NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

October 26, 2010

POWERPLANT GROUP CHAIRMAN'S FACTUAL REPORT

NTSB No: ANC-10-MA-068

A. ACCIDENT

Location:	Aleknagik, Alaska
Date:	August 9, 2010
Time:	1442 Alaska daylight time (ADT)
Aircraft:	DeHavilland Canada DHC-3 "Turbine Otter", N455A

B. POWERPLANTS GROUP

Safety Board Group Chairman:	Jean-Pierre Scarfo Powerplant Lead Engineer Washington D.C.
Honeywell Member:	Peter Baker Chief Engineer Phoenix, Arizona
Hartzell Propeller Inc. Member:	Thomas McCreary Manager, Air Safety Investigation Piqua, Ohio
Federal Aviation Administration Member:	Brad Roon Aviation Safety Inspector Scottsdale Arizona

C. SUMMARY

On August 9, 2010, about 1442 Alaska daylight time (ADT), a single engine, turbine-powered, amphibious float-equipped De Havilland DHC-3T airplane, N455A, impacted mountainous tree-covered terrain about 10 miles northeast of Aleknagik, Alaska. Of the nine people aboard, the airline transport pilot and four passengers died at the scene, and four passengers sustained serious injuries. The airplane sustained substantial damage. The flight was operated by General Communication, Incorporated (GCI), Anchorage, Alaska, under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91. The flight originated at a GCI-owned remote fishing lodge on the southwest shoreline of Lake Nerka about 1427 and was en route to a remote sport fishing camp on the banks of the Nushagak River, about 52 miles southeast of the GCI lodge. At the time of the accident, marginal visual meteorological conditions were reported at the Dillingham Airport, about 18 miles south of the accident site; however, the weather conditions at the accident site at that time are not known. No flight plan was filed.

The Powerplant group convened at the Honeywell engine facility in Phoenix, Arizona on October 13, 2010 to commence examination and documentation of the engine involved in the accident and completed its work on October 15, 2010. External visual examination of the engine revealed no signs of uncontainments, case breaches, or fire damage. All the power group hardware was intact and light circumferential scoring marks were noted throughout the engine between static and rotating parts consistent with the engine rotating at the time of impact. Dirt and debris were ingested by the engine and found throughout the compressor section in large quantities, and in the combustion and turbine sections to a much lesser degree. A lack of continuity was discovered between the propeller shaft and the engine power group. The high speed pinion-to-torsion shaft coupling shaft that connects the engine power section to the propeller through the output gearbox and was found sheared and the fracture features were consistent with an overload type failure, no signs of a progressive fatigue failure were noted. All the other gears in the output gearcase accessories drive housing were intact and in good condition.

After the examination of the engine, the Powerplant group then convened at the Ottosen Propeller Service facility in Phoenix, Arizona on October 14, 2010 to commence examination and documentation of the propeller involved in the accident and completed its work that same day. The propeller sustained a significant frontal impact that separated one propeller blade from the propeller hub while the other three propeller blades exhibited tip damage and aft bending. Witness marks indicate that the propeller blades and the pitch change mechanism were driven towards the low pitch or reverse pitch blade angle during the impact sequence. There were no conclusive witness marks on the propeller blade butts and on the hub arms to establish a pre-impact blade angle. There were no noted discrepancies that would preclude normal operation of the propeller and all the damage was consistent with impact.

In summary, there were no pre-existing failures or discrepancies that would preclude normal operation of either the engine or the propeller prior to impact. All the damage to the engine and propeller were consistent with impact forces.

D. DETAILS OF THE INVESTIGATION

1.0 ENGINE AND PROPELLER INFORMATION

1.1 ENGINE HISTORY

The accident airplane was powered by a single Honeywell (formerly AlliedSignal) TPE331-10R-511C turbopropeller engine, serial number (SN) P-37622C, part number (PN) 3102170-6. According to the Canadian Certificate of Airworthiness for Export, dated January 4, 1996, the accident airplane, SN 206, was designed as model DHC-3 and was originally equipped with a Pratt & Whitney R-1340-S3H1G Wasp radial piston engine with a Hamilton Standard propeller model 23D40-303. On March 2, 1996, the Federal Aviation Administration (FAA) issued a normal category standard airworthiness certificate and registration number N455A to the accident airplane.

On April 25, 2005, a Major Repair and Alteration, FAA Form 337, was issued stating that a Honeywell TPE331 turbopropeller engine, SN 37622C, and Hartzell Propeller model HC-B4TN-5NL/LT10890N, SN CDA5013, were installed on the accident airplane in accordance with Texas Turbine Conversions Inc. Supplemental Type Certificate (STC) number SA09866SC by Kal Air Repair LTD, Vernon, British Columbia, Canada. At the time of the incorporation of the Honeywell engine and Hartzell propeller, the airplane had accumulated 7,890 hours time since new (TSN) and the airplane Hobbs meter read 0.0 (zero.zero). The FAA issued STC number SA09866SC to Texas Turbine Conversions Inc. on May 5, 2001.

At the time engine SN 37622C was installed on the accident airplane in April 2005, the engine had accumulated 7,263 hours TSN, 10,082 cycles since new (CSO), and the time since overhaul (TSO) and cycles since overhaul (CSO) were zeroed as part of the engine overhaul that had been accomplished by Honeywell Aerospace Services, Phoenix, Arizona on February 24, 2005. The engine had been converted from a TPE331-10R-513C to a TPE331-10R-511C in accordance with Honeywell service bulletin (SB) 72-0509 and 72-0376 incorporation during the overhaul.

The engine remained installed on the airplane until November 2006. According to the engine service record sheet, Executive Aircraft Maintenance, located in Anchorage Alaska, removed the engine from the airplane on November 9, 2006 to perform a propeller strike inspection. The engine had accumulated 7,835 hours TSN, 10,626 CSN, 571 hours TSO, and 544 CSO when it was removed from the airplane. On November 28, 2006, the engine was approved for return to service and Executive Aircraft Maintenance reinstalled the engine on the accident airplane on February 22, 2007. The engine remained installed on the airplane up until the time of the accident.

The last engine inspection was an annual inspection performed by an Airframe and Powerplant (A&P) mechanic on May 5, 2010. The engine had accumulated 8,745 hours TSN, 12,198 CSN, 1,482 hours TSO, and 2,116 CSO.

Examination of the cockpit gauges after the accident revealed that the Hobbs meter read about 1,575 hours; therefore, the engine has accumulated 8838 hours TSN and 1575 hours TSO at the time of the accident. Final cycle counts on the engine could not be calculated due to missing airplane log sheets.

1.2 ENGINE INFORMATION

The Honeywell TPE331-10R-511C turbopropeller engine features a two-stage centrifugal compressor driven by a three-stage axial flow turbine, a single reverse-flow annular combustor and an integral reduction gearbox that runs the engine controls and drives the propeller. The TPE331-10R-511C turbopropeller engine has a takeoff and continuous power limit of 900 shaft horsepower with a corresponding maximum exhaust gas temperature 1202°F (650°C). The letter "R" in the model number (-10R) means auxiliary power reserve, which is not applicable to the Otter installation.

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

1.3 PROPELLER HISTORY

The accident airplane was propelled by a four-bladed Hartzell Propeller, model number HC-B4TN-5NL with LT10890N aluminum blades. On April 25, 2005, a new factory Hartzell Propeller model HC-B4TN-5NL/LT10890N, SN CDA5013, was installed on the accident airplane in accordance STC number SA09866SC.

The propeller remained installed on the airplane until November 2006. According to the engine service record sheet, Executive Aircraft Maintenance, removed the propeller from the airplane on November 9, 2006 and sent it to Dominion Propeller Corporation, located in Anchorage Alaska, to perform a propeller strike inspection. The propeller had accumulated 571 hours TSN when it was removed.

According to the Dominion Propeller Corporation work order 14326, the No. 1 blade, SN K09528, was removed and replaced with a new blade, SN H88181, and Hartzell SB 137A was complied with. Dominion Propeller Corporation repaired the propeller on November 30, 2006 and Executive Aircraft Maintenance reinstalled it on the accident airplane on February 22, 2007. The propeller remained installed on the airplane up until the time of the accident.

The last propeller inspection was an annual inspection performed by an Airframe and Powerplant (A&P) mechanic on May 5, 2010. The propeller had accumulated 1,482 hours TSN at that time. Based on the Hobbs time, the propeller had accumulated 1,575 hours TSN at the time of the accident.

1.4 PROPELLER INFORMATION

The Hartzell Propeller model HC-B4TN-5NL is a 4-bladed single acting constant-speed hydraulically actuated propeller with a feathering and reversing capability. The 4 aluminum blades have a feathered blade angle of +81.2°, a flight idle pitch blade angle of +5°±0.5°, a maximum reverse blade angle of -12°±0.5° and a start lock blade angle of -1.4°±0.1°.[1] The blade diameter is nominally 109.5-inches. Oil pressure from the propeller governor drives the blades to the low/reverse pitch blade angle and the blade mounted counterweights and feathering spring drives the blades towards the high pitch/feather blade angle in the absence of governor oil pressure. The propeller governor establishes

[1] All blade angle references are from the 42-inch station position.

propeller speed (Np) in flight by balancing the forces of the governor-boosted oil pressure on one side of the servo piston against the spring and blade counterweights. The propeller incorporates a start lock mechanism that holds the blades at low blade angle during engine start. The maximum propeller speed (Np) is 1,591 revolutions per minute (RPM) for takeoff and maximum continuous. The propeller rotates counterclockwise aft looking forward.

2.0 ENGINE DISASSEMBLY EXAMINATION AND DOCUMENTATION

The Powerplant group convened at the Honeywell engine facility in Phoenix Arizona on October 13, 2010 to commence examination and documentation of the engine involved in the accident, a TPE331-10R-511C turbopropeller engine, SN P-37622C and completed its work on October 15, 2010.

2.1 As-Received Condition

The engine was removed from its standard Honeywell shipping container in the presence of the Powerplant Group. The engine was intact and exhibited impact damage along the bottom of the engine but no signs of uncontainments, case breaches, or fire damage (**Photos 1 and 2**). The starter/generator, located on the aft left-hand side of the accessory drive housing, was not attached and was not returned with the engine in the shipping container. The on-scene documentation revealed that starter/generator input shaft was fractured and a portion of that shaft was still within the engine drive shaft. Upon inspection of the starter/generator pad, the fractured piece of the starter/generator input shaft was not installed in the engine drive shaft and was not returned with the engine in the shipping container. The fuel control/fuel pump assembly, located on the aft right-hand side of the accessory drive housing, remained attached and appeared to be intact. The oil bypass indicator poppet, located on the right-hand side of the accessory drive housing was found retracted (normal position).

Photo 1: Unboxed Engine

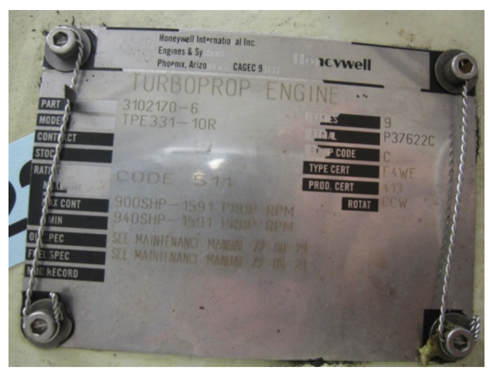

Photo 2: Engine Data Plate

All the forward engine mounts, located on the accessory drive housing, were intact except for the left-hand mount that was fractured exposing the two of the four threaded inserts. The oil tank, located along the bottom of the engine was pushed inwards and fractured open. No oil remained within the tank. Dirt was found along the air inlet duct of the accessory drive housing up to the 1st-stage compressor impeller (**Photo 3**). Looking through the inlet, dirt was noted on the P_2T_2 inlet sensor and on the 1st-stage impeller with some of the blades bent in the direction opposite of rotation while others appeared to have been straightened (See section *2.3 Compressor Section Disassembly* for more details). The air inlet duct exhibited about a 17-inch long crack but remained intact (**Photo 4**).

Fracture in the Air Inlet Duct

Photo 3: Lower Left-Hand Looking through Inlet

Photo 4: Lower Right-Hand Looking through Inlet

The propeller shaft mount flange and the two alignment dowels were intact and appeared undamaged. The propeller shaft was rotated by hand with some resistance but the engine's rotating group did not rotate along with it, consistent with a lack of continuity between the propeller and the engine power group. While turning the propeller shaft, audible sounds of the gears meshing and turning were heard within the gearcase.

2.2 Output Gearcase and Accessory Drive Housing Assembly Disassembly

The nose-cone housing (also referred to the output housing) was removed from the diaphragm assembly (also referred to as the intermediate housing), exposing both the propeller shaft and the forward propeller shaft bearing that remained attached to the nose-cone housing, as well as the planetary gear assembly and the sun gear that were still installed in the diaphragm assembly. The nose-cone housing was intact, exhibited no impact damage or housing breaches, and was oil wetted. The propeller shaft was intact and exhibited 4 localized circumferential scoring marks along the shaft length – 1 mark immediately aft of the propeller shaft nut, 1 mark in the middle of the shaft, and 2 marks aft of the shaft taper. None of the scoring marks were 360° circumferentially around the shaft and the largest was about 180° around (**Photo 5**). The propeller shaft forward bearing was not disassembled but rotated freely, appeared undamaged, and was oil wetted. The propeller shaft forward bearing oil jet was intact and undamaged. Two adjacent forward propeller shaft bearing mount bolts were missing while two other adjacent bolts were loose with their respective nuts displaced aft but still engaged with the bolt threads. The propeller shaft coupler was intact and exhibited three axial cracks in the forward spline area (**Photo 6**). Neither internal splines of the propeller shaft coupler nor the mating externals splines of the splined coupler exhibited heavy tooth damage which would have been consistent with the gears overriding each other.

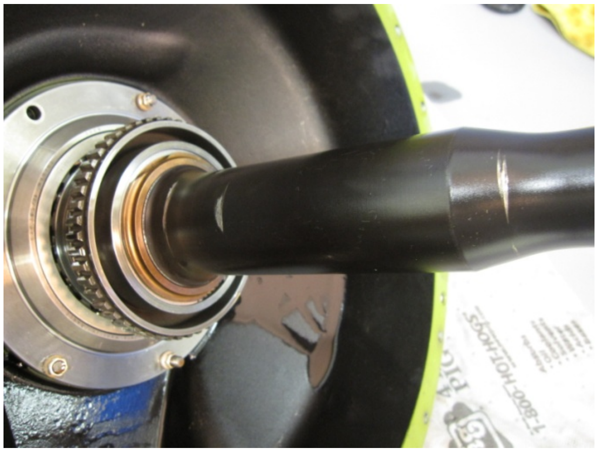

PHOTO 5: PROPELLER SHAFT WITH MULTIPLE SCORING

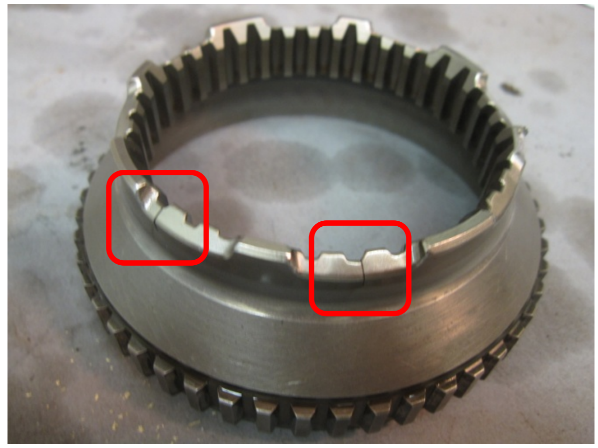

PHOTO 6: CRACKED PROPELLER SHAFT COUPLER

The planetary gear assembly was intact and removed from the ring gear with ease but was not disassembled further. All the planetary gears were oil wetted and turned freely. The contact patch was not around the entire circumference of the inner front face. Two adjacent planetary gears exhibited scoring on the aft face of 7 consecutive teeth consistent with contact with the ring gear support bumper plate (**PHOTO 7**).

PHOTO 7: PLANETARY GEAR TEETH WITH CONTACT SCORING

The ring gear, the ring gear support, and ring gear retainers were all in place, intact, and appeared to be undamaged. The ring gear support bumper exhibited two sets of distinctive circumferential scoring marks, one located from about the 8:00 – 9:00 o'clock position and the other centered at about the 11:00 o'clock position, consistent with contact from the planetary gear teeth (**PHOTO 8**). The sun gear was intact and appeared to undamaged but was not removed from the diaphragm assembly. Rotational scoring was noted on the sun gear inner bore near the aft end of the gear that corresponded to the rotational mark observed on the middle of the propeller shaft (**PHOTO 9**). The ring gear oil jets were all intact and appeared undamaged.

PHOTO 8: RING GEAR BUMPER LOCALIZED SCORING

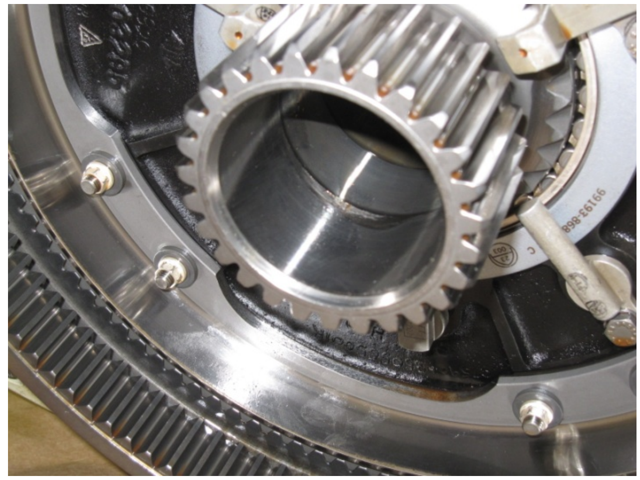

PHOTO 9: SUN GEAR INNER LOCALIZED SCORING

The diaphragm housing assembly was removed, exposing all the accessory drive gears installed on the aft side of the diaphragm housing and the gears in the accessory drive housing. The diaphragm assembly was not disassembled for detailed inspection, but the diaphragm housing, all the accessory drive gears,[2] and the bearings were intact, oil wetted, appeared to be undamaged, and all gears rotated freely by hand and in unison (**PHOTO 10**). The bull gear was not removed from the diaphragm housing assembly; however, by rotating the gear set, all the bull gear teeth were visible and they all appeared to be in good condition. The high speed pinion (HSP) gear appeared to be undamaged and was not removed from the diaphragm assembly. The HSP gear rotated freely along with bull gear and accessory gear set with no resistance. The HSP-to-torsion shaft coupling shaft was fractured/sheared consistent with overload, near the aft spline and was not removed from the HSP gear (**Photos 11 and 12**). The accessory drive housing was oil wetted and clean.

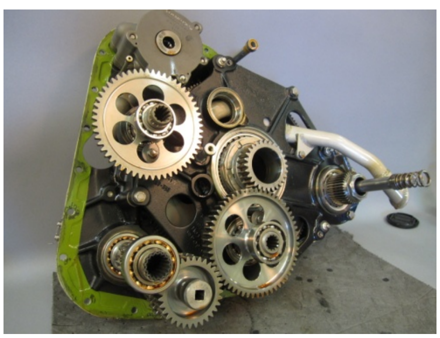

PHOTO 10: ACCESSORY GEARS INTACT

PHOTO 11: SHEARED COUPLING SHAFT

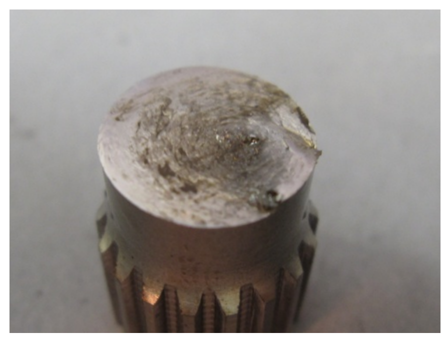

PHOTO 12: SHEARED COUPLING SHAFT

2.3 COMPRESSOR SECTION DISASSEMBLY

The shoulder main shaft was intact and the shaft itself was undamaged. The forward most knife edge of the rotating labyrinth seal was flattened forward over about a 0.400-inch arc. The torsion shaft was not removed from the shoulder main shaft.

The 1st-stage compressor impeller shroud was not removed from the forward crossover duct located in the accessory drive housing. The inducer part of the shroud exhibited a light

[2] Starter/Generator Idler Gears Assembly, Gearcase oil-scavenge pump drive shaft, Propeller Governor Drive Gear Assembly, and Hydraulic Pump Drive Gearshaft Assembly

circumferential rub from about the 9:00 to 11:00 o'clock position. All along the inducer part of the shroud were impact marks consistent with foreign object ingestion. The exit area of the shroud exhibited a circumferential scoring mark from the 5:00 to 9:00 o'clock position. All the blades on the 1st-stage impeller were present, several were missing parts of the blade tips, and the majority exhibited some form of leading edge damage. The majority of the blades were bent in the direction opposite rotation; however, there was a group of three adjacent blades that appeared to have their blade contour straightened (**PHOTO 13**). Dirt debris was found between the blades but the essentially the impeller was relatively clean. The aft curvic appeared to be undamaged and 360° circumferential scoring was noted on the aft hub consistent with contact with the inner diameter of the cross over duct housing seal. The 1st-stage compressor diffuser (crossover duct) was packed full of dirt (**PHOTOS 13 AND 14**). The forward part of the crossover duct had become detached from aft portion and remained wedged in accessory gearbox and was not removed for further examination.

PHOTO 13: 1ST-STG IMPELLER BLADE DAMAGE AND COMPRESSOR DIFFUSER PACKED WITH DIRT

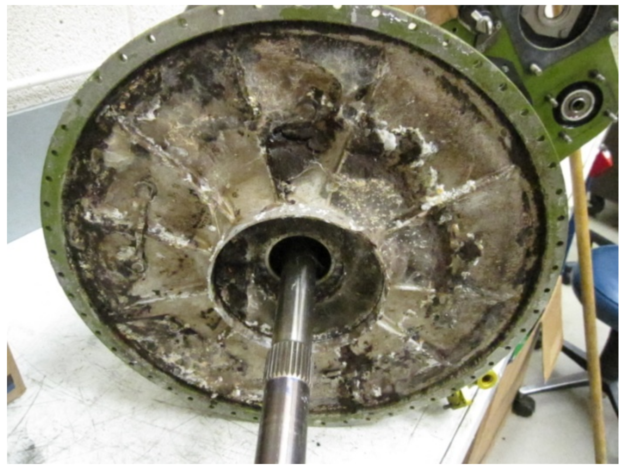

PHOTO 14: AFT SIDE OF COMPRESSOR DIFFUSER DUCT

The 2nd-stage compressor housing was intact and exhibited circumferential 180° inlet rub and circumferential 160° exit area rub consistent with contact with the 2nd-stage impeller blades. The two circumferential rub areas were opposite each other.

All the 2nd-stage compressor impeller blades were present and intact. The blades were coated with dirt, but similar to the 1st-stage impeller, were generally clean. The blades exhibited rotational scoring along the shroud edge line consistent with the blades contacting the 2nd-stage impeller shroud (**PHOTO 15**). The leading edge did not exhibit any visible impact damage. The forward hub exhibited circumferential scoring consistent with contact with the inner diameter of the crossover duct housing seal area. The forward and aft curvic coupling teeth were undamaged. The 2nd-stage compressor diffuser assembly was intact and packed with dirt (**PHOTO 16**).

Photo 15: 2ND-Stage Compressor Impeller Blades Scored Along the Shroud Edge Line

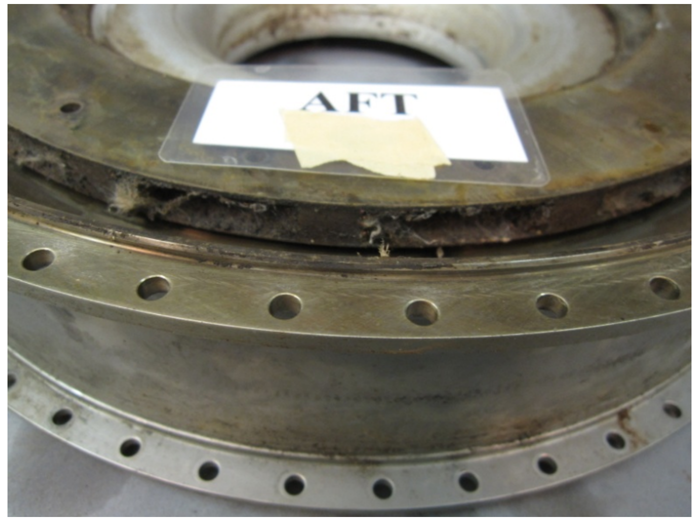

Photo 16: 2ND-Stage Compressor Diffuser Assembly was Intact and Packed with Dirt

2.4 Combustion Section Disassembly

The plenum, combustor chamber, de-swirl vane assembly, and fuel manifolds were removed from the engine as an assembly and were not disassembled any further. The plenum case and combustor chamber were intact and appeared to be undamaged. All fuel nozzles were in place with their bolts installed and safety wired. The fuel manifolds were intact and undamaged – one of the rubber shielding covers exhibited a slice but the manifold was not compromised. There was dirt debris found in various combustion chamber cooling holes, fuel nozzle swirlers, inner diameter seams and skirts of the combustor chamber as well as within the de-swirl vane assembly (**Photos 17 and 18**). The bleed air port fitting at the 8:00 o'clock position was removed from the plenum and the port was packed with dirt.

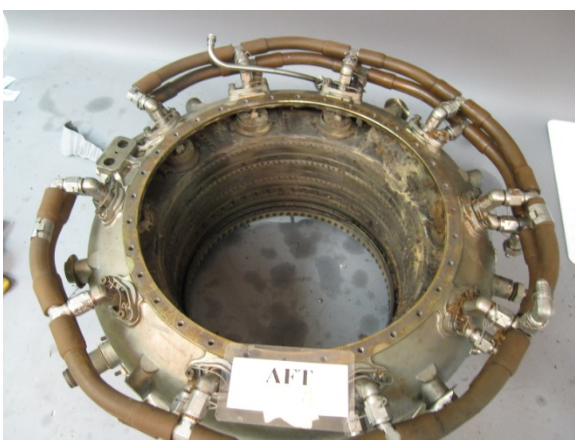

Photo 17: Combustor Full of Dirt

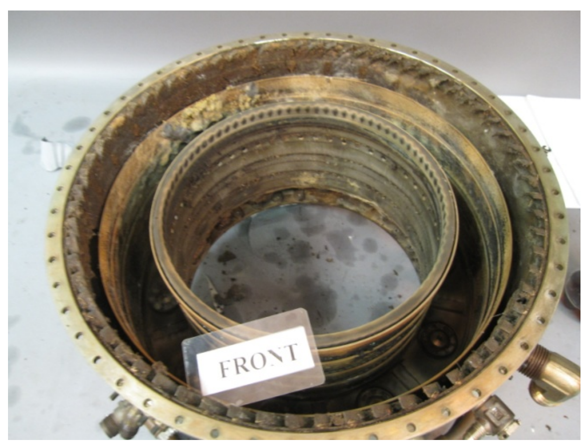

Photo 18: Combustor & De-Swirl Full of Dirt

The outer transition liner was intact, appeared undamaged and exhibited no heat discoloration or thermal distress. Dirt adhered to the inner and outer surfaces of the liner. The inner honeycomb static seal exhibited circumferential grooves.

2.4 TURBINE SECTION DISASSEMBLY

The center curvic coupling was intact and in good condition. The forward and aft coupling teeth were undamaged and the rotating knife edge seals (3 separate sets, forward 2 comprised of 3 seals with the aft comprised of 4 seals) exhibited no signs of rolling or impact damage.

The 1st-stage turbine stator assembly was not disassembled from the vane case. All the vanes were installed and intact within the vane ring. No leading or trailing edge erosion or missing airfoil material was noted. No metal spray was noted on the vanes; however, some sporadic dirt deposits were noted on some of the vane leading edges. The 1st-stage turbine blade tip shrouds were all intact and undamaged. Visually all the shrouds exhibited light rotational non-uniform contact rub or scoring; however, tactile examination revealed no significant raised edges or any appreciable depth of rub (**PHOTO 19**). The vane case exhibited contact wear and slight bluing of the ledge that supports the 2nd-stage turbine stator assembly. Dirt deposits were observed on the outside of the vane case.

PHOTO 19: LIGHT CONTACT SCORING ON THE 1ST-STAGE TURBINE BLADE TIP SHROUDS

The 1st-stage turbine rotor was intact with all the blades at full length and no leading or trailing edge damage noted. The forward and aft coupling teeth appeared undamaged. No metal spray was noted on the blades. Light rotational scoring was noted on the blade tips consistent with contact from the 1st-stage turbine blade tip shrouds (**PHOTO 20**). Light rotation scoring was also noted on some of the aft blade inner platforms consistent with 2nd-stage turbine stator assembly inner vane support contact (**PHOTO 21**). The scoring was not on all the blade aft platforms, but around a 180° arc.

PHOTO 20: 1ST-STG TURBINE ROTOR BLADE TIP SCORING

PHOTO 21: AFT INNER PLATFORMS SCORING

The 2nd-stage turbine stator assembly appeared undamaged and all the vanes were installed and intact within the vane ring. No leading or trailing edge erosion or missing airfoil material was noted. No metal spray was noted on the vanes; however, dirt deposits were noted on both the pressure and suction sides on the majority of the vanes. Light localized rotational scoring was noted on the inner vane support front face consistent with 1st-stage turbine aft platform contact (**PHOTO 22**). Localized in only one area, light rotational contact rub was observed on the 2nd-stage turbine blade tip shroud (**PHOTO 23**). Tactile examination revealed no appreciable depth to the rub. The inner stationary honeycomb seal was in good condition and did not exhibit any deep grooves.

PHOTO 22: LOCALIZED SCORING OF INNER VANE SUPPORT

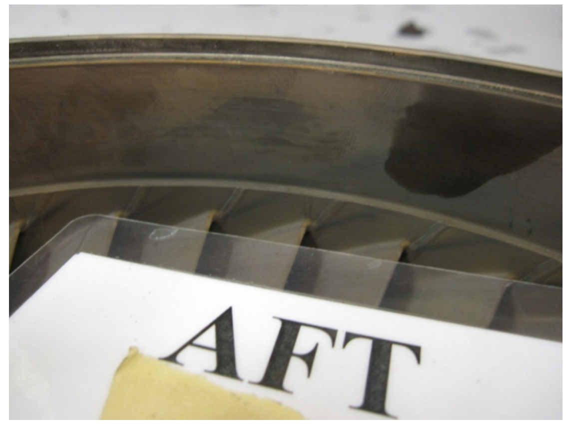

PHOTO 23: LOCALIZED SCORING OF BLADE TIP SHROUD

The 2nd-stage turbine rotor was intact with all the blades at full length and no leading or trailing edge damage noted. The forward and aft coupling teeth appeared undamaged. No metal spray was noted on the blades. Light rotational scoring was noted on the blade tips consistent with contact from the 2nd-stage turbine blade tip shroud. Circumferential scoring was noted on the aft side of the disk in the balance weight flange consistent with 3rd-stage stationary airseal forward lip contact; however the scoring was only in two light patches and was not continuous 360° around (**PHOTO 24**). The 2 sets of rotating knife edge seals (a single forward seal and a triple aft seal) exhibited no signs of rolling or impact damage.

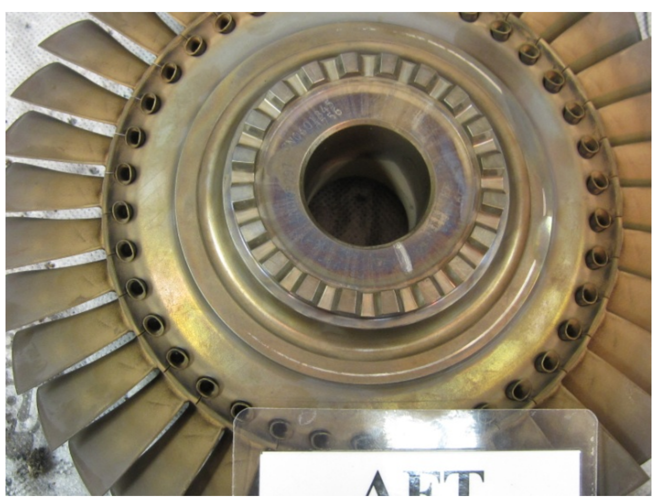

PHOTO 24: CIRCUMFERENTIAL SCORING ON THE 2ND-STAGE TURBINE ROTOR BALANCE FLANGE

The 3rd-stage turbine stator assembly appeared undamaged and all the vanes were installed and intact within the vane ring. No leading or trailing edge erosion or missing airfoil material was noted. No metal spray was noted on the vanes; however, dirt deposits were noted on the suction side near the leading edge on the majority of the vanes. Circumferential scoring was noted on the forward lip of the 3rd-stage stationary airseal consistent with 2nd-stage turbine rotor balance weight flange contact (**PHOTO 25**). The scoring was continuous 360° around. No rotational rub was noted on the 3rd-stage turbine blade tip shroud. The inner stationary honeycomb seal was in good condition and did not exhibit any deep grooves.

PHOTO 25: CIRCUMFERENTIAL SCORING ON THE FORWARD LIP OF THE 3RD-STAGE STATIONARY AIRSEAL

The 3rd-stage turbine rotor was intact with all the blades at full length and no leading edge damage was noted; however, some of the trailing edges exhibited light impact damage that was rough to the touch (**PHOTO 26**). The forward and aft coupling teeth appeared undamaged. No metal spray was noted on the blades. No rotational scoring was noted on the blade tips. The 2 sets of rotating knife edge seals (a single forward seal and a triple aft seal) exhibited no signs of rolling or impact damage.

PHOTO 26: TRAILING EDGE IMPACT DAMAGE ON THE 3RD-STAGE TURBINE ROTOR BLADES

The rear curvic coupling was intact and in good condition. The aft coupling teeth were undamaged and aft surface was coated in a black residue consistent with the coking deposits. The turbine bearing support and the turbine bearing were undamaged and in good condition.

2.5 Control and Accessories Examination

The fuel control and fuel pumps were removed as a unit, then separated for visual examination but were not disassembled or tested. Both the fuel control and fuel pumps appeared to be in good condition and no fractures of the housing were noted. The fuel control drive spline and the underspeed governor input shaft were both intact and free to rotate by hand. The power lever was bent and could only be rotated up to about 80° by hand. Due to the damage to the power lever input shaft, the fuel control could not be functionally tested. The fuel filter housing was removed from the pump and no visible debris was noted within the filter itself.

The propeller governor and the propeller pitch control were intact and appeared undamaged. The propeller pitch control sleeve pin was intact and the governor drive shaft and the pitch control cam and sleeve were free to rotate by hand.

The oil pressure pump was not removed from the output gearcase and the oil scavenge pump was not removed from the diaphragm, but both were free to rotate and appeared undamaged. The oil filter housing was removed from the output gearcase and examination revealed some black debris in the oil filter mesh itself and in the oil residue that remained in the filer housing; however, the amount was considered relatively small and the debris was not analyzed further.

3.0 PROPELLER DISASSEMBLY EXAMINATION

The Powerplant group convened at the Ottosen Propeller Service facility in Phoenix Arizona on October 14, 2010 to commence examination and documentation of the propeller involved in the accident, a Hartzell Propeller model HC-B4TN-5NL/LT10890N, SN CDA5013. The Powerplant Group completed its work that same day.

3.1 As-Received Condition

The spinner dome, spinner bulkhead, and three propeller blades remained attached to the propeller hub and the remaining blade was loose. The engine 'Beta' tube was still installed within the propeller hub and was cut so that the propeller could be placed in the holding fixture to facilitate disassembly and inspection (**Photo 27**). The propeller blades and their associated pitch change hardware were numbered 1 through 4, aft looking forward, in the clockwise direction with the No. 1 blade position chosen arbitrarily. All position references relating to the propeller in this report uses this numbering convention and was done to streamline the documentation process. The loose propeller blade was labeled as the No. 3 blade. According to the maintenance records, the No. 1 propeller blade was identified as SN H88181, the No. 2 as SN K09526, the No. 3 as SN K09527, and No. 4 as K09529. Since the propeller blades were labeled arbitrarily for documentation purpose, there is a difference between the two numbering systems. The two numbering systems are off by one number in the clockwise direction, hence the No. 1 propeller blade according to the maintenance records is labeled No. 2 for documentation purposes, the No. 2 propeller blade according to the maintenance records is labeled No. 3 for documentation purpose and so on.

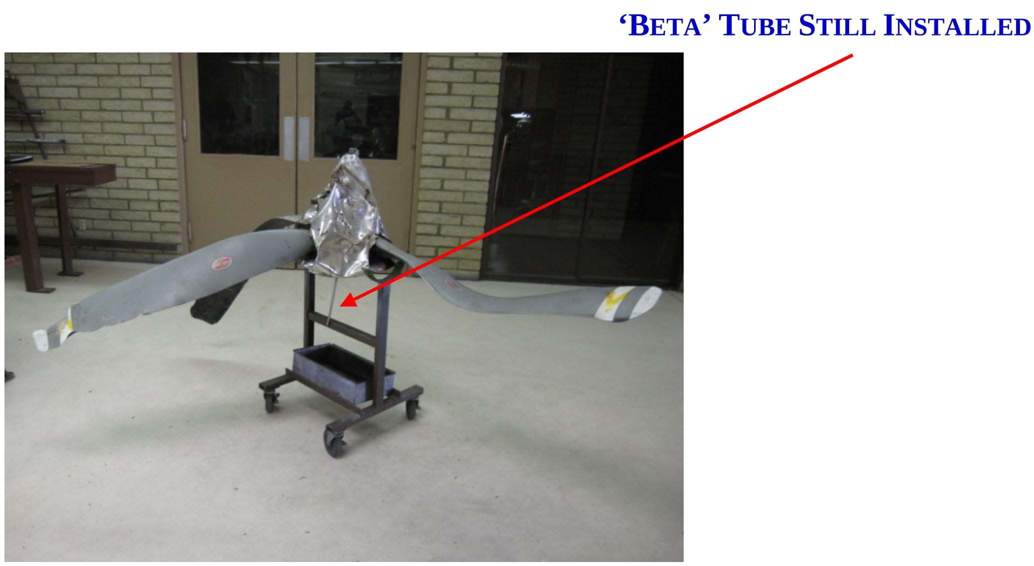

Photo 27: As-Received Propeller with 'Beta' Tube Still Installed

The spinner dome exhibited frontal impact damage, tears, cuts, missing material and was wrapped around the propeller hub and piston. The No. 4 counterweight arm, with the counterweight lug still attached, had broken through the skin of the spinner dome (**Photo 28**). All the attachment screws that the secure the spinner dome to the spinner bulkhead had been previously removed; however, the spinner dome remained secure around the hub and piston. The spinner bulkhead exhibited impact damage but was intact. The spinner dome was removed to expose the piston, the pitch change mechanisms and the propeller blade attachment hardware.

PHOTO 28: SPINNER DOME DAMAGE WITH THE NO. 4 COUNTERWEIGHT PUNCTURED THROUGH THE SKIN

3.2 PROPELLER DISASSEMBLY

All four propeller blade clamp sets were accounted for, installed, intact and secured tight. A blade clamp set is comprised of two clamp halves, one of which has a counterweight arm for the installation of the counterweight slugs. All sixteen blade clamp bolts were accounted for with all of them intact, installed and secured except for one from the No. 3 blade clamp set that was fractured and found underneath the spinner dome. The No. 3 clamp was slightly split apart adjacent to the fracture and missing bolt location. All the counterweight slugs were still attached and secure to their respective counterweight arm.

The counterweight for the No. 1 blade position (**PHOTO 29**) was found against the spinner bulkhead (blade had over-travelled in the reverse direction) in the counterclockwise direction looking down the length of the blade towards the hub. The counterweights for the No. 2, 3 and 4 blade positions were all pointing in the forward direction consistent with the reverse blade pitch position (**PHOTOS 29 AND 30**).

PHOTO 29: NOS. 1, 2, & 4 COUNTERWEIGHT POSITION

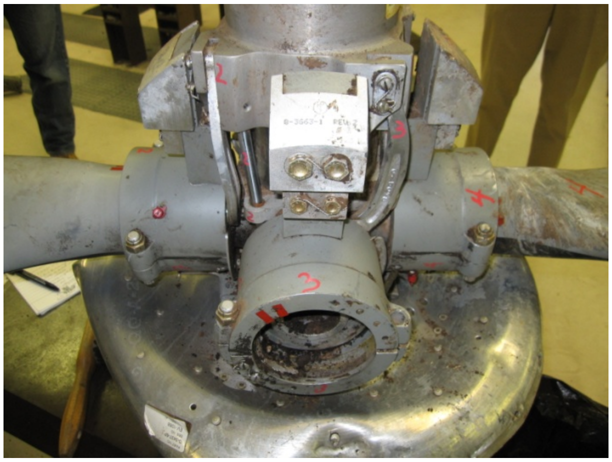

PHOTO 30: NOS. 2, 3, & 4 COUNTERWEIGHT POSITION

Each propeller blade, with its respective blade clamp set, had red indexing tape affixed to the blade airfoil near the blade retention end that aligned with red indexing tape affixed to the blade clamp. This indexing tape provides a visual indication of any rotational moment of the blade within the blade clamps. The indexing lines for the No. 1 blade position where not aligned and were about 240° out of phase with each other in the counterclockwise direction consistent with the blade rotating in the reverse direction with the blade clamp set. The index lines for the No. 2 blade position were in-line, while the index line for the No. 4 blade was off one line width in the counterclockwise direction consistent with the No. 4 blade rotating slightly within the blade clamp set. With the No. 3 blade missing, no indication of blade rotation within the clamp set could be made.

All 4 link arms were intact, exhibited some degree of twisting and bending distortion, and were secured to the piston. The No. 1 link arm was the least distorted of all the links arms and was the only one that did not remained engaged with the clamp link screw (**PHOTO 31**). One of the two attachment screws used to secure the No. 4 link arm to the piston was fractured but the screw shank remained installed. Link arms Nos. 2, 3, and 4 were buckled and twisted inwards, with the No. 3 and No. 4 link distorted enough that the link arm contacted the guide collar (**PHOTOS 32, 33, AND 34**).

PHOTO 31

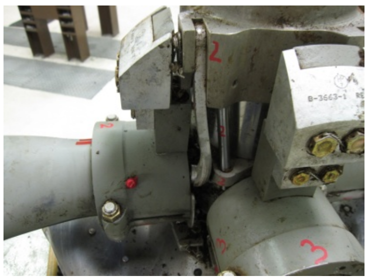

PHOTO 32

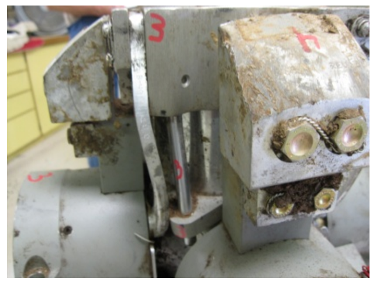

PHOTO 33

PHOTO 34

The piston was intact with no breaches or fracture; however, it had rotated in the counterclockwise direction, aft looking forward, about its longitudinal centerline. All 4 piston guide rods were intact, engaged with both the piston and the guide rod collar, and bent/twisted in the counterclockwise direction corresponding to the rotated piston orientation (**PHOTO 35**). The piston extension was measured from the guide rod collar to the piston guide rod flange at the No. 1 guide rod position. The exposed length of the guide rod was about 2.5-inches (**PHOTO 36**).

PHOTO 35: BENT AND TWISTED PISTON RODS

PHOTO 36: PISTON EXTENSION MEASUREMENT

The propeller blade clamps, blades, and the piston were removed exposing the guide rod collar, hub arms, the start locks, the cylinder, and the inside of the piston and blade clamps. The guide rod collar was fractured and missing a section of material between the No. 4 and No. 1 guide rod location (**PHOTO 37**). Deep gouge marks were noted between the No. 1 and No. 2 guide rod location and also No.

2 and 3 guide rod location. The gouge marks were consistent with the link arm-to-counterweight clamp attachment screw contact. All the propeller blade bearings were present, in good condition, and covered with grease. All the hub arms were in good condition and a faint circular witness mark was noted on the blade contact face (aft side) on the No. 3 and 4 arm that was similar to an inspection stamp found on the butt of the blade (**PHOTOS 38 AND 39**). The angular location of the imprint marks was consistent with the propeller blades at a reverse pitch position. All the blade pilot tubes were present and in good condition except for the No. 3 blade which was fractured with part of the pilot tube installed in the hub arm and in the bore of the blade. All four blade start locks were in-place, intact and were cycled by hand by depressing the spring and the lock sprung back when released. The cylinder was in good condition and exhibited no impact marks; however, the front spring retainer was difficult to remove due to thread binding. The inside of the piston exhibited light indentations consistent with contact from the feather stop screws. These light indentations on the inside of the piston are considered a normal contact pattern.

PHOTO 37: FRACTURED GUIDE COLLAR

PHOTO 38: IMPRESSION ON NO. 3 ARM

PHOTO 39: IMPRESSION ON NO. 4 ARM

The feather spring assembly was disassembled to expose the spring, reverse pitch stop components, and the change rod. The pitch change rod exhibited a light circumferential score mark that did not extend completely around the rod circumference. The score mark was located about 3-inches from the pitch change rod flange (**PHOTO 40**).

PHOTO 40: PITCH CHANGE ROD WITH CIRCUMFERENTIAL SCORE MARK

3.3 PROPELLER BLADE CONDITION

3.3.1 Blade No. 1, SN K09529

The No. 1 propeller blade was bent aft approximately 45° at about the $^{1}/_{3}$ blade span. The leading edge of the blade was missing approximately a 7-inch piece of the blade tip with a portion of the tip curled forward (**PHOTO 41**). The trailing edge exhibited multiple bends and waviness along the outer half of the span. The blade tip paint exhibited some scuffing and paint loss.

A semi-circular imprint mark was noted around the blade bore located towards the back side of blade (flat side) butt consistent with contact with the raised lip on the hub arm blade contact face (**PHOTO 42**).

PHOTO 41: NO. 1 BLADE AIRFOIL DAMAGE

PHOTO 42: NO. 1 BLADE BUTT CONTACT IMPRINT

3.3.2 Blade No. 2, SN H88181

The No. 2 propeller blade was bent aft approximately 20° at about the $^{1}/_{3}$ blade span and bent forward approximately 30° at about the mid-blade span (**PHOTO 43**). A 3-inch section of the leading edge was deformed aft about 2-inches from the blade tip. The trailing edge exhibited scoring along the on the outer ½ of the blade span. No significant paint damage was noted.

Similar to the blade butt damage noted on the No. 1 blade, a semi-circular imprint mark was noted around the blade bore located towards the back side of blade.

PHOTO 43: NO. 2 BLADE AIRFOIL DAMAGE

3.3.3 Blade No. 3, SN K09526

The No. 3 propeller blade had separated from the hub clamp and was found loose. The blade was bent aft approximately 45° at about the $^{1}/_{4}$ blade span and was slightly twisted towards the lower pitch. The outer 3 inches of the blade tip was curled aft (**PHOTO 44**). The leading edge was slightly deformed about $^{3}/_{4}$ span. The blade had significant spanwise and angular scoring on the camber side in the shank area (**PHOTO 45**). The blade tip paint exhibited some spanwise scratches and paint loss.

A fractured portion of the hub pilot tube remained inside the blade bore. The entire blade retention shoulder was sheared approximately $^{2}/_{3}$ around its circumference on the front side (camber side) of the blade and an arc-shaped portion of the retention shoulder on the butt end was sheared approximately 20% of the circumference on the aft side of the blade. Similar to the blade butt damage noted on the Nos. 1 and 2 blades, a semi-circular imprint mark was noted around the blade bore located towards the back side of blade butt; however, the depth of the imprint was significantly deeper on the No. 3 than what was noted on the first two (**PHOTO 46**).

PHOTO 44: NO. 3 BLADE AIRFOIL TIP CURLED

PHOTO 45: AIRFOIL SPANWISE SCRATCHES

PHOTO 46: RETENTION SHOULDER DAMAGE

3.3.4 Blade No. 4, SN K09527

The No. 4 propeller blade was bent aft approximately 45° at about the $^{1}/_{4}$ blade span and was slightly twisted towards the lower pitch similar to the No. 3 blade. The outermost 8 inches of the tip had multiple bends along both the leading and trailing edges. The blade had significant spanwise and angular scoring on the camber side in the shank area. The trailing edge had scoring/tearing on the outer half of the blade. The blade tip paint exhibited some spanwise scratches and paint loss (**PHOTO 47**).

A semi-circular imprint mark was noted around the blade bore located towards the back side of blade butt. The depth of the imprint was less than what was observed on the No. 3 blade but significantly more than what was observed on the Nos. 1 and 2 blades.

PHOTO 47: NO. 4 PROPELLER DAMAGE (TOP OF PICTURE) SIDE BY SIDE WITH THE OTHER BLADES

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