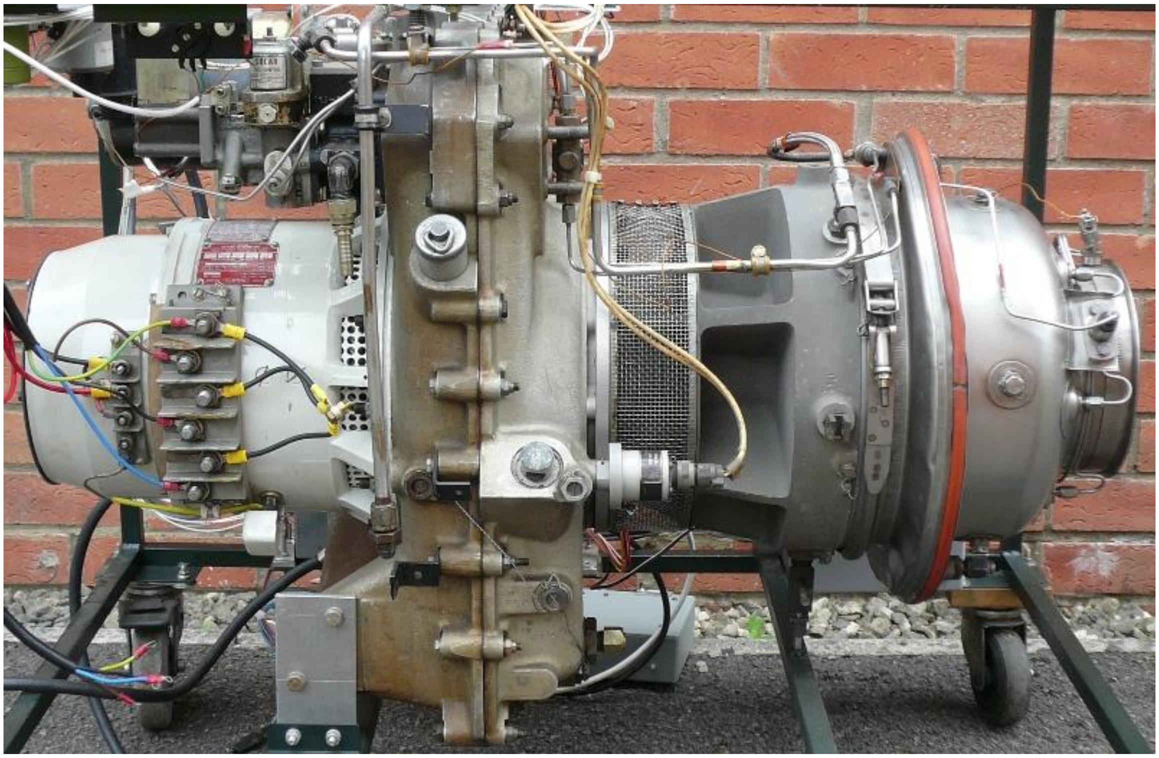
Chapter 7

Operating Procedures



Safety

Operating a small gas turbine can't probably be considered an entirely safe past time, but with a number of sensible precautions the risks can be minimized. There are several particular hazards associated with gas turbine operation; it is useful to consider them individually.

1. Mechanical failure: The number one hazard that comes to mind when witnessing an operating gas turbine is the consequences of mechanical failure. Small engines operate at very high speeds, this means the stored energy in the rotor is very high and the mechanical stresses placed upon it. Small gas turbines are generally designed to contain any failures of the rotating components in order to protect any airframe components around them, but this is not guaranteed.

Never allow people to stand in or near the rotational planes of a gas turbine, also it is sensible not to place other vulnerable systems such as fuel tanks of safety critical electrical systems in these regions. The best place to stand is in front of an engine and away from the exhaust and air intakes. An engine should always be operated at its rated speed, if possible speed sensing systems should be used to shut the engine down if it for some reason should over-speed. A re-settable interlock system is a good idea, this could also incorporate other parameters such as a low oil pressure warning.

2. Noise: Small gas turbine engines are very noisy, always wear ear defenders when controlling or working near a gas turbine engine. Communication with others in the region of a running engine is very difficult, it is sensible to brief others of any particular hazards and have a method in place for them to bring any problems to your attention. Ear defenders can sometimes help in listening to the sound of an engine, it is useful to be able to identify when an engine has lit up and the compressor whine can be heard clearly to confirm that the engine is accelerating properly.

3. Fire: Very high temperatures exist inside a gas turbine and so there is a possible risk of a fire if any part is to malfunction. Always take precautions against fire and have a suitable fire extinguisher available. CO2 units are useful for this purpose, if you must use one in anger be careful how you aim it, the discharge from it can be very cold and could damage the engine. Always mop up any spilt fuel and check for leaks, also make sure that there are no flammable objects or substances in the vicinity of the exhaust. During start up, the exhaust is generally hotter and more likely to set fire to objects near by. If an engine has been flooded with fuel due to an unsuccessful start or a wet cycle, it should be allowed to drain completely before attempting another start. It is often useful to "Ventilate" or "Dry Cycle" an engine to further remove any unwanted fuel.

Previously run engines which are still hot should be treated carefully, fuel vapour can collect inside the engine, if the ignition is inadvertently operated or tested the vapour could be ignited. When cold, engines are much less likely to suffer problems unless they are being operated on more volatile fuels such as petrol, although many engines will run on petrol it is not recommended that this type of fuel is used.

Always be careful when working in the area of an engine which has just been run, many components, particularly around the exhaust can be very hot and will sustain nasty burns if touched.

Exhaust blast: Care should always be exercised when placing an engine in an area for operation. The exhaust jet efflux can blow items around and create a dust storm. The ideal arrangement is to duct the exhaust upwards; care should be exercised when using upward facing exhaust ducts so that debris is not dropped into the exhaust when the engine is stationary. When sighting an engine always point the exhaust down wind so that it is not blown back into the operator's face or into the air intakes.

When operating an air bleed engine, care should be exercised here, the air discharge is very energetic and can be considered a jet exhaust in its own right.

Air intake Suction: Considerable suction is present at the intake of a running gas turbine engine. All loose objects should be kept well away from air intakes and care should be exercised so that stones or other loose objects are not kicked up and into the vicinity of the intakes. If possible, intake screens should be fitted to prevent the ingress of foreign matter and the likelihood of F.O.D (Foreign Object Damage). Never place your hand or fingers near the intake of a running compressor, the consequences could be disastrous and very painful!

Electrical Hazards: The main electrical hazard with any gas turbine engine is provided by the ignition system. Many engines use a high energy system which will produce a lethal electric shock if touched. High energy units contain capacitors which charge up to several thousand volts, at least two minutes should elapse before attempting to disassemble or disconnect a high energy igniter. When working on any part of the ignition system, always isolate the power supply to the engine so that the igniters can't be operated by mistake.

A second electrical hazard may be provided by generators. Gas turbine generators are often powerful for there physical size, a shock hazard may exist with a high voltage 400 c/s unit or a burn hazard from a high current 28V unit if a short circuit occurs.

Chemical Hazards: Synthetic turbine oil is not a pleasant substance to deal with. Avoid prolonged exposure to turbine oils and where possible, wear protective gloves when handling the oil.

Thrust Hazard: When operating propulsion engines, it is sensible ensure that the engine is restrained and cannot move even if it is to be only operated at idle speed. Air bleed engines may also tend to move due to the reaction on the air discharge.

Compressed Gas: Compressed air used for impingement starting may be supplied from tanks pressurized to 300bar (4500 PSI). All hoses, valves and fittings should be specified for the correct working pressure. Hoses bursting and flying off fittings may be hazardous. Compressors and reservoirs should be properly maintained. Diving style air tanks used for breathing air must be hydraulically checked for integrity at the prescribed intervals (UK= 3 years). It’s recommended that well maintained and serviced compressors should be used for recharging tanks with clean dry air to reduce the possibility of internal corrosion. Pressurized reservoirs and tanks should never be sighted in or near the plane of rotation in case of rotor burst failure.

Flammable gas supplies are hazardous and should be safely installed with suitable shut off devices. Gas and air fittings have alternatively handed threads, these fitting should be maintained to prevent cross connections.

Operating a small gas turbine engine

There are many different makes and models of small gas turbines, they all have varying fuel, lubrication, starting and load systems but their basic operation is similar. It is important when operating all engines to ensure that they are not overheated, particularly during starting, and they are not operated at excessive speed.

Preparation for running as small gas turbine

Good preparation is essential for the successful and safe operation of a small gas turbine engine, particularly if it has been recovered as a surplus or unknown unit. Firstly, an engine should be externally cleaned as much as possible so that all the components can be clearly seen and the intakes kept clear of loose dirt and debris. An engine should be thoroughly degreased and then re-protected with oil to ensure against corrosion. Care should always be exercised when cleaning in the region of the air intake and rotating inlet guide vanes i.e. the front of the compressor. Any loose material should be flushed away from the intake area with white spirit of kerosene. Many compressor wheels are relatively fragile so they should not be approached with hard metallic objects, or they could be scratched and scored. A stiff bristle brush and copious quantities of white sprit normally does the trick. After cleaning an engine, always allow it to dry off and any cleaning fluids drain from it. Except during a controlled compressor washing operation, never flush a gas turbine with water.

All the various systems and accessories should be checked thoroughly before starting a gas turbine engine. If any parts are to be dismantled, always record how they are fitted together, the locations of various pipes, and the connections of any electrical wiring. Unless a serious problem is known or suspected it is advisable not to dismantle the main part of an engine. Gas turbines contain many specialist seals, gaskets and fasteners which are expensive and difficult to replace. Specialist tools and jigs are often also required to dismantle parts such as rotors and bearing carriers.

Oil and Fuel

It is important before rotating an engine at any significant speed to ensure that the lubrication system is functioning. The oil reservoir or sump should be filled to the correct level and with the correct specification of oil. If the engine has been stored with the reservoir empty, if possible, attempt to inspect the inside of it and check for any possible dirt or corrosion. It may be worth dismantling the oil system if it is external to the engine and flushing it out with white spirit.

The inlet to the oil pump should always be kept lubricated so that the pump never runs dry, even with a filled tank this condition may occur briefly before it primes. Certain engines may be fitted with plugs or blanks which will allow access to the inside of a gearbox, these are useful apertures through which to inject oil, this will ensure adequate lubrication before the circulating system is primed. Engines that have been stored empty of oil for long periods will benefit from this treatment. It may also be possible to feed oil directly to the bearings by disconnecting the feed pipes and injecting oil directly into them. Syringes are useful devices for injecting lubricating oil into a gas turbine. A second method makes use of low-pressure air from for instance a car tyre, this air can be used to pressurize a vessel filled with oil, the oil is then forced along a tube and into an appropriate orifice on the engine.

If it is known that an engine has been stored for a long period and it appears to be filled with oil it may be that it has been filled with inhibiting oil to prevent corrosion. If this is the case or it is suspected that this is the case the oil should be replaced.

Before rotating an engine is advisable to also lubricate the fuel pump. Normally as a gas turbine engine runs the fuel pump is lubricated by the fuel that passes through it. If the engine has been standing for a long period or the pump has been allowed to run dry it will require lubrication. Fuel or slightly thicker oils such as WD40 should be supplied to the pump inlet, if the engine is not to be started, regular squirts should be sufficient. Most small fuel pumps consist of gear type pumps and will benefit greatly from this operation.

Priming of an oil system is normally achieved by rotating the engine by means of the starter. With an electric start engine, it should be motored up to speed for a few seconds and then the oil system inspected. The reservoir level may go down to indicate suction as the engine draws in oil, also if the oil pressure can be monitored a small amount of pressure may be indicated. The oil level may also rise as scavenge pumps return oil from the engine to the tank. It may be worth disconnecting an oil feed pipe and briefly rotating the engine on the starter to check for flow. Engines which are fitted with an oil cooler can be checked by disconnecting one of the oil cooler pipes. When using the starter to crank an engine care should be exercised to ensure that the starter motor is not overheated with repeated cranking operations. The British RAF recommends that after three consecutive starts the starter motor should be allowed to cool for 30 minutes.

It may take several attempts to prime the oil by means of the starter, if the oil system fails to prime look for any sticking check valves that may be placed in the oil pipes. Check-valves are sometimes fitted to oil systems to prevent siphoning actions or flooding of gearboxes when the engine is stationary. Unless there is confirmation of circulating oil never start a gas turbine engine.

The oil priming procedure is similar for hand started engines, it may be easier at first to crank the engine slowly and check for oil flow. Starting or cranking a gas turbine by hand can be an exhausting business, it is better to save one's energy for a proper start!

When cranking certain models of engine, oil may be seen to appear in the exhaust. In certain cases, this is acceptable, at cranking speeds very little air pressure is developed which may prevent the satisfactory operation of labyrinth type oil seals. Labyrinth seals normally require to be pressurized with air from the compressor that is not available at cranking speeds. Prolonged periods of cranking with this condition should be avoided.

If oil appears in the air intake this probably indicates an oil seal failure, it may be possible to run the engine with care, but oil consumption will be high and it will be detrimental to the engine in the long term. Operating an engine with a failed oil seal will result in a smoky exhaust and may also lead to carbon build up.

Fuel systems should be checked for operation in a similar way to that of the oil systems. It may be beneficial to remove certain components and flush them, particularly if the engine has been stood idle. When cleaning fuel systems always ensure that each part is kept clean and that no dirt enters the fuel system.

Fuel should always be supplied to an engine through a decent filter. Automotive diesel and fuel injection filters are useful devices here. The fuel flows for gas turbines are much higher than that of the equivalent piston engine so the filters will need replacing more often.

A fuel tank of at least a gallon capacity is advisable for testing a small gas turbine engine. Most engines should run satisfactorily with a gravity feed but engines originating from aircraft may benefit from a booster pump feed. Booster pumps normally raise the fuel line pressure to a few PSI, they will make priming the system and removing any trapped air easier and perhaps a little quicker. Always make sure the booster pump pressure is not too high, the maximum value should be limited to about 20 PSI.

Priming of the fuel system is essential to remove any trapped air and to ensure the correct operation of the control system. Firstly, the fuel should be primed with the engine stationary as far as the fuel pump inlet. Many engines are fitted with various bleed points, one may exist at the pump inlet.

With the fuel supply system primed the engine may be primed. The engine should be rotated by the starter and the fuel bled from any bleed points provided. It is also worth bleeding fuel from the supply to the burner(s) with the HP cock open, this can be achieved by loosening the pipe connection to it (them). After priming the fuel, all the connections and couplings should be checked for tightness and security.

To further ensure the correct priming of a gas turbine the engine may be "wet cycled". A wet cycle consists of rotating the engine by the starter with the HP cock open, fuel will then be admitted to the combustion chamber. Care should be exercised to ensure that the ignition system is switched off, otherwise the engine may light up. A wet cycle should be restricted to between 30 seconds and 1 minute to ensure that the starter motor is not overheated. After a wet cycle the combustion chamber should be allowed to drain of all fuel. Failure of the fuel to appear at the drain outlet may indicate a problem with the drain, often the combustion chamber drain is fitted with a small check-valve which may stick. Wet cycling may cause fuel to discharge from the exhaust, after a wet cycle clean up any fuel that may collect in the exhaust ducting or the surrounding area.

After wet cycling an engine it is possible to "Dry cycle" it to blow out any residual fuel. Dry cycling is simply carried out by rotating the engine by the starter and ensuring that the HP cock is closed. Repeatedly cycling an engine can lead to extra wear and tear on the starter motor, it may be possible to combine certain fuel and oil priming operations together to minimize this. During cycling operations, it is also useful to check any instrumentation. Small amounts of oil pressure may be indicated, and a satisfactory and realistic RPM indication checked. Most small gas turbines crank at between 10 and 20% depending on the condition of the starter and the battery feeding it.

Starting a gas turbine engine

This is a general procedure which applies to an electric start unit, hand started units may differ in detail. If available the manufacturers instructions should be adhered to. This applies to a purely manual system, many installations may be automatic or may contain semi-automatic functions such as a starter cut off.

Procedure-

1. Carry out the checks mentioned in the previous section i.e. carry out wet and dry cycles to prime and test the engine. Check that the engine is rotating freely and that there is no rubbing or untoward noises.

2. Check the area around the engine for hazards and warn any bystanders that the engine is about to be started. Make sure if the engine is partially indoors that there is plenty of ventilation e.g. an open door. Wear ear defenders and have a fire extinguisher available. If possible, place a mirror in such a position so that the exhaust can be watched as the engine is started, bear in mind it may be subjected to the jet efflux from the engine. Generally, if anything in the exhaust begins to glow cherry red for more than a second or two, shut the engine down and investigate the cause.

3. Functionally check each part of the control system i.e., check igniters (HP Cock shut), and check the HP Cock (Clunk may be heard from the solenoid or actuator). Reset any over-speed trip equipment if fitted. If the engine is fitted with an idle control, ensure it is selected.

4. Rotate the engine on the starter (Do not release the starter, if it is released by mistake allow the engine to come to rest before re-engaging it.)

5. When the engine reaches 10% RPM, switch on the ignition and then open the HP Cock.

6. Listen carefully, the engine should be heard to light up, this may sound like a rumbling or a dull boom. When the engine lights up the exhaust temperature should begin to rise, and heat should appear in the exhaust. When the engine lights up it should begin to accelerate accompanied with a rising compressor whine and flames may appear briefly in the exhaust. Do not release the starter at this point, immediately that satisfactory light up has occurred the igniters can be switched off or alternatively left on until completion of the start cycle.

7. Monitor the engine closely as it accelerates, look for increasing oil pressure, watch the RPM indication and the exhaust temperature. At between 30 and 40% RPM release the starter, the engine should continue to accelerate under its own power. If the starter is released too early the engine may not self sustain and will stop accelerating or even begin to slow down, if this occurs shut the engine down by closing the HP cock and allow it to come to rest. Do not hold the starter in beyond 40%. If the exhaust temperature exceeds the maximum permitted value or continuous flames appear in the exhaust, shut the engine down by closing the HP cock. Flames in the exhaust may indicate that the engine has not been sufficiently "Dried out" since a wet cycle and another dry cycle is required and/or a longer draining off period allowed for.

8. The engine should accelerate smoothly until either an idle speed or governed speed is reached. If the engine surges, shut it down at once, surging can be identified as a type of "Coughing action" or a "Hunting effect". The RPM may be seen to oscillate, and

smoke/un-burnt fuel may appear at the exhaust or intake areas. In severe cases the engine may "Flame out", flameouts are characterized by a rapid fall in RPM and large quantities of white smoke (un-burnt fuel vapor) will be discharged from the exhaust. If a flameout occurs, it is sometimes possible to "Re-light" the engine by operating the ignition system with the HP cock open. When the engine reaches a governed or steady state speed, the exhaust temperature should drop significantly and stabilize. A typical no-load temperature might be between 300- and 450-degrees C. When operating engines fitted with an idle speed, allow the engine to idle for a minute or two before accelerating it to higher speeds.

9. As the engine runs, monitor the instrumentation and check for oil pressure and temperature if available. Allow the engine to run for a few minutes before and after applying any load to it. Always watch the exhaust temperature so that the engine is not overloaded. When applying a mechanical load such as a generator, when the generator goes online the RPM may "Droop" slightly, this is a characteristic of most mechanical governors.

To stop the engine-

If fitted, return the engine to idle speed, to shut the engine down close the HP cock. Most gas turbines rapidly decelerate when shut down for the first few seconds and then run down more slowly. If possible, record the time taken for an engine to run down and stop, this can take between 10 seconds and over a minute depending on the engine model. As the engine runs down listen carefully to it for any strange noises, most engines will go through various resonances as they decelerate.

Inspect the engine for leaks and check the fuel and oil levels. Bear in mind certain components will be now be hot.

Trouble Shooting -

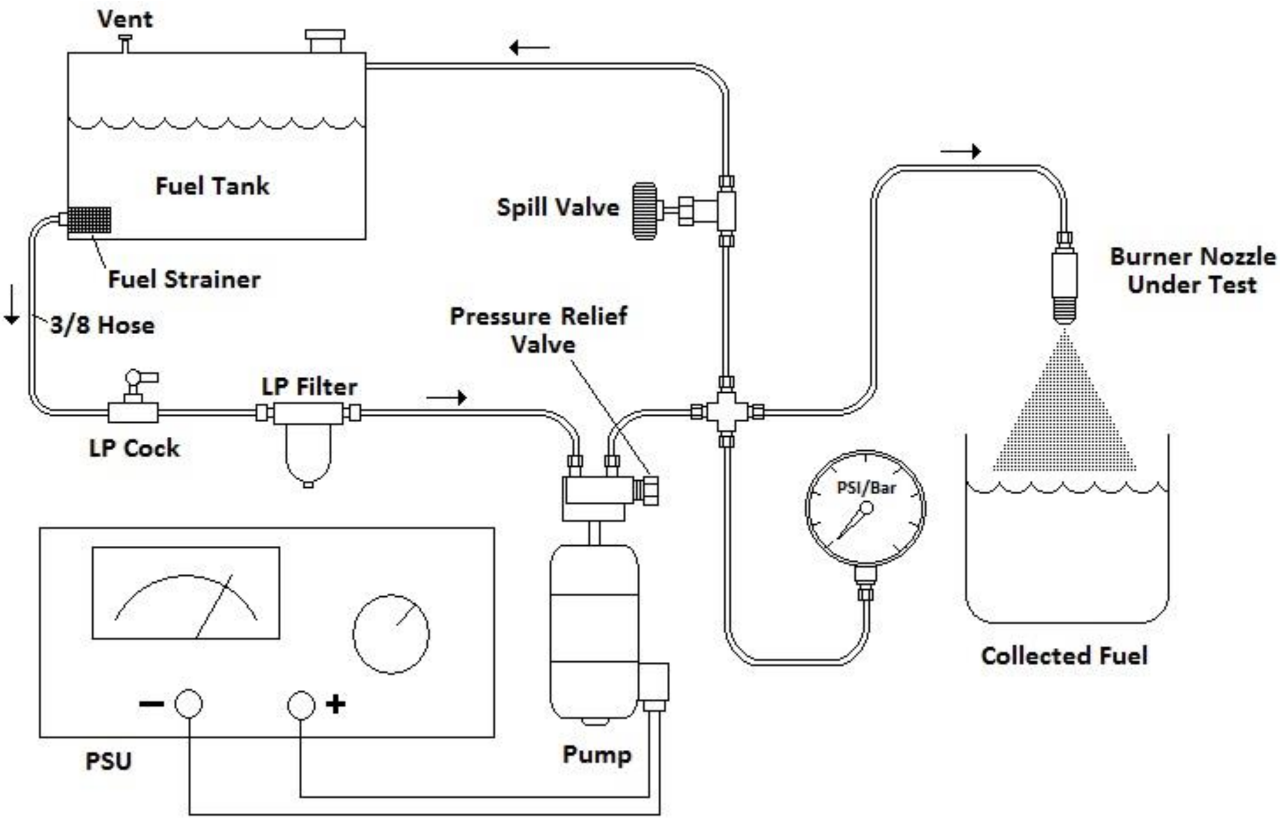
Symptom	**Possible cause**
Engine Does not Rotate on Starter	Engine Seized - examine engine. Flat Battery or poor connections. Faulty Starter Motor or engagement mechanism. Faulty starter contactor.
Starter Rotates but Engine Does not	Sheared starter drive. Faulty over-running clutch mechanism.
Engine Rotates but does not light up	Lack of fuel - Prime fuel and or check with wet cycle. Check pump pressure, check if booster pump is required. Increase “head” from fuel tank. Booster Pump Faulty. Disrupted spray from burner - check and clean burner nozzle(S)*. Incorrect fuel - do not use fuel of unknown origin or that which has been left in fuel tank for unknown periods. No spark from igniter-check igniter electrical system. Sparks can normally be heard with the engine stationary, remove plug and examine for sparks. Check HT cables to plug. If fitted. check torch igniter system for lack of fuel. Excessive fuel spill from control system i.e. insufficient light up fuel available. Fuel pump drive sheared. Engine rotating backwards.
Engine lights up but acceleration is poor and/or ceases. Hung Start	Poor Combustion - poor or disrupted spray pattern from burner (S). Compressor bleed valve open (If fitted). Low fuel pressure or fuel starvation - pump or control malfunction, check control unit/pump. Air leak in acceleration control system. Restricted LP fuel supply. Air emulsion pump faulty (If fitted). Speed control faulty (If fitted). Mechanical Load on engine- check for excessive load i.e. partially seized pumps, stiff generators etc. Hung Start - Battery or starter not providing sufficient power. Starter Motor released too early. Starter or starter-generator incorrectly wired. External components missing from fuel system or disconnected. One or more combustion chambers flamed out. Temperature limiter in operation-reduce EGT.

Hot Starts and or Continuous Flames in Exhaust	Poor Combustion Check burner as above. Accumulated Fuel in engine - drain engine and dry cycle. Check Combustion Drain System Air Emulsion Pump faulty (If fitted). Too much fuel during starting phase. Fuel/Air ratio incorrect. Fit manual fuel spill valve and accelerate engine manually. Insufficient starting power. Air bleed valve open.
Smoke in Exhaust Oil reaching the Exhaust	Faulty seal in the engine. Oil reaching exhaust through oil tank vent system. Accumulation of oil in combustion chamber when the engine is stationary. Faulty oil tank vent or breather system. Incorrect fuel i.e. diesel.
Engine Falters or Flames Out	Air in the fuel - re-prime the fuel system and bleed out all air. Control system overshooting causing momentary loss of fuel. Over-speed trip malfunction.
Vibration/Resonances	Rotor out of balance, worn bearings, incorrect assembly or clearances. Damaged rotor i.e. missing blades.
Hunting or RPM variation	Incorrectly adjusted governor, too much system gain. Lower gain or increase compensation/damping.
Engine Surges (Pops, thumps, fluttering or buzzing)	Acceleration too fast - Check calibration of fuel control unit and/or adjust acceleration control valve if fitted. Insert a needle spill valve into burner supply and control acceleration manually. Air bleed system closed or malfunctioning Exhaust Nozzle too small. Excessive Intake Pressure Drop due to restriction
No Oil Pressure or Flow	Oil not primed - prime oil system Oil Restriction - check oil filter, inspect oil check-valves. Faulty Indicator - check indicator and sender
RPM Drops under Load	Insufficient control loop gain, incorrectly adjusted governor. Low fuel pressure or restricted supply.

Testing burners

Burners may be tested, and the fuel spray pattern inspected. This may be done in a number of ways. In engines which are equipped with just one burner, the spray pattern can be investigated by removing the burner from the combustion chamber and reconnecting it to the fuel system so that it discharges into a container. The engine is rotated by the starter and the HP cock opened, at this point fuel should be seen to spray from the burner. Spray patterns vary according to the design of the engine but generally the pattern should consist of a cone shaped fine mist that is evenly distributed. The spray should not turn into a bubble-like film or break up into larger droplets. When operating the burner from the engine driven fuel pump, the characteristics are only valid for starting speeds, but this process does give an indication of the state of the burner. Poor atomization of the fuel at lower pressures and flows will indicate a potentially faulty burner nozzle.

With a fuel burner removed it is useful to inspect it for carbon deposits at the same time. Carbon formation around the burner will degrade the spray pattern and may also affect the air distribution around it. Accumulated carbon should be removed very carefully, metallic objects should not be used as they can scratch the burner head and damage it.



Simple burner test rig

Burners may often be tested when removed from an engine by constructing a test rig. A simple rig can be constructed by using a pressure pump and a bleed valve. Fuel is supplied to the burner from the pump and the pressure/flow varied using a needle valve to bypass or spill fuel back to the pump inlet. Electric car fuel injection pumps are useful for this purpose, also some surplus aircraft priming pumps find an application here. The pressure required depends on the burner but generally around 100 PSI is adequate for a simple test, a pressure gauge should be fitted to monitor the pressure supplied to the burner. Hydraulic pumps may be suitable provided they are fitted with a relief valve, maximum pressure should not exceed about 200 PSI.

Fuel supplied to a burner must be filtered to a high standard so that particles of dirt in the fuel do not damage it. Solvents may help clean a burner, but care should be exercised so that any rubber seal components do not become damaged by the solvent. It may also be possible to use an ultrasonic cleaning bath to clean a burner if one is available.

With the manufacturers data available burner characteristics can be more closely investigated, certain adjustable types can be optimized when fitted to a test rig.

The spray from burner nozzles is very fine, take care not to breath in the spray and operate the burner in a well-ventilated area. Obviously, the spray is also flammable; keep it away from any naked lights. Take care with high-pressure fuel feeds and do not restrict flows with figures and thumbs etc.

Torch igniters also consist of burner units; these may be tested with the above apparatus.

Compressor washing

Over a period of operating time the compressor section of a gas turbine engine may accumulate deposits of ingested material and consequently become dirty. Dirt built up in the compressor will reduce its efficiency, this results in a poorer overhaul engine efficacy and therefore power output. The need for a compressor wash can be characterized by a lack of useable power output and a higher-than-expected exhaust temperature. The frequency at which it becomes necessary depends on the environment in which the engine is run. It is recommended that rover gas turbines driving fire pumps aboard Navy ships are compressor washed after each day of use, certain GTS units never require compressor washing.

Compressor washing basically consists of a process whereby a cleaning fluid is sprayed into the air intake of the engine either whilst it is running or during a dry cycle operation. The cleaning fluid simply dissolves accumulated dirt which is present on the compressor wheel and in the diffuser section. The fluid is then discharged out of the engine through the exhaust. There are a few different detailed processes for compressor washing small gas turbines, the manufacturers exact instructions should always be followed.

Rover recommends the use of a special compressor-washing compound that is mixed with distilled/de-ionized water and kerosene. The mixture is injected into the engine through a specially provided nozzle that is aligned with the front of the compressor. The engine is dry cycled during and after the compressor wash. Before the washing operation, the various air bleed points (P2) around the engine are disconnected to prevent the washing solution from entering the burner system and any other devices which would normally be fed with P2 air.

A process recommended for Rotax ground power units requires the use of a fluorocarbon compound CFC. A solvent such as 111 trichloroethylene is sprayed into the engine as it operates at idle speed, this cleans the compressor. Fluorocarbons when burnt release toxic chemicals so the engine must be operated in a well-ventilated area and the exhaust fumes kept away from people. This operation may not be possible as certain CFCs are no longer available.

Ardrox® 6367

Compressor Cleaner

PRIMARY APPLICATION

Ardrox® 6367 is a liquid alkaline product formulated to clean the compressor sections of gas turbine engines. A blend of detergents, it is solvent free and removes atmospheric soils, oils, carbon and salt deposits during "in-situ" hot-fired and cold motor washes. Ardrox 6367 is safe on all aircraft metal, plastics, windows, etc., and is non-flammable and biodegradable. In addition, it contains an inhibitor which protects the engine components from oxidation and corrosion for up to 3 days. Regular cleaning with Ardrox 6367 helps maintain peak engine efficiency and reduces maintenance and fuel cost. Ardrox 6367 is compatible with recognized antifreeze materials used during cold weather cleaning.

CHEMICAL CHARACTERISTICS

composition……………….....surfactants and corrosion inhibitors
appearance………………....clear pale yellow solution
physical form………………liquid
flash point…………………..>200°F
odor…………………………mild surfactant
bulk density………………...8.2 lbs./gal
pH…….........................…...8.0

APPROVALS

Ardrox® 6367 conforms to the requirements of Boeing specification D6-17487, General Electric specification C04-140, Pratt & Whitney specification SPMC 87-10A and Rolls-Royce specification OMat 1070F.

APPLICATION PROCEDURE

Hot-Fired Wash:

Use Ardrox 6367 at 20% with demineralized water. Apply by spray; pressure and flow rate will depend upon the engine type and degree of contamination.

Cold Wash:

Use Ardrox 6367 at 20% with demineralized water. Spray on the surface. After cleaning, there is no need to rinse because Ardrox 6367 will protect the engine from oxidation for up to 3 days.

NOTES ON USE

Always apply Ardrox 6367 according to the procedures given by the engine manufacturer.