schedule

The unit was run at 65% and 96 % governor settings. Both of these settings tested above overhaul test point limits. The 65% underspeed governor point appears to have been set at 74.3% when the unit was set at a speed that corresponded to the 108 pph set point. Data from the rigging instructions on the aircraft normally set the low idle speed setting at 75%. This setting appears to be a rigging adjustment. The 96% governor setting was run and also was higher than the test point limit. The graph below shows the governor test points. The 96% underspeed governor speed to obtain 180 pph was 4582 CRPM (which is actually on the decel schedule). The graph shows the 96% underspeed governor (96% underspeed) operated about 90 rpm or 1.9% above the nominal setting. In addition, the graph shows the governor setting was interfered with by the decel schedule. Since the decel schedule is high due to the CDP sensor hysteresis described above, the full range of the underspeed governor could not be tested before the decel limit was obtained.



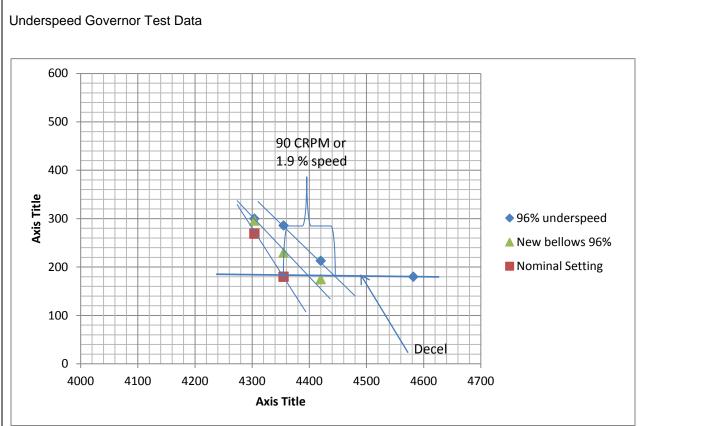


Figure 1

The engine is rigged with a 5% separation between the propeller governor and the underspeed governor. This shift of 1.9% would not have caused an issue on the aircraft.

It should be noted the test point 9.1 did not line up on the governor line for the 96% underspeed test points. Further testing described in later runs of the control found there was a hysteresis in the governor setting. By cycling the power lever (Manual Fuel Valve MFV) the underspeed governor setting would reduce by 39 CRPM. This appears to be why this point is not on the governor set point line. This first point does not show the hysteresis but the following point exhibit the characteristic. It is unknown if this hysteresis would be evident on the engine as the vibration on the engine would be more than on the test stand, but this would most likely make the 1.9% shift less.

Overspeed Governor

The overspeed governor test was set to 4695 rpm to meet the 220 pph required for test point 10.3 This is low by 0.5% speed of the 104% set point. This variation in set point would not have been identified or observed during normal operation of the unit.

Power lever schedule

The power lever schedule was run and found to be below overhaul test point limits at most test points. This is due to the Pt2 bias caused mostly by the leak in the Pt2 sense bellows. This reduction matches the output of the unit with a bellows leak. Power lever schedules with correction for altitude were not run due to the cover and bellows condition.



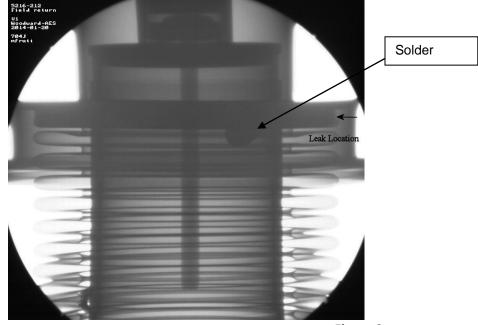
Partial Disassembly

The unit was removed from the test cell and the cover and Pt2 bellows removed. It was determined the unit would be retested with a new cover and a new bellows assembly (as it was determined by inspection the bellows was longer than it should be at a near sea level condition). The housing had impact damage at the Pt2 bellows bore and was machined to allow a new bellows to be installed. Additional notes of the assembly showed the nameplate which is attached with a high temperature epoxy was heat damaged. The epoxy is specified to withstand short term exposure to temperatures of 400 degrees F and the cover appears to have seen temperatures above the 400 degree F condition.

Pt2 Sense Bellows Disassembly and Inspection

The bellows was machined to allow the insert of a capillary tube into the cap of the assembly. A capillary tube was epoxied into cap. The capillary tube was pressurized with helium and put in a tank of MIL-PRF-7024 fluid to inspect for leaks. There was a leak observed at the joint between the cap and the end of the bellows. (The bellows is attached to the end cap using solder whose eutectic temperature is 430 degrees F.)

The bellows was x-rayed to inspect the integrity of the bellows and for any abnormalities. The x-ray showed there was a solder flow deposit on the inside of the cap. This deposit would have been rejected if it were there during the manufacturing process. This x-ray was compared to the x-rays from the production lot inspection. The comparison showed that none of the bellows from the manufacturing lot had a solder deposit as shown on the incident unit. It is concluded the solder joint degraded in the post crash fire.





Retesting of the unit with New Pt2 sense bellows and Cover

The test results for the unit are in appendix 2.

Acceleration schedule

The results showed the acceleration test points section 3.0 through 7.0 were within a 4 pph of overhaul test point limits except for 3.11 which was 13 pph low and 7.5 which was 7pph low. This shows the acceleration schedule and the Pt2 bias and temperature bias were functionally acceptable with the new cover and bellows assembly. The two test points appear to be low due to the low setting of Maximum flow stop on the unit but this was not verified as it was not pertinent to the investigation.



Decel Schedule

The decel schedule was within test point limits.

Underspeed Governor Schedule

The 65% speed setting was still high. The speed necessary to obtain the fuel flow of 108 pph in this configuration was not tested. The results of the 96% setting are shown in figure 1. The test results were about 1% lower than the initial run and about 1% above the nominal setting. It is believed the difference between this run and the initial was due to hysteresis which was observed in the initial run and identified in the final test run.

Overspeed Governor Schedule

The overspeed governor set point was still low. The speed necessary to obtain the fuel flow of 220 pph in this configuration was not tested.

Power Lever Schedule

The power lever schedule improved from the initial run however schedule did not come into overhaul test point limits. It was determined the unit still had a Pt2 bias on the of the power lever schedule. The control linkage which sets the multiplication for the Pt2 bias had shifted. The unit was disassembled to determine the amount of shift of the power lever shaft bias. An indicator WT-68705 S/N 3 was installed on the unit. It was determined the required dimension (L2) which determines position of the lever had shifted .097 in. (C-A dimension was .438, requirement is .530-.540.) This will happen during operation of the bellows in the un-evacuated condition. In the un-evacuated condition the Pt2 bellows amplifier overpowers a torqued adjustment in the unit and changes this set point. This can also happen due to impact loads on the unit. This was the cause of the shift in the power lever test points.

Reassembly of Unit and Retest

The unit was reassembled to further investigate the underspeed governor condition. The results of the test run are in appendix 3. The results show the unit repeated consistently after reassembled. The only difference of note was the decel schedule decreased by about 12 pph. This is expected as the decel adjustment screw needs to be removed to measure the L2 dimension. This also changed the flow allowed in test point 9.4 of the underspeed governor.

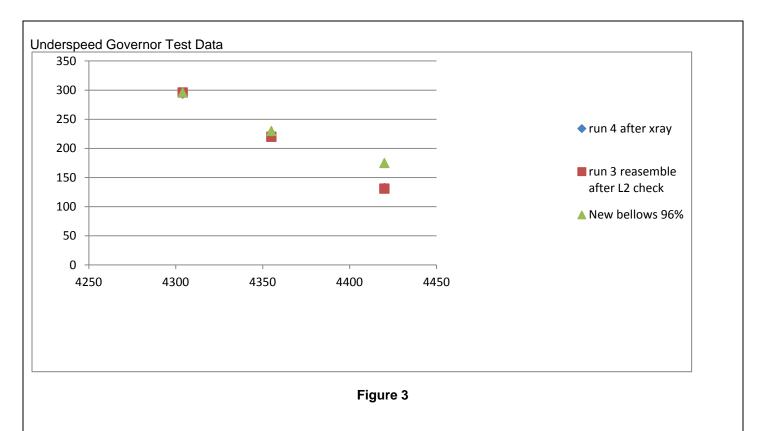
X-ray of unit

The unit was x-rayed to determine if there was anything unusual in the underspeed governor assembly area. Nothing was observed that indicated any anomaly with the operation of the assembly.

Retest of unit

The unit was reinstalled on the test stand and the results of the test are shown in appendix 4. The units repeated very closely with the before the x-ray run. The underspeed governor data plots are shown in figure 3. The plot contains the data from the replacement of the Pt2 bellows in the second run of the unit and runs 3 and 4. The plot shows the underspeed governor setting was the same except for when the decel schedule interfered with the low flow settings.





Further testing was completed at the underspeed governor setting. The underspeed governor was set by setting the other parameters in different orders in order to try to see if a different value of the underspeed governor could be obtained. P3 was set high and reduced slowly, the power lever was cycled, and Pt2 was adjusted to various conditions. The governor remained consistent except is was noted that if the P3 was set high, the initial underspeed governor set point would be high by 39 crpm and then cycling the power lever would decrease underspeed governor set point to the value in the test run. The phenomenon was recreated numerous times. This seemed to coincide with the original run which was about 1% higher. No cause for the 1% speed shift was determined.

Conclusions

The unit was damaged by fire and impact but functioned normally when the bellows and cover were replaced. The shift in the power lever schedule was caused by operating the Pt2 bias in an out of specification condition caused by the leak in the Pt2 bellows or due to impact. Resetting this to the 0.535 inch dimension would cause the power lever schedule points to be close to overhaul test point limits. No other anomalies were observed on the unit which would have prevented proper operation.

Appendix 1

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éı	Work Order: 9265758 Test Type: AR	Record	Case SN	USG PL PL	N£ N£	эм Эм	M£ M£ =WP_1-WP_2	WE WE_3-WF_4 ME_3-WF_4 WE	141 141 141 141	ल्स लन्द जन्द	VZE ME WE	W MA MA MA MA	WE ME ME	
NOODMAAD GOVENNOR COMPANY COCREDED, IL CAGE 66503 Desc: TSP - HONEYMELL TPE331 FCU ACCEPTANCE TEST Date: 26-DRR-2014	RESULTS FRINT REPORT Run No: 3 Run Status: F		UMBER	USS AND PL MIN AND MAX SETTINGS USS Min PL Min PL Min PL Max	SIERATION SCHEDULE al al - Sea level start	a a z	el el 11 Eysteresis	Standard Accel Standard Accel Standard Accel Standard Accel Hysteresis Standard Accel Standard Accel	ACCEL SCHEDULE Accel Accel Accel Accel Accel	ACCEL SCHEDULE Accel Accel Accel	aringana	EL SCREDULE el el el	UNDERSPEED GOVERNOR 65% SPEED Underspeed Governor 55% Speed Underspeed Governor 65% Speed Underspeed Governor 65% Speed	
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Page 2 of 3 3/26/2014 FAIL FAIL P FAIL FAIL FAIL F P FAIL FAIL FAIL FAIL FAIL P P FAIL FAIL FAIL FAIL FAIL EALL P FALL FALL FAIL FAIL P FAIL F FAIL F FAIL 4 Δ. 14.0 635.0 (Calc) 181.0 190.0 325.0 411.0 (Calc) 52.0 567.0 (Calc) 134.0 725.0 545.0 (Calc) 230.0 114.0 199.0 (Calc) 144.0 (Calc) (Calc) (Calc) 246.0 (Calc) (Calc) (Calc) 550.0 (Calc) 159.0 100.0 80.0 483.0 545.0 166.0 596.0 547.0 10.0 1116.0 226.0 4.0 725.0 185.0 215.0 230.0 15 **4.0** 219.0 45 37 97 102 3 5 296.0 220.0 131.0 214.0 11 533.0 526.0 189.0 97.0 198.0 536.0 536.0 536.0 0.0 536.0 230.0 242.0 242.0 205.0 537.0 537.0 537.0 0.0 0.0 280.0 280.0 280.0 0.0 278.0 137.0 142.0 76.0 57.0 433.0 396.0 37.0 478.0 45.0 46 38 96 102 ო œ -14.0 619.0 (Calc) 171.0 180.0 238.0 (Calc) 104.0 179.0 (Calc) (Calc) (Calc) (Calc) (Calc) (Calc) (28.0 (Calc) 522.0 (Calc) (Calc) 315.0 381.0 22.0 537.0 104.0 252.0 175.0 50.0 2210.0 13 50.0 521.0 210.0 463.0 525.0 154.0 558.0 527.0 -10.0 106.0 216.0 -4.0 -4.0 199.0 145.0 36.0 66.0 ~ 0 WF_20 WF_21 WE_15 WE_16 WE_12 WE_10 WE_11 WE_13 WE_14 WF_22 WE_17 WE_18 WE 7 WE 23 WE 8 WE_6 WE_9 ni dl ni dl ni dl ದೇರ ದೇರ ದೇರ ųdd ųdd qdd qdd qdd uqq dq ಗರ್ಧ ಗರ್ಧ ಗರ್ಧ ಗರ್ಧ hđđ pph pph deg deg ಗದ್ಗ ಗದ್ಗ ಗದ್ಗ udd udd ųđđ WE WÉ ME =WE_15-WE_16 ME ME_17-WE_18 =WE_17-WE_18 =NF_10~WF_11 Wf Wf -WF_13-WF_14 Wf WE ME =WE_20-WE_21 WE__22-WE_20 nser FLT NE NE NE NE 명명명명 ME WE WE MÉ WÉ ЪM ЪÆ 45 WΕ POWER LEVER ANGULAR TRAVELS Flight fole MAX Flight fole MAI Max POWEL MAX MAX fol POWE Lever Max fooud fole (Min Point) POWEL Lever Ground fole (Min Point) POMER LEVER SCHEDULE - TT2 POMER LEVER SCHEDULE - TT2 POWEr Lever Schedule - Increasing Tt2 Tt2 Tt2 POWEr Lever Schedule - Decreasing Tt2 Hysterseis POWEr Lever Schedule - Increasing POWEr Lever Schedule - Increasing POWEr Lever Schedule - Decreasing OTERSPEID GOVZERNOR OVERSPEED GOVERNOC - Initial Speed Overspeed Governor - Final Speed Overspeed Governor - Increasing Speed Speed Governor - Decreasing Overspeed Governor - Decreasing Speed UNDERSFEDD GOVERNOR 96.0% SFED Underspeed Governor 96.0% Speed Didarspeed Governor 96.0% Speed Didarspeed Governor 96.0% Speed Underspeed Governor 75.0% Speed Underspeed Governor 65% Speed PONER LEVER SCHEDULE - T+2 CORRECTION - 10,000 ft. CUARDETION - 10,000 ft. Fuel Flow - Standard Day Delta Flow - Hot Day Delta Flow - Cold Day Prel Flow - Coreasing Pt2 Fuel Flow - Increasing Pt2 Fuel Flow - Fuel Flow -LEVER SHAFT TORQUE LEVER SHAFT TORQUE SCHEDULE Schedule Schedule Schedule DECEL Decel Decel 8.4 9.0 9.2 9.3 9.3 9.4 9.5 9.5 10.1 10.1 10.2 10.2 10.3 10.3 10.3



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			Value	4423	6 102 102	41.0	110.0 196.0 265.0	311.0 311.0 0.0	391.0 393.0 -2.0 433.0 529.0	41.0 117.0 196.0 248.0 334.0	88.0 113.0 195.0	41.0 207.0 323.0 450.0	39.0 172.0 273.0 410.0 525.0	174.0 136.0 114.0	
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NOODWARD GOVERNOR COMERNY ROCKFORD, IL CAGE 66503	HONEYWELL TEE33. -2014 SPECIFICATION F	440734 us: A		CASE SERIAL NUMBER	USG AND FL MTI USG Min USG Max PL Min PL Max	STANDARD ACCEI Standard Accei Standard Accel	riow. Standard Acce. Standard Accel Standard Accel	Standard Acce. Standard Acce. Standard Accel Standard Accel	standard Accel standard Accel standard Accel Standard Accel Standard Accel Standard Accel standard Accel	15,000 FOOT ACCET 15,000 FOOT ACCET 15,000 FOOT ACCE1	30,000 FOOT ACCEL SCHEDULE 30,000 FOOT ACCEL SCHEDULE 30,000 Foot Accel 30,000 Foot Accel 30,000 Foot Accel	HOT DAY ACCEL SCHEDULE Not Day Accel Hot Day Accel Hot Day Accel Hot Day Accel Hot Day Accel	COID DAY ACCEL SCHEDULE Cold Day Accel Cold Day Accel Cold Day Accel Cold Day Accel Cold Day Accel	UNDERSPEED COVERNOR 65% 5 Underspeed covernor 65% 5 Underspeed covernor 65% 5 Underspeed covernor 65% 5	
WOODWARD GOV ROCKFORD, IL CAGE 66503	Desc: TSP - Date: 26-MAR IMTPC - TEST	Serial No: 1440734 Current Status: A	Test Point	1.0	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	3.0 3.1 3.2			3.8 3.8.3 3.9.8.1 3.10 3.10 3.11 3.11	নে যে লেখা থা ০ ৰ ৰ ৰ ৰ ৰ ৰ	5.0 5.2 5.3			ന്ന് പപ്പസ് പപ്പസ്	

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Δı	244.0 (Calc)	241.0	236.0 (Calc)	WF_14	ųďď	Мf	112 Power Lever Schedule - Decreasing T+2	12.8
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FAIL	114.0 207.0 (Calc)	97.0 194.0	104.0 187.0 (Calc)	WF_9	ಭದ್ ಭದ್	ne Ne	Overspeed Governor - Decreasing Overspeed Governor - Decreasing Speed	10.5
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General Cause: No Cause Found Cause: Cause Not Isolated or Determined Cause Notes:

CORRECTIVE ACTION PLAN (D5) Corrective Action:

CORRECTIVE ACTION IMPLEMENTATION (D6)

Corrective Action Status: NO ACTION

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