A STATISTICAL REVIEW OF AVIATION AIRFRAME ICING ACCIDENTS

Michal Filip – Peter Kandráč

For years, airframe icing has been recognized as a significant aviation hazard. An occurrence is defined as an accident when the operation of an aircraft, with the intent of flight, results in substantial damage to the aircraft or death or serious injury to any person. In contrast, an incident is an occurrence that influences the safety of an aircraft operation. The NTSB database was used to identify accidents in which airframe icing was either a cause or factor during the 19-year period from 1982-2000, with a factor defined as any condition or situation that played a role in the cause of the accident.
K e y w o r d s. Airframe icing accidents, statistical review of accidents,

1 INTRODUCTION

For years, airframe icing has been recognized as a significant aviation hazard. Icing encounters can lead to increased aerodynamic drag and weight, along with a reduction in lift and thrust. Together, these factors result in a higher stall speed and degradation in overall aircraft performance. To maintain altitude and counter the effects of drag during flight in icing conditions, the angle of attack is generally increased and power is applied to the engine(s). This can further expose unprotected regions of the aircraft to ice accretions. If exposure is prolonged, the aircraft will lose the ability to continue stable flight.

Of equal importance is ice that accumulates on aircraft surfaces prior to takeoff. One of the first jet air transport category accidents linked to airframe icing occurred on December 27, 1968. A Douglas DC-9, operated by Ozark Air Lines, Inc., crashed shortly after takeoff. In this case, the aircraft suffered substantial performance penalties when it was subjected to freezing drizzle before takeoff.

Considerable progress has been made in understanding the meteorological conditions associated with airframe icing. A substantial amount of interest and research into icing, with attention to supercooled large droplets (SLD), was generated when an ATR-72 was destroyed after it experienced an uncommanded departure from controlled flight and crashed near Roselawn, Indiana (1994). A ridge of ice that accreted behind the de-icing boots contributed to an unanticipated aileron hinge moment reversal and an abrupt loss of control. The accident raised awareness about the hazards of operating in SLD conditions, which are not accounted for in 14 Code of Federal Regulations (CFR) Part 25, Appendix C. Because supercooled large droplets can run back and freeze on surfaces behind an airplane’s de-icing boots, it is extremely hazardous.

In recent years, icing research has translated into applied technologies aimed at diagnosing and forecasting icing hazards for both ground and in-flight aviation operations. Continued development and improvement of such technologies, along with training initiatives, will aid in reducing the number of icing related accidents.

Past research has documented the hazards of aircraft icing by identifying icing related accidents in the late 1970s and 80s. The study herein attempts to provide contemporary statistics on airframe icing accidents by examining events that took place from 1982 to 2000. Although airframe icing accidents only accounted for a small percentage of the total aviation accidents, they resulted in 583 accidents and more than 800 fatalities during the 19-year period.

2 DATA AND METHODOLOGY

The National Transportation Safety Board maintains a database of civil aviation accidents and incidents. An occurrence is defined as an accident when the operation of an aircraft, with the intent of flight, results in substantial damage to the aircraft or death or serious injury to any person. In contrast, an incident is an occurrence that influences the safety of an aircraft’s operation, but does not meet the criteria for an accident (49 Code of Federal Regulations (CFR) 830.2). The NTSB database is composed mainly of accidents and contains over 650 fields for each accident record, including information regarding the aircraft, environment, crew, injuries, and phase of flight. The database was used to identify accidents in which airframe icing was either a cause or factor during the 19-year period from 1982-2000, with a factor defined as any condition or situation that played a role in the cause of the accident. This period was chosen to exclude the influence of September 11 and to ensure data continuity.

For portions of this study, accidents were stratified into their respective segments of operation, which include general aviation (GA) and 14 CFR Parts 135 and 121. The majority of general aviation flights are personal and recreational in nature; however, some flights are conducted with the intent of generating revenue. In general, GA constitutes civil aviation operations not covered under 14 CFR Parts 135 and 121. Part 135 generally refers to commuter airlines (i.e. scheduled) and air taxis (i.e. non-scheduled), and Part 121 normally references major airlines and cargo carriers. Because of distinct operating characteristics within the Part 135 segment of operations, further segregation into schedule and non-scheduled operations was performed. The regulatory differences between scheduled and non-scheduled Part 135 operations is beyond the scope of this paper, but detailed definitions pertaining to these sectors of operation can be found in 14 CFR 119.3.

3 FINDINGS

3.1 Annual Accidents, Fatal Accidents, and Fatalities

Figure 1 displays all airframe icing accidents from 1982 to 2000. The accidents have been grouped into the three predominant segments of aviation operations: GA, Part 135, and Part 121. It is clearly evident that GA accidents dominate the total number of accidents during the period. GA accidents were responsible for 80.6% of all airframe icing accidents, while Part 135 and Part 121 accounted for 17.6% and 1.7%, respectively. However, the annual GA accident rate significantly declined during the same period. The number of general aviation accidents dropped from a high of 49 in 1982 to 17 in 2000.

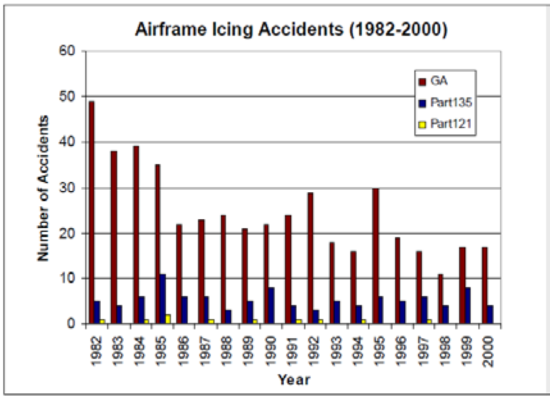

Figure 1. Aviation accidents associated with airframe icing for the period 1982-2000.

A graph depicting the number of fatal airframe icing accidents is provided in Figure 2. There were one or more fatalities in 47% of the GA accidents, while only 26% of Part 135 accidents were fatal. Six out of the ten Part 121 accidents during the period were fatal accidents.

Airframe icing accidents led to 819 deaths spanning the 19-year period reviewed in this study. As one might anticipate, GA accidents were responsible for the largest number of fatalities (522). The observed annual decrease in fatalities within the GA segment of operation is directly correlated with the decline in the overall number of GA accidents (Figure 3). Peaks in the number of fatalities linked to Part 135 and 121 operations are related to some very notable U.S. icing accidents, including Air Florida flight 90 (Washington, DC 1982), USAir flight 405 (Flushing, NY 1992), Comair flight 3272 (Monroe, MI 1997), and American Eagle flight 4184 (Roselawn, IN 1994).

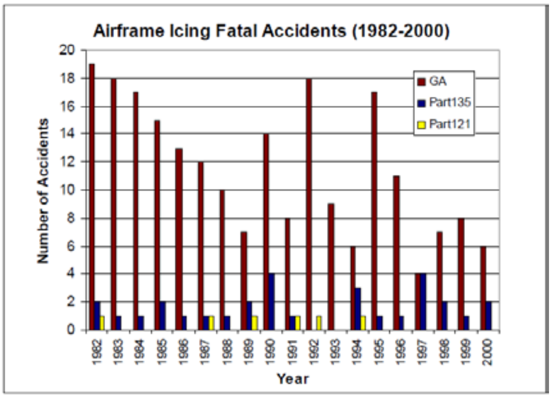

Figure 2. Fatal airframe icing accidents from 1982-2000.

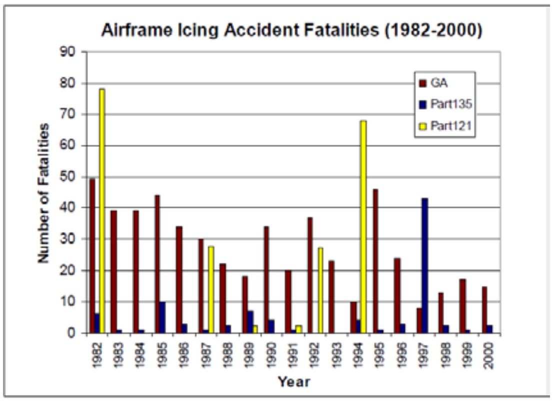

Figure 3. Fatalities resulting from airframe icing accidents for the period 1982-2000.

3.2 Annual Accidents, Fatal Accidents, and Fatalities

Eighty-one percent of all airframe icing accidents took place between the beginning of October and the end of March. Figure 4 presents the percentage of icing accidents by month, and it shows that the largest percentage of accidents happened in January. The monthly distribution of accidents is well-correlated with the frequency of freezing precipitation and ice pellets in the U.S. Cortinas et al. (2004) found freezing precipitation and ice pellets occur most frequently in the U.S. and Canada during December, January, and February. However, they noted that Arctic coastal regions experience these precipitation types mostly between May and October. Utilizing pilot reports and measurements from research aircraft, Bernstein and McDonough (2000) found a significant relationship between lower atmospheric SLD conditions and surface observations of freezing precipitation and ice pellets. General aviation and Part 135 aircraft traditionally fly at lower altitudes and at slower speeds than air transport category aircraft; as a result, they are more likely to encounter icing conditions, including SLD environments.

Although it is evident that icing accidents are more likely to occur in the winter months, it should be noted that icing accidents do occur throughout the year. Contrary to what might be expected, none of the summer accidents were located in Alaska. A more detailed examination of June, July, and August cases showed that these accidents were confined to the northern portions of the contiguous U.S.

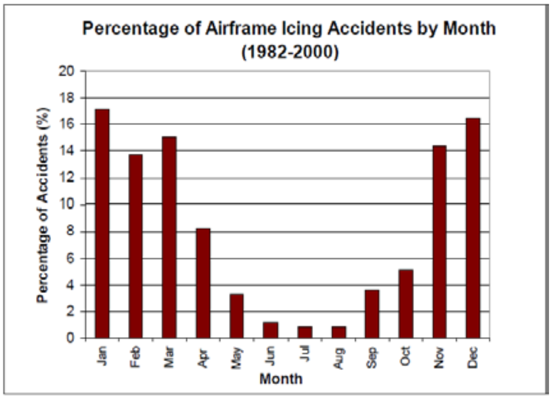

Figure 4. Percentage of airframe icing accidents by month for 1982-2000.

3.3 Phase of Flight

The NTSB accident database uses .occurrences to document and define the sequence of events for each accident. For example, an accident aircraft may have experienced (1) an in-flight encounter with weather, (2) a forced landing, (3) a runway overrun, and (4) an on- ground collision with an object. Associated with each of these occurrences is a phase of flight (e.g. takeoff, landing, etc.). This study uses the phase associated with the first occurrence in the accident to compute statistics related to phase of flight (Figure 5).

In Figure 5, the values in black indicate the percentage of accidents for each phase of flight, and those in blue represent the percentage of fatal accidents. The data show that almost 40% of airframe icing accidents occurred when the airplane was in cruise, and 50% of fatal accidents were also found in this phase of flight. This is a period when pilot workload is relatively low; thus, the opportunity to monitor and respond to icing should be reasonably high.

Takeoff accidents are responsible for almost 19% of airframe icing accidents and 11.7% of fatal accidents. The number of takeoff accidents would have been cut considerably if proper pre-flight inspections and de-icing procedures were followed. Seven out of the ten air transport category accidents reviewed in this study were takeoff accidents. Hence, attempting takeoff with frost/ice on an airframe is not only an issue in the general aviation community, but is a concern in all segments of aviation operations.

The percentage of total and fatal accidents that took place during the approach phase of flight is also noteworthy (15.8% and 14.9%, respectively). During the approach, adjustments are made to the configuration of the airplane (increase flap setting, reduce speed, etc.). When ice is present, configuration changes can cause an airplane to stall without warning.

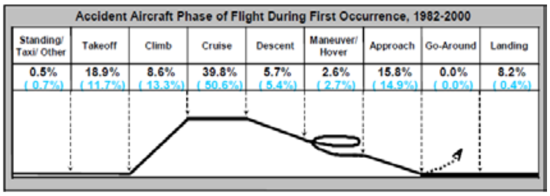

Figure 5. Percentage of accidents (black) and fatal accidents (blue) by phase of flight.

4 CONCLUSIONS

Airframe icing accident data for the period 1982-2000 suggests that that the number of icing related accidents is declining. The decline is mainly associated with the general aviation segment of aviation operations, which was responsible for the highest number of accidents during the period. It is conceivable that better icing analysis and forecasting techniques in recent years has played a role in reducing accidents. In addition, it is likely that pilots have become more aware of the hazards associated with airframe icing.

Icing accidents occurred throughout the year, with a peak frequency in January. A large part of accidents were located in mountainous regions and near large bodies of water. Operators should recognize that these areas may be more favourable for airframe icing.

Most accidents took place when the aircraft was in the cruise portion of flight. Takeoff accidents also accounted for a large fraction of icing related accidents. These findings suggest that flight-crews need to be more vigilant about ensuring airplanes are free of ice prior to departure. Even small amounts of frost on a wing can reduce its ability to generate lift. Every effort should also be made to monitor the aircraft for signs of icing while in flight. Pilots should have an understanding of how ice accretions will impact their aircraft's performance, keeping in mind that different aircraft will perform differently in identical icing conditions.

Airframe icing continues to be a serious aviation hazard, but following certain precautions and procedures can considerably reduce the probability of having an icing related mishap. Pilots should develop a comprehensive understanding of icing (type, environments, signs, etc.) and the impacts it can have on the performance of their aircraft. They should obtain current information regarding icing location, type, and severity along their route of flight just before departure, always make certain that frost/ice is removed prior to takeoff, and have an exit strategy in place in the event an unexpected icing encounter does occur.

5 REFEENCES

BIBLIOGRAPHY

[1] Bernstein, B.C., 2000: Regional and local influences on freezing drizzle, freezing rain, and ice pellet events. Wea. Forecasting, 15, 485-508.

[2] Sand, W.R., W.A. Cooper, M.K. Politovich, and D.L. Veal, 1984: Icing conditions encountered by a research aircraft. J. Climate Appl. Meteor., 23, 1427-1440.

[3] Politovich, M.K. and T.A.O. Bernstein, 2001: Aircraft icing conditions. J. Appl. Meteor., 41, 118-132.

[4] Cober, S.G., G.A. Isaac, and J.W. Strapp, 1995: Aircraft icing measurements in winter storms. J. Appl. Meteor., 34, 88-100.

[5] http://www.ntsb.gov/data

AUTHOR´(S) ADDRESS (ES)

Bc. Michal Filip, michael.filip@gmail.com
Ing. Peter Kandráč, PhD., peter.kandrac@tuke.sk

Reviewer: Ing. Róbert Rozenberg