FLIGHT SAFETY FOUNDATION
Accident Prevention
Vol. 45 No. 10 October 1988

Winter Flying: Sharing Experience

The author advises pilots to exchange winter operational information with one another as a means of spreading the benefit of collective experience with de-icing and anti-icing techniques.

by

Richard Clarke

Winter flying is not easy, and extensive flight crew experience with ice, slush, snow and sleet is not universal. Those pilots without it must listen, read or observe — preferably all three — before they can even begin to act independently in severe winter conditions.

Trial-and-effort flying in winter weather is a poor way to operate when knowledge can be gained by other means. It also is unwarranted when airlines and pilots who operate a certain type of aircraft in winter icing conditions discover its foibles and those of its engines and fail to pass them on to the aviation community as a whole.

An example of this unique knowledge is engine power indication. An engine may operate almost flawlessly in one aircraft, encountering few problems with ice. The same type of engine may be installed in another type of aircraft in a different location or type of installation and display entirely different icing characteristics.

If known and anticipated, the occurrence of engine ice usually can be handled satisfactorily. If an aircraft engine's forward pressure sensing probe becomes blocked, the engine pressure ratio (EPR) indication will be inaccurate. When applying power on takeoff, the pilot may see what appears to be a normal EPR indication accompanied by incompatible fuel flow and rpm. Recognition of the condition may lead to aborting the takeoff or advancing the throttles to achieve normal fuel flow and rpm. Circumstances and training should determine the pilot's action.

Unfamiliarity with the problem can lead to confusion and indecision. After an accident in which engine icing may have played a major role, it is interesting to hear a number of pilots say that in retrospect that such engine power problems are well known and easily compensated for in some aircraft. They may be known within the pilot ranks of a few experienced airlines but not necessarily by the crews of newer operators in the air transport field.

Hazards of Airfoil Ice

Another aspect of winter flying that must be re-emphasized is airfoil ice; accumulation of ice on the wings reduces lift dramatically. Although the ice-carrying capabilities of different types of airfoils vary, each is particularly sensitive to ice on the forward portion of the airfoil. A pilot cannot, by strength of will and aeronautical dexterity, avoid flow separation and the subsequent stall caused by the ice.

To quote aerodynamicist H.H. Hurt, Jr., "The most important surface of the airplane is the wing, and the formation of ice or frost can create significant changes in the aerodynamic characteristics." Remember that a pilot who chooses to attempt to defy the laws of aerodynamics is ignoring the increased drag and reduced lift caused by the ice or frost accumulation and their adverse affects on the airfoil characteristics. This can be offset only by a higher air speed to compensate for an increased stall speed. A pilot attempting to fly with airframe ice may become airborne — successfully — if the ice falls off uniformly, or he may become airborne- briefly — in ground effect.

The mobile equipment commonly used for the de-icing and anti-icing of larger aircraft is capable of rapidly applying solutions ranging from hot water to varying concentrations of water and ethylene glycol.

De-icing, the removal of accumulated frost, snow and ice from the airframe, can be accomplished with hot water when ambient temperatures are above freezing. At freezing temperatures, ethylene glycol is introduced into the water in increasing amounts as lower freezing ambient temperatures are experienced. The duration of the effectiveness of de-icing is limited when precipitation or freezing temperatures continue prior to takeoff.

Anti-icing — any method utilized to prevent ice accumulations — usually is performed with very high concentrations of ethylene glycol. However, anti-icing agents, like those for de-icing, also will lose effectiveness if the precipitation continues.

Follow Procedures

De-icing and anti-icing recommendations of the aircraft manufacturer and company procedures must be closely followed.

Another important aspect of winter is the accumulation of frozen precipitation on the runway. When this occurs, the length of time of the takeoff roll increases because of the drag of snow, ice or slush on the wheels. Air inlets become constricted, and control surfaces may become obstructed by the spray thrown from the wheels. If the pilot determines that the takeoff is going badly and decides to abort, the aircraft's stopping capability also is greatly reduced.

Wheel braking can be totally ineffective when the snow and slush turn into a frictionless surface beneath the wheels. When a pilot reviews the aircraft operating manual for revised stopping distances, he or she will find that in some countries the manual contains no correction factor or other indication of the increased stopping distance encountered in attempting to abort a takeoff under such conditions.

Refusal speeds and distances in some manuals are based only upon clear, dry runways.

There are several choices in dealing with ice. They include an abort on an icy runway, takeoff into a potential stall, asymmetric control effectiveness because of de-icing or waiting for an improvement in the weather. Both winter flying and decisionmaking require care, skill and knowledge. ♦

Handling Ice, Snow and Frost

The Three Horsemen of Winter can work independently or in concert to interfere with a smooth flight from A to B.

by

Robert I. Stanfield

Individually or together, they spell trouble.

Cold weather has again reached the Northern Hemisphere, and it is time for the reminder that cold-weather hazards can ruin a pilot's day — not to mention the effect they may have upon his or her aircraft and passengers. Following are some recent examples:

Few can forget the January 13, 1982, accident in which a Boeing 737, with 79 persons on board, struck Washington, D.C.'s 14th Street Bridge almost immediately after takeoff and crashed into the ice-covered Potomac River during a moderate-to-heavy snowfall and subfreezing temperatures. Seventy-four of the 79 persons on board and four occupants of vehicles on the bridge were killed.

The U.S. National Transportation Safety Board (NTSB) determined that the "probable cause" was the flight crew's failure to use engine anti-ice during ground operation and takeoff, their decision to take off with snow and ice on the airfoil surfaces of the aircraft and their failure to reject the takeoff during the early stages when anomalous engine instrument readings were suspected. (See the September, 1982, issue of the FSF FLIGHT SAFETY Digest for a full report on the NTSB findings - Ed.)

In an earlier instance, on February 12, 1979, a Nord 262 turboprop transport departed from Benedum Airport in Clarksburg, W. Va., with 25 persons on board. Fourteen seconds after liftoff, the aircraft crashed. Two persons were killed, another eight were seriously injured.

The probable cause? The NTSB cited the decision to take off with snow on the aircraft's wing and empennage surfaces. The result was a loss of lateral control and a loss of lift as the aircraft ascended out of ground effect. In this accident, the aircraft's wings and horizontal stabilizer, including the deicer boots, were partially covered by wet snow or frozen snow when the take off roll began.

Ice-related accidents are not limited to takeoffs.

Fuel Filter Icing

On February 16, 1982, a Nihon YS -I I A turboprop transport made an emergency landing with its gear partially retracted on the frozen Naknek River not far from its intended destination at Alaska's King Salmon Airport. The aircraft sustained substantial damage. Of the 36 passengers and three crew members on board, one crew member and two passengers were injured. Two fire fighters suffered minor injuries during the subsequent firefighting and rescue activities.

Why the emergency landing? Because, according to the NTSB report on the accident, one engine lost power because of icing in the fuel filter (after the fuel heaters had been turned off), followed by the overheating and destruction of the aircraft's second engine. The failure of the second engine was caused by over temperatures due to an excessive fuel flow for undetermined reasons.

The Board noted that the water in the fuel which turned into ice was not the result of improper handling but "of dissolved water coming out of a solution in a suspended state due to the unusually low fuel temperatures."

Landing Problems

There can be airport landing problems as well. On January 23, 1982, a DC- 10 jet transport carrying 212 persons slid off the end of the runway after landing at Boston's Logan International Airport. It plunged into the shallow waters of Boston Harbor at a speed of 49 knots. Two missing persons were presumed dead.

In this instance, the NTSB said the pilot was not provided sufficient information on the slippery condition of the ice- and snow-covered runway. Regretfully, the pilots did not know with any reasonable accuracy — since aircraft performance data are predicted on dry runways — the effects of runway contamination on stopping performance.

In the period 1976-1979, according to NTSB report, "Aircraft Icing Avoidance and Protection," there were a total of 16,997 aircraft accidents in the United States. Of these, about 17 percent, or 2,869, involved fatalities. During the same period, there were 178 accidents involving structural icing. Fifty-six percent, or 100, of these involved fatalities.

On the general-aviation side, only about 12,000, or 5.7 percent, of the then 21 1,000-aircraft U.S. general aviation fleet were certified by the U.S. Federal Aviation Administration (FAA) for flight into known icing conditions. Equipment on these aircraft is seldom adequate to handle severe icing. And, of those equipped with de-icing/anti -icing gear, most can operate safely in icing conditions for only a limited period of time.

Structural Ice

Structural ice, which can form on any external portion of an aircraft, reduces aerodynamic efficiency by decreasing lift and increasing drag. In severe instances, aerodynamic efficiency can be reduced to such an extent than an aircraft can no longer fly.

Induction system ice, which forms internally in the induction system, literally chokes up the breathing apparatus of an engine, causing loss of power and increased fuel consumption.

Thus, the total effect of aircraft icing is a loss of efficiency, both from an aerodynamic and a power standpoint. This loss of efficiency results in a number of adverse conditions, including decreased lift, increased drag, higher stalling speeds, loss of power, increased fuel consumption, lower flying speeds and decreased maneuverability.

In wind-tunnel experiments, the U.S. Air Force has found that an ice deposit of one-half inch at the leading edge of an airfoil will reduce the lifting power of the airfoil by up to 50 percent and increase the drag by an equal amount. The result: Substantially higher stalling speeds.

This same ice deposit, for example, on the wing of some swept-wing, pure-jet aircraft will alter the stalling speed by as much as 40 knots. Ice can also form on an aircraft very rapidly. There are cases on record where two to three inches of ice have been deposited on an aircraft within the time span of a few minutes.

Basically, there are three types of ice that form on aircraft - rime ice, clear ice and frost. Any of these may form alone or in combination with the others. There are two conditions required for their formation - the presence of visible liquid moisture (clouds) and free air temperatures at or below freezing.

Rime ice is formed by the instantaneous freezing of small supercooled water droplets upon impact with an aircraft surface. These droplets adhere in a more or less spherical shape, and air is trapped within the ice, giving it an opaque appearance and making it brittle. Rime ice does not spread easily and is found primarily along the leading edges of an aircraft. This type of ice is encountered most frequently in stratiform clouds. In

In comparison with clear ice, it builds up slowly and is relatively easy to break loose by conventional methods. Rime and clear ice often occur together. Freezing drizzle, for instance, frequently produces a combination of both.

'Glaze' Ice

Clear, or "glaze," ice is the most damaging form of aircraft icing. It is formed by the slow freezing of large supercooled droplets on the surface of an aircraft. The droplets have a tendency to spread and assume the shape of the surface on which they freeze. Because of the spreading, few air bubbles form, and the ice appears to be clear.

This type of ice is encountered most frequently in cumuliform clouds. It also forms rapidly on aircraft flying through an area of freezing rain. It is difficult to dislodge, reduces lift and increases drag.

Frost

Frost is a deposit of a thin layer of ice that can form on the exposed surfaces of parked aircraft. It occurs when surface temperatures are below freezing and forms during night radiational cooling in a manner similar to the formation of dew and frost on the ground. Frost increases drag and becomes a hazard at lower critical airspeeds, such as when becoming airborne after takeoff.

Frost also can form on an aircraft in flight when descent is made from subfreezing air into a warm, moist layer of air. In these circumstances, it can cover the windshield and completely restrict a pilot's vision.

Ice-Inducing Weather

Ice and water usually can exist in equilibrium at the freezing point of water (or the melting point of ice), 0 degrees C or 32 degrees F. But, in the atmosphere, liquid water droplets can continue to exist in a supercooled state at temperatures far below the freezing point of water. Some droplets have been found in liquid form at temperatures colder than -40 degrees C.

Supercooled water droplets freeze rapidly upon contact with the cold surface of an aircraft moving through an icing zone.

In areas of continuous precipitation, slush-icing — a mixture of water droplets and melting snow — may be found near the freezing level.

Heavy ice accumulations are more common over mountainous terrain because of the increased turbulence and lift associated with cumulus clouds. In a cumulus cloud that is developing into a thunderstorm, as one example, the cloud's particles above the freezing level will be at first entirely liquid, and icing conditions will be severe.

Pilots utilizing radar can choose the best course in approaching thunderstorm clouds. Remember the general rule: Icing may be anticipated at temperatures below freezing in all cumulus-type clouds. In some instances, however, the icing will be more severe than in others.

Warm/Cold Front

Freezing temperatures may occur at a] I levels above the surface in either a warm or a cold front.

In the case of warm fronts, icing is predominantly rime, especially in the over-running warm air. But, when this overrunning air is unstable, clear icing may be encountered in cumuliform clouds.

In the case of cold fronts, those that are fast moving include narrow cloud systems in which icing can be heavy. Slow-moving cold fronts have more extensive cloud decks, and icing conditions will exist for longer distances. Cold-front icing is usually clear.

Icing on an aircraft propeller reduces its efficiency, reducing airspeed and usually increasing fuel consumption. The vibration caused by the formation of propeller ice also can be disastrous, even when the entire length of the blade ices smoothly.

Reduced rpm is conducive to propeller icing when icing conditions are encountered. Propeller anti-icers should be turned on prior to entering anticipated icing areas. At night, it is often difficult to determine propeller icing without using a flashlight. If ice is collecting on the spinner, it probably is also forming on the blades.

Carburetor Ice

Carburetor ice may be formed in the reciprocating engine induction system even though outside conditions preclude external icing. Impact ice, which collects on scoop inlets, duct walls, carburetor inlet screens, exposed metering elements, etc., will reduce the airflow, which in turn, reduces engine power.

Carburetor icing, *which* may occur under a wide range of temperatures and conditions, can result in complete engine failure.

Pitot tube icing is usually easy to prevent with the heating element in the pitot tube. Windshield ice can be negated by the varying de-icing systems available.

So far as ground hazards are concerned, pilots have to deal with not only frost but sleet, freezing rain and snow. Aircraft surfaces should be cleaned, either by sweeping or placing the aircraft in a warm hangar, before flight is attempted. Also remember that a few minutes spent in putting on wing covers can save unnecessary delays and many hours of work removing ice and snow.

Another potentially hazardous situation is the presence of pools of water, slush or mud on airfields. When the temperature is at or below 0 degrees C, water blown by propellers or splashed by the wheels can form ice on aircraft protusions or freeze the flaps and other control surfaces.

Mud and water that freeze in the wheel wells and on wing flap hinges may prevent the retraction of wheels, flaps or, more seriously, freeze them in a retracted or semi-retracted position. More than one pilot has taken off, cranked in the autopilot for straight-and-level flight and then, on preparing for descent and landing, found everything frozen solid.

Jet Aircraft Icing

Icing poses special problems to jet aircraft. As the operational speeds of jet aircraft increase, there is an increase relative to aerodynamic heating, which offsets airframe icing. The temperature increase on the airframe becomes especially significant at true airspeeds above 400 to 500 knots.

While it is best not to rely on a definite temperature rise, if the rise is great enough, the heating of the aircraft and its boundary layer of air may prevent ice formation entirely. If ice does form, however, the freezing of the water droplets will proceed at a somewhat slower rate than at the rate within the surrounding air, allowing the droplets to flow over the surface, resulting in a more adhesive type of ice formation.

When operating at altitudes in excess of 30,000 feet, jet aircraft probably will not encounter icing. This is not true when operating at lower altitudes during climb, cruise, descent or on final approach. The amount of ice accretion will depend upon the altitude, temperature, moisture content and the true airspeed.

Induction icing is something else again. It occurs in the air intake duct of a jet engine. There are many vulnerable areas, including inlet lips, accessory housing domes, compressor inlet screens, inlet guide vanes and compressor blades. If the temperature is below 15 degrees C, the possibility of clear intake icing exists.

Tests have shown that serious ice formation can occur within two minutes because of clear intake icing. If the potential for critical conditions should exist, precautions, including inlet heat, should be taken.

As with the piston engine, ice accumulation decreases the performance efficiency of turbojet engines. Its accumulation restricts the flow of inlet air. This, of course, causes a loss of thrust and a rapid rise in exhaust gas temperatures. Attempting to correct any loss in engine rpm by adding more fuel only aggravates the condition.

The centrifugal-compressor engine is less susceptible to icing conditions than the axial-flow turbojet engine. In flight with the former, the turning of the air as it enters the engine separates the water droplets from the air and deposits them on engine interior surfaces, where icing effects are much less serious.

Normally, jet engines protected by anti-icing systems and retractable inlet screens are not susceptible to the icing hazard. But, if icing is encountered, immediate action should be taken to actuate the engine anti-icing system.

It is still good advice to pilots to refrain from flight in icing conditions whenever possible.

Many aircraft, of course, are not equipped with any type of deicing equipment. Boots, or rubber skins, usually cover the leading edges of the wing and tail surfaces and normally assume the contour of the airfoil. Compressed air is cycled through ducts in the boots, causing them to swell and change shape. The pulsating boot will cause the ice to crack, and the air stream will peel the ice fragments from the boots.

De-icing fluids are used on rotating surfaces, such as propellers, where the centrifugal force spreads the fluid evenly over the entire surface. These fluids are used for windshields, carburetors and the accessory sections of jet engines.

Use Available Heat

Heat — electrical or exhaust — is another method of dissipating ice. Electrical heat can be utilized to clear the pitot tube, an electrical wingboot and wing-tip tanks. Hot air piped from the manifold of the exhaust can be utilized to offset the most critical icing areas, the leading edges of wings and tail surfaces, the windshield, air intakes and canopy.

Intelligent preflight planning requires a consultation with a weather briefer to determine the best route and flight altitude to avoid, or minimize, the icing hazard. Weather maps also indicate the position of fronts and regions of possible icing hazard. PIREPS (pilot reports) of icing will often be included in teletype weather reports.

The bottom line is to anticipate flight difficulties in sufficient time to take appropriate action. If you plan wisely, you reduce the possibility of being surprised by enroute icing. ♦

ACCIDENT PREVENTION

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