



Aviation Investigation Final Report

Location:	Napa, California	Accident Number:	WPR18TA223
Date & Time:	August 11, 2018, 10:56 Local	Registration:	N328SK
Aircraft:	Zenair ZENITH STOL CH750	Aircraft Damage:	Substantial
Defining Event:	Powerplant sys/comp malf/fail	Injuries:	2 None
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The pilot/owner was conducting a flight in the experimental amateur-built airplane with a pilot-rated passenger, who was a potential buyer. The pilot reported that they flew in the local area for about 20 minutes, and then smoke entered the cockpit. The pilot declared an emergency and headed toward the departure airport. Within 1-2 minutes, the engine lost all oil pressure and then lost total power.

The pilot initially attempted to glide to the airport but, because it was too far away, decided to land on a road atop a nearby levee. The airplane touched down normally, but due to wind, the left wingtip struck the ground; the airplane spun, veered off the levee, and sustained substantial damage to the wing and fuselage.

The engine exhibited some impact-related damage but did not exhibit any external evidence of nonimpact-related damage. The engine was devoid of lubricating oil, and significant oil residue was observed on the muffler and the lower fuselage. Postaccident examination indicated that the source of the oil was via the seal for the engine case drive penetration of the starter ring gear, located just above the muffler. The oil exited via this seal and produced smoke when it contacted the hot muffler.

The engine control unit (ECU) was removed and shipped to the engine manufacturer's facility, where it was installed on a testbed engine. That engine operated normally with the accident ECU installed.

The engine was disassembled and examined in detail. All four pistons displayed evidence of significant erosion damage consistent with detonation, with at least one piston eroded to the point that it could no longer seal against the cylinder wall. A common cause of detonation is using a lower octane fuel than specified by the manufacturer. The damage was consistent with the use of fuel with octane rating(s) significantly below that required for the engine. Although the pilot did not specify the octane rating of the fuel that he used, it is likely that he used fuel below the required octane rating.

At least one piston was eroded to the point that it allowed cylinder combustion gasses to enter and pressurize the engine crankcase. This crankcase pressurization forced the engine oil past the starter ring gear drive seal and out of the engine, which resulted in the exhaustion of the engine oil and a subsequent complete loss of engine power. The pilot-provided maintenance records did not include any entries that documented maintenance activities, including oil changes. Had the pilot conducted regular inspections and maintenance, it is possible that the detonation-caused internal engine damage would have been detected before the accident flight.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's use of fuel below the required octane rating, which caused engine detonation and damage and subsequently led to oil exhaustion and a total loss of engine power in flight. Contributing to the accident was the pilot's inadequate service/maintenance of the airplane.

Findings

Aircraft	Fuel - Incorrect use/operation
Personnel issues	(general) - Pilot
Aircraft	Oil - Fluid level
Aircraft	(general) - Incorrect service/maintenance
Personnel issues	Scheduled/routine maintenance - Owner/builder

Factual Information

History of Flight

Prior to flight	Aircraft maintenance event
Enroute	Powerplant sys/comp malf/fail (Defining event)
Enroute	Fire/smoke (non-impact)
Enroute	Loss of engine power (total)
Emergency descent	Off-field or emergency landing

On August 11, 2018, about 1056 Pacific daylight time, an experimental, amateur-built Zenith CH-750 airplane, N328SK, was substantially damaged during a forced landing near Napa County Airport (APC), Napa, California. The commercial pilot/owner and his pilot-rated passenger were not injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight. Visual meteorological conditions existed at APC about the time of the accident. The local flight had originated from APC about 25 minutes earlier.

According to the pilot, who was also the builder of the airplane, the airplane was for sale, and the accident flight was a demonstration/familiarization flight for a potential buyer. The pilot reported that they flew in the local area for about 20 minutes, and then he handed airplane control to the potential buyer, who was in the right seat. The buyer wanted to see how slowly the airplane could fly, and decelerated to about 30 knots, which resulted in a significant airplane-nose-up pitch attitude. The airplane began "sinking," so the pilot/owner took back control and pushed the nose over to regain airspeed. Almost immediately smoke entered the cockpit. The pilot declared an emergency and headed towards APC. Within a minute or two, the engine lost all oil pressure, and then ceased developing power.

The pilot initially attempted to glide to the airport, but then realized that the airport was too distant. He then decided to land on a road atop a nearby levee. The airplane touched down on the road, and the initial rollout was satisfactory. However, due to wind, the left wingtip struck the ground, and spun the airplane around. Due to the narrow width of the road and levee, the airplane then veered off the levee, and damaged the wing and fuselage. The airplane came to rest below the top of the levee, about 0.6 miles west of the APC runway 6 threshold.

According to Federal Aviation Administration (FAA) information, about 1050 the pilot reported to the APC air traffic control tower (ATCT) local controller (LC) that he had an "oil pressure issue." The LC asked the pilot if he required any assistance, and the pilot replied in the negative. At 1055 the pilot re-contacted the LC, advising that he was having "more issues," but did not elaborate. The ATCT controller in charge (CiC) declared an emergency for the pilot. The pilot then radioed that he had lost all engine power and was attempting to reach runway 6. At 1056 the pilot advised the LC that he could not make the runway and was landing on a levee about 1/2 mile short of the runway. After the airplane came to rest, the pilot notified the LC of their situation.

Pilot Information

Certificate:	Commercial	Age:	67,Male
Airplane Rating(s):	Single-engine land	Seat Occupied:	Left
Other Aircraft Rating(s):	Helicopter	Restraint Used:	3-point
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	BasicMed	Last FAA Medical Exam:	April 3, 2017
Occupational Pilot:	No	Last Flight Review or Equivalent:	September 21, 2017
Flight Time:	7700 hours (Total, all aircraft), 200 hours (Total, this make and model), 7500 hours (Pilot In Command, all aircraft), 15 hours (Last 90 days, all aircraft), 5 hours (Last 30 days, all aircraft)		

FAA records indicated that the pilot held a commercial pilot certificate with airplane single-engine land, rotorcraft-helicopter, and instrument airplane ratings. He also held a repairman experimental aircraft builder certificate valid for the accident airplane. According to information provided by the pilot, he had approximately 7,700 total hours of flight experience, including about 200 hours in the accident airplane make and model. His most recent flight review was completed in September 2017, and his most recent medical certificate was issued under the Basic Med program in April 2017.

Aircraft and Owner/Operator Information

Aircraft Make:	Zenair	Registration:	N328SK
Model/Series:	ZENITH STOL CH750 No Series	Aircraft Category:	Airplane
Year of Manufacture:	2014	Amateur Built:	Yes
Airworthiness Certificate:	Experimental (Special)	Serial Number:	75-8975
Landing Gear Type:	Tricycle	Seats:	2
Date/Type of Last Inspection:	April 1, 2017 100 hour	Certified Max Gross Wt.:	
Time Since Last Inspection:		Engines:	1 Reciprocating
Airframe Total Time:	200 Hrs as of last inspection	Engine Manufacturer:	ULPower
ELT:	Installed, not activated	Engine Model/Series:	350iS
Registered Owner:		Rated Power:	130 Horsepower
Operator:	On file	Operating Certificate(s) Held:	None

General

FAA records indicated that the airplane was built by the pilot, and received its initial airworthiness approval in 2014. The airplane was equipped with a Belgian ULPower brand 350iS series piston engine that was rated at 130 horsepower.

Engine Fuel

The ULPower Operating Manual (OM) for the engine stated that "regular unleaded automotive fuel...should be used to operate" the engine. The OM specified minimum octane rating values of 98 RON, 90 MON, or 94 AKI. "RON" and "MON" are two different methods and indices for determining the octane value. "AKI" stands for anti-knock index, and is the arithmetic mean of RON and MON. In the United States, the octane ratings posted by automotive fuel vendors are AKI values. Predominant US AKI values range from 87 to 93. A ULPower representative stated that the 93 AKI fuel in the US is acceptable for use in the engine. Finally, the OM also stated that "AVGAS 100 LL and/ or AVGAS UL91 may be used if regular fuel is not available." The pilot did not specifically report the fuel(s), or the octane rating(s) of those fuel(s), that he used in the engine.

Logbook Information

The pilot-provided maintenance records were neither current nor in compliance with applicable FAA regulations. The records lacked the FAA-required documentation that certified the completion of the FAA-required Phase 1 flight test period. The airframe log only contained a single entry, dated 2014, which appeared to be the original post-build airworthiness signoff for the airplane. Although the pilot reported that he had an engine logbook, he did not provide one to the investigation. The records that were provided by the pilot did not include any entries that documented any maintenance activities.

Maintenance Information

According to pilot-provided information, the most recent "100 hour" inspection was completed on April 1, 2017, and that at that time both the airplane and engine total time in service was 200.5 hours. The pilot reported to an FAA inspector that he had previously had "low compression problems" with the engine, and that he had sent the engine back to the manufacturer for replacement of several components, including all four cylinder heads, one cylinder, and all piston rings. The pilot did not provide any documentation or other substantiation of that assertion. The incomplete maintenance records precluded evaluation of the maintenance history of the engine.

Engine Oil Changes

Regular oil changes that include examination of the oil filter and oil sample analyses are common practices that are proven to provide early detection of unusual engine wear or deterioration. The pilot-provided records did not include any entries that documented any oil changes, oil filter examinations, or oil sample analyses.

Pilot's Accident Accounts

In his initial communications with the NTSB about the accident, the pilot reported that he believed that the high pitch attitude during the demonstration flight had caused the oil to be vented overboard via the

oil breather assembly. In his subsequent written accident report to the NTSB, the pilot reported that "something broke in the engine and dumped oil into the muffler from the no.1 exhaust."

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	APC,36 ft msl	Distance from Accident Site:	1 Nautical Miles
Observation Time:	10:54 Local	Direction from Accident Site:	90°
Lowest Cloud Condition:	Clear	Visibility	10 miles
Lowest Ceiling:	None	Visibility (RVR):	
Wind Speed/Gusts:	11 knots /	Turbulence Type Forecast/Actual:	/
Wind Direction:	220°	Turbulence Severity Forecast/Actual:	/
Altimeter Setting:	29.97 inches Hg	Temperature/Dew Point:	23°C / 14°C
Precipitation and Obscuration:	N/A - Freezing -		
Departure Point:	Napa, CA (APC)	Type of Flight Plan Filed:	None
Destination:	Napa, CA (APC)	Type of Clearance:	VFR
Departure Time:	10:30 Local	Type of Airspace:	Class D

The 1054 APC automated weather observation included winds from 220° at 11 knots, visibility 10 miles, clear skies, temperature 23°C, dew point 14°C, and an altimeter setting of 29.98 inches of mercury.

Airport Information

Airport:	Napa County APC	Runway Surface Type:	Dirt;Grass/turf;Gravel
Airport Elevation:	36 ft msl	Runway Surface Condition:	Dry;Rough
Runway Used:		IFR Approach:	None
Runway Length/Width:		VFR Approach/Landing:	Forced landing

Wreckage and Impact Information

Crew Injuries:	1 None	Aircraft Damage:	Substantial
Passenger Injuries:	1 None	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	2 None	Latitude, Longitude:	38.2,-122.291664(est)

Examination of the airplane by an FAA inspector revealed that the wings and fuselage had sustained crush or buckling damage from the impact. The engine exhibited some impact-related damage, but it did not exhibit any visual evidence of any external non-impact related damage. The engine was found to be devoid of lubricating oil. Significant oil residue was observed on the muffler, and all along the lower fuselage. The source of the oil appeared to be in the region of the starter ring gear and its drive penetration of the engine case. The muffler was situated below the ring gear drive case penetration.

The hour meter registered a total time of 200.8 hours.

The engine was removed and shipped to the manufacturer's service facility in the US, where it was disassembled and examined in detail. All four pistons displayed evidence of significant erosion damage, consistent with detonation. At least one piston was eroded to the point that it could no longer seal against the cylinder wall. The engine manufacturer's representative attributed this level of damage to the use of 87 octane (AKI) fuel.

This piston damage would allow cylinder combustion gasses to enter and pressurize the engine crankcase, which in turn could force oil past any flexible seals and out of the crankcase. Specifically, pressurization of the crankcase could also force oil past the starter ring gear seal, out of the engine.

The engine control unit (ECU) was removed and shipped to the engine manufacturer's facility in Belgium. The ECU internal programming was validated, and then the ECU was installed on a testbed engine. That engine operated normally with the accident ECU installed.

Separately, and contrary to the pilot's unsubstantiated assertions that he had previously sent the engine back to the manufacturer for "low compression" problems, the manufacturer's records indicated no such event. Despite the fact that the engine was no longer under warranty, the engine manufacturer did provide the pilot with some replacement components at no charge. In addition, the sole US-based engine manufacturer's service center indicated that there were no records of that service center conducting any repair actions on that engine.

Additional Information

Detonation

Chapter 7 of the FAA publication Pilot's Handbook of Aeronautical Knowledge (PHAK) presented the following information regarding detonation:

Detonation is an uncontrolled, explosive ignition of the fuel-air mixture within the cylinder's combustion chamber. It causes excessive temperatures and pressures which, if not corrected, can quickly lead to failure of the piston, cylinder, or valves. In less severe cases, detonation causes engine overheating, roughness, or loss of power.

Detonation is characterized by high cylinder head temperatures and is most likely to occur when operating at high power settings. Common operational causes of detonation are:

- Use of a lower fuel grade than that specified by the aircraft manufacturer
- Operation of the engine with extremely high manifold pressures in conjunction with low rpm

- Operation of the engine at high power settings with an excessively lean mixture
- Maintaining extended ground operations or steep climbs in which cylinder cooling is reduced

Detonation may be avoided by following these basic guidelines during the various phases of ground and flight operations:

- Ensure that the proper grade of fuel is used.
- Use an enriched fuel mixture, as well as a shallow climb angle, to increase cylinder cooling during takeoff and initial climb.
- Avoid extended, high power, steep climbs.
- Develop the habit of monitoring the engine instruments to verify proper operation according to procedures established by the manufacturer.

Administrative Information

Investigator In Charge (IIC):	Huhn, Michael
Additional Participating Persons:	Craig Miller; FAA; Sacramento, CA
Original Publish Date:	June 3, 2020
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.nts.gov/Docket?ProjectID=98073

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report. A factual report that may be admissible under 49 U.S.C. § 1154(b) is available [here](#).