DCA21FA174

POWERPLANTS

Specialist's Factual Report – Attachment 5

No. 1 Engine Fuel System, Disassembly Examinations

October 5, 2022

A fuel system assembly recovered with the wreckage of Transair 737-275C, N810TA, was removed from NTSB storage at Ashburn, Virginia and shipped to Eaton Corporation on March 23, 2022. N810TA ditched in ocean water shortly after takeoff from HNL, Honolulu Hawaii on July 2, 2021. The assembly included a fuel pump, fuel control unit (FCU), fuel filter, and fuel heater. Members of the Powerplants Group met at Eaton Corporation in Cleveland, Ohio on April 5, 2021 to receive the evidence and witness a disassembly examination of the fuel pump.

The assembly was immersed in ocean water for approximately 4 months. See Figure 1.

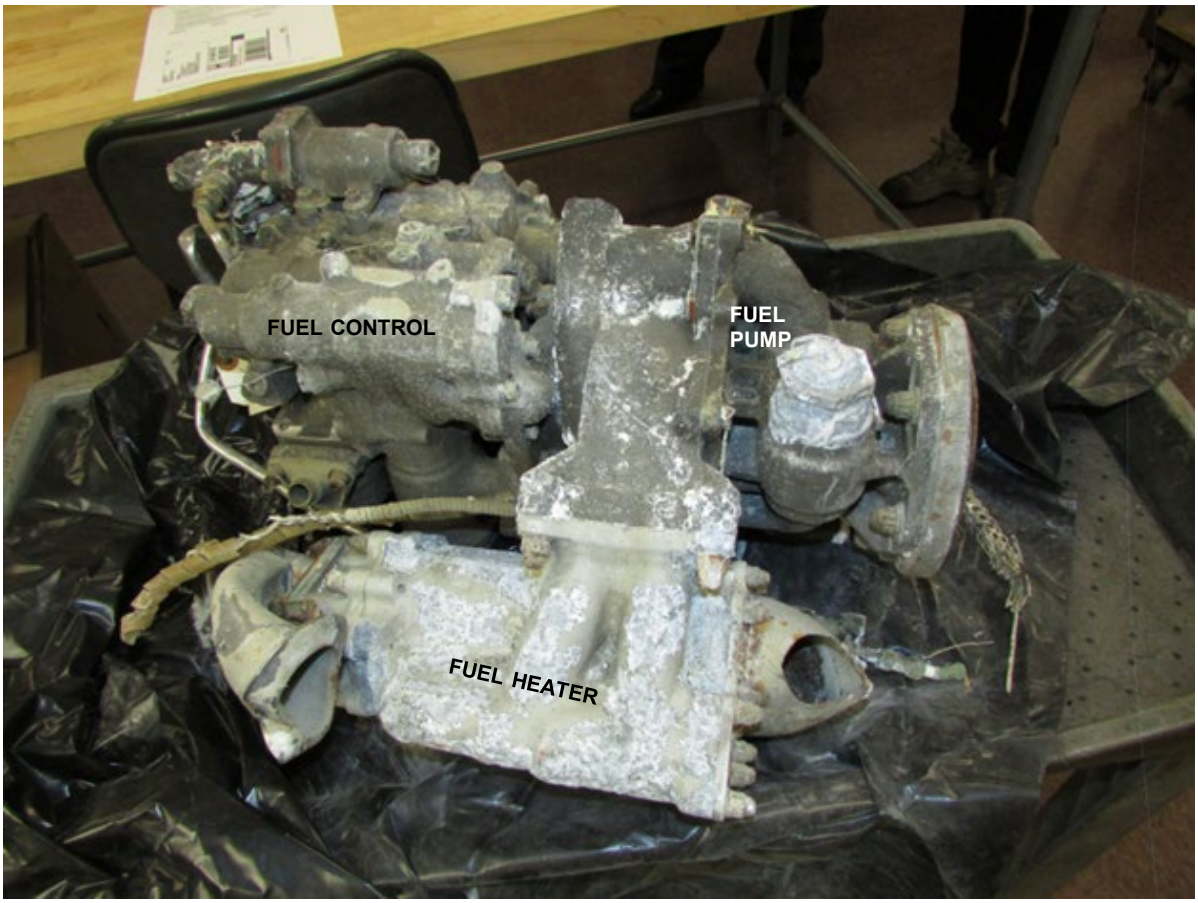

Figure 1 No. 1 engine fuel component assembly

1.0 Fuel pump investigation

1.1 Fuel pump description

The Argo-Tech[1] Model 378200 fuel pump is a positive-displacement gear pump consisting of a single-element gear stage with a high-speed centrifugal boost

[1] The Model 378200 fuel pump was designed and manufactured by Argo-Tech, which was acquired by Eaton

stage. It is driven off the main engine gearbox (MGB). The pump has an FCU mount pad with a fuel bypass passage and a splined receptacle that accepts and drives an FCU compressor rpm (N2) sense shaft at an rpm representative of engine core speed. A cartridge-type relief valve limits the pressure rise across the gear stage. An integral fuel filter is located between the discharge of the centrifugal stage and the inlet of the gear stage. If the pressure drop across the filter exceeds a predetermined limit, a bypass valve directs flow into the gear stage. A mounting pad provided on the filter housing permits the use of a remote reading differential pressure warning device. A removable cover contains a plug-type valve for draining both the sump and the center tube of the filter element. In the event of a boost stage malfunction, a bypass valve opens into the pump inlet passage to direct flow into the gear stage. This valve is normally held closed by a light spring force and remains closed due to boost stage pressure. Outlet and return ports are provided between the boost stage discharge and the filter inlet for installation of an external fuel heater. A drive shaft seal drain is located in the lower extremity of the mounting flange.

1.2 Fuel pump data

The fuel pump dataplate was missing, however by a process of elimination, it was identified as P/N 378200, S/N 3905, the pump from engine serial number (ESN) 674548, which was installed in the No. 1 position of the accident airplane.

1.3 Fuel pump service history

Eaton manufacturing records showed the date of manufacture for P/N 378200, SN 3905 as August 31, 1973. No repair or overhaul records were available.

1.4 Fuel pump external inspection

The assembly was inspected, and the fuel pump was separated from the other components. See Figure 2.

Corporation.

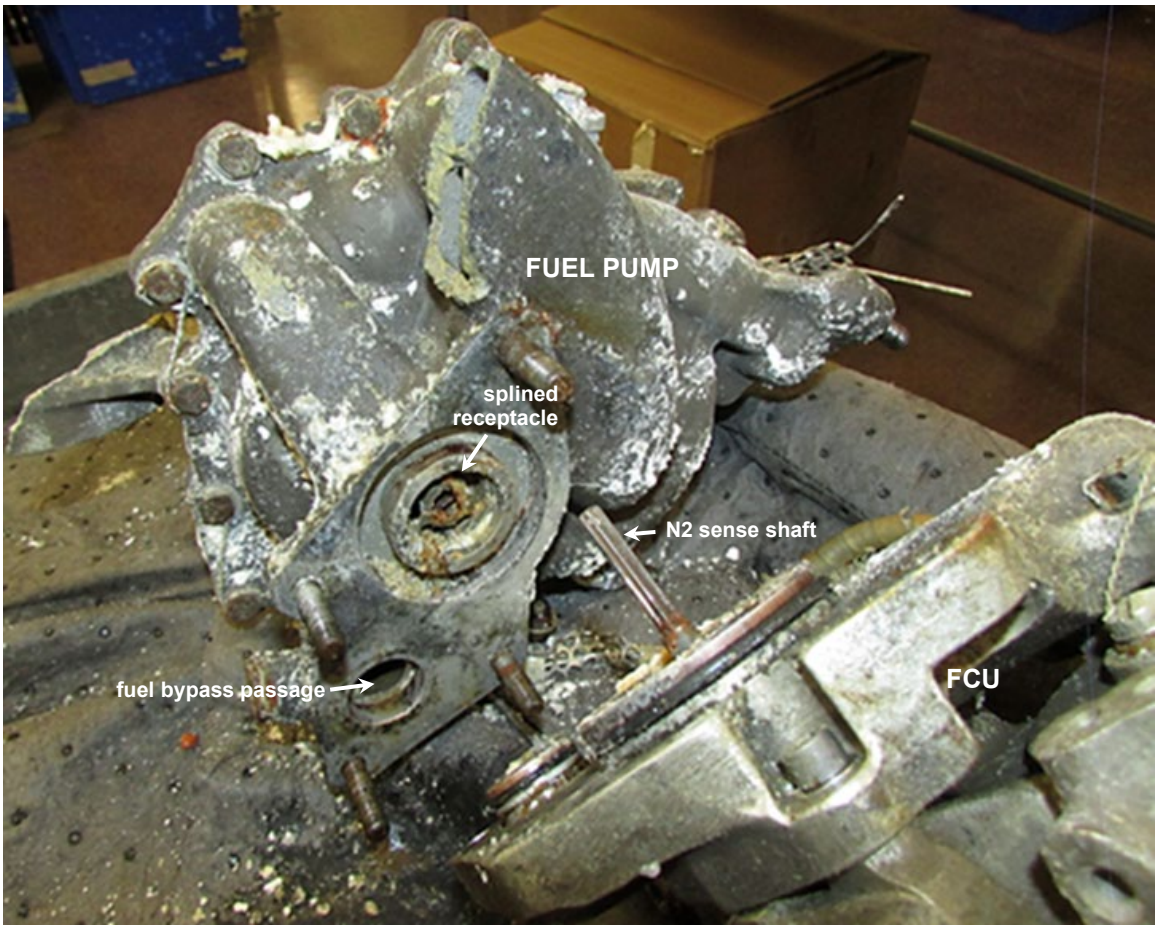

Figure 2 Fuel pump separation from FCU

The cast aluminum alloy housing and cover exhibited a white powdery coating that was easily removed. No surface corrosion was noted on the housing/cover surfaces where the deposit were removed. The steel components exhibited heavy corrosion consistent with saltwater immersion. The MGB drive pad mounting adapter and attachment clamp were attached to the drive side of the pump. The fuel heater was still attached. A segment of fire loop was attached by clamp. The filter bowl was fractured from the pump gear housing; the filter bowl and the associated components were missing. The bypass valve housing was fractured, and the bypass valve was missing. The gearbox end of the driveshaft was fractured at a 45 degree angle in the necked-down area and was missing.

1.5 Disassembly observations

The internal steel components of the fuel pump were heavily corroded; however, the fuel pump was disassembled without difficulty. The pump gear train was intact from the main drive shaft fracture to the N2 sense shaft drive spline, including the pump impeller. All fasteners were found present and secured. Assembly fitting fluid was observed. See Figure 3.

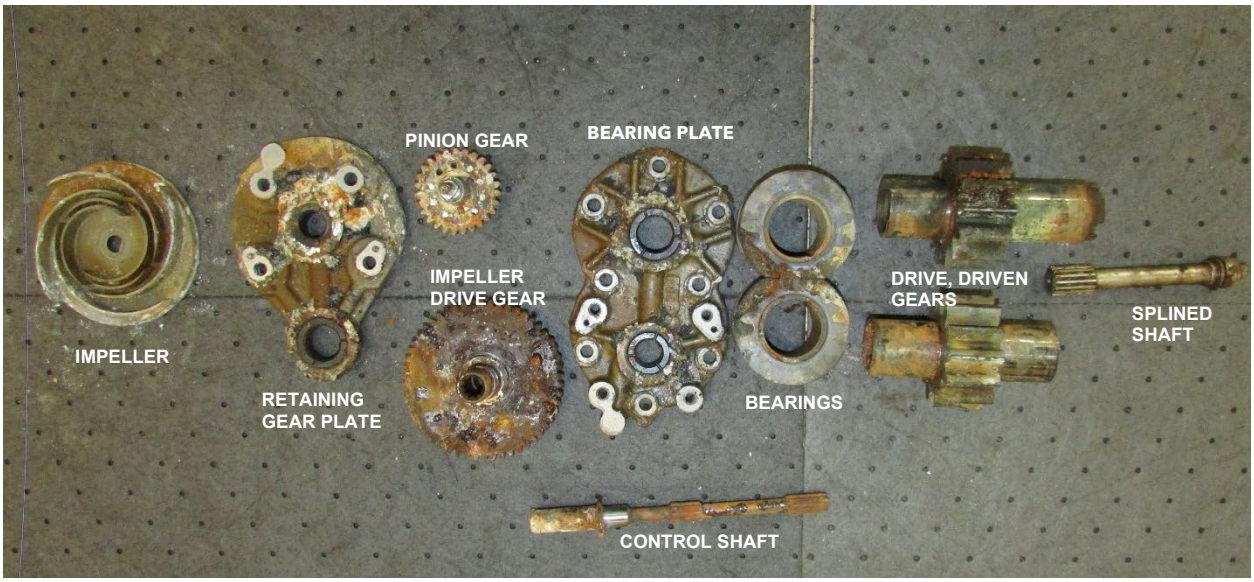

Figure 3 Fuel pump drive components

Both the main drive gear and the main driven gear, including their internal splines, were in good condition. The drive and driven pumping teeth were intact. No milling or cavitation erosion was found on the gear stage fixed and floating bushing thrust faces. The bushing journals showed no abnormal wear. No damage was noted to the bearings and bearing bores. The main stage gear housing bores exhibited no rotational scoring. No cavitation erosion was found at the inlet or discharge windows. See Figures 4 and 5.

Figure 4 Drive bearings

Figure 5 Gear housing bores

The pump output spline was in good condition. The control shaft input and gear train drive splines and the N2 sense shaft internal splines displayed no obvious wear or other damage. No wear was noted to the impeller (speed increaser) drive gear internal splines or the impeller pinion gear teeth.

The impeller was secured to the pinion gear; their anti-rotation features were engaged and intact. The impeller was intact and there was no remarkable blade damage. The impeller cover inside surfaces showed no rotational scoring. The impeller bypass strainer was distorted but intact. The poppet valve moved with light finger pressure. The screen was clear. The upper and lower gear retaining plates were intact.

The FCU was shipped to Collins Aerospace where it was examined on April 13, 2022.

2.0 FCU investigation

A cutaway HSD JFC60 unit and exemplar JFC60 parts were made available for comparison.[2]

2.1 FCU description

The Hamilton Standard (HSD)[3] JFC60-2 is a hydromechanical fuel control that governs the rotor speed of the high pressure compressor and schedules fuel flow to provide the thrust commanded by the cockpit thrust lever setting. An altitude-biased reset ensures that idle speed is sufficient to provide rapid engine acceleration capability during landing approach and to maintain aircraft environmental system pressure requirements, and a pressure ratio bleed control override signal activated by a deceleration schedule mechanism provides additional compressor stability margin by opening surge bleeds during rapid decelerations.

2.2 FCU data

The unit dataplate was missing, however the FCU was identified as JFC60-2 P/N 743602-5, S/N 87186, the FCU assembled to fuel pump S/N 3905,

2.3 FCU service history

A search of the Collins maintenance and repair database found no entries. The manufacturing build record was no longer available.

[2] The cutaway unit was a training aid. Measurements taken using the cutaway unit were for similarity only.

[3] The HSD JFC60-2 FCU was designed and manufactured by Hamilton Standard, which is now Collins Aerospace.

2.4 External inspection

Examination of the FCU noted that the steel components were rusted. A white powdery substance coated the cast aluminum alloy housing and cover. The substance was easily removed, and no surface corrosion was noted underneath. The power and run/shutoff levers were bent, and the power lever was fractured. Portions of the trimmer housing and the idle and MIL trim adjustment mechanisms were fractured off. The driveshaft and collar (N2 sense shaft) was bent but intact. The shutoff valve signal pressure tube was distorted. The metered flow outlet tube was fractured adjacent to the flange. The throttle valve transfer tube & restrictor plug was fractured off. See Figure 6.

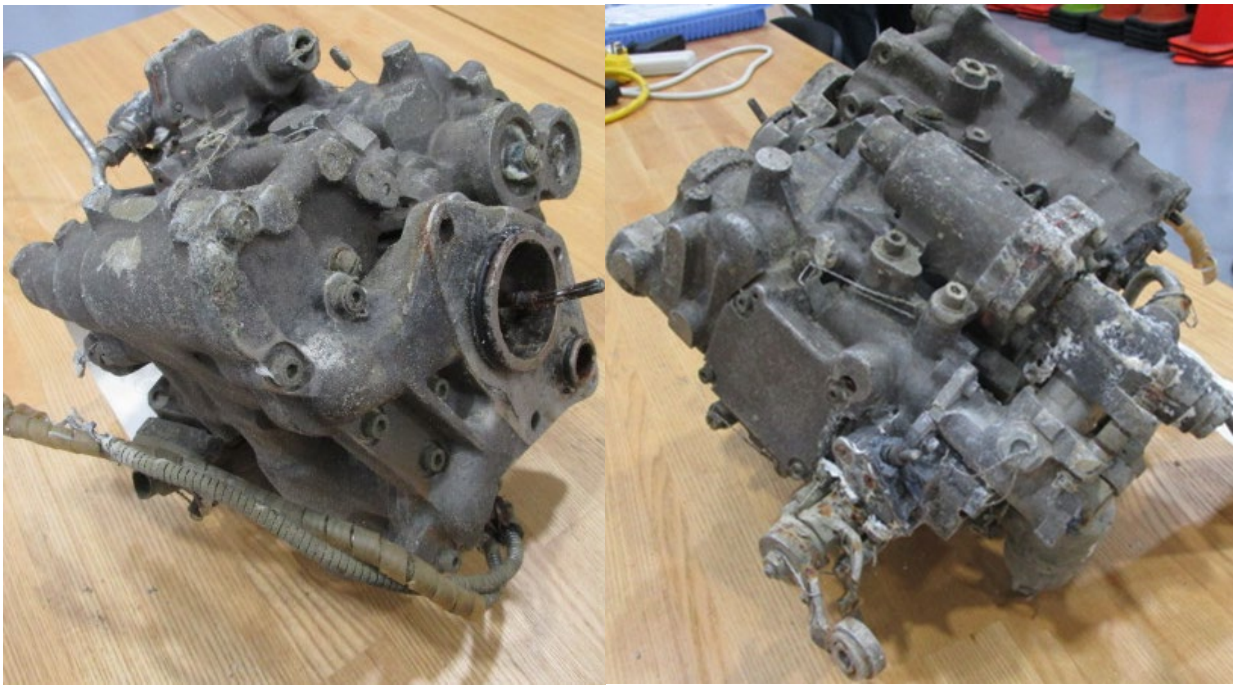

Figure 6 FCU as received, two views

All safety lead seals were marked with a triangle.

The compressor inlet temperature (CIT) sensor head was missing. The bolted flange at the control end of one of the CIT tubes was fractured off and the two attachment bolts were sheared. The hydraulic housing was scraped along its engine-facing surface in the area of the pressure regulating valve. The compressor discharge pressure (CDP) bellows cover plug & bleed head was corroded, and the head was missing. The CDP limiter housing was fractured 360° above the flange. See Figure 7. The flexure (bellows) cover was in place but was fractured and separated at the flange attachments. See Figure 8.

Figure 7 Fractured CDP limiter housing

Figure 8 Motor bellows cover flange fractures

2.5 Disassembly observations

The throttle valve cover was removed, exposing the multiplying bracket assembly and helical compression spring. The throttle valve cover material was deteriorated consistent with corrosion damage; this material crumbled during removal. A gelatinous substance was present in the bore.[4] Corrosion was noted on the multiplying lever and the valve piston, and on the extension spring. See Figures 9 and 10.

Figure 9 FCU throttle valve bore showing multiplying lever and extension spring

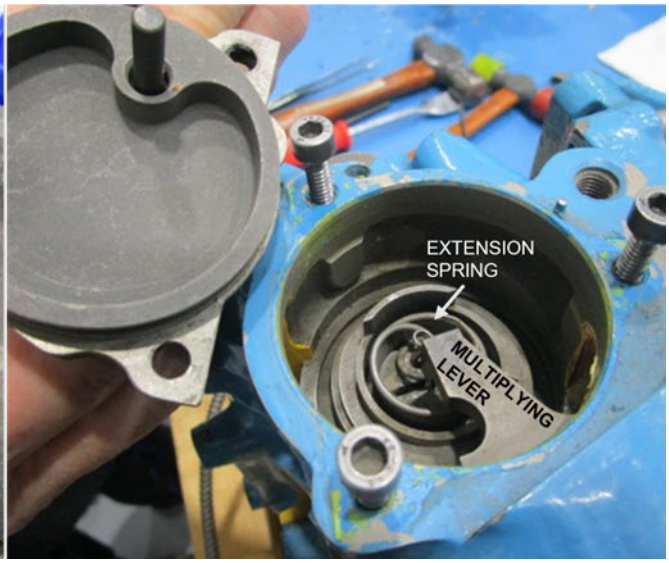

Figure 10 Exemplar FCU throttle valve bore

[4] This substance was found throughout the control. It had a strong fuel odor. It was whitish-gray in color and crystalline in appearance and had a slippery, waxy texture that easily broke into smaller chunks and became a paste when rubbed.

The multiplying lever and springs were heavily corroded but were intact. The lever moved smoothly with light pressure as assembled. The resistance was consistent compared to the exemplar FCU. After removal from the housing, the multiplying lever assembly function was compared with an exemplar assembly. The functioning was the same. See Figure 11.

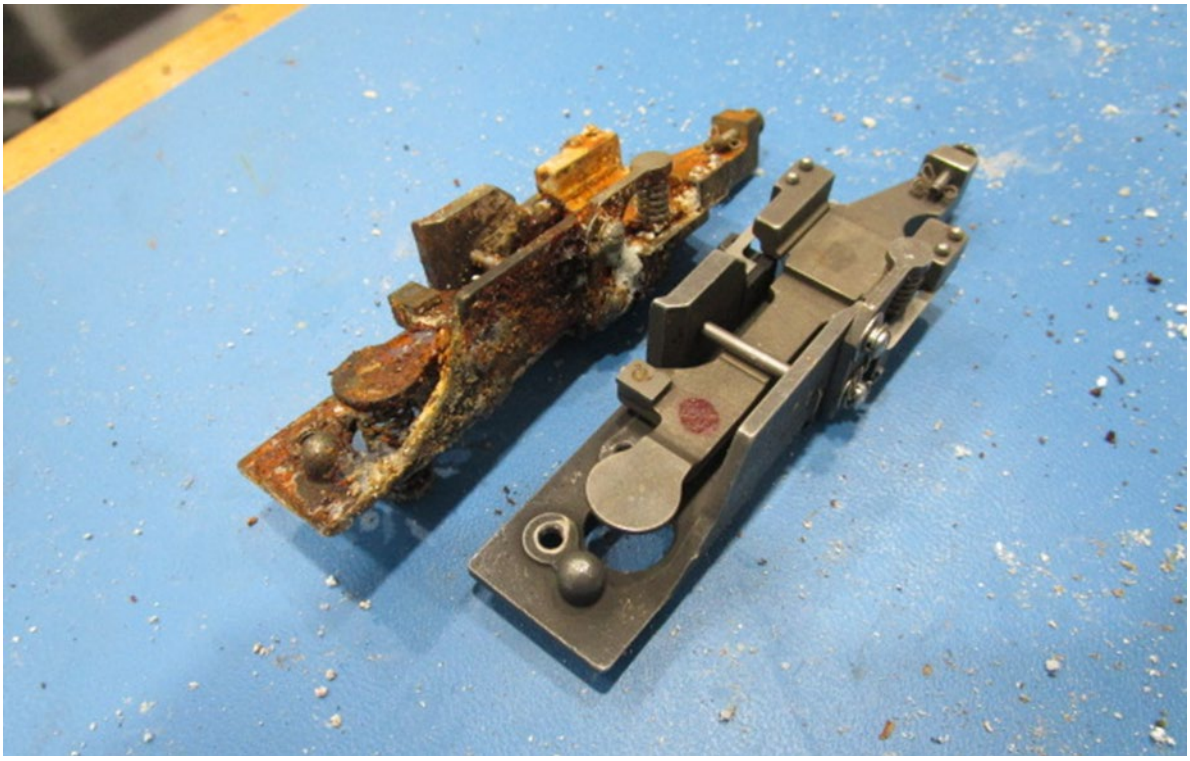

Figure 11 Multiplying lever assembly with exemplar

The top of the bellows housing plug was fractured off but the O-ring appeared intact. The bellows bore was clean.

A dial indicator was inserted on top the bellows and zeroed. The end of the multiplier lever was pressed. The dial showed 0.004 – 0.0075 inch, indicating linkage continuity from the bellows to the multiplying lever. A similar measurement made on the cutaway FCU resulted in 0.015-inch movement.

The linkage housing cover was removed, exposing the reset lever and speed setting lever mechanism. See Figure 12.

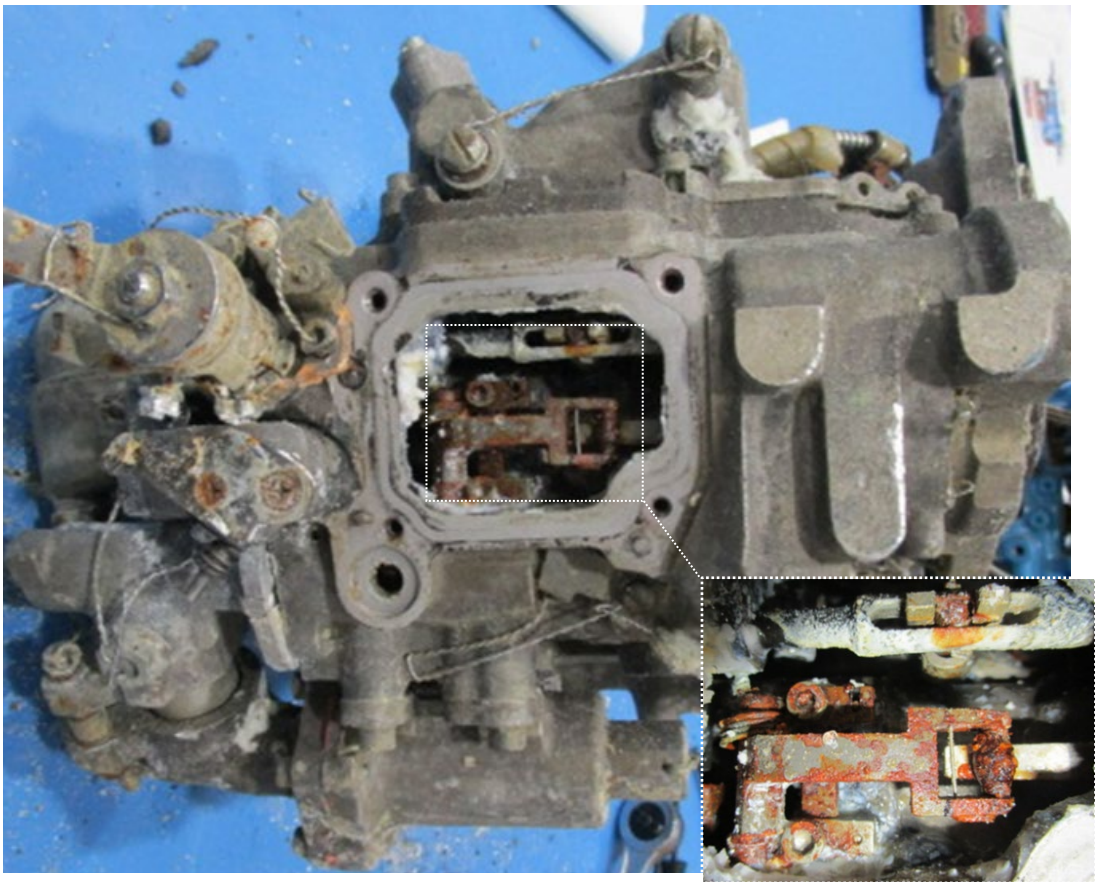

Figure 12 Reset bracket & speed setting lever in linkage housing cavity

The reset lever moved when pulled back but did not reset when released. The compressor inlet temperature (CIT) servo piston was viewable; no damage was noted.

The temperature sensor bellows assembly was removed. The O-ring was in good condition. The gelatinous substance was present. The transfer tube was removed; its O-rings were in good condition. The lever & rack plate was removed. A section of the 3D cam was visible; no gear teeth damage was found.

The linkage housing was separated from the hydraulic housing. The mating O-ring was in good condition. Both leaf springs were intact. More of the gelatinous substance was found inside the linkage housing cavity. See Figure 13.

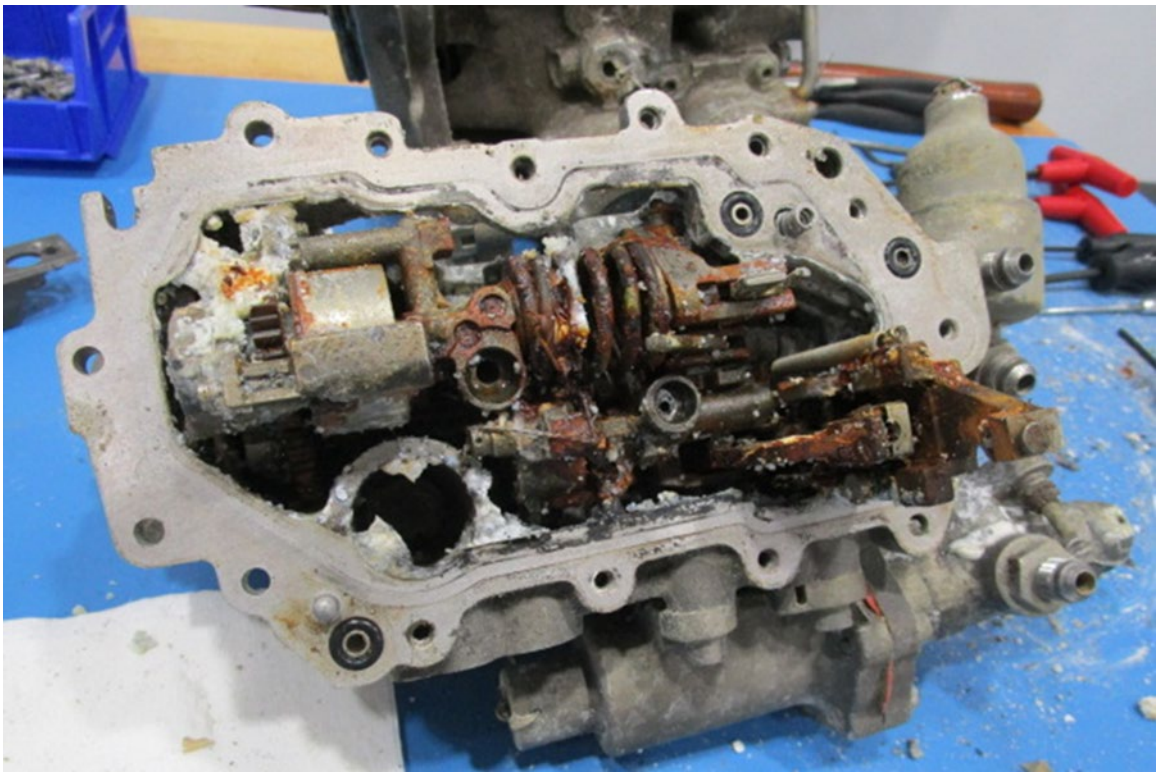

Figure 13 Linkage housing components exposed (gelatinous substance removed)

The pilot valve housing group was removed from the linkage housing. The flyweight head assembly, the throttle valve pilot valve, and the pilot valve were heavily corroded/rusted. The viewable springs and linkages were intact. The springs were operable. The drive line and gear teeth were intact but the gear train was seized in place with corrosion. The pilot valve housing group was not disassembled. See Figure 14.

Figure 14 Pilot valve and housing group, two views

The N2 sense shaft was not fractured at the shear neck. Shaft rotation was normal.

The limiting linkage group assembly was corroded. See Figure 15.

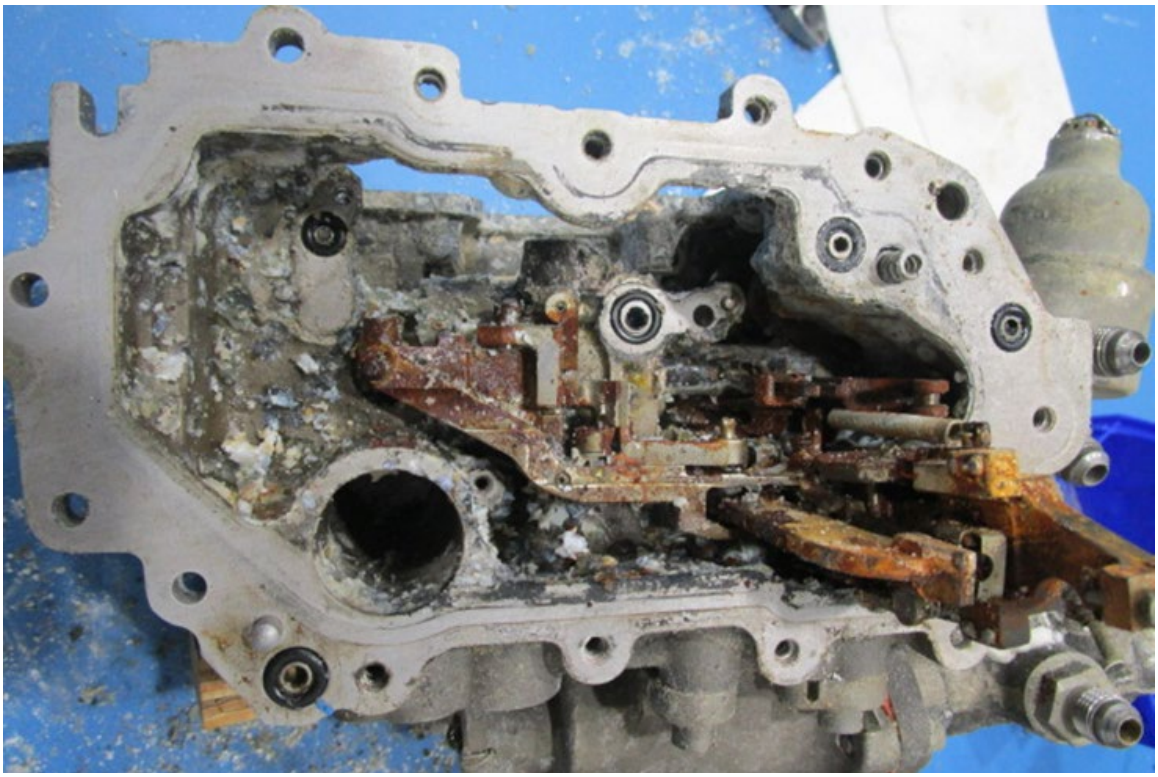

Figure 15 Limited linkage group in linkage housing

The linkage pivoted normally on its pin. Once the linkage assembly was removed all of the pieces moved smoothly. All the parts including the springs were intact. The push bar rollers appeared full diameter, and rotated with light finger pressure.

The CDP limiter was removed. The limiting lever pivoted freely. Spring-like resistance was felt consistent with positive connection with the bellows; springback was noted when the lever was pushed and released. The CDP output lever & bellows clevis was rusted but intact.

It was not possible to pressure check the motor bellows as installed due to the cracked housing. Instead, a hose was attached at the end of the motor bellows and 25 psig of shop air was applied. The pressure was deadheaded for two minutes, with no leakage noted.

Submitted by:

Carol M. Horgan
Powerplants Group Chair