WA-MA-1

Installation Guidelines for WAM-120 and WAM-160 "CITEC" Engines

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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 (WAM) offers these suggestions without prejudice and cannot be held liable for Experimental aircraft and other aircraft not certificated to any national standard. WAM presently does not offer any certificated 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.

Mounting

The WAM-120 and WAM-160 mounting lugs are sized to accept Lord J-7402-X type mounts. These consist of two “doughnuts” and a spacer; the assembly being held together with an AN-7 bolt and appropriately locked nut which should then be torqued to 40ft/lbs. Various stiffness mounts are available with different –X numbers.

The right stiffness for best isolation will vary with different airframe structures, however the “Parafocal” configuration used on the WAM-120/160 engines reduces deflection under “g” loading so that relatively soft mounts can usually be used, which may assist in reduction of the vibration transmitted through the mounts.

The J7402-16 and J7402-20 are commonly available and appear to be in a useful stiffness range for the WAM-120, -20 being stiffer than –16.

WAM P/N 001323 (J7402-16) is one pair of J7402-8 + steel spacer tube.
WAM P/N 001324 (J7402-20) is one pair of J7402-13 + steel spacer tube
Each engine will require 4off your selected stiffness e.g. 4 x 001323.
The number of the “doughnut” is moulded onto the rubber.

No part of the suspended engine assembly should make contact with the airframe or its associated components when the mounts are deflected to their limits.

Engine Combustion Air Supply System

The depression at the compressor inlet should not be allowed to exceed 3kPa with a new filter element and 5kPa between service intervals. (1kPa = 10cm water head).

A suitable foam air filter is available from WAM with an integral mounting ring, P/N 001672. This should be supplied with cool fresh air in a way that avoids water contamination either during aircraft storage or during operations. If the filter is fitted in an “air box” with a single entry that could be blocked by ice or a foreign object, some form of flexible or sprung flap should be provided to allow an alternate air entry source. Since this source is for emergency use only it could be warm air provided the resulting power loss is acceptable. Always remember that the airbox should always be supplying more air than the engine requires under all conditions (around 0.3kg/sec at full power). Also remember that the air inside the cowling will be heated considerably by the engine and cooling pack so is not suitable, except for emergency use as noted above. A drain hole should be provided in the airbox to allow any water to escape.

Hoses should be specified so that they cannot collapse due to the depression created by the filter under any service conditions. WAM can supply a suitable aerospace quality hose available as 2.5ft lengths P/N 001763. Longer lengths available on request.

Exhaust System

Exhaust systems must be designed to keep backpressure within the engine's allowed limit of 5kPa; again to allow for some degradation in service it is better to aim for somewhat less with a new system.

To achieve this the system should be based on an already proven design or the backpressure measured during proving trials. Measurement of back pressure will require a suitable pressure tapping at some point in the first pipe between the turbine outlet and first stage silencer box.

Care must be taken that only minimal loads are applied to the turbine exit flange. This can be achieved by bracing the system to the engine (through holes are provided on the crankcase and head to accept 6mm or ¼" bolts) while allowing for differential thermal expansion, or by providing a flexible joint. Previously proven systems should be used if at all possible. For applications where the 6.5mm holes are not accessible alternative bracing schemes must be considered and these should be discussed with WAM technical staff.

Gasket P/N 000919 is available for fitting between the turbine housing and the exhaust flange. Three 8mm cap head screws should be used P/N 0001430 and torqued to 10-15Nm. They should then be wired locked (the heads must first be drilled before fitting). After the first few hours of operation check for security of the gasket and gas leaks.

Exhaust systems are subject to mechanical and thermal cycles and should always be regularly inspected for security, signs of cracking or other problems.

Cooling System

Charge/Coolant Cooling

All aspects of engine performance affected by the cowling and installation features must be proven during careful ground runs and flight testing. The integral charge air/coolant cooling pack offers a simple cooling system installation to suit most tractor propulsion aircraft. Use of this "standard" cooling pack solution will allow accumulated experience and "know-how" to be shared across different aircraft types.

Where these items are relocated in a "non standard" cooling system, all aspects that could affect engine performance, cooling system effectiveness and reliability/durability must be carefully considered, re-engineered and proven. This applies to both component integrity (e.g. hoses, clips etc) and to system performance (e.g. limiting T's and P's, gas purging, warm-up stability, coolant flow rates etc). WAM would be happy to comment on any aspects of a proposed non-standard installation.

WAM engines are supplied with a coolant bottle that is suitable for many installations. Alternate bottles including larger volume bottles are also available. All of these coolant bottles include a means of low coolant warning. The bottle should always be mounted to be the high point of the system. Ensure that all hoses have a fall from the bottle and that there are no points where air could become trapped. This is especially important with taildragger installations when on the ground.

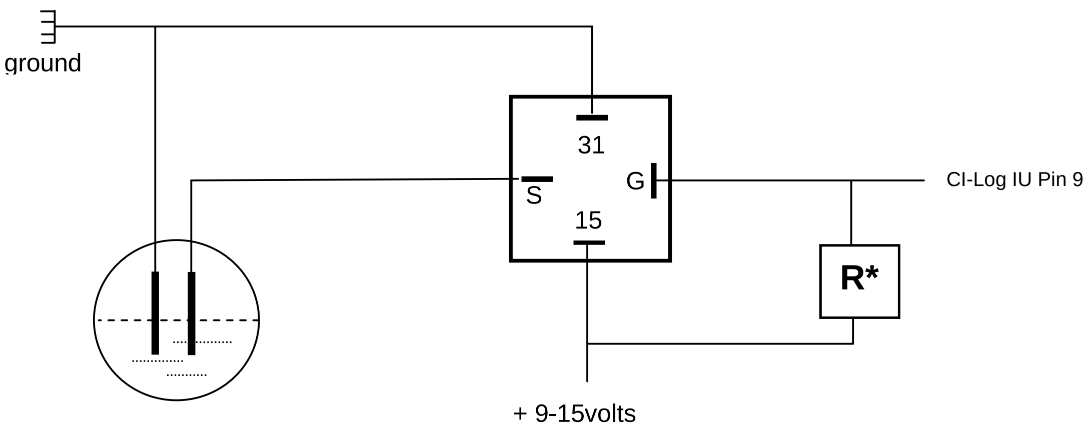
Low Coolant Warning

Some form of low coolant warning is recommended.

Capacitive Probe Type

WAM P/N 001777 is a Low Coolant Level warning kit. This works with the capacitive type probes used in the coolant bottle as supplied by WAM. It will provide the required signal for the CI-Log low coolant warning function or alternatively, drive a bulb or LED.

The Liquid Level Switch should be wired per the diagram here. R* can be a bulb of up to 1.2W rating. If no bulb is required (for example when the CI-Log system is installed), R* should be the 4700ohm resistor supplied in the kit. This is best fitted across pins 1 and 9 at the IU plug, pin 1 being the required power source.



Switch Type

Low coolant warning using a good quality comercially available float switch is also possible.
If this is used with the CI-Log system it must supply volts-high to the CI-Log IU Pin 9 when coolant is present and volts-low for the warning condition.

First Coolant Fill

Only use coolant as recommended by WAM (Cool Elf Supra 60/40 premix). This is available under WAM P/N 001487 in 5ltr containers. Typical coolant volume is 3.5 litres. The system should be filled to the “max” level on the coolant bottle and the engine warmed up to 80°C to open the thermostat and run for a further 5 mins. This should allow any air in the system to purge to the coolant bottle. The system can then be topped up again and the process repeated as necessary. Avoid adding coolant to a hot engine if the coolant bottle is empty. **REMEMBER !!** Always open the cap cautiously to avoid injury from pressurised hot fluid, preferably let the engine cool first.

Oil System

Oil Fill

Refer to the Operator’s Handbook for normal service lubrication guidelines. Sump quantity 6ltrs. Overfilling of the oil system may lead to oil loss from seals or breather. Do not run the engine if the oil level is greater than the maximum level.

Oil Cooling

An oil cooler may be connected using the oil filter sandwich plate supplied with your engine, and suitable sized flexible hoses. WAM stocks a range of oil coolers that have been found to be suitable for a variety of WAM engine installations. WAM can supply hoses that are suitable. These have a bore of 15mm approx. with JIC/AN –10 type connections. Bear in mind that long runs of hose will cause a high pressure drop at start-up in very cold weather, this can cause oil starvation to the engine and excessive pressure at the pump – minimise the length of hose runs and use greater bore if concerned.

Cabin Heat

Air heated by the oil cooler has been found to be an effective source of cabin heat air.
This has the advantage that heating is achieved under descent conditions as well as climbing and cruising. This can be achieved by placing a collector and duct behind a small portion of the oil cooler core and ducting it to the cabin by suitable means. The collector is typically placed at the hotter (oil inlet) end of the oil cooler core.

A jacket around the exhaust muffler is equally acceptable, provided it can be easily removed to allow inspection of the can. Due to the WAM engine's diesel cycle there is no risk of carbon monoxide poisoning when using an exhaust muffler jacket for cabin heating.

Some form of control flap or valve must be provided to achieve the following:

- modulate cabin heat as desired
- allow free flow through the oil cooler on hot days with cabin heat off – i.e. the cabin air must then bypass back to the cowling space
- provide an effective fire resistant seal between cowling space and cabin when closed.

For certain installations it may be more opportune to divert engine coolant to a heating core in the aircraft's cabin. Please contact WAM to discuss such a scheme in detail if this is proposed.

Electrical System

Battery and main leads

Cold cranking current capability should be at least 210 Amperes (ideally 250) to the standard "General Aviation" cold cranking current specification i.e. minimum 1.2V/cell maintained for 60 seconds at -18°C.

There are many zero maintenance recombinant gas (RG) lead acid batteries available that are designed for standby applications and not specifically for high cranking current.

Some RG lead acid batteries do provide high cranking current such as the Hawker Energy SBS and Odyssey ranges. The SBS-30 and SBS-40 are both suitable, as is the Odyssey PC925. The PC680 is marginal but can be used if mounted close to the engine to achieve low line resistance. Odyssey batteries are available from WAM. Call sales team for details.

Typical flooded (wet) aircraft batteries such as the Gill G25 and G35 and equivalents from Concord have been satisfactory. These manufacturers have now released RG versions in the same package size. These have proven to be suitable for starting WAM engines but appear to be less robust than the Hawker Energy range.

Automotive batteries may be suitable subject to satisfactory mounting, containment and venting arrangements – the applicable regulatory authority should be consulted. The cold cranking current specifications should be checked carefully. Note that aircraft and automotive batteries use different cold cranking specifications so that the "CCA" figures cannot be directly compared.

Due to the high currents drawn during starting, line resistance can be significant. As a general rule for the starter motor cable, 4 gauge leads are satisfactory for firewall mounted batteries; this should be increased to 2 gauge for remote mounted batteries. Connection must be made to the upper post of the starter motor solenoid.

The recommended main earth return points are:
- one of the 8mm starter motor mounting studs/nuts
- one of the 10mm alternator mounting studs/nuts
- the unused cast mounting bracket on the alternator

Engine Loom Installation

A ready made loom is supplied with your WAM engine to connect your engine electrical services. All engine terminations are made and it is up to you to cut the loose ends to length dependent upon where your airframe items are located. It is purpose made for connecting with the CI-Logger instrumentation and data logging system. See the Instrumentation section of this manual or contact the sales team for information on the CI-Log System.

An appendix at the end of this manual gives you the necessary information to help you connect the loom. Use this document in conjunction with manual MA-3 CI-Log System Installation for the connections to your data logging Input Unit (IU).

Glow/Start switch

A suitable switch is available under WAM P/N 001308
This switch has four positions:
1. OFF / remove key
2. Accessory (not usually used on aircraft application)
3. GLOW
4. GLOW and CRANK

This switch will carry engine glow plug current. Safety is enhanced by the push/turn required to start feature. The accessory function is not suitable for use as a master switch as it is turned off when glow and glow/crank are selected.

Switch connections:

Terminal Marking	**Function**	WAM Loom Wire No	Details
30	Main bus feed		Supply from 60A breaker
19	Glow	No 32 (White)	
17	Glow		Link to terminal 19
50a	Start	No 31 (Red)	
15	Not used		

Link terminal 19 and 17. This provides glow both before and during cranking. Use 10 guage wire for this link, or thicker. Any unused loom wire from No.32 can be used here.

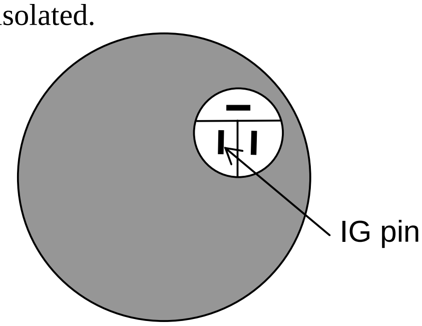
Alternative

For rear engine aircraft or other installations where the full glow plug current is not routed via the glow/start switch, an alternative switch using a remote relay is available from WAM. Switch P/N 001688 and relay P/N 001689.

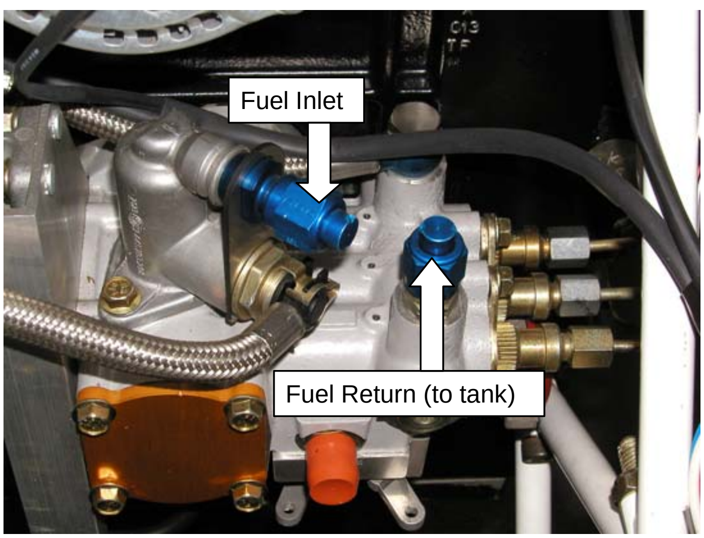
Alternator Connections

The lightweight automotive alternator fitted to WAM engines has an internal regulator unit, the complete specification of which is not known to WAM. Hence, means should be provided to completely isolate the alternator in flight should this become necessary, for example were it to become uncontrolled and produce excessive voltage. A circuit breaker (typically 40-60 Amps) should be connected between the alternator main current output (M5 stud and nut) and the main +12V bus. This wire should be able to carry around 40 amps (typically 10 guage wire). A relay, automatically triggered by an over-voltage sensing device, can also be used.

Alternator excitation is provided by applying 12volts to the "IG" terminal of the alternator. This can be provided via a switch and/or 1-2Amp "pullable" circuit breaker to provide functional checking and in-flight switch-off of alternator excitation. Wire No 33 (Blue) is provided on the loom supplied with your engine for this connection. A yellow wire (No 8) is adjacent to No 33 on the loom. This wire is no longer used and can be left unconnected. Alternatively you can fit it on one of the remaining terminals for cosmetic reasons, provided the other end of the wire is isolated.



Fuel System



Precautions

The engine must be provided with an uninterrupted supply of uncontaminated fuel of the recommended type. The design, maintenance and operation of the airframe fuel system must achieve this. In addition, fuel sources and refuelling practices must be monitored to guard against water and other contaminants. The final filter provided as part of the engine assembly (mounted on the fuel pump) is a fine paper element and is only configured to remove small quantities of contaminants.

Materials Compatibility

All materials used must be compatible with the intended range of fuels, including lines, filler pipes, tanks, fittings, instrumentation and so on.

Supply Fuel Line

Should be JIC/AN "–6" of a type suitable for carriage of aircraft turbine fuels and diesel fuels and meet applicable regulatory authority requirements for the applicable aircraft. Should resist collapse under possible depressions that could occur due to a line blockage. A JIC-6 nipple is provided at the mechanical low-pressure pump inlet (horizontal orientation).

Smaller lines may be suitable on systems with short runs subject to test runs to measure pressure drops.

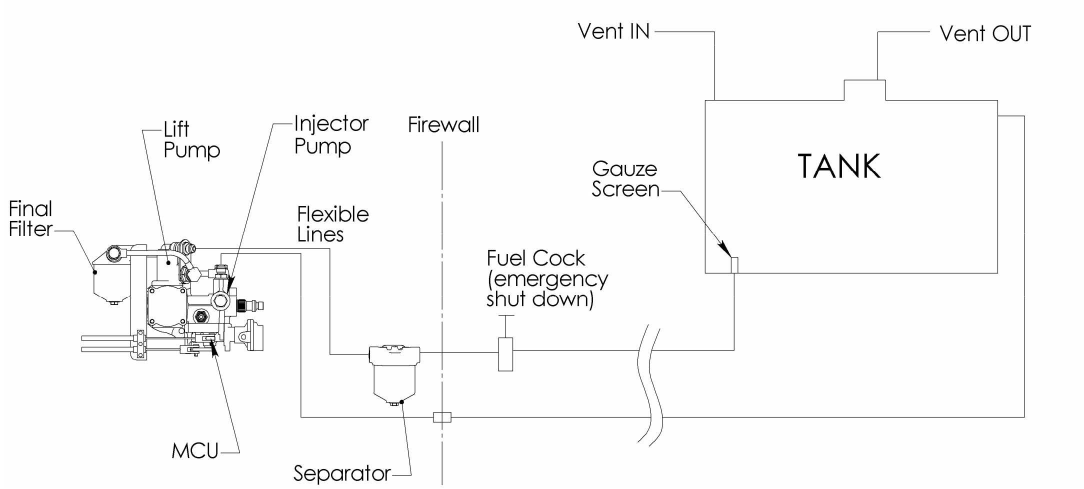
Contaminant Trap and Filter

A "gascolator" style first stage trap should be fitted with the following features in mind:

- Mounting in a position to maximise collection of heavy contaminants and water – usually at the lowest point in the fuel system.
- Readily accessible drain valve for checking and removal of contaminants.
- Easy bowl removal for internal inspection.
- Suitable exit filter – typically 70-100micron – not easily blocked.
- Compatible with transient negative "g" flight conditions.
- Suitable size ports

Electric Pump

For ease of priming the fuel system for the first time and to provide a degree of redundancy against engine fuel starvation due to a fuel system problem, an electric fuel pump may be fitted in the fuel supply line. The pump should provide enough pressure (0.14 bar is suitable for all WAM engines from No.19 on) and flow rate to circulate fuel around the system with the engine shut down while offering minimal resistance to forward fuel flow.



Fuel System Schematic

Return Fuel Line

The purpose of return flow of fuel to the tank is to purge any air bubbles from the system. Air could occur in the fuel system for example from a small leak on the feed line or from transient negative "g" flight. The return flow also serves to warm the contents of the fuel tank, and will also cool the fuel in the pump under certain extreme running conditions.

A JIC-6 nipple is provided on the fuel injector pump for connection of a return line (vertical orientation). A –6 sized line is typical but smaller lines may be used subject to testing to verify satisfactory return fuel flow (0.25 litre / minute minimum).
Where multiple tanks are used it is optimum to return fuel to the feeding tank by using a multi-stage fuel valve. If fuel is always returned to just one of the multiple tanks, the return flow must be measured and operating procedures developed to prevent return to a full tank (and hence fuel spill-over).

Tank Venting

Through tank venting is typically used in gas turbine powered aircraft where temperatures could approach the flash point of the fuel in use. Research on large aircraft fuel systems has indicated that some risk can exist if fuel temperature is allowed to exceed 35°C. Hence tank through venting is recommended for JET fuelled light aircraft fuel tanks in hot climates.

Check Points

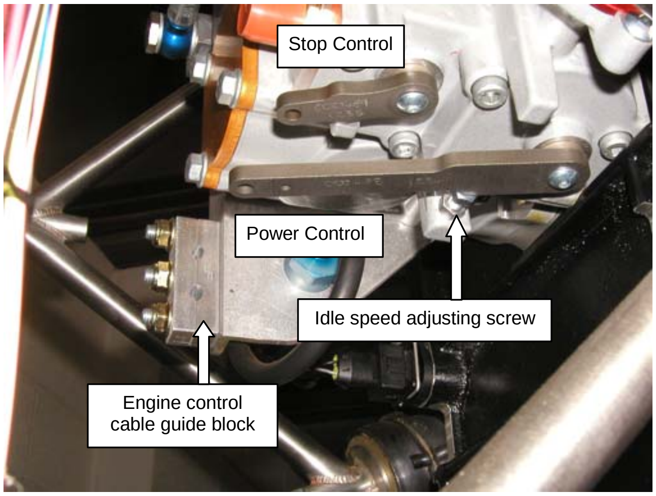
During ground test running the following limits should be achieved:

Engine Condition	**Electric Fuel Pump Condition (if fitted)**	**Fuel Rail Pressure**	**Return Flow**
Stopped	ON	at least 10kPa	5 - 10 ml/s.
Idle	OFF	at least 80kPa	10 - 15 ml/s
Idle	ON/OFF/ON	at least 10kPa increase when electric pump selected ON	no measurement required
Engine at typical cruise speed	OFF	Between 80kPa and 100kPa	no measurement required

The return fuel flow rate should be measured. The return flow should be carefully observed to ensure that no air bubbles are present. This can be done by diverting the flow into a suitable vessel or through a clear (temporary) line. To obtain confidence in the fuel system, particularly with low tank levels, the clear line can be diverted via the cockpit so that it can be easily observed during taxi trials. The aim is to gain a good appreciation of what conditions will induce air into the system and how much air content will begin to slow and/or stop the engine.

If necessary, the return flow rate can be reduced to suit the requirements of specific fuel systems, for example high wing aircraft with cross-connected wing tanks, an absolute minimum return flow of 250 ml/minute must be achieved under all conditions.

Engine Controls



Power Control

On WAM engines the “throttle” is connected to a Mechanical Control Unit (MCU) that controls the torque output of the engine when in the cruise and climb power ranges. The MCU also provides stabilised idle speed control and fuel cut-off during descent (zero power) conditions.

The MCU is located on the lower side of the fuel injection pump assembly and has two control levers. The longer MCU lever is the torque control. It has a 5mm (3/16”) hole intended for a clevis pin and can be driven with many standard “push to go” aircraft control cables. The cable should provide a minimum of 50mm of travel. It also has a small hole to allow a “default to go” spring to be fitted. We recommend fitting a spring in case of “throttle cable” failure. In this event it would be possible to maintain some speed control using the “Stop Control”.

The usual fastening and “safetying” practices should be followed with the clevis pin. The correct length clevis pins must be used to ensure they cannot foul each other or the levers during any combination of power and stop lever positions.

Stop Control

This is the shorter MCU lever. It has a 5mm (3/16”) hole intended for a clevis pin and can be driven by a standard “push to go” aircraft control cable.

Use of a (red) “mixture control” cable will allow Avgas engine practice to be followed for shutdown as the Stop Control will work in the same sense as a traditional mixture control. Use of a locking or friction locking control cable will allow the control to left fixed in the STOP position after shutdown, reducing the chance of inadvertent engine starting.

The Stop Control can serve as a backup power control. This will be more sensitive to control movement and will not have an inherently stable idle. It should only be used as a “get home” control or in an emergency. Pilots should familiarise themselves with operation in this way on the ground.

Control Cables

A selection of suitable control cables is available from WAM. P/N 000631 is a clevis designed to use with “trim to length” control cables with a mono-filament inner wire of 1.8mm. This clevis can also be used with stop control cables with mono-filament inner wire of 1.3 - 1.8mm Caution - this clevis is a “single use” device; once the screw is tightened home the cable will have to be cut to remove it, and the clevis thrown away.

A clevis pin MS20392-2C-17 WAM P/N 001291 should be fitted and retained with an AN split pin 1/16in x 3/8in long, WAM P/N 001292 or equivalent.

A guide block is provided on the bracket holding the fuel filter that can be used to secure control cable outers. Route the control cables entering the blocks from the left hand side and then to the control arms. The holes in the blocks are two different sizes to accommodate the standard control cables (available from WAM). The three posts are slightly offset to prevent the blocks being fitted the wrong way round. The smaller hole at the top is for the Stop control and the lower is for Power control. Ensure that the controls move the levers from mechanical stop to stop.
NOTE: With vernier type or push-button lock type cables, when withdrawing the inner cable to enable the outer to be trimmed to length, be aware that there is a small ball-bearing inside that is used to provide the locking. If the inner is withdrawn too far this may well fall out.

Backup Stop Control

A secondary means of stopping the engine can also be provided. This can be achieved by use of the fuel supply cock. If such an approach is used, the fuel cock should be readily accessible to both pilots when seated for normal aircraft operation; note that there is a non-return valve in the fuel return to tank connection in the fuel pump to ensure that the engine does not run-on on fuel from the return line.

Idle speed adjustment

The Idle RPM (%Np on the logger display) should be checked on the first engine run. This is set at the factory but will vary with each engine/prop combination.Therefore once the engine is up to temperature, close the power control and the idle speed should settle between 850 and 935 RPM (31%-34% Np). A stop screw is provided on the fuel pump power lever to allow adjustment. Idle speeds above and below that stated are acceptable as long as the engine speed is stable and the vibration levels are acceptable.

Instrumentation

CI-Log Instrumentation System

The WAM "CI-Log" System displays and monitors all engine parameters presently thought necessary for normal operation of WAM engines. Data is displayed on a ¼ VGA graphics screen and logged to memory for later download. WAM engines are shipped with engine sensors and a wiring loom ready for the CI-Log system. See the CI-Log Installation and Operations Manual WA-MA-3 for further details.
Customers may wish to fit their own system instead – this is perfectly feasible, please contact WAM for more information.

Propeller

The WAM-120 and WAM-160 are provided with propeller drive flanges compatible with ARP-502 type propeller hubs using six fasteners. By using a WAM provided adaptor, both types of propeller hubs tabulated below can be accomodated. Contact WAM for further information.

Standard	Pattern	Comments
SAE-1	6 x 0.624" dia holes on a 4.375" PCD. Uses threaded "top hat" bushes with 0.375-24UNF threads	Used for both traditional wooden propellers (wooden drive flange) and for propellers with metal drive hubs.
ARP-502	6 x 0.5" dia holes on a 4" PCD. 2 x 0.5" dowel holes on same PCD.	The ARP-502 standard is typically used for metal propeller hubs including VP propellers.

Early WAM-120 crankshaft flanges were also compatible with SAE-1 propeller hubs, although the fitting of top-hat dowelled bushes to suit is a difficult specialist task and not recommended.

The propeller/engine/aircraft combination must be approved by the applicable regulatory authority. The resulting engineering guidelines from the authority and propeller manufacturer must be carefully followed.

Propeller Control

All WAM engines are fitted with internal oil ways and an oil control signal transfer sleeve ready to drive a hydraulic VP propeller. A CSU (Constant Speed Unit or Propeller Governor) mount pad to standard “AND20010” is provided. A suitably skilled aircraft/engine technician can accomplish conversion of the engine to control a variable pitch propeller.

WAM can supply suitable lightweight CSU units and cable support brackets, if given the relevant propeller parameters. Note that currently only certain CSU suppliers will have had experience with diesel cycle engines and oils, ensure that the CSU supplier is aware of, and approves, the application.

The propeller flange must conform to ARP-502 and include an O-ring to seal to the engine spigot. The propeller manufacturer may or may not choose to supply with two dowel pins fitted. These pins serve to phase the propeller to the engine, not as torque transfer dowels. MT propellers have proven to provide good performance with a lightweight design. Please contact the Wilksch sales team for information and advice.

Propeller/engine compatibility must be addressed as a separate issue and cleared as appropriate with the propeller supplier, WAM and airworthiness authority.

CSU Installation Procedure

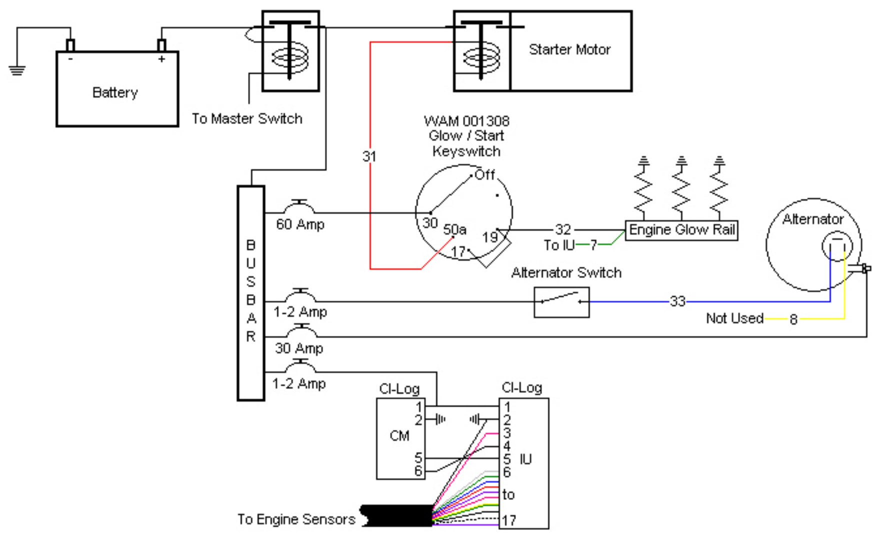
1. Ensure there is no risk of engine accidentally being cranked.
2. Locate aircraft in an environment that minimises risk of contamination.
3. Thoroughly clean areas around the pad/cover to remove contaminants
4. Proceed with caution ensuring that there is no chance of contamination of the engine internals and oil system.
5. Remove the AND20010 pad cover plate.
6. Install CSU using a new filter type gasket. WAM P/N 001378
7. Ensure the spline engages satisfactorily.
8. Tighten the four nuts to 20Nm.
9. Install governor control cable and bracket etc.
10. Remove old propeller and bolts
11. Remove ring gear carrier retention screw – M6 countersunk
12. Remove ring gear carrier
13. Carefully clean the crankshaft front flange/spigot area.
14. Remove the small brass o-ringed “Bobbin” pin from the crank spigot front face (retain for possible future use).
15. Replace ring gear carrier in correct position. In very cold weather it may be necessary to warm the ring gear carrier to ease replacement (no more than 100C)
16. Reinstall M6 countersunk screw but only lightly tighten.
17. Install propeller according to propeller manufacturers instructions including any engine/propeller timing requirement, tracking etc.
18. Check for free rotation of engine propeller – carefully by hand (again ensuring that there is no possibility of the engine firing).
19. Proceed with first test runs according to relevant approved engineering recommendations for propeller/CSU/engine combination.
20. Set propeller fine stop and CSU maximum and minimum speeds (if necessary) in accordance with propeller and CSU manufacturer’s recommendations (for example MT document E-124 “Operation and Installation Manual for Hydraulic VP propeller”)
21. Check for oil leaks.
22. Check again for oil leaks after each of the early flights, until confidence is gained.

LOOM INSTALLATION

Please find below information on the fitting of the loom supplied with your WAM engine. This refers to the installation of the loom to the engine and airframe parts. For details of the connections to the CI-Log please refer to the CI-Log Installation manual WA-MA-3 to latest issue.

The suggested wiring schematic has been provided to help with your electrical installation. It is however not definitive, and indeed may need to be altered to suit your particular aircraft. Please consult WAM if you have any queries.

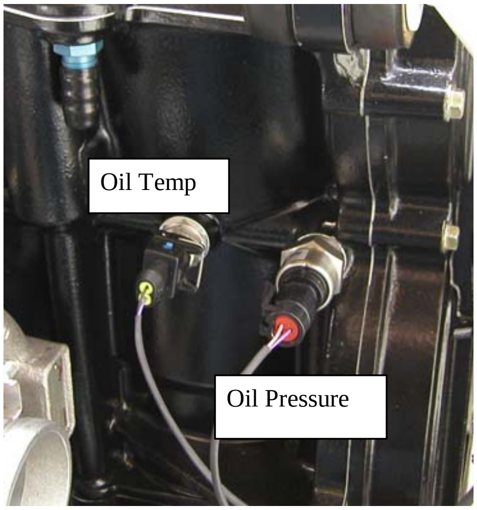
SUGGESTED WIRING SCHEMATIC FOR WAM-120



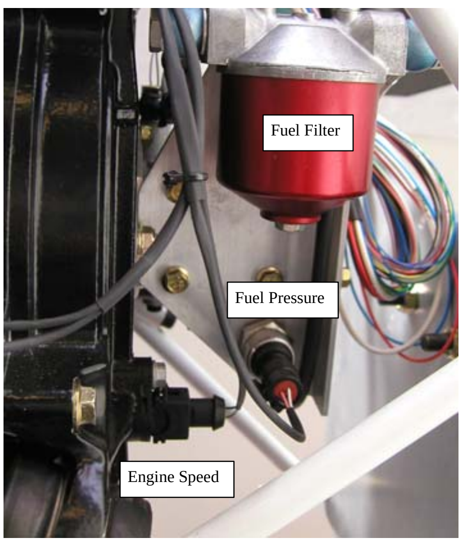
The loom comes with the plugs and terminals for the engine sensors already fitted. All wire ends are then marked with a numbered sleeve as well as being coloured. It is up to the installer to shorten the loose ends to their correct lengths, dependent upon where the CI-Log or instrumentation is fitted. The sleeves are loose on the wires to allow them to slide down to below where the wires are to be trimmed. Please be aware that once you have removed the elastic bands the sleeves will fall off the wires if not prevented. Pieces of masking tape or similar placed on the individual ends can prevent this.

Wire numbers 2 to 17 are for the CI-Log Interface Unit (IU) connections.
Wire numbers 31 to 33 are discussed below.

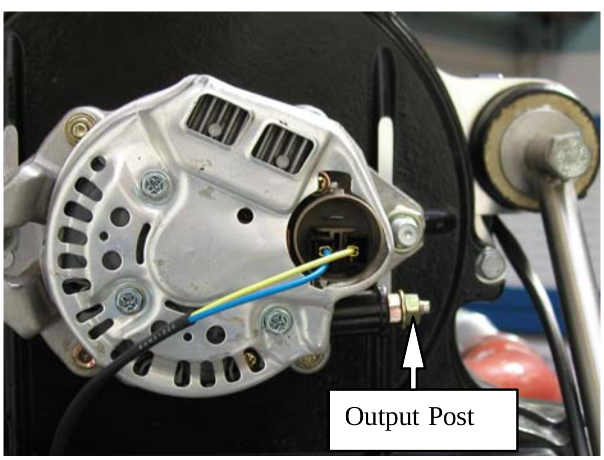
ENGINE CONNECTION.



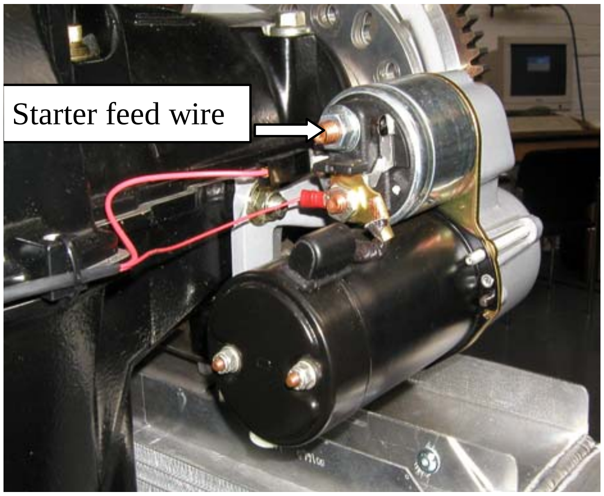
The Oil Temp and Oil Pressure connections are shown here. The temp and pressure sensor positions may be reversed, this is not important.
The Oil Temp plug has a violet and a black wire. The Oil Pressure has three wires, violet, pink, and black.



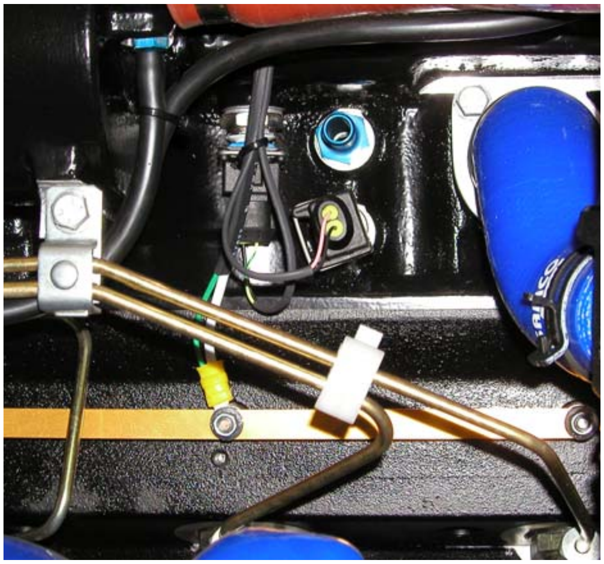
The engine speed connector is the same type as for the temperature sensors. This uses a grey and a black wire.
The Fuel pressure uses the same three-wire plug as the Oil Pressure but has a white, pink and black.



The blue wire is No 33. This is to turn the alternator on and off. It should be routed through the firewall to an alternator switch and/or a 1-2 amp circuit breaker.
The yellow wire (No8) is shown connected but can be left disconnected, as it is not used. If you do connect this wire ensure the other end is isolated. The output post should be connected to the aircraft's bus-bar via a 40-60 Amp circuit breaker (Wire not provided see comments in manual MA-1).



The wire with the black covered connector is placed onto the spade terminal. This is wire No 31 and is to activate the starter solenoid. This should be routed to the starter/glow key switch in the cabin.
The wire with the ring terminal is the starter engaged warning signal (No10). The terminal should be fitted under the lower nut on the solenoid as shown. The upper nut is for the starter feed. This should be at least a 4 gauge, preferrably a 2 gauge cable (Cable not provided) to the battery solenoid (see comments in WA-MA-1).
Also you can see the lugs available on the engine top cover for securing of the loom



Shown here are the connections for the Coolant Temp (horizontally mounted) and the Air Chest Temp (Vertically mounted sensor). The Air Chest uses the plug with the yellow and green striped wire.
You can also see the ring terminal, which is fitted under the middle nut on the glow rail. The end of the white wire (No32) should be routed to the glow/start switch or relay as required. The green wire (No7) goes to the IU for the glow warning signal. They use a common terminal to avoid a false warning if only one terminal failed.