



Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Investigation – AO-2007-019

Final

Icing event – 50 km SW Canberra – 4 July 2007

VH-VEG

Beech Aircraft Corp B58



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Reserved.

Abstract

On 4 July 2007, the pilot of a Beech Aircraft Corporation B58 (Baron), registered VH-VEG, was conducting a charter flight in accordance with the instrument flight rules from Sydney, NSW to Shepparton, Vic. At about 1415 Eastern Standard Time, the pilot departed Sydney Airport with one passenger on board. The flight was planned via overhead Canberra, ACT and Albury, NSW. The weather forecasts obtained by the pilot indicated that in the Canberra area the freezing level would be about 6,000 ft above mean sea level (AMSL) and that broken cumulus or stratocumulus cloud could be expected to extend between 5,000 and 10,000 ft with moderate icing in cloud. The aircraft was not equipped for flight into icing conditions.

The pilot climbed the aircraft to the planned cruise altitude of 10,000 ft AMSL and was generally clear of cloud until over Canberra at 1532. At about 50 km to the south-west of Canberra the aircraft entered cloud with high moisture content at a temperature below 0 degrees C, resulting in the rapid accumulation of clear ice on the airframe. The pilot continued on track, but the build-up of ice eventually forced the pilot to descend below 7,500 ft, the published lowest safe altitude for the route. After maintaining 7,100 ft in cloud for a short time the pilot was cleared to descend to 4,900 ft. The pilot became visual and was able to descend further and to dislodge the ice.

The investigation found that the pilot was inexperienced operating in conditions conducive to icing and had not assimilated the guidance provided by the operator and the aircraft manufacturer.

While on this occasion the aircraft did not get very close to terrain, the circumstances of the occurrence are a salutary reminder of the hazard that winter weather in southern Australia can present to pilots of aircraft not equipped for flight in icing conditions.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external organisations.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

Sequence of events

On 4 July 2007, the pilot of a Beech Aircraft Corporation B58 (Baron), registered VH-VEG, was conducting a charter flight in accordance with the instrument flight rules (IFR) from Sydney, NSW to Shepparton, Vic. At about 1415 Eastern Standard Time¹, the pilot departed Sydney Airport with one passenger on board. The flight was planned via overhead Canberra, ACT and Albury, NSW.

The pilot climbed the aircraft to the planned cruise altitude of 10,000 ft² and was clear of cloud until over the top of Canberra at 1532. The pilot recounted that, after passing Canberra, the aircraft was in and out of cloud and picked up some light rime³ ice. There was no noticeable effect on aircraft performance and the pilot continued on. About 10 minutes later, when the aircraft was in cloud, significant amounts of clear ice quickly built up on the aircraft.

The aircraft started to slow down, so the pilot increased engine power to maintain an indicated airspeed of at least 120 kts. At 1546, when the aircraft was about 27 NM (50 km) south-west of Canberra (Figure 1), the pilot transmitted 'how many track miles roughly before we can descend as we are picking up a fair bit of ice' to the enroute air traffic controller. The controller cleared the pilot to descend to 7,700 ft, which was the published grid⁴ lowest safe altitude. By 1551, the pilot was maintaining 7,700 ft and was still in cloud.

At 1558, the pilot transmitted a request for further descent or a diversion to the right of the aircraft's track. The enroute controller offered 7,500 ft with a further descent to 4,900 ft at the next on-track waypoint ARRAN. The aircraft was 30 NM (55 km) from ARRAN when the pilot advised the controller that the aircraft had picked up a 'fair bit of ice' and that he would have to descend. Recorded radar information showed a gradual descent to 7,100 ft.

The enroute controller established that the lowest safe altitudes to the right of the aircraft's track were above 7,000 ft and were therefore not immediately helpful. He consulted with the Albury tower controller who was able to offer a grid lowest safe altitude of 4,900 ft before ARRAN. At 1604, the enroute controller offered the pilot a descent to 4,900 ft. The pilot descended the aircraft, and at 1605 advised that he was visual and would be continuing descent while remaining clear of cloud to remove the ice. The ice dislodged from the aircraft and the pilot continued the flight to Shepparton.

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- 1 The 24-hour clock is used in this report to describe the local time of day. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.
 - 2 Unless otherwise stated, the quoted altitudes are referenced to mean sea level.
 - 3 Aircraft icing is described in the 'Aircraft icing' section following.
 - 4 Instrument flight rules charts used by controllers and pilots are divided into squares that have a specified lowest safe altitude applicable to that defined area.

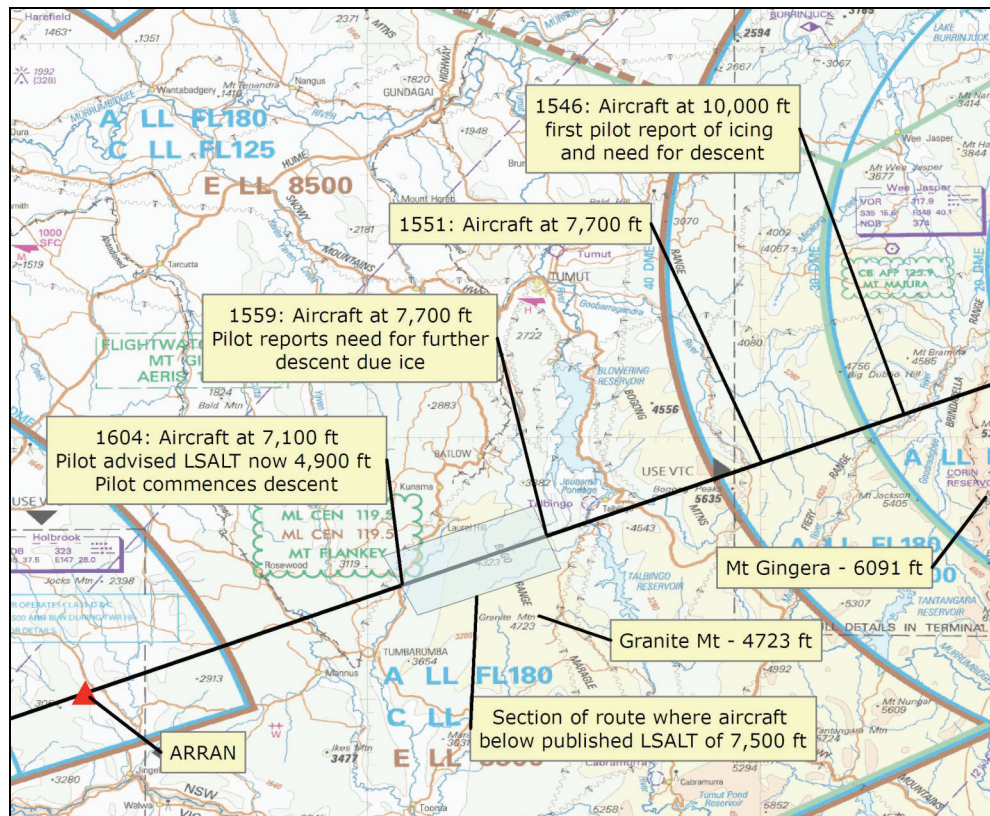
Geographical information

The track flown by the pilot between Canberra and Albury passed over the Brindabella range about 23 NM (43 km) to the south-west of Canberra. The highest spot height shown on the Sydney Visual Navigation Chart (VNC) within 10 NM (19 km) of the track was Mt Gingera at 6,091 ft. The Canberra to Albury route lowest safe altitude was 7,500 ft.

When the aircraft initially descended to 7,100 ft, the aircraft was about 20 NM (37 km) south of Tumut. The highest terrain shown on the VNC within 10 NM (19 km) of the aircraft's track while it was below the published lowest safe altitude was Granite Mountain, at 4,723 ft.

An alternative IFR route from Sydney to Albury was via Yass NDB⁵ and Wagga Wagga. That route was 17 NM (32 km) longer than the route planned by the pilot and the lowest safe altitudes were 4,600 ft and 3,600 ft for the respective route segments.

Figure 1: Sydney Visual Navigation Chart extract



Meteorological information

The Bureau of Meteorology produced aviation forecasts for defined geographical areas. For pilots, those area forecasts are an important source of information about enroute weather conditions.

⁵ Non directional beacon.

The area 21 forecast was applicable to the part of the route from Sydney to midway between Canberra and Albury. The forecast obtained by the pilot was valid from 0815 to 2100. It predicted scattered⁶ showers falling as snow above 4,500 ft to the west of Canberra. The forecast cloud in the vicinity of ranges was broken⁷ cumulus or stratocumulus between 5,000 ft and 10,000 ft. The freezing level was predicted to be 6,000 ft and moderate icing conditions were forecast in cumulus cloud.

The area 30 forecast was applicable for the rest of the flight. The forecast obtained by the pilot was valid from 0810 to 2100. The forecast cloud included areas of broken cumulus or stratocumulus between 3,000 and 8,000 ft near ranges and scattered cumulus tops to 16,000 ft. Broken altocumulus or altostratus was forecast above 10,000 ft. The freezing level was predicted to be between 5,000 and 6,000 ft and moderate icing was forecast in cloud.

Following the incident, the Bureau of Meteorology reviewed the available weather records and advised that at about the time and location of the incident, significant areas of cloud existed above 4,000 ft to 5,000 ft and, in some cases, cumulus cloud tops extended above 10,000 ft. Given the temperature within much of the cloud layer was below 0 degrees C and the cloud type, it was likely that significant amounts of supercooled droplets (liquid water below freezing) would have been present within cloud above the freezing level of 6,000 to 7,000 ft.

Pilot and operator information

The pilot held a commercial pilot (aeroplane) licence and a command multi-engine instrument rating. At the time of the icing event, the pilot had flown a total of 2,700 hours including 150 hours on the aircraft type.

Most of the pilot's commercial flying experience was acquired in the Northern Territory. In April 2007, after about 3 years in the Territory, the pilot began flying for the Canberra-based operator of VH-VEG. Initial training and checking of the pilot included an IFR check flight and a number of IFR flights as pilot in command under supervision.

The pilot related that flying in weather conditions that were conducive to airframe icing was a new experience for him. He considered that the operator had done a 'pretty good job' of preparing him for flying in icing conditions. In addition, the pilot had read articles about the dangers of icing in recent editions of the *Flight Safety Australia* magazine published by the Civil Aviation Safety Authority. That safety information was excellent, the pilot commented, but the dangers were not fully appreciated until they were experienced. Since being based at Canberra, the pilot had encountered some light rime icing, but not any clear ice while conducting flights.

The operator explained that the pilot induction process had included information pertinent to routes in the Canberra area, satisfying the route qualification requirements of Civil Aviation Regulation 219 in the process. That included information about the seasonal airframe icing risk in the high terrain of the Canberra area. New pilots were informed about previous icing events and were

⁶ Scattered = 3 to 4 eights of the visible sky covered by cloud.

⁷ Broken = 5 to 7 eights of the visible sky covered by cloud.

advised that if icing occurred in the Baron aircraft to maintain a minimum of 120 kts indicated airspeed. Pilots were also advised to select a different route or to cancel a flight if the freezing level was below the direct-route lowest safe altitude.

The *Flight Operations Department - Policy and Procedures Manual* produced by the operator contained information about airframe ice and icing conditions. It included the following guidance:

Operation of aircraft not approved (by Aircraft Flight Manual) for flight into known or forecast icing conditions is prohibited. Consideration must be given to changing cruising altitude or the route, diverting if necessary. Routes that offer a lower safe altitude may give better options and should be considered.

If inadvertent penetration of icing weather in a non-approved aircraft occurs the pilot must, without delay;

- Turn back out of the icing conditions
- Descend below the freezing level
- Climb above the freezing level clear of cloud, if the performance of the aircraft is adequate to do so.

Other operational information

The aircraft was not certified or equipped for flight in icing conditions. It was fitted with pitot heat, which the pilot advised was selected on during the icing event. As an unpressurised aircraft without supplemental oxygen, operation was limited to not above 10,000 ft.

The BE58 *Pilot's Operating Handbook and FAA approved Airplane Flight Manual* (POH/AFM) contained the following warnings:

Flight in known icing conditions prohibited

Stalling airspeeds should be expected to increase due to the distortion of the wing airfoil when ice has accumulated on the airplane. For the same reason, stall warning devices are not accurate and should not be relied upon. With ice on the airplane, maintain a comfortable margin of airspeed above the normal stall airspeed.

The safety information section of the POH/AFM included a sub-section titled flight in icing conditions. While the safety information was intended for pilots of aircraft equipped for flight in icing conditions, it included the following advice:

An airplane which is not approved or certificated for flight in icing conditions, or which does not have all the critical areas protected in the required manner by fully operational anti-icing equipment must not be exposed to icing encounters of any intensity. When icing is detected, the pilot of such an airplane must make an immediate diversion by flying out of the area of visible moisture or going to an altitude where icing is not encountered.

There was also a recommendation that if the POH/AFM did not specify a minimum speed for flight in icing conditions, the speed in icing conditions for the Baron models should be 130 kts.

Civil Aviation Regulation 238 referred to flight in icing conditions. Essentially, a pilot was not permitted to fly into known or expected icing conditions if the aircraft was not equipped with anti-icing or de-icing equipment.

Civil Aviation Regulation 178 specified the minimum height for flight under the IFR. Put simply, during cruise, the pilot of an aircraft in cloud was not permitted to descend below the published or calculated lowest safe altitude in cloud unless instructed to do so by air traffic control.

The lowest safe altitudes for IFR routes were published in Aeronautical Information Publication MAP. Those altitudes provided at least 1,000 ft clearance above the terrain or highest obstacle.

Aircraft ice⁸

The ice that forms on aircraft surfaces and components is known as structural or airframe ice. Ice forms when supercooled water droplets impinge on surfaces and freeze. Nearly all aircraft icing occurs in supercooled clouds. Ice accumulation is often greatest at temperatures not too far below 0 degrees C, where liquid water can be plentiful, and is usually negligible at temperatures below -20 degrees C, because most clouds are made up of ice particles. The greater the liquid water content of the cloud, the more rapidly ice accumulates on aircraft surfaces.

The type of ice that forms varies depending on the atmospheric and flight conditions in which it forms. Airframe ice is described as clear, rime or mixed (combination of clear and rime ice formed on the same surface).

Clear ice is glossy and transparent. It is formed by the relatively slow freezing of supercooled water. This type of ice is denser and harder than rime ice. Temperatures close to the freezing point, large amounts of liquid water, high aircraft velocities, and large droplets are conducive to the formation of clear ice.

Rime ice is rough, milky and opaque. It is formed by the instantaneous or very rapid freezing of supercooled water droplets as they strike the aircraft. The rapid freezing results in the formation of air pockets in the ice, giving it an opaque appearance and making it porous and brittle. Low temperatures, lesser amounts of liquid water, low aircraft velocities, and small droplets favour the formation of rime ice.

An aircraft without airframe ice protection that accumulates ice will sustain an increase in drag, which the pilot detects as a loss of airspeed. To maintain the same airspeed, an increase of engine power is required. The formation of ice on the wings can also significantly reduce the maximum coefficient of lift and the angle of attack at which it occurs. In that case, the aircraft will stall (aerodynamically) at a lower angle of attack and higher airspeed.

Airframe icing can also affect the operation of flight control surfaces, propellers, antennas, cooling inlets, pitot-static systems, stall warning systems and windscreens.

⁸ The information in this section has been adapted from FAA Advisory Circular AC 91-74 *Pilot Guide - Flight in Icing Conditions*, 12/12/02.

Aircraft certified for flight in icing conditions are equipped with anti-icing or de-icing systems. Anti-icing systems prevent the accumulation of ice usually through application of electric heat, hot air or chemicals. De-icing systems disrupt accumulated ice through inflation and deflation of pneumatic boots or through electro-impact systems.

ANALYSIS

The aircraft entered cloud with high moisture content at a temperature below 0 degrees Celsius, resulting in the rapid accumulation of clear ice on the airframe. The build-up of ice forced the pilot to descend below the specified lowest safe altitude for a short time. While on this occasion the pilot maintained control of the aircraft and did not get very close to terrain, the circumstances of the occurrence are a salutary reminder of the hazard that winter weather in southern Australia can present to pilots.

The weather forecasts available to the pilot before the flight indicated that in the Canberra area the freezing level would be about 6,000 ft and that broken cumulus or stratocumulus cloud would be up to 10,000 ft. The weather towards Albury was expected to be similar, with scattered cumulus tops to 16,000 ft and broken altocumulus or altostratus above 10,000 ft. Moderate icing was forecast in cloud. If the forecasts were realised, airframe icing at 10,000 ft was a definite possibility.

By flight planning overhead Canberra, the pilot exposed the aircraft to the risk of airframe icing on a route where the lowest safe altitude of 7,500 ft prevented a descent to below the freezing level. The pilot's limited exposure to reading and interpreting forecasts with icing, resulting from his flying in northern Australia, might have contributed to the flight planning decisions. Had the pilot tracked via Yass NDB and Wagga Wagga, the aircraft might still have accumulated ice, but the lowest safe altitudes would have allowed descent below the freezing level and dislodgement of the ice.

Rime ice resulted from the aircraft entering cloud tops after passing Canberra. Although the aircraft was not equipped for any icing conditions, previous exposure to rime ice might have induced the pilot to think that there was no significant threat posed by the weather conditions. Ten minutes or so after the rime ice appeared, however, the aircraft entered cloud with higher moisture content and clear ice rapidly accumulated.

On an aircraft without anti-icing or de-icing, the formation of clear ice on the airframe poses an immediate and significant threat to aircraft performance and controllability. In accordance with the guidance provided by the aircraft manufacturer and the operator, a pilot should divert out of icing conditions or descend below the freezing level. In this case, the pilot did not divert and was initially unable to descend to below the freezing level due to a higher lowest safe altitude. The quick formation of the clear ice surprised the pilot. That, and the pilot's relative inexperience in operating in southern Australian winter conditions, probably contributed to the pilot's decision to continue on track and attempt to maintain cruise altitude.

The Canberra-based operator provided pilots with written information and guidance about airframe icing, and senior pilots passed on stories of encounters with icing. However, it appears that the pilot did not assimilate that information and during flight planning and while enroute, did not foresee the consequences of entering the cloud above the freezing level and continuing on-track with accumulated ice. While guidance material and informal training is helpful, they don't provide a high level of assurance that a pilot with minimal operating experience in icing conditions will manage an inadvertent clear icing event appropriately. In that context, the provision

of a formal training course about airframe ice may enhance understanding of the risks and reduce the occurrence of inadvertent icing events.

FINDINGS

Contributing safety factors

- The actual weather conditions in the vicinity of the Canberra to Albury route were generally consistent with the applicable forecast of a 6,000 ft freezing level and broken cumulus and stratocumulus cloud up to 10,000 ft in the vicinity of the ranges.
- The pilot flight planned from Sydney to Shepparton at 10,000 ft via the Canberra to Albury route, part of which had a published lowest safe altitude of 7,500 ft.
- The aircraft was not equipped for flight into known icing conditions.
- The aircraft entered a substantial cloud mass that had a high moisture content at a temperature below 0 degrees Celsius, resulting in the rapid accumulation of clear ice on the airframe.
- By continuing on the flight planned track, the pilot's response to the formation of clear ice was not in accordance with the guidance provided by the operator and aircraft manufacturer and that led to the forced descent below lowest safe altitude.
- The operator's training and guidance did not provide a high level of assurance that a pilot would be equipped with the requisite knowledge and skills to manage an inadvertent clear icing event appropriately.

Other key findings

- Although the aircraft operated 400 ft below the published lowest safe altitude of 7,500 ft for about 4 minutes, the highest terrain within 10 NM (19 km) of the aircraft's track during that time was Granite Mountain, at 4,723 ft.

SAFETY ACTIONS

Aircraft operator

Following the icing event, the aircraft operator produced a notice to aircrew (NOTAC) titled 'Operation of Aircraft not approved for flight in icing conditions'. The NOTAC reproduced the operations manual guidance regarding icing and included the following:

A recent incident has highlighted the requirement to ensure that if the lowest safe altitude is higher than the freezing level and there is forecast cloud that crew must plan an alternative route in aircraft not certified for flight in icing conditions.

For example a flight Canberra direct to Albury has a LSAIt of 7500ft. If the freezing level is below the LSAIt the flight must be planned via Yass and Wagga. If the freezing level is below the LSALT for that route, the flight cannot go ahead in IMC [instrument meteorological conditions].

The aircraft operator also advised that computer based training regarding airframe icing and a number of other risks had been developed for inclusion in the induction process. Existing pilots had also participated in the computer based training.