Operation and Flight Line Maintenance WAM-120

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Introduction

This document is based on experience gained to date with installations of WAM engines for experimental aircraft. No claim is made regarding the airworthiness or otherwise of installations based on suggestions contained herein. Wilksch Airmotive Ltd offers these suggestions without prejudice and cannot be held liable for non-certificated or "Experimental" engine products.

In future these suggestions may be modified in the light of further experience.
Any relevant experiences and observations can be reported directly to WAM.
This document may be subject to change without notice.

WAM engines do not comply any national or federal safety regulations for aircraft. They are intended for use in non-certificated aircraft and only in circumstances in which an engine failure will not compromise safety. Please check that installation aspects conform to WAM recommendations and have been approved by the applicable regulatory authority. Please become familiar with this operator's manual before operating the engine. Refer to Wilksch Airmotive for further details.

WAM Warranty conditions include reporting, discussion and/or inspection of the engine installation before the first engine runs. The Warranty is only activated when these conditions are met and CI-Log data is forwarded to WAM. Check Warranty conditions before conducting engine runs.

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Key Nomenclature

Power Control	the control that determines fuel quantity injected into the engine cylinders, provides control very similar to a throttle on gasoline engines
Stop Control	cuts the fuel to the engine
MAP	a convenient number used to achieve repeatable power settings (manifold absolute pressure in kPa units / 2)
Np	crankshaft/propeller speed as % of maximum rated speed

General

Description

WAM engines are turbocharged two-stroke engines using a compression ignition or “diesel” cycle. Like all diesel engines, combustion temperature is achieved by compression and no spark plugs are required. Unlike conventional gasoline two-stroke engines WAM engines use a camshaft and valves for the exhaust process and piston ports for inlet. As well as the turbocharger, a roots blower is used to force air into the cylinders. The roots blower serves this function at starting and low load conditions while the turbocharger provides the additional boost required at cruise and full rating. The turbocharger has the advantage of a high compressor efficiency and inherent compensation for ambient pressure (altitude). As well as providing reliable starting and off-load running, the roots blower can also serve as a source of air pressure for in-cockpit instruments.

The inverted in-line configuration achieves a modular family of engines with packaging well suited to installation on a wide range of propeller driven aircraft. The high mounted crankshaft assists in achieving sufficient propeller clearance and a “wet” oil sump at the bottom of the engines provides a simple lubrication system suitable for most non-aerobatic aircraft. The camshaft and fuel injection pump are driven by gears and no timing adjustment is required during the normal life of the engine.

A conventional pump-line-nozzle fuel system is used with indirect injection. A mechanical control unit (MCU) is used to achieve engine control over the required range of conditions. This includes idle stabilisation, fuel cut-off during descents and fuel increase during cranking.

Provision is made to drive engine accessories such as vacuum pumps, hydraulic pumps, auxiliary alternators and a propeller governor.

The engine can run on a range of fuels compatible with the diesel cycle. Because of storage and regulatory issues not all of these fuels are recommended and/or authorised. Individual engine rating sheets will show expected MAP at maximum Np on the rated fuel. Different fuel densities will affect power achieved slightly. If a denser fuel than the rating fuel type is used, the pilot must use the MAP gauge to respect the rated peak MAP (and hence power). For example, if the engine is rated on Jet-A1 fuel, use of (denser) road diesel would overrate the engine by typically 5% if the MAP limit were not respected. Conversely, if a less dense fuel is used, a power reduction will result and MAP will not need to be monitored to respect the rating (but reduced aircraft performance must be considered).

Accessories and Interfaces

Alternator

The automotive type alternator fitted as standard to WAM engines is a 55 amp unit that is derated to 30 amps due to the lower drive speed available by the 1:1 coupling with the crankshaft. This rating has been found to be adequate on a typical experimental aircraft used for daytime VFR operation. The 30amp output is available at in-flight engine speeds. At low idle speeds (30-35%) no charge (or a small current drain) is typical. At warm-up and taxi speeds (50-55%) about 10amps of charge is available.

WAM Gyro Air Supply System (P/N 001794)

This system works in a similar way to conventional vacuum powered instrument systems and is intended only for use in daytime visual flight conditions. The system supplies pressure (not vacuum) taken from a tapping in the inlet manifold to the gyro instruments. In some cases gauges marked “vacuum” can be used to monitor the system since they can actually function as pressure or vacuum gauges. Sufficient instrument air supply should be checked during the engine “run-up” by reference to the pressure (or vacuum) gauge. During descent, a minimum cruise power must be applied to maintain instrument air supply. The exact setting will vary with the particular instrument air system installation and propeller/airframe combination.

Standard Vacuum Pump

A drive pad is provided on the rear of the engine fuel pump to run a standard aircraft vacuum pump(Anti-clockwise rotation). If a standard vacuum pump system is fitted, its operation should be in accordance with the pump and regulator manufacturer’s recommendations.

Cabin heater

The operation of the cabin heater and associated precautions will depend on the specific installation. Generally, the cabin heater is required to be OFF during takeoff, landing and other critical flight phases.

Maintenance

Maintenance Schedule

A schedule of the minimum required maintenance is provided in the manitenance manual.

Authorised Owner Maintenance

General daily inspection and top-up of oil and coolant levels at this time. At WAM we want to gain as much knowledge as possible about in service issues. By carrying out the maintenance ourselves , we can make improvements to provide you with the best product we can. Training courses for owners will also soon be available.

Other maintenance

All maintenance must be carried out by WAM staff until further notice.

Recommended Fluids

Coolant

Use only Cool-Elf Auto Supra coolant, available from WAM (P/N 001487). This coolant is pre-mixed – do not add additional water.

Oil

Use only oil available from WAM (P/N 001444) at this time. Other oils are being evaluated and details will be released when available.

Ratings and Limitations Schedule

Take—off rating – 5 minutes maximum
120HP (90kW) at 2750revolutions/minute (100% Np)

Max. continuous rating
100HP (75kW)

Rating at altitude
Unless specifically authorised by WAM technical personnel, the engine is restricted to Flight Level 100 (a pressure altitude of 10,000feet). Maximum continuous MAP is restricted to 110 above FL50.

RPM limits

Idle	30-35% Np	825 – 960 rpm
Maximum	100% Np	2750 rpm

Coolant Temperature Limit

Minimum for Take –off	50 degC
Maximum	100 degC

Oil Temperature Limits

Minimum for Take –off	50 degC
Maximum	110 degC

Oil Pressure Limits

Minimum	150 kPa
Maximum	500 kPa

Fuel Pressure Limits

Minimum	70kpa
Maximum	200kPa

Fuel Temperature Limitations

JET A-1 only	-30C to +75C
Diesel to BS EN590	-5C to +75C
Mix of Diesel and JET A-1 Or unknown fuel grade	-5C to +75C

Normal Procedures

Inspection

A thorough inspection of the installed engine and accessories is an essential component of the process of increasing safety of flight to acceptable levels. The more frequent the inspection is carried out, the greater the contribution to safety enhancement, hence no specific inspection intervals can be recommended with total confidence. If engine installations are designed with convenient access and inspection in mind an inspection before every flight is not an unreasonable inconvenience.

ALL THE TASKS BELOW SHOULD BE IN ADDITION TO ALL THE AIRCRAFT MANUFACTURERS REQUIREMENTS

Some suggestions on what to look for:

- Correct oil and coolant levels
- Tools or other foreign objects left behind
- Missing or disconnected items and components
- Sump plug with no evident locking wire (if no sump quick drain fitted)
- Signs of fluid loss
- Signs of cracking or fracture of the exhaust system and its supporting elements
- Lack of stiffness in the primary exhaust silencer and supports (feel for looseness – if exhaust is cold)
- Blackening due to exhaust leakage
- Loose nuts, bolts or other fasteners
- Blockage of the foam air-cleaner element
- Wear/chafing of hoses and cables
- Fouling or catching of engine control push/pull cables
- Contaminants in coolant header tank
- Metallic or other foreign matter on oil dipstick
- Cracking or deterioration of cooling pack suspension bushes/brackets
- Wear/chafing of coolers against mounts or cowling

Cold Start

- Complete appropriate checks and safety precautions
- Exercise power, stop controls
- Exercise and set prop control to fully fine (If fitted)
- Set stop control to “go”
- Set power control to idle
- Apply 12 seconds of glow (more in colder conditions)
- Crank while increasing the power control to about 50% or until the engine fires
- Check that the engine has oil pressure within 10 secs. If not shut down.
- Check that the Starter Warning and Glow warnings have extinguished.
- Warm up at 50-55% Np until oil minimum temperature is achieved

Hot Start

- Complete appropriate checks and safety precautions
- Set prop control to fully fine (If fitted)
- Set stop control to "go"
- Set power control to idle
- Apply 0 - 5 seconds of glow
- Crank, leaving the power control at idle

"Run-Up" check

- Typical holding point check can be conducted at 70-75% Np depending on the aircraft and propeller
- Check all engine parameters for normal readings.
- Exercise propeller control if fitted
- Check alternator charging via charging current or voltage increase
- Check flight instrument air pressure or vacuum.
- Check idle Np and stability
- Briefly operate stop control and check for rpm drop

Take-off

- Before commencing the ground roll, check for a reference MAP at a commanded Np, typically 70-75% Np.
- Check that Np and MAP are as expected before committing to a takeoff
- Check that the expected full power setting is achieved (Np and MAP)
- Monitor engine readings during take-off roll.
- Respect MAP limit by reducing power control (if a fuel denser than the rating fuel is used)

Climb

- Monitor engine readings regularly during climb-out
- Remember to respect the 5 min take-off rating
- Reduce power to Max Continuous setting
- Continue to regularly monitor engine readings

Cruise

- Reduce to cruise power setting (See charts at the end of this manual)

Descent

- Reduce Power as desired – full idle may be selected although a more considerate setting is desirable.
- Monitor Coolant temp in case of thermostat failure.

Shutdown

- Close down avionics and accessories as required.
- Reduce Power Control to idle.
- Allow a short period for the turbo speed and temperatures to settle.
- Operate stop control and leave it in the stopped position.
- Do not shut down directly from power settings above 50%.

Precautionary/Emergency Procedures

MAP, Temperatures, Pressures out of Limits or Unusual Behaviour

- Reduce power setting and monitor
- Download CI-Log data, backup and send to WAM
- Investigate and discuss with WAM or qualified person

Low Coolant Temperature during Descent

- Coolant thermostat may have failed or be stuck slightly open
- Adjust power setting and/or descent profile to maintain coolant temperature above 50°C
- If this condition reoccurs, coolant thermostat replacement is required

Low Coolant Warning

- Land at the next opportunity
- The reason for the coolant loss must be established and rectified by a suitable qualified person before further flight

Coolant and/or Oil Temperatures Over Limit and/or Increasing
(or other serious/deteriorating engine condition)

- Reduce power setting and monitor
- If temperatures continue to climb look for a suitable landing area
- If you have time try changing to a different fuel tank (If available)
- Switch on airframe fuel pump (If fitted)
- Manage a controlled descent to a suitable landing area
- While the pilot is free to exercise personal choice, it is generally accepted that that engine and airframe life is more expendable than human life

Power Control Jammed on Maximum

- The stop control can used as a power control
- “sensitivity” will be higher and idle speed will not be stabilised

Stop Control Inoperative

- Stop the engine using the main fuel valve (may take up to 30 seconds depending on airframe fuel system)

Engine Runs Backwards on Start-Up

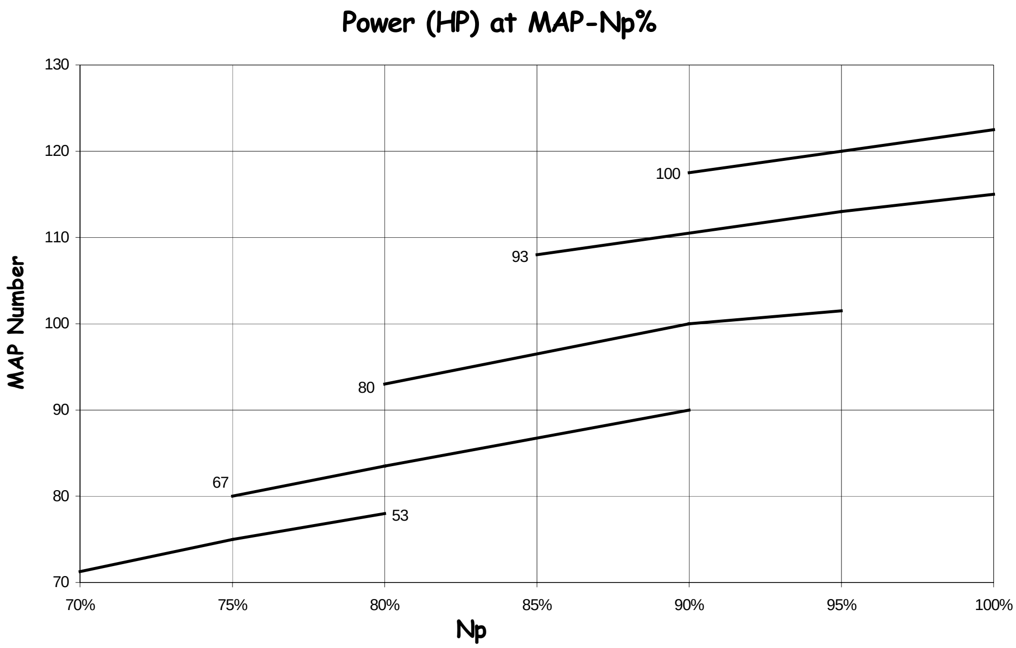
- This is an unlikely condition
- Smoke from the engine air inlet is a likely visible indication of this condition
- Exercise Stop Control
- Provided condition does not last longer than 5 seconds, attempt restart paying careful attention to correct engine rotation on start-up
- If this condition reoccurs it may indicate incorrect fuel injection timing and WAM should be consulted
- The condition will be accompanied by zero oil pressure (can be diagnosed from the CI-Log data).

Recommended Power Setting

To enhance engine life and reduce fuel usage, power settings below the approved maximum continuous power are desirable. Full power rating may also be limited in duration due to the available cooling achieved by the particular installation. Individual airframe and propeller limitations must also be respected.

Recommended Operating Schedule – fixed pitch propellers

MAP and %Np settings for take-off, climb and cruise will depend on airframe and propeller characteristics. Powers up to maximum continuous can be estimated from the following chart.



In practice, typically only three or four operating points need to be placarded and/or memorised for engine control and flight planning purposes. Below 80HP, with Jet-A1 fuel (density=0.8kg/ltr), a rule-of-thumb of 0.25 litres/HP/hr can be used to get a reasonable estimate of fuel consumption. A higher rate will apply for take-off power.

Recommended Operating Schedule – variable pitch propellers (sea level)

MAP	%Np	Nominal power (HP)	Typical Jet-A1 Fuel flow (ltrs/hr)	Comments
*	100	120	33	Full fuel control
110	100	88	23	
100	**100**	75	20	
95	**95**	70	18	
90	**90**	67	16	Typical cruise settings for 600-750kg touring aircraft
85	**85**	62	15	
80	**80**	57	14	
75	**75**	53	13	
* - check individual engine rating sheet				

The numbers in the above table shown in bold can be used for climb/cruise-climb/cruise and can usually be achieved by adjusting only the propeller speed control. By running MAP-%Np in the cruise matched or "square" the engine can readily be operated at its best available efficiency. Best engine health and lowest particulate emissions are achieved when operating "square" or "under-square", that is with MAP=%Np or MAP<%Np.

Power versus Ambient Temperature

The following "rule of thumb" can be used to estimate temperature effect from ISA (15°C) conditions: 3% loss of power for every 10°C increase.

Power increases at temperatures below ISA should not be assumed or relied upon.

Power versus Altitude (ambient pressure)

The WAM-120 is turbocharged and exhibits only a small reduction in power with pressure altitude (less reduction than a naturally aspirated engine). This trend has not yet been fully quantified, hence extra runway should be allowed for take-offs at altitude.

Manifold pressure is restricted to 110MAP above FL50. This restriction will be reduced when more data is available on altitude performance of WAM engines.