



- 3.1 **External Condition:** The propeller assembly was still attached to the propeller shaft (Photo No. 1). The 5 propellers all exhibited mechanical damages. The propeller shaft was still attached to the front reduction gearbox which was fractured at the “A” flange. The aircraft engine frame with the four aircraft mounts were still attached to their respective mount pads on the gas generator case (Photo No. 2). The gas generator case showed compression and mechanical deformation near the “C” flange along the 6 o’clock region (Photo No. 3). The gas generator case was fractured at the front inlet “F” flange resulting in the ejection of the first stage integrally bladed rotor (Photo No. 4). The exhaust case which showed mechanical damages was fractured at the “A” and “C” flanges exposing the first stage reduction gearbox carrier planet gear assembly and the first stage power turbine blades respectively (Photo Nos. 5 and 6 respectively). Both exhaust ducts showed mechanical damages and deformation, one exhaust duct was fractured from the exhaust case (Photo No. 6). The engine exhibited staining and burnt regions from exposure to the post flight fire. The engine data plate showed the serial number was PCE-RG0181 (Photo No. 7).



Photo No. 1
Propellers and front reduction gearbox housing



Photo No. 2

Aircraft frame with engine mounts was still attached to the gas generator case



Photo No. 3

Gas generator case fractured at the "C" flange, note the case is rotated 180°





Photo No. 4

Gas generator case fractured at "F" flange



Photo No. 5

Exhaust duct, first stage reduction gearbox carrier assembly and left side exhaust stack.



Photo No. 6

Exhaust case separated at the "C" flange





Photo No. 7
Engine data plate

3.1.1 External Cases

Reduction Gearbox: The reduction gearbox front housing could not be rotated. The scavenge and pressure lines were bent but accounted for. No evidence of oil starvation or distress was observed on the exposed first and second stage reduction gearbox planet gear assemblies.

Exhaust Duct: The exhaust duct showed compressional deformation inwards from approximately 5 to 9 O'clock (Photo Nos. 5 and 6).

Gas Generator Case: The gas generator case showed the first stage power turbine stator assembly and the power turbine support case entrapped inside the gas generator due to the external deformation of the gas generator case and partially encased in hard packed earth (Photo No. 3). The first stage compressor integrally bladed rotor and drum spacer were no longer in place exposing the first stage compressor stator (Photo No. 8).



Photo No. 8
First stage compressor stator



Accessory Gearbox: The accessory gearbox was in one piece with all the accessories still in place. The surface of the accessory gearbox and the accessories exhibited staining and burnt regions from exposure to the post flight fire (Photo No. 9).



Photo No. 9
Accessories gearbox

3.1.2 **Power Control and Reversing Linkage:** The beta lever guide pin was in place (red arrow, Photo No. 10). The propeller reversing lever was in place and secure (black arrow, Photo No. 10). The propeller speed control lever was missing from the governor (white arrow, Photo No. 10). The reset interconnect rod was complete and secure but was bent (red arrow, Photo No. 11). The linkage was severed towards the CAM box at the “C” flange region and also bent at the front clevis attachment to the propeller reversing lever (black arrow, Photo No. 11). The linkage was attached and secure on the CAM, which was fractured from the CAM box (black arrow, Photo No. 12). The CAM input lever was mechanically damaged and the airframe power cable was attached but found severed about a foot away (dashed yellow arrow and red arrow respectively, Photo No. 13). The interconnect rod between the CAM box and the fuel control unit was bent but observed to be in place and secure (black arrow, Photo No. 13). The fuel condition lever and linkage were mechanically damaged (white arrow, Photo No. 14). The aircraft cable to the fuel condition lever was connected but severed towards the aircraft end (black arrow, Photo No. 14).



Photo No. 10
Beta guide pin and the propeller reversing lever



Photo No. 11
Reversing linkage



Photo No. 12
CAM box





Photo No. 13

CAM input lever and airframe power lever cable



Photo No. 14

Condition lever and aircraft cable





3.1.3 Pneumatic Lines

Compressor Discharge Air (P3): The tube from the gas generator although damaged was in place and the retaining bolts secure (white arrow, Photo No. 15). The P3 line “B” nut at the filter housing inlet, which showed heat exposure and the lock wire fractured due to localized mechanical damage, was found loose (white arrow, Photo No. 16). Applying a black line at the location the of “B” nut as found and applying force in the direction of tightening with a wrench resulted in the rotation of approximately 1 “flat” before the fitting was tight. The P3 line at the outlet of the P3 filter bowl was tight and secure (circled, Photo No. 17). The P3 “B” nut to the P3 elbow fitting was tight and secure (white circle, Photo No. 18). The P3 elbow fitting nut to the fuel control adapter manifold which showed heat exposure was lock wired but found loose (circled, Photo No. 19). Applying a black line to the fitting nut as found and applying force in the direction of tightening with a wrench resulted in the rotation of approximately 1/2 “flat” before the fitting was tight. The P3 filter housing (black arrow, Photo No. 17) which had been heat exposed, was found lockwired and loose. The P3 filter exhibited some heat discoloration and staining from exposure to the post flight fire (Photo No. 20). A small region of the inner filter element that had not been heat affected appeared clean (red circle, Photo No. 20).



Photo No. 15

P3 at gas generator case



Photo No. 16
P3 at filter inlet



Photo No. 17
P3 filter bowl





Photo No. 18



Photo No. 19

P3 retaining nut at fuel control adapter manifold





Photo No. 20
P3 filter and housing

Power Turbine Control (Py): The Py line was found connected to the fuel control unit (Photo No. 21). The Py line (arrow, Photo No. 22), which was fractured near the connection at the propeller governor, was found to show damages from heat exposure. The fractured end at the propeller governor was found secure (arrow, Photo No. 23).



Photo No. 21
Py line at the fuel control unit

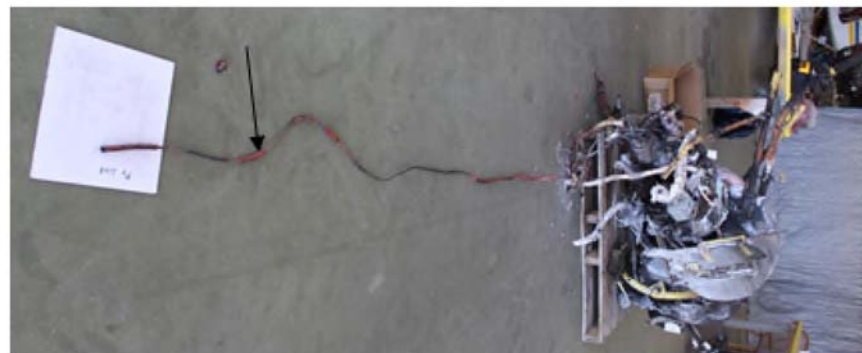


Photo No. 22
Py line



Photo No. 23

Py line at the propeller governor

3.1.4 Chip Detectors and Filters

Accessories Gearbox: The accessories gearbox magnetic chip detector in place was found secure and exhibited impact damages and heat exposure (arrow, Photo No. 24). Removal of the chip detector revealed the magnetic chip detector potting material to have deteriorated due to heat exposure freeing the two metal poles from the body of the detector (Photo No. 25).

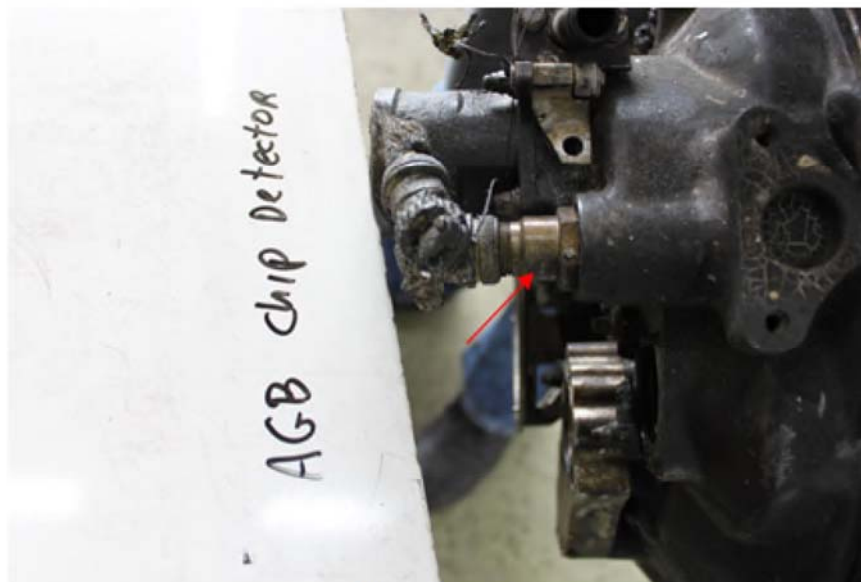


Photo No. 24

Accessories gearbox magnetic chip detector in place



Photo No. 25

Accessories gearbox magnetic chip detector

Reduction Gearbox Chip Detector: The reduction gearbox magnetic chip detector was found in place and secure although the connector showed mechanical damage and the cable was sheared (arrow, Photo No. 26). The magnetic chip detector was clean (Photo No. 27). The scavenge strainer was clean (Photo No. 28).



Photo No. 26

Reduction gearbox magnetic chip detector in place



Photo No. 27

Reduction gearbox magnetic chip detector



Photo No. 28

Reduction gearbox scavenge strainer

Oil Filter: The oil filter was removed and found clean with no metal debris contamination (Photo No. 29).



Photo No. 29

Oil filter

Fuel Filter: The fuel filter could not be removed with the tools available and such was not accessed.





3.2 Disassembly Observations

- 3.2.1 **Compressor Section:** Due to impact damages the first stage compressor integrally bladed rotor, first stage drum spacer and first stage stator were exposed. This allowed for observations as to their conditions. The remaining compressor stages of integrally bladed rotors, drum spacers, stators, centrifugal impeller and centrifugal impeller shroud for the purposes of this investigation were not accessed.

First Stage Compressor Integrally Bladed Rotor: The first stage compressor integrally bladed rotor was received separated from the engine (Photo No. 30). The blades showed rubbing damages to the blade tips in the opposite direction of rotation (black arrows, Photo No. 30). The trailing edge view of the blades showed circumferentially oriented rubbing and deformation as well as hard debris contact damages (Photo Nos. 31 and 32). Circumferential rubbing contact of the upstream face of the first stage integrally blade rotor was observed (arrow, Photo No. 31). The sheared remnants of two tie-rods were observed within two of the tie-rod holes (arrows, Photo No. 32). A fractured metal alloy debris was found wedged between two of the blades (Photo No. 33). The compressor drive shaft splines showed earth wedged between the teeth and inside the centre of the spring lock (white arrow, Photo No. 30). The spring lock insert was removed and found intact (Photo No. 34).



Photo No. 30

Leading edge view of first stage integrally bladed rotor, No. 1 bearing housing and compressor drive shaft



Photo No. 31

First stage compressor integrally bladed rotor downstream view

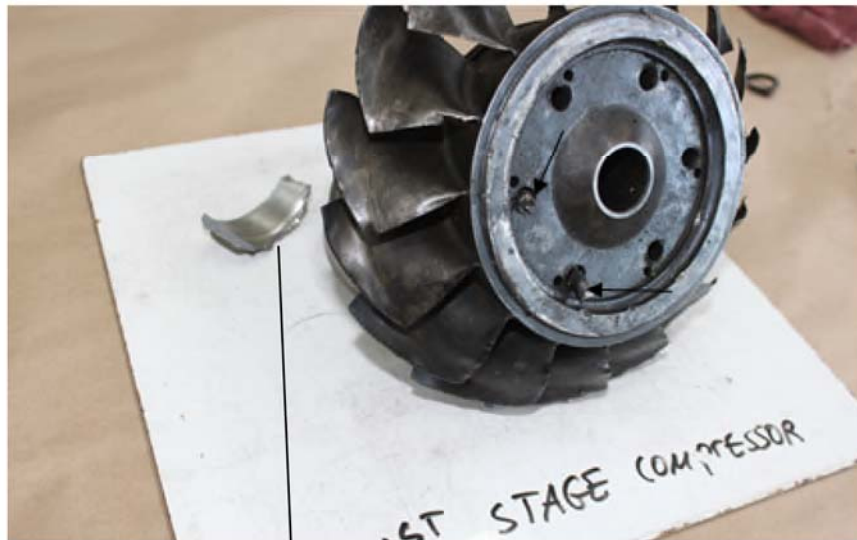


Photo No. 32

First stage compressor integrally bladed rotor sheared tie shaft bolts



Photo No. 33

Fractured light metal debris found lodged in between two first stage integrally bladed rotor blades



Photo No. 34
Spring lock insert

Compressor Stators and Shrouds: The first stage compressor stator as received insitu was missing the drum spacer and as a result exposing the second stage rotor disc (Photo Nos. 8). The stator airfoils showed occasional hard debris impact damage (arrows) and deformation of the airfoils (circled) in the direction of rotation of the drum spacer (Photo No. 35) (The missing drum spacer was put back in place for the photo). Circumferential rubbing of the airfoils was also observed resulting in raised material on the airfoil tip edges from contact with the drum spacer surface (white arrow, Photo No. 36). The shroud housing for the first stage integrally bladed rotor showed impact damages and circumferential rubbing contact (Photo No. 35). The trailing edge of the stator airfoils were observed to have rubbed with the leading edge of the second stage compressor rotor blades (Photo No. 36).



Photo No. 35
First stage stator and shroud





Photo No. 36

First stage stator airfoils showing rubbing contact at the tips and trailing edge

First Stage Compressor Drum Spacer: The first stage compressor drum spacer exhibited circumferential rubbing wear from contact with the first stage integrally bladed rotor (white arrow, Photo No. 37). The spacer outer diameter surface also exhibited circumferential rubbing marks from contact with the stator airfoil tips (Photo No. 38).



Photo No. 37

First stage compressor drum spacer



Photo No. 38

First stage compressor drum spacer outer diameter surface

Front Stub Shaft: The front stub shaft was not accessed for purposes of this investigation.

No. 1 Bearing and Airseals: The No. 1 bearing, which was not accessed, could be rotated. The airseals were not accessed for purposes of this investigation.

No. 2 Bearing and Airseals: The No. 2 bearing and airseals were not accessed for purposes of this investigation.

3.2.2 Combustion Section

Combustion Chamber Liner: The combustion outer liner could not be removed due to impact damages to the gas generator case resulting in the mechanical deformation of the liner as well as some damages from the disassembly of the inner combustion liner and turbine support housing (Photo No. 39). The outer combustion liner chamber which exhibited normal in-service wear showed no distress prior to the impact. Some material consistent in appearance to ground was observed inside the combustion liner (Photo No. 39). The inner liner which showed some disassembly damages was removed with the entrapped turbine support housing due to impact damages. The outer surface of the liner which exhibited normal in-service wear showed no distress prior to the impact (Photo No. 40).



Photo No. 39

Outer combustion liner and fuel nozzles



Photo No. 40

Inner combustion liner

Small Exit Duct: The small exit duct showed only some damages to the plasma coating due to disassembly but otherwise exhibited no distress (Photo No. 41)





Photo No. 41
Small exit duct

3.2.3 Turbine Section

Compressor Turbine Vane Ring: The compressor turbine vane ring downstream showed no prior distress (Photo No. 42). The inner wall showed circumferential rubbing with some material loss (arrow, Photo Nos. 42 and 43). The upstream side showed no distress or evidence of any foreign object damage (Photo No. 44). The inner baffle plate showed some circumferential rubbing at the surface adjacent the stator inner wall (red arrow, Photo No. 42).



Photo No. 42
Downstream view of compressor turbine stator and fuel nozzles



Photo No. 43

Compressor turbine stator removed



Photo No. 44

Compressor turbine stator upstream view

Compressor Turbine Shroud: The compressor turbine shroud segments showed rubbing wear, heat discoloration and material transfer from contact with the compressor turbine blades (arrow, Photo Nos. 45 and 46).





Photo No. 45

Compressor turbine shroud segments housing



Photo No. 46

Compressor turbine shroud segments

Compressor Turbine: The compressor turbine trailing edge view showed circumferential rubbing, scoring and wear on the trailing edge disc face, firtree region, blade platforms and airfoils (Photo No. 47). Circumferential rubbing marks were also observed at the disc inner diameter surface adjacent the retention bolt bore (arrow, Photo No. 48). The trailing edge wear on the airfoils also resulted in material removal, deformation, and cracking and /or fracture of sections of some airfoils (Photo Nos. 49 and 50). The blade tips showed rubbing wear and heat discoloration from contact with the compressor turbine shroud segments (arrow, Photo No. 50). The leading edge view of the compressor turbine disc showed rubbing contact with the inner wall of the compressor turbine stator at the leading edge blade platforms and the adjacent disc firtree region (arrow, Photo No. 51).



Photo No. 47
Compressor turbine in-situ



Photo No. 48
Compressor turbine disc inner diameter surface adjacent the retention bolt bore





Photo No. 49

Closer view of compressor turbine blades damages



Photo No. 50

View of compressor turbine blade tips



Photo No. 51

Leading edge view of compressor turbine disc





ITT Probes, Busbar, and Harness: The inter turbine temperature probes were damaged due to the deformation of the power turbine stator (Photo No. 52). The harness cable towards the trim junction block was sheared (circled, Photo No. 40). The temperature probes harness showed mechanical damages from impact deformation and from the disassembly (arrow, Photo No. 40).



Photo No. 52

Power turbine housing, inter turbine temperature probes and upstream view of first stage power turbine stator

Power Turbine Housing: The power turbine housing was deformed and entrapped within the gas generator case (Photo No 3). The housing was also surrounded by hard packed earth and the first stage stator was also entrapped within the power turbine housing (Photo No. 3). The power turbine housing had to be cut free from the gas generator case (Photo Nos. 52 and 53).



Photo No. 53

Downstream view of first stage power turbine stator





First Stage Power Turbine Vane Ring: The leading edge of the first stage vane ring airfoils showed no prior distress or any impact damages (Photo No. 52). The power turbine stator baffle showed circumferential rubbing marks, and the centre “button” was deformed and rubbed from contact with the compressor turbine inner diameter adjacent the retaining bolt bore (black arrow, Photo No. 52). The power turbine stator upstream inner wall was fractured through and showed circumferential rubbing wear from contact with the compressor turbine disc (red arrow, Photo No. 52). The downstream view of the power turbine stator shows an approximately 90° arc of circumferential rubbing on the inner and outer wall of the stator (white arrows, Photo No. 53). Within this arc the stator air foils show rubbing and loss of material in the direction of rotation (circled, Photo No. 53). Note that these damages correspond to the region of mechanical deformation not caused by disassembly on the turbine support housing (black arrow, Photo No. 53).

First Stage Power Turbine Shroud: The first stage power turbine shroud shows circumferential wear from contact with the first stage power turbine shroud tips (arrow, Photo No. 54).



Photo No. 54

First Stage Power Turbine Shroud

First Stage Power Turbine: The power turbine assembly retaining nut showed some mechanical damage, however it was found secure (Photo Nos. 6 and 55). The first stage power turbine blades were partially packed with earth (Photo No. 6). All the power turbine blades were observed displaced slightly rearwards (Photo No. 55 and red arrow, Photo No. 56). Circumferential shroud tip rubbing with occasional fracture / loss of material was observed on first stage power turbine blades (black arrow, Photo No. 56 and red circle Photo No. 57). Circumferential rubbing contact was observed in the blades firtree at the platform region from contact with the downstream inner wall of the power turbine stator (arrow, Photo No. 55).



Photo No. 55
First stage power turbine



Photo No. 56
Closer view showing first stage power turbine blades displacement





Photo No. 57

First stage power turbine

Second Stage Power Turbine Vane Ring: The second stage power turbine vane ring was not disassembled, however the limited access showed circumferential notch wear into the downstream airfoils near the outer wall from contact with the first stage power turbine shroud tips (white arrows, Photo No. 58). The limited access downstream view showed circumferential rubbing wear and deformation from contact with the fractured second stage power turbine blades (arrow, Photo No. 59).



Photo No. 58

Partial upstream view of second stage stator vane



Photo No. 59

Partial downstream view of second stage stator vane

Second Stage Power Turbine Shroud: The second stage power turbine shroud which was deformed and cut during removal of the power turbine shroud housing showed circumferential rubbing contact with the second stage power turbine blades (red arrow, Photo No. 53 and black arrows, Photo No. 60).



Photo No. 60

Second stage power turbine shroud

Second Stage Power Turbine: Partial view of the second stage power turbine blades revealed all the blades to have fractured uniformly near the shroud tips (Photo No. 59).





Power Turbine Shaft and Shaft Housing: The power turbine shaft and shaft housing was not accessed for the purposes of this investigation.

3.2.4 Reduction Gearbox

The reduction gearbox had fractured at the front housing to rear housing mating flange "A". Although the reduction gearbox was not accessed further for this investigation, the first stage reduction gearbox carrier planet gear assembly, ring gear and second stage sun-gear and coupling showed no distress (Photo No. 5). The second stage reduction gearbox carrier showed a barely perceptible deformation of the carrier lighting slots (arrow, Photo No. 61). The second stage carrier planet gear assembly and ring gear showed no distress (Photo No. 61)



Photo No. 61

Second stage reduction gearbox carrier assembly

3.2.5 **Accessory Gearbox:** The accessories gearbox was removed from the main oil tank with no contaminants observed in the main oil tank (Photo No. 62). Rotation of the accessories gearbox input drive shaft showed mechanical continuity of the accessories gear-train. The accessories rear housing was separated from diaphragm with no distress observed to the accessories gearshafts (Photo No. 63) or accessories bearings in the rear housing and diaphragm (Photo Nos. 64 and 65 respectively).



Photo No. 62
Accessories gearbox main oil tank



Photo No. 63
Accessories gearbox gear train





Photo No. 64

Accessories gearbox rear cover bearings



Photo No. 65

Accessories gearbox diaphragm bearings

3.3 Controls and Accessories Evaluation

3.3.1 Ignition System:





Exciter Box: The exciter box which showed heat exposure and mechanical damages was only attached by one ignitor lead (Photo No. 66).

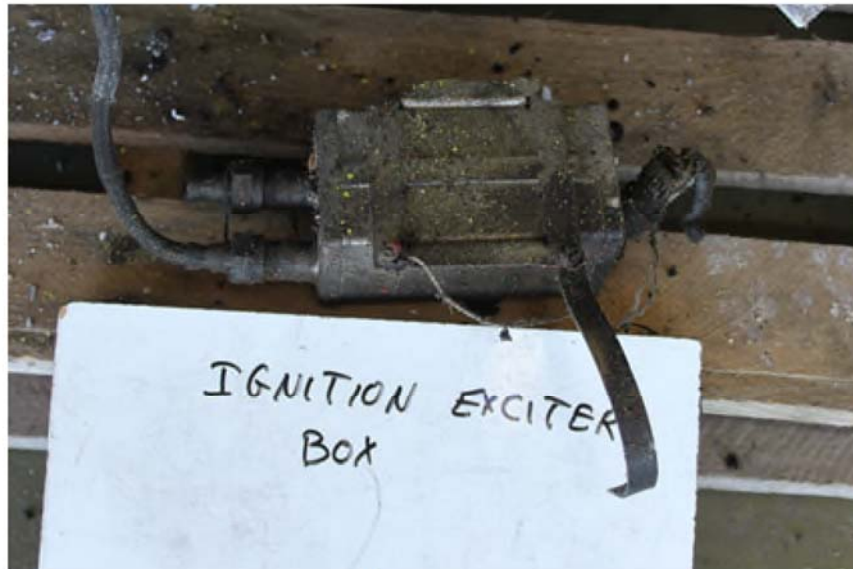


Photo No. 66
Ignition exciter box

Ignition Leads: The ignition leads showed heat exposure and mechanical damages with one ignition lead sheared at the ignitor box connector. The connections at the ignitor ends were connected (Photo Nos. 67 and 68).



Photo No. 67
One of the ignitor leads at the gas generator case

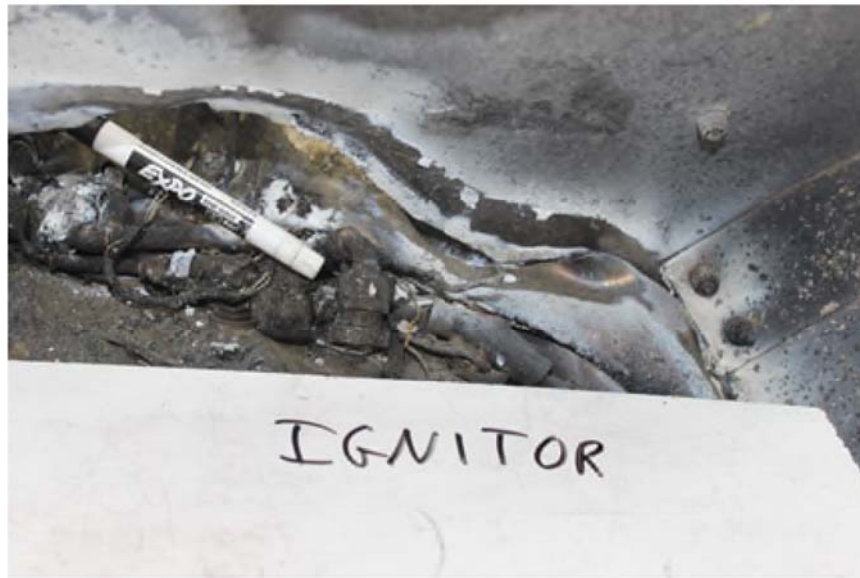


Photo No. 68

The other ignitor lead at the gas generator case

Ignition Plugs: One plug was in place, secure and intact, however it could not be removed, the other plug was also in place but showed mechanical damage from impact (Photo Nos. 69 and 70 respectively).



Photo No. 69

Intact ignitor plug



Photo No. 70

Fractured ignitor with lead still attached.

3.3.2 Fuel System

Fuel Heater: The heater was in place and secure. The housing exhibited heat distress from exposure to the post flight fire (Photo No. 71).



Photo No. 71

Fuel heater



Fuel Pump: The fuel pump was in place and secure. Some discoloration from heat exposure was observed (Photo No. 72).



Photo No. 72

Fuel pump

Fuel Control Unit: The unit which showed heat discoloration was in place and secure. Mechanical damage in the region of the power lever mechanism prevented its movement (Photo No. 73). The fuel pump metal drive splines were intact and could be rotated. The fuel control unit (P/N 3071071-01 S/N 17718651) was submitted by the NTSB to the original equipment manufacturer (OEM) for further analysis (Photo No. 73).



Photo No. 73

Fuel control unit



Fuel Nozzles: The fuel nozzles were all present (Photo Nos. 39 and 42), however due to some mechanical damages most could not be removed. Many of the fuel transfer tubes were damaged due to heat exposure and / or secondary mechanical damages.

Flow Divider: The flow divider was in place but had been impacted. The flow divider showed heat exposure and the fuel line at one end was fractured (Photo No. 74).



Photo No. 74
Flow divider

3.3.3 Air System

Compressor Bleed Valve: The compressor bleed valve was in place and secure (arrow, Photo No. 75). Due to mechanic deformation of the gas generator case it could not be removed.



Photo No. 75
Bleed off valve



3.3.4 Oil System

Propeller Governor: The propeller governor P/N 3075321-01 (supplier P/N 66503-8210-311), S/N 17844063) showed mechanical damages and was in place and secure. The Beta valve was found free to move. The propeller governor was submitted by the NTSB to the OEM for further analysis (Photo No. 76).

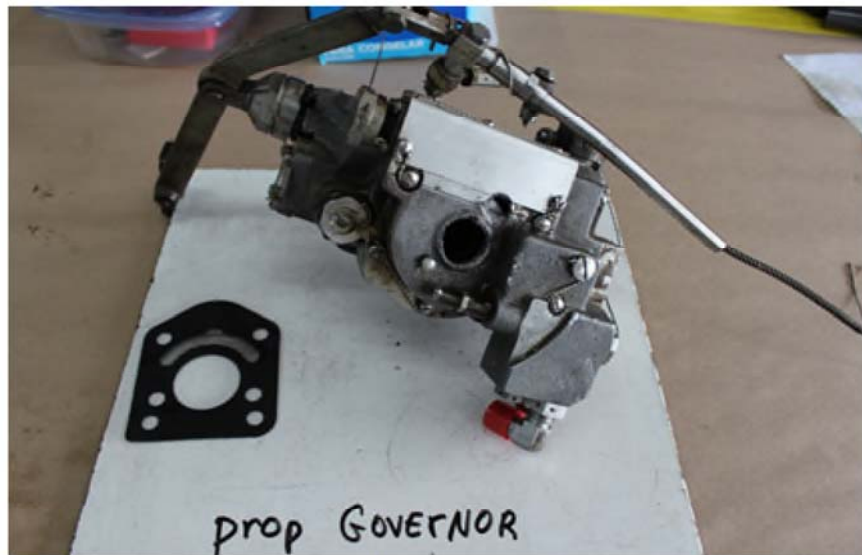


Photo No. 76
Propeller governor

Overspeed Governor: The overspeed governor was fractured (Photo No. 77). Upon removal of the overspeed governor the front reduction gearbox could be rotated. It was also observed that the debris (Photo No. 33) removed from between two blades on the first stage integrally bladed rotor was matched to be a fractured fragments from the overspeed governor (arrow, Photo No. 77).



Photo No. 77
Overspeed governor



Main Oil pump: The main oil pump could be rotated and showed no distress

Accessories Gearbox Scavenge Pump: The accessories gearbox scavenge pump could be rotated and showed no distress.

External Scavenge Pump: The external scavenge pump was not with the engine and its fractured base remnants were observed at the accessories mounting pad.

