PISTON ENGINE ICING

1 INTRODUCTION

a. Although this is mainly addressed to aeroplane operations, much of its content applies equally to piston-engined helicopters and gyroplanes.

b. Piston engine induction system icing, commonly referred to as carburettor icing, can occur even on **warm days,** **particularly if they are humid.** It can be so severe that unless **correct** action is taken the engine may stop (especially at low power settings during descent, approach or during helicopter autorotation).

c. Every year there are several accidents in the UK where engine induction system icing may have been a factor. Unfortunately the evidence rapidly disappears.

d. Some aircraft/engine combinations are more prone to icing than others and this should be borne in mind when flying different aircraft types.

2 TYPES OF ICING

There are three main types of induction system icing:

Carburettor Icing

The most common, earliest to show, and the most serious, is carb icing caused by the sudden temperature drop due to fuel vaporisation and pressure reduction at the carburetor venturi. The temperature drop of 20–30°C results in atmospheric moisture turning into ice which gradually blocks the venturi. This upsets the fuel/air ratio causing a progressive, smooth loss of power and slowly ‘strangles’ the engine. Conventional float type carburetors are more prone to icing than pressure jet types.

Fuel Icing

Less common, is fuel icing which is the result of water, held in suspension in the fuel, precipitating and freezing in the induction piping, especially in the elbows formed by bends.

Impact Ice

Ice which builds up on air intakes, filters, alternate air valves etc is called impact ice. It forms on the aircraft in snow, sleet, sub-zero cloud and rain, (if either the rain or the aircraft is below zero °C). This type of icing can affect fuel injection systems as well as carburettors. In general, impact ice is the main hazard for turbocharged engines.

Testing has shown that because of its greater and seasonally variable volatility and higher water content, carb icing is more likely when MOGAS is used.

Engines at reduced power settings are more prone to icing because engine induction temperatures are lower. Also, the partially closed butterfly can more easily be restricted by the ice build-up. Note: For the sake of simplicity, in the rest of this leaflet, the term Carb Icing includes Induction Icing and Carb Heat includes Alternate Air.

3 ATMOSPHERIC CONDITIONS

a. Carb icing is **not** restricted to cold weather, and will occur on **warm days** if the **humidity is high,** especially at **low power settings.** Flight tests have produced serious icing at descent power with the ambient (not surface) temperature over 25°C, even with relative humidity as low as 30%. At cruise power, icing occurred at 20°C when the humidity was 60% or more. (Cold, clear winter days are less of a hazard than humid summer days because cold air holds less moisture than warm air.) In the United Kingdom and Europe where high humidity is common, pilots must be constantly on the alert for the possibility of carb icing and take corrective action **before** an irretrievable situation arises. If there is an engine failure due to carb icing, the engine may not re-start and even if it does, the delay could be critical.

b. Carb icing can occur even in clear air and is therefore more dangerous due to the lack of visual warning. In cloud the risk of icing may be higher but the pilot is **less** likely to be caught unawares.

c. Specific warnings of induction system icing are not normally included in aviation weather forecasts and you must be prepared to deal with it on the basis of your knowledge and experience. When dewpoint information is not available, assume high humidity particularly when the surface and low level visibility is poor, especially in the early morning and late evening, and particularly when near a large area of water; the ground is wet (even with dew) and the wind is light; just below cloud base or between cloud layers (highest liquid water content is at cloud tops); in precipitation, especially if persistent; in clear air where cloud or fog may have just dispersed; in cloud and fog, these being water droplets; hence the relative humidity should be assumed to be 100%.

The chart overleaf shows the wide range of ambient conditions where the formation of carb icing is most likely. Particular note should be taken of the much greater risk of serious icing with descent power. The closer the temperature and dewpoint readings, the greater the relative humidity.

4 RECOGNITION AND GENERAL PRACTICES

Paragraphs 4 and 5 are intended as a general guide to assist you to avoid icing, but reference should be made to the relevant sections of Pilot's Operating Handbook or Flight Manual for specific procedures related to the particular airframe/engine combinations.

These may vary for a different model of the same aircraft type.

- **a.** With a fixed pitch propeller, a light drop in rpm and airspeed are the most likely indication of the onset of carb icing. This **loss of rpm** can be smooth and gradual and the usual reaction is to open the throttle slightly to compensate. However, this action, whilst restoring the power hides the loss. As the icing builds up, rough running, vibration, loss of airspeed and ultimately stoppage of the engine may follow. The primary detection instrument is the **rpm gauge** in conjunction with the ASI.

- **b.** With a constant speed propeller, and in a helicopter, the loss of power would have to be large before a reduction in rpm occurs. Onset of icing is even more insidious, but there will be a **drop in manifold pressure** and reduction in airspeed in level flight. Thus, in this case the primary detection instrument is the **manifold pressure gauge**.

- **c.** If fitted, an exhaust gas temperature gauge will show a noticeable decrease in temperature before any significant decrease in engine and aircraft performance.

d. Carb icing is cleared by the pilot selecting an alternative air source which supplies air, (heated in an exhaust heat exchanger) which melts the ice obstruction. This source by-passes the normal intake filter.

e. Engines with fuel injection generally have an alternate air intake located within the engine cowling via a valve downstream from the normal air intake. This alternate air is warmed by engine heat, even though it does not normally pass through a heat exchanger.

f. Always use **full** heat whenever carb heat is applied, partial hot air should only be used if an intake temperature gauge is fitted and only then in accordance with the Flight Manual or Pilot's Operating Handbook. Partial heating can induce carb icing because it may melt impact ice particles (which would otherwise pass into the engine without causing trouble) but **not** prevent the resultant mixture from freezing when it passes through the induction system; partial heat can raise the induction air temperature into the critical range.

g. Hot air should be selected:

- whenever a drop in rpm or manifold pressure is experienced,
- when icing conditions are suspected, or
- when flying in conditions within the high probability ranges indicated in the chart.

But always be aware that hot air, whilst selected, reduces engine power. This reduction may be critical in certain flight phases. Unless expressly permitted, (or necessary), **the continuous use of hot air should** be avoided. It should be selected for long enough to pre-empt the loss of engine power or restore the engine power to the original level.

h. If a loss of power is due to icing, and the use of hot air disperses it, re-selection of cold air **should** produce an increase in rpm or manifold pressure over the earlier reading. This is a useful check to see whether ice is forming. If it is, monitor the engine instruments as it may re-occur. Lack of carb icing will mean that there will be no increase in rpm or manifold pressure beyond that noted prior to the use of hot air. Remember, selection of hot air, when ice is present, may at first make the situation appear worse due to an increase in rough running as the ice melts and passes through the engine. If this happens the **temptation to return to cold air must be resisted** so that the hot air has time to clear the ice. **This time may be in the region of 15 seconds,** which will, in the event, feel like a very long time!

5 PILOT PROCEDURES

a. *Maintenance*

Periodically check the carb heating system and controls for proper condition and operation. Pay particular attention to the condition of seals which may have deteriorated allowing the hot air to become diluted by cold air.

b. *Start Up*

Start up with the carb heat control in the **COLD** position.

c. *Taxying*

Generally, the use of carb heat is not recommended while taxying because the air is usually unfiltered when in the **HOT** position. However, if it is necessary – USE IT.

d. *Ground Run-Up*

Check that there is a **significant** power decrease when hot air is selected (typically 75–100 rpm or 3–5" of manifold pressure) and that power is regained when cold air is re-selected. If it is suspected that ice is present, the hot position should be selected until the ice has cleared and normal power is restored.

e. *Immediately Prior to Take-Off*

Since icing can occur when taxying with low power settings, or when the engine is idling, select carb heat ON for 5 seconds and then OFF, immediately before take off to clear any build-up. If the aircraft is kept waiting at the holding point in conditions of high humidity, it may be necessary to carry out the run-up drill more than once to clear ice which may have formed.

f. *Take-Off*

Take-off should **only** be commenced when you are sure the engine is developing full power. When at full power and as airspeed is building, you must check that the full throttle rpm and/or manifold pressure is as expected. **Carburettor heat must NOT be used during take-off** unless specifically authorized in the Flight Manual or Pilots Operating Handbook.

g. *Climb*

Be alert for symptoms of carb icing, especially when visible moisture is present or if conditions are in the high probability ranges in the chart.

h. *Cruise*

Monitor appropriate engine instruments for any changes which could indicate icing. Make a carb heat check at least every 10 minutes, (more frequently if conditions are conducive to icing). **Use full heat** and note the warning of para 4 (e), it may take up to 15 seconds to clear the ice and the engine will continue to run roughly as the ice melts and passes through the engine. If the icing is so severe that the engine has died, keep the hot air selected as residual heat in the rapidly cooling exhaust **may** be effective. In all cases, it is vital to select carb heat before any selector valves or linkages are frozen solid by an accumulation of ice around them. Avoid clouds as much as possible, note; that few piston engined aircraft are cleared for flight in icing conditions.

i. *Descent and Approach*

Carb icing is much more likely at reduced power, so select hot air **before, rather than after,** power is reduced for the descent, and especially for a practice forced landing or a helicopter autorotation, ie, before the exhaust starts to cool. (This also allows a check that no ice is present and that the carb heat is still working.) Maintain FULL heat during long periods of flight with reduced power settings. At intervals of about 500 ft or more frequently if conditions require, increase power to cruise setting to warm the engine and to provide sufficient heat to melt any ice.

j. *Downwind*

Ensure that the downwind check includes the following check:
— Note the RPM/Manifold Pressure
Apply Full Carb heat for about 15 seconds and note the reduced indication.
— Return Carb heat to Cold. The RPM/Manifold Pressure will return to the earlier indication if there was no icing. If it is higher – icing was present.

k. *Base Leg and Final Approach* Unless otherwise stated in the Pilot's

Operating Handbook or Flight Manual, the HOT position should be selected on base leg when power is reduced. On some engine installations, to ensure better engine response and to permit a go-around to be initiated without delay, it is recommended that the carb heat be returned to COLD at about 200/300 ft on finals.

l. *Go-around or Touch and Go*

Ensure the carb heat is COLD, ideally before, or simultaneously as power is applied for a go-around.

m. *After Landing*

Return to the COLD setting before taxying, if not already set COLD, (para k).

6 SUMMARY

1. Icing forms stealthily.

2. Some aircraft/engine combinations are more susceptible han others.

3. Icing may occur in warm humid conditions and is a possibility at any time of the year in the UK.

4. Mogas makes carb icing more likely.

5. Low power settings, such as in a descent or in the circuit, are more prone to give carb icing.

6. Use full carb heat frequently when flying in conditions where carb icing is likely. Remember that the RPM gauge is your primary indication for a fixed pitch propeller; manifold pressure for variable pitch.

7. Treat the carb heat as an ON/OFF control – either full hot or full cold.
8. It takes time for the heat to work and the engine may run roughly while the ice is clearing.

9. Timely use of appropriate procedures can PREVENT THIS PROBLEM.

FINALLY

In the event of carb heat system failure in flight:

- Keep out of icing conditions.

- Maintain high throttle setting – full throttle if possible.

- Weaken the mixture slightly.

- Land as soon as reasonably possible.

"PREVENTION IS BETTER THAN CURE"

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This article originally appeared as CAA GENERAL AVIATION SAFETY SENSE LEAFLET 14A