Icing

It's that time of year again, time for a reminder about the dangers of ice. While airframe icing is primarily a problem for IFR pilots, pilots of VFR aircraft need to remember that they are not immune.

This article provides only a light dusting over the issue of ice. For detailed information refer to the *Aircraft Icing Handbook*, available on the CAA web site, www.caa.govt.nz, see "Publications", or go to the NASA web site where they have two online courses, one on ground icing, the other on in-flight icing, http://aircrafticing.grc.nasa.gov/courses.html.

Where to Find Ice

Accurate prediction of where icing is found, and how much icing you will encounter, is difficult. It is, however, possible to identify the general conditions that make icing more probable.

New Zealand's alpine chain lifts and cools the warm maritime air coming off the Tasman Sea – this high moisture-content air is perfect for producing ice.

Knowing the Outside Air Temperature (OAT) and having a detailed knowledge of the weather are the best cues for predicting icing conditions. However, sometimes the only way of knowing where the icing is, is to encounter it – or to hear from someone else who has.

Induction System Icing

Induction icing is a comprehensive term that includes all types of fuel metering and all parts of the induction system where ice can accumulate. This includes the air filter, bends in the system, and critical areas of the fuel metering device, like the throttle plate in a float-type carburettor.

Induction system icing forms insidiously, and some aircraft/engine combinations are more susceptible than others.

Impact Icing

Impact ice forms on the surface of the air intakes, air filter, and possibly in the bends in the system, creating disturbances in the airflow and gradually closing off the air intake.

Visible airframe ice should immediately alert you to the danger of a similar build-up in the induction system. In aircraft that have fuel-injection systems, this may be the only indication of induction system icing.

NASA GRC Icing Branch

Refrigeration Icing

Refrigeration icing forms in a float-type carburettor as a result of fuel vaporisation and low pressure, when the relative humidity is more than 50 percent, and in air temperatures anywhere up to 35°C.

The rapid cooling in the carburettor is caused by two factors: the absorption of heat from the air during vaporisation of the fuel, and the high air velocity, which causes a low-pressure area – accompanied by a drop in temperature – through the venturi. If the air contains a large amount of moisture, the cooling process from these two factors can cause ice on the inlet manifold walls and the throttle 'butterfly'. This can seriously restrict the airflow, reducing the power output of the engine, possibly even stopping it.

Symptoms

The best cure for carburettor icing is prevention, and this requires a sound knowledge of the symptoms.

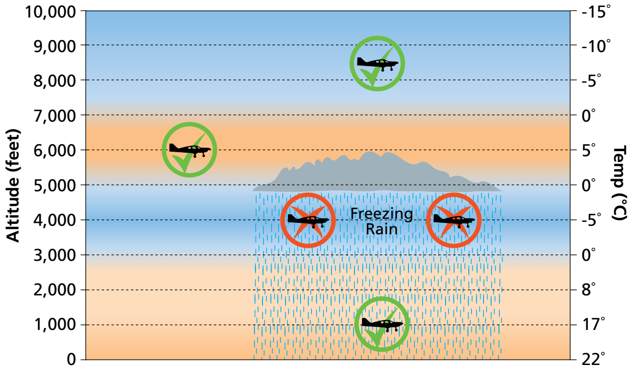
Fixed-Pitch Propellers

For aircraft with fixed-pitch propellers, a gradual loss of rpm and airspeed are early warning signs – exactly as if the throttle was being closed very slowly. If left unheeded, the next warning will be a rough-running engine combined with severe power loss, and finally a complete power loss.

Constant-Speed Propellers

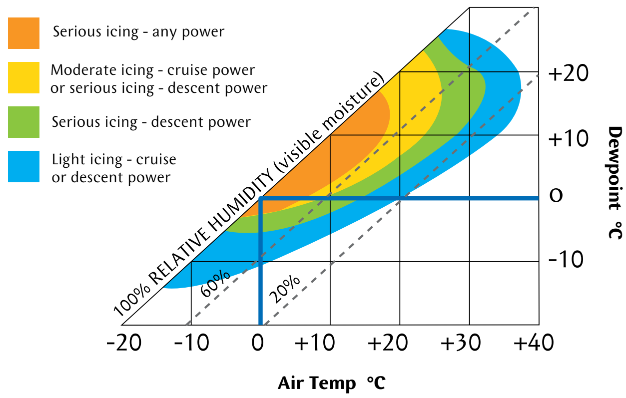
In the early stages, the propeller governor will maintain a constant engine rpm despite the loss of power. The first positive signs will be decreasing airspeed coupled with falling manifold pressure, but these symptoms come on gradually and insidiously, and may go unnoticed. Eventually, other symptoms will be experienced, such as rough running and rpm loss.

Freezing rain associated with a frontal system inversion layer



A temperature inversion at altitude can produce freezing rain conditions. See next page.

Carburettor Icing Chart



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Cures

At the first indication of a reduction in rpm/manifold pressure/airspeed or height, full carburettor heat should be applied for at least 30 seconds and the mixture leaned slightly to correct the over-rich situation. A gradual return of airspeed (and engine rpm with fixed-pitch propellers) will indicate that ice had been present.

The application of alternate air may produce similar effects, therefore the mixture may need to be leaned to restore smooth engine operation and to reduce power loss from an over-rich mixture.

Where considerable ice has accumulated, be prepared for some engine roughness when you apply carburettor heat. The mixture changes, caused by the heated air and pieces of partly melted ice passing into the engine, cause this roughness. If the use of carburettor heat is left until engine roughness has already occurred, the resultant rough running can seem quite severe, but wait until the engine returns to smooth running before reselecting COLD.

Airframe Icing

Although ice can build up on all aeroplane surfaces, of significant concern is aerofoil icing – on the mainplane and on the tailplane. Ice destroys the smooth flow of air over the aerofoil, diminishing its ability to generate lift. It increases drag, increases the aircraft weight, and degrades the control authority of the pilot. As power is added to compensate for the additional drag, and the aircraft nose is raised to maintain altitude (increasing the angle of attack), additional ice will accumulate on the underside of the aerofoils and fuselage.

Ice accumulation (on the leading edges or upper aerofoil surfaces) no thicker than a piece of coarse sandpaper can reduce lift by as much as 30 percent and increase drag by as much as 40 percent.

One particular hazard of severe icing is the tailplane, or empennage, stall. Sharp-edged surfaces are more susceptible to collecting ice than large blunt ones. For this reason, the tailplane will begin accumulating ice before the wings, and at a faster rate. Because you cannot see the tailplane, you may be unaware of the situation until a stall occurs when the critical angle of attack is exceeded (this can occur at a relatively high airspeed). Since the tailplane provides a balancing nose-down force, when it stalls, the aeroplane will pitch nose down, sometimes uncontrollably. Application of flaps can initiate or aggravate this process. Caution should be used when applying flaps during an approach if there is the possibility of tailplane icing. More information on the symptoms of this phenomenon is available in the *Aircraft Icing Handbook.*

Loss of thrust or lift due to ice build-ups on the propellers, rotor blades, or around engine intakes is also a serious consideration. Not only will ice accretion significantly reduce the amount of thrust or lift produced, it is also likely to cause the propeller or rotor to become unbalanced.

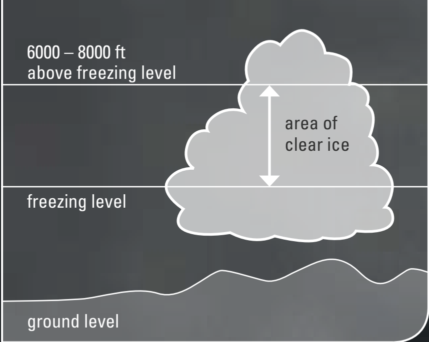
The blockage of pitot intakes and static vents by ice will produce pressure instrument errors. The best defence against pitot icing is to ensure that the heating elements are working during the pre-flight, and are switched on well in advance of any anticipated icing conditions.

It is now recommended that as soon as you enter icing conditions, turn the boots on, and leave them on.

Clear Ice

Clear ice occurs when large super-cooled water droplets freeze (relatively) slowly on contact with a cold surface. It normally occurs when the outside air temperature is between 0° and –15°C. It is most commonly encountered in cumulus cloud within the first 6000 to 8000 feet above the freezing level, but occasionally can be found in stratiform clouds.

Area most likely to encounter clear ice



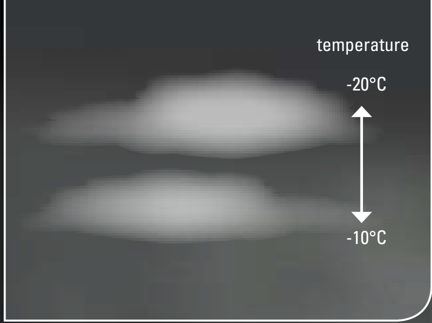
Clear ice is dangerous for many reasons. It can quickly build up – dramatically increasing the aircraft weight and stall speed. It can spread back over a large area and can be difficult to detect, particularly at night. Initially, it may not affect aerodynamic performance, but if allowed to flow back to the hinge line of a control surface, it may render the control unusable. When the aircraft encounters warmer air, it can break off in large chunks, possibly causing airframe damage.

Rime Ice

Rime ice is rough and uneven in appearance and fairly brittle in comparison to clear ice. The rapid freezing of small, super-cooled water droplets traps pockets of air, giving it a rough and crystalline look.

Rime ice is usually associated with stratiform cloud, with an outside air temperature between 0° and –40°C, but is most common within the range –10° to –20°C.

Area most likely to encounter rime ice



It dramatically affects the aerodynamic qualities of leading edges, but unlike clear ice, it does not usually cause a significant increase in aircraft weight. It can be easily cleared using de-ice equipment.

Freezing Rain

Freezing rain occurs when rain from a warm layer of cloud falls into an air mass that has a temperature below 0°C. Freezing rain is normally associated with the cold sector directly under the slope of a warm front, or in the cold sector just behind a cold front. It can cover the entire aircraft with clear ice in a matter of minutes – to the point where de-icing equipment is unable to cope. If these conditions are encountered, it is essential to vacate them as soon as possible.

Frost

Frost forms on aircraft when the OAT falls below 0°C and there is visible moisture in the air – usually while on the ground overnight.

Frost does not have the same weight penalties as other icing, but it does roughen the smooth surface and disrupt the airflow over the wing. This can lead to flow separation and significantly reduced takeoff performance. It is essential to ensure that the wings, tail-plane, and windscreens are cleared of ice before flight. Frost can be carefully brushed or washed off the aircraft, but be careful not to scratch surfaces or provide more water that can refreeze later!

Frost can also form in flight. It usually occurs when the aircraft has spent long enough in temperatures below 0°C to have 'cold soaked' to that temperature and then encounters moist air. This can occur after takeoff on a winter's morning, or when an aircraft descends into warm moist air. Remember this can also happen to VFR aircraft in clear air.

Cures

Remove all ice or frost on any lifting surface before flight. Your Aircraft Flight Manual or company Standard Operating Procedures will have guidance on how best to achieve this.

Avoid icing conditions if you can. The freezing level in ARFORs and SIGMET warnings will alert you to the areas you are most likely to find ice, and if you can't avoid them, then limit your exposure and don't rely on the de-icing capability of your aircraft to cover all situations. No aircraft are certificated for flight into severe icing conditions, and if you encounter them, you must get out as soon as you can.

Know how your particular de-icing or anti-icing system works. There are a number of different methods used, so know when and how to use yours. If you fly a variety of types, make sure you know the differences.

Recent research has indicated that if you have pneumatic boots, the conventional wisdom of waiting until there was a build-up of ice before you cycled them, is flawed. This advice was based on the original pneumatic boots design and materials, and newer versions have a lot higher pressure and better materials.

It is now recommended that as soon as you enter icing conditions, turn the boots on, and leave them on.

Finally, for those of you flying IFR, we would like to draw your attention to rule 91.421:

"...a pilot-in-command operating an aircraft under IFR shall not—

(1) perform a take-off in an aircraft that has—

(i) snow, ice, or frost adhering to any propeller, windscreen, or powerplant installation, or to an airspeed, altimeter, rate of climb, or flight attitude instrument system; or

(ii) snow, ice, or frost adhering to the wings, stabilisers, or control surfaces; and

(2) fly an aircraft into known or forecast icing conditions unless the aircraft is certificated with ice protection equipment for flight in the type of known icing conditions." ■

Ice accumulation (on the leading edges or upper aerofoil surfaces) no thicker than a piece of coarse sandpaper can reduce lift by as much as 30 percent and increase drag by as much as 40 percent.