



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

STRUCTURES GROUP CHAIRMAN'S FACTUAL REPORT

August 31, 2017

A. ACCIDENT: WPR17LA031

Operator: Private
Location: Missoula, Montana
Date: December 5, 2016
Time: 1300 Mountain Standard Time
Aircraft: Piper PA-31T
Registration Number: N909PW

B. STRUCTURES GROUP

Chairman: Clinton R. Crookshanks
 National Transportation Safety Board
 Denver, Colorado

C. SUMMARY

On December 5, 2016, about 1300 mountain standard time, the pilot of a Piper PA-31T, N909PW, made an unscheduled landing at the Missoula International Airport (MSO), Missoula, Montana, after the left windshield fractured and separated from the airplane. The private pilot and passenger were not injured. The airplane was registered to and operated by the pilot under the provisions of 14 *Code of Federal Regulations*, Part 91, as a personal flight. Instrument meteorological conditions prevailed and the flight was operated on an instrument rules flight plan. The flight originated from Kalispell City Airport (S27), Kalispell, Montana at 1215.

The pilot reported that he was in cruise flight at flight level (FL) 230 when the left windshield fractured and departed the airplane. He immediately performed an emergency descent to the nearest airport, and landed without further incident. In a post-accident interview, the pilot reported that he normally flew the airplane at an altitude of FL 190 to FL 210. On this particular flight, air traffic control (ATC) assigned him an altitude of FL 230 though he had filed a flight plan for FL 220. He stated he was watching the pressurization to make sure that he did not exceed the redline on the gage, the cabin altitude was set for 7,500 feet, and windshield heat was off. After reaching FL 230, he recalled noticing the outside air temperature gage was showing -40°F. At the time of the windshield failure the pilot “heard a momentary hiss, then an explosion, followed by the sound of wind.” The pilot and passenger donned their oxygen masks and the pilot radioed to ATC his intent to divert to Missoula. He never was able to hear a response from ATC due to the noise in the airplane. The pilot did not consult the pilot operating handbook or emergency procedures during the diversion and landing. He reported no controllability issues during the approach and landing though he did keep his speed up above normal and landed with only the first notch of flaps set. During the previous day while he was getting the airplane ready, the pilot washed the windshields. He noticed there was some cracking or what he thought looked like delamination around the edges, especially the upper edge.

D. DETAILS OF THE INVESTIGATION

1.0 Airplane

The Piper PA-31T Cheyenne is a twin engine, propeller driven, low wing, pressurized airplane equipped to carry 4-6 passengers. The airplane is of all metal construction, has a conventional tail and is equipped with a retractable tricycle landing gear system. The airplane is powered by two Pratt & Whitney PT6 engines and has a maximum takeoff weight of 9,000 pounds. The airplane is 34 feet, 8 inches long, has a wingspan of 42 feet, 8.25 inches and a tail height of 12 feet, 9 inches.

The PA-31T is equipped with two electrically heated main windshields, right and left, that are manufactured with two layers of glass (Figure 1¹). The windshield stack-up from outboard to inboard consists of a 0.125-0.155 inch thick layer of semi-tempered glass, a 0.250 inch thick layer of vinyl, and a 0.310-0.350 inch thick layer of tempered glass. A conductive coating is applied to a portion of the inboard surface of the outboard glass layer during manufacture to provide a heated area for anti-ice capability. An aluminum retainer about 2 inches wide is installed in the vinyl layer around the periphery of the windshield. Holes (97 total) through the vinyl layer and aluminum retainer with aluminum bushings provide the means for attaching the windshield to the airframe. The entire windshield assembly is heat cured so that the glass, vinyl, and aluminum are bonded together as a unit.

¹ All Figures are presented in Appendix A.

2.0 Accident Aircraft Examination

S/N: 31T-7720060

TAT: 6,389.5 hours

TAC: 7,085 cycles

Almost all of the left windshield glass and vinyl departed the airplane during the event (Figure 2). The entire aluminum retainer and the vinyl layer surrounding it, beneath the fuselage windshield frame, remained installed. Small areas of glass and vinyl were present around the edge of the windshield frame. Only a few small glass fragments were found in the cockpit. The right windshield remained intact and installed in the airplane. There was no evidence of impact damage to the fuselage aft of the windshield or the tail of the airplane. There were small fragments of glass embedded in the left propeller blades. No evidence of bird impact was noted anywhere on the airplane. The fuselage windshield frame, sealant, and paint around both windshields were intact with no obvious discrepancies.

The fractured left windshield and the intact right windshield were removed from the airplane under NTSB supervision December 19-21, 2016. The remaining glass fragments on the left windshield were secured with tape prior to removal. A heat gun was used to soften the sealant between the windshields and the fuselage window frame after all the fasteners were removed. There was a dark brown sealant material between the windshield frame and the left windshield that peeled off easily leaving almost no evidence on the left windshield flange. The dark brown sealant material between the windshield frame and right windshield was much more difficult to separate and did not peel off the windshield frame (Figure 3).

The left windshield data tag listed part number (PN) 45213 and serial number (SN) 7-H-1-2-147 and the right windshield data tag listed PN 45213-1 and SN 1-H-8-16-310. Based on the information on the data tags, both windshields were manufactured by PPG in Huntsville, Alabama. The left windshield was manufactured in January 1977 and the right windshield was manufactured in August 1981.

The cabin altitude and pressure gage in the cockpit was examined. The green arc on the altitude portion of the gage extended from 0 to 10,000 feet and the yellow arc extended from 10,000 to about 27,000 feet. The green arc on the pressure portion of the gage extended from 0 to about 5.7 psi with a red radial line at its upper end.

The left and right windshields were shipped to PPG Aerospace Transparencies in Huntsville, Alabama, where they were examined under NTSB supervision May 23-24, 2017².

The fractured left windshield aluminum retainer and flange area was intact (Figure 4). There were areas of warped vinyl noted around the periphery of the window in the flange area and surrounding many of the aluminum bushings (Figure 5). Several areas of retainer discoloration with a lighter color (white versus gray) were noted in the flange area on the inboard and outboard sides of the retainer. These areas were scattered around the periphery of the windshield with varying sizes. The largest single area was located along the lower flange and extended across the width of the retainer

² The PPG report is presented as Attachment 1 to this report.

for about 6 inches on both the inboard and outboard sides of the retainer. Upon disassembly of this area, a white powdery residue consistent with corrosion of the aluminum retainer was present and the vinyl was no longer adhered to the aluminum (Figure 6). The fracture faces on the remaining glass fragments were examined visually and with an optical microscope for evidence of Wallner³ lines. The limited amount of remaining glass indicated the glass fracture on both inboard and outboard layers initiated somewhere in the aft portion of the windshield near the center.

The right windshield was intact with no fracture of the inboard or outboard glass layers (Figure 7). There were areas of warped vinyl noted around the periphery of the window in the flange area and surrounding many of the aluminum bushings similar to the left windshield. Areas of retainer discoloration with a lighter color (white versus gray) were noted in the flange area on the inboard and outboard sides of the retainer though it was less severe than the left windshield. These areas were scattered around the periphery of the windshield with varying sizes and there was no large single area like noted on the left windshield. The electrical resistance of the heating system was measured and found to be within the manufacturer's specifications. There was cloudiness, interlayer cracking, and delamination noted along the top and bottom edges of the windshield consistent with moisture ingress into the laminate. The discrepancies were noted along the entire upper edge and extended about 3/8 inch from the edge of the outboard glass layer towards the center of the windshield. The same discrepancies were also noted along the forward 13 inches of the lower edge and extended about 1/2 inch from the edge of the outboard glass layer towards the center of the windshield. Delamination was also noted at all four corners and along the bus bars at the lower forward and lower aft ends of the glass area. There was a small expanding triangular or V-shaped area of fractured glass consistent with a peel chip located about 14.5 inches aft of the forward edge and about 5/8 inch below the upper edge of the outboard glass layer (Figure 8). The peel chip penetrated from the inboard surface of the outboard glass layer towards the outboard surface to a depth of 0.144 inch as measured with an optical micrometer. According to the manufacturer, peel chips usually occur outside the heated areas of the windshield and will only occur at the vinyl to glass interface areas where there is an excessive local adhesion of the glass to the vinyl. The peel chip type fracture has historically been an issue on windshields of this configuration and can lead to spontaneous fracture of the glass layer. In response, the manufacturer redesigned the windshield in 2001 for those windshields still in production. The new windshield design incorporated a urethane layer between the vinyl interlayer and the outboard glass layer to relieve stresses in the outboard glass layer and prevent peel chip fractures. The Piper PA-31T ceased production in 1984 and the windshield was never redesigned.

3.0 Maintenance Records

Piper Aircraft Company completed manufacture of the incident airplane on August 26, 1977. The final inspection sheet for the airplane listed the left windshield as PN PIP-120-007-2 and SN 7-H-1-2-147 and the right windshield as PN PIP-120-008-2 and SN 7-H-3-20-266. According to PPG, the listed part numbers are the internal PPG code for a PN 45213 windshield.

The airplane logbooks were examined during the removal of the windshields. The first entry in the logbook was a stamp that issued a standard airworthiness certificate on August 26, 1977 and mentioned that the airplane was exported. The next entry in the logbook was dated December 8,

³ Wallner lines are rib shaped marks that indicate the direction of fracture progression in glass.

1981, and forwarded a time of 1712.12 hours with an annotation that the airplane was registered as D-IASG⁴ up to this time. The airplane was ferried back to the United States and issued an FAA Standard Airworthiness Certificate on December 17, 1981, with a total time of 1734 hours. There were no logbooks supplied for the period of time when the airplane was registered overseas. No information was found in the records to indicate when or why the right windshield was replaced.

The airplane was painted in its current livery, white with gold and green trim, in July 2005. The airplane was registered as N909PW in September 2005. The most recent inspection of the airplane was accomplished on February 1, 2016, at a total time of 6267.5 hours when the events 1 and 2 special inspections per the Piper PA-31T maintenance program were completed. There were no windshield discrepancies reported in the logbook.

4.0 Tests and Research

Examination of the engineering records at PPG indicated that the windshield design underwent qualification testing prior to the certification of the airplane at Piper Aircraft Corporation. Both a left and right windshield were tested and were subjected to pressurization loads of 6.2 psi for 40,000 cycles followed by an ultimate pressure test at 12.5 psi without failure. The report noted that delamination was noted on the test windshields along the edges that extended up to 1.5 inches into the daylight opening and no peel chips developed in the windshields.

The Piper Cheyenne Service Manual provides guidance to operators for Window Inspection and Repair⁵. The manual defines the areas of the windshields as follows.

Critical	The viewing area of the windshields used for taxiing, takeoff, climb, cruise, and landing.
Semi-Critical	The viewing area used for general flight vision.
Non-Critical	Viewing areas not normally used for flight operations.

Further, the manual defines anomalies such as distortion, cracks, crazing, scratches, chips, haze, blemishes, mark-off, and delamination for use when inspecting the windshields. The inspections are broken up into three sections, one for each of the window areas defined above. Only the critical and semi-critical sections have inspection guidelines for the glass windshields. The non-critical section is only for the cabin windows. Cracks and crazing are considered critical for the glass windshields. Cracking of either the inboard or outboard glass layer is cause for immediate replacement. Crazing, as defined in the manual, is a “mesh of fine hairline cracks that do not penetrate the full depth of the material, located on the surface or within the structure of the transparent material.” Crazing of 0.062-inch depth or greater is cause for immediate windshield replacement. The delamination guidance for the critical and semi-critical areas is similar. The guidance in the critical section includes sections (a) and (b) while the guidance in the semi-critical section includes sections (a), (b), and (c).

⁴ The registration number indicates the airplane was registered in Germany.

⁵ See Attachment 2 for the relevant pages from the Piper Cheyenne Service Manual and the Piper Cheyenne Progressive Inspection.

Delamination.

- (a) Cloudy or milky appearance in the delamination indicates moisture or solvent penetration. Windshields with this condition should be replaced at the earliest opportunity.
- (b) Delaminated areas characterized by irregular or jagged boundaries indicate uneven separation of the vinyl and glass. This condition may cause the vinyl to pull chips from the inner glass surface, resulting in failure of the glass ply. Conduct periodic inspections to determine if the damage is progressive or if chipping of the inner glass surface is present.
- (c) Replace windshield if any of the following conditions are noted:
 - 1) Evidence of chipping of inner glass surface.
 - 2) Area of vision required for safe operation is affected (pilot's discretion).
 - 3) Windshield heat system inoperative.

The Piper Cheyenne Progressive Inspection details the recommended maintenance program for the airplane. The program contains two event inspections (Events 1 and 2) that are to be performed every 100 hours that will have the entire airplane inspected each 200 hours. Inspection of the windshields is part of both event inspections. For the Event 1 inspection the recommended step states "Inspect windshield and all windows for cracks and condition." For the Event 2 inspection the recommended step states "Check all windows and windshield for condition and cleanliness."