National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 12, 1998

In reply refer to: A-98-65 through -66

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On January 5, 1997, a Fairchild Aircraft SA227-AC, N165SW, equipped with two AlliedSignal (formerly Garrett Turbine Engine Company) TPE331-11U-612 turbopropeller engines, experienced an ice-induced dual-engine flameout.[1] The flight had originated at Long Beach, California, as an on-demand Title 14 Code of Federal Regulations Part 135 air taxi passenger flight to Grand Canyon Airport, Tusayan, Arizona. The weather at Grand Canyon Airport had deteriorated below the allowable landing minimums, requiring the pilot to execute a missed approach. The airplane was subsequently diverted to the Bullhead City Airport, Bullhead, Arizona, and was on final approach when both engines flamed out. The pilots were unable to restart the engines, so they executed a forced landing 1.5 miles south of the Bullhead City Airport, which caused substantial damage to the airplane. The two pilots sustained minor injuries; none of the 19 passengers were injured.

Weather data for the Grand Canyon and Bullhead City airports indicated that the airplane had flown in moist air with temperatures at minus 5°C. The pilots stated that they observed ice accumulating on the airplane wings while flying en route to the Grand Canyon Airport and they had cycled the deice boots[2] to shed the ice. However, they stated that they did not activate the engine's override ignition system or the engine inlet heat as required by procedures in the airplane's flight manual (AFM) for flight-in-icing conditions. The Safety Board concluded that the dual-engine flameout was caused by ice ingestion and by the pilots' failure to select engine override ignition as required when flying in icing conditions. (See enclosed accident brief.)

[1] An ice-induced flameout is the unintentional termination of combustion that occurs when ice or slush momentarily interrupts airflow to the engine causing an over-rich fuel/air mixture within the engine's combustion chamber.

[2] Deice boots are inflatable rubber tubes that are attached along the wing's leading edge. After a nominal amount of ice accumulates, the pilot inflates the boots, which breaks away the ice from the leading edge of the wing.

On April 1, 1993, a Fairchild Aircraft SA227-TT, N500AK, equipped with two AlliedSignal TPE331-10U-513G turbopropeller engines, experienced a dual-engine flameout and crashed while the pilot was performing an instrument landing system approach to the Tri-City Regional Airport, Blountville, Tennessee. The airplane was destroyed, and all four people on board were killed.

Weather at the time of the accident was reported as light rain, fog, temperature 7°C, dew point 5°C, and a visibility of 6 miles. Additionally, several pilots landing at the Tri-City Airport about the time of the accident reported light-to-moderate rime icing between 5,000 and 14,000 feet.

During the Safety Board's investigation of this accident, it was discovered that neither engine was rotating and the propellers were feathered at impact. Additionally, examination of the pilot's annunciator panel revealed that both engine and propeller heat "ON" captions were illuminated at impact, indicating that the pilot had turned these systems on, most likely when he became aware of the ice accumulation. The ignition switch panel was destroyed by fire; therefore, the positions of the ignition switches could not be determined. The Safety Board concluded that both engines stopped operating before impact because of simultaneous flameouts or flameouts in rapid succession caused by ice ingestion and that the flameouts most likely occurred because the pilot did not follow the approved procedures for icing conditions as specified in the AFM. (See enclosed accident brief.) The feathered propellers indicated that the pilot recognized the dual-engine flameout situation and was attempting to restart the engines. The AFM provides a single-engine restart procedure but does not provide a dual-engine restart procedure. The Safety Board concludes that AFM procedures are necessary to provide pilots proper guidance if a dual-engine flameout occurs.

Conditions for engine and airframe ice formation are ideal when the outside air temperature is approximately 10°C or below with visible moisture (with a temperature/dew point spread of 3°C or greater). However, engine inlet duct icing can occur without airframe icing at ambient temperatures above freezing when intake air is drawn into the engine rather than being rammed in, such as when an airplane is climbing at low speed and high power. The suction reduces the static air pressure within the inlet duct, causing the incoming air to expand and cool to subfreezing temperatures. Under those conditions, with outside air temperatures well above freezing, ingested water vapor will freeze and be deposited in the engine inlet duct. The pilot may not recognize the potential for engine inlet icing conditions and may not anticipate the need to take specific actions to prevent an engine flameout.

Most TPE331-powered airplanes have a pilot-activated engine anti-ice system to prevent the accumulation of ice in the engine inlet duct. When selected by the pilot, the anti-ice system directs hot engine bleed air to the engine inlet lip to prevent ice formation in the engine inlet. This system is designed to be activated before ice accumulation; it is not intended as a deicing system. Activation of the anti-ice system after ice has accumulated can cause pieces of ice to shed from the inlet lip and cause an engine flameout. As an added flameout protection, some TPE331-powered Fairchild airplanes incorporate an "automatic" ignition system (see right side of figure 1) that can detect a flameout and automatically activate the ignition system. This system is

not truly automatic because the pilot must first select an ignition mode using a manually selectable three-position switch. Flameouts can be detected by the decay in certain engine parameters, such as engine revolutions per minute or torque. The automatic ignition system can relight the engine without pilot action or awareness of any engine or airplane performance changes if the ignition mode switch is in the automatic position.

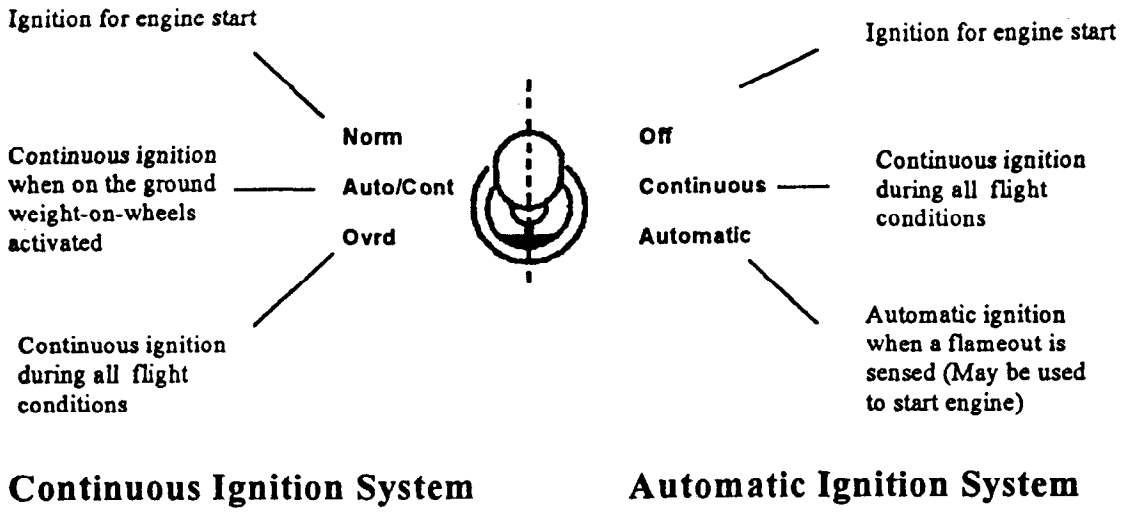

Figure 1. Typical Ignition Switch Position Labeling in TPE331-powered Airplanes

The Fairchild Aircraft ignition system installed in the Bullhead City and Blountville accident airplanes did not incorporate the automatic ignition system but a "continuous" ignition system (see left side of figure 1), which provides continuous ignition in flight when the pilot selects the "override" mode using a similar three-position switch. The Fairchild SA227-AC and SA227-TT airplane AFMs state that in advance of intentionally flying into icing conditions and heavy rain, the pilot should select engine and propeller heat and override ignition. The procedures for inadvertent flight-into-icing conditions state that after discovering ice accumulation, the pilot should select "override" ignition, then engine and propeller heat for one engine (to ensure that the engine is operating satisfactorily), and then engine and propeller heat for the other engine.

To address reports of ice-induced dual-engine flameouts in TPE331 engines, from 1982 through 1986, Garrett introduced two improved ignition system exciters,[3] and also issued various

[3] Garrett has introduced improvements that have increased the exciter duty cycle from 5 minutes to 1 hour to unlimited. All three of these exciter systems are still in use in TPE331-powered airplanes in the United States. The exciter serves to convert either AC or DC low-voltage power to a high-voltage potential for delivery to the igniter plug.

operating information letters[4] to emphasize the proper use of engine anti-ice and to provide additional information on the proper use of engine ignition systems in icing conditions. Additionally, on July 8, 1985, following a January 8, 1985, dual-engine flameout incident in Covington, Kentucky, the Safety Board issued Safety Recommendations A-85-50 through -52 to the Federal Aviation Administration (FAA) to require that Fairchild relabel the ignition switch positions on SA226 and SA227 airplanes to remove any ambiguity with regard to the ignition switch position, to issue an air carrier operations bulletin (ACOB) to advise operators of the appropriate use of the continuous ignition mode, and to require that Fairchild revise the SA226 and SA227 AFMs to include a warning to place the engine ignition system in the continuous mode during flight-into-icing conditions.

On December 15, 1986, the FAA responded to the Safety Board's recommendations by issuing Airworthiness Directives (ADs) 86-24-11 and 86-25-04, which required revision of Fairchild Aircraft SA226 and SA227 AFMs to include the new warnings and procedures for flight-into-icing conditions, and issuing an ACOB with procedures to prevent engine flameout during and after flight into heavy precipitation or icing conditions, but did not relable the switch positions. The Safety Board classified the recommendation to relabel the switch positions "Closed—Acceptable Alternate Action" because it believed the AFM changes regarding engine heat and continuous ignition eliminated the ambiguity of when to use each ignition mode.

The FAA also issued several ADs for other TPE331-powered airplanes, such as those manufactured by Beech, Dornier, Gulfstream, Mitsubishi, British Aerospace, and Pilatus Britten-Norman.[5] The ADs addressed flight limitations, engine ignition systems, engine flameout protection, placards, increased duty-cycle exciter units, automatic ignition systems, and changes to the AFMs.

The Safety Board is aware of 25 reported incidents of ice-induced engine flameouts of TPE331-powered airplanes since 1974. Many of these were dual-engine flameouts. Despite changes mandated by the ADs, the Bullhead City and the Blountville accidents show that these improvements do not prevent all ice-induced flameouts.

The accident data show that pilots may fail to recognize icing conditions and to take appropriate action to prevent ice-induced engine failures. Pilots can easily misinterpret icing conditions when the temperature is well above freezing, especially at night when they may be unable to observe ice formations. The data show that many ice-induced flameouts occur during approach and landing, which are periods of high crew workload. In all of these circumstances it is difficult for the pilot to recognize icing conditions and then to manually select the appropriate ignition switch position. The Safety Board is concerned that the current ignition system designs

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[4] On April 30, 1985, Garrett issued Operating Information Letter OI 331-11. After April 30, 1985, AlliedSignal reissued Operating Information Letter OI 331-11R1 in February 1988, OI 331-11R2 in November 1993, and OI 331-11R3 in April 1997. Additionally, on November 15, 1994, AlliedSignal issued Pilot Advisory Letter 331-04R1 regarding ice-induced dual-engine flameouts.

[5] Beech-AD 86-24-09, December 15, 1986; Dornier-AD 96-09-14, June 11, 1996; Gulfstream (Aero Commander)-AD 87-24-07R1, February 9, 1988; Mitsubishi-AD 84-12-04, AD 86-26-02, AD 96-25-02, dated June 29, 1984, December 31, 1986, December 12, 1996, respectively; British Aerospace-AD 86-24-10, December 15, 1986; Pilatus Britten-Norman-AD 91-05-09, March 25, 1991.

in TPE331-powered airplanes still leave those airplanes susceptible to ice-induced engine flameouts. Therefore, the Safety Board believes that the FAA should require that all TPE331-powered airplanes be equipped with an engine ignition system that is activated automatically (without pilot input) following an engine flameout. Because no dual engine flameout procedures are in the AFMs and many of the 25 reported ice-induced flameouts were dual-engine, as an interim measure, until an automatically activated ignition system is installed, the Safety Board believes that the FAA should require that the AFMs or pilot's operating handbooks for all TPE331-powered airplanes be modified, if necessary, to incorporate dual-engine failure or flameout procedures.

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

> Require that all TPE331-powered airplanes be equipped with an engine ignition system that is activated automatically (without pilot input) following an engine flameout. (A-98-65)
>
> As an interim measure, until an automatically activated ignition system is installed, require that the airplane flight manuals or pilot's operating handbooks for all TPE331-powered airplanes be modified, if necessary, to incorporate dual-engine failure or flameout procedures. (A-98-66)

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

By: Jim Hall
Chairman

Enclosures

National Transportation Safety Board
Washington, D.C. 20594

Brief of Accident

Adopted 03/16/1994

ATL93MA068
FILE NO. 470 04/01/93 BLOUNTVILLE,TN AIRCRAFT REG. NO. N500AK TIME (LOCAL) - 21:28 EST

MAKE/MODEL - Fairchild SA227-TT
ENGINE MAKE/MODEL - Garrett TPE331-10U513
AIRCRAFT DAMAGE - Destroyed
NUMBER OF ENGINES - 2

	FATAL	SERIOUS	MINOR/NONE
CREW	1	0	0
PASS	3	0	0

OPERATING CERTIFICATES - None
TYPE OF FLIGHT OPERATION - Executive/corporate
REGULATION FLIGHT CONDUCTED UNDER - 14 CFR 91

LAST DEPARTURE POINT - KNOXVILLE,TN
DESTINATION - Same as Accident

AIRPORT PROXIMITY - Off airport/airstrip
AIRPORT NAME - TRI-CITY REGIONAL
RUNWAY IDENTIFICATION - 23
RUNWAY LENGTH/WIDTH (Feet) - 7999/ 150
RUNWAY SURFACE - Asphalt
RUNWAY SURFACE CONDITION - Dry

CONDITION OF LIGHT - Night (dark)

WEATHER INFO SOURCE- Weather observation facility

BASIC WEATHER - Visual (VMC)
LOWEST CEILING - 3500 FT Broken
VISIBILITY - 0006.000 SM
WIND DIR/SPEED - 250 /013 KTS
TEMPERATURE (F) - 46
OBSTR TO VISION - None
PRECIPITATION - None

PILOT-IN-COMMAND AGE - 48

CERTIFICATES/RATINGS
Commercial, Airline transport
Single-engine land, Multiengine land
INSTRUMENT RATINGS
Airplane

FLIGHT TIME (Hours)

TOTAL ALL AIRCRAFT - 19105
LAST 90 DAYS - Unk/Nr
TOTAL MAKE/MODEL - 235
TOTAL INSTRUMENT TIME - Unk/Nr

N500AK ENCOUNTERED ICING IN FLIGHT BEFORE START OF ILS APPROACH. RADAR DATA SHOWED THAT BEFORE REACHING OUTER MARKER, IT SLOWED IN A MANNER THAT WAS CONSISTENT WITH A POWER REDUCTION (OR PARTIAL LOSS OF POWER), THEN IT ENTERED A STEEP DESCENT & CRASHED. EXAMINATION REVEALED ENGINES WERE NOT OPERATING AT IMPACT & THAT PROPELLERS HAD BEEN FEATHERED. NO PREIMPACT PART FAILURE OR MALFUNCTION OF ENGINES, PROPELLERS OR ANTI-ICE SYSTEM WAS FOUND. THERE WAS EVIDENCE THAT ENGINE INLET ANTI-ICE ANNUNCIATOR LIGHTS & STABILITY AUGMENTATION SYSTEM (SAS) FAULT WARNING LIGHT WERE ILLUMINATED DURING IMPACT. THE ENGINE MANUFACTURER REPORTED THAT FLAMEOUTS HAD OCCURRED IN OTHER AIRCRAFT, DURING OR FOLLOWING OPERATION IN ICING CONDITIONS, SOMETIMES AFTER DESCENT INTO WARMER AIR. FLIGHT MANUAL NOTED THAT IF ICING WAS ENCOUNTERED WITH ANTI-ICE SYSTEM OFF, SELECT CONTINUOUS IGNITION & THEN SELECT ENGINE & PROPELLER HEAT (1 ENGINE AT A TIME, ENSURING FIRST ENGINE WAS OPERATING SATISFACTORILY BEFORE SELECTING SECOND ENGINE) & ENGAGE SAS HEAT.

Brief of Accident (Continued)

ATL93MA068
FILE NO. 470 | 04/01/93 | BLOUNTVILLE,TN | AIRCRAFT REG. NO. N500AK | TIME (LOCAL) - 21:28 EST

Occurrence# 1 IN-FLIGHT ENCOUNTER WITH WEATHER
Phase of Operation CRUISE

Findings
1. - LIGHT CONDITION - DARK NIGHT
2. - WEATHER CONDITION - ICING CONDITIONS
3. - NACELLE/PYLON - ICE

Occurrence# 2 LOSS OF ENGINE POWER(TOTAL) - NON-MECHANICAL
Phase of Operation APPROACH - IAF TO FAF/OUTER MARKER (IFR)

Findings
4. - ALL ENGINES
5. - PROCEDURES/DIRECTIVES - NOT FOLLOWED - PILOT-IN-COMMAND
6. - ANTI-ICE/DEICE SYSTEM - IMPROPER USE OF - PILOT-IN-COMMAND

Occurrence# 3 LOSS OF CONTROL - IN FLIGHT
Phase of Operation DESCENT - EMERGENCY

Findings
7. - AIRSPEED - NOT MAINTAINED - PILOT-IN-COMMAND
8. - STALL - INADVERTENT - PILOT-IN-COMMAND

Occurrence# 4 IN-FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation DESCENT - UNCONTROLLED

The National Transportation Safety Board determines that the probable cause(s) of this accident was:
FAILURE OF THE PILOT TO FOLLOW PROCEDURES CONCERNING USE OF THE ENGINE INLET ANTI-ICE SYSTEM AND/OR CONTINUOUS IGNITION WHILE OPERATING IN ICING CONDITIONS, WHICH RESULTED IN PROBABLE ICE INGESTION AND LOSS OF ENGINE POWER; AND THE PILOT'S FAILURE TO MAINTAIN SUFFICIENT AIRSPEED WHILE COPING WITH THE ENGINE PROBLEM, WHICH RESULTED IN A STALL. FACTORS RELATED TO THE ACCIDENT WERE: DARKNESS, ICING CONDITIONS, AND ENGINE INLET (NACELLE) ICE.

National Transportation Safety Board
Washington, D.C. 20594

Brief of Accident

Adopted 03/25/1998

LAX97FA082
FILE NO. 577 01/05/97 BULLHEAD CITY,AZ AIRCRAFT REG. NO. N165SW TIME (LOCAL) - 12:43 MST

MAKE/MODEL - Fairchild SA227-AC
ENGINE MAKE/MODEL - Garrett TPE331-11U612
AIRCRAFT DAMAGE - Destroyed
NUMBER OF ENGINES - 2

	FATAL	SERIOUS	MINOR/NONE
CREW	0	0	2
PASS	0	0	19

OPERATING CERTIFICATES - On-demand air taxi
NAME OF CARRIER - FNG AVIATION INC
TYPE OF FLIGHT OPERATION - Non-scheduled
- Domestic
- Passenger

REGULATION FLIGHT CONDUCTED UNDER - 14 CFR 135

LAST DEPARTURE POINT - LONG BEACH,CA
DESTINATION - GRAND CANYON,AZ

AIRPORT PROXIMITY - Off airport/airstrip

CONDITION OF LIGHT - Daylight

WEATHER INFO SOURCE- Weather observation facility

BASIC WEATHER - Visual (VMC)
LOWEST CEILING - None
VISIBILITY - 0020.000 SM
WIND DIR/SPEED - 010 /007 KTS
TEMPERATURE (F) - 50
OBSTR TO VISION - None
PRECIPITATION - None

PILOT-IN-COMMAND AGE - 33

CERTIFICATES/RATINGS
Airline transport
Single-engine land, Multiengine land
INSTRUMENT RATINGS
Airplane

FLIGHT TIME (Hours)

TOTAL ALL AIRCRAFT - 3200
LAST 90 DAYS - 50
TOTAL MAKE/MODEL - 300
TOTAL INSTRUMENT TIME - 250

After executing a missed approach at the Grand Canyon Airport, the pilots diverted to the Bullhead City Airport. The pilots reported that minimal icing conditions were encountered with about 1/8 inch of ice accumulating on the aircraft wings. The pilots stated they cycled the deice boots to shed ice. They did not observe ice on the propeller spinners, and they did not activate the engines' "override" ignition systems, as required by the airplane's flight manual. Use of "override" ignition was required for flight into visible moisture at or below +5 degrees Celsius (+41 degrees Fahrenheit) to prevent ice ingestion/flameouts. Subsequently, both engines flamed out as the airplane was on about a 3 mile final approach for landing with the landing gear and flaps extended. The aircraft was destroyed during an off-airport landing.

LAX97FA082
FILE NO. 577 | 01/05/97 | BULLHEAD CITY,AZ | AIRCRAFT REG. NO. N165SW | TIME (LOCAL) - 12:43 MST

Occurrence# 1 IN-FLIGHT ENCOUNTER WITH WEATHER
Phase of Operation CRUISE

Findings
1. - WEATHER CONDITION - ICING CONDITIONS
2. - AIRFRAME - ICE

Occurrence# 2 LOSS OF ENGINE POWER(TOTAL) - NON-MECHANICAL
Phase of Operation APPROACH

Findings
3. - ALL ENGINES
4. - IGNITION SYSTEM,AUTO RE-LIGHT SYSTEM - NOT INSTALLED
5. - AIRCRAFT/EQUIPMENT INADEQUATE
6. - IGNITION SYSTEM,IGNITER - NOT ACTIVATED
7. - CHECKLIST - NOT FOLLOWED - PILOT-IN-COMMAND
8. - MISCELLANEOUS,ENGINE - ICE INGESTION

Occurrence# 3 FORCED LANDING
Phase of Operation EMERGENCY DESCENT/LANDING

Occurrence# 4 IN-FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation EMERGENCY LANDING

Findings
9. - TERRAIN CONDITION - NONE SUITABLE

The National Transportation Safety Board determines that the probable cause(s) of this accident was: failure of the pilot(s) to use "override" ignition as prescribed by checklist procedures during an encounter with icing conditions, which subsequently led to ice ingestion and dual engine flame-outs. Factors related to the accident were: the adverse weather (icing) conditions, the accumulation of airframe/engine ice, and lack of suitable terrain in the emergency landing area.