National Transportation Safety Board
Aviation Accident Final Report

Location:	Texarkana, Arkansas	**Accident Number:**	CEN16LA197
Date & Time:	May 23, 2016, 21:56 Local	**Registration:**	N804ST
Aircraft:	Cessna 501	**Aircraft Damage:**	Substantial
Defining Event:	Pressure/environ sys malf/fail	**Injuries:**	3 Minor, 1 None
Flight Conducted Under:	Part 91: General aviation - Executive/Corporate		

Analysis

The small jet airplane, which was being operated by a single pilot, experienced a loss of cabin pressurization during cruise flight about 43,000 ft. The pilot and passengers lost consciousness and the airplane entered an uncontrolled descent. The pilot regained consciousness and control of the airplane at 7,000 ft and landed the airplane at an alternate destination without further incident. The airplane sustained substantial damage to both wings due to the excessive aerodynamic loads incurred during the descent/recovery. Given the airplane's cruise altitude, the pilot was required by Federal Aviation Regulations to wear a supplemental oxygen mask; however, he was not doing so at the time of the loss of pressurization.

Postaccident examination of the airplane revealed that the aft pressure bulkhead check valve flapper was fractured. Additionally, the air conditioning system's primary pressurization duct leading to the cabin was separated from its connection with the water separator due to a loose retaining clamp on the duct's metal worm-gear. Material analysis of the fractured flapper valve indicated the presence of progressive cracking and a loss of mechanical properties due to physical aging; exposure to atmospheric pollutants and oxygen can degrade the flapper material.

The airplane lost pressurization when the air conditioning system's primary pressurization duct separated and the pressurized air was discharged into the unpressurized section of the airplane. The subsequent failure of the flapper valve then allowed the pressurized air to escape the cabin.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's failure to use supplemental oxygen as required during high-altitude flight, which

resulted in his loss of consciousness following a loss of cabin pressurization. Contributing to the accident was the separation of the air conditioning system's primary pressurization duct and the subsequent failure of the aft pressure bulkhead check valve flapper due to progressive weakening from age.

Findings

Personnel issues	Incorrect action selection - Pilot
Aircraft	Air distribution system - Failure
Aircraft	Crew oxygen system - Not used/operated
Personnel issues	Other loss of consciousness - Pilot
Aircraft	Dynamic load - Capability exceeded
Aircraft	Altitude - Not specified

Factual Information

History of Flight

Prior to flight	Aircraft inspection event
Enroute	Pressure/environ sys malf/fail (Defining event)
Enroute	Loss of control in flight
Uncontrolled descent	Attempted remediation/recovery

On May 23, 2016, about 2156 central daylight time, a Cessna 501, N804ST, lost cabin pressurization during cruise at flight level (FL) 430 and entered an uncontrolled descent near Texarkana, Arkansas. The pilot regained consciousness and control of the airplane. The pilot landed the airplane without further incident at Texarkana Regional Airport-Webb Field (TXK), Texarkana, Arkansas. The airplane sustained substantial damage to both wings due to the excessive aerodynamic loads on the wings during the descent/recovery. The airline transport pilot and two passengers sustained minor injuries and one passenger was uninjured. The airplane was registered to and operated by Eagle II Aero LLC under 14 Code of Federal Regulations Part 91 as an executive/corporate flight that was operating on an instrument flight rules (IFR) flight plan. Night meteorological conditions prevailed at the time of the accident. The flight last departed from Perryville Municipal Airport, Perryville, Missouri (K02), about 2056, and was destined to San Antonio International Airport (SAT), San Antonio, Texas.

The airplane was flown by a single-pilot for the accident flight. According to air traffic control (ATC) radio communications, N804ST made initial contact with Memphis Center at 2056, after departing K02, to report climbing through 9,200 feet with an IFR flight plan on file. N804ST responded to all ATC transmissions while climbing to and leveling off at flight level 430, which was an altitude that was above reported cloud tops at FL 390. At 2154, Fort Worth Center called N804ST, but there was no response from N804ST. At 2155, Fort Worth Center attempted to contact N804ST three times and issued the Fort Smith altimeter. Fort Worth Center contacted Memphis Center and advised that N804ST had an "issue" and was descending. At 2156, Memphis Center instructed American Airlines flight 93 (AAL93) to attempt to contact N804ST on guard frequency. Fort Worth Center asked N804ST to IDENT; N804ST reported an explosive decompression. Fort Worth Center advised Memphis Center that they were now communicating with N804ST. At 2157, AAL93 advised Memphis Center that they were unable to contact N804ST on guard frequency. N804ST reported that the airplane was under control and would level off shortly. Fort Worth Center asked whether N804ST would like to fly to TKX or Fort Smith Regional Airport (FSM), Fort Smith, Arkansas. At 2148, the pilot of N804ST asked for a few minutes to "figure this out" and then advised he would like to land at TKX. Memphis Center advised that N804ST was located 12 o'clock and 35 miles from TKX. The pilot performed a visual approach and landing to runway 13 (5,200 by 100 feet, asphalt) at TXK, where the flight landed without further incident.

The pilot reported in a written statement that within 20 seconds, the airplane lost all cabin pressurization, and the cabin altitude climbed from 8,000 feet and 8.5 psi differential (psid) to ambient altitude and 0 psid. All the occupants lost consciousness. The pilot regained consciousness and control of the airplane at 7,000 feet.

According to the Federal Aviation Administration (FAA) coordinator for the accident, the pilot stated that he was not wearing an airplane supplemental oxygen system crew mask during the flight.

Pilot Information

Certificate:	Airline transport; Commercial	**Age:**	58,Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Glider; Helicopter	**Restraint Used:**	Lap only
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine; Glider	**Toxicology Performed:**	No
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	August 22, 2015
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	May 11, 2016
Flight Time:	15000 hours (Total, all aircraft), 5000 hours (Total, this make and model), 14800 hours (Pilot In Command, all aircraft), 50 hours (Last 90 days, all aircraft), 20 hours (Last 30 days, all aircraft), 2 hours (Last 24 hours, all aircraft)		

The pilot held an airline transport pilot certificate with the following type ratings: CE-500, CE-525, CE-650, MJ-300, BE-400, G-1159, DC-3, N-P51N, N-T28, T-33. On November 15, 2014, the pilot completed single-pilot exemption training including differences training for CE-500, CE-550, and CE-560 training. The pilot's last flight review was dated May 11, 2016, using a Beechcraft BE400. The pilot reported a total flight time of 15,000 hours, of which 5,000 hours were in the make and mode of the accident airplane.

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N804ST
Model/Series:	501	**Aircraft Category:**	Airplane
Year of Manufacture:	1980	**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	501-0146
Landing Gear Type:	Retractable - Tricycle	**Seats:**	8
Date/Type of Last Inspection:	April 15, 2016 Continuous airworthiness	**Certified Max Gross Wt.:**	12500 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:	7424.8 Hrs as of last inspection	**Engine Manufacturer:**	Williams International Company
ELT:	Installed	**Engine Model/Series:**	FJ44-2A
Registered Owner:		**Rated Power:**	2300 Lbs thrust
Operator:		**Operating Certificate(s) Held:**	None

The airplane's type certificate, held by Textron Aviation Inc., shows that the Cessna 501 was certified under Part 23 with two Pratt & Whitney Aircraft of Canada, Ltd. JT15D-1A or JT15D-1B turbofan engines and had a maximum operating altitude of 41,000 feet.

The accident airplane was modified from its type design by supplemental type certificates (STCs), held by Sierra Industries Ltd., which increased the maximum operating altitude to 43,000 feet. The two STCs were:

SA732NW was for the installation of the Eagle SP performance system, including recontoured wing leading edge, wing tip extension, increased gross weight, increased fuel capacity, and other minor refinements.

ST09559AC was for the installation of Williams International Company. L.L.C. FJ44-2A engines in Cessna 501/500 aircraft or Williams International Company, L.L.C. FJ44-3A engines in Cessna Model 550/S550 aircraft. This STC increased the maximum operating altitude to 43,000 feet.

The Model 500 Maintenance Manual (Rev 39), Floor Panels – Inspection/Check called for the inspection of the air conditioning system in section D. Inspect Air Conditioning System: (1) Inspect all duct work and tubing for security of installation, evidence of damage or leakage, and (3) Inspect flapper check valves at air mixer assembly for ease of operation or evidence of binding.

The most recent maintenance inspection of the airplane was a Phase 5 inspection. A copy of the maintenance checklist used for the inspection, Model 500 Maintenance Manual (Rev 37) had the following entries: "Date:" - no entry made, "Registration Number: N804ST", "Serial Number: 501-0146", and "Total Time: 7424.8".

A Sierra Industries Ltd. Maintenance Transaction Report, dated April 15, 2016, stated, "Completed

phase inspections in accordance with Cessna 500 maintenance manual chapter 5," at 7,424.8 aircraft hours, 6,411 landings, and no. 1 engine and no. 2 engine total hours were 846.8 hours and 539 cycles.

The Hobbs meter following the accident indicated 0411.3 hours.

The airplane oxygen system supplies breathing oxygen to the crew at all times and to the passengers when required. The pilot can manually drop the passenger masks by selecting manual drop on the oxygen control valve, or the passenger masks will automatically drop at 14,800 ±200 feet cabin altitude. The pilot can select crew only which will shutoff flow to the passengers.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night/dark
Observation Facility, Elevation:	TXK	**Distance from Accident Site:**	
Observation Time:	21:53 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Scattered / 9500 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	4 knots /	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:	120°	**Turbulence Severity Forecast/Actual:**	/ N/A
Altimeter Setting:	29.94 inches Hg	**Temperature/Dew Point:**	23°C / 18°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Perryville, MO (K02)	**Type of Flight Plan Filed:**	IFR
Destination:	San Antonio, TX (SAT)	**Type of Clearance:**	IFR
Departure Time:	20:56 Local	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	1 Minor	**Aircraft Damage:**	Substantial
Passenger Injuries:	2 Minor, 1 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 Minor, 1 None	**Latitude, Longitude:**	33.441665,-94.03778(est)

Post-accident examination of the airplane by the FAA coordinator revealed that the cockpit supplemental oxygen supply gauge indicated about 17 "psi x100," which was in the gauge's green arc of 16-18 psi x100.

The cockpit supplemental oxygen system switch was in the "Normal" position (which would have provided oxygen to the cabin masks). The cabin oxygen masks were not deployed. The pilot stated to

the FAA coordinator that the switch was in the "Crew" position, and he did not know how or why it was in the "Normal" position. The pilot later told the FAA coordinator that he changed the oxygen switch position after the accident.

The examination revealed that the aft pressure bulkhead check valve flapper had half of its non-metallic flapper fractured into several pieces, which were resting on the fuselage floor. The second half of the check valve flapper was intact in valve body. The air conditioning system's primary pressurization duct leading to the cabin was separated from its connection with the water separator. The duct's metal worm-gear retaining clamp was resting around the duct and away from its attachment point to the separator. The clamp's retaining screw was in place. The clamp was not fractured. The clamp, the check valve, and the flapper pieces were sent to the National Transportation Safety Board Material Laboratory for examination.

Additional Information

Part 91 Regulations on the Use of Supplemental Oxygen

Part 91.211 Supplemental oxygen.

(a)General. No person may operate a civil aircraft of U.S. registry –

(b) Pressurized cabin aircraft.

(1) No person may operate a civil aircraft of U.S. registry with a pressurized cabin -

(i) At flight altitudes above FL 250 unless at least a 10-minute supply of supplemental oxygen, in addition to any oxygen required to satisfy paragraph (a) of this section, is available for each occupant of the aircraft for use in the event that a descent is necessitated by loss of cabin pressurization; and

(ii) At flight altitudes above FL 350 unless one pilot at the controls of the airplane is wearing and using an oxygen mask that is secured and sealed and that either supplies oxygen at all times or automatically supplies oxygen whenever the cabin pressure altitude of the airplane exceeds 14,000 feet mean sea level, except that the one pilot need not wear and use an oxygen mask while at or below FL 410 if there are two pilots at the controls and each pilot has a quick-donning type of oxygen mask that can be placed on the face with one hand from the ready position within 5 seconds, supplying oxygen and properly secured and sealed.

Tests and Research

Materials Laboratory Examination of Check Valve and Hose Clamp

The examination labeled the check valve flapper half pieces recovered from the fuselage floor as flapper 1, and the flapper that was intact in the valve body as flapper 2. Both flappers were fabricated from glass-filled polybutylene terephthalate (PBT). Based on the presence of an injection gate and ejection pin marks, the flappers were fabricated by injection molding. Based on unique artifacts molded into the surfaces of the flappers, both flappers were molded from the same mold cavity. Both flappers had the following number molded onto the downstream side surface, DSP 904-0012-3, and did not exhibit any other identifying marks such as a date code or mold cavity number.

Flapper 1 exhibited radially-oriented cracks originating within its approximate center; two of the primary cracks were nearly bilaterally symmetric in shape consistent with possible flow patterns and knitting in the part from the mold filling process. In all instances, the cracks initiated on the downstream side and propagated through the thickness towards the upstream side—driven primarily by bending stresses on the flapper.

One fragment from flapper 1 was selected for deeper examination, which showed the presence of networks of fine cracks (also known as surface checks, surface crazing, or craze cracks). A fine network of cracks was present adjacent to the main fracture surface. The primary fracture surface of the polymeric resin phase was smooth and glassy with hackle marks indicative of though-thickness crack propagation from the downstream side to the upstream side. The fracture surface exhibited yellow discoloration in areas along its length indicating that portions were pre-existing. Scanning electron microscope examination also revealed a fine network of secondary cracks along the second primary fracture.

The hinge fragments for flapper 1 exhibited cracks that progressed radially outward from the inside surface to the outside surface. The fracture surfaces on two of the hinge cracks exhibited yellow discoloring, consistent with progressive crack development with time (slow crack growth).

Flapper 2 exhibited a primary crack on the downstream side. A portion of one of the flapper hinges was also missing. Stereo-zoom microscopic evaluation indicated that a portion of one of the hinges fractured due to the development of a crack that initiated at the inner surface and propagated to the external surface. One of the fractures exhibited yellow discoloring, consistent with progressive crack development with time (slow crack growth).

The inside surface length of the hose clamp is about 11.1 inch and corresponds to an approximately 3.5 inch diameter. The hose clamp design is consistent with a worm gear style with a safety collared screw and perforated band manufactured by C. McGunnigle Co. Inc. Kenilworth, NJ, under the Breeze Aero Seal ® trademark. The clamp is consistent with an SAE J1508 Type F size 48 (2 9/16 to 3 1/2 diameter size range).

Administrative Information

Investigator In Charge (IIC):	Gallo, Mitchell
Additional Participating Persons:	Danny Brickey; Federal Aviation Administration; LIttle Rock FSDO; Little Rock, AR
Original Publish Date:	July 5, 2018
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=93256