Gas Turbine Code of Safe Operation

Code of Practice for the Safe Operation of Miniature Gas Turbine Engines in Radio Controlled Model Aircraft

Contents

1. Introduction and General Requirements

1.1 This Code of Practice has been prepared with the primary intention of promoting the safe operation of miniature gas turbine engines which are designed for use in radio controlled model aircraft. For the most part, these engines will have been designed, manufactured and supplied by commercial Companies who specialize in this type of product. The user will, therefore, have purchased an engine which will have been the subject of an intensive research and development process as well as proper quality control and safety-oriented regimes. It is of the utmost importance, therefore, that the modeller/user understands and adheres to the manufacturer's instructions as regards the set-up, installation, use, and safety guidelines applicable to the engine in question including, in particular, the absolute necessity to follow the recommended service requirements.

1.2 Insofar as home-built gas turbine engines which are assembled by the modeller/user from a kit of parts supplied by a recognised manufacturer of such parts or engines, or which are designed and built more or less from scratch by the individual concerned, the general provisions of this Code are equally applicable. In this case, however, the onus and responsibility on the user is of an appreciably higher standard, and the relevance of the provisions of **Section 3** and **Section 4** following are of importance in that regard and should be strictly adhered to.

1.3 For the avoidance of doubt, this Code of Practice applies to both types of miniature gas turbine engines currently in use, that is those powered by liquid propane and paraffin based fuels.

2. General Safety Issues

2.1 Gas turbine engines and model aircraft powered by them, share many of the safety considerations which are applicable to conventional propulsion systems, particularly ducted fan and the larger petrol engines, and the types of models powered by them. However, the operation of a gas turbine in any circumstances requires the taking of additional safety precautions, and particularly so when a model aircraft powered by one is used. Accordingly, a person who intends to construct and operate a gas turbine powered model should familiarise themselves with and adhere strictly to the requirements drawn up by the MACI for the registration of such large models as regards the conditions which have to be satisfied before they will be covered under the MACI Insurance Scheme.

2.2 Furthermore, in addition to the normal safety rules which are applicable to all powered model aircraft, there are certain other particular matters that need to be borne in mind in the case of model aircraft using gas turbines. These mainly concern the fact that the exhaust gases are hot, that these power plants require properly sequenced start up and shut down procedures, that take off, flying and landing skills and techniques need to be of the highest order, and that the ground handling of such models requires practice and experience in view of the relatively high idle thrust of the latest generation of gas turbine engines.

2.3 For all of these reasons the MACI has determined that -

- the possession of a current fixed wing B Certificate of proficiency by the operator of a gas turbine model is a mandatory requirement.

- the operator of a gas turbine engine and the person in control of the model aircraft (who may be one and the same person in most cases, but there may be exceptions) must have a sufficiently high level of skill, knowledge and experience to enable him or her to deal safely with any difficulty that arises, either in the operation of the turbine or the flying of the model.

- care should also be taken to ensure that proper attention is paid to reliability issues and that careful systematic design procedures, operational procedures and maintenance of engines and model airframes are followed to the highest standards.

- electronic fail safe and fuel cut off mechanisms should be fitted in the model.

- to ensure the highest standards of safety, gas turbine engines and gas turbine powered models should never be operated by a single operator. In particular, where such a model is to be flown, whether in public or in private, the modeller should always be accompanied by a helper who will be familiar with the particular requirements of turbine operation such as, for example, the use of a fire extinguisher.

- gas turbine engines should always be operated at a conservative maximum power level to ensure a proper safety margin.

- At all times the model **must** be operated from a suitable flying site. The most stringent attention should be paid to where and when the model is flown, or where the engine is operated, in order to ensure that the safety of persons and property is not compromised, and that no damage is caused to the environment. In this connection, it should be noted that simply because a flying site has the approval of the MACI for general flying purposes, it does not follow automatically that it is also suitable for gas turbine powered models.

- All turbine powered models must be fitted with a receiver battery of a minimum capacity of 1400 milliamp-hours.

3. Design Considerations

3.1 The provisions of this paragraph are mainly applicable to gas turbine engines that are built from scratch or assembled from a kit of parts supplied by a recognised designer/manufacturer. In the case of such engines -

- they should be subject to rigorous testing to establish a service history and to ensure that all components are capable of sustaining the stresses which arise from their use, before they are operated in a place to which the public have access, whether as of right, or whether such access is restricted on the basis of payment of a fee or otherwise.

- all materials and components **must** be suitable for the use to which they will be put.

- no inferior parts or materials should be substituted for those specified by the designer/ manufacturer in an engine constructed from a published design or blue print by a home builder, or in an engine which is available from a recognised commercial manufacturer;

- no modifications should be made to any component or part which is subject to significant stresses, unless the designer's or manufacturer's approval is first obtained in writing and subsequent certification is capable of being produced.

- in the case of home built engines, the design of the outer casing **must** be such as to guarantee as far as possible that in the event of the disintegration of any internal rotating parts, such parts will be contained within the casing.

4. Certification

4.1 All home-built gas turbine engines **must** be returned to the original designer or manufacturer for written certification as to their compliance with the appropriate design and safety parameters/specifications.

4.2 In the case of gas turbine engines which have been supplied by recognised manufacturers, all appropriate documents originally supplied with the engine relating to testing and compliance with design and safety matters should be kept available for inspection.

4.3 Home-built engines which are under development should be thoroughly tested, and during such testing should be protected against exceeding design parameters, in particular those which relate to speed and temperature, by limiting, if necessary, maximum fuel flow and by other appropriate fail-safe methods.

4.4 Under speed protection mechanisms should be incorporated in the engine control system.

4.5 Fuel control systems should be designed to prevent engines from operating outside the range of permissible temperatures during normal operation.

4.6 Engine protection systems should, wherever possible, be operated in such a manner so as to return engines to safe operating conditions and only shut them down when no other option remains.

5. Start up and Static Running

5.1 Where engines are operated statically, for example on a test bed, or during initial operation in a model aircraft, a manual shut off mechanism, such as a fuel valve or electrically operated switch, independent of the normal throttle control, should be fitted so as to cut power to the fuel pump. Where a valve is used in a liquid fuelled system, it should be located in the low pressure part of the fuel line between the tank and the pump. In a self pressurised (gas) system, it should be located as close as possible to the engine in order to ensure as rapid a shutdown as possible.

6. Operation under Remote Control

6.1 The following provisions apply in the case of engines which are operated remotely, such as a model in flight where the manual switch referred in paragraph 5 above is not accessible.

- The control system should incorporate two fully independent fuel shut down mechanisms, both of which should be capable of remote operation. One of these will be the valve or pump speed controller, as used by the throttle control. The other could, for example, be a servo operated valve in the fuel line, in which case the consideration with regard to the position as given in the previous paragraph 5 shall apply. Alternatively, a relay or additional transistor in the pump circuitry may be used.

- Gas turbine powered model aircraft should incorporate a form of radio fail safe, for example, that commonly incorporated in PCM systems, which will shut down the engine as described in the previous paragraph in the event of interference with or a loss of radio signal. Care should be taken in the operation of such systems to ensure that that this facility is correctly programmed. Under no circumstances should the radio transmitter be left at the default setting. Where both fuel cut off mechanisms are operated by a single control unit, this unit should be configured so that an internal failure will activate at least one of the mechanisms.

- Radio transmitters used for the control of gas turbine powered model aircraft should incorporate a control mechanism that that will instantly shut the engine down when operated. This control mechanism should be easily accessible and should operate in a single action, independent of the throttle control.

7. Fuel Systems

7.1 Several types of fuel may be used in gas turbine engines e.g., JP-4/Kerosene, Paraffin, Jet A1 and Turpentine. However, it is recommended that once a particular fuel type has been chosen, it should remain the preferred option for all further use with that engine.

7.2 Where possible, fuel tanks should be located in a separate compartment from the engine. The tank should also be protected from the heat of the engine.

7.3 Fuel tanks and fuel system components should be adequately secured and protected so as to minimise the risk of rupture in the event of a crash.

7.4 The use of flexible fuel tanks of the plasma bag type is not recommended. If such tanks have to be fitted, they should be located in a separate compartment from the engine.

7.5 Fuel lines and associated equipment must be made from materials which are suitable for the intended service and which can cope adequately with the environmental conditions of the installation.

7.6 Separate feed lines for starting gas and liquid fuels should be used to avoid dangers associated with the migration of the starter gas back into the liquid fuel system.

7.7 The fuel tanks of liquid fuelled engines should not be subjected to any form of high pressure pressurisation. Low pressure pressurisation is permitted in systems of a suitable pressure rating up to a maximum of 5psi (0.35 bar) for the purpose of aiding fuel movement between tanks and to fuel pumps.

7.8 Tanks for gaseous fuel are pressure vessels and they must be certified accordingly.

7.9 All tanks and fuel lines should be regularly checked for deterioration and renewed where necessary, and particular attention should also be paid to the possibility of hardening of flexible pipes and seals in the vicinity of joints which are subjected to high pressures.

7.10 Only clean filtered fuel should be used and appropriate precautions should be taken to prevent the contamination of fuel systems.

8. Lubrication systems

8.1 The following criteria are applicable mainly to gas turbines which use a separate oil lubrication supply as opposed to those which use a percentage of oil mixed in the fuel.

8.2 The oil reservoir should be positioned so that the oil level can be quickly and easily determined.

8.3 The lubrication system should be designed or measures taken by the operator to ensure that when not in use oil cannot migrate into the engine due to thermal expansion or siphoning.

8.4 The oil reservoir should be positioned in close proximity to the engine; otherwise, the oil line to the engine should be primed to minimise the delay in establishing an oil supply during the start up operation.

8.5 The lubrication system should be capable of maintaining a continuous supply of oil to the engine under all flight conditions.

8.6 The oil flow should be controlled to give the appropriate oil consumption as specified by the designer or manufacturer of the engine, and a suitable filter should be fitted upstream of any restrictor or flow regulator.

8.7 Only appropriate oil specified for use in gas turbine engines should be used, e.g., Aeroshell Turbine Oil.

8.8 Oil lines and associated equipment should be made from materials which are suitable for the intended service and which can withstand the environmental conditions of the installation.

Checks should be made periodically to ensure that lines and equipment are not degraded by aging or by other factors.

8.9 Only oil lines and associated equipment should be used which are designed to withstand the maximum operating pressure of the lubrication system without leakage or failure.

8.10 The installation should permit the operator to confirm that oil flow has been established once an engine has commenced running.

9. Installation

9.1 Engines should be securely mounted in the airframe in such a manner that they remain fixed in position throughout all operating regimes.

9.2 All components situated in the vicinity of the engine should be secured so as to prevent ingestion into the engine

9.3 Care should be taken to ensure that the possibility of ingestion of external foreign objects is reduced to an absolute minimum.

9.4 All ancillary equipment such as pipes, lines, wires, control cables etc., should be routed away or suitably screened from the hot parts of the engine, unless they are specifically designed to cope with high temperatures associated with turbine use.

9.5 It is strongly advised that, until experience has been gained of the operation of gas turbine engines in model aircraft, models which are designed to use externally mounted engines should be selected.

9.6 In the case of all internally mounted installations, proper heat protection from exhaust gases should be provided.

9.7 The use of in-built restraining devices such as brakes may be necessary to ensure that the model remains stationary when the engine is at idle.

10. Operating Safety

10.1 Considerations relating to the possibility of fire

10.1.1 An effective carbon dioxide or halon gas preferably, or other suitable fire extinguisher should be available where gas turbines are in operation, and its condition and capacity should be checked regularly.

10.1.2 Gas turbine engines should not be operated if there is a risk that the surrounding environment may be damaged, and it is not possible to take whatever measures may be necessary to avoid that risk.

10.1.3 The smoking of cigarettes or like products should not take place within a radius of 50 metres from the pits area where gas turbine engines are in use.

10.1.4 The venting of liquefied gas fuel should be conducted in a safe manner and, in any event, never undertaken within a radius of 50 metres and never upwind, of any other gas turbine engine which is being used.

10.1.5 All fuels whether liquid propane or paraffin based should be contained in appropriate containers, which should be clearly marked with a description of the contents.

10.1.6 All operators of gas turbine engines should be aware of the risk of fire and should take particular note of the following hazards;

- Residual fuel in the engine leading to the possibility of a “wet start”.
- An incorrect starting procedure.
- Turbine rubbing.
- The introduction of excess lubrication oil during the priming stage.
- The possibility that debris has partially blocked the air intake, thus reducing the performance of the compressor.
- Blocked fuel jets.
- The expansion of fuel into the engine after shut down of the fuel pump.
- The tail pipe pointing into wind during the start up phase.

10.2 Test running of engines

10.2.1 A check list procedure should be used prior to and during any test runs.

10.2.2 The initial testing of any prototype engines should not be conducted in a public place; and only those persons essential for the operation of the engine or the performance of safety duties should be present.

10.2.3 A test bed should be used, and the engine should be fixed securely to it and located in a controlled area with adequate ventilation.

10.2.4 Adequate eye and ear protection should be worn at all times during protracted ground running tests.

10.2.5 Any mechanical abnormalities indicated by the presence of vibration, unusual or excessive noise, excessive temperature, underspeed or overspeed, or any other unexpected phenomena should result in the engine being shut down immediately, and the causes or factors investigated and corrected before any attempt is made to restart the engine.

10.2.5 During ground running tests, particularly in built up areas, due regard should be paid to the need to prevent nuisance caused by excessive noise.

10. 3 Operation of gas turbine engines in public

10.3.1The exclusion areas and minimum distances associated with the use of gas turbine engines are indicated in Annex I to this Code of Practice.

10.3.2 An engine should only be used in public after the operator has gained sufficient experience to be confident and fully familiar with its use.

10.3.3 All engine runs should be conducted at a safe distance from non essential personnel. The jet pipe should always face away from any persons present or property at risk, and in cases where wind direction may require the pipe to be directed otherwise, the distance between the pipe and such persons or property should be increased to ensure that jet blast and temperature are of no consequence.

10.3.4 No person should be permitted to stand close to an engine in operation in the rotational plane of the compressor or the turbine.

10.3.5 Particular attention should be paid to the site where the engine is being operated to reduce the risk of foreign damage to the turbine by ingestion of loose grass, dirt, gravel etc.

10.3.6 The operator should also ensure that all items of loose clothing, jewellery, and ancillary equipment associated with the model, such as glow clips, spanners and tools for example, are stored safely away so that they cannot be ingested by the engine.

10.4 Operating Instructions

10.4.1 The manufacturer's or the designer's operating instructions should be followed at all times.

11. Maintenance

11.1 Engine maintenance is essential and should be performed regularly. The frequency and detail of checks and actions will depend on the engine installation, the operator's experience, and the manufacturer's or designer's instructions, and will vary between external inspections prior to flight through to the stage of full engine dismantling and inspection at predetermined intervals.

11.2 As a minimum the following checks should be carried out prior to every flight:

- a visual check of the fuel and oil systems for leaks (the latter in the case of separate lubrication systems)
- a visual inspection of the engine for any signs of damage. Even minor damage to a compressor blade, visible from the inlet, should be investigated and the strong presumption in this case would be that the engine should not be used due to the risk of vibration.
- a visual inspection of all fuel and oil filters (where fitted).

11.3 As a minimum the following checks should be undertaken at regular intervals, for example, prior to each flying session:

- cleaning of all fuel and oil filters (where fitted).
- checking of the fuel and oil systems (in the latter case where separate oil lubrication is used).
- checking the engine and systems installation for deterioration, damage and insecurity.

11.4 The maintenance of an individual engine log book is strongly recommended in which should be recorded the dates on which the engine was run, the length of time the engine was run, the total running time accumulated, details of any service, maintenance or repair work carried out, (including details of parts replacement), and any other details which would be of value in creating a service history and establishing service intervals.

12. Operator Qualifications

12.1 Inexperienced operators should, wherever possible, seek the assistance of an experienced operator before running a gas turbine engine. If there is any doubt present about the procedures involved, experienced help should be sought.

12.2 All initial runs of a gas turbine engine should be done on a secure test stand in order to gain experience with start up procedures and the running characteristics of the engine. The

operator should not attempt any operation of the engine in public until such experience has been gained.

13. Flying of Models

13.1 All operators of gas turbine powered model aircraft must comply with the requirements of this Code of Practice which has been adopted by the MACI for the purposes of ensuring the safety of all persons involved and for the public at large.

13.2 In particular, attention is drawn to the conditions as set out in **Sections 2.1** and **2.3** of this Code of Practice in relation to the prior registration and approval of these models under the appropriate MACI Scheme currently in operation, and the requirement for the holding of a fixed wing B Certificate of proficiency, respectively.

13.3 The attention of operators is hereby drawn to particular characteristics associated with gas turbine engine powered models, namely

- a delay period, which can vary between different engines, in the response to opening and closing the throttle.
- the high speeds, relatively speaking, which, due to aerodynamic factors, gas turbine powered models are capable of achieving.
- the relatively high thrust, even at engine idle speeds, which can necessitate the need for the fitting of flaps, spoilers, and other speed reducing devices on models to slow the approach for landing.