Aviation Investigation Final Report

Location:	Portland, Oregon	**Accident Number:**	WPR09LA013
Date & Time:	October 14, 2008, 08:05 Local	**Registration:**	N3BT
Aircraft:	Piper PA-31-350	**Aircraft Damage:**	Substantial
Defining Event:	Powerplant sys/comp malf/fail	**Injuries:**	1 None
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled		

Analysis

The pilot reported that shortly after departure, and about 1,000 feet above ground level, she noticed that the left engine's manifold pressure dropped about 6 inches below the right engine's indications. The engine was surging, and she thought that the turbocharger had stopped operating. The left cylinder head temperature was reading 0 degrees, but all other gauges were normal. No smoke or flames were noticed as the pilot returned to the airport for landing without declaring an emergency or shutting down the engine. During taxi to the ramp, the engine lost power. Postflight examination revealed a broken exhaust pipe on the right side of the exhaust system, with evidence of a fire in the accessory section and a burned-through section of skin. Metallurgical examination disclosed that the aft exhaust pipe flange had cracked and fractured due to fatigue. Dimensional measurements of the flange wall thickness were within design limits. The hardness was as expected for the specified type 321 steel, indicating that bending stresses acting on the flange exceeded its design capability. The cracking occurred due to excessive stresses that developed from thermal expansion of the exhaust line and insufficient sliding action at the slip joints within the exhaust pipe system. Bending of the flange and subsequent fatigue cracking indicated that the slip joints had likely not been working properly for some time.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: An in-flight engine fire due to the fatigue fracture of an exhaust pipe that resulted from a failure of the pipe's slip joint.

Findings

Aircraft	(general) - Malfunction
Aircraft	(general) - Fatigue/wear/corrosion

Factual Information

History of Flight

Initial climb	Powerplant sys/comp malf/fail (Defining event)
Initial climb	Fire/smoke (non-impact)

On October 14, 2008, about 0805 Pacific daylight time, a Piper PA-31-350, N3BT, experienced an in-flight fire in the left engine shortly after departure from Portland International Airport, Portland, Oregon. Ameriflight, Inc., was operating the airplane under the provisions of 14 Code of Federal Regulations (CFR) Part 135. The certificated commercial pilot was not injured; the airplane sustained substantial damage to the left rear spar. The cross-country cargo flight departed Portland about 0800 with a planned destination of Pendleton, Oregon. Visual meteorological conditions prevailed, and an instrument flight rules (IFR) flight plan had been filed.

The pilot reported that shortly after departure, and about 1,000 feet above ground level (agl), she noticed that the left engine's manifold pressure dropped about 6 inches below the right engine's indications. The engine was surging, and she thought that the turbocharger had stopped operating. The left cylinder head temperature (CHT) was reading 0 degrees, but all other gauges were normal. The pilot requested to return for landing without declaring an emergency as she did not believe that she had one. The engine was not shut down in flight and no flames or smoke were noticed. After an uneventful landing on runway 21, the left engine lost power during taxi to the ramp.

The operator reported that a post flight inspection revealed copious oil streaming aft of the left engine. There were two holes burnt in the lower skin of the left flap aft of the cowling exit area, a hole burnt in the exterior skin of the left outboard main gear door, and evidence of fire in the accessory area inside the left cowling. No oil showed on the left engine dipstick. A head pipe on the left engine (leading from the cylinders to the waste gate) had broken off at the flange where it attaches to the waste gate with a V-clamp, allowing raw exhaust flames to go into the accessory area.

A Safety Board Materials Laboratory specialist examined the broken pipe. The Federal Aviation Administration (FAA) inspector and the FAA Small Airplane Directorate identified four other fractured exhausts on other airplanes of the same make and model. Some of these components were manufactured by different companies using different production methods. The Safety Board specialist also examined these pieces in order to determine any commonalities. He identified the samples as A, B, C, and unknown. Some were from the left sides of engines, and others were from the right side.

The exhaust pipes from the accident airplane, and airplanes A, B, and C consisted of two or

three pipe sections. The aft ends of the aft sections had a flanged end that, when installed in the airplanes, were clamped to a cross-shaped transition piece below the turbocharger. The forward end of each section of pipe had an expanded diameter into which the aft end of the next forward section was installed to form a slip joint. The aft flanges on all the submitted pipe components were either cracked or fractured in the transition radius between the skirt and the flange face. Some fractures were on the forward side of the flange, while others were on the aft side.

The specialist observed light gray metallic deposits on the forward side of the aft pipe section in the inner radius of the bend of the exhaust pipe from the accident airplane. The fracture was generally in a plane perpendicular to the flange surface with step features separating flat fractures. These features were consistent with fatigue initiating from multiple origins. Post fracture damage, oxidation, and deposits obliterated fine fracture features. Several branching cracks emanating from the fracture toward the radial direction were on the flange face at the upper and lower sides of the flange. The crack initiated at the forward side of the flange and propagated toward the aft side.

Exhaust pipes from airplanes A, B, and C exhibited obtuse fracture angles.

The unknown airplane's pipe fracture was in a plane perpendicular to the flange surface with step features separating flat fractures. These features were consistent with fatigue initiating from multiple origins.

The specialist measured the wall thickness of the flange at a location on the flange face adjacent to the transition radius between the flange skirt and flange face. In each case, the flange thickness was greater than the minimum thickness specified on the engineering drawing provided by the flange manufacturer.

The specialist measured the transition radius between the flange skirt and the flange face on the forward and aft sides on four of the pipes. In general, the transition radii measured on the forward sides of the flanges were greater than those measured on the aft sides. Combining and averaging measurements at the forward and aft sides of each flange, the average transition radius measurements on the flanges from the accident airplane and airplane B were within drawing specifications; however, the radii for A and C were slightly greater than engineering drawing specifications.

The internal surfaces of the exposed slip joints at the forward ends of the submitted pipe sections were examined. The intact slip joints in each section were rigid and could not be separated or moved by hand forces. The internal surfaces of the exposed slip joints in sections removed from the accident airplane, airplane A, and airplane B were generally a mix of gray, brown, and orange in color. Scrapings from the interior surface of these exposed slip joints felt smooth and slippery. Airplane C's deposits were darker gray to black in color. Scrapings from this slip joint had a relatively sticky, gummy texture.

Examination of the scrapings with a scanning electron microscope (SEM) revealed peaks for elements typical of stainless steel and for combustion deposits. However, samples removed from the slip joints from the accident airplane, airplane A, and airplane B indicated a significant peak of copper. Copper is an element commonly found in antiseize compounds such as Loctite (Fel-Pro) C5-A. The sample from the slip joint from airplane C showed greater distortion when imaging in the SEM, and a peak of copper was generally not found in this sample.

The inner diameters of the exposed female ends of the slip joints at the forward ends of the submitted pipe sections were measured vertically and horizontally. All diameters in the vertical direction and two in the horizontal direction were greater than the engineering drawing specification. One measurement in the horizontal direction was within drawing specification, and one was less than the drawing specification.

Hardness measurements were conducted on the back face of the flange face piece from the exhaust flange from the accident airplane. Average hardness was 85 HRB. According to the Aerospace Structural Metals Handbook, the typical hardness of annealed Type 321 stainless steel tube is 85 HRB.

Pilot Information

Certificate:	Commercial	**Age:**	25,Female
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 2	**Last FAA Medical Exam:**	
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	(Estimated) 1500 hours (Total, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Piper	**Registration:**	N3BT
Model/Series:	PA-31-350	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	31-7752172
Landing Gear Type:	Retractable - Tricycle	**Seats:**	2
Date/Type of Last Inspection:	September 30, 2008 AAIP	**Certified Max Gross Wt.:**	7000 lbs
Time Since Last Inspection:	29 Hrs	**Engines:**	2 Reciprocating
Airframe Total Time:		**Engine Manufacturer:**	Lycoming
ELT:	Installed, not activated	**Engine Model/Series:**	TIO-540-J2B
Registered Owner:	UAS TRANSERVICES INC	**Rated Power:**	350 Horsepower
Operator:	Ameriflight, Inc.	**Operating Certificate(s) Held:**	On-demand air taxi (135)
Operator Does Business As:		**Operator Designator Code:**	JIKA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KPDX,30 ft msl	**Distance from Accident Site:**	
Observation Time:	07:53 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Few	**Visibility**	10 miles
Lowest Ceiling:	Broken	**Visibility (RVR):**	
Wind Speed/Gusts:	3 knots / None	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	300°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.45 inches Hg	**Temperature/Dew Point:**	11°C / 9°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Portland, OR (PDX)	**Type of Flight Plan Filed:**	IFR
Destination:	Pendleton, OR (PDT)	**Type of Clearance:**	IFR
Departure Time:	08:00 Local	**Type of Airspace:**	

Airport Information

Airport:	Portland PDX	**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	Full stop;Precautionary landing

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	In-flight
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 None	**Latitude, Longitude:**	45.530632,-122.679054(est)

Administrative Information

Investigator In Charge (IIC):	Plagens, Howard
Additional Participating Persons:	Tony Moore; Federal Aviation Administration FSDO; Portland, OR
Original Publish Date:	September 10, 2009
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=69289