Australian Government
Civil Aviation Safety Authority

AIRWORTHINESS BULLETIN

Engines Operating in a Fire Fighting Environment

AWB 72-002 **Issue** : 1
Date : 29 September 2006

1. Applicability

All aircraft powered by turbine engines.

2. Purpose

This AWB discusses the continuing airworthiness of turbine engines that are engaged in or are likely to engage in fire fighting operations.

3. Background

Aircraft operating in fire-fighting environment carry an increased risk of uncommanded in-flight engine shutdown due to flameouts and failures. The operating environment for such aircraft differs from the normal environment in various ways, for example:

- ⇒ A different composition of air
- ⇒ Local pockets of very hot air
- ⇒ Air contamination

1) Atmosphere with a different composition of air

Dry air in our natural environment is approximately 78% nitrogen, 21% oxygen, and 1% other gases and all aircraft engines are designed to work around that composition. Oxygen supports the combustion process and if the concentration of oxygen drops below a certain level in the engine inlet air, the combustion process may no longer be sustainable and the engine may flameout.

A limited oxygen environment may be a result of intense ground fires, power station exhausts, gas flares on oil rigs or industrial chimneys. An aircraft operating in such an environment (especially when flying slow and low over bush fires) may experience an engine surge or flameout.

Not all turbine engines are fitted with auto ignition and in this situation if an engine flameout occurs, the pilot has to attempt a manual restart in the air.

2) Hot and high atmosphere

Inlet air density depends on the local atmospheric temperature (OAT) as well as local pressure. Under normal operating conditions, as the altitude increases, the loss of atmospheric pressure is partially compensated by a drop in OAT but for a fire-fighting aircraft, operating in an environment of intense fire on ground, it’s different.

When flying in the vicinity of a bush fire, such aircraft may enter air pockets where local OAT is much higher than the ambient. Sudden increases in OAT are likely to result in increased inlet air temperatures, EGT fluctuations, EGT excursions and / or turbine blade over-temperatures.

Turbine blades, when subjected to over-temperatures, experience a change in internal grain structure and substrate material properties. Creep and loss of mechanical properties follow and a sudden blade failure becomes an imminent risk.

Sudden EGT fluctuations and intermittent exceedances are a tell-tale sign that the engine is experiencing local pockets of hot atmospheric air.

2. Contaminated atmosphere

During fire fighting operation, turbine engines may ingest very fine floating particles such as bushfire smoke, soot, ash and fine dust. Continuous ingestion of these particles may result in:

a) Blocking of fine and intricate pressure sense and control lines resulting in erratic fuel metering to the combustion chamber, erratic engine controls and malfunction of accessories.

b) Blocking of fine cooling air holes resulting in loss of cooling air to the turbine blades, exposing blades to the temperatures beyond their design parameters. Continuous exposure to high temperatures may result in blade failure, extensive damage to the turbine and engine IFSD.

c) Deposition of contaminants inside heat exchangers (e.g. oil cooler) which may block free air flow and result in decreased heat transfer and elevated fluid temperatures. Higher than permitted fluid temperatures result in rapid deterioration of internal engine components.

d) Rapid erosion or contamination of the compressor aerofoil surfaces on aircraft not fitted with effective air inlet filters, causing loss of compressor efficiency, loss of EGT margin and compressor stall.

If the aircraft has ingested large amounts of smoke or soot, indicators would be the smoky or acrid odour, haze, abnormal engine indications (eg surging, sudden EGT fluctuations, flameouts) and decreasing or fluctuating indicated airspeeds.

4. Recommendation

Operators engaged in or intending to engage in fire-fighting operations are advised to seek advice from aircraft / engine manufacturers for additional maintenance requirements related to their particular aircraft make and model.

CASA also recommends the following additional actions:

a) Maintenance organisations are encouraged to discuss the increased maintenance requirements for engines flying in a fire fighting role with the aircraft operators.

b) The operators should encourage pilots to report all engine abnormalities.

c) Wherever possible, the pilots should avoid flying in pockets of high localised temperatures, in an environment with limited oxygen content or where air is contaminated.

d) If any of the above conditions are reported by the pilot, ensure that the engine goes through a series of inspections to ascertain engine internal condition.

e) All EGT exceedances and engine surge events must be dealt with in accordance with the approved data / manufacturer's published data and where this data is not available; the engine manufacturer should be contacted for further instructions. Among other requirements, the engine assessment should have consideration for:

   i. Thorough visual as well as boroscopic inspection (BSI) of engine inlet, compressor and turbine aerofoil surfaces and engine exhaust for signs of physical damage.

   ii. Inspection of engine inner gas path for nicking of aerofoils, dents and bending of blades, de-bonding and re-deposition of plasma coating on blades and/or guide vanes.

   iii. Inspection of turbine blades for loss of coating, oxidation, exfoliation and creep.

   iv. If the contaminant ingestion is confirmed – removal of accessories (that might have ingested contaminants) for bench-check and engine compressor wash is recommended.

f) Corrective action should be taken for any anomalies noted.

g) If the helicopter or aeroplane does not have engine auto ignition feature and a modification is available to install 'auto re-ignition' that helps relighting the engine in case of uncommanded engine shutdown then CASA recommends the incorporation of such a modification.

h) Fitment of engine inlet air filters have also proved to be effective in keeping contaminants, soot, ash and dust particles from being ingested into the engine inlet, though the benefits must be weighed against loss in engine performance as well as additional maintenance requirements. Such a modification, if available for your engine, should also be evaluated.

5. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletins should be made via the direct link e-mail address: AirworthinessBulletin@casa.gov.au

Or in writing, to:

Manufacturing, Certification and

New Technologies Office,

GPO Box 2005, Canberra, ACT, 2601