



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

December 21, 2021

POWERPLANT GROUP CHAIRMAN'S FACTUAL REPORT
NTSB No: CEN19MA312

A. ACCIDENT

Location: Monclova, Ohio

Date: September 11, 2019

Time: 0240 eastern daylight time (EDT)

Aircraft: Convair 440, Registration Number N24DR

B. POWERPLANTS GROUP

Group Chairman	Robert Hunsberger National Transportation Safety Board Washington, DC
Member	Douglas Zabawa Pratt & Whitney East Hartford, Connecticut
Member	Michael Mannette Collins Aerospace Windsor Locks, Connecticut

C. SUMMARY

On September 11, 2019, at 0239 eastern daylight time, a Convair 440 airplane, N24DR, powered by two Pratt & Whitney R2800-52W (also known as the Double Wasp CB17) radial engines, impacted trees and terrain while on final approach to runway 25 at the Toledo Express Airport (TOL). The accident site was located about 1/2-mile from the runway arrival threshold in Moncolva, Ohio. Both pilots were fatally injured. The airplane was destroyed by impact forces and a postimpact fire. The airplane was registered to a private individual and operated by Ferreteria E Implementos San Francisco under Title 14 *Code of Federal Regulations* Part 125 as a non-scheduled cargo flight. Night visual meteorological conditions prevailed, and the flight was being operated on an instrument flight rules flight plan. The flight originated from the Millington-Memphis Airport (NQA), Millington, Tennessee, at 2314 central daylight time and was destined for TOL.

1.0 ENGINE INFORMATION

1.1 Engine History/Maintenance

According to the maintenance records provided by the operator, the No. 1 (left) engine, serial number (SN) P36235 had accumulated 1,081.2 hours since overhaul and the No. 2 (right) engine, SN P33661 had accumulated 384.6 hours since overhaul.

The last engine related maintenance inspections were “A” and “B3” checks that were completed on February 24, 2019, by Ferreteria E. Implementos San Francisco. Maintenance included: engine cylinder compression checks, spark plug inspections, fuel boost pump pressure checks, and detailed visual inspections of engine components. The No. 1 engine carburetor mixture control and fuel pump were removed and replaced as part of the maintenance. The airplane logged 39.2 hours between the “A” and “B3” checks and start of the flight leg from Laredo International Airport (LRD), Laredo, Texas to NQA prior to the accident flight.

1.2 Engine Information

The Pratt & Whitney R2800-52W (also known as the Double Wasp CB17) engines are supercharged, 18 cylinder, twin row, radial, air cooled engines, having a total piston displacement of 2,804 cubic-inches. The engine incorporates a two-speed impeller (supercharger) which is driven by two clutch assemblies.

According to the Federal Aviation Administration (FAA) type certificate data sheet No. 5E-8, undated, the R2800-52W engine has a takeoff (5 minute) sea level rating of 2,200 shaft horsepower (SHP) at 2,800 revolutions per minutes (RPM) and a maximum continuous sea level rating of 1,900 SHP at 2,600 RPM.

All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made aft looking forward (ALF). Diagrams of the engine are shown below in **Figures 1 and 2**. The engine cylinder head numbering and firing order are shown below in **Figure 3**.

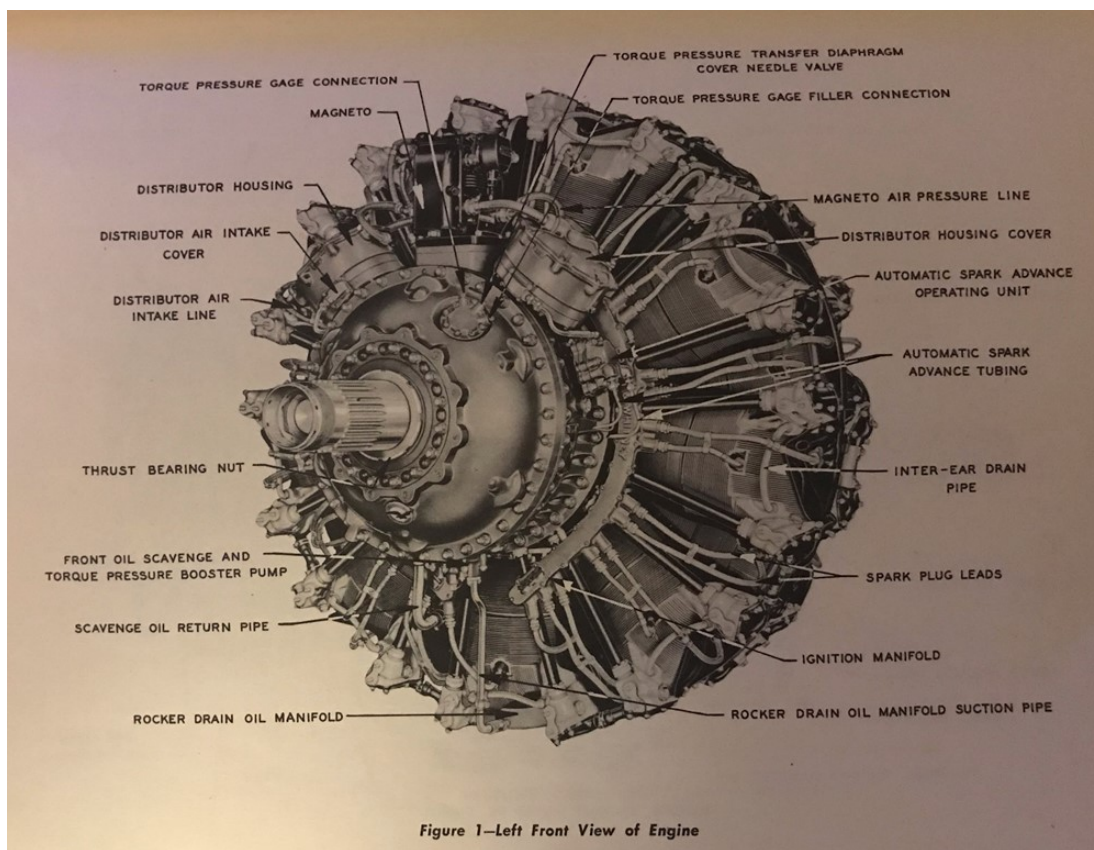


Figure 1- P&W R2800 Radial Engine (Front) (Figure Courtesy of Pratt & Whitney)

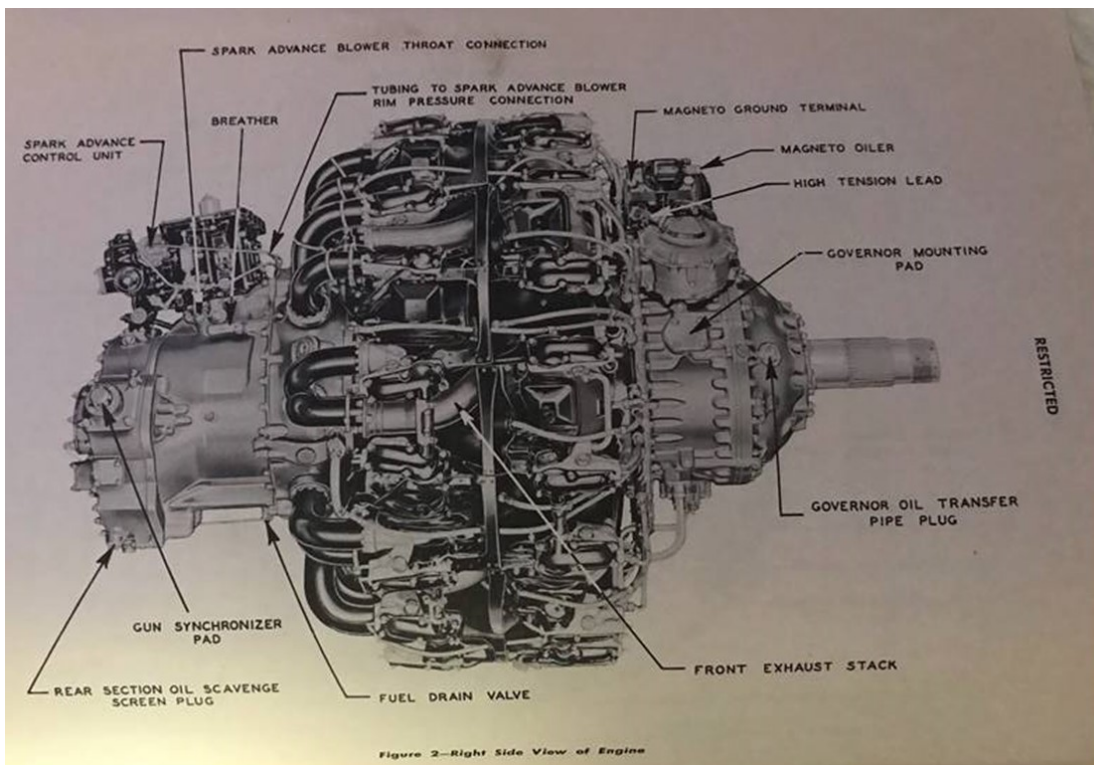


Figure 2- P&W R2800 Radial Engine (Right Side) (Figure Courtesy of Pratt & Whitney)

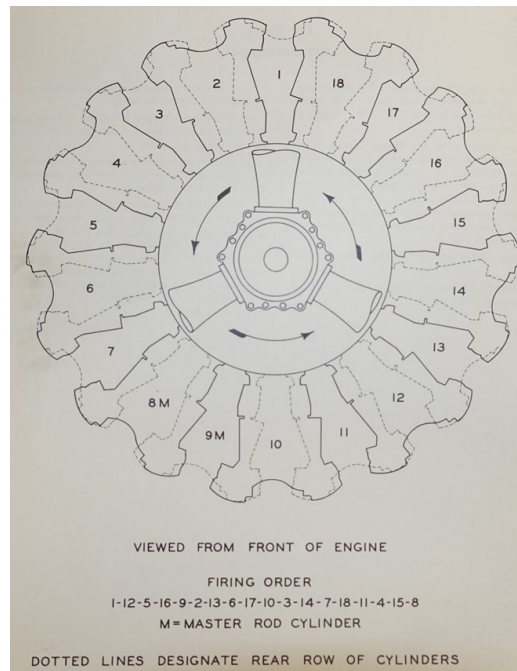


Figure 3- R2800 Cylinder Numbering (Figure Courtesy of Pratt & Whitney)

2.0 PROPELLER INFORMATION

2.1 Propeller History/Maintenance

The No. 1 (left) and No. 2 (right) propeller operating history according to the aircraft component listing is shown below in **Table 1**.

Propeller Position	Serial Number	Installation Date	Time Since New (hours)	Time Since Overhaul (hours)
Left	203511 / A8543	1/7/2017	47,112.2	779.4
Right	521460 / A3378	5/27/2014	45,651.2	1,303.0

Table 1- Propeller Assembly Hours and Cycles

During the propeller examination, a number was visible on the left propeller hub mating flange that matched the left propeller serial number documented in the aircraft component listing. The right propeller serial number marking was not located. According to Aviation Propeller, assembly serial numbers for the Hamilton Standard 43E60 propellers historically begin with a letter. Markings A8543 and A3378 were identified on the left and right propeller hub flanges (**Photo 1**).



Photo 1- Propeller Assembly Serial Numbers on Hub Mating Flange (L) Left Propeller, (R) Right Propeller

2.2 Propeller Information

The Hamilton Standard 43E60 is a three-bladed, constant speed hydraulic propeller (**Figure 5**). The propeller features a steel hub and part number (P/N) 6895-8 aluminum alloy blades. The blade feather position is at $+80.5^\circ$ blade angle, low pitch stop position is at $+14^\circ$ blade angle, and reverse is at -21.5° blade angle.

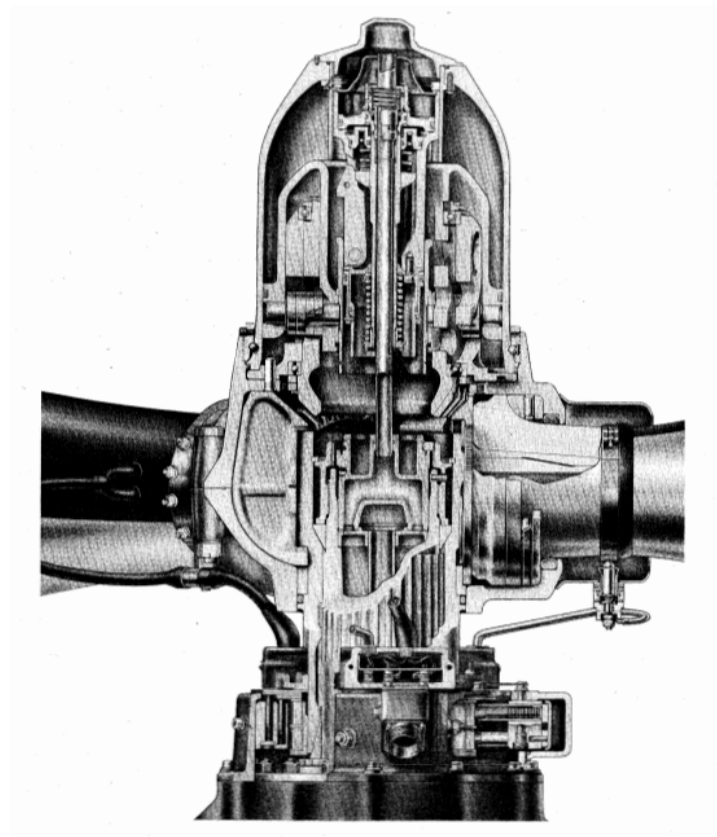


Figure 4- Hamilton Standard 43E60 Constant Speed Propeller Cutaway (Figure Courtesy of Collins)

3.0 ON SCENE EXAMINATION- NO. 1 (LEFT) ENGINE AND PROPELLER

The No. 1 engine and propeller assembly came to rest on the ground against the aft side of a semi-trailer. The engine was laying on its right side, (3 o'clock position) facing approximately 150° relative to the flight path (**Photos 2 and 3**). Both the engine and propeller were thermally damaged by the post-crash fire. The Global Position System (GPS) positions and location within the debris field were documented with an unmanned aircraft system (UAS) and are available in the UAS Aerial Imagery report in the investigation docket. Investigation party members from Pratt & Whitney, the FAA, and the NTSB documented the accident site between September 12-15, 2019.



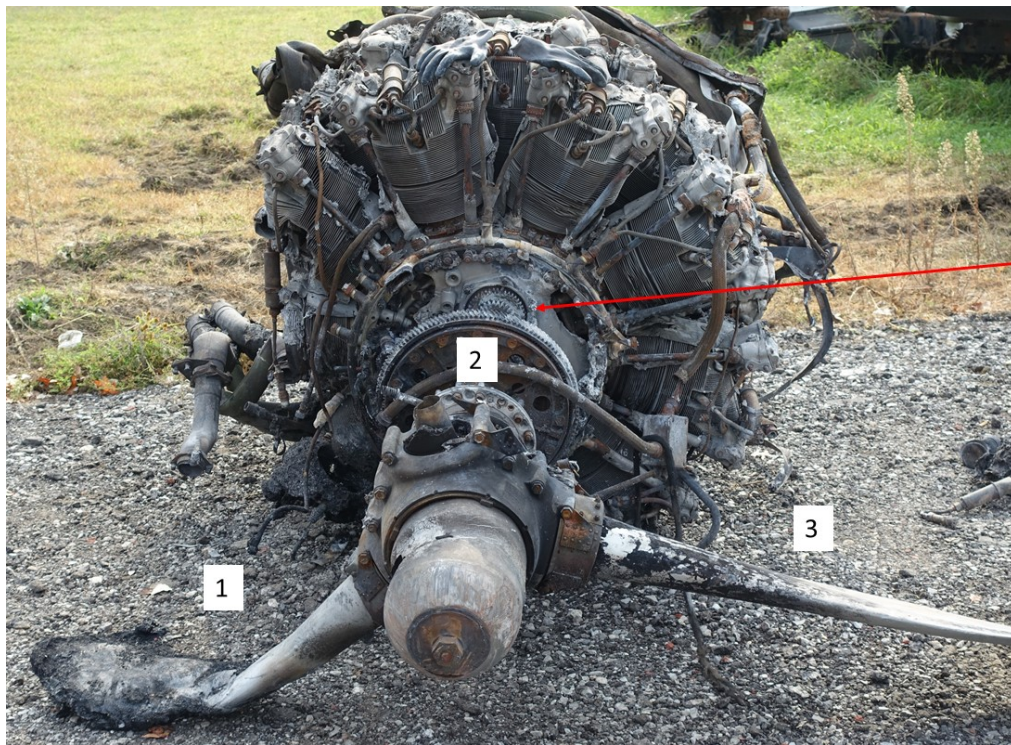
Photo 2- No. 1 Engine and Propeller in Wreckage



Photo 3- No. 1 Engine and Propeller

3.1 No. 1 (Left) Engine

The No. 1 engine was lifted out of the wreckage with a tow truck and a visual examination was performed to document the external condition (**Photos 4, 5, and 6**). The front case and front accessory case were thermally consumed exposing the internal gear assemblies. All visible gears had dark discoloration and were coated in soot. Resolidified metal slag was adhered to the top half of the gear surfaces relative to the resting position of the engine. All 18 cylinder heads had varying levels of impact and thermal damage. The cylinder damage was most concentrated between the 12 and 5 o'clock positions. Cylinder heads 1, 2, 3, 4, 5, 7, and 18 were either fully or partially consumed exposing the piston heads. The cylinder heads between the 5 and 12 o'clock positions were complete but exhibited thermal deformation of the cooling fins and rocker head covers.



Front Case
and Front
Accessory
Case
Consumed

Photo 4- No. 1 Engine, Front



Piston Heads
Visible

Photo 5- (L) No. 1 Engine, 6 o'clock Position, (R) No. 1 Engine, 12 o'clock Position



Photo 6- No. 1 Engine, Aft Side

The exhaust manifolds all appeared to be present but exhibited crushing deformation and several were separated from the cylinders. The engine accessories aft of the crankcase were thermally consumed. The accessory driveshaft, accessory gear, and starter spline were intact but were soot covered and discolored. The engine aft bulkhead/firewall appeared to be complete but exhibited crushing deformation and material tearing. A large quantity of metal slag and loose accessory internal components were found under the engine after it was lifted from the impact site. The engine data plate was not located in the wreckage.

3.2 Left Propeller

The left propeller assembly and blades were thermally damaged and heavily sooted consistent with exposure to a post-crash fire. The right facing propeller blade (blade 1) was melted approximately 13 inches from the blade collar, outward along the rest of the span. What remained of the propeller blade measured 34 inches from the blade collar to the resolidified blade tip.

The propeller blade that came to rest facing upward (blade 2) was fractured at the blade root and the fracture surface appeared rough and jagged. The separated blade section was recovered near the engine against a semi-trailer frame. The length of the recovered propeller blade section was approximately 68 inches and exhibited bending in the clockwise direction and had leading edge impact strikes.

The left facing propeller blade (blade 3) was complete and measured approximately 71 inches. The blade exhibited bending in the clockwise direction and had leading edge impact gouges over the outer 30 inches of the blade span. The leading edge gouges were at approximately the same spanwise location as the separated section of propeller blade 2. The propeller dome was thermally consumed from the 12 to 5 o'clock positions, coincident with the area of most severe thermal damage on the engine cylinders and external engine components (**Photo 7**).



Photo 7- Left Propeller Blades

3.3 Left Propeller Blade Strikes

A semi-trailer parked on the right side of the flight path had a series of propeller strikes that sliced through the roof and left side of the trailer¹. Two additional propeller strikes were also observed on the wood floor/deck of the trailer. The propeller strikes on the left side the trailer were spaced approximately 38 inches apart and the two slices in the wood floor were approximately 42 inches apart (**Photos 8 and 9**). Propeller blade fragments that appeared to be the blade tips were recovered loose on the trailer floor (**Photo 10**). The position of the trailer appeared to have shifted during the impact sequence.

¹ Evidence at the accident scene indicated that the airplane became inverted after initial impact with the ground.



Photo 8- Trailer Propeller Strikes



Photo 9- Trailer Floor Propeller Strikes



Photo 10- Propeller Blade Tip Fragments (L) In Trailer

4.0 ON SCENE EXAMINATION- NO. 2 (RIGHT) ENGINE AND PROPELLER

The No. 2 engine was separated from the wing and thrown clear of the wreckage, further along the intended direction of flight, and came to rest in a parking area. The right propeller was separated from the engine during impact and was recovered in the main debris field. The engine came to rest on its left side (9 o'clock position) and was facing approximately 180° relative to the flight path (**Photos 11 and 12**). The GPS positions and location within the debris field were documented with an UAS and are available in the UAS Aerial Imagery report in the investigation docket.



Photo 11- (L) Engine Front, (R) Engine Rear (After Removal of Cowling and Bulkhead Material)



Photo 12- (L) No. 2 Engine, 12 o'clock Position, (R) No. 2 Engine, 6 o'clock Position

4.1 No. 2 (Right) Engine

The engine front and front accessory cases were fractured and separated forward of the crankcase. The fracture surfaces appeared rough and jagged. Exposed engine surfaces were oil wetted, and oil was pooled beneath the engine. The oil color appeared normal and did not smell acrid. The exposed reduction drive gear was deformed consistent with impact damage. The reduction drive gear had a crack that ran from the outer diameter into the gear web. The engine propeller shaft journal had 360° rotational scoring in plane with the reduction drive gear (**Photo 13**).



Photo 13- Reduction Drive Gear Deformation and Propeller Shaft Journal Scoring

All 18 cylinders were present and complete. Branches, leaves, and dirt debris were collected in the front cylinder head cooling fins between the 12 and 5 o'clock positions (**Photo 14**). The exhaust rocker cover on cylinder 2 and the intake rocker cover on cylinder 18, both located near the 12 o'clock position were separated and the surfaces around the separated covers had impact/rub damage in the axial direction. The exhaust manifold plumbing was all present, but some crushing deformation was observed at about the 1 o'clock position. There was a small area of localized thermal damage at approximately the 12 o'clock position (left side as the engine was resting), immediately aft of the cylinder

rows. The thermal sleeves of the wires routed over the area of localized thermal damage were charred and discolored. A small puddle of resolidified metal slag, consistent with puddling after the engine had come to rest, had collected on a section of the engine cowling that remained partially attached to the aft side of the engine.

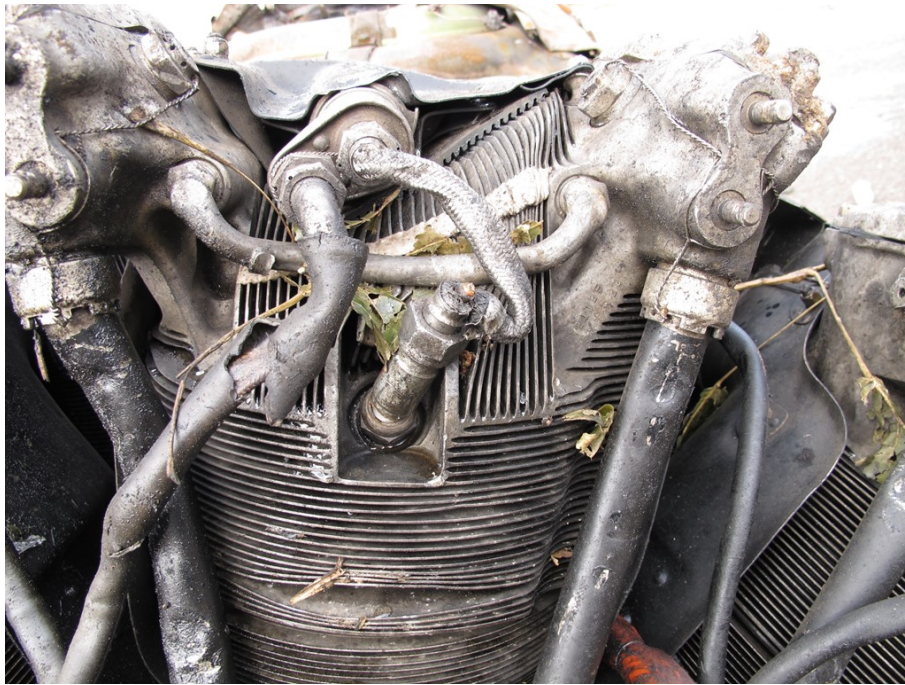


Photo 14- Tree and Leaf Debris Lodged into Cylinder Heads

The engine firewall/bulkhead appeared to be complete but had significant impact deformation. Sections of the cowl were still attached to the engine and were crushed and against the engine cases and accessories. The cowl and bulkhead material were removed to expose the aft side of the engine. All engine cases aft of the crankcase were intact. The carburetor, starter, water injection pump, hydraulic pump, fuel pump lines, oil supply/scavenge lines, and tachometer were all secured to the engine. The generator was separated but remained tethered to the engine by its wiring. The generator input spline shaft was bent.

Two front accessory case fragments, including one with an engine data plate, were recovered along the debris path. The fracture surfaces of the recovered case fragments matched the fracture surfaces on the right engine front accessory case (**Photo 15**).



Photo 15- Front Case Fragment and Engine Data Plate

4.2 Right Propeller

The right propeller was separated from the engine during the accident sequence. The propeller was recovered in the wreckage field with a section of the engine front case still attached. There was a puddle of oil under the propeller assembly that appeared to be a normal color and did not smell acrid.

The aft end of the propeller shaft was separated during the impact sequence. The separated section of the shaft was recovered near the propeller (**Photo 16**). On both sides of the shaft fracture there was circumferential scoring. The scoring was coincident with the scoring documented in the engine propeller shaft journal. The propeller came to rest with the propeller dome and two of the blades against the ground (**Photo 17**). All three propeller blades were full span, approximately 71 inches from blade collar to tip. One propeller blade (blade 2) was rotated 180° relative to the other two. The blades labeled 1 and 2 both exhibited bending in the clockwise direction. The anti-icing boot on all three blades was thermally damaged. The as-recovered blade angles did not appear consistent with the deformation on the blade collars.



Photo 16- Right Propeller Shaft Separation



Photo 17- Right Propeller Assembly

5.0 ENGINE EXAMINATION AND DISASSEMBLY

Following the on-scene examination in Monclova, Ohio, the wreckage was transported to AMF Aviation, LLC in Springfield, Tennessee for storage. AMF crated the engines and shipped them to Vintage Radials in Tehachapi, California for examination and teardown. The engine crates were secured in a metal shipping container when the investigation team arrived at Vintage Radials (**Photo 18**). The

engine examinations were completed with investigation party members from the FAA and the NTSB between October 4-5, 2021².



Photo 18- Engine Shipping Crates, as Received

5.1 No. 1 (Left) Engine Serial number P36235

The No. 1 engine was uncrated and left on the shipping pallet for examination and partial disassembly (**Photos 19 and 20**). The intake and exhaust duct manifolds were cut with a reciprocating saw to access the engine cylinders (**Photo 21**). The remaining spark plugs that were not consumed by the fire were removed and inspected³. The removed spark plugs did not appear uniform. Several spark plug electrodes appeared ashy/white⁴ and others appeared to be corroded (**Photos 22 and 23**). Cylinders 16, 17, and 18 were partially seized in the crank case and pry bars and a dead blow hammer were required for removal. The interior surface of each of the cylinders were rusted, but the walls of the cylinder and the valve heads were unremarkable. The exposed piston heads were rusted but there was no evidence of detonation⁵ or material deformation (**Photo 24**). The mechanics were unable to remove the piston head cylinder pin from cylinder 18, so a reciprocating saw was used to cut the piston connecting rod. The rear and aft sides of the crankcase were inspected visually and with a handheld borescope. The internal surfaces were rusted but there was no evidence of internal failure or loose debris.

² The engine teardown examinations were delayed due COVID-19 travel restrictions.

³ Each of the 18 cylinders has a front and rear spark plug.

⁴ According to Vintage Radials, ashy or light colored spark plug electrodes are commonly seen when the engine is operated with a lean fuel mixture.

⁵ Signs of detonation include uneven wear, material loss, and/or discoloration on the top surface of the piston head.



Photo 19- No. 1 Engine, Left Side, as Received



Photo 20- No. 1 Engine, Right Side, as Received



Photo 21- No. 1 Engine, After Manifold Removal



Photo 22- No. 1 Engine Spark Plugs



Photo 23- Cylinder 11 Front Spark Plug Electrode



Photo 24- Cylinder 16, (L) Piston Head, (R) Cylinder Interior and Valves

5.2 No. 2 (Right) Engine Serial Number P33661

The No. 2 engine was uncrated and left on the shipping pallet for examination and partial disassembly (**Photo 25**). As noted in Section 4.1 of this report, the propeller reduction case was separated from the engine during the accident sequence and the fracture surface of the gearbox that remained attached to the engine appeared rough and jagged (**Photo 26**). According to Vintage Radials, it is common for the propeller assembly to separate from an R2800 engine when the propeller impacts a hard surface while operating a high power. A random sample of spark plugs were removed, and all spark plugs electrodes were in good condition (**Photos 27 and 28**). Intake and exhaust manifold ducting was cut with a reciprocating saw to allow for removal of cylinders 5, 6, and 16 for inspection. The inside of the

cylinders and the exposed piston heads were in good condition with no evidence of detonation or other anomalies (**Photos 29 and 30**). The forward and aft sections of the crankcase were inspected visually and with a borescope. The internal components were oil wetted and in good condition.



Photo 25- No. 2 (Right) Engine, (L) Left Side, (R) Right Side, as Received



Photo 26- No. 2 Engine (L) Front Face, (R) Propeller Reduction Case Flange

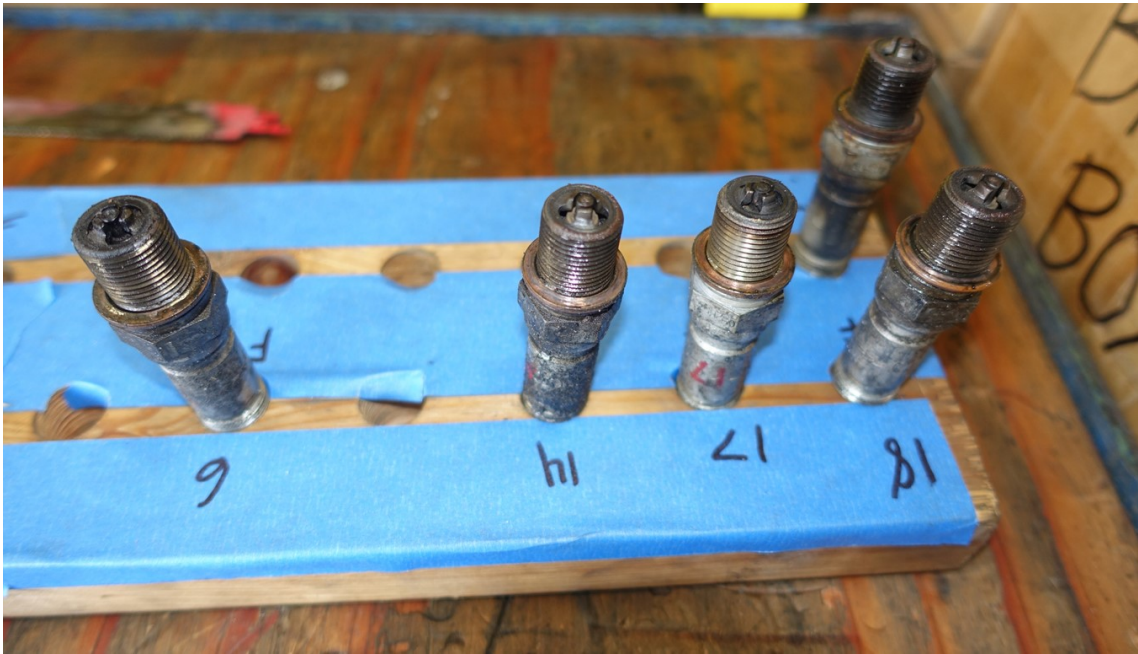


Photo 27- Sample of No. 2 Engine Spark Plugs



Photo 28- No. 2 Engine Cylinder 18 Front Spark Plug

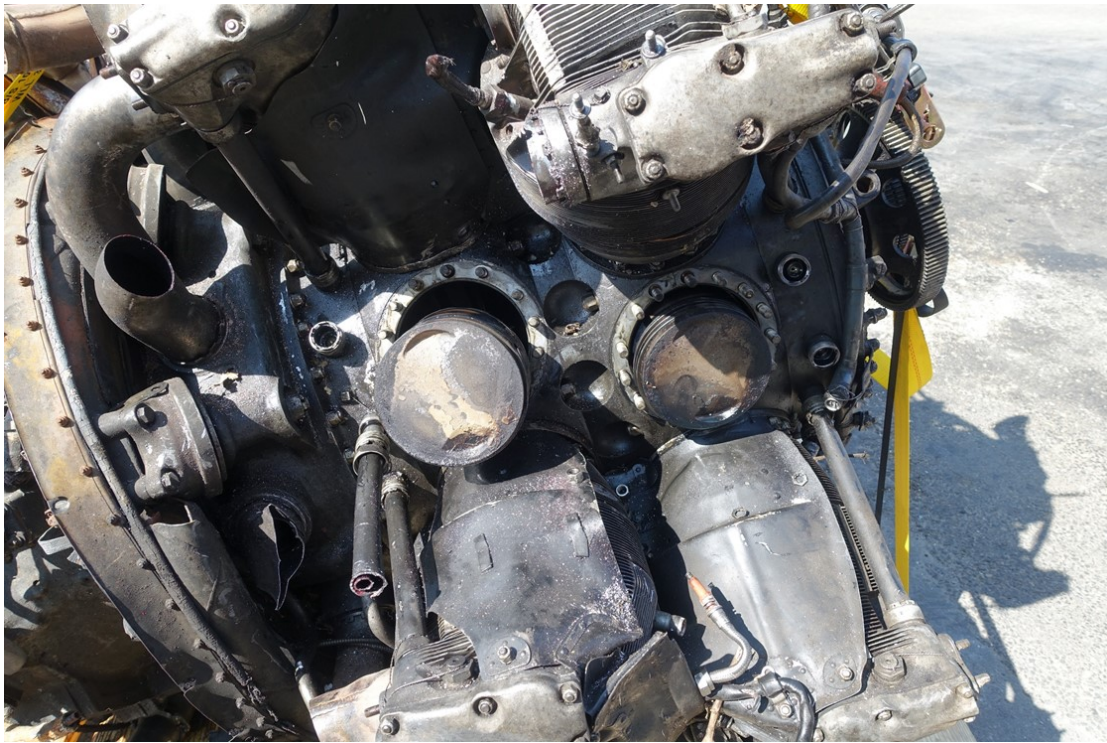


Photo 29- No. 2 Engine Piston Heads, Cylinders 5 and 6



Photo 30- No. 2 Engine, (L) Cylinder Heads/Sleeves 5, 6, and 16, (R) Inside of Cylinder 16

6.0 PROPELLER EXAMINATION AND TEARDOWN

To facilitate wreckage transport, the left and right propeller blades were cut at approximately 1/3 span at the accident site prior to transport to AMF Aviation, LLC in Springfield, Tennessee for storage. The propeller hubs and separated propeller blades were then packaged in three crates by AMF and shipped to Aviation Propellers, Inc. in Opa Locka, Florida. The crates were in good condition and the lids were secured with screws when the investigation team arrived at Aviation Propeller (**Photo 31**). Group members from the FAA, Collins Aerospace, and the National Transportation Safety Board (NTSB) completed the examination and teardown from November 19-20, 2019.



Photo 31- Propeller Shipping Crates, as Received

6.1 Left Propeller Assembly, Serial Number A8543

The left propeller was removed from the shipping crate and visually examined. There was no additional damage noted when compared to the photographs that were taken during the on-scene portion of the investigation (**Photo 32**).



Photo 32- Left Propeller, As-Received

The left propeller dome was thermally damaged and missing material. Prior to disassembly, an index mark was created to identify the as-received piston position. The dome nut was seized and could not be removed with standard tooling. The nut was cut in three places with a pneumatic cutting wheel and then a hammer was used to unthread the nut and separate the dome. The dome oil transfer tube and transfer housing were intact. The dome stop ring position⁶ was measured with a Collins Aerospace protractor template and revealed an angle of 40° (**Photos 33**).

⁶ According to Collins Aerospace, propeller dome stop ring position is a secondary measurement that may help support the shim impact mark evidence. The final position of the dome stop ring often differs in angle from initial impact due to effects of residual system pressure and impact forces.

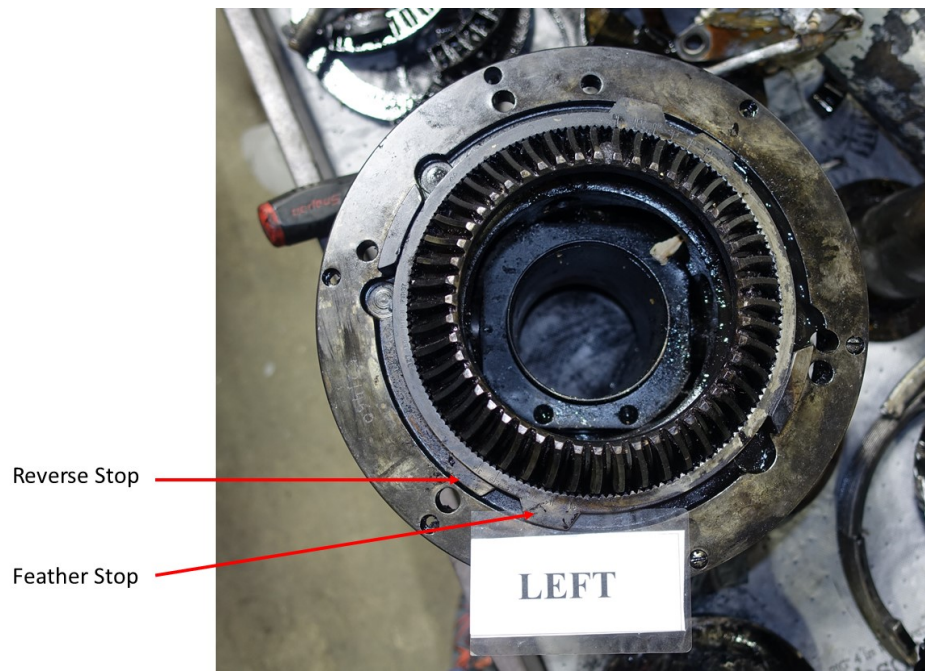


Photo 33- Left Propeller Dome Assembly

The left propeller hub and propeller blade thermal and impact damage resulted in deformation that made propeller blade removal difficult (**Photo 34**). Small metal fragments were recovered inside the propeller hub cavity. The hub flanges exhibited metal adhesion and wear outboard of the gasket seal (**Photo 35**). The shims on blades 2 and 3 were fractured and all three shims had an area of uniform discoloration consistent with thermal exposure and impact witness marks (spider impact marks). The shim discoloration and spider impact mark angles were measured with a protractor template to approximate blade angle (**Photo 36, 37, and 38**) and summarized in **Table 2**. The bushing retaining pins and screws located on the blade butts were fractured on blades 2 and 3 (**Photo 39**).



Photo 34- Left Propeller Hub Cavity

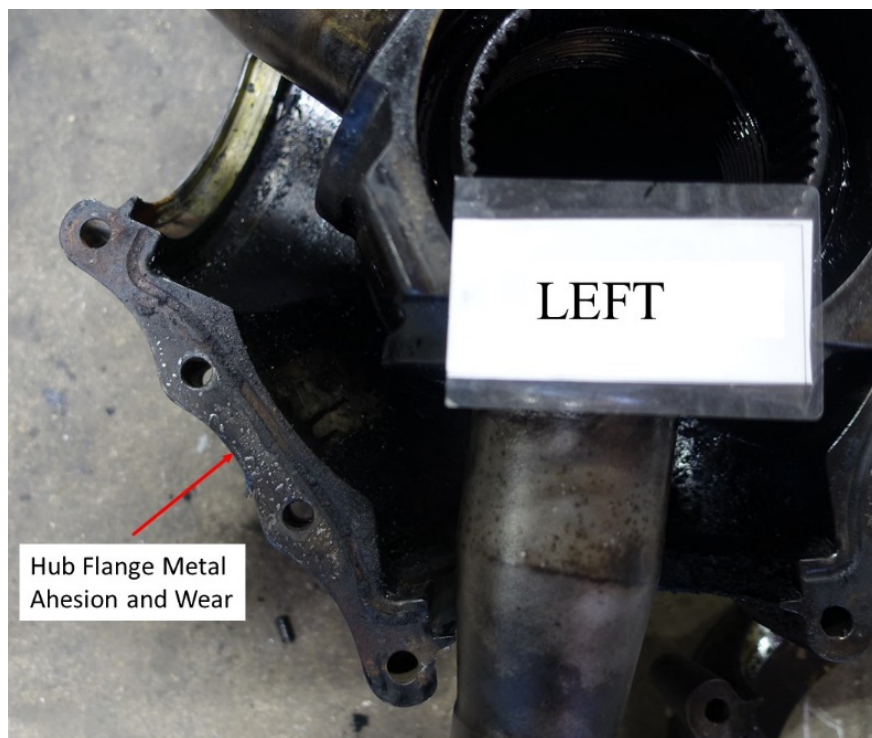


Photo 35- Left Propeller Hub Flange, Metal Adhesion and Wear

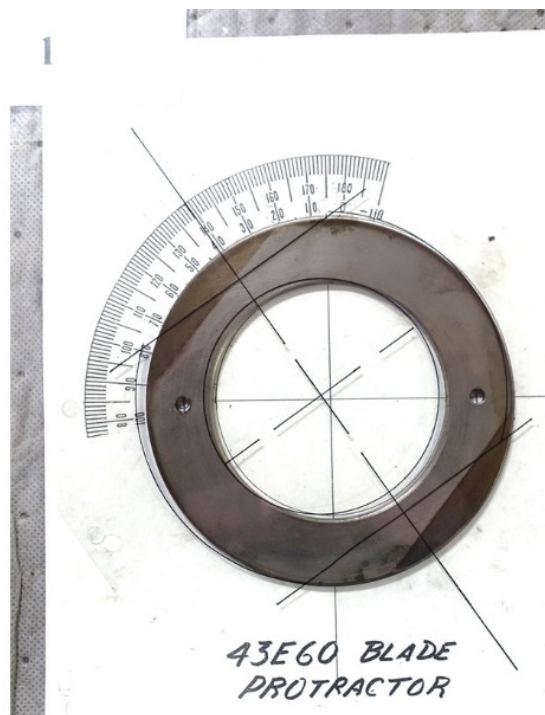
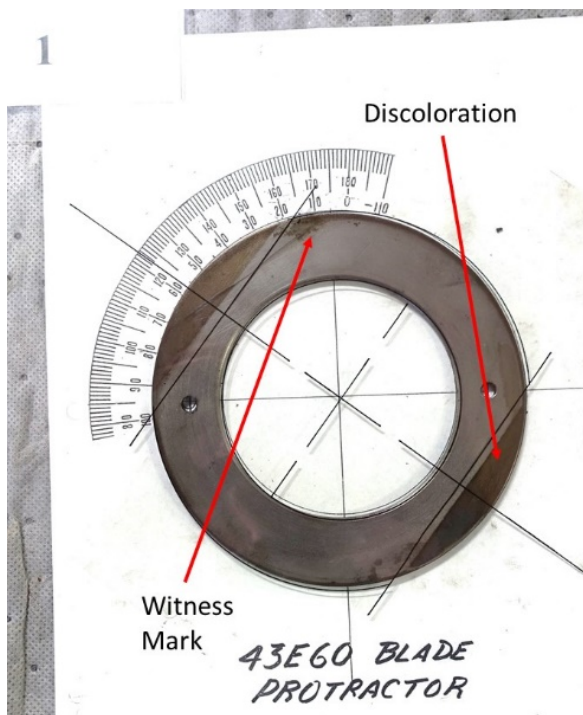


Photo 36- Left Propeller, Blade 1 (L) Discoloration Angle, (R) Witness Mark Angle

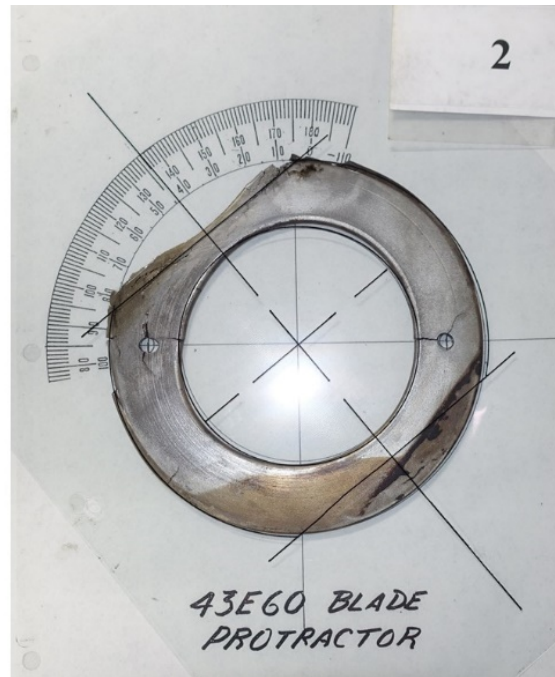
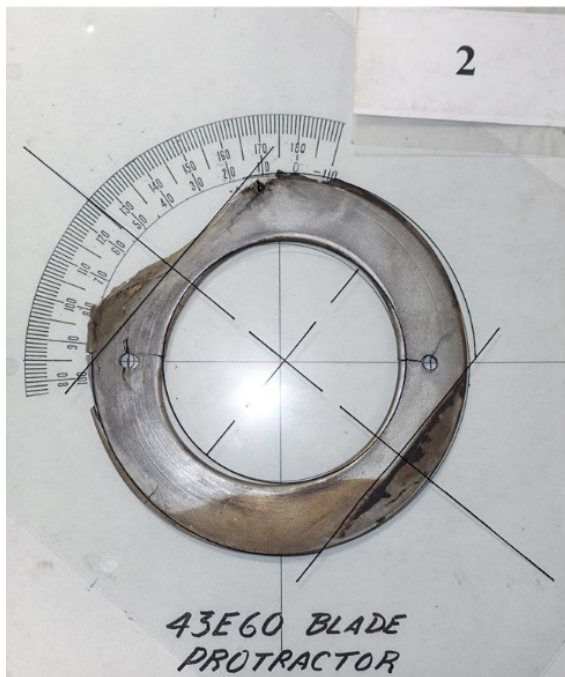


Photo 37- Left Propeller, Blade 2 (L) Discoloration Angle, (R) Witness Mark Angle

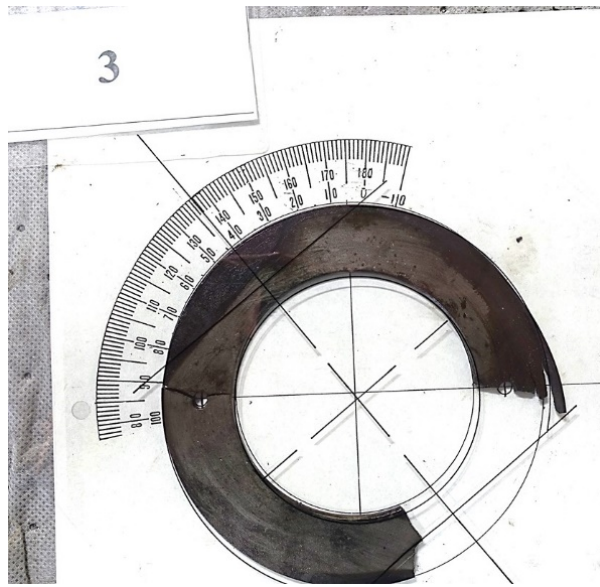


Photo 38- Left Propeller, Blade 3 Witness Mark Blade Angle

Blade Shim	Discoloration Angle (degrees)	Spider Impact Mark Angle (degrees)
1	55	41
2	55	44
3	55	43

Table 2- Blade Shim Witness Mark Blade Angle Approximations

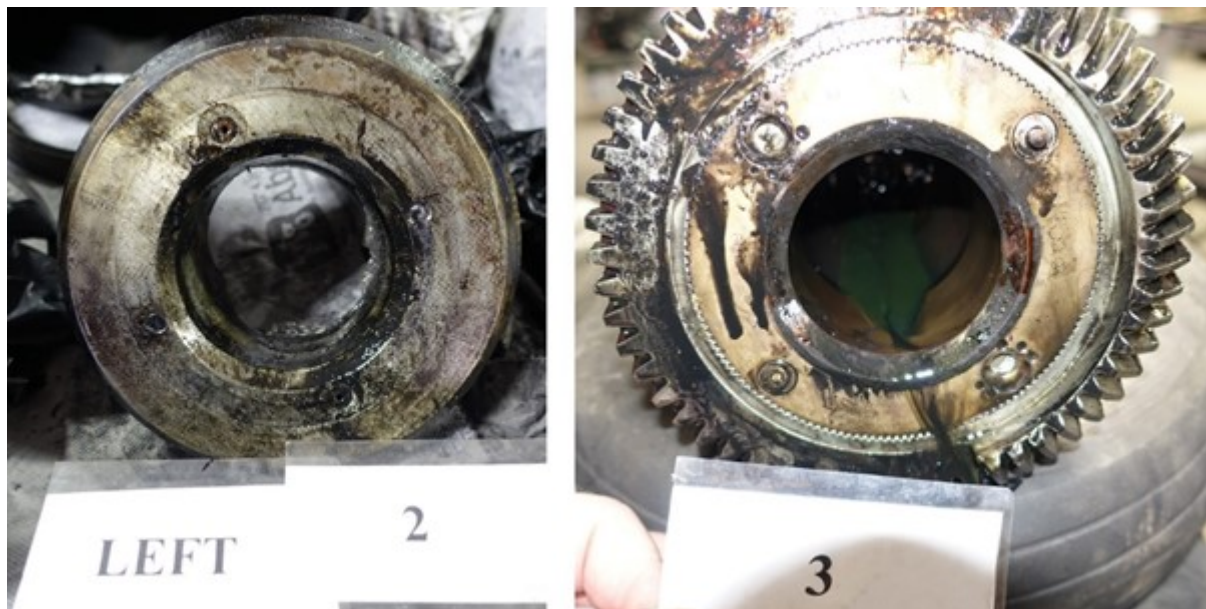


Photo 39- Left Propeller Blades 2 and 3 Bushing Drive Pins and Retention Screws Broken

6.2 Right Propeller Assembly, Serial Number A3378

The right propeller assembly was removed from the shipping crate and visually examined. There was no additional damage to the assembly when compared to the photographs that were taken during the on-scene portion of the investigation (**Photo 40**).

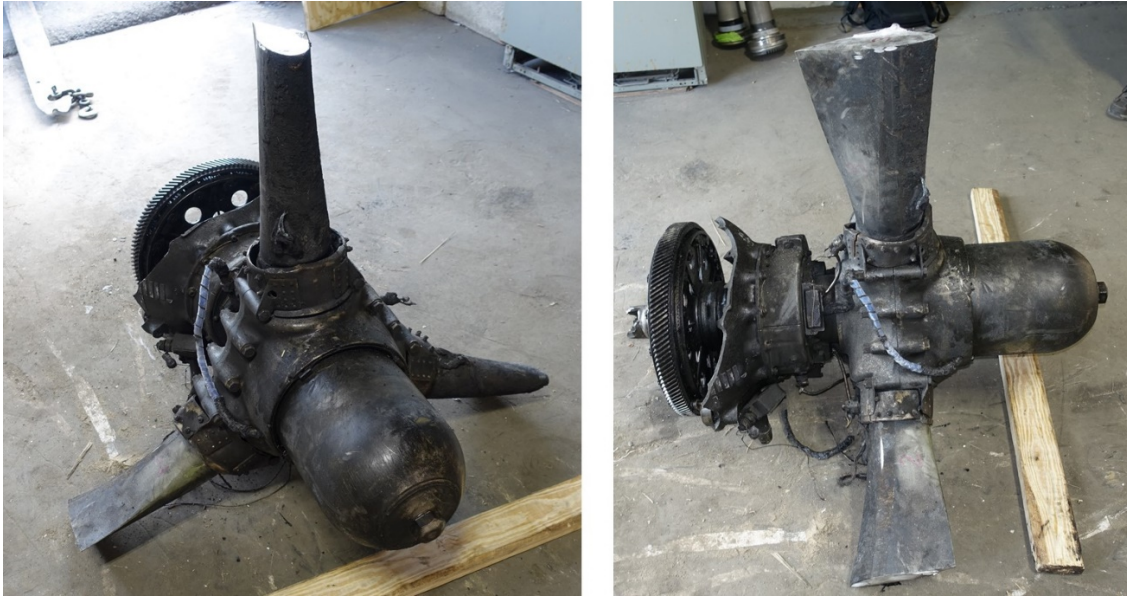


Photo 40- Right Propeller Assembly, As-Received

The propeller dome oil transfer tube and transfer housing were intact. The approximate as-received blade angle according to the dome feather pitch stop position was measured using a Collins Aerospace protractor template. The dome stop ring position was measured with a Collins Aerospace protractor template and revealed an angle of 26°.

The propeller hub had multiple small metal fragments that were recovered loose inside the hub cavity. The hub bolts all had minimal torque and a gap was visible between the hub halves with o-ring material protruding from the gap (**Photo 41**). Blade 2 had rotated about 180° relative to the other two blades.

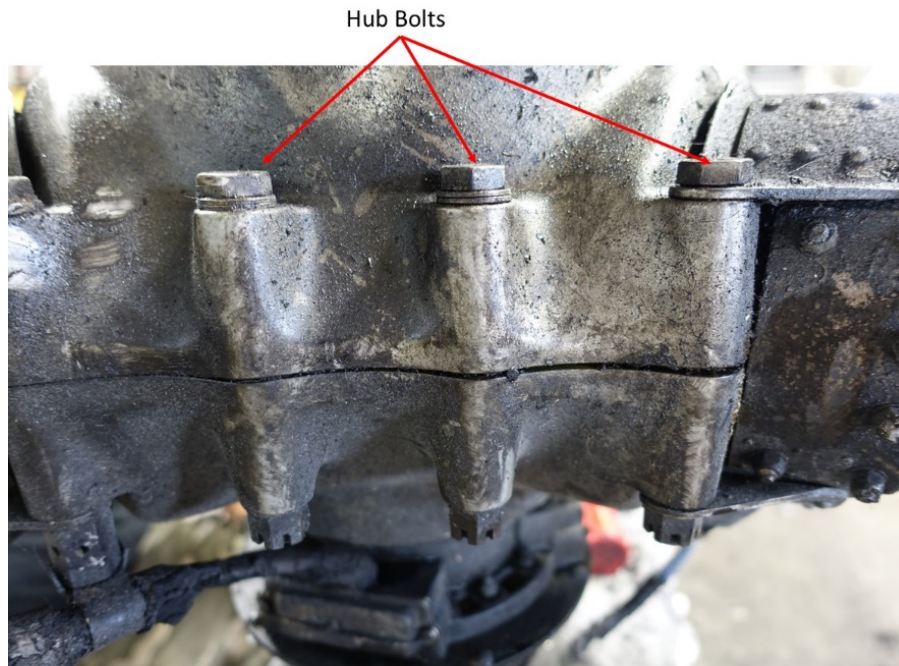


Photo 41- Right Propeller Hub Gap

The blade 1 bevel washer was split and partially separated. Metal shavings had accumulated between the split halves (**Photo 42**). A coincident rub with material loss was observed on the arm bore. A section of each of the three propeller blade shims were fractured and a spider impact witness mark was visible on each shim. A Collins Aerospace protractor template was used to approximate the propeller blade angle at the time of impact (**Photos 43, 44, and 45**) and summarized in **Table 3**. Propeller blade 2 (recovered rotated 180° relative to the other blades) had one bushing retaining screw fractured. Both the propeller blade bushing retaining screws and one of the retaining pins was fractured on blade 3 (**Photo 46**).



Photo 42- Blade 1 Thrust Bushing Split, (R) Metal Shavings in Split

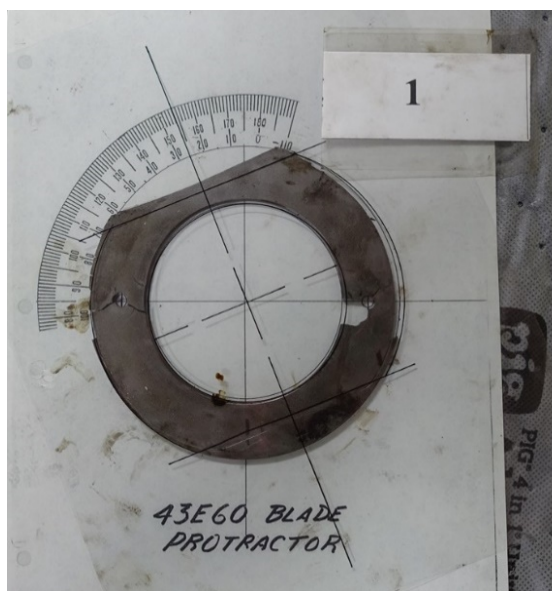


Photo 43- Right Propeller, Blade 1 Witness Mark with Blade Angle Protractor

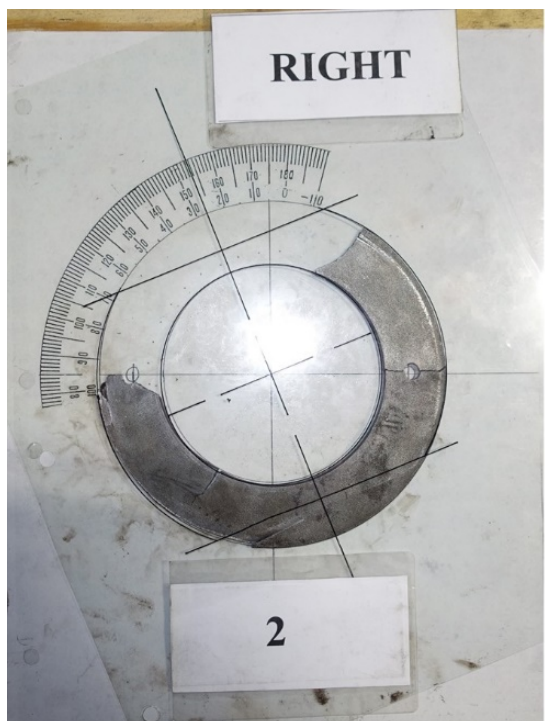
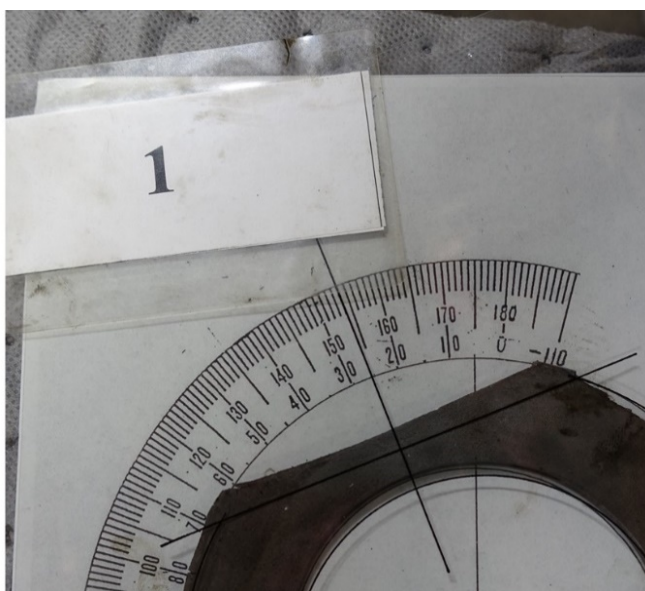


Photo 44- Right Propeller, Blade 2 Witness Mark with Blade Angle Protractor

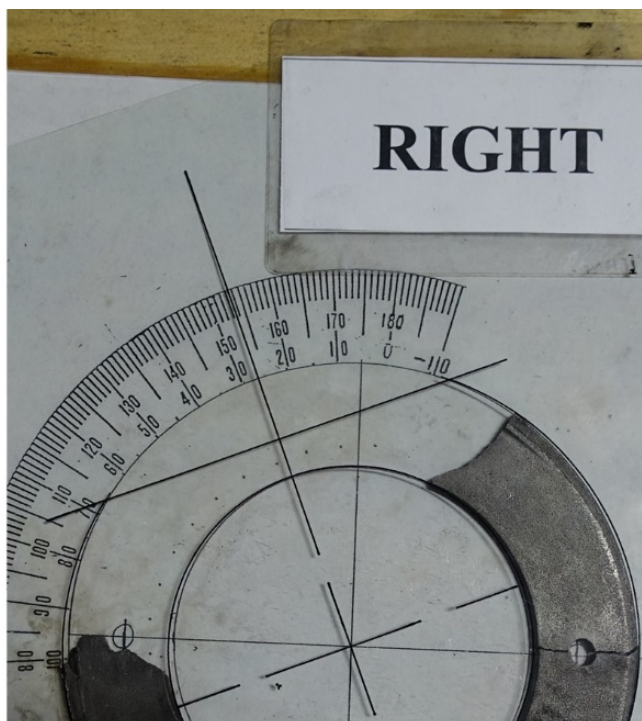




Photo 45- Right Propeller, Blade 3 Witness Marks with Blade Angle Protractor

Blade Shim	Witness Mark Angle (degrees)
1	26
2	27
3	26

Table 3- Blade Shim Witness Mark Blade Angle Approximations



Photo 46- Blades 2 and 3, Bushing Retaining Pin and Screw Damage

7.0 ADDITIONAL INFORMATION

7.1 Left Propeller Aerodynamic Performance Calculations

Collins Aerospace performed an aerodynamic analysis of 43E60 propeller performance given the approximate flight conditions⁷ at the time of the accident and the propeller blade angles at impact, as estimated from the blade shim spider impact marks. The analysis findings were then compared to the left propeller RPM estimates calculated from the propeller strikes measured on the semi-trailer deck. To perform the analysis, multiple assumptions were made to estimate the No. 1 engine SHP. Due to the assumptions, it was determined that the aerodynamic analysis findings could not be included in the factual report.

Robert Hunsberger
Aerospace Engineer
Powerplants

⁷The last recorded Mode C TOL airport surveillance radar (ASR) altitude reading during the accident flight was 800 ft +/- 50 ft. The estimated airspeed calculated from the time and distance travelled between the final radar readings was 70-75 knots calibrated airspeed (KCAS). The ambient temperature at the time of the accident was 24° Celsius.