Subject: Monthly Safety Briefing - Inflight Icing

"Those that cannot remember the past are condemned to repeat it"

- George Santayana

This seems to be the one true constant in the universe: we constantly forget the lessons learned by repeating the same mistakes over and over. This month, we are going to take a look at inflight icing and, hopefully, remember the lesson here.

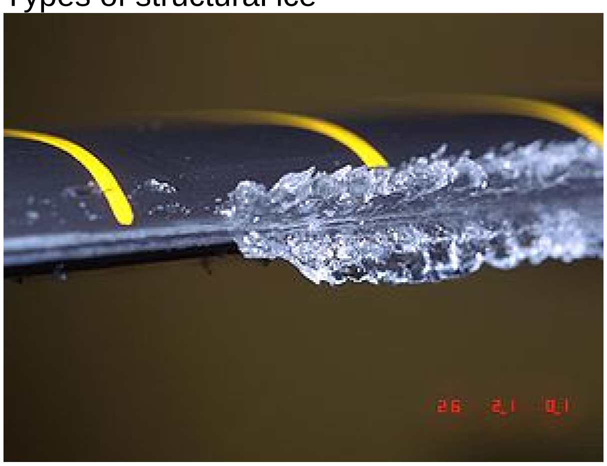
In aviation, **icing conditions** are those atmospheric conditions that can lead to the formation of water ice on the surfaces of an aircraft, or within the engine as carburetor icing. Inlet icing is another engine-related danger, often occurring in jet aircraft. These icing phenomena do not necessarily occur together. Many aircraft, especially general aviation aircraft, are not certified for flight into *known icing*—icing conditions certain or likely to exist, based on pilot reports, observations, and forecasts.

Definition of icing conditions

Icing conditions exist when the air contains droplets of supercooled liquid water; icing conditions are characterized quantitatively by the average droplet size, the liquid water content and the air temperature. These parameters affect the extent and speed that characterize the formation of ice on an aircraft. Federal Aviation Regulations contain a definition of icing conditions that some aircraft are certified to fly into. So-called SLD, or supercooled large droplet, conditions are those that exceed that specification and represent a particular hazard to aircraft.

Qualitatively, pilot reports indicate icing conditions in terms of their effect upon the aircraft, and will be dependent upon the capabilities of the aircraft. Different aircraft may report the same quantitative conditions as different levels of icing as a result.

Types of structural ice



Ice protrusions on the rotor blade

- **Clear ice** is often clear and smooth. Supercooled water droplets, or freezing rain, strike a surface but do not freeze instantly. Often "horns" or protrusions are formed and project into the airflow.
- **Rime ice** is rough and opaque, formed by supercooled drops rapidly freezing on impact. Forming mostly along an airfoil's stagnation point, it generally conforms to the shape of the airfoil.
- **Mixed ice** is a combination of clear and rime ice.

- **Frost ice** is the result of water freezing on unprotected surfaces while the aircraft is stationary. This can be dangerous when flight is attempted because it disrupts an airfoil's boundary layer airflow causing a premature aerodynamic stall and, in some cases, dramatically increased drag making takeoff dangerous or impossible.
- **SLD ice** refers to ice formed in Supercooled Large Droplet (SLD) conditions. It is similar to clear ice, but because droplet size is large, it extends to unprotected parts of the aircraft and forms larger ice shapes, faster than normal icing conditions. This was a factor in the crash of American Eagle Flight 4184.

Effect

The wing will ordinarily stall at a lower angle of attack, and thus a higher airspeed, when contaminated with ice. Even small amounts of ice will have an effect, and if the ice is rough, it can be a large effect. Thus an increase in approach speed is advisable if ice remains on the wings. How much of an increase depends on both the aircraft type and amount of ice. Stall characteristics of an aircraft with ice contaminated wings will be degraded, and serious roll control problems are not unusual. The ice accretion may be asymmetric between the two wings. Also, the outer part of a wing, which is ordinarily thinner and thus a better collector of ice, may stall first rather than last.

These are from the crash of American Eagle 4184 on Oct 31, 1994. 68 people lost their lives that day. Inflight icing was the cause.

Icing prevention and removal

Several methods exist to reduce the dangers of icing. The first, and simplest, is to avoid icing conditions altogether, but for many flights, this is not practical.

If ice (or other contaminants) are present on an aircraft prior to takeoff, they must be removed from critical surfaces. Removal can take many forms:

- Mechanical means, which may be as simple as using a broom or brush to remove snow
- Application of deicing fluid or even hot water to remove ice, snow, etc.
- Use of infrared heating to melt and remove contaminants
- Put the aircraft into a heated hangar until snow and ice have melted
- Position aircraft towards the sun to maximize heating up of snow and ice covered surfaces. In practice this method is limited to thin contamination, by the time and weather conditions.

All of these methods remove existing contamination, but provide no practical protection in icing conditions. If icing conditions exist, or are expected before takeoff, then anti-icing fluids are used. These are thicker than deicing fluids and resist the effects of snow and rain for some time. They are intended to shear off the aircraft during takeoff and provide no inflight protection.

To protect an aircraft against icing in-flight, various forms of anti-icing or deicing are used:

- A common approach is to route engine "bleed air" into ducting along the leading edges of wings and tailplanes. The air heats the leading edge of the surface and this melts or evaporates ice on contact. On a turbine powered aircraft air is extracted from the compressor section of the engine. If the aircraft is turbocharged piston powered, bleed air can be scavenged from the turbocharger.

- Some aircraft are equipped with pneumatic deicing boots that disperse ice build-up on the surface. These systems require less engine bleed air but are usually less effective than a heated surface.
- A few aircraft use a weeping wing system, which has hundreds of small holes in the leading edges and releases anti-icing fluid on demand to prevent the buildup of ice.
- Electrical heating is also used to protect aircraft and components (including propellors) against icing. The heating may be applied continuously (usually on small, critical, components, such as pitot static sensors and angle of attack vanes) or intermittently, giving an effect similar to the use of deicing boots.

In all these cases usually only critical aircraft surfaces and components are protected. In particular only the leading edge of a wing is usually protected.

Carburetor heat is applied to carbureted engines to prevent and clear icing. Fuel-injected engines are not susceptible to carburetor icing but can suffer from blocked inlets. In these engines an alternate air source is often available.

Note there is a difference between deicing and anti-icing. Deicing refers to the removal of ice from the airframe; anti-icing refers to the prevention of ice accumulating on the airframe.

There are other adverse effects of flying in icing conditions such as blockage of pitot tubes and static vents and ice forming on radio antennaes which can cause the antennae mast to break off the aircraft.

The pictures of the American Eagle ATR-72 crash was something that I personally dealt with. I knew the flight crew, flew with them and was based at ORD when that happened. The pilots were top notch, highly experienced and very seasoned aviators. I firmly believe that they had no clue what was happening to them while they were fighting for their lives and lost. The point that I am trying to make here is that if these two pilots had this happen to them in an aircraft certified for known icing, what chance do you have in a simliar situation in an aircraft that is not. I have been in very heavy icing conditions in the Great Lakes Region and it is not fun. If there is even the slightest chance of icing in the forecast, bag it and go home. Live to fly another day.

Region staff, please let me know that you have seen this month's safety education by emailing me at rcarman@kywg.cap.gov and let me know.

Lets be careful out there!!!

Lt. Colonel Roy L. Carman

Director of Safety

Great Lakes Region