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### 1 INTRODUCTION

a) This leaflet is intended to assist pilots of carburetted piston-engined aircraft operating below 10,000 feet. Although it may appear to be mainly aimed at aeroplane operations, much of its content applies at least equally to piston-engined helicopters and gyroplanes.

b) Piston engine induction system icing is commonly referred to as carburettor icing, although, as described later, carb icing is only one form. Such icing can occur at any time, **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 engine induction system icing is assessed as being a likely contributory factor in several aircraft accidents. Unfortunately the evidence rapidly disappears.

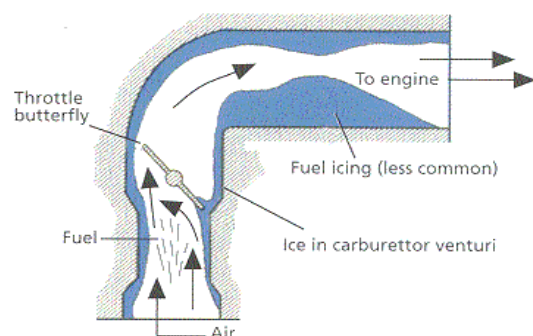
d) Some aircraft/ engine combinations are more prone to icing than others and this should be borne in mind when flying different aircraft types.

e) The aircraft Flight Manual or Pilot's Operating Handbook is the primary source of information for individual aircraft. The advice in this leaflet should only be followed where it does not contradict that Flight Manual.

### 2 TYPES OF ICING

There are three main types of induction system icing:

BUILD-UP OF ICING IN INDUCTION SYSTEM



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#### a) *Carburettor Icing*

The most common, earliest to show, and the most serious, is carburettor (carb) icing caused by a combination of the sudden temperature drop due to fuel vaporisation and pressure reduction as the mixture passes through the carburettor venturi and past the throttle valve.

If the temperature drop brings the air below its dew point, condensation results, and if the drop brings the mixture temperature below freezing, the condensed water will form ice on the surfaces of the carburettor. This ice gradually blocks the venturi, which upsets the fuel/air ratio causing a progressive, smooth loss of power and slowly 'strangles' the engine. Conventional float type carburettors are more prone to icing than pressure jet types.

#### b) *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.

#### c) *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.

### **3 ENGINE FACTORS**

a) 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.

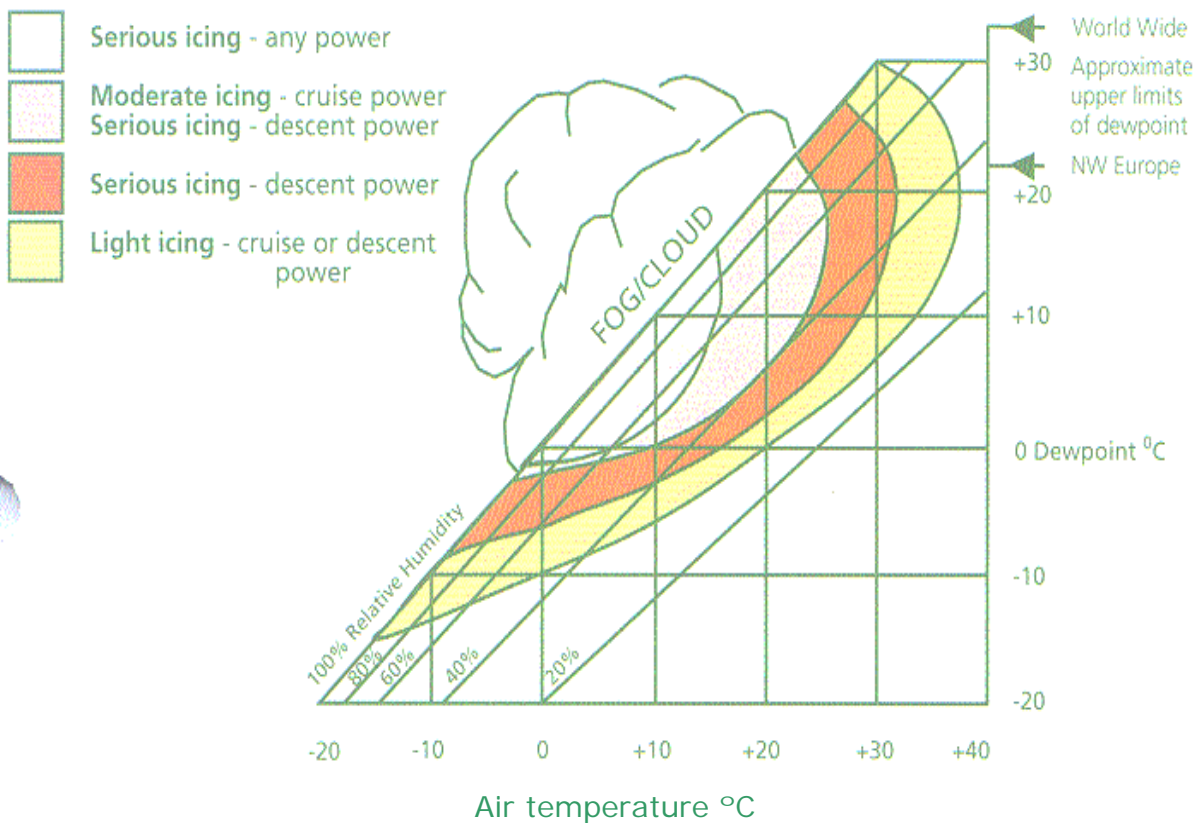
b) Engines at reduced power settings are more prone to icing because engine induction temperatures are lower. Also, the partially closed butterfly can more easily be restricted by the ice build-up. This is a particular problem if the engine is de-rated as in many piston-engined helicopters and some aeroplanes.

c) A rough carburettor venturi surface is also likely to increase carburettor icing severity.

d) Water-cooled engine bodies tend to cool less quickly when power is reduced, reducing the carburettor icing severity. Coolant directed around the carburettor body may maintain the venturi temperature above freezing.

Note: For the sake of simplicity, in the rest of this leaflet, the term 'Carb Icing' is used to cover all Induction Icing, and 'Carb Hot Air' includes Alternate Air.

## CARB ICING



## 4 ATMOSPHERIC CONDITIONS

a) Carb icing is **not** restricted to cold weather. It will occur on **warm days** if humidity is high, especially at **low power settings**. Flight tests have produced serious icing at descent power with ambient (not surface) temperature above 25°C, even with relative humidity as low as 30%. At cruise power, icing occurred at 20°C when relative 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 carb icing and take corrective action **before** an irretrievable situation arises. If the engine fails due to carb icing, it may not re-start (even if it does, the delay could be critical).

b) Carb icing can occur in clear air and is therefore made more dangerous by the lack of any visual warning. In cloud, the icing risk 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. Pilots must therefore use knowledge and experience. The closer the temperature and dewpoint readings, the greater the relative humidity. However, the humidity reported at an aerodrome may bear little relation to the humidity at flying altitudes. When dewpoint information is not available, assume high humidity particularly when:

- in cloud and fog; these are water droplets and the relative humidity should be assumed to be 100%;

- in clear air where cloud or fog may have just dispersed, or just below the top of a haze layer;
- just below cloud base or between cloud layers (highest liquid water content is at cloud tops);
- in precipitation, especially if persistent;
- the surface and low level visibility is poor, especially in early morning and late evening, and particularly near a large area of water; or
- the ground is wet (even with dew) and the wind is light.

However, the lack of such indications does not mean low humidity.

d) The chart shows the wide range of ambient conditions in which carb icing is most likely. Particular note should be taken of the much greater risk of serious icing with descent power.

## 5 RECOGNITION

a) Paragraphs 5, 6 and 7 are intended as a general guide to assist you to avoid icing, but reference must be made to the relevant sections of the 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.**

b) With a fixed pitch propeller, a slight drop in rpm and performance (airspeed and/or altitude) are the most likely indications 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, whilst restoring power, hides the loss. As icing builds up, rough running, vibration, further loss of performance

and ultimately engine stoppage may follow. The primary detection instrument is the **rpm gauge** in conjunction with ASI and altimeter.

c) 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 a performance reduction. In this case the primary detection instrument is the **manifold pressure gauge**.

d) In steady level flight, an exhaust gas temperature gauge, if fitted, may show a decrease in temperature before any significant decrease in engine and aircraft performance.



## 6 GENERAL PRACTICES

a) Some engines have electric heaters which on selection directly increase the temperature of the carburettor body, encouraging ice to clear. A similar effect may be obtained in a liquid cooled engine by directing the flow of coolant.

b) On other air-cooled engines, carb icing is normally 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 bypasses the normal intake filter.

c) Fuel injected engines generally have an alternate air intake located within the engine cowling via a valve downstream from the normal air intake. Alternate air is warmed by engine heat, and does not normally pass through a heat exchanger.

d) 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 if specifically recommended in the Flight Manual or Pilot's Operating Handbook.

e) Select carburettor body heat whenever carb icing is likely. Hot air should be selected:

- as a matter of routine, at regular intervals to prevent ice build up;
- whenever a drop in rpm or manifold pressure, or rough engine running, is experienced;
- when carb icing conditions are suspected; and
- when flying in conditions within the high probability ranges indicated in the chart.

But always be aware that hot air, while selected, reduces engine power, as, to a much lesser extent, does body heating. This may be critical in certain flight phases.

f) During the cruise, carburettor heat should be applied at regular intervals, to prevent carburettor ice forming. It should be selected for long enough (at the very least 15 seconds but considerably more in certain aircraft) to pre-empt the loss of engine power or restore power to the original level.

g) If icing has caused a loss of power, and the 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, but does not prove that all the ice has melted! Carry out further checks until there is **no** resultant increase, monitor the engine instruments, and increase the frequencies of the routine checks, as it may re-occur. Absence of carb icing should produce no increase in rpm or manifold pressure beyond that noted prior to the use of hot air.

h) 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!

i) Unless necessary, the continuous use of hot air at high power settings should be avoided. However, carburettor heat should be applied early enough **before** descent to warm the intake, and should remain fully applied during that descent, as the engine is more susceptible to carb icing at low power settings.

## **7 PILOT PROCEDURES**

### a) *Maintenance*

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

### b) *Start Up*

Start up with the carb hot air control in the **COLD** position.

### c) *Taxiing*

Although carb body heat should normally be selected ON, generally the use of carb hot air is not recommended while taxiing - the air is usually unfiltered when in the HOT position. However, ice may build up at the low taxiing power settings, and if not removed may cause engine failure after take-off. If carburettor heat is needed – USE IT.

### d) *Ground Power Checks*

Select carburettor hot air fully ON for at least 15 seconds. 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 (but to a level no higher than before) when cold air is re-selected. If the power returns to a higher value, ice was present and further checks should be carried out until the ice has cleared.

### e) *Immediately Prior to Take-Off.*

Since icing can occur when taxiing with low power settings, or when the engine is idling, select carb hot air ON for a minimum of 15 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*

Ensure the engine is warm enough to provide carb body heat if appropriate. 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 hot air must NOT be used during take-off** unless specifically authorised in the Flight Manual or Pilot's 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. Be aware if your Flight Manual restricts the use of carb heat at full power.

### h) *Cruise*



Avoid clouds as much as possible. (Note that few piston-engined aircraft are cleared for flight in airframe icing conditions.) Monitor appropriate engine instruments for any changes which could indicate icing. If a body heat system is fitted, check it is ON whenever carb icing is possible. If a hot air system is fitted, make a carb heat check (see below) at least every 10 minutes (more frequently if conditions are conducive to icing). **Use full heat** and note the warning of paragraph 6 (h), it may take 15 seconds or more 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 (opening the throttle fully and closing the mixture control for a while may also help).

i) *Carburettor heat check*

- Note the rpm/manifold pressure (consider slightly increasing power beforehand to prevent a reduction in performance during the check).
- Apply full Carb heat for at least 15 seconds.
- Return Carb heat to Cold. The rpm/manifold pressure will return to approximately the earlier indication if there was no icing. If it is **higher** - icing was present, and may not yet be completely clear, so repeat the check until no increase results.



j) *Descent and Approach*

Carb icing is much more likely at reduced power, so select carb heat **before, rather than after**, power is reduced for the descent, and especially for a practice forced landing or a helicopter autorotation, i.e. before the exhaust starts to cool. (A full carb heat check just before selecting hot air for the descent is advisable.) 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.

k) *Downwind*

Ensure that the downwind check includes the cruise carburettor heat check at 6(i) above. If you select and leave the heat on, speed or altitude will reduce on the downwind leg unless you have added some power beforehand.

l) *Base Leg and Final Approach*



Unless otherwise stated in the Pilot's Operating Handbook or Flight Manual, the HOT position should be selected well before power is reduced and retained to touchdown. On some engine installations, to ensure better engine response and to permit a go-around to be initiated without delay, it may be recommended that the carb hot air be returned to COLD at about 200/300 ft on finals.

m) *Go-around or Touch and Go*

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

n) *After Landing*

Return hot air to the COLD setting before taxiing, if not already set COLD.

## 8 **SUMMARY**

- Icing forms stealthily.
- Some aircraft/engine combinations are more susceptible than others.
- Icing may occur in warm humid conditions and is a possibility at any time of the year in the UK.
- MOGAS makes carb icing more likely.
- Low power settings, such as in a descent or in the circuit, are more likely to produce carb icing.
- Warming up the engine before take-off improves the effectiveness of any carb body heat.
- Use full carb hot air frequently when flying in conditions where carb icing is likely. Remember the rpm gauge is the primary indication for a fixed pitch propeller; manifold pressure for variable pitch.
- Treat the carb hot air as an ON/OFF control – either full hot or full cold.
- It takes time for the heat to work and the engine may run roughly while ice is clearing.
- Timely use of appropriate procedures can PREVENT THIS PROBLEM.

## FINALLY

In the event of carb heat system failure in flight:

- Avoid likely carb icing conditions.
- Maintain high throttle settings – full throttle if possible.
- Weaken the mixture slightly.
- Land as soon as reasonably possible.