Aviation Investigation Final Report

Location:	Crete, Nebraska	**Accident Number:**	CEN18LA363
Date & Time:	September 1, 2018, 09:00 Local	**Registration:**	N210PF
Aircraft:	Cessna P210N	**Aircraft Damage:**	Substantial
Defining Event:	Low altitude operation/event	**Injuries:**	2 Serious, 2 Minor
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The pilot started the "turbo-normalized" 310-horsepower engine, but then it stopped. He stated that he used the low-pressure boost pump to restart the engine and then turned off the boost pump after it had started. He indicated that he completed an engine run-up before takeoff and that the engine was operating normally. The airplane traveled about halfway down the runway before it became airborne. When the airplane had a positive rate of climb, the pilot raised the landing gear and flaps. He stated that when the airplane was about 500 ft above ground level, he heard the engine "miss," and the engine did not seem to be producing total power. He turned on the low-pressure boost pump and turned back toward the airport, but the engine eventually lost total power. He performed a gear-up forced landing to a cornfield; the airplane impacted the ground hard and slid through the cornfield on its belly.

A witness who watched the airplane take off reported that the airplane sounded like it was full throttle but was "overweight sounding" during the takeoff. He reported that the airplane "finally got in the air at the end of the runway." He stated that it was "running rich" and that he could see "dark exhaust" trailing the airplane during the takeoff. The airplane veered to the right, and he lost sight of it behind a tree line.

An engine monitor installed on the airplane indicated that the manifold pressure reached 37 inches of mercury (inHg) and fuel flow reached 48 gallons of fuel per hour (gph) during takeoff. The pilot operating handbook for the supplemental type certificated engine stated that the full rated horsepower is achieved at 31 inHg of manifold pressure and that full throttle fuel flow during takeoff is 35-37 gph.

The engine was run on the engine manufacturer's test cell and operated within normal operating specifications. There were no mechanical malfunctions or failures with the turbocharger controller, wastegate actuator, pressure relief valve, manifold pressure transducer, and fuel flow transmitter that would have precluded normal operation.

However, a static demonstration run on the same airplane model/engine conversion, with the oil line from the wastegate to the wastegate controller disconnected to simulate a wastegate stuck in the closed

position, showed similar indications of manifold pressure as on the accident flight; the manifold pressure far exceeded the design criteria. Sporadic black smoke was observed coming from the turbo exhaust. The engine was rough and lost power as the mixture became richer while the throttle was held fully forward. Reducing the throttle position to reduce manifold pressure allowed more normal operation to resume and the fuel flow to reduce to a less rich mixture. The engine resumed somewhat normal operating conditions except for the wastegate still being fully closed.

Given this information, it is likely that the turbocharger wastegate was "stuck" in the closed position during the takeoff roll for reasons that could not be determined because it was not stuck or binding during the postaccident examination. The stuck wastegate resulted in high manifold pressure and high fuel flow, which caused the fuel mixture to be excessively rich. Instead of pulling back on the throttle to reduce the manifold pressure, the pilot turned on the fuel boost pump, which exacerbated the problem; the fuel mixture became too rich, and the engine stopped producing power.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The stuck turbocharger wastegate in the closed position for reasons that could not be determined based on the available information. Also causal was the pilot's failure to reduce the throttle during takeoff when the manifold pressure and fuel flow exceeded the takeoff limitations and the pilot's decision to turn on the fuel boost pump, which exacerbated the excessively rich fuel mixture and resulted in a total loss of engine power.

Findings

Aircraft	Turbocharger - Malfunction
Personnel issues	Incorrect action performance - Pilot

Factual Information

History of Flight

Initial climb	Low altitude operation/event (Defining event)
Initial climb	Loss of engine power (partial)
Initial climb	Loss of engine power (total)
Landing-flare/touchdown	Collision with terr/obj (non-CFIT)

On September 1, 2018, about 0900 central daylight time, a Cessna P210N, N210PF, sustained substantial damage during a forced landing to a cornfield following a partial loss of engine power after takeoff from the Crete Municipal Airport (CEK), Crete, Nebraska. The pilot and right seat passenger received serious injuries, and the two rear seat passengers received minor injuries. The airplane was owned and operated by the pilot under the provisions of Title 14 *Code of Federal Regulations* Part 91 as a personal flight. Visual meteorological conditions prevailed at the time of the flight, which was not on a flight plan. The flight was departing CEK and was en route to the Cozad Municipal Airport (CZD), Cozad, Nebraska.

The pilot reported that he and the co-owner had flown the airplane the night before the accident occurred. He stated that the airplane flew normally and that there were no indications of any problems. On the morning of the accident, he started the engine but then it stopped. He used the low-pressure boost pump to start the engine a second time and turned off the boost pump after it had started. He completed an engine run-up before takeoff, and he stated that the engine was operating normally. He departed runway 17 (4,201 ft by 75 ft, concrete) and the airplane took about 2,000 ft of runway before it became airborne. Once he had a positive rate of climb, he raised the landing gear and flaps. He said that when the airplane reached about 500 ft above ground level (agl), he heard the engine "miss" and the engine did not seem to be producing full power. He turned on the low-pressure boost pump and turned back toward the airport, but the engine continued to lose power until it stopped producing power. The airplane was about 200 ft agl when he decided to conduct a gear up forced landing to a cornfield. During the final approach to the cornfield he saw an irrigation pivot and he pulled up to clear the pivot, which caused the airplane to lose airspeed. The airplane impacted the ground hard and skidded through the cornfield on its belly.

A witness who was waiting for his airplane to be fueled stated that he watched the airplane takeoff. He reported that the airplane sounded like it was full throttle but "overweight sounding." He reported that the airplane "finally got in the air at the end of the runway." He stated that it was "running rich" and he could see "dark exhaust" trailing the airplane during the takeoff. The airplane veered to the right and he lost sight of it behind a tree line.

A Federal Aviation Administration (FAA) inspector examined the airplane engine's turbocharger wastegate to determine if it exhibited any binding or if it was stuck. The examination revealed that the wastegate was not stuck or binding. Representatives from the airplane and engine manufacturer, under the supervision of the FAA inspector, examined the wreckage at a hangar. The examination revealed

that the airplane's flight controls exhibited continuity from the flight controls to the control surfaces. The examination of the airplane's fuel system did not reveal any abnormalities. The visual examination of the propeller revealed that the propeller remained attached to the engine. Two of the three blades were bent aft and were loose at the propeller hub. None of the propeller blades exhibited leading edge damage. The propeller spinner was not damaged.

The visual examination of the engine revealed that the crankcase remained intact and there were no signs of a catastrophic internal engine failure. There was minor damage to the induction and exhaust. All six cylinders remained attached to their cylinder bays and were undamaged. The magnetos were undamaged and there were no signs of damage to the ignition harness. All the spark plugs remained installed in their cylinders and were undamaged. The six bottom spark plugs were removed and visually inspected. All the bottom spark plug electrodes were black in color and displayed significant soot deposits. The engine was removed from the airframe and shipped to the engine manufacturer for examination.

The engine was a 310-horsepower Continental IO-550-P, serial number 1009768-R, that was converted from a normally aspirated engine to a turbo-normalized engine by Vitatoe Aviation under Supplemental Type Certificate (STC) SA02918CH on March 1, 2014 at a tachometer time of 3,549.6 hours. The last annual inspection was performed on May 16, 2018 at an engine monitor time of 585.3 hours (engine total time of 272.1 hours since engine conversion).

The Vitatoe engine conversion STC required that an engine monitor be installed on the airplane to record engine and airplane performance. A JPI 830 engine monitor was installed on the accident airplane during the engine conversion and the data from the accident flight was downloaded. The data indicated that during the takeoff accident, the manifold pressure (MP) steadily rose from 15.4 to 37.1 inches of mercury (" Hg) in about 18 seconds. During the same time frame, the fuel flow showed a steady rise from 5.5 gallons per hour (gph) to about 48 gph of fuel. The MP remained steady at about 37" Hg and the fuel flow remained steady at about 48 gph of fuel for about 42 seconds. Then the MP and fuel flow started to fluctuate and decrease until the end of the data recorded 32 seconds later. The last MP reading was 33.3" Hg and the last fuel flow reading was 33 gph. The JPI data also indicated that the exhaust gas temperature (EGT) readings for the six engine cylinders started dropping about 12 to 22 seconds before the MP and fuel flow started to fluctuate and decrease.

The engine was visually examined at the engine manufacturer's teardown facility and it was determined that the damage was minimal, and that the engine could be run on a test cell. The engine was not disassembled prior to the engine run. The cylinders were borescoped and all the cylinder bores, valve heads, and piston faces displayed normal operating and combustion signatures. The top spark plugs were removed and visually inspected. All the top spark plug electrodes were black in color and displayed significant soot deposits.

The engine was mounted on the test stand and it started without hesitation. However, it was determined that the turbocharger installation required an induction scoop be installed to prevent the compressor from cavitating. An induction scoop was installed onto the turbocharger and the engine was restarted.

The engine rpm was advanced to 1,200 rpm and stabilized for five minutes. The engine was then advanced to 1,600 rpm and stabilized for five minutes. The engine rpm was then advanced to 2,100 rpm and stabilized for five minutes; during this period a magneto check was performed, and the magnetos

operated normally. The engine rpm was then advanced to 2,450 rpm and stabilized for five minutes. The engine throttle was then advanced to full open and stabilized for five minutes. The engine rpm stabilized at 2,676 rpm and the manifold pressure stabilized at 32.54" Hg. The fuel flow at full throttle was noted to be 201.68 lbs/hour (approximately 33.61 gph), and the unmetered fuel pressure was 20.31 psi. After running the engine at full power, the engine rpm was brought back to a lower rpm and was advanced quickly to full throttle several times. The engine did not stumble or hesitate and was capable of normal operation.

The specifications in the Vitatoe STC Instructions for Continued Airworthiness specified an rpm of 2,700 rpm (+/- 25 rpm), a maximum manifold pressure of 31.0" Hg (+/- .2" Hg), a full throttle fuel flow of 35-37 gph, and full throttle unmetered fuel pressure of 19-23 psi.

According to the Continental Motors maintenance standard practices manual, the IO-550-P should have the following: maximum rpm of 2,700 rpm, unmetered fuel pressure of 28.0-30.0 psi, and a fuel flow of 25.6-27.3 gph. There is no specification for manifold pressure for an IO-550-P due to the engine being a normally aspirated engine.

The turbocharger controller, wastegate actuator and the pressure relief valve (PRV) were shipped to Hartzell Engine Technologies (HET) to examine the turbocharger system components. The tests of the components confirmed normal operation with no discrepancies that would prevent or degrade normal operation. The HET report is available in the public docket associated with this investigation.

The manifold pressure transducer and the fuel flow transmitter were shipped to JP Instruments, Inc. for bench testing. The tests indicated that both components operated normally.

The Vitatoe Pilot Operating Handbook (POH) Supplement Rev. B issued on July 24, 2014 stated the following information concerning minimum fuel flow during takeoff:

Takeoff: 2,700 rpm. 31.0 inches of manifold pressure. 205 lbs/hr, 35 gph.

The POH stated the following:

Full rated horsepower is achieved at 31" Hg MP. Cold oil may cause momentary overboost to 33" Hg MP. Do not exceed 33" Hg MP. Do not exceed 31" Hg MP for prolonged periods.

The POH stated the following under TAKEOFF POWER CHECK:

"It is important to check takeoff power early in the takeoff roll. Any sign of rough engine operation or sluggish engine acceleration is good cause for discontinuing the takeoff"

"On the first flight of the day, when the throttle is advanced for takeoff, manifold pressure will normally exceed 31.0 inches of Hg and fuel flows will exceed 37 GPH if the throttle is opened fully. Momentary manifold pressures up to 33.0 inches HG are acceptable. If manifold pressure consistently exceeds 31.0 inches of HG, mechanical adjustment may be necessary. On any takeoff, the manifold pressure should be monitored, and the throttle set to provide 31.0 inches Hg; then, for maximum engine power, a full rich mixture should provide at least 35 GPH (36-37 GPH preferred). With a heat-soaked engine on a hot day, it may be necessary to use the right half auxiliary fuel pump switch to LOW BOOST to obtain the recommended takeoff fuel flow of 35-37 GPH preferred."

The Emergency section of the POH turbocharger supplement did not contain information (nor was it required) regarding turbocharger failures relating to the loss of engine power and/or potential hazards relating to fire in flight.

On December 5, 2019, the owner of Vitatoe Aviation LLC conducted a static demonstration of a 1979 P210N (N4789K) modified with the Vitatoe TN550 engine conversion in accordance with STC SA02918CH. A video of the demonstration was produced and is included in the docket material associated with this investigation. The owner provided the following description of the static demonstration and its results:

"Two normal takeoff runups were accomplished showing typical engine readings in takeoff mode after the engine was sufficiently warmed up. On the first takeoff of the day it is not unusual for the Manifold Pressure to slightly exceed the normal adjusted value of 31.0". If Manifold Pressure exceeds 33.0", the pilot should bring back the throttle until Manifold Pressure is within the desired limits. If the Manifold Pressure exceeds 34" of Manifold Pressure, the Pressure Relied Valve (PRV) in the induction system will start to open to relieve excessive pressure. If the PRV opens frequently, adjustment of the wastegate controller to control the Manifold Pressure should be made by a certified mechanic.

Normal climb out engine configuration is 31"MP, 2700 RPM, and 35-37 GPH fuel flow. This setting can be maintained until reaching the desired cruise altitude.

After the initial takeoff tests, the engine was shut down and the oil line from the wastegate to the wastegate controller was disconnected at the wastegate controller and blocked. This was to simulate a wastegate or wastegate controller stuck in the closed position. The turbocharger performance is regulated by the wastegate and wastegate controller. Oil from the engine is pumped to the wastegate and enters a hydraulic cylinder with activation of the wastegate butterfly by a mechanical arm. The wastegate is spring loaded in the open position allowing some exhaust gas to be directed to the tail pipe avoiding the turbocharger. When additional turbo boost is desired, the wastegate controller restricts oil coming from the wastegate causing the wastegate butterfly to close diverting all or most of the exhaust gases to the turbocharger, increasing turbocharger speed and producing higher pressure in the induction system.

The engine was restarted and static takeoff runup initiated. The Manifold Pressure far exceeded the standard reading going as high as 37" MP. The Manifold Pressure or upper deck system influences the fuel pump output by way of an aneroid bellows. The higher MP causes a higher fuel flow output. Above 34" of MP, the Pressure Relief Valve opened to try to restrict engine output. The original equipment turbocharger has high enough output to be able to supply the engine with boosted induction pressures as well as inflate the aircraft cabin to 3.35 psi. With the wastegate or wastegate controller stuck in the closed position, the Manifold Pressure far exceeded the design criteria. When the Pressure Relief Valve opens with the throttle fully open, the air to the engine is somewhat reduced below what it would be if the PRV didn't open. The upper deck reference signal to the fuel pump is also reduced but not enough to balance the loss of compressed air causing a very rich mixture and loss of power. Sporadic black smoke was observed coming from the turbo exhaust during this portion of the test. The engine was rough and lost power as the mixture became richer while the throttle was held fully forward.

Reducing the throttle position to reduce Manifold Pressure back below 33" MP, allowed the PRV to close and more normal operation to resume. This also allowed the fuel flow to reduce to a less rich

mixture. The engine resumed somewhat normal operating conditions except for the wastegate still being fully closed."

The National Transportation Safety Board issued Safety Recommendation A-94-81 to the Federal Aviation Administration on April 11, 1994. The recommendation stated the following:

"Require the amendment of pilot operating handbooks and airplane flight manuals applicable to aircraft equipped with engine turbochargers by including in the "Emergency Procedures" section information regarding turbocharger failure. The information should include procedures to minimize potential hazards relating to fire in flight and/or loss of engine power."

Pilot Information

Certificate:	Private	**Age:**	46,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	3-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 3 Without waivers/limitations	**Last FAA Medical Exam:**	June 26, 2018
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	456.8 hours (Total, all aircraft), 22.5 hours (Total, this make and model), 34.2 hours (Last 90 days, all aircraft), 8.1 hours (Last 30 days, all aircraft), 0.5 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N210PF
Model/Series:	P210N	**Aircraft Category:**	Airplane
Year of Manufacture:	1978	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	P21000018
Landing Gear Type:	Retractable - Tricycle	**Seats:**	6
Date/Type of Last Inspection:	May 16, 2018 Annual	**Certified Max Gross Wt.:**	4000 lbs
Time Since Last Inspection:	35 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	3859.3 Hrs at time of accident	**Engine Manufacturer:**	Continental
ELT:	Installed	**Engine Model/Series:**	TSIO-550-P
Registered Owner:		**Rated Power:**	300 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	CEK,1499 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	08:54 Local	**Direction from Accident Site:**	0°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	3 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	170°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.88 inches Hg	**Temperature/Dew Point:**	24°C / 19°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Crete, NE (CEK)	**Type of Flight Plan Filed:**	None
Destination:	Cozad, NE (CZD)	**Type of Clearance:**	None
Departure Time:	09:00 Local	**Type of Airspace:**	

Airport Information

Airport:	Crete Municipal Airport CEK	**Runway Surface Type:**	Concrete
Airport Elevation:	1499 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	17	**IFR Approach:**	None
Runway Length/Width:	4201 ft / 75 ft	**VFR Approach/Landing:**	Forced landing

Wreckage and Impact Information

Crew Injuries:	1 Serious	**Aircraft Damage:**	Substantial
Passenger Injuries:	1 Serious, 2 Minor	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Serious, 2 Minor	**Latitude, Longitude:**	40.618331,-96.925834

Administrative Information

Investigator In Charge (IIC):	Silliman, James
Additional Participating Persons:	Rick Love; FAA Lincoln FSDO; Lincoln, NE Kurt Gibson; Continental Motors; Mobile, AL Les Doud; Hartzell Propellers; Piqua, OH Larry Vitatoe; Vitatoe Aviation; Chillicothe, OH
Original Publish Date:	June 3, 2020
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=98212