CODE OF PRACTICE FOR THE SAFE OPERATION OF GAS TURBINE POWERED MODEL AIRCRAFT

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THE CODE OF PRACTICE

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Foreword

This Code of Practice has been prepared by members of the NZMAA Turbine Special Interest Group and is submitted in good faith to promote the safe operation of gas turbines in model aircraft. The content of the Code is drawn from the collective knowledge of those individuals who, in recent years, have amassed significant experience in the building and operating of gas turbines in model aircraft.

Whilst every effort has been made to avoid errors and omissions, the authors cannot be held responsible for any eventuality arising from the application of this code. The safe operation of any gas turbine powered model must remain the sole responsibility of the operator.

Definitions

Persons complying with the requirements of the Code must be aware that throughout the Code there are certain words which have specific meanings, defined as follows:-

> **must -** Indicates an absolute obligation to comply. (There are no circumstances under which the requirement could be relaxed).
>
> **should -** Indicates an obligation to comply so far as is practicable but allows a relaxation of the requirement under exceptional circumstances. (There has to be a very good reason why the requirement is not complied with).
>
> **may -** Indicates a preferred course of action, based on collective experience. (Non-compliance is not expected to result in an unsafe situation)

Introduction

Gas turbine engines and model aircraft powered by them share many of the safety issues of conventional model power-plants and aircraft. Those embarking upon the model aircraft powered by such an engine should first make themselves familiar with these safety issues, as detailed in (for example) the NZMAA Handbook. Specific safety issues relating to gas turbine aircraft in particular are as follows:

a. Danger of burns or damage caused by hot exhaust gases.

b. Danger of fire after a crash, ignited by hot components and made more serious by the relatively high fuel loads commonly carried.

c. Danger of fire caused by overheating as a result of poor start-up procedures or engine failure.

d. Danger of fire or explosion caused by mishandling of liquid propane or similar fuels.

e. Dangers relating to the relatively large size, power and wing loading of many (but not all) turbine powered aircraft. These dangers are of course shared with many other large, powerful models.

f. Problems of ground handling relating to the relatively high idle thrust of some engines.

g. Risk of injury caused by engine parts which may be ejected at high velocity after engine failure.

To prevent or minimise risk from all of these possibilities there are various approaches.

i. Ensure that operators and pilots have a high level of skill, knowledge and experience to enable them to avoid dangerous situations.

ii Ensure that failures and incidents happen as infrequently as possible by paying detailed attention to reliability issues and by careful, systematic design procedures, operational procedures and maintenance.

iii Provide fail safe and cut-off mechanisms whenever practicable to ensure that most failures follow a “low risk” path.

iv Run the engine at a conservative maximum operating power rating to provide a safety margin in case of over-speed or over-temperature.

v Pay attention to where and when we fly (or operate the engine) to ensure the safety of people, property and the environment.

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1. Design

1.1 All engines, however designed, must be subject to rigorous testing before operation in public to establish a service history and to ensure that all components will sustain the stresses arising from the engines’ operation.

1.2 All materials must be suitable for the use to which they will be put.

1.3 Where a design has been published or an engine is being manufactured commercially no inferior materials should be substituted for those specified, nor modifications made to any component which is subject to significant stress, before seeking the designer’s or manufacturer’s approval.

2. Engine Protection and Control

2.1 Engines under development must be rigorously tested and during such testing must be protected against exceeding design parameters, especially those of speed and temperature.

2.2 Engines must be prevented from exceeding safe operating speeds and temperatures by limiting the maximum fuel flow by fail-safe methods.

2.3 Under-speed protection should be incorporated in the engine control system.

2.4 Fuel control systems should be designed to prevent engines operating beyond permissible temperatures during normal operation.

2.5 Engine protection systems should, wherever possible, return engines to safe operating conditions and only shut engines down completely when no other option remains.

3. Fuel Systems

3.1 Where possible fuel tank(s) should be located in a separate compartment from the engine. The tank(s) must be protected from the heat of the engine.

3.2 The fuel tank(s) and fuel system components must be adequately secured.

3.3 The fuel line must have a mechanical shut-off valve, in the delivery line from the fuel tank(s), which can be manually operated in addition to any servo control, and which is **readily** accessible.

3.4 A fail-safe device should be incorporated to shut off the fuel supply in the event of loss of radio contact and to ensure that the supply remains isolated should radio contact be restored. A short delay in fail-safe fuel shut-off may be incorporated to avoid unnecessary action during short-term events. The delay must not be so long that the benefits of any fail-safe action are lost.

3.5 Fuel lines, connectors and associated equipment must be able to withstand the pressure imposed without leakage or failure when the engine is operating at maximum safe speed. A drainage hole should be made in every part of the model where fuel could collect as a result of a leak.

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

3.7 Separate feed lines for starting gas and liquid fuel should be used, check valves may also be used, to avoid the dangers of migration of the starter gas back into the liquid fuel system.

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

3.9 Tanks for gaseous fuel are pressure vessels and must comply with the relevant regulations.

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

4. Lubrication Systems

4.1 The oil reservoir, where used, should be positioned so that the oil level can be quickly and easily determined.

4.2 The lubrication system must be designed or measures taken by the operator so that, when not in use, oil cannot migrate, due to siphoning or thermal expansion, into the engine.

4.3 The reservoir should be positioned in close proximity to the engine or the oil line to the engine should be primed to minimise delay in establishing the oil supply during starting.

4.4 The lubrication system should be able to maintain a continuous supply or keep interruptions arising from aircraft maneuvers to a minimum.

4.5 The oil flow must be controlled to give the appropriate oil consumption, as specified. by the designer or manufacturer.

4.6 A suitable filter should be fitted upstream of any restrictor or flow regulator.

4.7 As appropriate oil suitable for use in gas turbines should be used.

4.8 Oil lines and associated equipment must be made from materials suitable for the intended service and which can withstand the environmental conditions of the installation. Checks must be made periodically to ensure that lines and equipment are not subject to degradation.

4.9 Oil lines and associated equipment must be able to withstand the maximum operating pressure of the lubrication system without leakage or failure.

4.10 Means should be available to confirm that oil flow has been established once an engine has been started.

5. Installation

5.1 Engines must be securely mounted and attached in a manner to ensure that they remain so for all operating regimes.

5.2 All components anywhere in the vicinity of the engine must be adequately secured to prevent ingestion.

5.3 The engine must be protected from Foreign Object Damage (FOD) by suitable screens or by virtue of the position of the air intake(s).

5.4 Pipes, lines, wires, control cables etc, should be routed away from the hot parts of the engine or be suitable for the temperatures arising.

5.5 Until experience has been gained in operating gas turbines, engines powering aircraft or other vehicles should be mounted externally.

5.6 For internal turbine installations adequate heat protection from the hot exhaust gases must be provided.

5.7 The idle thrust of a gas turbine can be very high. If the model does not remain stationary with the engine at idle, positive measures must be taken to restrain it.
Note: The behavior of the aircraft may vary depending upon the nature of the runway surface.

6. Operating Safety

6.1 Fire

6.1.1 An effective, operational, Carbon Dioxide or other suitable fire extinguisher and a designated competent operator **must** be present during all engine runs.

6.1.2 Gas turbines must not be run if the surrounding environment presents a fire risk unless adequate precautions are taken to negate the risk.

6.1.3 Smoking or other sources of ignition are **prohibited** within a radius of 5 metres of decanting, venting or fueling of flammable gases.

6.1.4 Any venting of liquified gas must be conducted in a safe manner, in particular venting must not be undertaken within a radius of 5 metres, and never upwind, of any other gas turbine which is running.

6.1.5 All fuels must be contained in appropriate vessels clearly marked with a description of the contents.

6.1.6 Engine Fires constitute a major hazard and awareness of potential causes must be fully understood, they include -

6.1.6.1 Residual fuel in the engine leading to a "wet start".

6.1.6.2 Incorrect starting procedure.

6.1.6.3 Turbine rubbing.

6.1.6.4 Excess lubrication oil introduced during the priming of the lubrication system.

6.1.6.5 Debris partially blocking the air intake, reducing compressor performance.

6.1.6.6 Blocked fuel jets.

6.1.6.7 Expansion of fuel into the engine after shut-down of the fuel pump.

6.1.6.8 Tail-pipes pointing into wind at start-up.

6.2 Operating in Public

6.2.1 An engine must only be run in public after the operator is fully familiar and competent with its operation.

6.2.2 All engine running **must** be conducted at a safe distance from non essential personnel with the jet pipe always facing away from them. When wind direction requires that tailpipes are directed towards people or property, the distance from the tailpipe to people or property must be increased to the point where jet blast and temperature effects are of no consequence. A deflector shield could also be used.

6.2.3 No person must be allowed to stand close to an operating engine in the rotation plane of the compressor or turbine.

6.2.4 Particular attention must be paid to site husbandry and cleanliness to reduce the risk of foreign object damage to the gas turbine by ingestion and to prevent any loose articles being carried in the jet efflux.

6.3 Operating Instructions

6.3.1 The manufacturer's or designer's operating instructions must be followed at all times.

7. Maintenance

7.1 Engine maintenance must be regularly performed. The frequency and detail of checks and actions will depend upon engine installation, experience and any manufacturer's instructions, and will vary between external inspections prior to flight to major dismantling and inspection of the engine at predetermined intervals.

7.2 As a minimum the following checks must be made prior to every flight -

7.2.1 Visual check of the fuel and oil systems for leaks.

7.2.2 Visual inspection of the compressor and turbine wheels for any signs of damage. Minor damage to a compressor blade, visible from the inlet, could indicate serious foreign object damage within the engine and must be investigated further before the engine is again operated.

7.2.3 Visual inspection of filters (if accessible and applicable) to ensure that they are contaminant free.

7.3 As a minimum the following checks must be undertaken at regular intervals, preferably prior to each flying session -

7.3.1 Cleaning all fuel and oil filters.

7.3.2 Checking the fuel and oil systems for blockages.

7.3.3 Checking of the engine and systems installation for deterioration, damage and insecurity.

7.4 There are many benefits in keeping an individual engine operating log, in which would be recorded -

7.4.1 Dates on which the engine was run.

7.4.2. Length of time engine was run.

7.4.3 Total running time accumulated to date.

7.4.4 Date and details of any service, maintenance or repair work carried out, including details of parts replaced.

7.4.5 Any other details which would be of value in creating a service history and establishing servicing intervals.

8. Operator Qualifications

8.1 Inexperienced operators should, wherever possible, seek the assistance of an experienced operator before running a gas turbine. If in doubt - seek help.

8.2 In order that the operator shall gain experience with the start-up procedure and the running characteristics of the engine, initial runs of any gas turbine **should** be carried out on a test stand. The operator must not attempt any operation of the engine in public until experience has been gained in the operation of the engine.

9. Flying

9.1 Operators in NZ must comply with the requirements of the Civil Aviation Authority publication CAR 101 and the current issue of the NZMAA Members Handbook.

9.2 Operators of gas turbine powered models should have attained a recognised standard of flying proficiency WINGS BADGE 'A' before attempting to fly a gas turbine powered aircraft unsupervised. Persons supervising gas turbine flying activities should also be qualified to this standard, and have experience with turbine powered model aircraft.

9.3 Gas turbine operation requires that operators must be aware of the flying characteristics which arise from the application of gas turbine power. Paying particular attention to:-

9.3.1 The delay in response to opening the throttle.

9.3.2 The high speeds which can result from the available thrust not decreasing with increasing air speed.

9.3.3 The residual thrust at engine idle speed which can make for difficulties in slowing the aircraft down for landing.