



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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In reply refer to: A-11-75 through -78

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On March 22, 2009, about 1432 mountain daylight time, a Pilatus PC-12/45, N128CM, was diverting to Bert Mooney Airport (BTM), Butte, Montana, when it crashed about 2,100 feet west of runway 33 at BTM. The pilot and the 13 airplane passengers were fatally injured, and the airplane was substantially damaged by impact forces and a postcrash fire. The airplane was owned by Eagle Cap Leasing of Enterprise, Oregon, and was operating as a personal flight under the provisions of 14 *Code of Federal Regulations* Part 91. The flight departed Oroville Municipal Airport (OVE), Oroville, California, on an instrument flight rules flight plan with a destination of Gallatin Field, Bozeman, Montana. Visual meteorological conditions prevailed at the time of the accident.

The National Transportation Safety Board (NTSB) determined that the probable cause of this accident was (1) the pilot's failure to ensure that a fuel system icing inhibitor was added to the fuel before the flights on the day of the accident; (2) his failure to take appropriate remedial actions after a low fuel pressure state (resulting from icing within the fuel system) and a lateral fuel imbalance developed, including diverting to a suitable airport before the fuel imbalance became extreme; and (3) a loss of control while the pilot was maneuvering the left-wing-heavy airplane near the approach end of the runway.¹

Background

The accident occurred during the third and final flight leg of the day. The airplane had previously flown from its base of operations at Redlands Municipal Airport (REI), Redlands, California, to Nut Tree Airport (VCB), Vacaville, California, and then from VCB to OVE. Analysis of data downloaded from the airplane's central advisory and warning system

¹ For more information, see *Loss of Control While Maneuvering, Pilatus PC-12/45, N128CM, Butte, Montana, March 22, 2009*, Aircraft Accident Report NTSB/AAR-11/05 (Washington, DC: National Transportation Safety Board, 2010), which is available on the NTSB's website at <<http://www.nts.gov/publictn/2011/AAR1105.pdf>>.

(CAWS)² showed that, during the flight from REI to VCB and the accident flight leg, a low fuel pressure state existed, which necessitated the automatic operation of the left and right fuel boost pumps to provide the required fuel pressure to the engine. The flight from REI to VCB concluded uneventfully. However, for the accident flight leg, the low fuel pressure state and a restricted flow of fuel from the left wing tank led to a 1,300-pound left-wing-heavy fuel imbalance,³ which ultimately resulted in a loss of control as the pilot maneuvered the airplane near the approach end of the runway.

Pilatus PC-12 airplane flight manual (AFM) procedures required the pilot to (1) monitor the fuel quantity indicator in the cockpit to ensure fuel symmetry between the left and right fuel tanks during flight and (2) land the airplane as soon as practical if the maximum allowable fuel imbalance (about 150 pounds) was exceeded and the difference could not be balanced.⁴ During the accident flight, the pilot began to divert to BTM about 30 minutes after the maximum allowable fuel imbalance was reached, even though several closer airports along the airplane's route of flight were available. If the pilot had diverted earlier in the flight to one of these airports, the outcome of this flight would likely have been different because the airplane would have had a less severe fuel imbalance and the pilot would not have had to contend with the airplane's deteriorating performance as the imbalance steadily progressed.

The low fuel pressure state during the two flight legs and the restricted flow of fuel from the left wing tank during the accident flight leg resulted from icing within the fuel system with an initial concentration at the fuel filter. It is important to note that the fuel system continued to provide fuel to the engine throughout the flight, even with the low fuel pressure state and the degraded performance of the left-side fuel system.

The airplane had been serviced with fuel on the day before the accident and after landing at VCB, but the pilot failed to ensure that a fuel system icing inhibitor (FSII) had been added to the fuel. The Pilatus PC-12 AFM, section 2, Limitations, dated March 30, 2001, stated that a FSII "must be used for all flight operations in ambient [outside air] temperatures below 0° C." On a

² Nonvolatile memory data downloaded from the airplane's CAWS contained information about the airplane's 480 flights made during the 2 years before the accident. For 477 of the 480 flights, the left and right fuel boost pumps activated a total of 29 times. These activations were consistent with the operation of the automatic fuel balancing system to laterally balance the fuel load. For the three remaining flights—REI to VCB (on the day of the accident), the accident flight leg (OVE en route to BZN with a divert to BTM), and a flight occurring on October 16, 2007 (from Cabo San Lucas, Mexico, to San Diego, California)—both fuel boost pumps activated 176, 337, and 260 times, respectively.

³ The fuel supplied to the engine was being drawn solely from the right wing fuel tank by the right fuel boost pump. With the fuel return system operating normally, any excess fuel flow to the engine would have been returned and distributed equally to both fuel tanks. Thus, the left and right fuel tanks were equally receiving fuel through the fuel return lines, but the left-wing-heavy fuel imbalance continued to increase during the flight because fuel was only being drawn from the right fuel tank. The increasing fuel level in the left tank and the accelerated depletion of the fuel from the right tank should have been apparent to the pilot because that information would have been presented on the fuel quantity indicator in the cockpit.

⁴ In addition to providing fuel system pressure when a low fuel pressure state exists, fuel boost pumps balance the fuel load between the left and the right wing fuel tanks.

standard day, the temperature is 0° C at 7,500 feet, so most PC-12 flights would require the use of a FSII.⁵

The NTSB obtained surveillance video from VCB that showed the accident airplane's arrival at the VCB self-service fueling island. The video showed the pilot performing some parts of the required preflight inspection. However, the video showed no evidence that the pilot had sampled fuel from either of the underwing fuel tank drains or the fuel filter drain. Also, the surveillance video did not show any evidence that the pilot examined the fuel filter bypass indicator to ensure that it was flush with the filter housing assembly.⁶ If the pilot had performed a complete preflight inspection before the flight to OVE, he would have had an opportunity to detect whether ice crystals or water were present in the fuel and determine whether the fuel filter bypass indicator was extended, which could have explained the reason for the fuel boost pump advisories annunciated during the preceding flight.

Fuel Limitations

Section 2 of the PC-12 AFM, Limitations, detailed the requirements for FSII. The section stated that a FSII must be used for all flight operations in ambient temperatures below 0° C. The section further specified that the concentration of FSII must be between 0.06 and 0.15 percent by volume. A caution advised operators and pilots that the correct mix of anti-icing additive with the fuel was important because concentrations greater than 0.15 percent by volume would cause damage to the protective primer and sealants of the fuel tanks, the fuel system, and engine components. Section 8 of the AFM, Handling, Servicing, and Maintenance, contained the same caution but also included the statement, "concentrations [of FSII] lower than 0.06 [percent by volume] may not be enough to inhibit ice formation."

The NTSB is aware of three other turbine-powered single-engine airplanes that require a FSII: the Cessna 208B, Piper PA-46-500TP, and Socata TBM-700C.⁷ The AFM for each of these airplanes provided information about the correct FSII usage directly in the limitations section or included a reference in the limitations section to another AFM section that contained specific FSII information. However, the use of cautions and warnings to highlight FSII information was inconsistent among the manuals.

Title 14 CFR 23.1583, Operation Limitations, paragraph (b), states that AFMs must specify powerplant limitations, including the fuel designation for turbine-powered airplanes. However, the powerplant limitations information does not reference the requirement for FSII or other fuel additives. If a FSII is required by an airframe manufacturer, then the additive is a

⁵ According to the Federal Aviation Administration's Instrument Flying Handbook, in the standard atmosphere, sea level pressure is 29.92 inches of mercury, and the temperature is 15° C. The standard lapse rate for temperature is a 2° C decrease per 1,000-foot increase.

⁶ The fuel filter has a spring-loaded bypass valve that would open and allow fuel to bypass the filter if it were blocked. The valve has an indicator that extends a red button when fuel has bypassed the fuel filter.

⁷ The Prist Aerospace Products website (<<http://www.pristaerospace.com>>, accessed June 10, 2011) indicated that the following twin-engine aircraft require a FSII: Beechcraft Raytheon Beechjet 400 and Starship; Bombardier Learjet 23, 24, 25, 28, 29, and 35/36; Cessna Corsair/Conquest and Citation I and II; Hansa HFB-320; Mitsubishi MU-2 and MU-300; and Piaggio Avanti. The website also indicated that some very light jets (referred to as VLJs) require a FSII.

critical fuel system limitation, and the omission of a FSII from fuel (when required) could lead to a situation resulting in personal injury or loss of life, as demonstrated by the circumstances of this accident.

Federal Aviation Administration (FAA) Advisory Circular (AC) 25.1581-1, "Airplane Flight Manual," dated July 14, 1997, identified the information that must be provided in AFMs for transport-category airplanes and provided guidance regarding the form and content of the approved portions of the AFMs. The AC stated that AFM operating procedures and techniques could be categorized as warnings or cautions. A warning was defined as "an operating procedure or technique that may result in personal injury or loss of life if not followed." A caution was defined as "an operating procedure or technique that may result in damage to equipment if not followed."

The safety hazard involving fuel system ice accumulation could be mitigated if manufacturers of aircraft requiring FSII for operation placed a warning within the limitations section of their respective AFMs that described the need to ensure that fuel contained the additive in a concentration between the specified minimum and maximum values. Therefore, the NTSB recommends that the European Aviation Safety Agency (EASA) amend certification requirements for aircraft requiring fuel additives, including FSII, so that those limitations are highlighted by a warning in the limitations section of the AFM. The NTSB further recommends that EASA require all existing certificated aircraft (both newly manufactured and in-service aircraft) that require fuel additives, including FSII, to have those limitations highlighted by a warning in the limitations section of the AFM.

Fuel Filler Placards

The PC-12 fuel filler placard, which was located near each fuel filler port, specified the total fuel capacity (203 gallons) and usable capacity (201 gallons) for each fuel tank and the type of fuel to be used (Jet A, Jet A-1, or Jet B). The placard, however, did not note the requirement for a FSII during flight operations with outside air temperatures below 0° C. The PC-12 fuel filler placard was consistent with the requirements of 14 CFR 23.1557, "Miscellaneous Markings and Placards," which stated that fuel filler openings for turbine-powered airplanes must be marked at or near the filler cover with the words "Jet Fuel" and either the permissible fuel designations or references to the AFM for the permissible fuel designations. The regulation does not specifically require manufacturers to reference any necessary fuel additives on the fuel filler placard.

AC 20-29B, "Use of Aircraft Fuel Anti-Icing Additives," indicated that the use of a FSII would meet the provisions of 14 CFR 25.997, "Fuel Strainer or Filter," paragraph (b), which required, at the time of the AC's issuance, "a means to automatically maintain the fuel flow if ice-clogging of the [fuel] filter occurs." Further, the AC stated that, for aircraft requiring a FSII, placards near the fuel filler cover should indicate that the fuel must contain the anti-icing additive.

Title 14 CFR 23.997(d) contained the same requirement as 14 CFR 25.997(b) but for normal- and commuter-category aircraft with turbine engine fuel systems. These regulations, however, did not provide protection for ice accumulation in other fuel system components. As a result, the requirements of both regulations were subsequently included in 14 CFR 23.951

and 25.951, “Fuel System, General.” Specifically, sections 23.951(c) and 25.951(c) both required that the entire fuel system be capable of sustained operation throughout its flow and pressure range with water-saturated fuel cooled to the most critical condition for icing to be encountered during operation. It is important to note that the FAA did not include a related provision from AC 20-29B in sections 23.951(c) and 25.951(c) when they first became effective or in any revision to the regulations since that time: for manufacturers of airplanes that used a FSII for meeting regulatory requirements to indicate, on fuel filler placards, the need to add a FSII to the fuel.

The Cessna 208B, Piper PA-46-500TP, and Socata TBM-700C all have fuel filler placards with a reference to FSII in addition to the information required by 14 CFR 23.1557. These fuel filler placards state, “anti-ice additive required. See Pilot’s Operating Handbook for other approved fuels, quantity and type of additive.” This placarded information provides a prominent reminder to pilots and fuel service personnel of the importance of a FSII during flight operations. The NTSB concludes that the safety hazard involving fuel system ice accumulation could be mitigated if fuel filler placards installed aboard aircraft requiring a FSII specified that requirement. Therefore, the NTSB recommends that EASA amend aircraft certification fuel placarding requirements so that aircraft requiring fuel additives, including FSII, have a fuel filler placard that notes this limitation and refers to the AFM for specific information about the limitation. The NTSB further recommends that EASA require all existing certificated aircraft (both newly manufactured and in-service aircraft) that require fuel additives, including FSII, to have a fuel filler placard that notes this limitation and refers to the AFM for specific information about the limitation.

Therefore, the National Transportation Safety Board recommends that the European Aviation Safety Agency:

Amend certification requirements for aircraft requiring fuel additives, including fuel system icing inhibitors, so that those limitations are highlighted by a warning in the limitations section of the airplane flight manual. (A-11-75)

Require all existing certificated aircraft (both newly manufactured and in-service aircraft) that require fuel additives, including fuel system icing inhibitors, to have those limitations highlighted by a warning in the limitations section of the airplane flight manual. (A-11-76)

Amend aircraft certification fuel placarding requirements so that aircraft requiring fuel additives, including fuel system icing inhibitors, have a fuel filler placard that notes this limitation and refers to the airplane flight manual for specific information about the limitation. (A-11-77)

Require all existing certificated aircraft (both newly manufactured and in-service aircraft) that require fuel additives, including fuel system icing inhibitors, to have a fuel filler placard that notes this limitation and refers to the airplane flight manual for specific information about the limitation. (A-11-78)

Also, the National Transportation Safety Board made five recommendations to the Federal Aviation Administration.

In response to the recommendations in this letter, please refer to Safety Recommendations A-11-75 through -78. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred with these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman