Aviation Investigation Final Report

Location:	Bakersfield, California	**Incident Number:**	WPR14IA297
Date & Time:	July 16, 2014, 21:30 Local	**Registration:**	N6756P
Aircraft:	Beech B100	**Aircraft Damage:**	Minor
Defining Event:	Loss of engine power (total)	**Injuries:**	1 None
Flight Conducted Under:	Part 91: General aviation		

Analysis

The pilot reported that, while in cruise flight, the left engine of the twin turboprop airplane lost power. The pilot secured the left engine and performed an uneventful single-engine landing at an airport. Examination revealed damage to the left nacelle and external damage to the left engine, consistent with an uncontained engine failure. Further examination of the left engine revealed an overload failure of the 2nd-stage turbine wheel. The investigation determined that a repair to a brazed joint on the 2nd-stage main nozzle casting support baffle and outer flange had failed. This baffle directs cooling air to the aft face of the 1st-stage turbine wheel and knife-edge seal ring. Once the baffle failed and cooling air was lost, the temperature of the knife-edge seal ring cavity increased, which precipitated its fracture. Once the seal ring fractured, it sprang open slightly from normal internal stresses, became loose in the cavity, and then migrated axially aft until it contacted the rotating 2nd-stage turbine wheel web and started to machine the web material, weakening it until the overload failure occurred.

According to the engine manufacturer, without the cooling air, metal temperatures of the knife-edge seal ring at the forward and aft ends were estimated to be 1446°F and 1263°F, respectively. Intergranular fractures were initiated after exposure to these high temperatures. The nominal cavity temperature should be 1060°F.

A review of the repair history of the 2nd-stage stator assembly revealed that the forward braze joint had been repaired about 5 years before the accident using a repair process specification that was not applicable for the assembly part being repaired. Further, the engine manufacturer does not consider the part a repairable item and advises that it be removed from service. However, the Federal Aviation Administration designated engineering representative had approved the repair process and did not include technical substantiation.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be:

The failure of the 2nd-stage turbine wheel due to an improper repair of the 2nd-stage stator assembly, which the manufacturer does not consider a repairable item. Contributing to the incident was the designated engineering representative's approval of the repair process.

Findings

Aircraft	Turbine section - Failure
Aircraft	Turbine section - Incorrect service/maintenance
Organizational issues	Oversight of reg compliance - FAA/Regulator

Factual Information

History of Flight

Enroute-cruise	Loss of engine power (total) (Defining event)

On July 16, 2014, at 2130 Pacific daylight time, a Beech B100, N6756P, was not damaged after it experienced an uncontained failure of its left engine in flight near Bakersfield, California. The commercial pilot was not injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

The pilot reported to the NTSB investigator-in-charge (IIC) that he was cruising at flight level 190 (19,000 feet mean sea level (msl)), about 30 miles east-northeast of Bakersfield, when the left engine spooled back. The pilot executed the engine failure in-flight procedures and landed uneventfully at Meadows Field Airport. Post flight inspection revealed damage, consistent with an uncontained engine event, to the left nacelle and external damage to the left engine.

Examination of the engine by a Safety Board powerplants specialist and the engine manufacturer identified failure of the second stage turbine wheel. The 2nd stage turbine wheel assembly is a repairable assembly of two parts: the 2nd stage turbine wheel and the 2nd stage rotating labyrinth curvic seal (referred to as the 'knife edge seal ring' for the remainder of this report) and they are assembled using a tight interference fit. The knife edge seal ring was fractured and was separated from the 2nd stage turbine wheel hub. The knife edge seal ring was severely scored rotationally on the inner minor assembly faying diameter. Approximately 1/3 of the forward edge was heat eroded, resulting in a wedge shape eroded edge. The knife edge seal ring features 2 castellations, used for assembly ease. One castellation was completely hot gas eroded. A small crack was found on each of the inner corners of the remaining castellation. Only the hub portion of the 2nd stage turbine wheel was found with the web, platform and blades missing. A fractured surface through 360^{o} remained. The forward outer curvic shaft diameter was severely rotationally scored, consistent with contact against the fractured knife edge seal ring. The curvic teeth of the forward and aft coupling were undamaged.

A materials laboratory evaluation of the thermally degraded 1st stage stator vanes revealed that weld repairs had been done to the part. Additionally, a microstructure analysis indicated that the metal had sustained operational temperatures in excess of 1650°F in 1840°F for a long period of time at the outboard leading edges and trailing edge regions respectively.

The 2nd stage stator assembly is an assembled part consisting of a main nozzle casting, onto which an outer support baffle with outer flange is brazed. The outer support baffle, when brazed onto the main nozzle casting, defines an inner cavity with the main nozzle casting that acts as a passage for compressor discharge air which cools the aft face of the 1st stage turbine wheel and the knife edge seal ring and honeycomb seal. Additionally, it is also a structural component since it is along the load path between the outer mounting flange/forward ring/baffle assembly to the nozzle casting. The braze thickness is a tightly controlled dimension during the fabrication of the part. Due to the close proximity of any weld

repair of the leading edge of the vane to the forward braze joint presents a risk of oxidation and porosity of the braze material due to the high temperature induced in the braze joint as part of the welding repair.

The cooling airflow that is directed to the back face of the 1st stage turbine wheel and the knife edge seal ring comes from the compressor discharge air through the second stage stator outer housing, through the internal passages of the stator vanes and into the cavity. If areas of the braze joint became separated at any location around the circumference of the nozzle during service prior to the uncontained event, these areas would account for the loss of secondary cooling to the nozzle cavity. Instead of the cooling air being directed to the knife edge seal ring cavity, some of the air would escape the outer support cavity and be drawn to the lower pressure areas near the internal turbine temperature (ITT) probes and into the gas flow path. The loss of cooling flow will result in increased gas flow path ingress into the seal cavity and a corresponding rise in temperature. To further exacerbate the situation, the secondary cooling air passing by the ITT probes will cause a lower ITT indication than the true operating temperature of the engine, causing the pilot to be unaware of the increased engine operating temperature and the resulting insufficient cooling of the knife edge seal ring.

The 2nd stage turbine wheel outboard of the curvic hub exhibited wear/rub that reduced the web thickness by over 0.4 inches at the separation location. The wear/rub was consistent with contact against the fractured and expanded knife edge seal ring. The fracture surface exhibited indications of overload separation in the area of the reduced web thickness.

According to the Honeywell laboratory report, metal temperatures of the knife edge seal ring at the forward and aft ends were estimated to be 1446 °F and 1263 °F respectively. Intergranular fractures were initiated after exposure to these high temperatures. The nominal cavity temperature should be 1060°F.

Repair History

A review of the Authorized Release Certificate Federal Aviation Administration (FAA) Form 8130-3, Airworthiness Approval Tag reveals that the 2nd stage stator assembly, P/N 894528-15, S/N 0-01345-3454, was repaired by Texoma Turbines, in Durant, Oklahoma in accordance with process 72-IR-10 #9 and repair process specification (RPS) SP003 Rev. 2 on February 17, 2009.

At the time this part was repaired, the RPS applicability was for repairing only 2nd stage turbine stator assemblies part numbers 894528 -1, -2, -3, -5, -6, -10, and -11. It was not applicable to the -15 & -16 parts, making the event part, repaired by Texoma Turbines, unapproved.

According to Honeywell's Instructions for Continuing Airworthiness (ICA), there are no instructions or authorizations for vane weld repairs on the 2nd stage stator. When this component fails its respective service limit criteria, Honeywell guidance states that it should be removed from service.

The entire powerplants group chairman factual report is contained in the official docket of this investigation.

Record Retention Requirements

The owner of the repair station stated that he had destroyed the documentation of the repaired part after the FAA prescribed 2-year retention limit. The component was repaired February 17, 2009.

CFR Part 145.219 is applicable for the 2-year retention of records for Repair Station repaired parts/articles.

Sec. 145.219 Record keeping.
(a) A certificated repair station must retain records in English that demonstrate compliance with the requirements of Part 43. The records must be retained in a format acceptable to the FAA.
(b) A certificated repair station must provide a copy of the maintenance release to the owner or operator of the article on which the maintenance, preventive maintenance, or alteration was performed.
(c) A certificated repair station must retain the records required by this section for at least 2 years from the date the article was approved for return to service.
(d) A certificated repair station must make all required records available for inspection by the FAA and the National Transportation Safety Board.
(Amdt. 145-27, Eff. 1/31/2004)

The regulatory requirement allows for the disposal of these records and the true history, which could have helped to understand the problem, is no longer available.

FAA Designated Engineering Representative (DER) Process and Procedures

The original technical documents used to substantiate the repair processes in the RPS could not be located, therefore a review of it could not be done. An FAA technical staff member interviewed from the Fort Worth ACO Branch, believed that there was no technical substantiation data written for this repair and that only the process steps were written by the original DER because the technical substantiation data was not included in the DER's approval. It is not known if the DER considered (1) the braze joint oxidation and porosity sensitivity to welding and heat-treatment heat or (2) of the impact of loss of cooling air of this part on any adjacent or downstream components of the engine.

The technical substantiation data should have been retained by the original DER and the original Repair Station; however, he was no longer a DER and not in the DER directory. Guidance for the retention of technical substantiation documents is defined in FAA Order 1350.15C, Records Management, Chapter 11, Flight Safety, Item 8113 Designated Engineering Representative states that original document destruction is not authorized. There is no guidance for the transfer of documents when a DER quits or dies.

Pilot Information

Certificate:	Commercial	**Age:**	29,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	4-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	May 28, 2014
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	October 1, 2013
Flight Time:	5000 hours (Total, all aircraft), 1000 hours (Total, this make and model), 50 hours (Last 90 days, all aircraft), 15 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Beech	**Registration:**	N6756P
Model/Series:	B100 NO SERIES	**Aircraft Category:**	Airplane
Year of Manufacture:	1980	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	BE-92
Landing Gear Type:	Retractable - Tricycle	**Seats:**	10
Date/Type of Last Inspection:	May 5, 2014 Continuous airworthiness	**Certified Max Gross Wt.:**	11800 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo prop
Airframe Total Time:	7807 Hrs as of last inspection	**Engine Manufacturer:**	Garret
ELT:	Installed, not activated	**Engine Model/Series:**	TPE331-6
Registered Owner:	On file	**Rated Power:**	715 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night
Observation Facility, Elevation:	KBFL,510 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	20:54 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	5 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	11 knots /	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:	300°	**Turbulence Severity Forecast/Actual:**	/ N/A
Altimeter Setting:	29.86 inches Hg	**Temperature/Dew Point:**	29°C / 13°C
Precipitation and Obscuration:	N/A - None - Haze		
Departure Point:	S. Lake Tahoe, CA (KTVL)	**Type of Flight Plan Filed:**	None
Destination:	Carlsbad, CA (KCRQ)	**Type of Clearance:**	VFR flight following
Departure Time:	20:30 Local	**Type of Airspace:**	Class A

Airport Information

Airport:	Meadows Field Airport KBFL	**Runway Surface Type:**	
Airport Elevation:	510 ft msl	**Runway Surface Condition:**	Dry
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	Unknown

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Minor
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 None	**Latitude, Longitude:**	35.433887,-119.057777(est)

Administrative Information

Investigator In Charge (IIC):	McKenny, Van
Additional Participating Persons:	Greg Nolting; FAA; San Diego, CA David Studtmann; Honeywell; Phoenix, AZ Marc Belhumeur; FAA ACO; Fort Worth, TX
Original Publish Date:	September 23, 2020
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this incident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=89690