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20 DEC, 1998

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Rev. 1

R.A. Microjets, Inc.

OPERATING and MAINTENANCE

MANUAL

for the

RAM 750F TURBINE

PREFACE

A brief Introduction to R.A. Microjets and the RAM 750 design

R.A. Microjets, Inc. has been in development of the RAM 750 turbine since early 1997. **Ray Gonzalez** and **Albert Ajurio** are the principals of RAM. The RAM 750 engine has been designed to fulfill a need to physically downsize the Turbine to fit a very large cross section of *available* airframes while maintaining excellent thrust capabilities.

The RAM 750 is a single shaft turbojet with an annular combustor. The single stage, centrifugal compressor is driven by a single **stage**, axial flow turbine wheel. The shaft is supported by two lubricated, pre-loaded angular contact bearings. The compressor / turbine rotor shaft was kept very short which yields a very stiff and rugged unit with no resonance problems. The fuel pump is of a gear type driven by a dc motor. **This pump controls turbine r.p.m., and therefore thrust, by varying the rate at which fuel is fed to the combustion chamber.**

R.A. Microjets, Inc. wishes to thank you for your purchase of this unit and feel strongly that you have purchased one of the finest miniature turbines available today.

We have a committed on going research effort designed to insure that R.A. Microjets incorporates the most current technology in the design, manufacture and operations of all our Turbojet engines.

PLEASE READ AND UNDERSTAND THIS MANUAL IN ITS ENTIRETY "BEFORE" YOU ATTEMPT TO INSTALL OR RUN YOUR RAM 750F TURBOJET UNIT.

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SAFETY INFORMATION:

RISK ZONES: (Also see FIG.-1 Diagram)

- 1) The RAM 750 engine develops high energy levels that command respect while in operation. These engines are not TOYS and are not tolerant of misuse or inappropriate handling by the operator.

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- 2) There exists the potential for serious damage and injury to personnel and property if the Operating and Emergency Procedures are not followed as presented in this manual.
- 3) When operating this Turbojet Engine, always have a fire extinguisher present as a fire or explosion hazard exists as with all type of engines utilizing combustible materials combined with high rotational speeds of the rotating parts.
- 4) During Turbine Operations the use of Hearing Protection and Safety Glasses with Side Shields are required.
- 5) ***Read ALL instructions carefully. If ANY doubt exists concerning the Safe operation of this Turbojet Unit, contact your R.A. Microjets, Inc. dealer or field representative immediately for assistance.***
- 6) ***Prior*** to operating your RAM 750F Turbojet engine, you are required to obtain instruction on the proper operation of the turbine by a RAM Representative. This generally takes place at the time of delivery but field representatives can render this service as well .
Contact R.A. Microjets, Inc. [954-441-9810] for the representative nearest you. ***This training is a pre-requisite to obtaining an A.M.A. turbine waiver.***
- 7) All servicing is to be conducted by R.A. Microjets, Inc. or Bob Violett Models, Inc. **At NO time is the Turbojet unit to be disassembled by the owner / operator.**

CUSTOMER SUPPLIED EQUIPMENT:

8. Compressed Air Supply: (Avail. From R.A. Microjets or Local Dive Shop)

- 1) 9 - 80 cu/ft Aluminum or Steel Scuba Tank.
- 1) 1st. Stage Regulator w/ Low Press. Hose.
- 1) High Press. Gauge (0-3000 #) OPTIONAL
(Installed in the high press. side of the 1st. stage regulator to indicate remaining Tank Pressure)

2. Fuels:

Small Propane Cylinder
Jet-A, A1 or Clear Kerosene

3. Oil:

Exxon #2380, or equivalent Turbine Oil

4. Eye and Ear Protection:

Ear Plugs
Safety glasses w/ Side Shields

5. Fire Extinguisher. (UL Rated for Class “B” fires)

CO2 or Halon. **Dry chemical extinguishers are NOT recommended.**

TURBINE SYSTEM COMPONENT DESCRIPTIONS:

TURBINE:

The RAM 750 Turbine is a single shaft turbojet with an annular combustor. The single stage, centrifugal compressor is driven by a single stage, axial flow turbine. The shaft is supported by (2) oil lubricated pre-loaded angular contact bearings. The turbine speed (**and, therefore, thrust**) is controlled by a **geared electric** pump.

Turbine Specifications:

Thrust Class:	75 Newtons; (17 lbs.)
Thrust Range:	5 N.(1.0 lbs.) - 75 N. (17 lbs.)
Fuel Consumption:	90 ccm / min. @ Idle 280 ccm / min. @ Max R.P.M.
R.P.M.:	36,000 @ Idle - 115,000 Max
Pressure Ratio:	2.1:1

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Exh. Gas Temp. : **590°C (Max)**
Weight: **Turbine: 2.4 lbs., Additional on-board equipment: XX.X lbs.**

Max. Diameter: **108 mm, (4.25")**

O.A. Length: **216 mm, (9.5")**

FUEL SYSTEM:

The fuel system consists of the following components:

- a) Geared Pump
- 4) Fuel Tanks
- 5) Tubing
- 6) Pump Battery
- 7) Fuel Filter
- 8) Fuel Shutoff Ball Valve

A dedicated, on-board battery powers the geared pump. The pump speed is controlled by the E.C.U (Electronic Control Unit).

The Fuels used are Jet A, A1 or Clear Kerosene and Propane for the Start sequence.

OIL SYSTEM:

Lubrication is achieved by mixing in one quart of turbine oil to five gallons of fuel. A FESTO "T" is placed in the fuel line at the engine to divert some fuel to the special lubrication manifold in the engine.

Caution: It is very important to filter the fuel. A filter must be used in your fueling system as well as in the aircraft fuel lines.

Caution: One quart of EXXON 2380 or equivalent turbine oil must be added to five gallons of fuel.

START BOX / COMPRESSED AIR SYSTEM:

The Start Box consists of the following components:

- a) Start Fuel Switch
- b) Compressed Air Supply Switch
- c) Engine Data Display

The Start Box is the “Control Center” during the start phase of the Turbine and is used to connect Ignition, Compressed Air and Start Fuel (Propane) to the Turbine for start. It also displays the EGT, Compressor Pressure, and ECU status during operation. The Start Box display is also used to provide information during the **programming** of the ECU **in conjunction with** the Transmitter.

The compressed air system consists of a 9 - 80 cu. ft. scuba Tank with a 1st stage regulator and low pressure hose. This tank is filled to 3000# psi at any dive shop. The 1st stage regulator reduces the output of the tank to 125 psi at the start box connection. **On Initial Use, you must install the quick-disconnect fitting supplied with your start box to the end of the low-pressure hose and clamp.**

E.C.U. (Electronic Control Unit):

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The E.C.U. is the “Brain” of the Turbine operating system. This unit is plugged into the Throttle Channel of your receiver and delivers a proportional signal to the Aircraft Fuel Pump, which in turn controls the Turbine Speed relative to the amount of fuel being supplied to the Turbine.

The E.C.U. senses the Turbine exhaust gas temperature and compressor pressure. Should the exhaust gas temperature of the Turbine exceed 850°C, the E.C.U. will shutdown the turbine. The E.C.U also incorporates the Glow Plug Driver.

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INSTALLATION

NOTE: *All photos referenced in the following steps are located between pages 22 and 23 in the aft part of this section.*

FUEL TANK PREPARATION: (also see FIG.- 8)

Decide whether you will use a simple 2-liter bag OR 2) 1-liter bags. This decision is based on available airframe space. Keep fuel cells as close to the aircraft C.G. as possible. **NOTE: Hard tanks such as DuBro etc. may be used in place of the fuel bags if desired.**

1. Single Bag Assembly:

- A. Place a 6mm clear Green tube into one of the openings of the 2-liter bag. You will need to wet the fuel line in order to slip it into the opening as far as possible. **SEE Photo 5.**
- B. Tie wrap this connection.
- C. Repeat steps A and B with 6mm solid Red tubing in the other opening.
- D. The clear Green tube will be used as the FUEL PICK-UP and the solid Red as the FUEL FILL line. **SEE Photo 7.**
- E. Place the tank in proper position in the airframe and determine the length of Green tubing which will reach the pump. Connect this tube to the pump Inlet.
- F. Now Install the Fuel Shutoff Ball Valve and the Filter into the clear Green tubing. **SEE Photo 6.**
- 7. The Shut-off Ball Valve needs to be readily accessible.
- 8. Determine the length of the solid Red Tubing. The end of this tube also needs to be readily accessible for Fueling.
- 9. Place the 6mm Shut-off fitting at the end of the solid Red tube. This fitting will allow flow only *into* the fuel bags and will *close* when the fuel filling line is removed. **SEE Photo 7.**

9. 2 (Two) Bag Assembly:

- 9. Same as for the Single bag system except that the 2 bags are joined together with "T's" in the clear Green and solid Red tubes. **SEE Photo 8.**

ENGINE PREPERATION:

10. Teflon tubing Connections: (also see FIG.-8 & 10)

10. One 30 inch piece of 4mm Teflon Tubing has been provided for hook-up to the engine fittings. **SEE Photo 9.**

11. Cut this tubing into one 2 1/8 " piece, one 7/8 " piece, one 7 "in piece, and two 10 " pieces. One of the 10" lines must be drilled out with a #36 drill and will be used as the airline. The other 10" line will be the propane. The 7" line will be for compressor pressure. The remaining small pieces will be used for lubrication hookup.

12. Install the Teflon tubes into the engine fittings. **SEE Photo 10.**

CAUTION: Make sure all Teflon tubes are LOCKED into the engine fittings and are tight !!

11. Front Engine Cover modification: (also see FIG.-10)

13. The Front Cover has been left undrilled for lines so that you may decide the preferred locations.

14. You can either drill one hole for each line (METHOD-1) or drill one or two large holes for multiple lines to pass thru. (METHOD-2).

15. Drill the Front Cover as desired. Be sure to remove ALL SHARP edges in all holes drilled.

16. Using the "Hole Locator Templates" taped in place on the engine, mark the front cover for drilling. Remove the cover and drill the 3 locations with a 1/8" dia. **drill.**

E. If you decide to drill one or two large holes for all

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tubing, then the union between the Teflon tubing and polyethylene tubing occurs inside the front cover. When using this method you must make sure that there are no kinks in the lines.

F. Re-Install the Front Cover.

G. Now install one 4mm union to each of the Teflon tubes coming out of the engine if using METHOD-1. For the fuel line use the 4mm check valve. Make sure the flow is in the correct direction. **SEE Photo 12.**

CAUTION: *Never run the engine without the front cover installed. This could lead to excessive heat and could cause damage to the engine.*

12. Engine Mounts and EGT Probe (See Photo 13)

17. Place the EGT probe into the opening on the tailpipe. Insert no more than 1/16" – 1/8" into tailpipe.

18. Place straps around the engine with one mounting flange on each side.

19. Place EGT Probe underneath straps and tighten the 6-32 screws.

20. Do not tighten straps completely until exact flange location has been determined.

21. The flange location will vary among different installations.

22. When satisfied with flange locations tighten the 6-32 screws.

23. Drill out flanges for preferred mounting screws.

24. The engine is now ready for installation into the airframe.

4. Compressor Pressure and Fuel Hook-up: (also see FIG.-7 & 8)

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25. Attach 4mm clear Red line to fuel fitting (# 5) on the engine. Make sure 4mm check valve is in place correctly. **SEE Photo 11.**
26. Route line to pump and connect to 4mm side of pump.
SEE Photo 8
27. Route clear green 4mm tubing from Compressor Pressure fitting (#3) to the ECU and connect to silicone tubing on ECU. Silicone tubing should be small or medium **size and must fit securely with no air leaks.** **SEE Photo 16.**

CAUTION: *Insure all fuel lines are secure and no leaks are present.
Fuel leaks can cause a fire.*

5. Start Air and Propane Line Preparation: (also see FIG.-8)

28. Prepare a 4mm clear Blue and a 4mm solid Red line to go from the engine to an accessible area in the aircraft. **SEE Photo 17.**
29. Connect the Blue line to Engine fitting # 1 and the Red line to engine fitting # 2. **SEE Photo 11.**
30. Connect 4mm shutoff unions in both lines. NOTE: Insure correct FLOW direction of these fittings when installing.

13. ECU Hook-up (SEE Photo 16 & ECU Hook-up Diagram, FIG.-2)

31. Connect Sermos connectors for Pump and Glow Plug. Note proper color coding of these connectors.
 32. Connect EGT probe to ECU.
 33. Connect 4mm clear Green pressure line to silicone tubing, which in turn is connected to the pressure port on the ECU.
 34. Connect receiver lead to mating ECU lead. **The ECU lead must connect to your receiver's throttle channel.**
 35. ECU battery should be located in an accessible location.
 36. Charging cables are provided for your use with any field or home charger. A complete charge will give you about five flights but we recommend charging all onboard batteries after three flights.
-

7. Glow Plug preparation for installation into the Engine

37. Refer to the “Glowplug Modification” Diagram **FIG.-9**.

Insure that your glowplug has several of the element coils “Exposed” as per this detail. If not, use a straight pin to pull the coils down. Test the glowplug with a 1-1/2 volt power source to insure that the plug is working prior to installing it into the engine. **Hint: you can make this job easier by heating the element with an appropriate glow driver while pulling the coils down.**

B. Remove the copper washer supplied with the Glowplug and insert the plug into the Ring-Lug of the Black Glowdriver wire from the ECU then install into the engine.

Do not over tighten.

8. ECU Setup:

Please familiarize yourself with all connections and features of the ECU that will be discussed during the ECU setup.

INSURE ALL BATTERIES HAVE BEEN CHARGED PRIOR TO ATTEMPTING THIS SETUP!!

You will need to plug the Start Box Cable into the mating receptacle on the ECU to obtain the “DISPLAY” as referenced in the programming steps.

Note: some Futaba radio systems emit a spurious signal, upon energizing the receiver, which confuses the ECU. An indication of this phenomenon is if the Start Box will not display “Setup Throttle High” and immediately proceeds to “Setup Throttle Low” upon attempted ECU setup. To remedy this situation, unplug the ECU from the receiver, turn the transmitter on with throttle stick at low, turn receiver power on, wait approximately 5 seconds, plug the ECU into the receiver’s throttle channel. The start box should now display “Setup Throttle High”. Proceed with normal ECU setup.

This procedure need only be done once, for ECU initial setup. If the ECU and/or receiver are in an inaccessible location in your aircraft, an extension (or several) can be installed between the receiver and ECU so that you can plug/unplug the ECU from the receiver at a convenient location. Once the ECU is setup properly, the extension may be removed for normal operation.

38. High Throttle setup:

14. Turn on Transmitter.

15. Push and *hold* the “Set” button while turning the Rx power ON. Turn on Transmitter.

Note: In all future references, “xxxx” = Temp. in °C
“yyyy” = Pressure in Millibars

The Start Box Display reads:

Setup Throttle
High -> xxxx

At this time the “IGN” LED flashes.

3. Release the SET button.

4. Move Throttle stick and Trim lever to Full throttle.

16. Adjust the ATV (if required) until the “IGN” LED stops flashing.

17. Push the “SET” button to memorize.

39. Low Throttle Setup:

The Start Box Display reads:

Setup Throttle
LOW -> xxxx

At this time the “EGT” LED is flashing

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18. Move the Throttle stick to Low throttle, High Trim.
19. Adjust the ATV (if required) until the “EGT” LED stops flashing.
3. Push the “SET” button to memorize.

C. Idle Cutoff Setup:

The Start Box Display reads:

Setup Throttle
SHUTDN -> xxxx

At this time the “CP” LED is flashing

20. With Throttle stick to Low throttle, Mid Trim.
21. Adjust the ATV (if required) until the “EGT” LED stops flashing.
22. Push the “SET” button to memorize.

The ECU is now programmed. Turn the Rx power OFF.

Note: If the “SET” button is held down and not released after step 3, the Start Box display will show the following until “SET” is released.

RAM 750
Rev xxxx

NOTE: SAFETY TIP

The ECU will NOT operate on power up if the throttle stick is not within 10% of the LOW throttle and EGT is NOT below 100°C

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All 3 LED's will flash and the ECU will not turn on the Glow Plug until the throttle stick is moved to within 10% of LOW throttle and the engine has cooled down below 100°C from a previous start / run.

TURBINE OPERATION

TURBINE OPERATION:

Pre-start Preparations:

- 1) Inspect the inlet and exhaust for FOD (Foreign Object Damage) or any other debris.
- 2) All switches in the Start Box, Radio and Aircraft "OFF".
- 3) Connect Start Box "FUEL" and "AIR" tubing to the Turbine.
- 4) Connect the compressed air bottle (Scuba Tank) to the Start Box.
- 5) Open the valve on the compressed air tank.
(Take note of tank pressure. Do Not attempt to start the Turbine with less than 300 # of air pressure.)
- 6) Turn the "AIR" switch in the Start Box "ON". The Turbine will begin to rotate. Listen for abnormal noises, rubbing, **vibration**, etc. Allow the rotation to continue for 5-10 seconds.
- 7) Turn off the "AIR" switch.

You guys may or may not want to include this. I did this while at work from memory. Please verify that all instructions reflect the proper chain of events that must occur to purge the line.

Note: Before your first engine run of the day, it is advisable to purge the fuel system of air. To do this, disconnect the fuel line between the Fuel Pump and the Turbine at the Turbine side of the 4mm FESTO fitting. Connect an extension of 4mm tubing to the FESTO. Make this tube long enough to direct a small amount of fuel away from the direct vicinity of your model. Turn on your transmitter, set throttle to low, turn on your receiver. Turn the Fuel Shutoff Valve to the open position. Advance the transmitter's throttle stick to full and depress the Start button on the Start Box. This

will cause the Fuel Pump to operate. Continue to depress the Start button until fuel forces all of the air out of the fuel system at least up to the previously mentioned 4mm FESTO fitting. Remove the 4mm extension and reconnect the Turbine's fuel line to the FESTO. Your engine is now ready to start. Cycle receiver power on/off and enjoy your flight.

TURBINE START-UP:

Beware of ALL Risks associated with the Operation of a Turbine Engine. Keep ALL unnecessary personnel away from the start area and abide by all AMA Turbine operating guidelines.

23. With all connections still attached to the Turbine from the Pre-Start Preparation check, Plug the Start Box Data Cable into the ECU, then turn on the Radio.

The Display will read:

RAM 750 Display
Rev xxxx

2. The ECU will check for LOW throttle and a "Cool" engine. If the Throttle stick is not LOW or the Throttle stick / Trim is at the Idle "Cutoff" position, all LED's ("IGN", "EGT", "CP") will Flash and the Display will read:

THROTTLE LOW

Set throttle to LOW, trim to HIGH.

If the engine is hotter than 100°C, ECU will display and the "EGT" LED flashes.

OVERTEMP
EGT xxxx CP xxxx

Switch OFF the ECU power and wait for the engine to cool down (or spool the compressor with air to cool it down) Then switch the ECU power back ON.

When engine is cool and throttle is set properly the ECU will display:

RAM 750 START
Cycle # xxxx

The engine is now ready to start.

3. Press the “Start” button on the Start Box to activate the Glow Driver.

The ECU will light the Glow Plug and display:

RAM 750 IGN ON
EGT xxxx CP yyyy

The “IGN” LED lights steadily.

The ECU waits in this state until the EGT exceeds 150°C (Flame ON). If engine does not ignite in approx. 30 seconds, the ECU switches OFF the glowdriver to conserve power and the display will read:

START FAILURE
TIMEOUT

Switch off ECU power and switch on again to re-start.

4. **Simultaneously** switch on the Start AIR and PROPANE.
The engine ignites.

When the EGT is greater than 150°C, the ECU shuts off the glowdriver and the “IGN” LED, and starts the fuel pump. The ECU slowly ramps up the fuel pump output until the Compressor Pressure exceeds 84 millibars.

The display will read:

FUEL RAMP
EGT xxxx CP yyyy

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The “CP” LED lights when compressor pressure is greater than 64 millibars. The EGT may exceed 850°C during start but not for more than 3 seconds continuously or the ECU will assume a FIRE is in progress and will shutoff the fuel pump. The “EGT LED will flash.

The display will read:

**START FAILURE
OVERTEMP**

If the CP falls below 42 millibar at any time, the ECU assumes a flameout and will shutoff the fuel pump. The EGT and CP LED’s will flash.

The display will read:

**START FAILURE
FLAMEOUT**

Throttle stick / trim must be at or near LOW and higher than Idle Cutoff. All LED’s will flash and the display will read:

**THROTTLE LOW!
Egt xxxx CP yyyy**

Move the throttle stick to LOW throttle and HIGH Trim.

When everything has executed properly the engine should now be running and the display should read:

**RAM 750 RUNNING
EGT xxxx CP yyyy**

5. Propane and Compressed Air my now be turned off.

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The engine RPM will drop slightly as the Air and Propane are turned off but the ECU will retrim the minimum throttle setting to automatically maintain a *minimum of 84 to 98 millibars.*

6. Under certain conditions, inconsistent fuel supply at startup due to air in the fuel line and so on, the Idle CP at the end of the Fuel Ramp may be **too** high.

Press the Ignition Button and HOLD it down for 1 second to manually reduce the minimum throttle setting.

Do not over due this setting as it can cause a flameout due to the throttle being reduced too far!

The Start Box Cable can now be disconnected.

7. Perform a visual inspection for any Fuel or Oil Leaks.
If ANY are found, SHUTDOWN the engine immediately and correct the condition.
 8. The Turbine can now be run up to Full Power after 1 Min. at Idle.
24. The Turbine is now ready for flight.

E.C.U. FAILSAFE INFORMATION

RX Failsafe:

From this point on, if the ECU should stop receiving servo pulses from the RX for approx. ¼ second, it will shut down the engine and resets.

Note that in PPM (FM) systems, this means if the RX does not receive a signal from the TX for more than ¼ second, the engine will shut down.

However, in case of RF interference, this mechanism may not always work, as interfering signals may still be decoded by the RX as legitimate servo commands.

In PCM radio systems, the RX will continue to send out servo

pulses even if the TX is off, defeating this safety feature of the ECU.

Its is the customers responsibility to program the radio's PCM failsafe to shut down the engine !

BATTERY FAILSAFE:

The ECU is also equipped with an RX battery voltage detector. If the battery voltage drops below approx. 3.5 volts, the ECU will shut the engine down. *This is a "Last Ditch" safety feature.*

Note: On a 4.8-volt 4-cell battery system, you may have a short time to get the aircraft down deadstick.

On a 6.0-volt 5-cell battery system, there may be too little voltage left for sufficient control as most batteries are completely exhausted at less than 0.6V per cell.

It is emphatically recommended that your RX batteries be diligently tested PRIOR to each flight.

TURBINE SHUTDOWN (NORMAL):

Avoid shutting down the Turbine from a Full Power setting without a cooldown cycle of at least 1 min.

1) Throttle set to idle.

2) Operate at this setting for 1 min.

3) Shutdown the Turbine with the Radio throttle trim tab or

Turn off the radio which will terminate the E.C.U. and fuel pump operation.

4) Connect the start box "AIR" to the Turbine and windmill the engine if it is a calm day. Otherwise just point the inlet into the wind. **(Turn Air on for 5 seconds then OFF for 10 seconds. Repeat 4 times.)**

5) White smoke may appear at this time. It is unburned fuel and oil running through

6) **Record the run time on the Run Log. (See Appendix-"B")**

An alternate shutdown strategy:

- 3) Close the Fuel Shutoff Ball Valve. It is a good idea to shut the engine down in this manner as it precludes subsequent fueling with the valve in the open position. Fueling with the valve in the open position may dump raw fuel into the engine causing a “wet” start on the next cycle.

TURBINE SHUTDOWN (EMERGENCY):

- 1) Throttle and trim setting to idle or turn off power to the ECU.
- 2) Cool the Turbine down by wind milling with air if possible.
- 3) Record this event on the Turbine run Log. Return the Turbine to R.A. Microjets, Inc. if necessary.**

COMPONENT MAINTENANCE:

TURBINE:

- 1) After Each Run Cycle (1 Start and Stop), Visually inspect the turbine for damage to the Compressor Wheel, Turbine housing, mounting system and discharge nozzle. Should any damage be observed, the Turbine must be returned to R.A.Microjets, Inc. for Servicing.

- 2) **When the Turbine has achieved a total of *100 Run Cycles*, the unit must be returned to R.A.Microjets, Inc. for a factory inspection of the Rotating components.**

FUEL PUMP:

- 1) After Each Run Cycle, Visually inspect the pump for leaks.

ECU:

- 1) The ECU is not serviceable by the Owner. Should a problem develop with the ECU, it must be returned to R.A.Microjets, Inc. for service.

START BOX:

- 1) The unit is not serviceable by the Owner. Should a problem develop with the Start Box, it must be returned to R.A.Microjets, Inc. for service.

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AUTHORIZED SERVICE CENTER:

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Mr. Albert Araujo