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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 10, 1997

In reply to refer to: A-97-41 through -45

Mr. Barry L. Valentine
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

On March 4, 1994, a Piper PA-38-112 Tomahawk, N2496L, crashed during a biennial flight review for a private pilot in Inman, Kansas. The flight review was being administered by a certified flight instructor (CFI) who held airplane single engine, multiengine, and instrument ratings and had 7,945 hours total flight time, including 745 hours in the PA-38-112. The private pilot's logbook was destroyed in the accident, but he was believed to have had approximately 100 hours total flight time. Witnesses reported that the airplane was in a 5- or 6-turn left spin and that the airplane spun until just before it struck the ground. Both occupants were killed, and the airplane was destroyed. Postaccident examination revealed no mechanical problems with the airplane.

The Safety Board determined that the probable cause of this accident was an unintentional spin that occurred during the maneuvering phase of a biennial flight review. A factor related to the accident was the airplane's lateral-directional characteristics at or near the stall. This accident, along with several other accidents involving similar circumstances, prompted the Safety Board to review the stall/spin characteristics of the PA-38-112. This review revealed that the fatal stall/spin accident rate for the Piper PA-38-112 was higher than for comparable aircraft and that certain required stall tests had not been performed during the certification of the airplane. Although the FAA is planning a flight test program to perform the omitted tests, this review raises significant concerns about the stall/spin characteristics of the PA-38-112.

Stall/Spin Accident History

To provide a basis for comparison, the Safety Board estimated the fatal stall/spin accident rate for Piper PA-38-112 and for Cessna 150/152 series aircraft for the period 1985 through 1994.[1] During this period, Piper PA-38-112s were involved in 12 fatal accidents in which a stall/spin was cited by the Board as a cause or factor; Cessna 150/152s were involved in 35 such accidents.

To calculate rates for comparison, the Board used aircraft exposure data gathered and reported by the FAA.[2] Each year, the FAA uses survey results to calculate an activity estimate

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[1] Both the PA-38-112 and the Cessna 150/152 are used as primary flight training aircraft.

[2] All activity data are from the following publications: *General Aviation Activity and Avionics Survey*, Federal Aviation Administration: Washington, D.C. 1985-1992. *General Aviation and Air Taxi Activity and Avionics Survey*, Federal Aviation Administration: Washington, D.C., 1993. *General Aviation and*

(total flight hours) and an associated standard error statistic for each model aircraft. Survey data are subject to sampling error, and the error statistic is used to create an interval within which the actual number of flight hours is assumed to lie.[3]

Using lower- and upper-bound estimates of flight hours, the PA-38-112 accident rate ranged from 0.336 to 0.751 fatal stall/spin accidents per 100,000 flight hours, compared to 0.098 to 0.134 for the 150/152. The Board concludes that the PA-38 has been more likely to be involved in these kinds of accidents than the 150/152.

Since the airplane was introduced, the Safety Board has investigated 51 PA-38-112 stall or stall/spin accidents that resulted in 49 fatalities. A review of these accidents found similarities between the Inman, Kansas, accident and accidents in Romeo, Michigan; Huron, South Dakota; Gadsden, Alabama; Lakeview, Arkansas; Green Valley, Arizona; and Danville, Indiana.[4] Each of these accidents involved inadvertent spins that occurred during instructional flights while attempting slow flight or stall training.

The PA-38-112 Pilot's Operating Handbook (POH) states that a properly executed 1-turn spin will require 1,000 to 1,500 feet, and a 6-turn spin will require 2,500 to 3,000 feet to complete the recovery. The POH recommends that spins should only be started at altitudes high enough to recover fully at least 4,000 feet above the ground, so as to provide an adequate margin of safety. In each of the accidents cited, the investigations revealed that slow flight or stall training was in progress when the airplane entered a spin. In all cases (for which evidence was available to determine altitude), the training was being performed at altitudes below that specified in the handbook as adequate for spin training.

Stall Testing Performed During Certification of the PA-38-112

Certification flight testing of the PA-38-112 was performed in 1977, under the provisions of Title 14 Code of Federal Regulations (CFR) 23. Section 23.203, "Turning Flight and Accelerated Stalls," required turning flight and accelerated stalls to be demonstrated, with the flaps retracted and extended. Both types of stalls are performed in 30° banked turns, using an entry rate of 1 knot per second during turning flight stalls and 3 to 5 knots per second during accelerated stalls.

Based on the certification flight testing, in 1977 Piper issued Piper Aircraft Company Report FT 118, "Model PA-38-112 Certification," which the Safety Board reviewed. The report indicates that only the turning flight stalls (with flaps retracted) were performed. The Board found no documentation that turning flight stalls (with flaps extended) or accelerated stalls (in both flap configurations) were ever tested.

On May 9, 1997, the Safety Board held a teleconference with the FAA to discuss the omission of these required certification tests. On May 15, 1997, the FAA Manager, Small Airplane Directorate, issued an action memorandum to the FAA Manager, Recommendation & Quality Assurance Division, which stated the following:

Air Taxi Activity Survey, Federal Aviation Administration: Washington, D.C., 1994.

[3] The estimated 95 percent confidence interval for total flight hours during the period ranges from 26,050,879 to 35,546,459 for the Cessna 150/152, and from 1,596,908 to 3,570,598 for the Piper PA-38-112.

[4] See Brief of Accidents CHI78FEC47, DEN81FA016, ATL82FA001, FTW84FA060, LAX88FA190, and CHI95FA326.

> A review of the Piper Certification report, FT 118, indicates that the FAR 23.203 requirements for accelerated stalls with the flaps extended were either not accomplished or, if accomplished, the results were not included in the report. It was decided to require Piper to complete the stall tests.

A follow-up memorandum issued on June 11, 1997, from the FAA Manager, Small Airplane Directorate, to the FAA Manager, Recommendation & Quality Assurance Division, states the following:

> This is to confirm that the tests to be conducted are, per FAR 23.203(a)(1) and (2), the turning flight stalls with the flaps fully extended and the accelerated turning flight stalls with the flaps extended and retracted. The schedule for these tests is not known at this time, but it is not expected to be started before mid July [1997].

Stall Characteristics of Production PA-38-112 Airplanes

Report FT 118 indicates that stall certification flights were performed on one airplane, N38PA, which was built at Piper's Vero Beach, Florida, facility. (A second airplane, N381PT, was used during the last week of the certification flight test program for lighting and vibration tests; however, no stall tests were performed using this airplane.) During the program, stalls were tested on 13 flights, and no unsatisfactory stall characteristics were reported.

After certification was granted, Piper moved production of the PA-38-112 to the company's Lock Haven, Pennsylvania, facility, where more than 2,400 PA-38-112 airplanes were built between 1978 and 1982, when production ceased. The Safety Board has learned of reports of significant differences in the stall characteristics between the certification-tested airplane and the production airplanes.

According to testimony from a Piper engineer,[5] shortly after delivery of production airplanes began, owners and operators of the airplane complained that the lateral directional characteristics at the stall were abrupt and unpredictable, and that the airplane exhibited a rapid roll as the stall occurred. In 1979, in an attempt to improve the airplane's stall characteristics, Piper modified the wing design of the PA-38-112 by adding two additional stall strips.[6] An airworthiness directive (AD 83-14-08) mandated that all existing airplanes be retrofitted with the additional stall strips.

However, the additional stall strips may not have solved the problems with the stall characteristics. According to an August 1982, *Aviation Safety* article, "Test pilots and flight instructors have found that both the two-strip and four-strip Tomahawks have a tendency to drop a wing (as much as 90 degrees) in an intended straight-ahead stall if prompt and positive recovery controls are not used."

[5] Obtained in a Safety Board deposition following the Inman, Kansas, accident.

[6] The PA-38-112 was originally designed with two stall strips, triangular cross-section blocks approximately 8 inches long and ½ inch wide, placed on the outboard leading edge of the each wing. They are designed to modify the stall characteristics of an airplane by inducing a stall at a controlled location along the wing.

In an April 1995 letter to the Safety Board, a former test pilot, employed by Piper at the Lock Haven facility from 1978 to 1984, stated that the production PA-38-112 aircraft that he flew were "totally unpredictable, one never knew in which direction they would roll-off, or to what degree, as the result of a stall." These sentiments were echoed by a second former test pilot, employed by Piper at the Lock Haven facility for at least six years beginning in 1979, in a January 1997 interview with a Safety Board investigator. He stated that "the airplanes were very unpredictable in a stall. Each airplane did not perform stalls the same from one flight to the other."

In January 1997, Safety Board staff interviewed a third former test pilot, employed by Piper from 1973 to 1978, who held the company title of chief pilot and served as the FAA Delegation Option Authority (DOA) and Designated Engineering Representative (DER). He stated that the production PA-38-112 airplanes built at the Lock Haven facility were "nothing like the article certified [by the FAA] as far as stall characteristics are concerned." He reported that Piper test pilots who performed post-production flight tests were "shocked at the stall characteristics observed." He claimed that the additional stall strips did not eliminate the stall/spin defects that he observed in the airplane.

The Safety Board attempted to determine if the FAA had ever evaluated the stall characteristics of production PA-38-112 airplanes, in either the two-strip or four-strip wing configuration. In a letter dated March 3, 1997, the FAA informed the Safety Board, "We requested that Piper search the DOA files for any indication that the FAA was involved in any such testing, and the search did not reveal any such tests. Piper conducted stall/spin tests at their Lock Haven, Pennsylvania, facility prior to the issuance of AD 83-14-08; however, only Piper DOA flight test pilots participated, the FAA was not involved in these tests."

The Safety Board is concerned that production PA-38-112s may have stall characteristics different from those documented on the single pre-production airplane used during the original certification program. Therefore, the Safety Board believes that the FAA should expand the upcoming certification flight test program to include a minimum of two test airplanes, and should document any changes necessary to bring these test airplanes into conformance with the type certificate.

Swedish Flight Test Program

The Safety Board recently learned that in 1979, following a fatal stall/spin training accident in a PA-38-112 in Sweden, the National Aeronautics Board Investigation Commission of Sweden conducted a PA-38-112 flight test program. The purpose of the program was to study the low speed, stalling, and spin characteristics of the airplane. Two production airplanes were used, one configured with two stall strips and the other configured with four stall strips.

A report on the flight test program concluded that after performing more than 60 stalls, PA-38-112 stall characteristics did not meet the 14 CFR Part 23 certification requirements for wings-level stall characteristics. Section 23.201, "Wings Level Stall," states that wings-level stall characteristics must be demonstrated by slowing the airplane "until a stall is produced, as shown by an uncontrollable downward pitching motion of the airplane." However, the test report concluded that the PA-38-112 did not exhibit the conventional nose-down pitching moment at the stall, regardless of stall strip configuration. Instead, stalls were characterized by a roll disturbance without pitch change.

In addition, the report concluded that the airplane did not meet the 14 CFR Part 23 requirement for stall warning. Section 23.207, "Stall Warning," states that a clear and distinct stall warning must begin at a speed exceeding the stall speed by at least 5 knots. The Swedish program found that the stall warning horn "is engaged too late, approximately 2 knots prior to stalling with full flap, and 3 - 6 knots prior to stall without flap."

Based on the findings in the Swedish flight test report, the Safety Board believes that the FAA should expand the upcoming PA-38-112 certification flight test program to include the following: (1) section 23.201 wings-level stall tests, to ensure that among other requirements, the stall is defined by a downward pitching motion of the airplane, and (2) section 23.207 stall warning tests, to ensure the stall warning horn activates at least 5 knots before stall.

Aircraft Owners and Pilots Association (AOPA) PA-38-112 Safety Review

In 1996, the Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation published a report titled "Safety Review Piper Tomahawk PA-38-112." The report found that production airplanes had a tendency to roll off on one wing or the other at the point of stall. The stall strips added in 1979 reduced the rate of roll, but the tendency to roll off on a wing at the point of stall still existed. The report stated, "The Tomahawk has a tendency to roll at the time of stall, sometimes at a fairly rapid rate. This is more pronounced in the PA-38 than in other trainers."

In analyzing stall/spin accident statistics, the report acknowledges that the Tomahawk has a higher involvement than the Cessna 150/152 and concludes, "In our assessment, the Tomahawk has a higher involvement in stall/spin accidents because it is unlike nearly all other light training aircraft by design." Their statistical analysis concludes by stating, "Does this make the aircraft unsafe? We don't believe so, but pilots must respect the aerodynamics and operational differences."

Based on the high rate of stall/spin accidents involving PA-38-112s, the numerous accidents caused by inadvertent spin entry during training flights, and the findings of the AOPA Air Safety Foundation Safety Review, the Safety Board believes that the FAA should immediately require that the slow flight and stall training in the PA-38-112 be conducted at or above the minimum altitude currently specified in the POH for spin training, pending completion of the upcoming certification flight test program.

PA-38-112 Flat Spin Mode

Most airplanes spin with the nose pitched down below the horizon. However, if the nose of the airplane begins to rise, a flat spin may develop. FAA Advisory Circular 61-67B, "Stall and Spin Awareness Training," states that a flat spin is characterized by a near-level pitch and roll attitude and that recovery from a flat spin may be extremely difficult and, in some cases, impossible (because airflow disruptions prevent the flight control surfaces from effecting spin recovery). Section 23.221 states that it must be impossible to obtain unrecoverable spins with any use of the flight or engine power controls either at the entry into or during the spin. However, during the Board's review of PA-38-112 accidents/incidents, the Safety Board learned of several incidents in which unsafe, flat spins have been encountered in the PA-38-112.

PA-38-112 Flat Spin Incidents/Accidents

The Safety Board obtained a videotape of an October 1979 flight conducted by a NASA test pilot in a rented PA-38-112. The airplane was neither modified by NASA nor was it instrumented, as the flight was performed solely to familiarize the pilot with the airplane's spin characteristics. The flight was videotaped using a ground-based tracking camera at NASA's Wallops Flight Facility, and pilot comments were recorded via a VHF radio communications link. The videotape shows a series of 12 spins using various entry and recovery techniques.

One maneuver documented by the videotape was a right spin with an attempted elevator-only recovery. After several revolutions, the nose of the airplane began to rise. The test pilot immediately terminated the test and recovered the airplane. He stated that he "went ahead and recovered that one manually because it looked ... like it was beginning to flatten ... ." He later stated, "It surprised me. In a test aircraft, that's often an indication that there's something we don't understand, and would likely want to investigate."[7] The pilot involved is well respected throughout the industry for his experience in the spin testing of general aviation airplanes.

In addition, the former Piper chief test pilot interviewed by Safety Board staff in January 1997 described a PA-38-112 "flat spin" that he experienced in 1983. He stated that during an intentional spin, after approximately 2 turns, the nose started to rise to a more level pitch attitude, the rotation rate increased, and the spin "went flat." He said that even with full recovery rudder and elevator control, the "flat" spin continued for at least two more turns; then the nose slowly dropped and rotation ceased. He described the experience as "frightening. I didn't think that it was going to recover."

In April 1991, an FAA inspector from the Rochester, New York, flight standards district office was administering a check ride to a flight instructor from a 14 CFR Part 141 flight school in a PA-38-112. The FAA inspector had about 13,500 flight hours and had served as an aerobatics instructor; he had reportedly performed numerous spins in at least 15 different airplanes, including many spins in the PA-38-112. As part of the required check ride maneuvers, the inspector asked the candidate to perform a 1-turn spin to the right at an altitude of 5,000 feet. The candidate placed the airplane into a spin; however, the nose began to rise and a flat spin developed.

According to the inspector, the candidate immediately attempted to recover from the spin using the recovery procedures described in the airplane flight manual, but the airplane continued to spin. The inspector then took control of the airplane and described moving the flight controls to maximum deflection with no response. In desperation, the inspector released his seat belt, pulled himself fully forward against the instrument panel, and instructed the other pilot to do the same (a maneuver which the inspector credits with saving their lives). After several more revolutions, the nose of the airplane dropped and a recovery was effected. Control of the airplane was regained less than 1,000 feet above the ground. After landing, the airplane was immediately inspected. No discrepancies were found and it was determined that the flight control rigging, weight and balance, and configuration of the airplane all complied with the airplane certification.

According to Piper Aircraft Company Report FT 118, 99 spins were performed during certification flight testing. The report states, "Irrespective of the loading or entry or number of turns, the aircraft will recover in one additional turn after input of anti-spin controls." However, the "flattening" spin captured on NASA videotape, the experience of the former Piper chief test pilot, and the flat spin experienced by the FAA inspector raise concerns about the possibility of a flat spin mode. Therefore, the Safety Board believes that the FAA should expand the upcoming PA-38-112

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[7] *Aviation Safety*, April 1982, "Jump in Stall-Spins Mars Tomahawk's Safety Record."

certification flight test program to include section 23.221 spin tests, to ensure that it is impossible to obtain unrecoverable spins with any use of the flight controls or throttle and to verify that the results obtained in the original certification program (spin recovery is always possible in one additional turn after input of anti-spin controls) can be duplicated on production airplanes. Pending completion of the flight test program, the FAA should inform pilots of alternative methods of recovery from an inadvertent, possibly flat spin (e.g., moving fully forward against the instrument panel).

Therefore, the National Transportation Safety Board recommends the following to the Federal Aviation Administration:

> Expand the upcoming PA-38-112 certification flight test program to include the following:
> (1) a minimum of two test airplanes. Document any changes necessary to bring these test airplanes into conformance with the type certificate. (A-97-41)
> (2) section 23.201 wings-level stall tests, to ensure that among other requirements, the stall is defined by a downward pitching motion of the airplane. (A-97-42)
> (3) section 23.207 stall warning tests, to ensure the stall warning horn activates at least 5 knots before stall. (A-97-43)
> (4) section 23.221 spin tests, to ensure that it is impossible to obtain unrecoverable spins with any use of the flight controls or throttle and to verify that the results obtained in the original certification program (spin recovery is always possible in one additional turn after input of anti-spin controls) can be duplicated on production airplanes. (A-97-44)
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> Pending completion of the flight test program specified in the above recommendation, immediately require that the slow flight and stall training in the PA-38-112 be conducted at or above the minimum altitude currently specified in the PA-38-112 pilots operating handbook for spin training; and inform pilots of alternative methods of recovery from an inadvertent, possibly flat spin.
> (Urgent) (A-97-45)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman