Ethanol In Rotax Engines

Fuel

For ROTAX aircraft engines different fuel types are available. See Operators Manual of the relevant engine type and/or the table in chapter 5.3.

Automotive fuels

In addition to AVGAS various automotive fuel types with different quality are available. Due to various environmental, economic and political reasons a number of fuel types with different amount of ethanol blend is available. Therefore the maximum amount of ethanol blend is defined as follows:

E10 (Unleaded gasoline blended with 10 % Ethanol)

In addition to AVGAS and unleaded automotive fuel (Mogas) the ROTAX, 912/914 series of engines are now approved for use with E10. Fuels that contain more than 10 %ethanol blend have not been tested nor are they permitted for use.

Suitability of fuel system components of airframe

ROTAX urges owners to confirm with their airframe manufacturer that ethanol blended fuels of up to 10% (E10) are compatible with all fuel system components. It is the responsibility of the aircraft manufacturer to test the fuel system components and supply any further information on techniques, procedures and limitations of using ethanol blended fuel.

ROTAX recommends that aircraft manufacturer and owner/operators read the following: - FAA Advisory Circular Letter AC 23.1521-2

- FAA Special Airworthiness Information Bulletin CE-07-06

- EASA Safety Information Bulletin – SIB 2009-02

These contain details regarding the use of ethanol (alcohol) blended fuels and the type certificate requirements.

It is strongly recommended that also non-certified aircraft also conform to the information given in the above documents.

AVGAS fuel additives

Additives, which aid the scavenging of lead deposits under the names of Decline® and AlcorTCP,, have not been tested by ROTAX®. Field experience gained shows that these products have no detrimental effect on the engine, when used in the recommended manner.

1 <u>INTRODUCTION</u>

a) Before an aircraft is granted a Certificate of Airworthiness or a Permit to Fly it must be demonstrated that the aircraft, including its engine(s), complies with the applicable airworthiness requirements. The aircraft or engine designer will normally define, by reference to a recognised specification, the fuel or fuels he is using when showing compliance. The evidence of that compliance will normally be based upon testing using the nominated fuel(s) only. Consequently, when EASA or the CAA as appropriate is satisfied that compliance with the requirements has been shown and issues an approval for the aircraft or engine, that approval will be conditional upon the use of fuels conforming with the particular nominated specifications.

b) For many decades the industry-standard fuel for piston engine aircraft has been 100LL Avgas, conforming with specification DEFSTAN 91-90. This specification is comprehensive, and any changes to be made to it are subject to wide consultation and rigorous analysis before adoption. Production of Avgas is subject to stringent quality control and chemical analysis of the product. The delivery of Avgas to aerodromes is subject to procedures to protect the fuel from contamination and to maintain its quality and traceability. The Air Navigation Order (ANO) places obligations on the managers of aviation fuel installations at aerodromes and personnel carrying out refuelling, to apply procedures to maintain the quality of the Avgas. CAP 748 provides guidance on these matters.

c) Compared with the Avgas specification the specifications for motor gasolines (MOGAS) allow greater variability in the composition of the fuels, and proposed changes to the specifications themselves are not subject to the same level of scrutiny. The major oil companies consider that the systems in place for the production and delivery of Avgas are essential for a fuel which is to be used in aircraft and consequently they do not support the use of MOGAS for aviation purposes. Most major aircraft engine manufacturers (other than a few whose engines have been developed from car engines) have aligned themselves with the oil industry and have refused to obtain approval for the use of MOGAS in their engines. However, some third-parties, mostly in the US, have provided evidence to the various Airworthiness Authorities to justify continued compliance with the airworthiness requirements for some engine and aircraft types when using certain motor gasolines.

d) Information on the types of aircraft which have been approved by the CAA to use leaded or unleaded MOGAS is in CAP 747, Mandatory Requirements for Airworthiness, Appendix 8, General Concessions (GC) 2, 3, 4 and 5. This leaflet provides guidance on the use of MOGAS and does **not** override GCs.

e) **GC No. 2** permits leaded motor gasoline (Leaded MOGAS) to be used with certain engine/aircraft combinations **provided** that the fuel is obtained from an aerodrome aviation fuel installation in full compliance with the applicable requirements of the ANO (equivalent to the storage and quality control procedures applied to Avgas). Therefore the permissions granted under GC No. 2 **exclude** the use of fuel obtained from a filling station/ garage forecourt.

f) **GC No. 3** provides a partial exemption from the relevant Article of the Air Navigation Order to allow certain light aircraft to use Leaded MOGAS obtained from garage forecourts **subject to the conditions contained in the Notice**.

g) **GC No. 4** provides a partial exemption from the relevant Article of the Air Navigation Order to allow microlight aeroplanes to use Unleaded MOGAS obtained from garage forecourts **subject to the conditions contained in the Notice**.

h) **GC No. 5** provides a partial exemption from the relevant Article of the ANO to allow certain light aircraft to use Unleaded MOGAS obtained from garage forecourts **subject to the conditions contained in the Notice**.

i) It should be noted that the CAA does not accept any responsibility for any infringement of manufacturers' warranties, possible accelerated deterioration of engine or airframe components or any other long-term damaging effects resulting from the use of MOGAS.

2 <u>SPECIFICATION & SUPPLY</u>

a) ***<u>Leaded MOGAS</u>***

The CAA approvals to use Leaded MOGAS apply **only** to motor gasoline conforming with BSI Specification **BS4040:1988**. If you use a mixture AVGAS/MOGAS with more than 25% MOGAS, it will be assumed that your aircraft is using MOGAS. Note: "Lead Replacement Petrol", "Unleaded 4-Star", and other products intended to replace leaded petrol are **not** equivalent to BS:4040 and their use is **not** approved.

b) ***<u>Unleaded MOGAS</u>*** Where approval has been given to use Unleaded MOGAS, this **must** conform with BSI Specification **BS:7070** or **EN228**. Beware of other fuels which are widely available (often advertised as having special properties).

c) Aircraft with Certificates of Airworthiness carrying out flights for the purposes of commercial air transport or aerial work, and multi-engine aircraft with Certificates of Airworthiness when flying for any purpose, are not approved to use fuels obtained from garage forecourts. Such aircraft must obtain their fuels in full compliance with the specific demands of the Air Navigation Order (Aviation Fuel at Aerodromes - Article 137 of ANO 2005).

d) Because the sampling, analysis and acceptance controls for MOGAS obtained from garage forecourts are less stringent than those for Avgas obtained at aerodromes, it is essential to ensure that the MOGAS is free from water, alcohol and other contamination. The following conditions must be met:

• The engine/airframe combination must be approved to use MOGAS, either by being listed in Schedule 1 of GC No. 2, or by specific approval as specified in the Generic Concessions.

• The aircraft must be either:

o a microlight aeroplane,

o a powered sailplane,

o a gyroplane, or

o a single-engine light aircraft with maximum authorised weight below 2730 kg operating on a private flight.

e) If your engine is a two-stroke don't forget to add the correct quantity of oil, or purchase premixed fuel/oil to the correct ratio.

3 <u>OPERATING LIMITATIONS</u>

Motor gasolines have a higher vapour pressure than Avgas and are also subject to seasonal variation. To reduce the likelihood of interruption of fuel flow to the engine due to vapour lock, the following operating limitations are imposed for all flights using MOGAS:

a) Prior to take-off, the temperature of the fuel in the aircraft tank(s) must be **less than 20°C**

b) The aircraft must not be flown at altitudes greater than **6000 ft**, unless the CAA has agreed, in writing, to different limitations for that particular aircraft.

4 FUEL HANDLING AND TESTING

a) ***Fuel supply***

MOGAS is more volatile than AVGAS, especially in winter (to help cold starting). Consequently MOGAS is more susceptible to fuel vaporisation at above average ambient temperatures, so beware of hot weather in the Spring and:

- Use freshly obtained fuel from a major supplier with a high turnover. (Note that local Regulations may only allow transportation of limited quantities in your own vehicle.)

- Avoid long storage in the aircraft fuel tanks.

- Record the source of supply. (Note that most credit card receipts show the type of fuel, the quantity, and when and where it was purchased. Retention of such receipts is a means of satisfying this requirement.)

b) ***Testing for alcohol***

The use of fuel containing alcohol is prohibited.

Alcohol is increasingly being added to motor gasolines by the oil companies for environmental reasons. However, if water accumulates in the fuel tanks, or forms within them due to condensation, the alcohol may migrate from the fuel and combine with the water. This may cause loss of power in two ways:

- Firstly, the aqueous alcohol solution may be drawn into the engine in place of the fuel and cause the engine to stop.

- Secondly, the migration of the alcohol away from the fuel and into the water will lower the octane rating of the fuel. Operation using fuel of insufficient octane rating may damage the engine.

- Also, alcohol is incompatible chemically with certain rubbers and plastics used in “0” rings and seals, and with certain adhesives, sealants, pipelines, gaskets etc.

Because of these potential adverse effects MOGAS must be tested to ensure that **NO** alcohol is present. Commercial testing kits are available, and testing for alcohol can also be carried out as follows:

1) Obtain a clear tube (like a test tube or fuel drain device), and mark a line on it about 10% from the bottom.

2) Add water to the tube until it comes to the line. Now, fill the tube with your fuel sample until it is near the top.

3) Shake vigorously for 10-15 seconds, let it settle and if the meniscus is on the line, the fuel sample is alcohol free.

4) If it is above the line (because the alcohol has mixed with the water) alcohol is present and the fuel must not be used in an aircraft.

c) ***Water and other contaminants***

Fuel must be filtered to remove water and any other contaminants. Either use a chamois and funnel or one of the proprietary devices which are available.

d) ***Fuel containers***

These must be properly labelled, clean and free from corrosion etc. There is always a risk of fire when refuelling from cans due to static electrical discharge. There have been several cases of fire, including one in the UK.

Plastic fuel containers SHOULD NOT be used. The process of filling, as well as sloshing in the can during transportation, can cause an electro-static charge to build up, which then discharges as the can is brought near to the aircraft filler neck. Use a METAL container and funnel, and earth them both.

Make up a proper earthing device from copper braid, heavy-duty crocodile clips and a 'ground stake' so that the tank, funnel and fuel container are ALL earthed. Static charges build up most easily in dry air. The driest days in the UK can be clear, crisp days in winter.

e) ***Maintenance indoors***

Refuelling and working with fuel, or on fuel systems, in enclosed areas is hazardous because of the accumulation of fuel vapour, which is heavier than air. In an incident overseas, mechanics were killed by an explosion when pouring fuel into a container attached to a wing fuel tank inside a heated hangar on a very cold (and possibly dry) day. Such work must be done outside and there must be effective electrical bonding between the aircraft, fuel source, piping or funnel and the ground.

REMEMBER - PETROL IS DANGEROUS

THERE IS ALWAYS THE POSSIBILITY OF FIRE OR EXPLOSION

Note: CAP 748 ‘Aircraft Fuelling and Fuel Installation Management’' contains further information on the storage and handling of fuels.

5 MAINTENANCE & PRE-FLIGHT PRECAUTIONS

a) ***Non-metallic parts***

Because of the different constituents of MOGAS and AVGAS, non-metallic fuel pipes and seals must be carefully inspected for signs of leakage or deterioration.

b) ***Water Drains***

If the aircraft has been standing overnight or longer, check the drains for water.

(This should be normal practice.)

c) ***Fuel temperature***

Prior to flight you should make sure that the 20°C limitation will not be exceeded, ideally by measuring the fuel temperature (the top of the tank will be several degrees warmer than the bottom), or by considering:

- The length of time the ambient temperature has been above 20°C.

- Whether the aircraft has been, or will be, standing in the sunshine. (In metal aircraft with integral wing fuel tanks, white-painted wings significantly reduce the rate at which fuel temperature increases, compared with dark ones. Even in the UK a fuel temperature rise of 15°C (from 19°C to 34°C) in 3 hours has been measured in an aircraft with light-coloured wings and integral wing fuel tanks.)

- How long it has been since the aircraft was refuelled, noting the method of fuel storage; e.g. underground tank or small bowser standing in the sunshine.

6 PRE-TAKE-OFF

a) Carburettor icing is more likely when using MOGAS because it has a higher volatility (and possibly a higher water content) than AVGAS. Pay particular attention to the serviceability of carburettor heating (if fitted). If carburettor heating is selectable, ensure that a satisfactory RPM drop is obtained when heating is selected on during pre-take-off checks. Note: If there is an increase above the original engine speed afterwards, it shows that ice was already present when heating was selected on.

b) After any prolonged period of 'heat soak' at low fuel flow (e.g. during taxiing and holding before take-off on a hot day), local hot spots in the engine baY may induce vapour lock in fuel pipes. Before becoming committed to taking off, ensure full power is available and can be maintained. Be particularly alert for the possibility of power loss necessitating abandonment of the take-off.

c) On certain aircraft, the front fuel tank **must** be used for take-off, initial climb and landing. This is because the tank is higher than the engine and provides a positive head of fuel thus reducing the likelihood of vapour-lock. These aircraft are listed in GC No. 2 and GC No. 5.

7 IN FLIGHT

a) ***Fuel pressure***

Pay particular attention to the fuel pressure gauge (if fitted) and be on the alert for any signs of power loss when you switch off the electric fuel pump (if fitted) after take-off. For aircraft fitted with electric fuel pumps; in the event of:

• fuel pressure fluctuations,

• loss of fuel pressure, or

• engine misfiring when temperature or altitude are high,

switch the pump ON immediately.

b) ***Carburettor heating*** Make regular selections of full carburettor heat lasting at least 15 seconds duration; longer if your engine is particularly prone to carburettor icing.

8 RECORDING MOGAS USE

The airframe logbook must be annotated such that the operating hours using MOGAS can be determined. Block records must be transferred at appropriate intervals into the engine logbook(s) where applicable.

9 PROBLEMS

If you experience any problems when using MOGAS, do not hesitate to contact the CAA Safety Investigation & Data Department. Please provide as much detail as possible about the circumstances AND the source of the fuel as soon as practical after the incident.

10 SUMMARY

Do not fly using MOGAS if the fuel tank temperature is greater than 20°C.

Do not fly above 6000 ft using MOGAS.

Only use MOGAS (leaded or unleaded) if your aircraft/engine combination is approved to do so.

Use Leaded MOGAS conforming with BS:4040, or Unleaded MOGAS conforming with BS:7070 or EN228 as applicable.

Always use fresh fuel from a major supplier with a high turnover (or fuel from a managed aerodrome installation).

Test for the presence of alcohol.

Filter the fuel to ensure it is free from contaminants and water.

When refuelling use metal containers and earth everything properly.

Certain aircraft must use the front fuel tank during take-off, climb, and landing (see CAP 747 Appendix 8, GC No. 2 and GC No. 5).

In the event of fuel pressure fluctuations or engine misfiring, switch any fuel pump on.

Be aware that carburettor icing is more likely.

Install a placard, visible to the pilot, providing the following information:

USE OF LEADED MOGAS:

See CAP 747 Appendix 8, GC No. 3)

Use freshly obtained fuel conforming with the specification BS:4040

Test the fuel to ensure that it is free from water and alcohol.

Inspect fuel system non-metallic pipes and seals daily for deterioration and leaks.

Verify correct functioning of the carburettor heating system.

Verify take-off power prior to committing to take-off.

Fuel tank temperature not to exceed 20 degrees Celsius.

Maximum operating altitude 6000 ft.

USE OF UNLEADED MOGAS

(See CAP 747 Appendix 8, GC No. 5)

Use freshly obtained fuel conforming with the specification EN228 or BS:7070.

Test the fuel to ensure that it is free from water and alcohol.

Inspect fuel system non-metallic pipes and seals daily for deterioration and leaks.

Verify correct functioning of the carburettor heating system.

Verify take-off power prior to committing to take-off.

Fuel tank temperature not to exceed 20 degrees Celsius.

Maximum operating altitude 6000 ft.

CARBURETTOR ICING AND VAPOUR LOCK ARE MORE LIKELY WITH MOGAS

Record the use of MOGAS in the logbooks. Report any problems involving MOGAS to the CAA Safety Investigation and Data Department.