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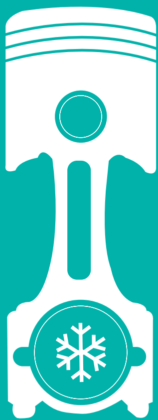
UK Civil Aviation Authority



PISTON ENGINE
ICING

SAFETY SENSE

SSL 14

YOUR SAFETY SENSE LEAFLET FOR: PISTON ENGINE ICING

This leaflet provides guidance to pilots on icing in the induction and fuel system of aircraft equipped with piston engines.

Many aircraft use a carburettor to deliver the fuel and air mixture to the engine and are therefore subject to carburettor icing. Fuel injected engines do not experience carburettor icing, however they may be subject to ‘impact’ ice or fuel system icing.

Icing in piston engines is possible in a variety of temperatures and conditions, but particularly when the air is humid. Some aircraft and engine combinations are more prone to icing than others. The design and location of the induction system may influence the likelihood of icing.

The Aircraft Flight Manual (AFM) or Pilot’s Operating Handbook is the primary source of information for individual aircraft. In the case of a conflict between the guidance in this SSL and the applicable AFM, the latter shall take precedence.

Types of Icing

Carburettor icing

The most common type of piston engine icing is carburettor icing, often referred to as 'carb icing'. It affects aircraft in which the fuel and air mixture is delivered to the engine via a carburettor.

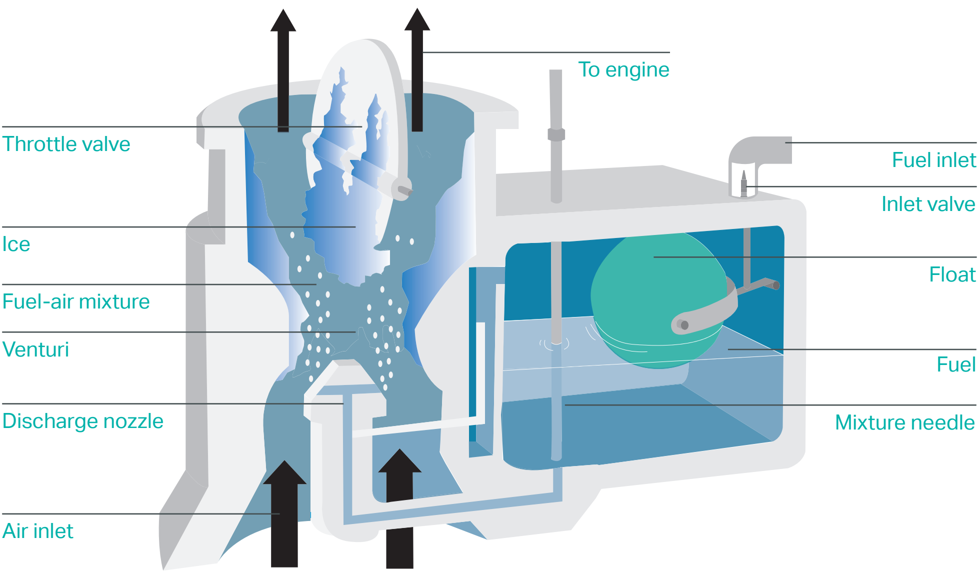
A carburettor controls the amount of fuel and air mixture entering the engine, via a throttle valve or 'butterfly'. Most aviation carburettors are of a 'float' design, in which the fuel tank feeds a small bowl or chamber, controlled by a float and valve arrangement.

Fuel exits the bowl and flows into a venturi. The fuel is atomised into the induction air, prior to the throttle valve. The loss of fuel from the bowl causes the float to drop and this opens a valve in the fuel inlet, allowing in fresh fuel.

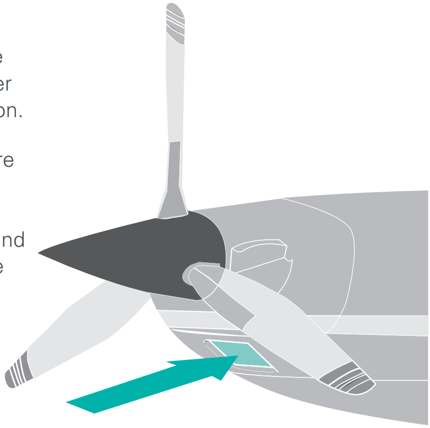
Within the venturi, the fuel atomisation and associated pressure reduction has a significant cooling effect. The temperature inside the carburettor can be as much as 35°C less than the ambient. Water vapour present in the induction air may therefore condense and turn to ice.

The ice will constrict the venturi and throttle valve, reducing the amount of fuel-air mixture flowing to the engine. The mixture will also tend to become richer. Power is often lost gradually, going unnoticed until a large amount of ice is present.

Engines with a fuel injection system eliminate carburettor icing. The fuel is delivered under high pressure and closer to the heat of the engine, either at some point in the inlet manifolds or directly to individual cylinders.



Impact icing



Impact or intake icing is where ice builds around or inside the air intake, restricting airflow to the engine. The air filter may also become blocked, especially in heavy precipitation.

Impact ice may accumulate when flying in visible moisture with the temperature below 0ºC, but is more likely in snow, sleet or freezing rain. Freezing rain occurs when supercooled precipitation hits the surface of the aircraft and freezes rapidly. It is also possible for normal rain to freeze on impact if the aircraft is 'cold soaked' from prolonged flight in cold air.

Impact icing can affect fuel injected and carburetted engines.

Fuel system icing

The aircraft's fuel tank and system may contain water, for example from condensation or rainwater ingress. Dissolved water may also be present in the fuel, which in normal conditions would go unnoticed but may cause a problem in low temperatures. The combination of an aircraft being left outside in a wet or humid environment, followed by a flight in cold air is conducive to fuel system icing.

As the temperature drops, air present in the fuel tank and system may cause additional condensation and therefore a source of ice. The fuel lines in light aircraft are normally very thin and particularly around bends, it may only take a small amount of ice to block the fuel flow. Blockage of fuel filters is also a possibility.

There is some evidence that MOGAS is more susceptible to fuel icing than AVGAS, due to possible increased volatility and water content. Diesel piston engines that run on JET A-1 may also be affected. Always follow the guidance in the AFM and any supplementary procedures for cold weather operations. In extreme cold, a fuel additive may be appropriate.

Symptoms of fuel system icing may vary. If you experience a loss of power when in cold but clear conditions and it is not carburettor icing, fuel icing may be present. Descending to warmer air is normally the best course of action.

Water present in the fuel system may cause a loss of power or engine failure, even if it does not freeze. Always be diligent in checking for water in the fuel, particularly during the winter. Even an aircraft kept in a hangar may have condensation present in the fuel tanks. Leaving the aircraft with the tanks full will provide some mitigation against internal condensation forming.

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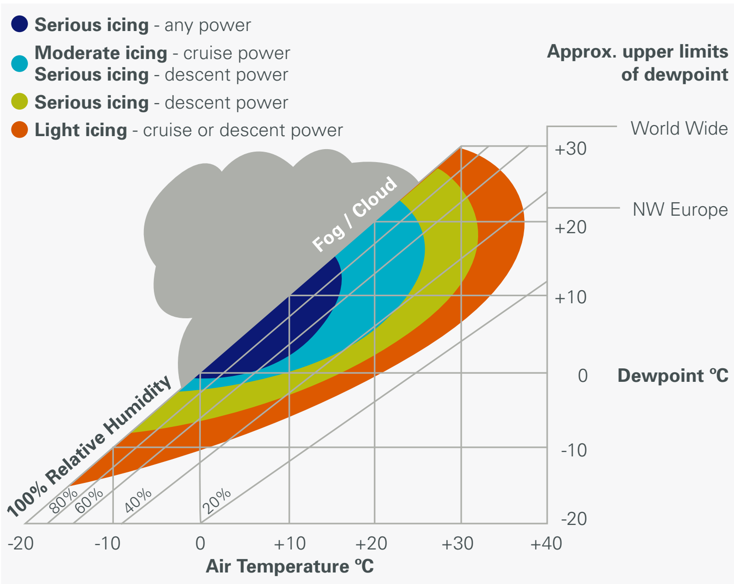
Atmospheric conditions

Piston engine icing is not restricted to cold weather. Particularly carburettor icing may occur on warm days if the humidity is high enough, especially at low power settings. For example, cold and clear winter conditions with low humidity may be less of a hazard than warm and humid days in the summer.

Carburettor icing becomes more of a risk in the range between 0ºC and 10°C and with high relative humidity. However, tests have produced serious icing at descent power with the outside air temperature above 25°C and with relative humidity as low as 30%. In the United Kingdom and Northern Europe where high humidity is common, you must be constantly on the alert.

Signs of high humidity include the temperature and dew point being similar, visible moisture on the ground, rain, fog or a low cloud base.

Carburettor or fuel icing may occur in clear air. Impact icing normally requires some visible moisture to form. However, the risk of all forms of engine icing is higher in cloud.



The chart above shows the wide range of ambient conditions conducive to the formation of carburettor icing for a typical light aircraft piston engine. Note the greater risk of serious icing at descent power.

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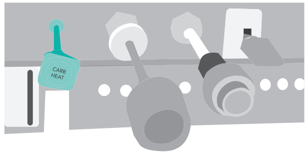
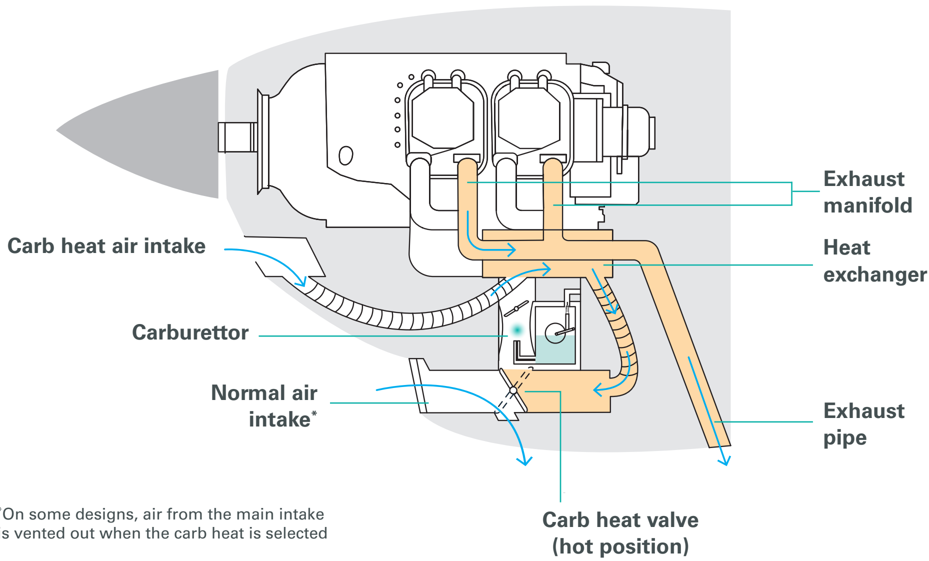
Prevention

Carburettor Heat

In most piston engine aircraft, carburettor icing is prevented by heating the intake air in an exhaust heat exchanger before it reaches the carburettor. This is normally via a manually operated carburettor heat control, marked ‘hot’ or ‘cold’. In the hot position, air is drawn through the heat exchanger, bypassing the normal air intake filter.



Typical carburettor heat system - location of components may vary



*On some designs, air from the main intake is vented out when the carb heat is selected

When carburettor heat selected to hot, the engine power will reduce slightly, due to the reduced density of hot air. This loss in power should not be confused with the effects of carburettor icing.

On some aircraft, parts of the intake or carburettor are heated electrically. The advantage of electrical systems is that they tend to cause less of a reduction in power compared to those that use hot air. Electrical heating should be applied in accordance with AFM guidance.

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Alternate Air

Engines with fuel injection normally have an 'alternate air' intake, operated by a valve downstream of the normal air intake. Selection of alternate air bypasses a potentially frozen intake or blocked air filter. The design of alternate air systems varies – some take air from within the engine cowling, others have a separate external intake. Where air is taken from inside the cowling it will be warmer and therefore cause a slight reduction in power.

If flying in visible moisture and you observe a build-up of ice on the windscreen or wings, there is a possibility of impact icing. Consider exercising the alternate air function prior to any loss of engine performance – in extreme cases the associated door or valve may freeze in the closed position. Some engines have automatic alternate air selection, activated by pressure-sensitive valves.

Recognition of icing

A loss of engine power or apparent drop in aircraft performance is normally the first sign of engine icing. If an autopilot is engaged, watch for a loss of airspeed, since normally the autopilot will continue to hold the aircraft's altitude. If not addressed, the icing may cause complete engine failure.

If the aircraft is fitted with an exhaust gas temperature (EGT) gauge, you may see an abnormal change in EGT before any significant decrease in engine power occurs. Carburettor icing will often cause a drop in EGT, due to the restriction of air flow enriching the mixture.

Fixed pitch propeller

With a fixed-pitch propeller, a slight drop in RPM may indicate the onset of icing in the induction or fuel system. There will be an associated loss of airspeed and/or height. The loss of RPM may be gradual with no discernible rough running. The usual reaction is to open the throttle slightly to restore the RPM and this will disguise the early symptoms.

As the icing increases the engine will start running rough, causing vibration and a further RPM reduction.

Constant speed propeller

With a constant-speed propeller, or in a helicopter, engine icing will initially cause only the manifold pressure (MP) to drop – the propeller will automatically maintain RPM until a large drop in MP occurs. Since the RPM will initially remain stable, there will not be the audible change in engine sound as with a fixed pitch propeller.

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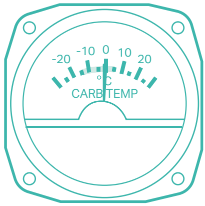
Recommended Procedures

The following is a guide to best practice, always use procedures in the AFM.



Unless expressly permitted, the continuous use of the carburettor heat should be avoided at high power settings. When using carburettor heat, select it for long enough (usually at least 15 seconds) to allow any ice to melt. The time required to clear ice will vary depending on the aircraft type and conditions.

If carburettor ice has already formed, the selection of the hot position may initially cause increased rough running as the ice melts and passes through the engine. If this occurs, maintain the hot position and allow time for the engine to recover. If engine failure occurs and you suspect carburettor icing, also maintain the hot position – residual heat from the exhaust may be sufficient to melt the ice and enable a restart.

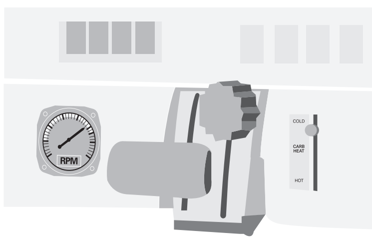
Normally the carburettor heat is selected fully on. If the aircraft is equipped with a carburettor temperature gauge, this may allow use of partial heat to obtain the most optimum induction temperature for removal or prevention of ice. Partial heat is sometimes recommended with larger engines.

It is possible that in very cold outside air temperatures, the use of carburettor heat may raise the carburettor temperature into the icing range, however this is unlikely to be the case in the UK.

On fuel injected engines, selection of alternate air is normally only required when in conditions conducive to impact icing. It should be applied in the fully on position. If ice has formed on the intake or air filter, it will be necessary to use the alternate air function until you have vacated icing conditions and the temperature is high enough for the ice to have melted. Exercise caution since partially melted ice could still be present and affect airflow into the engine.

Engine power checks

Select carburettor heat fully on during the engine power checks, for at least 15 seconds. Check that there is a significant power decrease when the heat is selected (typically 75–100 rpm or 3-5″ of manifold pressure), and that power is regained when it is selected off. If the power returns to a higher value than before, ice was likely present and further checks should be carried out until the ice has cleared. Depending on the design of an alternate air system, procedures for checking correct operation may vary. Follow AFM guidance.



Engine start and taxi

The engine should be started with the carb heat or alternate air in the cold or off position.

The use of carburettor heat or alternate air is not normally recommended while taxiing since on most aircraft the air will be unfiltered. There is a risk of dust or other foreign matter being ingested by the engine. If the engine loses power during taxi, this may indicate that icing is present, and the use of carburettor heat will be the only way to remove it.

Prior to take-off

If any significant time has elapsed between conducting engine power checks and take-off, reselect carburettor heat on for around 15 seconds, immediately before take-off. This will clear any build up that may have occurred while the engine has been sitting at a low power setting. In conditions conducive to serious carburettor icing, it may be necessary to run the engine to a high power setting several times, to clear any ice and confirm that take-off power will be available.

Take-off and climb

Take-off should only be attempted when you are sure the engine is developing the appropriate power. When at take-off power and as airspeed is building, check that the RPM and/or manifold pressure is correct. Carb heat or alternate air should not be used for take-off, unless specifically authorised in the AFM.

During the initial climb, be alert for symptoms of induction icing, especially when visible moisture is present. It is possible to experience icing at any power setting. If you suspect carburettor icing is occurring with full power selected, it may be advisable to discontinue the flight. Be aware if the AFM restricts the use of carburettor heat or alternate air at full power.

Cruise

Monitor the engine RPM or manifold pressure. If fitted, a carburettor temperature or EGT gauge may also be useful for indicating the possibility of induction icing. If conditions are conducive to carburettor icing at cruise power, periodically select the carburettor heat as a preventative measure. Remember that it may take 15 seconds or more to clear the ice and the engine may run rough as the ice melts. Induction icing is more likely in visible moisture.

Descent or autorotation

As induction icing is much more likely at reduced power, carburettor heat should be selected before power is reduced for the descent. Maintain the hot position during long periods of reduced power settings, such as practice forced landings or helicopter autorotation. Increase power regularly during the descent to warm the engine and reduce the likelihood of ice forming.

Landing

When conducting 'downwind' or 'joining' checks prior to landing, select the carburettor heat on to remove any ice that may be present. It should be selected to hot before power is reduced on base leg or final approach. In many aircraft it is recommended to select the carburettor heat to cold again at around 300 ft, to give improved power in the event of a go-around or touch and go.The carburettor heat should be selected cold after landing if this was not already done on final.

Go-around or touch and go

If the carburettor heat is still in the hot position, ideally it should be moved to cold, prior to the application of take-off or go-around power. Check after applying power that you have remembered to do so. This is to ensure the engine is developing full power for the manoeuvre.

Carb heat failure

If you suspect a failure of the carburettor heat during flight, avoid likely induction icing conditions. Maintain higher throttle settings during descent. Weakening the mixture slightly may also help, but do not cause the engine to run rough as a result.

Maintenance

Periodically check the carburettor heat or alternate air system and controls for proper condition and operation. Pay particular attention to seals which may have deteriorated, allowing the hot air to become diluted and reducing the effectiveness of the system.

Monitor any tendency for water to enter the fuel – filler cap seals may deteriorate and allow rainwater in. Be particularly vigilant when using MOGAS or filling up from barrels or tanks that are not used frequently. For more information on fuel handling and storage, see SSL 28.