NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594

December 5, 2006

POWERPLANTS GROUP CHAIRMAN'S REPORT

NTSB ID: DCA07MA003

A. ACCIDENT

Location: Manhattan, New York

Date: October 11, 2006

Time: 1442 Eastern Standard Time (EST)

Aircraft: Cirrus Design SR-20, Reg. No. N929CD, Operator: Cory Lidle

B. POWERPLANTS GROUP

Chairman: Carol Horgan
National Transportation Safety Board
Washington, District of Columbia

Member: Tom McCreary
Hartzell Propellers
Piqua, Ohio

Member: Andrew Swick
Teledyne Continental Motors
Mobile, Alabama

Member: Terry Horton
Teledyne Continental Motors
Mobile, Alabama

Member: Brannon D. Mayer
Cirrus Design Corporation
Duluth, Minnesota

C. SUMMARY

On October 11, 2006, about 1442 eastern daylight time, a Cirrus Design SR-20, N929CD, crashed into an apartment building while maneuvering above Manhattan, New York. The airplane was destroyed by impact forces and a post crash fire. The owner of the airplane, a certificated private pilot, and a certificated flight instructor, were fatally injured. Visual meteorological conditions prevailed, and no flight plan was filed, for the personal sightseeing flight, which departed from Teterboro Airport, Teterboro, New Jersey, and was conducted under the provisions of 14 Code of Federal Regulations Part 91.

A Powerplants Group was formed in Manhattan on October 12, 2006. A cursory inspection of the engine and propeller was made on site October 12, 2006. The propeller was disassembled and examined on October 19, 2006. An engine teardown examination was conducted Oct 30-31, 2006.

D. DETAILS OF THE INVESTIGATION

1.0 Powerplant information

The accident aircraft was powered by a Teledyne Continental Motors (TCM) Model IO-360-ES(6)B engine, driving a Hartzell Model PHC-J3YF-1RF propeller.

1.1 Powerplant description

The TCM Model IO-360-E(6)B is a six-cylinder, air-cooled, fuel injected, horizontally opposed reciprocating engine with 360 cubic inch displacement. The engine has cross-flow cylinders with overhead inclined valves, top-mounted downdraft intake inlets and bottom-mounted exhaust outlets. The 360 cubic inch displacement is achieved by using a cylinder design with a 4.438 inch diameter bore and a 3.875 inch stroke. As certificated, the engine crankshaft rotates at 2,800 rpm, producing 210 horsepower.[1] The weight of the engine with installed accessories is approximately 370 pounds. The IO-360-E(6)B engine has a doweled six bolthole configuration propeller flange. A mounting pad is provided for a governor which provides control for a hydraulically operated constant speed propeller.

The Hartzell Model PHC-J3YF-1RF is a 3-blade single acting, hydraulically operated constant speed propeller.[2] Oil pressure from the propeller governor is used to move the blades toward high pitch (high blade angle) positions.[3] A spring and blade

[1] **The engine is derated to 200 hp in the Cirrus SR-20 installation.**

[2] **A constant-speed propeller system is one in which the propeller blade angle is automatically adjusted by a governor unit to maintain a selected RPM.**

[3] **Blade pitch refers to the angle between the blade section chord line and the plane of rotation of the propeller. This angle represents the theoretical distance that an aircraft will move forward in one revolution of the propeller.**

twisting moments move the blades in the low pitch direction in the absence of governor oil pressure. The blades and hub are of aluminum construction. Rotation is clockwise as viewed from the rear. As installed in a Cirrus Design SR-20 aircraft, selected propeller positions will result in the following blades angle settings:

Low pitch: 13.9 +0.1°[4]
High pitch: 35.0 +1.0°

1.2 Powerplant data

component	*model*	*serial number*	*date of manufacture*	*TSN*	*TSO*
ENGINE	IO-360-ES(6)B	357473	06/28/2002	383.7*	new*
PROPELLER (hub)	PHC-J3YF-1RF	FP1685B	03/26/2002	383.7*	new*
blade #1		J71002A	03/26/2002		new*
blade #2		J71006A	03/26/2002		new*
blade #3		J71049A	03/26/2002		new*

* TSN/TSO as of June 21, 2006 – recorded during an annual inspection. The airplane logbooks were destroyed and no other records were available.

Table 1 Powerplant data

1.3 Service history

A June 21, 2006 annual inspection was performed by Mass Aviation Services, LLC, Worchester Regional Airport, MA.

2.0 On-site investigation

The airplane's engine and propeller were found inside a room on the 32nd floor of the Belair condominium building at 524 E. 72nd Street, Manhattan. (See Figure 1.) The interior wall, and an approximate 5 ft x 2 ft section of the lower right exterior wall beneath a large north-facing window frame were collapsed into the room. The interior wall was destroyed. The engine and propeller were lying about eight feet beyond the north wall in the middle of the room at an approximate 160° heading.[5] The room was grossly damaged by fire and firefighting efforts, and the engine and propeller were coated with ash, debris, and fire-extinguishing agent.[6]

[4] **Blade angles are measured at the 30-inch blade station (30 inches from the center of the hub).**

[5] **All references to position are as viewed from the rear unless otherwise noted.**

[6] **The fire burned for approximately 3¼ hours.**

Figure 1. Engine and propeller on 32nd floor of the Belair condominium building

The engine was inverted. It was thermally damaged, with a large portion of the oil sump missing. The propeller was separated from the engine.

The propeller had separated just aft of the engine crankshaft forward flange (propeller flange), and was lying close to the front of the engine. The broken end of the propeller flange was retained under the propeller mounting hardware. Approximately 50% of the #1 blade was missing, with the remaining stub showing melting damage. The #2 blade was underneath the propeller and engine, where it had been protected from the fire. It was intact, and its blade tip was curled aft, twisted toward low pitch, and showed rotational scoring. There was some light leading edge (LE) damage. The #3 blade was missing about 25% of its length, with its stub end showing melting damage; its remaining length had a large-radius, forward bend, and LE gouging damage.

The components were removed from the building and packaged for shipment. The propeller was shipped to Hartzell Propellers, Piqua, Ohio. The engine was shipped to Teledyne Continental Motors, Mobile, Alabama.

3.0 Propeller teardown investigation

Members of the Powerplant Group examined the propeller at Hartzell Propellers, Piqua, Ohio, on October 19, 2006.

3.1 Receiving inspection

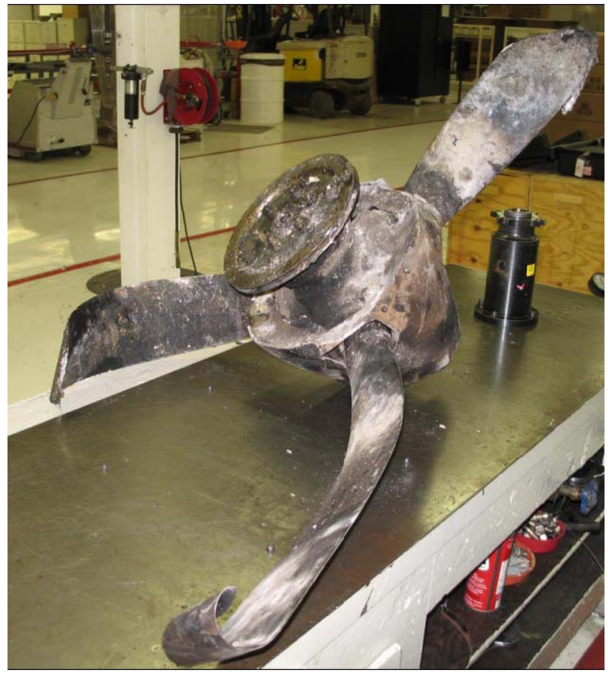

Figure 2. Propeller S/N FP1685B

Ash, soot, and fire-extinguishing agent were deposited on the propeller surfaces. (See Figure 2.) The #1 blade was positioned at a low angle; the #2 blade was positioned at a low/ reverse angle; the #3 blade was turned approximately 90° toward a higher blade angle, and was cocked aftward. The hub serial number was marked between the #1 and the #2 blades.[7] The spinner dome was crushed onto the cylinder; no twisting deformation was noted. The propeller flange, retained by mounting hardware, had separated in the radius immediately aft of the flange. The fracture surface was jagged and had a grainy appearance with a smaller area of shiny, smeared metal consistent with the compression side of an overstress bending fracture. There were multiple spiral cracks outboard of the fracture. (See Figure 3.)

3.2 Test

Cycling of the pitch change mechanism was not attempted.

3.3 Disassembly observations

[7] **In order to document the condition of the propeller, the blades were numbered on site, #1 #2, #3 in the clockwise direction. These numbers are then referenced from the location of the hub serial number, which is identified during disassembly.**

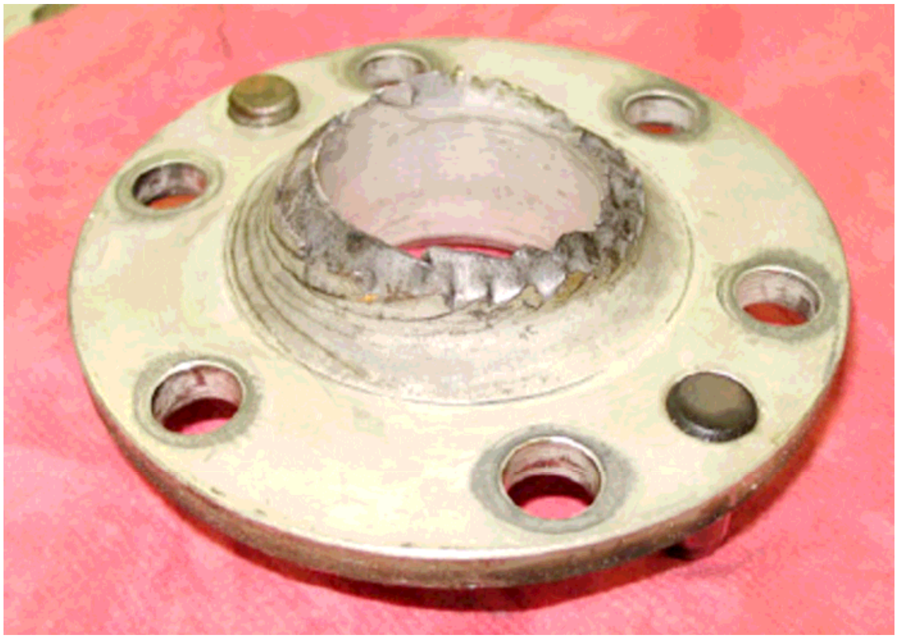

Figure 3. Propeller flange fracture

The propeller was disassembled and inspected.

3.3.1 Hub assembly

The hub assembly mounting flange dowels were retained in the crankshaft flange when it was removed. The inner surface of the hub was gouged consistent with forcible contact by the inward movement of a blade, but was otherwise intact.

3.3.2 Pitch change mechanism

The propeller cylinder and piston were in good condition.

The pitch change rod was bent slightly at the fork location. There were two circumferential bands of dark discoloration, $4\text{-}^{9}/_{32}$ inches and $5\text{-}^{18}/_{32}$ inches from the aft end of the rod.[8] A small burr was noted at the backside of the split ring groove.[9]

The fork was cocked approximately 10° on the pitch change rod. The propeller spring was in good condition. Both low pitch and high pitch stops were in good condition.

[8] This portion of the rod length is radially in line with the rod opening in the aft side of the hub.

[9] This split ring retains the high pitch stop on the rod.

3.3.3 Preload plates

There were marks on all preload plates consistent with contact with the fork. The #3 preload plate was distorted and cracked at the high blade angle end of its slot. (See Figure 4c.)

(a) (b) (c)

Figure 4. Preload plate marks and calculations (a) #1 blade preload plate; (b) #2 blade preload plate; (c) #3 blade preload plate

3.3.4 Propeller blades

All blades were blackened and covered with deposits consistent with the byproducts of fire and with exposure to fire-extinguishing agent.

blade	*blade condition*
#1	- outer ½ of the blade length missing - stub end thermally damaged
#2	- bent aftward approximately 20° at 10 inches from the butt end - outer 6 inches of the tip was curled aft, twisted toward low pitch, and had rotational scoring - pitch change knob separated; a 45° shear lip was evident on the fracture surface - LE lightly gouged
#3	- outer ¼ of the blade length missing - stub end thermally damaged - approximately 90° forward bend - fractured pitch change knob - side of pitch change knob gouged consistent with contact with preload plate extreme low pitch position. - multiple gouges, approximately 1/4–inch deep, in LE

Table 2. Propeller blade condition

3.4 Equivalent blade angle calculations

Equivalent blade angles[10] were determined from the preload plate witness marks based on their locations with respect to the hub parting line. (See Figure 4.) A mark found on the inside wall of the # 2 preload plate slot was consistent with impact by the pitch change knob.

plate	*witness mark*	*calculation*	*equivalent blade angle* [11]
#1	fork mark at 11° fork mark at 32°	45° - 11° 45° - 32°	34° 13°
#2	fork mark at 10.5° fork mark at 19° fork mark at 22° knob mark at 33°	45° - 10.5° 45° - 19° 45° - 22° 45° - 33°	34.5° 26° 23° 12°
#3	no usable marks		

Table 2. Witness marks and equivalent blade angles

4.0 Engine teardown investigation

4.1 As-received inspection

The engine exhibited localized mechanical damage and extensive thermal damage. Ash, soot, fire-extinguishing agent, and small amounts of re-solidified metal were deposited on the engine. The thermal damage was concentrated at the bottom of the engine (oil sump), [12] with approximately 90% of the oil sump structure below the sump rail missing/destroyed. The mechanical damage was concentrated on the left hand (LH) side of the engine.

4.2 Tests

No tests were possible due to severe damage.

4.3 Disassembly observations

[10] Equivalent blade angles are determined by the angular relationship of the witness marks to a known reference. The geometry of this propeller type is such that when the blade knob is centered on the hub parting line, the blade angle at the reference station will be 36° plus the designated knob angle (stamped on the blade butt). The designated knob angle for these blades is 9°. Therefore, for this propeller, the reference blade angle is 45° (knob (9°) + 36° = 45°).

[11] Propeller blade angles derived from witness marks have error tolerance both in measurement and in the accuracy of the reference point used for measurement.

[12] The engine was found inverted.

The oil filter canister was badly dented, but intact and secured with safety wire. The filter adapter housing had separated into two pieces and was thermally damaged. The filter element was not examined.

The starter and starter relay housings were blackened and the relay lead-to-starter insulator was melted. The starter driveshaft was intact and could be rotated by hand. The starter mount flange was intact. The starter adapter was still attached to the engine accessory case, but the vacuum pump had separated from the starter adapter. The vacuum pump was blackened and was thermally damaged. Its mount flange was fractured. The plastic vacuum pump drive coupling was melted.

The starter adapter assembly was intact. One dowel pin was slightly bent. The input shaft rotated freely by hand. The worm wheel gear showed normal wear. It was cleaned and examined for witness marks; none were noted. The starter adapter clutch spring was fractured. The fracture was cleaned and a TCM metallurgist confirmed that the fracture exhibited tensile overload failure features.

The ignition harness insulation and much of the outer shielding were thermally destroyed, and the twelve ignition harness lead wires were severed.

The LH magneto was heavily coated with thermal byproducts and fire-extinguishing agent deposits. The harness cover had melted away, exposing the harness springs. The driveshaft nut and cotter pin were intact. The magneto shaft could not be rotated by hand. The thermal damage had progressed into the inside of the magneto and it was determined that disassembly inspection would not be useful.

The RH magneto was blackened, with apparent soot and fire-extinguisher agent deposits. It was fractured at the mounting flange. The driveshaft nut and cotter pin were intact. There was normal movement of the impulse coupling mechanism, but the magneto shaft could be not be rotated by hand. The harness cover was removed, exposing the distributor block, which was melted. The end housing was removed. All of the internal components exhibited extensive thermal damage.

Correct engine camshaft to crankshaft timing was verified by gear tooth spacing.

The oil cooler, which is mounted to extend horizontally from the aft left side of the engine, was bent aft and upward approximately 20°. Its outboard core end cover was missing. With the exception of the mount leg, which was fractured through, the oil cooler adapter was intact.

The accessory case was intact. Portions of the magneto mount flanges were retained under the magneto retaining hardware at the magneto drive pads. The oil pump[13] drive gear shaft was intact, and the oil pump cavity was in good condition.

[13] The oil pump is an integral part of the engine accessory case.

The oil pump gears were undamaged. The pressure relief valve was intact; its spring was heat damaged. The oil suction screen was unrestricted.

The throttle and metering assembly was blackened and the metering assembly cover and safety wire were intact. The throttle shaft was bent away from the stop pin; this damage prevented the throttle lever from moving. The throttle position was frozen at approximately 40% movement from the idle stop position. A throttle and metering assembly flow vs. pressure test could not be accomplished due to thermal and impact damage. Disassembly inspection found the parts intact and undamaged, with no evidence of contamination.

The fuel pump drive coupling gear shaft was intact and the pump could not be rotated freely by hand. The thru bolt and safety were intact; a loop for a lead seal was present, but the lead was melted away.[14] The inlet and vapor return fittings were in good condition. The ambient pressure reference, outlet, and seal drain fittings were damaged. The end of the aneroid housing was thermally distorted. The low-pressure adjustment screw was intact and secure. The mixture lever was distorted and was frozen in the idle cutoff position. A section of the mixture cable was securely attached. The fuel pump assembly flow vs. pressure test could not be accomplished due to damage. Fuel pump disassembly found that the vanes were intact and showed no unusual wear.[15] The pump-to-vapor separator housing interface O-ring was undamaged. The ball check valve was intact and in position. Corrosion of the internal pump components was preventing pump rotation.

Visual inspection of the six fuel nozzle and line passages found no restrictions. The lower nozzle body of the #6 nozzle was fractured away from the upper (jet) portion of the nozzle. The fuel lines, nozzles and manifold valve assembly were tested on a TCM test bench and functioned properly through the full range of operation.

The spark plugs were inspected per Champion AV-27 Check-a-Plug standards and were determined to be in normal service condition. The #2 top and bottom plugs contained corrosion deposits. The barrel of the #6 top plug was fractured just above the nut flats.

The outside surface of the belt-driven alternator was heat damaged and blackened, and its driven sheave (pulley) was intact.

The gear-driven alternator had separated at the mount flange, which remained attached to the accessory case. The bearing retainer remained in the drive end housing still attached to the case and was distorted and bent consistent with overload fracture at impact. The end housing, the stator assembly, and the rotor assembly were recovered separately. The drive shaft was fractured aft of the drive coupling. The drive coupling

[14] An intact "TCM" lead seal on the thru bolt safety is an indication that the unit has not been field disassembled.

[15] The fuel pump is a positive displacement carbon vane type pump.

gear, retaining nut, and cotter pin were intact. The couplings' elastomer material was thermally damaged.

The oil pickup tube was intact and undamaged.

The induction system was intact and was not thermally damaged. The LH (2-4-6) side of the induction system displayed numerous dents, and the #6 cylinder head mating flange was damaged. The RH (1-3-5) side was undamaged. Visual inspection of all air passages found no internal restrictions. The manifold pressure transducer and a section of the wiring harness remained attached to the induction system.

The engine cylinders were blackened and showed deposits of ash, soot and fire-extinguishing agent. Traces of spot putty were evident at the cylinder hold-down nuts.[16] The cylinder combustion chambers showed minimal combustion deposits. The bores contained corrosion. The bores were free of scoring, and rust etching was noted the upper ring travel area. Hone marks were evident in all bores. The skirts were intact and undamaged. The intake and exhaust valve heads showed minimal deposits and normal wear. The intake and exhaust guides and intake guide seals were lubricated and undamaged. The #4 cylinder exhibited impact damage to the exhaust head fins in the bridge area. The #6 cylinder exhibited impact damage to the first five head fins below the upper spark plug bore, and 16 of the head fins above the exhaust rocker cavity were crushed.

The heads of all six pistons displayed normal amounts of combustion deposits. The piston skirts were free of scoring and were undamaged. The rings were intact, free in their grooves, normal wear. The pin and plug assemblies were intact and undamaged.

The faces of the lifters were undamaged and showed no spalling. The lifter bodies were undamaged and exhibited normal wear signatures.

The crankshaft was fractured just aft of the flange radius. The separated forward section was examined by the NTSB materials lab. (See Paragraph 5.0.) [17] The crankshaft connecting rods journals, main journals and thrust surfaces were undamaged and showed no evidence of abnormal wear or lubrication distress. The crankshaft counterweight pins, plates and snap rings were intact. The crankshaft hanger blades were undamaged and had free and unrestricted movement. The crankshaft cluster gear was intact and showed normal wear. The gear bolts were tight and safetied, and the gear teeth were undamaged. Visual inspection of the oil transfer passages found no restrictions, and the oil transfer plug was tight and in position. The forward end of the crankshaft was cleaned and sprayed with dye penetrant developer, revealing 45° axial spiral fractures along the OD.

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[16] Spot putty is used in this area by TCM production and can be an indication of whether cylinders have been removed since manufacture.

[17] The forward end of the crankshaft remained attached to the propeller assembly. It was fractured in the radius immediately aft of the flange.

All six connecting rods were intact and undamaged. The connecting rod nuts and bolts were intact and secured. The connecting rod bushings exhibited normal operating and lubrication signatures. The connecting rod bearings were intact and showed an insignificant amount of contamination and hard particle passage, and exhibited normal operating and lubrication signatures. There were no signs of lubrication distress.

The camshaft was intact and blackened. There was no spalling damage. The intake and exhaust lobes and bearing journals showed normal wear. The governor drive gear was intact and the gear teeth exhibited no unusual wear patterns. The camshaft gear was also intact, with normal wear patterns, however due to its unprotected location, it was blackened.

Both the LH (2-4-6) and RH (1-3-5) sides of the engine crankcase were blackened, with deposits of ash, soot and fire-extinguishing agent. Both sides were intact. Debris consistent with residue from the destruction of the oil sump and fire-extinguishing agent was found inside. The mating surfaces showed no fretting damage. The main bearing support diameters were intact, exhibiting no signs of bearing movement or bearing tang lock slot elongation. The LH crankcase was gouged at the upper side of the nose seal cavity gouged, but was otherwise undamaged. Visual checks of the oil galleys and passages on both LH and RH crankcase halves found no restriction.

The rear, intermediate, and front main engine bearings exhibited normal operating and lubrication signatures, with no underlying copper exposed.

The LH and RH magneto accessory drive gears were recovered loose and were not identified as LH or RH. Both were blackened, and coated with deposits of ash, soot and fire-extinguishing agent. One gear was impact damaged. The rubber drive bushings of both were partially consumed. All gear teeth and both needle bearings were intact. The two propeller governor drive gears (one on end of cam and one in crankcase) were intact and undamaged.

Magneto-to-engine timing could not be determined due to the separation of both magnetos from the accessory case.

The propeller governor was blackened. The lever support, lever, and a portion of the control cable were fractured from the governor body. The governor screen showed no contamination.

The RH exhaust riser assembly exit flange was distorted and the #5 mount flange was bent; the exhaust assembly was otherwise intact, and there was no evidence of exhaust leakage. Visual examination of the passages found no restrictions. The heater muff was damaged and was distorted around the RH muffler. The muffler was moderately deformed but appeared intact, and the cone showed no restriction. The LH exhaust riser assembly was crushed. The #2 exhaust riser flange was cut away to allow removal of the LH riser assembly. An exhaust thermocouple probe was located on the #6 exhaust riser. The LH muffler was flattened and the heater muff was severely deformed. (See Figure 5.)

Figure 5. Crush and contact damage to LH side of engine

5.0 Materials investigation

The propeller flange fracture surface was submitted to the NTSB materials lab for evaluation.[18] The lab reported that the fracture exhibited features generally in a jagged slant plane with a matte gray appearance consistent with overstress fracture. Slant plane features were located around approximately 330°. The remaining 30° portion of the fracture had a shiny, smeared appearance consistent with compression side of an overstress bending fracture. Spiral cracks were observed in the outer diameter hardened layer adjacent to the fracture, approximately 180° around the circumference, approximately opposite from the smeared area. The cracks intersected jagged features of the fracture. The direction of the spiral was consistent with fracture under torsion loading, where the aft side of the fracture rotated clock wise (as viewed looking forward) relative to the forward side of the fracture. On the inner diameter of the crankshaft adjacent to the fracture and slightly clockwise from the smeared area, parallel circumferential cracks were observed and also consistent with bending. Further to the clockwise direction on the inner diameter, angled cracks were observed in the hardened layer that intersected jagged features on the fracture surface and turned circumferential near the crack tips. On the outer diameter near where the radius intersected the flange, nearly parallel circumferential cracks turning toward the radial direction near the crack tips were observed. These cracks were centered slightly clockwise from the position opposite the smeared area on the fracture surface.

[18] **See DCA07MA003 Docket Item, NTSB Materials Laboratory Factual Report No. 06-095.**

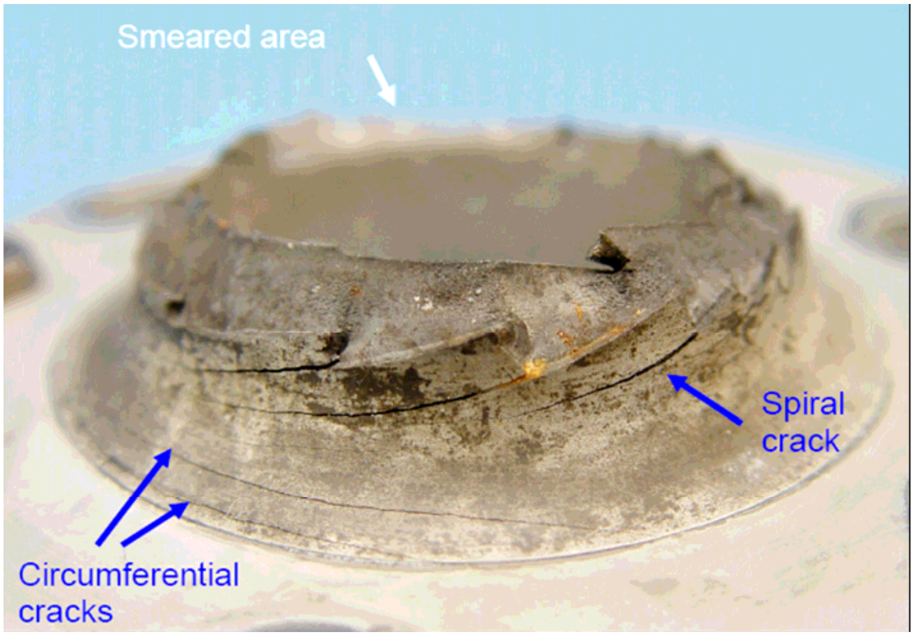

Figure 6. Propeller flange fracture. *NTSB Materials Lab Image # 0610A00955, Project # 200610021*

Carol M. Horgan
Powerplants Group Chairman