Aviation Investigation Final Report

Location:	Willows, California	**Accident Number:**	WPR17LA042
Date & Time:	December 27, 2016, 15:53 Local	**Registration:**	N602L
Aircraft:	AIR TRACTOR INC AT 602	**Aircraft Damage:**	Substantial
Defining Event:	Loss of engine power (partial)	**Injuries:**	1 None
Flight Conducted Under:	Part 91: General aviation - Positioning		

Analysis

The commercial pilot of the turboprop-equipped airplane departed from the maintenance facility airport following the completion of a 100-hour inspection, which included a compressor bleed valve overhaul. He did not perform an engine run-up or a postmaintenance performance check as recommended by the engine manufacturer but noticed that the engine was "sluggish" during takeoff. Near the conclusion of the 25-minute flight, the pilot initiated a straight-in approach to his destination airport and slightly reduced engine power. Immediately, he heard a "pop" noise and observed a reduction in airspeed. When the pilot advanced the throttle to full power, the engine power and airspeed did not change, and the airplane began to sink. The pilot conducted an off-airport forced landing and the airplane nosed over and came to rest inverted.

Postaccident examination of the engine revealed that the valve seat had not been installed on the overhauled compressor bleed valve. The maintenance manual overhaul procedure requires that the bleed valve seat remain with the engine, which requires that the seat be removed from the old core unit and installed on the replacement or overhauled bleed valve before installing that component on the engine. At the time of the inspection, the inspection facility's director of maintenance encountered trouble retrieving the maintenance manual for this model engine from the manufacturer's website and decided to continue the service under the assumption that the bleed valve replacement was similar to another engine model with which he was familiar. The inspection facility submitted the core unit without removing the bleed valve seat, and the valve overhaul facility did not install any seat on the overhauled bleed valve, which was in compliance with the overhaul procedure. The inspection facility then installed the overhauled unit on the engine without the necessary valve seat. Additionally, the inspection facility failed to complete the bleed valve closing check procedure required by the engine manufacturer, which likely would have revealed a malfunctioning bleed valve. Further, the inspection facility reported that they performed an engine run up after completing maintenance, but contrary to required procedures did not record any power settings. Without the power setting data, the investigation was unable to positively determine whether the bleed valve closed properly during the ground test. Additionally, neither the

maintenance facility nor the pilot completed the engine manufacturer's recommended engine performance check after the service was completed.

The airplane was sluggish during takeoff because the engine was not able to achieve full power due to the absence of the bleed valve seat and consequent malfunctioning of the bleed valve. The "pop" sound heard by the pilot when he attempted to increase power during his approach was likely a compressor stall caused by the malfunctioning bleed valve. The malfunctioning bleed valve would have prevented the engine from responding to any additional power demand at this critical moment, and once the engine failed to respond, the pilot likely determined that the airplane would not reach the runway and completed a forced off-airport landing.

Probable Cause and Findings

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

The decision of the maintenance facility mechanic to conduct maintenance without reference to the applicable manufacturer's guidance, which resulted in the improper reassembly and subsequent failure of the engine compressor bleed valve, which in turn prevented the engine from responding to further power demand at a critical phase of flight. Contributing to the accident was the failure of the maintenance facility's director of maintenance to ensure that the overhaul was conducted properly and that the required post-maintenance test procedures were accomplished.

Findings

Aircraft	Compressor bleed valve - Incorrect service/maintenance
Personnel issues	Decision making/judgment - Maintenance personnel
Personnel issues	Installation - Maintenance personnel

Factual Information

History of Flight

Approach-VFR pattern final	Powerplant sys/comp malf/fail
Approach-VFR pattern final	Loss of engine power (partial) (Defining event)
Emergency descent	Off-field or emergency landing
Landing-flare/touchdown	Nose over/nose down

On December 27, 2016, about 1553 Pacific standard time, an Air Tractor AT-602, N602L, was substantially damaged when the airplane landed short at Willows-Glenn County Airport (WLW), Willows, California. The commercial pilot was not injured. The airplane was owned and operated by the pilot under the provisions of Title 14 *Code of Federal Regulations* Part 91. Visual meteorological conditions prevailed and no flight plan was filed for the cross-country flight that departed Medlock Field Airport (69CL), Davis, California at approximately 1527. The personal flight was destined for WLW.

According to the pilot, he was returning the airplane to WLW after a recent 100-hour inspection with 160 gallons of JET A fuel onboard. The airplane seemed sluggish during takeoff and the engine did not produce more than 97% power, but the pilot did not observe an exceedance of the engine's turbine inlet temperature or any further abnormal instrument indications. At the conclusion of the 25-minute flight, the pilot initiated a straight-in approach to runway 31 and slightly reduced the throttle. Immediately, he heard a "pop" noise, and observed a reduction in airspeed. When the pilot advanced the throttle to full power the engine power and airspeed did not change, and the airplane began to sink rapidly. Further attempts at recycling the throttle were unsuccessful in restoring engine power. As the airplane approached the south end of the airport, the pilot deployed the wing flaps, and the main landing gear touched down on a gravel road beyond a ditch. The tailwheel impacted the ditch and bounced, and the airplane nosed over and came to rest inverted.

The pilot later reported that he did not complete an engine run-up or power assurance check before the accident flight, which is not a required item by the airplane manufacturer. The pilot also reported that the "pop" sound may have been from a hunting party that was in the area at the time of the accident.

Postaccident examination by a Federal Aviation Administration (FAA) inspector revealed substantial damage to the rudder and left wing spar. Additionally the inspector reported an unknown quantity of fuel in the left main fuel tank. The fuel and fuel filter did not appear to be contaminated, and the fuel lines and fuel strainer did not appear to be obstructed.

Pilot Information

Certificate:	Commercial	**Age:**	30,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Single
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	5-point
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	February 22, 2016
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	February 1, 2016
Flight Time:	4147 hours (Total, all aircraft), 2085 hours (Total, this make and model), 4055 hours (Pilot In Command, all aircraft), 35 hours (Last 90 days, all aircraft), 16 hours (Last 30 days, all aircraft), 0 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	AIR TRACTOR INC	**Registration:**	N602L
Model/Series:	AT 602 NO SERIES	**Aircraft Category:**	Airplane
Year of Manufacture:	1999	**Amateur Built:**	
Airworthiness Certificate:	Utility; Restricted (Special)	**Serial Number:**	602-0526
Landing Gear Type:	Tailwheel	**Seats:**	1
Date/Type of Last Inspection:	December 26, 2016 Annual	**Certified Max Gross Wt.:**	
Time Since Last Inspection:	0 Hrs	**Engines:**	Turbo prop
Airframe Total Time:	6537 Hrs at time of accident	**Engine Manufacturer:**	Pratt & Whitney
ELT:	Not installed	**Engine Model/Series:**	PT6A-65ag
Registered Owner:	On file	**Rated Power:**	1300 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	Agricultural aircraft (137)

According to FAA records, the airplane was manufactured in 1999, and registered to the pilot's family in 2010. The airplane was powered by a Pratt and Whitney PT6A-65AG, 1,300 shaft horsepower turboprop engine. The aircraft logbooks showed that the airplane's most recent 100 hour inspection was completed on December 22, 2016 at which time the airframe had accumulated 6,537 total flight hours and the engine had accumulated 4,974.5 total flight hours. The airplane accumulated 0.4 hours between that inspection and the accident. The engine's previous hot section inspection was completed on May 1, 2014 at a total time of 4,078 flight hours.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	OVE,194 ft msl	**Distance from Accident Site:**	27 Nautical Miles
Observation Time:	15:53 Local	**Direction from Accident Site:**	90°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/ N/A
Altimeter Setting:	30.31 inches Hg	**Temperature/Dew Point:**	11°C / 1°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	DAVIS, CA (69CL)	**Type of Flight Plan Filed:**	None
Destination:	WILLOWS, CA (WLW)	**Type of Clearance:**	None
Departure Time:	15:27 Local	**Type of Airspace:**	Class G

Airport Information

Airport:	WILLOWS-GLENN COUNTY WLW	**Runway Surface Type:**	Asphalt
Airport Elevation:	141 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:	31	**IFR Approach:**	None
Runway Length/Width:	3788 ft / 60 ft	**VFR Approach/Landing:**	Straight-in

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 None	**Latitude, Longitude:**	39.509445,-122.216941(est)

Tests and Research

An initial examination of the airplane was completed under the supervision of the NTSB Investigator-in-Charge by a representative of Pratt and Whitney Canada who was an airframe and powerplant mechanic. The oil filter, fuel filter, and filter to the high pressure fuel pump were inspected. The oil filter displayed some carbon debris, while both the fuel filter and filter to the fuel pump were free of contamination. A clear liquid was observed in the fuel bowl that exhibited an odor and appearance that resembled JET A fuel.

Compressor Bleed Valve

The purpose of the compressor bleed valve is to prevent a compressor stall at low gas generator speeds. The unit is comprised of a piston that is pushed into the closed position by P3 air and moved to the open position using P2.5 air from the inter-stage compressor area. At low power settings, P3 pressure is lower than the P2.5 pressure, which causes the bleed valve to position itself to the open condition. As compressor speed increases, P3 pressure rises faster than the P2.5 pressure, which causes the bleed valve to move towards the closed condition.

The speed at which the valve closes is both a function of P3 pressure and surface area on which P2.5 pressure is pushing on the piston. P3 pressure is dependent on the restriction at the outlet of the cavity where it is drawn. The surface area on which P2.5 air pushes depends on the inside diameter of the bleed valve seat.

According to the engine manufacturer, the piston will normally extend to the closed position against the valve seat in response to a power demand from the operator. The piston is equipped with a carbon ring that is normally compressed between the piston and the piston guide collar. If the valve seat is not installed, the piston can travel beyond its normal range, which allows the carbon ring to expand and come out of its groove. This will then prevent the valve piston from moving within its guide collar. The absence of the valve seat will cause a permanent air leak around the piston, which will allow P2.5 pressure to escape the engine. This condition can prevent the engine from accommodating any additional power demand and/or result in significantly slower accelerations.

At the time of the accident airplane's recent 100 hour inspection, the bleed valve was replaced with an overhauled unit from the bleed valve overhaul facility, Prime Turbines. The original bleed valve had been submitted to Prime Turbines a few weeks earlier as a core unit.

During the post accident examination, when the bleed valve was removed from the engine, its internal piston fell out, indicating that it was not secured within the valve body, as it was supposed to have been. An inspection of the bleed valve showed that the valve filter was intact and free of contamination. A comparison of the accident bleed valve with the manufacturer's illustrated parts catalogue revealed that the valve seat was absent and the two screws that normally secure the seat to the valve body were installed finger tight and protruded from the flange of the valve body, preventing proper seating when the valve was installed on the engine. In response to a query by the investigation, a representative of bleed valve overhaul facility discovered the valve seat among the components that comprised the previously submitted core unit.

According to the section of the engine maintenance manual entitled "Compressor Bleed Valve – Maintenance Practices," the bleed valve seat must be removed from the core unit and remain with the gas generator assembly after the bleed valve has been removed. Once the overhauled bleed valve arrives, the previously retained seat should be installed on the replacement bleed valve and tightened to 5 to 6 inch lbs before the unit is installed on the engine.

Maintenance Facility

The Director of Maintenance (DOM) to Grower's Air Service, the service facility, who also signed off the airplane's most recent 100 hour inspection, reported that his facility started working on PT6A-65AG engines about 2 years ago. During this time period, the company only serviced 2 PT6A-65AG model engines, including the engine from the accident airplane. Initially, the DOM stated that they completed the engine inspection in accordance with the manufacturer's maintenance manual (MM), which was revised in March 2016. Normally, the maintenance facility DOM will review the applicable service manuals prior to engaging in a particular maintenance activity. However, the DOM had trouble accessing the manuals through the manufacturer's website, and decided not to review the bleed valve guidance prior to the maintenance on the accident engine because he assumed that the procedures were similar to those prescribed for the PT6A-34A and PT6A-60 engines, which the facility regularly services. According to a PT6A-34A diagram, the bleed air valve is not equipped with a calibrated seat similar to the bleed valve assembly on the PT6A-65AG engine as it contains a metering orifice in the P3 air inlet.

The DOM stated that he removed the old bleed valve from the engine, and that another mechanic installed the overhauled unit. When asked about the valve seat by the investigative team, the DOM stated that he was not aware that the bleed valve on the PT6A-65AG had a removable valve seat, and was certain that the mechanic who installed the overhauled bleed valve on the engine was not aware of that removable valve seat either.

At the conclusion of the inspection, the line mechanic completed two engine runs to dynamically balance the propeller; however, the run-up power settings were not recorded by the maintenance facility. According to the maintenance manual, a bleed valve closing check procedure is required after the unit is installed to verify the gas generator speed at which the valve closes. This value is charted using the gas generator speed and plenum pressure. This procedure was not completed by the maintenance facility.

The engine maintenance manual includes guidance for completing an engine performance check to measure engine torque, fuel flow, gas generator and gas generator speed at various temperatures and specified power settings. This check is only recommended by the engine manufacturer at regular intervals and after major service. The maintenance facility did not conduct an engine performance check following the service that included the bleed valve replacement.

Engine and Component Examinations

A subsequent examination of the engine was completed at the engine manufacturer's facility under the supervision of the NTSB. The accessory gearbox section gears and shafts rotated freely when actuated by hand. The compressor was not displaced and did not exhibit any impact damage signatures. The N1 rotated freely through the tach generator. A small corner piece to one of the 2nd stage compressor blades had separated and several 3rd and 4th stage compressor blades exhibited trailing edge damage. The prop flange, reduction gearbox, and power turbine blades rotated freely when actuated by hand at the main drive shaft. The turbine blades and stator vanes did not display any abnormal wear. Some rotational scoring was observed along the power turbine shroud, but the turbine blades did not display any visible damage. The left side exhaust case was damaged.

All 14 fuel nozzles tested within normal limits with the exception of the nozzles at position nos. 5, 9, 10, and 12. The spray angles produced by fuel nozzle No. 5 were uneven and a subsequent microscope inspection revealed the presence of varnish along the circumference of the tip. Fuel nozzle no. 9 displayed a small leak during the pressure test, a pencil streakiness was observed from nozzle no. 10 and the flow rate of nozzle no. 12 was below the minimum specification. Further, the tab washer tangs to nozzle nos. 2, 3 and 10 were wider than the manufacturer's production part. The flow divider tested normally and produced results within the manufacturer's limitations. According to the manufacturer, the condition of the fuel nozzles would not have had an influence on the engine's ability to make power.

The fuel control unit (FCU) low and high idle fuel flow values were above the manufacturer's

limitations. However, those limits are the manufacturer's pre-delivery/production values, and the manufacturer assumes that the operator will make some adjustments to FCU flow values in service. Additionally, the recorded results for power lever speed (rpm) were higher than manufacturer limitations, which is also a factory requirement. This indicates that the operator and/or the maintenance facility adjusted the low idle, high idle, and max forward and reverse compressor speed positions.

The FCU was run on a test stand at a simulated cruise power setting, with a fixed speed, fixed P3, and power lever angle. The unit was allowed to run for 16 minutes and did not yield any change in the fuel flow, consistent with normal operation. Fuel flow values were normal when the unit was operated at lower RPM speeds, but exceeded the limits by a few pounds per hour at simulated cruise speeds. The FCU was then adjusted to meet production standards. A subsequent test revealed that the FCU produced similar results to its pre-calibration settings.

The fuel pump was placed on a test stand and a pump calibration test was conducted, which tested for leakage at various shaft speeds; the results were within the acceptable range. A subsequent seal drain leakage test was performed with the discharge valve closed. An inlet pressure of 50 psig was selected and maintained for about 5 minutes and no leaks were observed. The filter bypass valve pressure drop was computed by subtracting the discharge pressure from the filter inlet pressure and the results were within the manufacturer's prescribed limitations.

The fuel to oil heat exchanger was tested for core matrix internal leakage and to test the travel of the unit's thermal element. No leaks were observed in the exchanger and the thermal element showed wear. A full description of the fuel to oil heat exchanger test is included as a record of conversation with the engine manufacturer in the NTSB public docket.

Engine Surge

According to the engine manufacturer, a "pop" sound is characteristic of an engine surge. As designed, the compressor assembly draws in too much air at low speeds, which can lead to a compressor stall. The compressor bleed valve opens at low speeds to bleed this excess air and prevent the stall. If the bleed valve setting is improper, the valve will not close correctly and an engine surge can occur, which can lead to a compressor stall. As discussed above, the missing bleed valve seat would result in improper bleed valve function, which in turn could result in compressor stalls.

Administrative Information

Investigator In Charge (IIC):	Stein, Stephen
Additional Participating Persons:	Brian Allen; Federal Aviation Administration; Sacramento Kyle Schroeder; Air Tractor, Inc.; Olney, TX Marc Gratton; Pratt and Whitney Canada; Montreal
Original Publish Date:	November 6, 2018
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=94539