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HISTORY OF FLIGHT

On January 20, 1999, at 1527 mountain standard time (mst)*, a Cessna P210N, N79NL, was destroyed when it broke up in flight and collided with terrain in the Sandia Mountain Wilderness Area, near Albuquerque, New Mexico. The instrument rated private pilot and two passengers were fatally injured. Visual meteorological conditions prevailed at the accident site, but the pilot reported being in instrument meteorological conditions. An IFR flight plan had been filed for the personal flight being conducted under Title 14 CFR Part 91. The flight originated in Scottsdale, Arizona (SDL), at 1243 Pacific standard time (Pst), and was en route to Wichita, Kansas (ICT).

According to a spokesman for Advanced Industries, Inc., to which the airplane was registered, the pilot and his passengers had flown to Scottsdale on January 15, 1999, to participate in a golf tournament. They were returning to Wichita when the accident happened.

According to the Federal Aviation Administration, the pilot telephoned the Wichita, Kansas, Automated Flight Service Station (AFSS) at 0606 Pst, and began filing an IFR flight plan. The cellular telephone connection was lost but reestablished a minute later, and the pilot finished filing his flight plan. He then asked for an "outlook" weather briefing. The pilot was told there was an area of high pressure along his route, and that a weak trough would be moving across Kansas, Oklahoma, and Texas. Across the northern half of Arizona, the forecast was for scattered clouds at 15,000 feet; across New Mexico, scattered to broken clouds at 12,000 to 14,000 feet, with a chance of an isolated snow shower across the mountains; across Kansas, scattered clouds around 15,000 feet, becoming broken to scattered cirrus by the afternoon. Winds aloft at FL (flight level) 230 over Arizona were forecast to be from 300 degrees at 70 to 75 knots; over Albuquerque, 300 degrees at 60 knots; over western Kansas, 250 degrees at 30 knots; at Wichita, 250 degrees at 40 knots. The briefing was terminated at 0611 Pst.

At 0729 Pst, the airplane was serviced with 38 gallons of 100LL fuel. According to Corporate Jets' fuel invoice, both wing tanks were filled to capacity, and 15 gallons were put in the baggage compartment fuel tank. At 1235, the pilot was issued his IFR clearance. At 1237, he was cleared to taxi to runway 21. He was cleared for takeoff at 1243, and told to contact Phoenix Departure Control. Communications with Phoenix TRACON (terminal radar control) were routine, and the pilot was subsequently instructed to fly a 090 heading and intercept J (jet route) 18.

The flight proceeded without incident until 1519:10, when the Albuquerque controller told the pilot, "Verify you're level at [flight level] two three zero, [I'm] showing you four hundred feet low." The pilot replied, "We've just figured out we've had a dual vacuum pump failure. We've lost both our vacuum pumps, so we're gonna need to look for someplace. We've got electric back up systems here, but we're having a little trouble holding altitude and everything." The pilot then asked, "What's the bottom of the cloud layer? We're IFR at this time." When told cloud bases in the area were "around 13,000 [feet agl]," the pilot advised he wanted to descend and "get below the bases." He was cleared to descend and maintain 14,000 feet.

At 1521:47, the controller asked the pilot if he wanted to "continue on to Wichita or [if he wanted to] land early [at Albuquerque]." The pilot answered, "If we can get down below the cloud layer, we'd like to get to Liberal, Kansas, if we could." (It was later learned that the airplane was scheduled to undergo an annual inspection the next day at a maintenance facility in Liberal, Kansas.) The controller acknowledged and instructed the pilot to contact a different air route traffic control center (ARTCC)

sector. Before the pilot could do so, at 1524:35, he reported, "We're having trouble. I think we're in a spin." Fifteen seconds later the pilot reported, "We're back with you," and said he was at 18,000 feet. He was then instructed to contact Albuquerque Approach Control.

When the pilot contacted Albuquerque Approach Control at 1526:06, he verified that he was at 17,600 feet, and added, "We've lost both our vacuum pumps, and I think we just went through a roll. We've got electric driven backup systems -- electric horizon and electric compass -- and they're not agreeing with each other at this time. We're gonna need some help." The controller asked the pilot if he was "stable there at one seven thousand four hundred," to which the pilot replied, "Negative. . .we're not necessarily stable." At 1526:48 the pilot said, "Nine November Lima, we're going to need some help!" At 1527:07 the pilot said, "We're at one four thousand four hundred [feet]." At 1527:20 the pilot radioed, "Nine November Lima, we're going down. We're dead."

Eleven witnesses, six of whom submitted written statements, reported seeing a wing separate from the airplane, then observed the airplane spiral vertically to the ground. Three witnesses were at the bottom of the Sandia Peak Aerial Tramway (see WITNESS LOCATION MAP). Their attention was drawn to the sound of an airplane engine "racing, as if it was pulling out of a stall or dive." The airplane "was already in a pure vertical spin" when one of the three witnesses saw it emerge from the cloud base. "There was no spiral component to its attitude." After the airplane made a couple of revolutions, he saw a "puff" at one of the wing roots, followed by the wing separation. The airplane continued to spin "in the pure vertical. . .traveling approximately 300 knots straight down." He added that the engine sounded like it was at full throttle.

Another of the three witnesses said the airplane "broke over the top of a loop" when he first saw it. "As I watched it go over it started straight down and it was somewhere at this time I saw something come off the plane." The airplane continued "straight down." The engine "sounded like it was running."

Two witnesses were at a home located at 1063 Red Oaks (see WITNESS LOCATION MAP) when they heard and saw the airplane. One witness said the engine sounded "stressed out." The other witness said the plane "spiraled clockwise, at a tremendous speed, vertically into the ground. . .The left wing was missing. . ."

Another witness was working on the roof of house at 1179 Laurel Pl., S.E. (see WITNESS LOCATION MAP) when he heard what sounded like "a plane diving at full power." The sound subsided momentarily, then returned. The witness looked up and saw the airplane in a vertical dive. The plane rotated and he could see only one wing.

The accident took place during the hours of daylight at a location of 35 degrees, 10.255 minutes north latitude, and 106 degrees, 26.422 minutes west longitude, or about 20 DME miles out on the 055 degree radial from the Albuquerque VORTAC (Very high frequency omnidirectional radio range tactical air navigation).

PERSONNEL (CREW) INFORMATION

The pilot, age 42, held a private pilot certificate, dated July 13, 1994, with airplane single-engine land and instrument ratings. He also held a repairman certificate, dated July 13, 1994, and a third class airman medical certificate, dated May 27, 1998, with the restriction that the holder shall wear corrective lenses.

Two pilot logbooks were recovered at the accident site. The first logbook contained entries from May 3,

1980, to January 21, 1998. The second logbook contained entries from January 21, 1998, to December 23, 1998. The pilot had logged 1,345.4 total hours, of which 491.3 hours were in the Cessna P210N. An additional 98.9 hours were accrued in the Cessna T210, and 5.9 hours were logged in a Cessna 210 simulator at Flight Safety International in Wichita, Kansas (a summary of the pilot's flight time is attached as an exhibit to this report).

According to Flight Safety International (FSI) training records, the pilot attended Cessna 210 Pilot Proficiency Training Courses in May 1993, January 1996, and December 1998. In each case, he satisfied the requirements of FAR 61.56 (flight review) and FAR 61.57 (instrument competency check). Each course consisted of 8 to 16 hours of classroom instruction, written tests, and training sessions in the flight simulator and the Cessna P210N airplane. The FSI instructor said that during one of the training sessions, he failed the Cessna 210 simulator's vacuum system to test the pilot's "partial panel" skills. He said that the pilot recognized the failure and resorted to partial panel without difficulty. The FSI simulator differs from N79NL in that the directional gyro (heading indicator) is electrically driven as opposed to being vacuum driven. Thus, when the vacuum system was failed in the simulator, only the artificial horizon (attitude indicator) was disabled.

AIRCRAFT INFORMATION

N79NL (s.n. P21000260), formerly N4690K, was manufactured by the Cessna Aircraft Corporation in 1979. It was equipped with a Continental TSIO-520-P engine (s.n. 278702-R), rated at 310 horsepower, and a McCauley D3A34C402C propeller (s.n. 971982).

The last annual inspection was performed on January 8, 1998, when the airframe had accrued 2,705.5 total hours (tachometer 1,305.5 hours). The rebuilt engine, which had been installed on December 9, 1994, had accrued 570.6 hours. At the time of the annual inspection, a new McCauley propeller was installed. The recording tachometer was not found in the wreckage but, based on the pilot's logbook, the airplane flew another 151.7 hours from the time of the annual inspection until December 23, 1998, the date of the last logbook entry. It is estimated that at or near the accident date, the airframe, engine, and propeller had accrued 2,857.2, 722.3, and 151.7 total hours, respectively. Both altimeters, the static system, altitude reporting system, and transponder were recertified for IFR operations on December 12, 1997.

The airplane maintenance records were reviewed, concentrating on those items pertaining to the vacuum pumps, vacuum gauge, filters, associated plumbing, and instruments used for flight in instrument meteorological conditions, to wit:

08/29/87 Installed Cessna Kit SK210-103B, dual vacuum pump kit. TACH 60.8, ATT 1,452.2.

03/24/94 Replaced vacuum pump p/n 212CW, s/n 08AH003048, and filter. TACH 580.9.

08/03/94 Replaced left side vacuum pump with p/n 212CW, s/n 03AK001308 unit, replaced vacuum filter. HOUR METER 668.0

08/28/96 Replaced central vacuum filter p/n C294502-0201. Found vacuum pump inop. Removed old pump p/n 212CW, s/n 08AH003048, and installed new pump p/n 212CW, s/n 3AM000830. Ops check OK. RECORDER 1,097.6.

10/02/96 Repaired electric turn coordinator C661003-0506, s/n 803-446.

11/01/96 Installed standby electric gyro horizon. TACH 1,108.

01/08/98 Vacuum gauge not working. Sent out for repair. L/R source button full of carbon. Overhauled by Kelley Instruments. Reinstalled. RECORDER 1,305.5, ATT 2,505.5.

06/19/98 Installed new Sigma-Tek vacuum pump m/n 1U128B, s/n T31443H, new filter C294502-0201, and two new B3-5-1 regulator filter bands. TACH 1,426.2.

METEOROLOGICAL INFORMATION

The following are the weather conditions that were observed at Albuquerque International Airport two minutes before and three minutes after the accident:

1525 MST: Wind 220 degrees at 14 knots; visibility 10 statute miles; ceiling broken 6,500 feet; temperature 14 degrees C. (57.2 degrees F.); dew point 0 degrees C. (32 degrees F.); altimeter 29.85 inches of mercury.

1530 MST: Wind 230 degrees at 10 knots; visibility 10 statute miles; ceiling broken 6,000 feet; temperature 14 degrees C. (57.2 degrees F.); dew point 0 degrees C. (32 degrees F.); altimeter 29.86 inches of mercury.

At the time of the accident, SIGMET (Significant Meteorological Advisory) Whiskey 6, AIRMETs (Airmen's Meteorological Information) Sierra Update 4 and Zulu Update 4, and a PIREP (Pilot Report) were in effect (see exhibits). SIGMET Whiskey 6, which included New Mexico and was valid at the time of the accident, called for "moderate occasional severe turbulence below FL 180 due to strong low level and mid level winds over mountainous terrain." It is not known whether the pilot was aware of this SIGMET. AIRMET Sierra Update 4, which included Arizona and New Mexico and was valid at the time of the accident, called for "mountains occasionally obscured in clouds, precipitation, mist." It is not known whether the pilot was aware of this AIRMET. AIRMET Zulu Update 4, which included New Mexico and was valid at the time of the accident, called for "occasional moderate mixed icing in clouds and precipitation between freezing level at FL 2000. Freezing level 8,000 to 12,000 feet." It is not known whether the pilot was aware of this AIRMET. The PIREP was filed at 1519 by a Cessna 172 pilot flying at 12,500 feet and 56 miles southwest of the Albuquerque VORTAC. He reported an 8,000 foot broken cloud layer, a west-southwesterly wind at 30 knots, light turbulence, and scattered rain showers.

WRECKAGE AND IMPACT INFORMATION

Access to the accident site was gained on January 21, 1999. Light snow had fallen during the previous 24 hours. The wreckage was spread out in a fan-shaped pattern on a heading of 155 degrees. The propeller blades were buried in the ground underneath the engine. Next to the engine was the instrument panel. Nearby lay the wing carry-through spar with the left portion lying to the left of the flight path. Just beyond were portions of the left wing. The fuselage, horizontal stabilizer, elevator, and vertical stabilizer lay nearby. Parts of the left wing containing the stall warning vane were identified. The engine was turned over and the Parker Hannifin vacuum pump was removed from its left mounting pad which remained attached to the engine case. The second vacuum pump, a Sigma-Tek, was broken off the right mounting pad and was buried underneath the instrument panel.

The right wing could not be accounted for and it was determined that it had separated from the airplane

during the breakup sequence. It was later found by hikers and recovered by the salvage company on April 15, 1999.

MEDICAL AND PATHOLOGICAL INFORMATION

An autopsy was performed on the pilot by the New Mexico State Medical Examiner's Office. A toxicological screen was not possible due to the paucity of remains and identification difficulties.

TESTS AND RESEARCH

Radio transcripts were collated with the airplane's flight path and encoded altitude as derived from NTAP (National Track Analysis Program) data and studied. The data showed N79NL departing runway 21 at Scottsdale, making a right turn to a 090 heading, then joining J 18 (the filed flight plan route was Scottsdale direct Wichita).

Shortly after 1500, the airplane began to make slight heading and altitude deviations (from FL 230). It was at 1519:10 when the airplane was just north of the Albuquerque VORTAC that the controller asked the pilot to verify his altitude. The pilot replied he had lost both vacuum pumps. At that time, N79NL's altitude varied between FL 228 and FL 229 feet. At 1520:38, the pilot was cleared to descend to 14,000 feet. He acknowledged the clearance. Yet at 1522:32, while just north of Albuquerque International Airport, the airplane was still at FL 220. At 1523:27, it was at FL 214. At 1524:28, it was at FL 193, a loss of 2,100 feet.

Seven seconds later and 1,300 feet lower (a calculated descent rate of 11,143 feet per minute, or 110 knots vertical velocity), when the airplane was at FL 180, the pilot said: "I think we're in a spin." At 1524:50, at an altitude of 17,100 feet msl (above mean sea level), the pilot said: "We're back with you."

At 1526:06, the controller asked the pilot to verify that he was at 17,600 feet and the pilot replied, "That's affirmative (NTAP data also showed an encoded altitude of 17,600 feet). . . we've lost both our vacuum pumps, and I think we just went through a roll. We've got electric driven backup systems -- electric horizon and electric compass -- and they're not agreeing with each other at this time. We're gonna need some help."

At 1527:14, the airplane was at 13,800 feet; at 1527:28, it was at 8,600 feet. It had lost 5,200 feet (a calculated descent rate of 22,285.7 feet per minute, or 220 knots vertical velocity). According to the 1979 Cessna P210N Information Manual, Vne (Never Exceed Speed) is 200 knots indicated airspeed (KIAS). Vne is 90 percent of Vd (Design Dive Speed). Vd, therefore, would be 222 KIAS. At 1527:20, the pilot said: "We're going down. We're dead."

On February 2 and 3, 1999, the Sigma-Tek vacuum pump and attitude gyro, turn coordinator, and horizontal situation indicator were disassembled and examined at the facilities of Sigma-Tek, Inc., in Augusta, Kansas. The vacuum pump (m/n 1U128B, s/n T31443H) was manufactured on June 16, 1998, and installed on the right mounting pad of N79NL on June 19, 1998, by Yingling Aircraft, Wichita, Kansas (61.6 hours estimated time in service before accident, see INSTALLATION AND SERVICE HISTORY, VACUUM PUMPS INSTALLED IN N79NL, attached). Internal examination disclosed all six composite vanes were intact and measured .740 inches with some tapering. New vanes measure .765 inches. According to Sigma-Tek, "the vane wear was somewhat higher than expected." The rotor was free to rotate. Radial striations were noted on the rear surface of the rotor. The pencil drive was sheared near the point where it attaches to the anodized rotor. Short rotational scratches were visible on the

fracture surface. The engine side of the drive was never recovered. Rotational scoring was noted on the rear air transfer plate. Normal wear was seen on the walls of the pump body.

The NSD360 horizontal situation indicator (HSI) was manufactured by Edo-Aire Mitchell (gyro m/n 1U293-002, s/n 8267B). The HSI was jammed on a heading of 180 degrees. The air pivot was sheared and the end of the gyro housing was crushed. Removal of the gyro rotor assembly revealed faint striations on one end of the rotor and on the matching end cap. The power warning flag was not recovered.

The Edo-Aire Mitchell attitude gyro (m/n 1U 284-001-3) yoke assembly to the autopilot roll coil was indicative of a 90 degree left bank. Not pitch information could be determined. The rotor and housing bore no rotational scoring.

The electric turn coordinator was manufactured by Electric Gyro Corporation (EGC), and had been overhauled by Aero-Mach Labs, Inc., on November 1, 1996 (approximately 745.8 hours since overhaul). The rotor housing was broken, exposing the rotor. Examination of the rotor disclosed a faint scratch on the beveled edge that extended 180 degrees around its perimeter.

On February 3, 1999, the standby electric gyro horizon (m/n RCA 26BK-9A, s/n 93MR053) was disassembled and examined at the facilities of Kelly Manufacturing Company in Wichita, Kansas. The instrument was manufactured by R.C. Allen, Inc., but the product line has since been taken over by Kelly Manufacturing Company. It had been overhauled by Aero-Mach Labs, Inc. on September 19, 1996. Faint rotational scoring was noted on the inside of the gyro housing. The rotor bore no such marks. The cooling impeller vanes on the back side of the rotor were broken and had been pushed down into the rotor.

On February 4, 1999, the Airborne vacuum pump was disassembled and examined at the facilities of Parker Hannifin Corporation in Elyria, Ohio. The vacuum pump (p/n 212CW, s/n 3AK1308) was manufactured by Parker Hannifin in March 1994, and was installed on the left mounting pad of N79NL on August 3, 1994, by Signature Flight Support, Huntsville, Alabama (819.8 hours estimated time in service before accident, see INSTALLATION AND SERVICE HISTORY, VACUUM PUMPS INSTALLED IN N79NL, attached). It did not separate from the engine during the impact sequence. The external side of the flex coupler was still attached to the splined external drive, but the flex coupler shaft was broken. The fractured surfaces showed rotational scoring and shaft material was smeared outward, forming a lip. Black powder was found inside the mounting flange inlet ports. The ceramic seal was intact. Oil contamination radiated outward on the driven spline flange and on the ceramic seal, consistent with radial deflection by centrifugal force. The rotor was fractured and all but one vane was broken into many pieces. Wear was evident on the rotor vane slots and on the one intact vane. Parker Hannifin engineers said the flank (side) wear was excessive. The vane was measured at its thinnest point (near the center) and found to be .107 inches. A new vane measured .125 inches. Parker Hannifin engineers said that the wear could be caused by too high a vacuum setup, or a blockage in either the inlet or outlet passages. The amount of tip wear was similar to that of a 600-hour pump. The width of the vane was measured and found to be .689 inches. The width of a new vane is approximately .845 inches. After removing the rotor and vanes, a small piece of Plexiglas (approximately .25 inches x .3 inches x .057 inches) was found in the chamber.

Along with other items, both vacuum pumps and the various flight instruments were sent to NTSB's metallurgical laboratory for examination. According to the Materials Laboratory Factual Report 99-104 (attached), "the housing body of the [Sigma-Tek] pump was deformed inward on one side, and five of

the six bolts that attach the housing cover plate to the housing body were separated at the interface between the body and the cover plate. The sixth bolt was reportedly intact. The rotor contained rotational scoring around the perimeter of the face. The inside of the cover plate contained a series of arcing score marks. The radius of curvature of these marks on the cover plate matched the approximate diameter of the rotor, but the marks were not concentric with the axis of the rotor. The cover plate was partially reattached to the body of the housing using the one intact bolt, which was inserted in the bolt hole position in which it was reportedly recovered. The arcing score marks on the cover plate matched the perimeter of the rotor when the cover plate was rotated about this bolt about 45 degrees. SEM (scanning electron microscope) examination of the Sigma-Tek vacuum pump drive shaft fracture surface revealed "rotational damage and elongated ductile dimples in a pattern characteristic of torsional overstress."

The Airborne vacuum pump plastic drive gear fracture surface "contained rotational smearing and deformation indicative of continued rotation after separation."

Examination of the gyros removed from the attitude indicator, turn coordinator, horizontal situation indicator, and the electric stand-by attitude indicator "revealed no evidence of rotational damage on the surface of the gyro rotors." Examination of the airspeed indicator and tachometer faceplates was inconclusive, but examination of the vertical speed indicator faceplate revealed a needle impression at "a vertical speed of about 3,000 feet per minute, the maximum descent rate recordable by the instrument." Bench binocular microscope examination of one of the valves from the check valve manifold showed that it had not been breached.

On June 15, 1999, the engine was disassembled and examined at the facilities of Air Transport in Phoenix, Arizona. There was an indentation on the number 2 piston aligned with and similar to an exhaust valve strike. According to Teledyne Continental Motors, in order for this to occur, the engine would have to overspeed to approximately 4,000 rpm (top speed for the TSIO-520-P is 2,700 rpm). According to Sigma-Tek, the engine-to-vacuum pump gear ratio is 1:1.5. If the engine was operating at 4,000 rpm at impact, the vacuum pump would be turning at 6,000 rpm. No other discrepancies were noted that would have precluded normal engine operation.

The recovered right wing was also examined. All of the fractures were similar to, typical of, and consistent with overload failures. There was no evidence of metal fatigue or corrosion.

The vacuum system operation was discussed in detail with experts from Parker Hannifin and Cessna Aircraft. Outside air is drawn through an air filter and into the vacuum-driven gyroscopic flight instruments. This high velocity air strikes the buckets of the gyros, causing them to spin approximately 20,000 to 30,000 rpm. The air is then drawn out of the instrument cases to the vacuum pumps and vented overboard. Parker Hannifin offered this explanation as to why carbon dust had previously been found in the vacuum gauge: If the carbon vanes in a vacuum pump were to break, carbon dust would normally be vented overboard. There is an open line between vacuum gauge and vacuum pump, and a vent on the back of the vacuum gauge. Leakage through the gauge indicator would allow air to flow through the gauge source indicator to the pump side of the check valve manifold and to the pump (not from the pump to the gauge). Carbon dust could back up to the gauge indicator if a pump were to break. As the vacuum would drop, the check valve (on the side of the check valve manifold connected to the broken pump) would close by its seating spring and the vacuum created by the other vacuum pump connected to the other side of the check valve manifold. The closed check valve will not allow carbon dust to back up towards the gyros.

Because the 1H5 check valve manifold incorporates elastomeric components that deteriorate with age,

Parker Hannifin recommends "that beginning five years from date of manufacture, the serviceability of these components be verified every twelve months, . . . [and] replaced ten years from date of manufacture." They also recommend that vacuum hoses should be inspected regularly for obstructions and cleanliness. There was no documentation in the maintenance records that this had ever been done.

Examination of Cessna Service Letter SK210-103 (outlining the steps to be followed for installing dual vacuum pumps) disclosed the following warning: "Since check valves in the manifold provide no pressure relief, pump life when connected backwards is only seconds."

Airworthiness Directive 82-06-10 applied to N79NL. Essentially, it prohibited IFR operations unless (1) the airplane was equipped with "an attitude indicator powered by an independent power source," (2) Cessna Service Alert Letter SE82-13 be incorporated, or (3) the Airborne 442CW-8 pump be replaced by either an Airborne (Cessna p/n C431003-0102) pump or an Edo-Aire (p/n 1U128-001 or -003) pump. N79NL had complied with the provisions of A.D. 82-06-10.

ADDITIONAL DATA/INFORMATION

In addition to the Federal Aviation Administration, parties to the investigation included the Cessna Aircraft Company, Teledyne Continental Motors, Sigma Tek, Inc., Kelly Manufacturing Company, and Parker Hannifin Corporation. Kelly Manufacturing Company was later removed as a party to the investigation because they were not responsive to the needs of the investigator-in-charge.

The wreckage, including various components retained for testing, was released to a representative of the pilot's insurance company on June 25, 1999.

*All times stated herein are mountain standard time (mst) unless otherwise noted.

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