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

January 12, 2005

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT

NTSB No: DCA05MA004

A. ACCIDENT

Location: Kirksville Regional Airport, Kirksville, Missouri

Date: October 19, 2004

Time: 1945 CDT

Aircraft: American Connection Flight 5966, BAe Systems Jetstream 3201, N875JX

B. POWERPLANTS GROUP

Group Chairman: Jean-Pierre Scarfo
National Transportation Safety Board,
Washington, D.C.

Member: Val Ziedins
Federal Aviation Administration
Kansas City, Missouri

Member: Randall Prine
Federal Aviation Administration
Scottsdale, Arizona

Member: Marlin Kruse
Honeywell
Phoenix, Arizona

Member: Harald Reichel
Honeywell – Principal Engineer
Phoenix, Arizona

Member: Thomas Knopp
McCauley Propeller
Wichita, Kansas

C. SUMMARY

On October 19, 2004, at approximately 1945 central daylight time (CDT), a Corporate Airlines, Inc., operating as American Connection flight 5966, BAe Systems Jetstream 3201, N875JX, operating in accordance with 14 CFR Part 121, crashed while the flight was on approach to the Kirksville Regional Airport, Kirksville, Missouri. The flight was conducting a non-precision LOC/DME Runway 36 approach at the time of the accident. Eleven of the 13 passengers and the 2 flight crewmembers were fatally injured. The two surviving passengers received serious injuries. The airplane was destroyed by impact and a post-impact fire. The reported weather at the time of the accident was visibility 3 miles in mist and an overcast ceiling at 300 feet.

The engines and propellers assemblies were initially examined on site and were then sent to their respective manufacturers for disassembly and examination by the Powerplants Group. Both Honeywell TPE331-12UHR-702H turbopropeller engines were sent to the Honeywell facility in Phoenix, Arizona and both McCauley 4HFR34C653 propeller assemblies were sent to the McCauley facility in Wichita, Kansas. No pre-existing defects or anomalies were found that would have prevented normal operation of either the engines or propellers.

Both engines were found separated from the airplane. The right engine (No. 2), was recovered within the main airplane wreckage area while the left engine (No. 1) was recovered just forward of the main wreckage area in the general direction of flight. Visual examination of the right engine revealed no signs of external fire or any case uncontainments or breaches. The left engine exhibited extensive fire damage due to the post impact fire but none of the cases exhibited an uncontainments or breaches. Disassembly and examination of both engines exhibited the following characteristic: 1) rotational damage throughout the compressor and turbine sections, 2) metal spray was observed on both static and rotating parts in the turbine sections, and 3) dirt/vegetation was found throughout compressor and combustion sections.

Both propeller assemblies were recovered separated form their respective engines. All the propeller blades remained attached to the respective hub except for the No. 3 blade on the left propeller, which was found just outside the wreckage area. No impact marks were found on either propeller that could positively identify the exact blade pitch angle at the time of the accident. The only indication of propeller blade position was the position of the piston rod assembly. The measurement of the exposed aft length of the piston rod assembly from both propellers were transferred to a propeller mock-up of the same make and model as the accident propeller to determine an approximate blade pitch angle. For the left propeller the blade the piston rod length corresponded to a blade angle of 36.3° and for the right propeller it corresponded to a blade angle of 43.1°. This suggests that both propellers were not in feather or reverse but within the operating range.

D. DETAILS OF INVESTIGATION

1.0 ENGINE DESCRIPTION

Both accident engines were Honeywell (formally Allied Signal) TPE331-12UHR-702H turbopropeller engines. These turbopropeller engines feature a two-stage centrifugal compressor driven by a three-stage axial flow turbine, a reverse-flow annular combustor, and an integral reduction gearbox that runs the engine controls and drives the propeller. The TPE331-12UHR-702H turbopropeller engine has maximum takeoff power of 1,100 shaft horsepower (SHP) flat-rated to 62.6°F (17°C).[1]

The letter "U" in the model number (-12**U**HR) means that the inlet orientation is up — spanning from the 9:00 to 3:00 o'clock positions aft looking forward (ALF). The "–702H" designation in the model number indicates that engine was configured with McCauley propeller and a single red line (SRL) computer installed.[2]

All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made ALF. The directional references to forward and aft, upstream and downstream are made in relationship to airflow path from the compressor inlet to the exhaust.

2.0 PROPELLER ASSEMBLIES DESCRIPTION

The accident propellers were four-bladed McCauley Propellers, model number 4HFR34C653 with A-L106FA-0 model aluminum blades. The 4HFR34C653/A-L106FA-0 is a constant-speed, full feathering, reversible, hydraulically actuated aluminum blade propeller, with a feather blade angle of 88° ± .5º, a flight idle blade angle of 15.75° ± .1°, and a reverse blade angle of -4° ± .4º.[3] The propeller utilizes an aluminum one-piece hub assembly with four aluminum blades that have a diameter of 105 to 106-inches. Oil pressure from the propeller governor drives the blades to the low pitch blade angle and the blade mounted counterweights and feathering spring drives the blades towards the high pitch blade angle in the absence of governor oil pressure. The propeller governor establishes propeller speed (N_p) 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. For takeoff, climb, and cruise, the maximum N_p is 1,591 RPM and the maximum horsepower is 1,020 shaft horsepower (SHP). The propeller rotates counterclockwise aft looking forward.

The number "4" in the model number represents the number of blades, the letter "H" represents the number of bolts and stud configuration of the flange, the letter "F" means the propeller is full-feathering, the letter "R" means reverse pitch capability, the number "34" means blade shank size, the letter "C" means constant speed, and the number "653" defining the specify design and major change affecting eligibility or interchangeability of parts.

[1] Flat-rated to a specific temperature indicates that the engine is capable of producing the rated shaft horsepower up to the specified inlet temperature.
[2] According to Honeywell, all engines in regional service have SRL computers.
[3] All blade angle references are from the 30-inch station position.

3.0 ON-SITE EXAMINATION

3.1 GENERAL OBSERVATIONS

Both engines were found separated from the airplane and both propellers had separated from their respective engines. The right engine, along with both propellers, was recovered within the main airplane wreckage area while the left engine (**Photo 1**) was recovered just forward of the main wreckage area in the general direction of flight.

PHOTO 1: LT ENG JETTISONED FROM CRASH SITE

3.2 LEFT ENGINE OBSERVATIONS

Examination of the left engine, SN P-66357C, PN 3103380-53, in-situ, resting on its right side, revealed that the nacelle sheet metal was missing so that left side of the engine was exposed for examination. External examination of the engine revealed no signs of external fire or any case uncontainments or breaches; however, the combustor case (plenum) was buckled at the 12:00 o'clock position (ignitor plug location) with the ignitor plug bent towards the front of the engine and the oil tank exhibited was impact damaged with the oil cap still present but was disengaged from the tank. The engine remained attached to its forward mounts. The elastomeric mount bolts were fractured; however, the engine flange mount bolts were still intact. Both the nose cone and accessory gearbox housings remained attached to the front of the engine and no gearbox breaches were noted. All three reduction gearbox torque load assemblies, located at the 2:00, 7:00, and 10:00 o'clock positions, were intact. The propeller shaft flange was intact and all 8 propeller assembly attachment studs were in position and visually appeared to be intact. Both propeller shaft dowel pins were intact and straight. The "Beta" tube was fractured.

Examination of the controls and accessories revealed the following: 1) the impending oil bypass indicator pin retracted, 2) the fuel control unit (FCU) and the fuel pump (FP) remained together and were still attached to the accessory gearbox, 3) the starter generator, hydraulic pump, oil filter housing were all intact and installed in their normal position, 4) the fuel filter housing was intact but the feed line was pulled from the housing, 5) the left hand ignitor box exhibited impact damage, 6) the input and output cables were separated from ignitor box, 7) the manual fuel valve protractor was at 100%, 7) the manual fuel value and speed setting input shafts were both bent, 8) manual fuel valve was against the high end stop (open), 9) fuel control speeding setting was against the low-end stop, 10) the propeller pitch control protractor was at 36º and, 11) the fuel shutoff switch and feather valve operation were confirmed and the linkages were free to move.

The airframe inlet shroud (duct) was torn from the engine inlet duct allowing an internal examination of the 1st-stage impeller. The engine inlet duct was intact and it contained dirt. The P2/T2 inlet sensor was intact but was covered in dirt. Leading edge impact marks were noted on the 1st-stage impeller and some blades exhibited bends in the direction opposite rotation (**Photo 2**). The exhaust duct tailpipe assembly was torn, ripped, and pushed radially inwards almost closing off the back end; however, a portion of the power section of the 3rd-stage power turbine rotor was visible. Light metal splatter (shiny specks of metallic material) was noted on the suction side of the 3rd-stage power turbine blades. No visible signs of tip rub or circumferential shroud wear were noted.

PHOTO 2: LT ENG 1ST-STAGE IMPELLER DAMAGE

3.3 RIGHT ENGINE OBSERVATIONS

The right engine, as documented in the maintenance records, SN P-66360C, PN 3103380-53, could not be confirmed by examination of the engine because the data plate was completely destroyed during the post-impact fire, as was the accessory gearbox housing on which the data plate is affixed (**Photo 3**). The right engine was recovered in the main wreckage area in the general location of the right wing. Examination of the engine in-situ revealed extensive fire damage; however, none of the cases that remained exhibited any uncontainments or breaches. The combustor plenum was buckled at the 12:00 o'clock position but the ignitor plug remained installed.

PHOTO 3: RT ENG AT MAIN WRECKAGE SITE

Fire heavily damaged and/or consumed many of the engine parts and the extent of the post-crash fire damage was as follows: 1) the nacelle sheet metal totally consumed, 2) no airframe inlet was visible – consumed, 3) the reduction gearbox (nose cone)[4] and accessory gearbox housings were melted, 4) numerous accessory gearbox gears were fire damaged and found loose (**Photos 4 and 5**), 5) the intermediate housing front and aft portions were present but approximately 50% was melted, 6) the propeller pitch control housing was consumed by fire; however, the control shaft was recovered loose, and 7) the ignitor box was burned and only the shell remained.

[4] With the loss of the nose cone housing, the internal gears were exposed and the spur & helical gear assembly appeared visually intact. The spur & helical gear assembly is commonly referred to as the sun/bull gear and is comprised of a spur drive gearshaft, referred to as the sun gear, and splined spur gearshaft, referred to as the bull gear. The sun gear consists of a forward gear that drives the planet gears and an aft gear that drives the accessory gears.

PHOTO 4: ACCESSORY GEARBOX DAMAGE

PHOTO 5: BULL GEAR

The propeller shaft flange was intact, all 8 propeller assembly attachment studs were fractured (sheared), and the threads of the studs were covered with resolidified metal. Only one propeller dowel pin was observed still in the propeller shaft flange. The "Beta" tube was fractured.

Internal examination of the engine revealed leading edge impact marks on the 1st-stage impeller and at least two blades were bent in the direction opposite rotation. The 1st-stage diffuser vanes were visible and appeared intact. Light metal splatter (shiny specks of metallic material) was noted on the suction side of the 3rd-stage turbine blades.

3.4 PROPELLER OBSERVATIONS

The left propeller[5] was found upright resting on its propeller blades with one entire propeller blade missing while the right propeller was found face down (spinner shell down) with all the blade still attached (**Photo 6**). One relatively intact propeller blade, with a small piece of its tip missing, was recovered near the main wreckage site, just aft and to the right of the general direction of flight. This blade was bent in an "S"-shape configuration and the leading edge of the blade exhibited a blunt impact mark and was pushed aft. Within that leading impact mark, a tear was observed and within the tear was what appeared to be fragments of wood. Two pieces of propeller blade tips were recovered some distance away from the main wreckage area. They both were located aft and to the right of the general direction of flight (See

PHOTO 6: LT PROP IN WRECKAGE AREA

[5] Both propellers were documented on site, but confirmation of installation position was not determined until closer examination of their serial numbers at the McCauley facility.

Structures Group Chairman's Factual Report Wreckage diagraph for exact location of engine and propeller hardware).

4.0 ENGINE DISASSEMBLY AND EVALUATION

The Powerplants Group convened at the Honeywell facility located in Phoenix, Arizona from November 30 to December 3, 2004, to disassemble and examine the accident TPE331-12UHR-702H turbopropeller engines.

4.1 LEFT ENGINE HISTORY, PN 3103380-53, SN P-66357C

The left engine on the accident airplane, a Honeywell TPE331-12UHR-702H turbopropeller engine, PN 3103380-53, SN P-66357C was installed on the left hand side of N860AE on October 12, 2003 after undergoing a bird ingestion inspection. The engine accumulated the following times and cycles at the time of bird ingestion inspection:

Time Since New (TSN)	Cycles Since New (CSN)	Time Since Hot Section Inspection (TSHSI)	Time Since CAM Inspection (TSCI)	Cycles Since Cam Inspection (CSCI)	Time Since Gearbox Inspection (TSGBI)
11,946	17,668	1,377	6,439	7,774	6,439

The engine accumulated 630 flights hours and 874 cycles while installed on N860AE before it was removed on April 19, 2004 and sent to Garrett Aviation, Augusta, Georgia to comply with the engine's 7,000 hour CAM inspection and its 3,500 hour HSI. The engine had accumulated the following times and cycles at the time the engine was removed for the CAM and HSI:

Time Since New (TSN)	Cycles Since New (CSN)	Time Since Hot Section Inspection (TSHSI)	Time Since CAM Inspection (TSCI)	Cycles Since Cam Inspection (CSCI)	Time Since Gearbox Inspection (TSGBI)
12,576	18602	2,007	7,069	8,648	7,069

On July 26, 2004, the engine was then installed on the left hand side of N875JX where it remained until the accident.

The last maintenance inspections performed on engine SN P-66357C prior to the accident flight were a detailed "B" check that occurred on October 5, 2004 and a inlet inspection for foreign object damage (FOD) on October 18, 2004. At the time of the accident, the engine had accumulated 12,917 hours TSN and 19,000 CSN.

4.2 LEFT ENGINE TEARDOWN

4.2.1 Propeller Shaft and Pitch Control General Observations

External visual examination of the engine with all the airframe hardware removed revealed that: 1) the propeller shaft was pushed towards the nose cone assembly - aft of its normal installed position, 2) the propeller pitch control, which is attached to the aft face of the accessory drive housing assembly (accessory gearbox housing), was fractured at all three of its housing mount lug locations, and 3) the entire propeller pitch control was pushed aft away from the accessory gearbox housing on which it mounts.

4.2.2 Nose Cone, Intermediate Diaphragm, and Accessory Gearbox Assemblies

The nose cone assembly (output gearbox housing assembly) was removed and visual examination of the planet carrier & gear assembly, the internal stationary planetary gear, the forward sun gear (spur drive gearshaft), the torque ring support, the propeller shaft, and the coupling shaft revealed that they were all intact. The propeller shaft front bearing outer race mount flange, which is installed in the front of the nose cone assembly, was displaced aft and the mounting bolts that secure the outer race to the nose cone housing remained installed and intact; however, all the corresponding nuts were pushed aft across the stud threads. The propeller shaft coupling nut, which secures the coupling spline to the propeller shaft, exhibited 360° rotational rub on its aft face corresponding to 360° rotational rub observed on the forward face of the sun gear.

Under normal operating conditions, the sun gear front face is axially flush with planet carrier & gear assembly and the internal stationary planter gear. The sun/bull gear assembly was aft of its normal installed position and each of the four planet gears had some small burrs or impact gouges on the aft corner of several of the gear teeth corresponding to impact marks observed on the planet gear stop. Some rotational scoring was also noted on the planet gear stop; however, according to Honeywell, this scoring is typical since the planet carrier & gear assembly and the planet gear stop contact each other during normal operation. All the planet gears were free to rotate by hand within the carrier.

The intermediate housing and gear assembly diaphragm (intermediate housing) was removed from the accessory drive housing assembly exposing the accessory gears, as well as the entire sun/bull gear assembly. All the accessory gears, as well as the sun/bull gear assembly, appeared visually intact and were free to rotate. Rotational scoring was noted on the inner diameter of the sun gear/bull gear assembly corresponding to rotational scoring observed on the outer diameter (OD) of the propeller shaft in the vicinity of the shaft diameter reduction. Light impact marks were noted on the aft sun gear's aft face; however no obvious corresponding impact marks were observed on the propeller shaft aft bearing outer race.

The torque shaft assembly (high speed pinion shaft drive) was fractured at the drive spline gear end (aft end) at the designed shear point location (**Photo 7**). Although the high speed pinion gear was seized within its carrier and not disassembled, no visual damage was observed on any of the exposed teeth. The splined coupling, which connects the high speed pinion assembly (torque shaft assembly) to the tie shaft (shouldered main shaft), was intact and still installed in the accessory drive housing assembly. The feather valve boss, which is integral to the accessory drive housing assembly, exhibited a light impact mark across its front face; however, no corresponding impact marks were noted on the outer race of the sun/bull gear aft bearing.

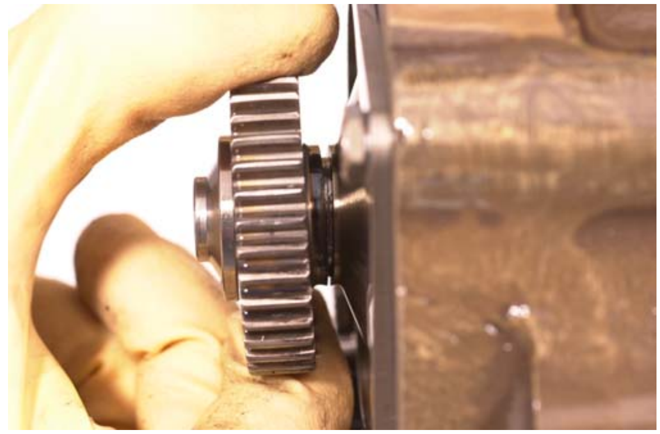

PHOTO 7: FRACTURED TORQUE SHAFT ASSEMBLY

4.2.3 Compressor Section

Disassembly of the compressor revealed dirt and vegetation throughout the entire compressor section.[6] The 1^{st}-stage impeller shroud exhibited impact marks and gouges in the inducer portion of the shroud. The leading edges of the 1^{st}-stage impeller blade inducers exhibited impact damage, some were missing airfoil material, and approximately nine blades were bent in the direction opposite rotation (**Photo 8**). No damage was observed on the aft curvic coupling teeth of the 1^{st}-stage impeller. Four diffuser assembly (cross-over assembly) vanes exhibited leading edge damage. The 2^{nd}-stage impeller shroud exhibited 360° rotational rub at the inducer/exducer transition radius and all the 2^{nd}-stage impeller blades exhibited corresponding rotation rub along their shroud line edge (**Photo 9**). The forward hub portion of the 2^{nd}-stage impeller exhibited 360° rotational rub corresponding to rub was observed on the inner diameter of the 1^{st}-stage diffuser bore. No damage was observed on the forward or aft coupling teeth of the 2^{nd}-stage impeller. Metal

PHOTO 8: 1^{ST}-STAGE IMPELLER DAMAGE

PHOTO 9: 2^{ND}-STAGE IMPELLER DAMAGE

[6] Dirt and/or vegetation debris was deposited on the 1^{st}-stage shroud, on the pressure side of the inducer and exducer portions of the 1^{st}-stage impeller blades, packed in-between seven vanes of the 1^{st}-stage diffuser assembly (cross-over duct), on the 2^{nd}-stage compressor diffuser duct (part of the compressor housing), on the leading edge of nearly all the vanes of the 2^{nd}-stage diffuser assembly, on the leading edge of approximately 75% of the vanes of the deswirl assembly, and on the pressure side on the leading edges of all the 2^{nd}-stage impeller blades.

spray was on the pressure side of the 2nd-stage exducer impeller blades as well as on the vanes of the 2nd-stage diffuser assembly. The tie shaft exhibited no visual distress and the oil transfer tube remained installed.

4.2.4 Combustion Section

Disassembly of the combustion section revealed dirt was heavily deposited on the inner wall of the plenum, and dirt/vegetation debris was packed into the cooling holes of the combustion chamber and into the fuel nozzle swirlers (**Photo 10**). The plenum was buckled inwards at both igniter bosses locations (11:30 and 5:00 o'clock positions) and at the anti-ice boss (5:00 o'clock position). The forward fuel drain boss was fractured/torn approximately 180° around the weld. The combustion chamber was undamaged as was the inner and outer transition liners. Charred dirt/vegetation was found lodged in the cooling holes of the inner transition liner (turbine interstage liner seal assembly). Metal spray deposits were observed on the dome of the outer transition liner.

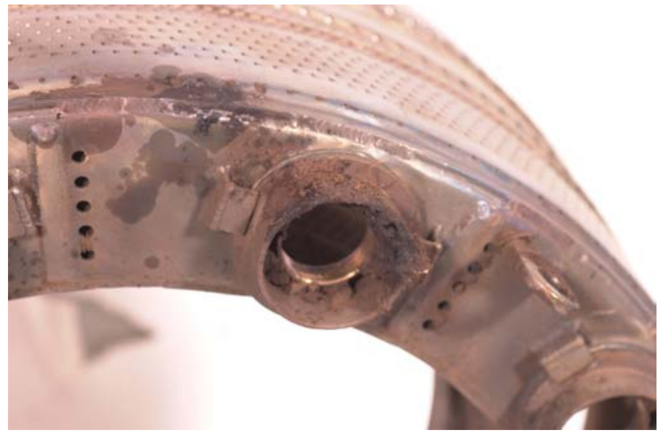

PHOTO 10: DEBRIS IN COMBUSTION CHAMBER

4.2.5 Turbine Section

The forward face outer diameter of the rotating air seal & coupling assembly (center curvic) exhibited 360° rotational rub. No damage was observed on the forward and aft curvic coupling teeth. All the vanes of the 1st-stage turbine nozzle assembly were present and intact. Debris was packed into the cooling air holes located in the outer diameter of the vane shroud (**Photo 11**). Metal spray was observed on the suction side of the nozzle vanes. The 1st-stage turbine rotor assembly was intact and all the blades remained installed in the disk. The trailing edge platforms of the blades, as well as the blade tips themselves, exhibited 360° rotational rub. Metal spray was noted on the suction side of all the blades airfoils. No damage was observed on the forward or aft coupling teeth of the 1st-stage turbine rotor disk. Nine of the twelve 1st-stage turbine blades outer shroud segments exhibited rotational rub.

PHOTO 11: DEBRIS IN SHROUD COOLING HOLES

PHOTO 12: ROTATIONAL RUB ON 2^{ND} DISK

All the vanes of the 2^{nd}-stage turbine nozzle assembly were present and intact. Some of the vanes exhibited some leading edge cracks, coating loss, and slight erosion. Light rotational rub was noted on the front face of the leading edge inner platform of the 2^{nd}-stage turbine nozzle assembly corresponding to rub observed on the 1^{st}-stage turbine blade trailing edge platform. Metal spray was observed on the suction side of all the 2^{nd}-stage turbine nozzle vanes. An approximately 180° arc of rotational rub was observed on the 2^{nd}-stage turbine shroud. The 2^{nd}-stage turbine rotor assembly was intact and all blades remained installed in the disk. Rotational rub was noted on the tips of the 2^{nd}-stage turbine blades corresponding to rub observed on the 2^{nd}-stage turbine shroud. Some 2^{nd}-stage turbine blades also exhibited rub on the aft face of the trailing edge inner platform. Metal spray was noted on the suction side of all the blades airfoils as well as on the trailing edge inner platform. The disk balance flange (aft face) exhibited rotational rub almost 360° around (**Photo 12**). No damage was observed on the forward or aft curvic coupling teeth of the 2^{nd}-stage turbine rotor disk.

PHOTO 13: RUB & METAL SPRAY ON 3^{RD} SHROUD

All the vanes of the 3^{rd}-stage turbine nozzle assembly were present and intact. Rotational rub was noted on the front face of the inner abradable air seal corresponding to rotational rub observed on the 2^{nd}-stage disk balance flange. The front attachment flange of the inner abradable seal exhibited some light sporadic rub marks near the outer edges corresponding to rub marks observed on the 2^{nd}-stage turbine blade trailing edge inner platform. Metal spray was noted on both the suction and pressure sides of the vanes. An approximately 180° arc of rub was observed on the 3^{rd}-stage turbine shroud (**Photo 13**). The 3^{rd}-stage turbine rotor assembly was intact and all the blades remained installed in the disk. All the 3^{rd}-stage turbine blades exhibited tip rub and an approximately 135° rotational rub was observed on the aft face of the trailing edge blade platforms. Metal spray was observed on both the suction and pressure side of all the blades airfoils. No damage was observed on the forward or aft curvic coupling teeth of the 3^{rd}-stage rotor disk. The rear bearing housing forward face exhibited an approximately 135° rotational rub corresponding to rub observed on the 3^{rd}-stage turbine blade trailing edge platforms. The rear face of the aft curvic coupling exhibited an approximately 90° rotational scoring arc in two places and one of the four turbine seal assembly bolt heads exhibited a corresponding light rub mark.

4.2.6 Accessories

The fuel filter was removed from the FP and residue fuel was noted at the bottom of the filter bowl. No visible debris or contaminants was noted in the fuel or in the fuel filter itself. The oil filter was removed from the accessory gearbox and residue oil was noted. No visible debris or contaminants was noted in the oil or in the oil filter itself. The oil tank was crushed, deformed, but it still had some residual oil in it.

All three electrical connectors of the ignition exciter were damaged. The starter generator was intact, except the gearshaft was sheared aft of the input splines.

The following items appeared to be undamaged but were not disassembled or functionally tested: fuel solenoid shutoff valve, FP (drive not free to rotate), FCU (speed lever shaft and power lever shaft were bent)[7], propeller governor, anti-ice valve (valve closed), feather valve, fuel flow divider (residue fuel was present), and P2/T2 sensor.

4.3 RIGHT ENGINE HISTORY, PN 3103380-53, SN P-66360C

The right engine on the accident airplane, a Honeywell TPE331-12UHR-702H turbopropeller engine, PN 3103380-25, SN P-66360C was installed on the left hand side of N921AE on July 6, 2000 after undergoing a repair. The engine accumulated the following times and cycles at the time of the engine repair:

Time Since New (TSN)	Cycles Since New (CSN)	Time Since Hot Section Inspection (TSHSI)	Time Since Cam Inspection (TSCI)	Cycles Since Cam Inspection (CSCI)	Time Since Gearbox Inspection (TSGBI)
9,043	14,192	229	--	--	229

The engine accumulated 2,765 flights hours and 3,491 cycles while installed on N921AE before it was removed on December 26, 2001 and sent to Garrett Aviation, Augusta, Georgia to comply with the engine's 7,000 hour CAM inspection. Along with the CAM inspection the engine was converted from a –25 to a –53. The engine had accumulated the following times at the time the engine was removed for the CAM:

Time Since New (TSN)	Cycles Since New (CSN)	Time Since Hot Section Inspection (TSHSI)	Time Since Cam Inspection (TSCI)	Cycles Since Cam Inspection (CSCI)	Time Since Gearbox Inspection (TSGBI)
11,808	17,683	2,994	--	--	2,994

On August 28, 2002, the engine was then installed on right hand side of N875JX where it remained until the accident.

The last maintenance inspections performed on engine SN P-66360C prior to the accident flight were a detailed "B" check that occurred on October 5, 2004 and a inlet inspection for foreign object damage

[7] The fuel pump and fuel control were not separated from each other.

(FOD) on October 18, 2004. At the time of the accident, the engine had accumulated 14,581 hours TSN and 21,436 hours CSN.

4.4 Right Engine Teardown

4.4.1 Nose Cone, Intermediate Diaphragm and Accessory Gearbox Assemblies

The nose cone assembly, the intermediate housing & gear assembly diaphragm, and the accessory drive housing assembly were all consumed by fire. All the recovered accessory and reduction gears were found loose, separate from the engine. The propeller shaft, the planet carrier & gear assembly, the internal stationary gear, and the sun/bull gear assembly were all recovered as a single unit, was covered in a white powder and exhibited varying amounts of corrosion (**Photo 14**). No attempt was made to separate the unit into its individual parts; however, all the individual pieces appeared visually to be intact, none of the exposed gear teeth exhibited any significant damage, and all the gears were seized together and could not be rotated by hand. All the propeller shaft attachment studs remained installed and intact.

Photo 14: Propeller Shaft, Planet Gear, & Sun/Bull gear Unit

The accessory gears that were recovered loose exhibited one or more of the following same general conditions – covered in white powder, some corrosion, impact damage and distortion, and bearings seized to their respective gearshafts. No accessory gears were fractured and no gear teeth damage was noted. The high speed pinion assembly (consists of the outer bearing sleeve (carrier), torque shaft assembly, and pinion spur gearshaft) remained together as a single unit and could not be rotated by hand. No attempt was made to separate the unit into its individual parts; however, the pinion spur gearshaft and the torque shaft assembly appeared to be intact and no gear teeth damage was noted.

4.4.2 Compressor Section

As a general observation, white powder covered the 1st-stage compressor impeller, shroud, and diffuser. The compressor group assembly was turned by hand with some resistance and the turbine group rotated along with the compressor group. With the accessory drive housing assembly completely consumed by fire, the 1st-stage compressor shroud, impeller, and diffuser were all exposed. The tie shaft was found still installed in its normal position, extended out the front end of the 1st-stage impeller bore, and the oil transfer tube remained installed within it. Heat distress was noted on the forward spline of the tie shaft. Removal of the 1st-stage compressor group from the engine exposed the entire tie shaft and no additional anomalies were noted. The 1st-stage compressor shroud was almost completely consumed by fire and the remains of the shroud were melted onto the 1st-stage impeller blades (**Photo 15**). The leading edges of the 1st-stage impeller blade inducers exhibited impact damage, some were missing airfoil material, and approximately seven blades were bent in the direction opposite rotation. All the 1st-stage impeller blade airfoils exhibited heat discoloration. Rotational scoring through 360° was observed on the OD of the impeller aft bore (**Photo 16**). No damage was noted on the aft curvic coupling teeth. The diffuser assembly was heavily damaged, melted, crushed, and partially consumed by fire.

PHOTO 15: 1ST STAGE SHROUD AND IMPELLER

PHOTO 16: SCORING ON 1ST STAGE IMPELLER HUB

The compressor housing assembly remained intact. Fibrous debris, dirt, and white powder was observed on the compressor diffuser duct, throughout the 2nd-stage compressor diffuser vane assembly passages, and on the leading edges of many of the deswirl vanes (**Photo 17**). The 2nd-stage impeller shroud exhibited 360° rotational rub at both the inducer and exducer locations and all the 2nd-stage impeller blades exhibited corresponding rotation rub along the shroud line edge. Static impact marks were also observed on top of the 2nd-stage impeller shroud rotational rub mark at the exducer location. All the 2nd-stage impeller blades exhibited rotation rub along the shroud line edge and a 360° rotational rub on the outer diameter of the forward hub. No damage was observed on the forward or aft coupling teeth of the 2nd-stage impeller.

PHOTO 17: DEBRIS IN THE 2ND-STAGE DIFFUSER

4.4.3 Combustion Section

The combustion plenum was deformed, buckled, twisted clockwise at the 1:00 o'clock position, and covered with a white powder residue. Disassembly of the combustion section revealed dirt/vegetation debris packed into the large cooling holes of the combustion chamber, charred debris in the large cooling holes of the inner transition liner, and dirt on the outer transition liner dome (**Photo 18**).

PHOTO 18: DEBRIS LODGED IN COOLING HOLES

4.4.4 Turbine Section

As a general observation, a white powdery substance coated most of the turbine section parts. The rotating air seal & coupling assembly exhibited no damage and the forward and aft curvic coupling teeth were intact. All the vanes of the 1st-stage turbine nozzle assembly were present and intact. Three vanes exhibited axial leading edge cracks and one vane exhibited slight leading edge erosion. Nearly all the vanes exhibited trailing edge axial cracks. Metal spray was observed on the suction side of the nozzle vanes. Two of the eight piston ring housing-to-baffle attachment bolts were missing. The 1st-stage turbine rotor assembly was intact and all the blades remained installed in the disk. All the blades tips exhibited rotational rub at the trailing edge and erosion near the leading edge. Slight metal spray was noted on the suction side of the blade airfoils. The disk aft face exhibited rotational rub at the corner of the face-to-web transition radius. No damage was observed on the forward or aft coupling teeth of the 1st-stage turbine rotor disk. Eight of the twelve 1st-stage turbine shroud segments exhibited rotational rub (**Photo 19**).

PHOTO 19: SCORED 1ST-STAGE SHROUD SEGMENTS

All the vanes of the 2nd-stage turbine nozzle vane assembly were present and intact. Fibrous debris was observed wrapped around the leading edge of three vanes (**Photo 20**). Some of the 2nd-stage turbine nozzle vanes exhibited leading edge cracks, coating loss, and slight erosion while one vane exhibited an axial trailing edge crack. Slight metal spray was observed on the suction side of all the nozzle vanes. Two 30° arcs of light rotational rub were noted on the forward face of the seal corresponding to rub observed on the 1st-stage turbine disk face-to-web radius. An approximate 45° arc of rotational rub was observed on the 2nd-stage turbine shroud. The 2nd-stage turbine rotor assembly was intact, and all the blades remained installed in the disk. Light rotational rub was noted on some of the tips of the 2nd-stage turbine blades, but not all, corresponding to rub observed on the 2nd-stage turbine shroud. Metal spray was noted on the suction side of all the 2nd-stage turbine blade airfoils. Light rotational rub was observed on the aft balance flange of the disk. No damage was observed on the forward or aft curvic coupling teeth of the 2nd-stage turbine rotor disk.

PHOTO 20: FIBROUS DEBRIS IN 2ND-STAGE NOZZLE

All the vanes of the 3rd-stage turbine nozzle assembly were present and intact. Three consecutive nozzle vanes exhibited airfoil axial cracks and one of the vanes had some leading edge erosion and material loss. Some 3rd-stage turbine nozzle vanes exhibited airfoil coating loss near the outer shroud. Metal spray was noted on the suction side of the vanes (**Photo 21**). A light approximate 60° arc of rotational rub was noted on the forward face of the 3rd-stage turbine nozzle air seal corresponding to rub observed on the 2nd-stage rotor disk aft face. The 3rd-stage turbine rotor assembly was intact and all the blades remained installed in the disk. No rub marks were visibly noted on the blades or on the disk. No damage was observed on the forward or aft curvic coupling teeth of the 3rd-stage rotor disk. No damage or wear was observed on both the rear bearing housing and the aft curvic coupling.

PHOTO 21: METAL SPRAY ON VANE AIRFOILS

4.4.5 Accessories

The following items were either consumed by fire or were not recovered from the accident site: fuel solenoid shutoff valve, feather valve, fuel filter housing, fuel flow divider, oil filter, oil tank, and P2/T2 sensor.

The FP housing was completely consumed by fire and what remained was the high pressure and low pressure elements, which were intact, corroded, and fire damaged. The oil pressure pump housing was consumed by fire and what remained was only the g-rotor, which was intact, corroded, and fire damaged. The FCU housing was completely consumed by fire and what remained was the flyweight governors and some assorted control linkages, which were all intact, corroded, and fire damaged. The propeller governor housing was completely consumed by fire and what remained was the drive shaft and g-rotor, which was intact, corroded and fire damaged. Fire damage was observed to the solenoid of the anti-ice valve housing. The starter generator was not recovered; however, a sheared segment of the gearshaft was recovered. The propeller pitch control housing was completely consumed by fire and what remained was the actuator shaft, which was intact, corroded, and fire damaged. One of the three torque sensor load arms was recovered and was heavily fire damaged.

5.0 PROPELLER DISASSEMBLY AND EVALUATION

The Powerplant group convened on November 3, 2004, at the McCauley Propeller facility in Wichita, Kansas to examine the accident propeller assemblies, PN 4HFR34C653, SNs 940962 and 000477 respectively. The propeller teardown was completed on November 4, 2004.

5.1 LEFT PROPELLER HISTORY (LEFT), PN 4HFR34C653-JKL, SN 940962

In May 2001, Piedmont Hawthorne Aviation, Winston-Salem, North Carolina, performed the last overhaul of the left propeller assembly, SN 940962. According to the maintenance records, propeller SN 940962 had accumulated 11,502 hours TSN at the time of the overhaul and four new factory A-L106FA-0 blades, SN UH02017, UI2075, UJ2101, and UJ2139, were installed. On May 28, 2001, Corporate Airlines, installed the propeller on the left hand side of aircraft N856TE where it remained until August 27, 2002 when it was removed and then installed on the left hand side of aircraft N883CH. The propeller had accumulated 1,778 flight hours while installed on N856TE. When installed on aircraft N883CH, propeller SN 940962 had accumulated 13,280 hours TSN and 1,778 hours TSO.

On July 12, 2004, the propeller was cannibalized from N883CH, and installed on the left hand side of N875JX where it remained until the accident. The propeller had accumulated 676 hours while installed on N833CH and had accumulated 13,956 hours TSN and 2,454 hours TSO when it was installed on AC N875JX.

The last maintenance inspections performed on propeller SN 940962 prior to the accident flight were a detailed "B" check that occurred on August 19, 2004 and a de-icing boot inspection on October 18, 2004. At the time of the accident, the propeller had accumulated 16,028 hours TSN and 4,526 hours TSO.

5.2 LEFT PROPELLER TEARDOWN

5.2.1 As-Received Condition

The spinner shell and the bulkhead assembly, which houses the slip ring assembly, were missing from the propeller assembly. Propeller blades Nos. 1, 2, and 4 all remained installed in the hub and the No. 3 blade was recovered separate from the hub (**Photo 22**). The No. 3 blade socket was fractured from the rest of the hub while the No. 1 blade socket was partially fractured but primarily intact. Several pieces of the hub were recovered loose at the crash site. Both the pitch change cylinder and the spring housing (feather/reversing spring) remained attached to the front of the hub and were intact. The front end of the piston rod assembly protruded approximately 0.027-inches out past the front of the spring housing. The aft portion of the piston rod assembly stuck out of the back of the hub but was bent so two measurements were taken from the hub aft face to the aft end of the piston rod assembly. The exposed length of the piston rod assembly measured approximately 1.273 and 1.207-inches respectively (**Photo 23**). The phonolic bushing was missing from the aft side of the hub. The "Beta" tube was found fractured within the piston rod assembly but the beta lock was still in place. The "Beta" tube projection out the front of the piston rod assembly was approximately 10 threads.[8]

PHOTO 22: LEFT PROPELLER

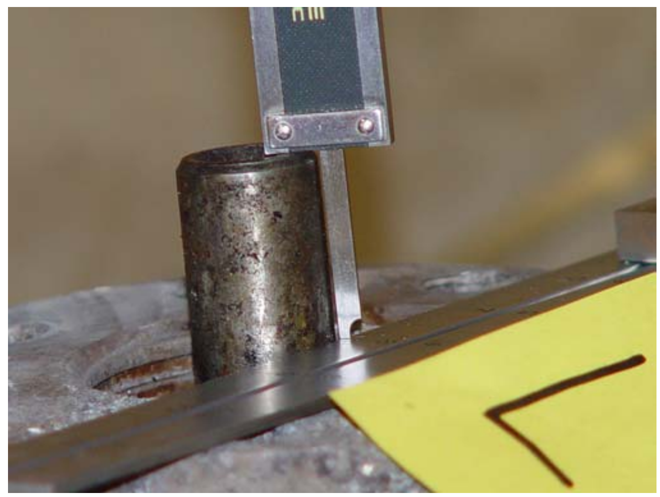

PHOTO 23: PISTON ROD LENGTH (BACK OF HUB)

[8] This is the "Beta" tube projection length set during assembly.

The measurement of the exposed aft length of the piston rod assembly from the accident propeller was transferred to a propeller mock-up of the same make and model as the accident propeller to determine an approximate blade pitch angle. Since two measurements were taken due to the damage to the piston rod assembly, the average exposed piston length of 1.240-inches was used. A blade pitch angle of 36.3° on the mock-up corresponded to the 1.240-inch aft protrusion of the piston rod assembly (**Photo 24**).[9] The forward protrusion of the piston rod past the spring housing on the mock-up measured 0.027-inches, which corresponded with the length that was measured on the accident propeller.

PHOTO 24: BLADE ANGLE MEASUREMENT

5.2.2 Propeller Disassembly

5.2.2.1 Pitch Change Mechanism

The pitch change rod assembly was intact but had a slight bend aft of the pitch change yoke. All four pitch change links were intact and remained installed to the pitch change yoke; however, the holes for the actuating pin in the links of the Nos. 2, 3 and 4 blades were all distorted. All the pitch change yoke ears were intact and straight except for the ears on the No. 3 blade, which was bent and one of the ears were fractured and torn.

The actuating pin for the No. 1 blade had fractured from its respective blade butt and remained installed to its respective pitch change link. The actuating pin for the No. 2 blade had broken from its respective blade butt and was found loose within the hub. Actuating pins for the Nos. 3 and 4 blades were fractured from their respective blade butts and did not remain attached to their respective pitch change links; however, they were recovered loose at the crash site.

The reversing/feather spring exhibited heat damage, and loss of its length and spring tension were noted. The piston assembly was intact and exhibited indentations marks on both sides. Two indentation marks on the aft side of the piston assembly were consistent in size, shape, and quantity as the two feather stop bolts and the marks, according to McCauley were considered normal; however, two sets of four overlapping indentation marks were noted on the forward side of the piston assembly consistent with size, shape, and quantity of the four reverse stop screws but the overlapping nature of the marks were not considered normal.

[9] Blade angle measurements are taken at the 30-inch blade station location on the blade. This location is 30-inches outboard of the blade butt and is marked with a distinctive line on the suction side of the blade.

5.2.2.2 Propeller Blade 1, PN A-L106FA-0, SN UH02017

PHOTO 25: BLADE 1 MISSING TIP

Blade No. 1 remained installed in the hub but was fractured and the fracture surface had melted and resolidified (**Photo 25**). Approximately the outboard 18-inches of the blade was missing and the remaining part of the end of the blade was bent and curled in the direction opposite rotation. The shim pack[10] remained installed. The counterweight no longer remained attached to the butt of the blade and the counterweight hole was damaged and distorted. No longer installed on the bottom of the blade butt was the actuating pin.

5.2.2.3 Propeller Blade 2, PN A-L106FA-0, SN UI02075

PHOTO 26: BLADE 2 BENT AND CURLED

Blade No. 2 (**Photo 26**) remained installed in the hub, was intact, and the tip was bent and curled in the direction opposite rotation and twisted towards a decreasing pitch angle (towards reverse). The shim pack was dislodged. The counterweight no longer remained attached to the butt of the blade and the counterweight hole was damaged and distorted. No longer installed on the bottom of the blade butt was the actuating pin.

5.2.2.4 Propeller Blade 3, PN A-L106FA-0, SN UJ02101

Blade No. 3 was recovered loose from the hub. The blade tip was missing and the outer portion of the blade was bent and curled in the direction opposite rotation and twisted towards a decreasing pitch angle. A round bottom soft body impact mark at approximately the 18.20-inch blade station position was noted on the trailing edge of the blade. The shim carrier and the retaining ring remained on the blade but the shims themselves were all missing. The counterweight no longer remained attached to the butt of the blade and the counterweight hole was damaged and distorted. No longer installed on the bottom of the blade butt was the actuating pin.

[10] The shim pack consists of the shim carrier, the various shims, wire ring, and retaining ring.

5.2.2.5 Propeller Blade 4, PN A-L106FA-0, SN UJ02139

Blade No. 4 remained installed in the hub, was intact, and blade tip was bent and curled in the direction opposite rotation and towards a decreasing pitch angle (**Photo 27**). A large round bottom soft body impact mark at approximately the 38 to 39-inch blade station was noted on the leading edge of the blade while several soft body impact marks were noted along the trailing edge of the blade with the trailing edge folded over towards both the pressure and suction sides of the blade. The shim pack was dislodged. The counterweight no longer remained attached to the butt of the blade and the counterweight hole was damaged and distorted. No longer installed on the bottom of the blade butt was the actuating pin

PHOTO 27: BLADE 4 BENT AND CURLED

5.3 RIGHT PROPELLER HISTORY PN 4HFR34C653-GHJKL, SN 000477

In August 2001, Piedmont Hawthorne Aviation, Winston-Salem, North Carolina, overhauled propeller SN 901168 to create propeller SN 000477. According to the maintenance records, a new propeller hub, SN 000477, and four new factory propeller A-L106FA-0 blades SNs UL0213, UL02015, UL02025, and UJ02030, were installed. Because a new hub was installed, the propeller assembly was zeroed out (TSN and TSO were 0.0)[11]. On August 29, 2001, Corporate Airlines, installed propeller SN 000477 on the left hand side of aircraft N432AM where it remained until August 27, 2002, propeller SN 000477 when it was removed. The propeller had accumulated 1,589 flight hours while installed on aircraft N432AM.

On September 3, 2002, propeller SN 000477 was installed on the right hand side of aircraft N875JX. On October 11, 2002, propeller SN 000477 was removed from the right hand side of aircraft N875JX due to excessive twist to blade No. 1. The propeller had accumulated 173 flight hours while installed on aircraft N875JX before it was removed for repair. Piedmont Hawthorne Aviation disassembled the propeller and discovered a worn link bushing. On November 5, 2002 the repair to propeller SN 000477 was complete and on February 14, 2003, the propeller was installed on the left hand side of aircraft N860AE with 1,762 hours TSN and TSO, where it remained until May 2004.

On May 10, 2004, the propeller was removed from the left hand side of aircraft N860AE, where it had accumulated 1,329 flight hours, and installed on the right hand position of N875JX where it remained until the accident. The propeller had accumulated 3,091 hours TSN and TSO when it was installed on N875JX.

The last maintenance inspections performed on propeller SN 000477 prior to the accident flight were a detailed "B" check that occurred on October 5, 2004 and a de-icing boot inspection on October 18, 2004. At the time of the accident, the propeller had accumulated 3,699 hours TSN and TSO.

[11] The propeller assembly carries the SN of the propeller hub. When a new hub is installed, the SN of the propeller assembly changes and the TSN and TSO equal 0.0 hours.

5.4 Right Propeller Teardown

5.4.1 As Received Condition

The spinner shell and the bulkhead assembly remained installed on the propeller assembly. The spinner shell exhibited several impact marks, two counterweight impression marks - one at the No. 1 blade position and the other at the No. 2 blade position - and was torn at the No. 4 blade position exposing the No. 1 blade counterweight (**Photo 28**).

Photo 28: Counterweight Impression

All the propeller blades remained installed in the hub and the hub was intact (**Photo 29**). Both the pitch change cylinder and the spring housing (feather/reversing spring) remained attached to the front of the hub and were intact. The front end of the piston rod assembly was retracted approximately 0.354-inches into the front of the spring housing while the aft portion of the piston rod assembly was fairly straight and stuck out the back of the hub approximately 1.441-inches. The exposed aft portion of the piston rod assembly was measured in the same manner as what was described for the No. 1 propeller (See section 5.2.1 As-Received Condition). The phonolic bushing remained installed on the aft side of the hub. The "Beta" tube was fractured at its metering holes, what remained was bent, and the beta lock was still in place. The "Beta" tube projection out the front of the piston rod assembly was approximately 11 threads.

Photo 29: Right Propeller

As in the case of the No. 1 propeller, the measurement of the exposed aft length of the piston rod assembly from the accident propeller was transferred to a propeller mock-up of the same make and model as the accident propeller to determine an approximate blade pitch angle. A blade pitch angle of 43.1° on the mock-up corresponded to the 1.441-inch aft protrusion of the piston rod assembly.

5.4.2 Propeller Disassembly

5.4.2.1 Pitch Change Mechanism

The pitch change rod assembly was intact and straight. All four pitch change links were intact and no significant damage was noted. They all remained installed to the pitch change yoke and were all attached to their respective actuating pins. No visible damage was noted on any of the ears of the pitch change yoke, except there was a slight bend of one ear on both the Nos. 2 and 3 blade locations. All the actuating pins were still attached to their corresponding propeller blades except for the No. 2 that was found still attached to its pitch change link.

The reversing/feather spring exhibited no damage and no loss of length and spring tension was noted. The piston assembly was intact and exhibited indentation marks on both sides. Two indentation marks on the aft side of the piston assembly were consistent with size, shape, and quantity of the two feather stop bolts and the marks were considered normal; however, two sets of four overlapping indentation marks were noted on the forward side of the piston assembly consistent with size, shape, and quantity of the four reverse stop screws but the overlapping nature of the marks were not considered normal.

5.4.2.2 Propeller Blade 1, PN A-L106FA-0, SN UL02013

Blade No. 1 remained installed in the hub, a piece of the blade tip was missing, and the outer portion of the blade was bent and curled in the direction opposite rotation and twisted towards a decreasing pitch angle (**Photo 30**). The blade tip leading edge exhibited a pronounced curl towards a decreased pitch angle. The shim pack remained installed. The counterweight remained attached to the butt of the blade and the spinner shell was folded over leaving an impression on the spinner shell. Visual comparison of the counterweight impression mark in the spinner shell with the propeller mock-up placed in roughly the same position indicated that the propeller blade was not in reverse or in feather, but in a position within the normal operating range. The actuating pin remained installed on the bottom of the blade butt.

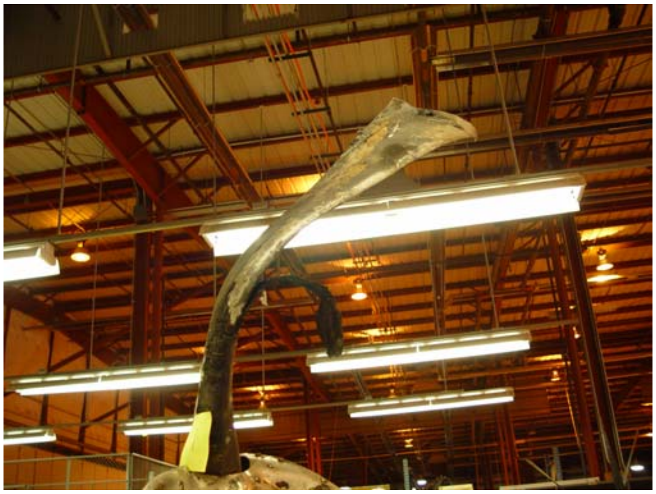

PHOTO 30: BLADE 1 BENT AND CURLED

5.4.2.3 Propeller Blade 2, PN A-L106FA-0, SN UL02015

Blade No. 2 remained installed in the hub, was intact, and was found past the normal reverse position (leading edge pointing aft). The blade was bent and curled in the direction opposite rotation and twisted toward a decreasing pitch angle (**Photo 31**). One smooth round bottom soft body impact mark was noted on the leading edge camber side near the blade tip while three smooth round bottom soft body impact marks inboard of the leading edge mark were noted on the trailing edge. The shim pack was dislodged. The counterweight remained attached to the butt of the blade and the spinner shell was folded over leaving an impression on the spinner shell corresponding to the blade in the reverse pitch position. No longer installed on the bottom of the blade butt was the actuating pin.

PHOTO 31: BLADE 2 TWISTED

5.4.2.4 Propeller Blade 3, PN A-L106FA-0, SN UL02025

Blade No. 3 remained installed in the hub but was fractured, approximately the outboard 16 to 18-inches of the blade was missing and the remaining part of the end of the blade was bent and curled in the direction opposite rotation and twisted towards decrease pitch angle at the fracture location (**Photo 32**). The shim pack was dislodged. The counterweight no longer remained attached to the butt of the blade and the counterweight hole was damaged and distorted but was found within the spinner shell. The actuating pin remained installed on the bottom of the blade butt.

PHOTO 32: BLADE 3 FRACTURED

5.4.2.5 Propeller Blade 4, PN A-L106FA-0, SN UL02030

Blade No. 4 remained installed in the hub, was intact, and blade tip was bent and curled in the direction opposite rotation and towards a decreasing pitch angle. The blade trailing edge exhibited a jagged impact mark about 4-inches from the blade tip and the tip was bent forward at the impact location. The shim pack remained installed. The counterweight remained attached to the butt of the blade and the actuating pin remained installed on the bottom of the blade butt.

PHOTO 33: BLADE 4 BENT AND TWISTED

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