



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

March 21, 2014

POWERPLANT GROUP CHAIRMAN'S FACTUAL REPORT

NTSB No: DCA-13-MA-121

A. ACCIDENT

Location: Soldotna, Alaska

Date: July 7, 2013

Time: 1120 Alaska Daylight Time (ADT)

Aircraft: de Havilland DHC-3 'Otter', Registration No. N93PC

B. POWERPLANTS GROUP

Group Chairman: Harald Reichel
National Transportation Safety Board
Washington, DC

Honeywell Member: David Studtmann
Staff Engineer, Product Integrity
Phoenix, Arizona

Hartzell Member: Dan Boggs
Air Safety Investigation Manager
Piqua, Ohio

C. SUMMARY

On July 7, 2013, about 1120 Alaska Daylight Time, a de Havilland DHC-3 "Otter" airplane, N93PC, sustained substantial damage after a collision with terrain shortly after takeoff from the Soldotna Airport, Soldotna, Alaska. The airplane was registered to Rediske Family Limited Partnership, Nikiski, Alaska and was operated by Rediske Air, Inc. under provision of 14 CFR Part 135, as an on-demand charter flight. The commercial pilot and nine passengers were fatally injured. Visual meteorological conditions prevailed and no flight plan was filed for the flight destined to Bear Mountain Lodge, approximately 90 miles southwest of Soldotna.

On-scene, the engine was found within the main wreckage still contained within the nacelle/firewall engine mount frame and 'horse-collar' which had rolled on its right side. The engine exhibited extensive fire damage due to the post impact fire but none of its cases exhibited evidence of an un-containment or breach. All four propeller blades were present, attached to the propeller hub, and exhibited rotational scoring on the front surfaces, dents on the leading edges and torn tips.

The engine and propeller assemblies were initially examined on scene and were then sent to the Honeywell facilities in Phoenix, Arizona for evaluation by the powerplants group. The Honeywell TPE331-10R-511C engine was disassembled and examined at the Honeywell teardown facility in Phoenix and the Hartzell propeller model HC-B4TN-5NL was transferred to Ottosen Propeller in Phoenix, Arizona where it was disassembled and examined.

Disassembly and examination of the engine revealed the following significant characteristics, consistent with rotation during impact: (1) sheared torsion shaft, (2) corresponding rotational scoring of the propeller shaft and sun gear, and (3) rotational scoring throughout the compressor and turbine sections. Metal spray¹ was present throughout the turbine components in the air stream path.

Disassembly and examination of the propeller revealed the following characteristics, consistent with rotation under an amount of torque: (1) rotational scoring on the blade tips, (2) leading edge dents and tears, (3) loss of tips on two blades, and (4) similar twist and bend patterns of all four blades. There was no evidence of impression marks on the propeller hub components that could determine the blade angle prior to impact.

¹ Metal Spray – During engine operation, compressor rotors turn at high speeds. Shrouds are stationary, are typically coated with a thick aluminum spray material and are in close proximity to the turning rotors. Impact forces can force these components to contact with each other. During contact, the high speed rotors shaves the soft aluminum material off the shrouds and the engine airflow sends the small shaved particles through the engine. As the aluminum particles enter the combustor, they become molten if there is a flame. The melted particles continue to flow along the air stream and become deposited on the cooler surfaces of the turbine blades and stator vanes. Visually, they appear as silver colored speckles. The evidence of metal spray is consistent with engine operation; it indicates that there is engine rotation, positive engine airflow, and flame in the combustor.

D. DETAILS OF THE INVESTIGATION

D.1 Engine Description

The engine was a Honeywell (formerly Allied Signal, formerly Garrett) TPE331-10R-511C turbo-propeller engine. The TPE331 is a single-shaft engine consisting of 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 (Figure 1). The TPE331-10R-511C turbo-propeller engine has maximum takeoff power of 940 shaft horsepower (SHP).

D.2 Propeller Description

The propeller was a four-bladed Hartzell model HC-B4TN-5NL (Figure 2) with type 10890 blades, and is a single-acting, hydraulically operated constant speed model with feathering and reverse pitch capability. Oil pressure from the propeller governor is used to move the blades to the low pitch (blade angle) direction. A feathering spring and blade counterweight forces are used to move the blades to the high pitch/feather direction in the absence of governor oil pressure. The propeller incorporates a Beta mechanism that actuates when blade angles are lower than the flight idle position. The propeller features an aluminum hub with aluminum blades. Rotation is counter-clockwise as viewed from the rear. The propeller operating speed is 1,591 revolutions per minute (RPM) at 100 percent engine speed.

D.3 On-Scene Examination Of The Powerplant

The propeller assembly was partially separated from the engine propeller shaft flange. All 4 blades of the propeller were present and found attached to the propeller hub. The spinner was dented and deformed but otherwise intact. Three propeller attachment bolts were found loose in the wreckage within 4 feet of the propeller. The bolts were intact, but the threads had been deformed. Two of the three bolts were still lock-wired together. All four propeller blades were rotationally scored on the blade front surface within 12 inches of the tip (Figure 3). The scoring was deep enough to remove the paint as well as some of the metal blade material below the paint. The leading edges of all four blades were dented and torn with associated loss of some material. Three blades displayed very similar damage characteristics, being sharply bent aft, spanwise to approximately 90 degrees at about 1 foot from the shank collar (Figure 4). There was also an aft twist on all three blades. The fourth blade displayed two small spanwise reversed bends. A 1 ½ inch section of the tip of one sharply bent blade was fractured and missing. A 2 ½ inch section of the tip of the unbent blade was fractured and missing. All blades

were free to turn in their hub bearings. When the propeller was initially moved during the recovery, oil was seen leaking from the hub onto the blades.

The engine was found still contained within the nacelle/firewall engine mount frame and 'horse-collar' and had rolled on its right hand side (Figure 5). The engine is supported in the front by three elastomeric engine mounts situated on the right, top and left side of the main gearbox. The left hand engine mount was fractured at the 'horse-collar' location of the engine mount frame and was missing. The upper engine mount was intact and attached to the engine and 'horse-collar'; however the elastomeric components were severely fire damaged. The right hand engine mount was intact, in location and undamaged. The single aft engine mount which is located on the top of the engine was connected to the engine, and the engine mount hanger was connected to the engine mount frame; however the hanger had slid along the engine mount frame support tube approximately 7 inches to the right of its normally centered location. All the metal mount tube surfaces were coated with a layer of tan-rust colored corrosion, consistent with fire damage.

The majority of the nacelle skin is of a composite material, consistent with that of a fiberglass/resin construction. Almost the entire resin component of the composite material of the nacelle skin was consumed by fire, leaving only the fibrous matrix which no longer had structural integrity (Figure 6). Most of the loose fiber was separated from the nacelle frame and was on the ground around the nacelle area. The engine air inlet is aluminum crescent shaped duct which was intact but dented at the lower right hand corner with a maximum deformation of approximately 1 inch towards the left. The duct contained loose grass and dirt debris, most of which was near the front.

The primary exhaust pipe was intact; however it was bent near the engine attachment flange and dented near its aft section. The secondary exhaust tube was intact; however it was flattened along its length.

The main airframe fuel supply line was intact but severely fire damaged. The airframe oil cooler was severely impact and fire damaged.

There are three engine control push-pull tubes which transmit pilot input from the (1) power lever, (2) speed lever, and (3) fuel shut-off and feather lever. From the cockpit control quadrant, the three primary push-pull tubes run through the firewall into a bell-crank assembly (Figure 7). From the bell-crank assembly, three secondary push-pull tubes run to the engine accessories they control: the (1) Fuel and pitch controller, (2) Propeller speed governor and engine speed control, and (3) Fuel shut off and feather valve. The cockpit control quadrant assembly was fractured, separated and fire damaged. Only the top portion two levers were found but they were separated from the quadrant assembly, and therefore no final lever position could be established. The primary push-pull tubes were found intact and in location but bent. The aft ends of the primary push-pull tubes were not connected to the quadrant levers, however the spherical bearings on both ends were intact, as were the connecting bolts, nuts and cotter pins. The forward ends of the primary push-pull tubes were still connected to the bell-crank assembly. The

three secondary push-pull tubes were intact but bent. The aft spherical bearing ends were connected to the bell-crank assembly and the cotter pins were in location. The forward ends of the secondary push-pull tubes were still connected to their respective engine accessory and the cotter pins were still in location.

The engine was generally intact with all external components and accessories fire damaged. There were no signs of uncontainment. The front of the engine was sooted while the aft was free of soot and oil, consistent with pyrolytic cleaning. The 1st stage impeller appeared to be clean and undamaged as viewed through the inlet duct (Figure 8). Once the powerplant was removed from the airplane, the propeller could be turned with some even resistance. With the 3rd stage turbine wheel physically restrained, the propeller shaft could be turned, indicating discontinuity between the power section and the gearbox, which is consistent with a sheared torsion shaft, consistent with a sudden propeller stoppage event. Removal of the primary exhaust duct permitted access to the 3rd stage turbine wheel, which was found to be intact and undamaged (Figure 9).

The propeller shaft was intact; however the propeller mount flange was bent and deformed. The nose case housing and the diaphragm assembly were undamaged. The main gearbox housing was intact, however the aft flange and bell housing was melted at the 2 - 3 o'clock position, exposing the 1st stage compressor cross-over duct which appeared to be undamaged. The 2nd stage compressor housing was undamaged. The combustor plenum and the exhaust pipe were undamaged.

The oil tank was intact and in location but dented and buckled. The external tank surface was oil wetted. There was a fracture approximately 1-1/2 inches long at one sharp buckle near the center of the outer tank surface. The drain plug was removed and no oil was seen to drain out, however the internal surfaces of the tank were oil wetted. All the tube fittings on the oil tank and fuel oil heater were secure. The oil filter housing was oil wetted. The oil filter was removed and the filter element was clean and oil wetted, however the oil filter housing was not filled with oil. The gearbox chip detector was removed and found to contain no metallic particles.

The ignitor box, its high tension leads, and the exhaust gas temperature compensator were severely fire damaged. The thermocouple harness was intact, in location and undamaged.

The engine fuel shut-off valve was intact but fire damaged. The scribe mark at the end of the input shaft was at the 12 o'clock location, indicating that the valve was in the open or 'flow' condition. The input lever arm was intact and in location and the input shaft was free to rotate. The fuel control unit (FCU) was present; however, the back cover was melted, exposing the internal mechanical components (Figure 10) and preventing the manual fuel valve (MFV) shaft from turning. The link rod between the MFV shaft crank to the concentric shaft assembly (CSA) was intact. The underspeed governor (USG) shaft was present and could be turned but with difficulty. The link rod between the USG shaft crank to the CSA was intact. The fuel pump assembly was intact and appeared to be undamaged. The fuel filter removal and inspection revealed a clean metallic element;

however, the elastomeric seals were distorted. There was no fuel in the filter housing. The flow divider was present; however, a corner of it was heat damaged and fractured. The fuel nozzles and manifolds were intact, in location, and undamaged.

The propeller feather valve could be actuated with the input rod and its operation was smooth. The propeller governor (PG) was coated with soot, but otherwise appeared to be undamaged. The input shaft could be turned with little resistance and the link rod between the PG and the CSA was intact and in location. The CSA was intact; however, it was fire damaged and the shafts could be rotated but with high resistance. The propeller pitch control (PPC) was coated with soot, but otherwise appeared to be undamaged. The input shaft could be turned with little resistance. The link rod between the PPC and the CSA was intact and in location.

The starter-generator was intact and in location; however, the internal aft cooling fan blades were partially melted. The starter-generator shaft was sheared at the spline shear location.

D.4 Engine Disassembly and Evaluation

The powerplants group convened at the Honeywell facilities, located in Phoenix Arizona from January 14 to 16, 2014 to disassemble and examine the accident engine.

D.4.1 Engine History

The engine was a Honeywell TPE331-10R-511C, Part Number 3102170-6, serial number (S/N) P42145C. The engine was overhauled on April 26, 2010 and installed on the airplane on July 7, 2010. According to the logbook, the engine total time since overhaul was 295.3 hours; the cycles since overhaul was estimated at 186 since the last cycle count in the logbook was not entered.

D.4.2 Engine Teardown and Examination

D.4.2.1 General

The engine ([Figure 11](#)) was externally generally intact; however, coated with an oily film. Additionally, the left side of the gearbox and compressor housings were coated with soot. A section of the gearbox housing 'boat-tail' flange between 1:30 and 3:00 o'clock² was melted, exposing the inner 1st stage compressor housing ([Figure 12](#)). The engine showed damage generally consistent with impact and fire damage.

² 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. Top is the 12 o'clock position. The direction of rotation of the engine is clockwise. 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.

The power section could be turned by hand with higher than normal effort and when turned, a slight grinding noise was heard from the core.

The inlet duct contained small particle of debris and dirt. The impeller was intact; however the leading edges of most of the vanes had multiple small nicks.

The gearbox chip detector was removed and found to be oily and clean.

A one-third section of the oil tank was crushed, however it was still intact and did not leak oil. The oil bypass indicator was in its normal, un-extended position.

The fuel pump was intact but was not removed from the engine. The aft cover of the fuel control was melted, exposing the internal mechanical controlling components. The internal components were also fire damaged and corroded, making testing of the fuel control impossible (Figure 13).

D.4.2.2 Gearbox

The nose cone was intact and undamaged, and oil was seen leaking from the mating flange when removed from the gearbox housing (Figure 14). The two propeller shaft flange dowel pins were missing. The propeller shaft flange was bent along a line of three consecutive bolts. The propeller shaft had several rotational score marks along its length, consistent with contact against the inner bore of the sun gear while rotating (Figure 15 & Figure 16). The forward propeller shaft bearing was clean, oil wetted, and rotated freely. The threads of four of the 7 propeller shaft bearing support bolts in the lower right quadrant were sheared, but the nuts were still in location.

The propeller shaft coupling was intact and undamaged. The planetary gear assembly (Figure 17) was intact and undamaged and all the planet gears were free to rotate.

The ring gear and its three retaining brackets were intact & undamaged. The forward gear teeth of the sun gear exhibited coarse witness marks on the contact surfaces, however it was intact and otherwise undamaged. The internal bore of the sun gear was rotationally scored in the locations where bore diameters changed, consistent with the matching score locations of the outer diameter of the propeller shaft (Figure 18). The oil nozzles, which direct oil into the sun gear mesh, were intact and undamaged.

D.4.2.3 Diaphragm Assembly Components

A sheared section of the airframe starter/generator (S/G) output shaft was found in the S/G input spline of the gearbox (Figure 19), consistent with a sudden stoppage of the engine. The diaphragm was removed from the gearbox and the internal components were all oil wetted. All of the hydraulic drive, propeller governor drive, S/G drive gears and

bearings were undamaged (Figure 20). The bull gear and the high-speed pinion assembly rotated, meshed smoothly and were undamaged. No further diaphragm assembly components were disassembled or examined.

D.4.2.4 Gearbox Housing Components

All the components in the gearbox housing were oil wetted (Figure 21). The direct drive fuel control (DDFC) assembly, oil pressure pump, FCU/fuel pump gears and bearings were undamaged. The high-speed pinion and high-speed pinion coupler were undamaged. Rotation of the 3rd stage turbine wheel resulted in the corresponding rotation of all the gearbox housing gearset components.

The torque sensor external gears were undamaged (Figure 22). The helical cam gear was easily removed from the torque sensor assembly, revealing an undamaged cam gear mesh. The torque sensor assembly was undamaged. No further diaphragm components were dis-assembled or examined.

D.4.2.5 Turbine Assembly

The rear turbine bearing housing was undamaged and the rear bearing was oil wetted and darkened, consistent with normal operation (Figure 23). The rear oil scavenge pump was removed from the rear bearing turbine housing and was undamaged. The front internal and aft external splines of the torsion shaft were undamaged; however, the torsion shaft itself was sheared just forward of the aft external spline, consistent with a rotating engine sustaining a sudden propeller stoppage (Figure 24).

The 3rd stage turbine wheel (commonly referred to as a blisk³), consisting of a hub, blades and curvic couplings was undamaged. The knife edge seals were intact.

The 3rd stage turbine nozzle was undamaged. There was metal spray on the convex side of the several vanes near the trailing edge (Figure 25). The honeycomb labyrinth seal was moderately grooved.

The 2nd stage turbine blisk hub, blades and curvic coupling were undamaged. The knife edge seals were intact. There was metal spray on the convex side of several blades near the leading edges (Figure 26).

The 2nd stage turbine nozzle was undamaged. There was metal spray on the convex side of the several vanes near the trailing edge (Figure 27).

The 1st stage turbine disk and blades were undamaged.

³ A blisk is a contraction of a bladed disk. Instead of a turbine wheel being assembled from a hub and separate blades, a blisk hub and blades are cast as one piece.

The 1st stage turbine nozzle was undamaged. There was metal spray on the convex side of the several vanes near the trailing edge (Figure 28).

D.4.2.6 Compressor

The 1st stage impeller was intact; however, the leading edges of all vanes had numerous very small dents (Figure 29). The aft curvic coupling was undamaged. The 1st stage impeller shroud showed heavy rotational scoring in the lower right hand quadrant near the inducer side, where all the abradable material was missing, exposing the parent structural metal below. This is consistent with an impact from the right side.

The 2nd stage impeller was intact as well as its fore and aft curvic couplings. The 2nd stage impeller shroud was rotationally scored near the inducer side between 1 and 6 o'clock, consistent with an impact from the right side.

D.4.2.7 Combustor

The combustor and combustor housing were coated with a light-gray powdery material but were otherwise intact and undamaged (Figure 30). The fuel nozzles were intact and undamaged (Figure 31). The combustor was not further disassembled.

D.5 Propeller Teardown and Examination

The powerplants group convened at the Ottosen Propeller facilities, located in Phoenix Arizona on January 15, 2014 to disassemble and examine the propeller.

D.5.1 Propeller History

The propeller was a four-bladed Hartzell model HC-B4TN-5NL, S/N 280 with type 10890 blades. It was manufactured on April 27, 2010 and installed on the airplane on July 7, 2010. According to the logbook, the total time since new was 295.3 hours. There was no record of any further servicing.

D.5.2 Propeller Teardown and Examination

D.5.2.1 As Received Condition

All four blades had been cut near the hub on-scene for shipping (Figure 32). The spinner was not returned. The blades were numbered 1 to 4 in a clockwise pattern as viewed from the rear of the propeller. Blade No. 1 was chosen randomly. The hub serial number was between the No. 3 and No. 4 blades. Blade No. 1 was in the feather position,

blade No. 2 was in the low blade angle setting, blade No. 3 was in the reverse setting and blade No. 4 was in extreme reverse when received. The spinner bulkhead was intact, however it was slightly bent along the edges. All eight engine/prop mounting bolts were stripped out of the mounting flange threads. It was not possible to functionally test the propeller because of the severe damage.

D.5.2.2 Pitch Change Mechanism

The piston and cylinder assembly was stripped from the hub thread (Figure 33) and was held in place only by the link arms. Additionally, the cylinder base was fractured near one of the guide rod sleeve holes (Figure 34). The guide rods were intact, however they were bent. The pitch change rod was bent and could not be removed from the piston. The link arms were intact. The feathering spring and guides were intact (Figure 35).

D.5.2.3 Pitch Stops

The low pitch stop, feather stops and start locks were intact and undamaged. All four start lock springs were operational.

D.5.2.4 Hub Assembly

The cylinder attachment threads were stripped. The P1 and P4 pilot tubes were fractured. The P3 pilot tube remained in the blade and had impression marks at the 5 o'clock position.

D.5.2.5 Blade/Clamp Rotation

The red paint blade and clamp alignment indicators of all four blades were not coincident, indicating that they had rotated within their respective clamps (Figure 36), consistent with a severe prop strike.

D.5.2.6 Propeller Blades

All four blades were rotationally scored within 18 inches inboard from the tips and they were all twisted spanwise. They all had gouges, and tears. Blades No. 3 and 4 had the tips torn off. An individual blade damage assessment follows:

Blade No. 1 (S/N K99765) damage description:

Camber Side	Paint scratches, rotational scoring, thermal damage at tip
Flat Side	Paint scratches
Bend	Bent aft at hub base
Twist	Twist forward at mid-blade to tip
Leading Edge	Gouges at tip
Trailing Edge	None
Root Impression Mark	Hub ring mark at trailing edge

Blade No. 2 (S/N K99764) damage description:

Camber Side	Paint scratches, rotational scoring, thermal damage at tip
Flat Side	Paint scratches
Bend	Bent aft at hub base
Twist	Twist forward at mid-blade to tip
Leading Edge	Gouges, tear approx. 12" from tip
Trailing Edge	None
Root Impression Mark	Hub ring mark at trailing edge

Blade No. 3 (S/N K99766) damage description:

Camber Side	Paint missing - thermal damage, rotational scoring
Flat Side	Paint missing - thermal damage
Bend	Bent aft at hub base
Twist	Twist forward
Leading Edge	Gouges, 2 inches of tip torn away
Trailing Edge	None, 2 inches of tip torn away
Root Impression Mark	Hub ring mark at trailing edge

Blade No. 4 (S/N K99763) damage description:

Camber Side	Paint scratches, rotational scoring
Flat Side	Paint scratches
Bend	Bent aft at mid-blade
Twist	Twist forward
Leading Edge	Gouges, 2 inches of tip torn away
Trailing Edge	None, 2 inches of tip torn away
Root Impression Mark	Hub ring mark through 360 degrees

Harald Reichel
Aerospace Engineer - Powerplants

Figure 1 – Honeywell TPE331 Turbo-propeller engine

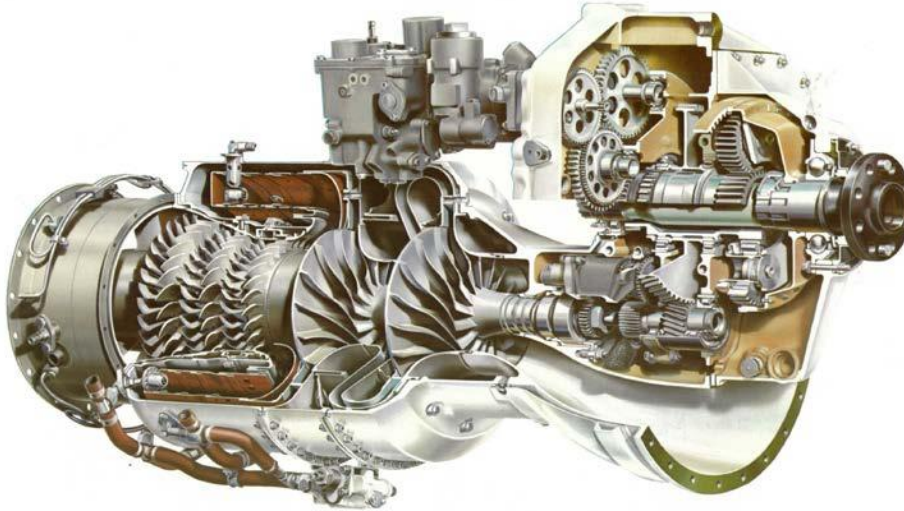


Figure 2 – Hartzell HC-B4 -5 Propeller

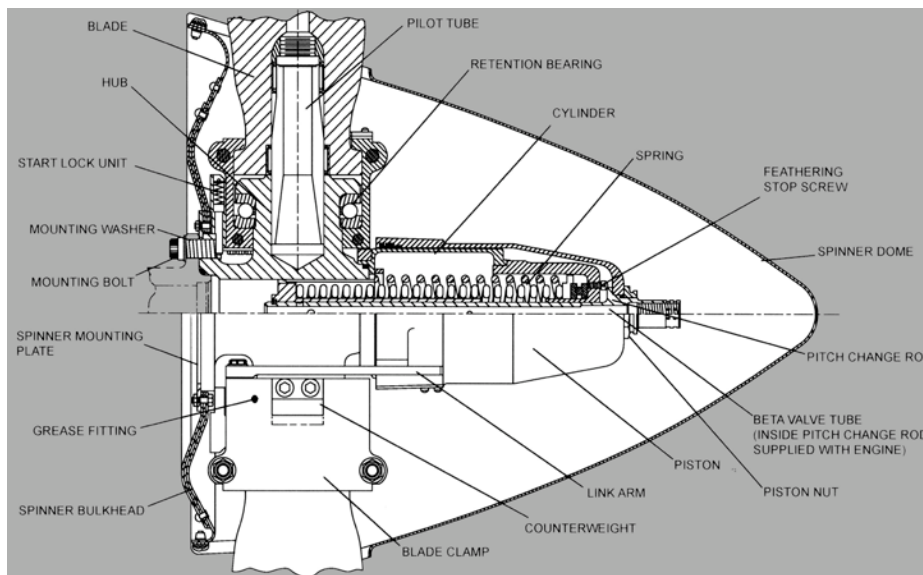


Figure 3 - Propeller blade – In-situ



Rotational
Scoring
Marks

Leading Edge
Dents and Tears

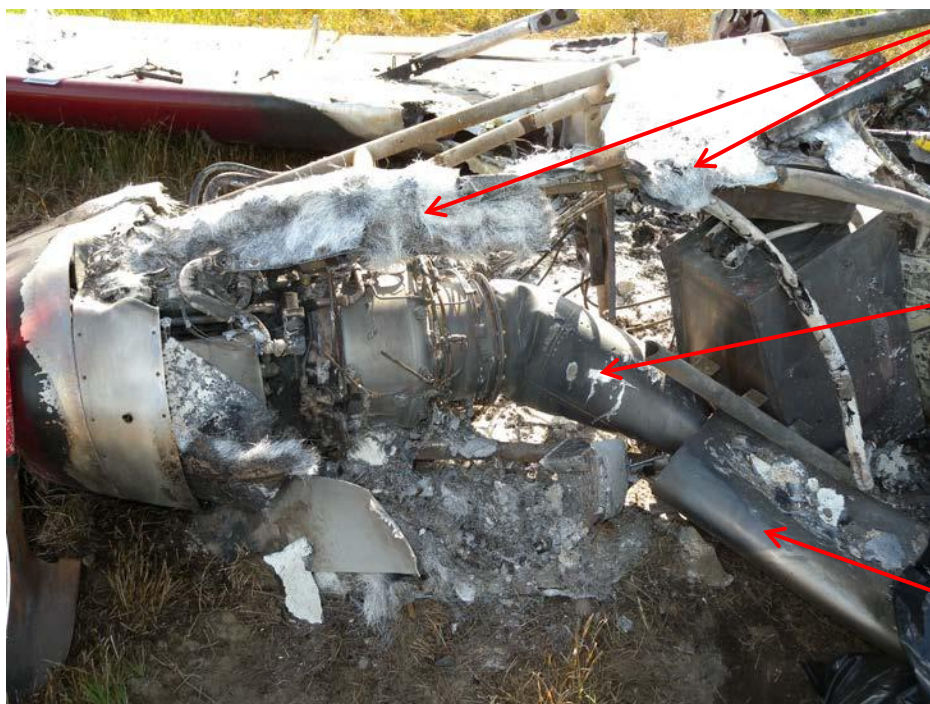
Figure 4 – Propeller – General View in Hangar



Figure 5 – Honeywell TPE331 Engine – On Scene



Figure 6 – Honeywell TPE331 Engine – On Scene



Nacelle
Composite
Skin Residuals

Primary
Exhaust Pipe

Secondary
Exhaust Pipe

Figure 7 – Push-pull Tubes and Bell-crank Assembly

Bell-crank
Assembly



Push-pull Tubes

Figure 8 – 1st Stage Impeller – Intact



Figure 9 – 3rd Stage Turbine Wheel – Intact



Figure 10 – Fuel Control Unit (FCU) - Breached



Figure 11 – Honeywell TPE331-10R-511C Engine – As Received



Figure 12 – Honeywell TPE331-10R-511C Engine – As Received

Gearbox
Housing
'Boat-Tail'
Flange Melted



Figure 13 – Fuel Control Unit – Melted Aft Cover



Figure 14 – Nose Cone & Propeller Shaft Being Removed



Figure 15 – Propeller Shaft – Rotational Scoring



Figure 16 – Propeller Shaft – Rotational Scoring



Figure 17 – Planetary Gear Set – Intact and Undamaged

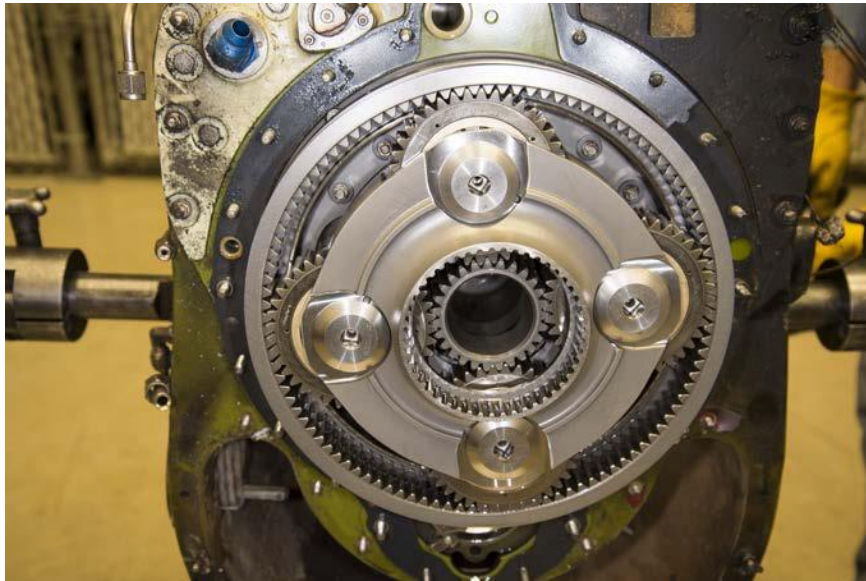


Figure 18 – Rotational Scoring On Inner Bore Of Sun Gear



Figure 19 – Sheared Starter Generator spline



Figure 20 – Diaphragm Assembly Components

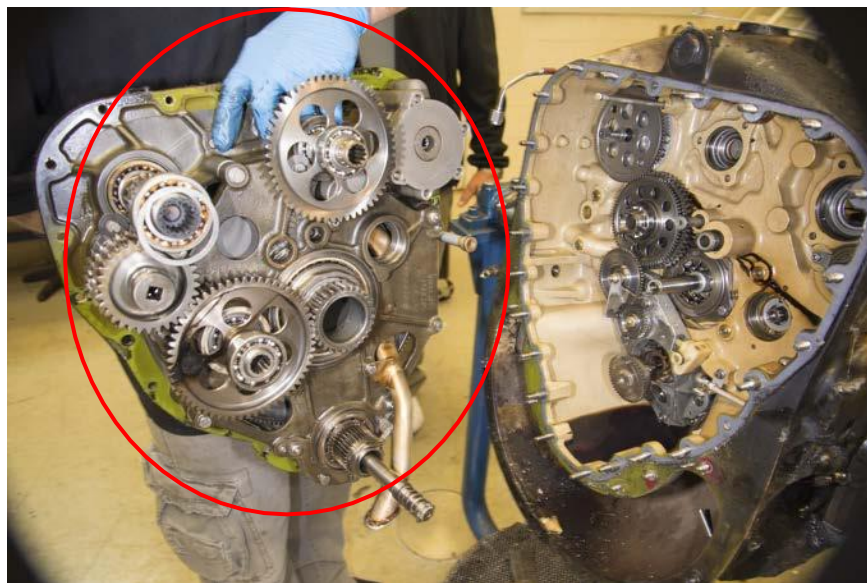


Figure 21 – Gearbox Housing Components



Figure 22 – Torque Sensor

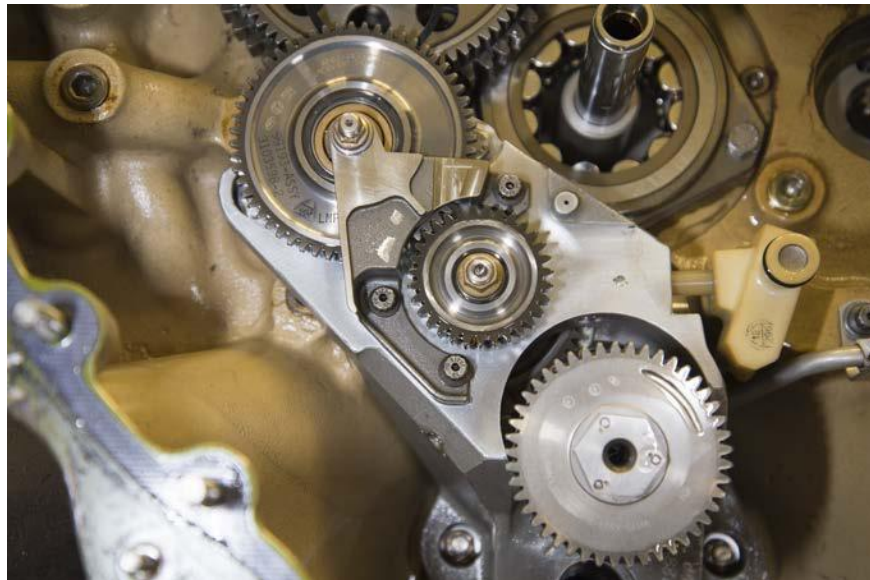


Figure 23 – Rear Turbine Bearing Housing



Figure 24 – Sheared Torsion Shaft



Figure 25 – 3rd Stage Turbine Nozzle – Metal Spray (White Speckles)



Figure 26 – 2nd Stage Turbine Blisk – Metal Spray (Silver Speckles)



Figure 27 – 2nd Stage Turbine Nozzle – Metal Spray (Silver Speckles)



Figure 28 – 1st Stage Turbine Nozzle – Metal Spray (White Speckles)



Figure 29 – 1st Stage Impeller Wheel – Intact



Figure 30 – Combustor Housing and Liner



Figure 31 – Fuel Nozzles



Figure 32 – Propeller – As Received



Figure 33 – Piston and Cylinder Assembly Stripped From Hub

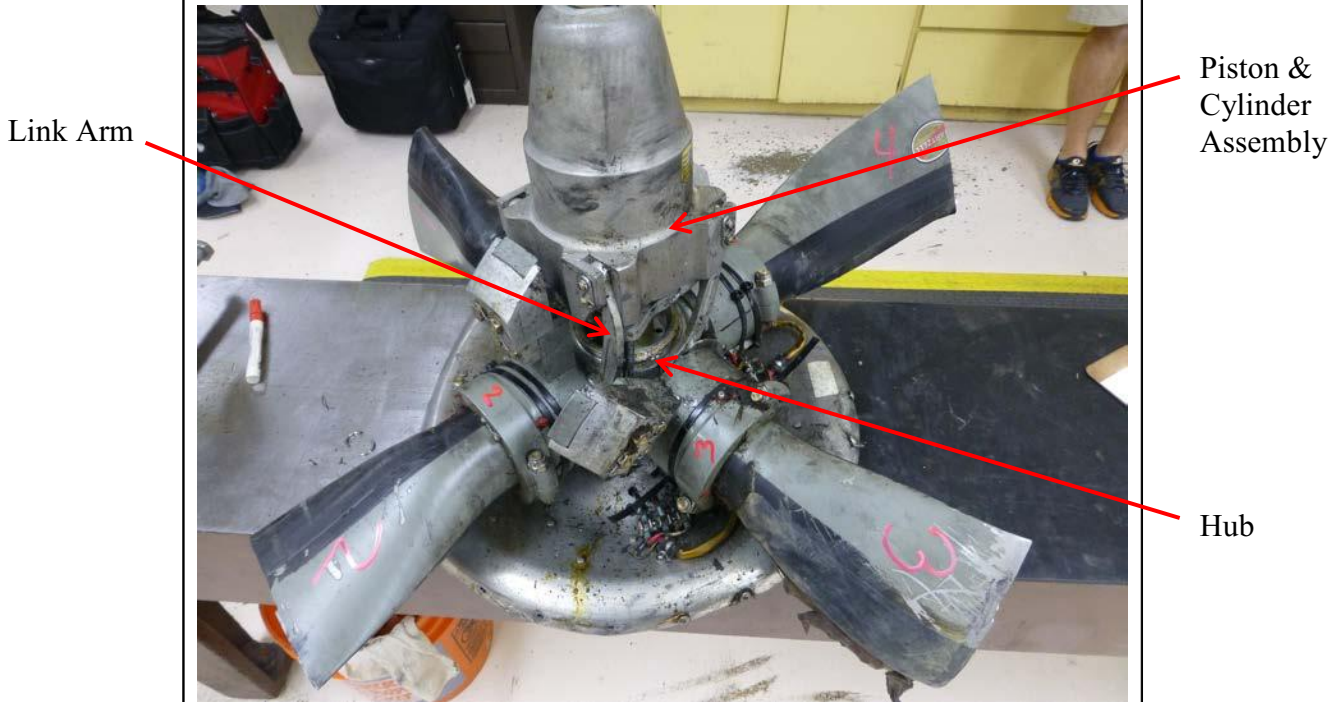


Figure 34 – Pitch Change Components – Laid Out on Bench

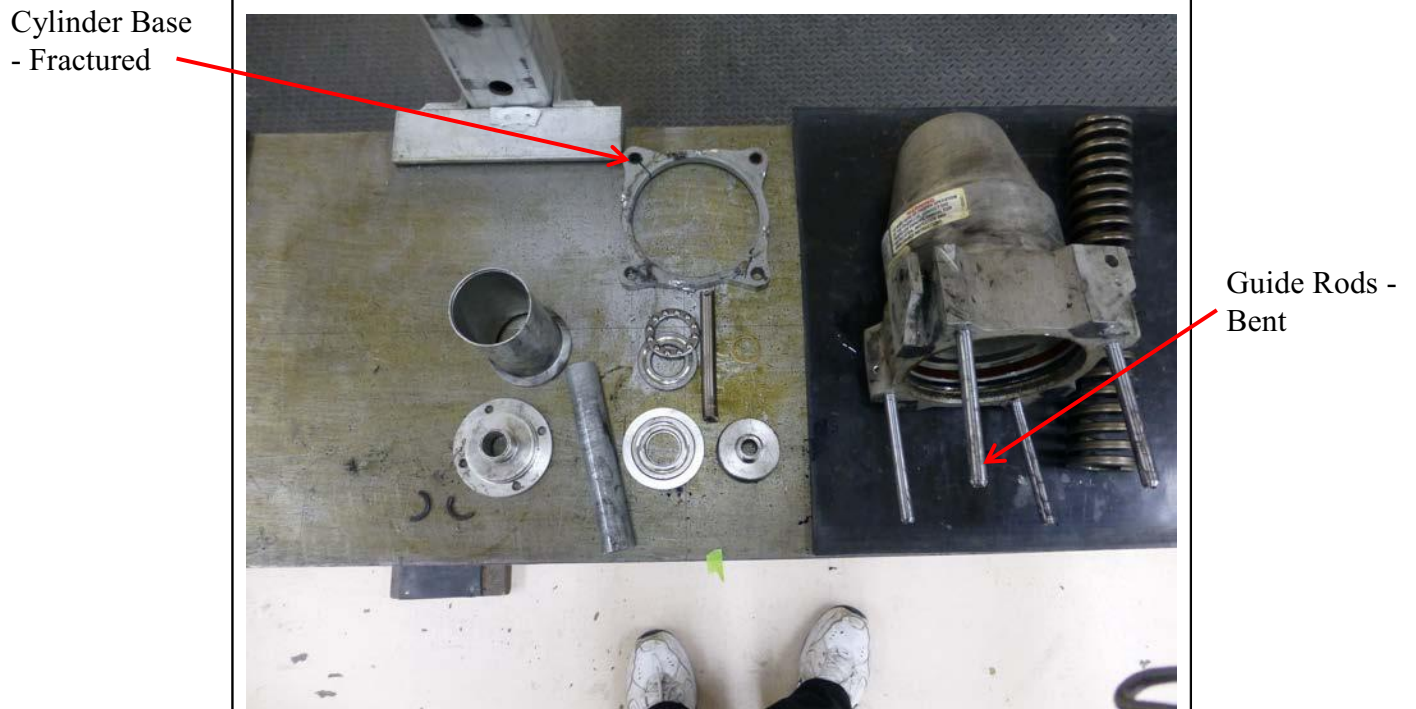


Figure 35– Pitch Change Components – Laid Out on Bench



Figure 36 - Blade Alignment Indicators - Misaligned

