

## **J600 Instruction Manual**

(Version 1.5.1/2003)



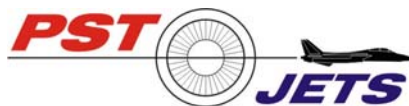
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## J600 Instruction Manual

### Welcome Notes

Dear PST J600 owner,

Congratulations with your new PST J600 miniature turbojet engine.

Let us greet you with our warm Thai tradition, “Sawasdee” which means welcome or greeting in Thai. We are committed in producing and delivering quality products to our customers.

The J600 is a result of R&D commitment and dedication since 1997 to turbojet design and manufacturing. The engine controller unit, TEMS, is state-of-the-art device which is specifically manufactured/programmed for the J600. Your engine and the supporting system have been factory tested and passed our high quality control standard. The appearance of the bluish tinge on the exhaust cone is normal after factory starting and running of the engine prior to shipment. Factory test run also serves as “break-in” and seating of bearings and internal components.

Safety is our strict standard. Regardless of your turbine experience, it is necessary to carefully read this manual in its entirety before any attempt to operate the J600. This manual has important issues and notes that will ensure safe operation of the J600.

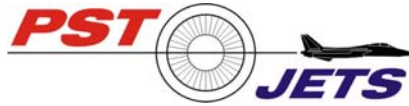
### Please read it !

We are dedicated to customers' satisfaction. Technical support is available 7 days a week. Replacement parts are always in stock for prompt services of our engines to ensure quick turn-around time.

Thank you and enjoy.

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## J600 Instruction Manual

### Legal & Disclaimer

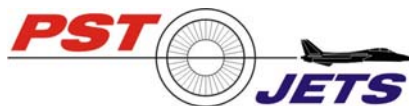
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**Disclaimer:** Turbojet is a sophisticated piece of machinery. Experience and basic turbine knowledge is required. Always seek experts or experienced turbine operators before operating. If not operated properly, it is capable of causing property damage and/or bodily harm to both operator and spectators. PST Jets assumes no liability for damage that could occur from the use/misuse of this product. We recommend that you visit GTBA and read about turbine safety and code of practice.

PST JETS assumes no responsibility for errors contained in this document and is not liable for any damages resulting from such errors. For most current updates, check our website [www.pstjets.com](http://www.pstjets.com) or contact us at [info@pstjets.com](mailto:info@pstjets.com)



## J600 Instruction Manual

### Warranty

PST JETS Co., Ltd. is referred as “PST”. The warranty period for the PST J600 is 1 year from original date of purchase or 150 run cycles, whichever reaches first. Warranty is valid for original owner only and non-transferable upon resale. The warranty includes parts and labor and is limited to manufacturing and material defects only. The limited warranty does not cover the electric starter motor, batteries, or glow plug. Upon replacement of components from a warranty failure, the replaced components will be subject to the original warranty coverage period.

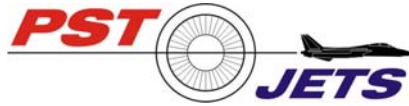
Shipping costs (including insurance and applicable duty taxes) to the local PST representative for any warranty claim are the sole responsibility of the customer. Return shipping is covered by PST in the same method of receiving the shipment from the customer. Should any part of the product need to be returned from the PST representative to PST headquarter (Bangkok, Thailand), this shipment cost is covered by PST. Any additional costs are the responsibility of the customer. PST assumes no liabilities for damage to products during shipping.

This warranty is void if any one or more of the following conditions applies. If any one of the following statements is true, PST assumes no liability for personal damages, loss of models, or any other consequences arising from the J600 operation.

- a. The serial number or identification information is defaced, modified, or removed.
- b. The product is used for purposes other than that of radio-controlled model airplanes without written authorization by PST.
- c. The product has been damaged from a crash or otherwise accidental event, ingestion of foreign materials, improper installation / configuration, or weather / act(s) of god.
- d. The product has been subject to any form of start-up or operation with any incorrect fuel, oil, or fuel/oil mixture ratio.
- e. Dirty or contaminated fuel is used.
- f. Unauthorized maintenance or modifications have been performed on any part(s) of the product.
- g. The product has been abused, incorrectly maintained, or neglected.
- h. The product has not followed the mandatory check-up procedure, whereby every PST J600 should be inspected by a certified PST service representative after 150 starts.

Yearly inspection is highly recommended but not mandatory. Components required in the inspection / warranty claim include the complete turbine as purchased, ECU, thermocouple, and fuel pump. Please contact your PST representative for further details.

All turbines will be partially disassembled, inspected, and shipped within 5 business days of receiving. Damaged components that are deemed to be warranty covered are replaced, tested, and returned at PST cost.

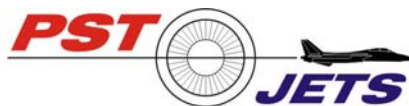


## J600 Instruction Manual

### Warranty (cont)

For crash damaged, depending on the extent of damage, the turbine may required more than 5 days downtime, at which time the customer will be immediately contacted for a consultation. Please verify all service details with PST representative before shipping. Shipping cost and insurance is the sole responsibility of the customer in addition to the repair/service costs.

When upgrade option becomes available and the original owner wishes to have the engine upgraded, the newly installed components shall be given a 1-year warranty (valid from the return shipment date). Other original parts/components remain under the original warranty. Shipping cost and insurance is again the sole responsibility of the customer and is not covered under the modification costs.



## J600 Instruction Manual

### PST Dealers/Representatives

#### USA/Canada

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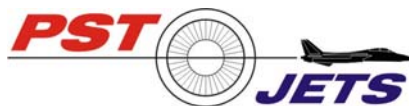
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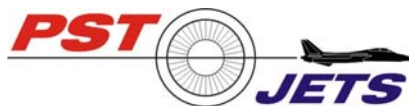
For more updated information, please visit our website at [www.pstjets.com](http://www.pstjets.com)



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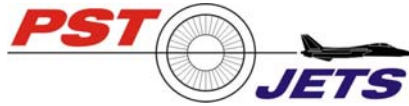


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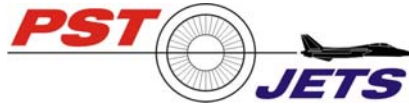
## J600 Instruction Manual

### Introduction to turbine



First phase of turbine operation is intake and compression. In large-scale jet engines, the compression phase may involve several stages of axial and radial compression. For simplicity only a single centrifugal (radial) stage will be discussed in this manual. Axial compression is rarely seen in model turbines and is more reliant on having a clean air intake, similar to a ducted fan configuration. Centrifugal compressors are far less reliant on ram air effects, clean intakes, and Reynolds number effects, making them much more predictable at speed and much more suitable for use in model jets. After the air leaves the radial compressor, it flows outward through a set of primary and secondary diffuser vanes which harness the high velocity radial flow and transform it to high pressure axial flow into the pressure chamber. Diffuser design is critical due to the amount of losses induced in the transformation; the less energy lost in the compression process, the less energy is needed to drive the compressor for the same overall mass flow and thrust output. Poorly designed diffusers can be susceptible to elevated temperature at the engine's front end and compressor surge / stall at different atmospheric situations. The turbine outer diameter of this size is also a contributing factor to the efficiency of the diffuser design. As the outside diameter increases, the airflow through the diffuser is smoother and has lower velocity gradients. PST J600 is an excellent example of a balancing act between performance vs. size and design complexity.

Next is the combustion phase. The combustion chamber is basically just a container that houses a continuous and very intense explosion. High temperature materials such as stainless steel Inconel and titanium are commonly used in large-scale turbines, but thin stainless steel / Inconel sheet is usually the more cost effective material of choice for models. The annular style chambers used in models have holes strategically located in the inner and outer walls for feeding the combustion flame and for cooling the exhaust gasses as they exit. Some holes are dimpled inward to produce higher velocity mixing jets. Fuel is added from the rear end of the chamber, sprayed forward through a number of vaporizer tubes that heat the fluid to produce a combustion ready air-fuel mixture. Combustion occurs in the front section of the chamber and only persists for a short distance rearward. After combustion, the optimized holes mix cool air (relatively cool...+100°C approx.) with the exhaust gasses to bring them down to a more suitable level in the exhaust turbine. (Absolute design maximum: 800° C in this case)

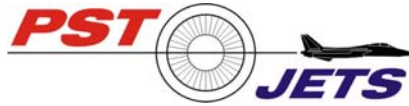


## J600 Instruction Manual

### Introduction to turbine (cont)

The turbine stage can also be radial or axial and involve multiple stages. For simplicity, a single stage is discussed here. As the exhaust exits the combustion chamber, it enters the nozzle guide vanes (NGV) which convert axial velocity to axial flow with a large radial component. The swirl induced in the NGV is optimized for interaction with the blade profile on the turbine wheel. The turbine wheel then harnesses a great deal of energy from the exhaust gas flow's radial component, leaving axial flow behind. The harnessed energy is transferred through the shaft and used to drive the compressor while the energy remaining in the exhaust flow after the turbine stage is converted directly into thrust. Miniature turbines today are equipped with modern technology's ceramic bearing to support the shaft with the rotor assembly turning at more than 160,000 rpm. The J600 uses two GRW angular contact cageless ceramic bearings with rating up to 220,000 rpm.

That's enough for introduction and theory on turbine. Let's begin the exploration of the miniature turbine world and see what we have in stored for you.



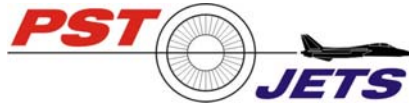
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### Packing List

Please check that all components listed below are shipped with the J600 turbine. Contact us if any items below are missing or damaged during shipment. E-mail: [info@pstjets.com](mailto:info@pstjets.com)

#### SN600AC – Auto start complete package:

- 1 PST J600 Turbojet Engine with electric starter
- 1 PST TEMS
- 1 GDT (Ground Display Terminal)
- 1 Fuel Pump
- 1 Gas solenoid valve
- 1 Festo ball valve (Fuel Shutoff valve)
- 1 EGT probe
- 1 Glow plug (mounted on engine)
- 1 ECU switch with protective 15A Slow-Blow fuse
- 1 Battery pack (Ni-Cad 7.2V 1800mAh)
- 1 set of engine mounting brackets
- 1 set of quick disconnect fitting
- 1 set of 4mm gas/fuel tubing (tubing for fuel tanks installation not included)
- 1 Gas Canister with 3-way connector and 1-way valve
- 1 PST J600 Instruction Manual
- 1 set of promotion batch and stickers (while supply last)



## J600 Instruction Manual

### Safety & Notes

#### **IMPORTANT !!!**

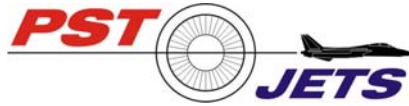
**Safety:** Model turbine engine is highly sophisticated and should be treated with high level of safety standard. The following safety guidelines must be adhered to for successful and continual enjoyment of model aviation.



- Always have good fire extinguisher ready when starting turbine engines (Halon 1211 or BF2000 type recommended). Chemical fire extinguisher can be used but the engine must be returned to PST Jets for cleaning and inspection.
- Always protect your eyes and ears during start or in close vicinity of starting turbine.
- Always start the turbine outdoors with good ventilation.
- Always handle Jet A1, Kerosene, and propane/butane gas in well-ventilated area away from any open flame or heat sources. These substances are highly flammable.
- Do not stay in the high-risk perimeters of the turbine: on the side and in the area of hot air behind it; and immediate area in front of the compressor wheel.
- Do not touch the engine while it is running. Turbine rotates at very high rpm and the engine casing can reach very high temperature. Severe burns or body injuries can occur if come into contact with the casing and/or exhaust nozzle.
- Do seek expert advice for installing the turbine and support system to the airframe.
- Abort start or any flight attempts if excessive vibration or abnormal noise is evident.
- Keep unauthorized persons, especially children, away from starting area. Recommended at least 25 feet away.

#### Notes:

- The recommended and default settings programmed into the ECU should not be altered unless absolutely necessary. The engine is tested and operated to the designed performance and specification under these parameters. We cannot guarantee proper operation of the J600 if the parameters are altered or different fuel pump and accessories are used. E-mail us for technical helps if uncertain.
- Use good chargers to charge both ECU and Rx batteries. Limit the ECU battery (7.2V Nickel Cadmium with at least 1700mAh capacity) to two flights for one full charge. The fuel pump drains lots of amps at high rpm and the flight should not be made without recharging the ECU battery after approximately 25 minutes run time.
- Make certain that all wiring and plumbing are correct.



## J600 Instruction Manual

### Safety & Notes (cont)

- d. Use filtered and moisture free Jet A1, Jet A, or kerosene fuel only.
- e. Use turbojet oil, we recommend Exxon 2380, Aero Shell 500, or Mobil Jet Oil II). 2-stroke oil is not allowed and will cause damage to the engine thus voiding the warranty.
- f. Fuel/Oil mixture of 5% should be used (See Fuel section for more details).
- g. Extra fuel and gas filters are highly recommended to avoid clogging up of the “last chance filters” located inside the front cover. Kavan filter as shown in this manual is suitable. Avoid cheap motorcycle or automobile plastic filters, they may be used in the refueling system but not in the main system.
- h. Bubble-elimination devices should be used in or as the header tanks for bubble-free fuel. Seek expert advice if you are not experienced.
- i. For manual or emergency shutdown, fuel shut-off valve (Festo Ball Valve) is included and should be installed between header tank and turbine fuel inlet.
- j. LPG or camping gas with maximum 70/30 Propane/Butane mix can be used. Use one-way valve for filling the gas canister. High pressure propane can freeze up the solenoid valve thus locking the valve in the close position.
- k. Fitting valves and connectors supplied are of high quality and other similar products may be used.
- l. When new devices or accessories are adopted, it is wise to test them on the bench prior to installation into airframe.

## Fuel System

### A. Fuel Tanks



1. Use sturdy polyurethane plastic bottle(s) or specially made kevlar tank(s) with total capacity of at least 1.5 liter (2 liters recommended).
2. Use bubble-free filtered clunks for header tanks. We recommend OS Super Filter (Large or Small to suit tank size) as shown in the picture above. These filters are inexpensive and do the job well. Similar bubble-elimination device may be used as well.
3. Use clear 4mm tubing provided for fuel line. Silicone gasoline/benzene (Tygon) fuel line can also be used if preferred. If you want to connect Tygon fuel line with the 4mm fuel line, insert at least 1/2 " inch of the 4mm line into the Tygon line.
4. Vent the fuel system to avoid vacuuming. See pictures above and diagram A. **Important: Make sure the vent line is large enough, as insufficient venting will cause vacuums overcoming the fuel pump suction capability resulting in flameout.**
5. Run fuel line from the main tank vent to an external fuel tank out of the airframe. The external fuel tank can serve as overflow and also as ground start / run-up supplementary fuel. The airframe vent tube should be at least 3/4" in length and cut 45 deg facing forward to avoid boundary air effects.
6. If multiple tanks are used, make sure that the tanks are of same size/shape and fuel lines connecting the tanks are of equal length and that vent line is provided. See diagram C for more details. Seek experience or expert help if uncertain.
7. Fueling is through the header tank into the main tank. Make sure that air bubbles are removed from the header tank. Air inside the fuel line will cause flameout. Do not use flex tube or clunk inside the header tank. The feed line should be geometrically centered in the header tank. See diagram C for more detail.
8. After header tank is filled you can then fuel directly into the main tank for faster fueling. Your tanking system must be fitted with this filling tube to main tank.
9. Safety wired all line connections to prevent them from coming loose during operation.



## Fuel System (cont)

### B. Fuel Pump



1. Observe the pump fueling direction. Fuel goes in on the side marked by small indentation and out on the other.
2. Use clear 4mm tubing provided for fuel line connection.
3. Install ball valve between header tank and engine, either between the header tank and the pump (on suction side), or between the pump and engine (on pressure side).
4. Use good gasoline filter between fuel pump and engine. It is better to have the filter behind the pump to avoid bubbles caused by suction/cavitations.
5. Safety wired all line connections to prevent them from coming loose during operation.

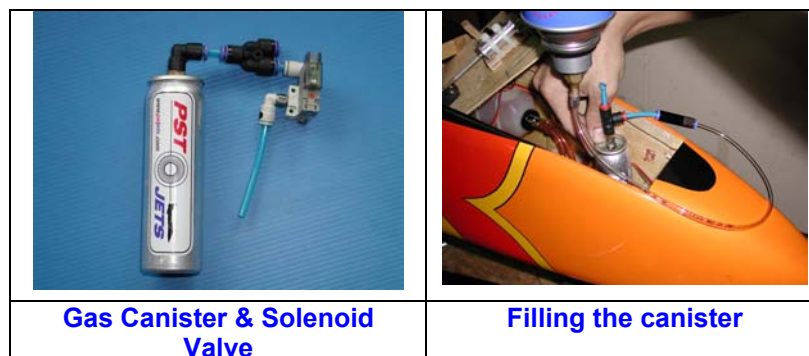
### C. Fuel and Oil



1. Use Jet A, Jet A1, or kerosene. Make sure that the fuel is clean and free from moisture. Water is heavier than fuel and will settle at the bottom of the container.
2. The fuel tank must be free from foreign particles.
3. Use good quality turbo oil such as those in the picture above. **2-stroke oil will cause serious damage to the engine.**
4. The fuel must be mixed with 5 percent turbo oil. For simplicity, mix five parts of oil to 100 parts of kerosene. The J600 will tolerate mixture imperfection between 4-6%. Too little oil will shorten the bearings life due to higher temperature. Too much oil will reduce the engine performance due to unnecessary stress on the bearings.
5. We recommend that the fuel be mixed in gallon scales, as the mixing will be more accurate. Example: mix 1 quart of oil to 5 gallons (19 liters) of kerosene. Most turbo oil comes in quart can, so mixing with 5 gallons of kerosene is simple and ideal.

## Gas System

### A. Internal Gas Canister



1. Internal gas canister is provided with quick connector attached.
2. Use blue 4mm tubing provided for gas connection.
3. The two-way quick connect is connected to the gas solenoid valve and the one-way valve.
4. Direction of the one-way valve is marked on the valve itself. "IN" direction is from the end with silver tape. The valve must be connected with the "IN" direction facing away from the canister to serve as filling. In pictures above the "IN" direction is plugged with orange stopper.
5. The tube ends should be pushed in all the way into the connector/valve to avoid leakage.
6. Fill the canister by connecting an external gas source (Propane/butane mix, butane, or LPG) to the one-way valve "IN" direction. Point the external gas-filling tank down to let the liquid propane flow into the canister.
7. Stop the filling when the canister is 1/4 to 1/2 filled with liquid propane. Since there is no visual indication, just approximate the filling amount. Very little is actually required for one successful auto start. The canister supplied is larger than required. From our test, we can obtain more than 5 starts with one fill.
8. Disconnect the filling line carefully, as excessive pressured propane is present in the line and will be forced out briefly. **Safety: Use towels or rag to cover the valve and keep your face and eyes away during the disconnection.**
9. Make sure that the canister stands upright in the airframe to avoid the liquid propane from entering the engine. During start, excessive flame and engine surge will result if the liquid propane is allowed to enter the engine. This is not healthy.
10. **For extra safety, gas canister should be emptied after flying sessions prior to storage. Simply disconnect the line to the solenoid valve or the one-way valve. Safety: Use towels or rag to cover the valve and keep your face and eyes protected during the disconnection.**



## Gas System (cont)

### B. External Gas Tank



1. External gas tank may be used to replace the internal canister.
2. Use similar manual valve connection as shown in the picture above (the valve is not included but available from PST).
3. Connect the external gas line to the solenoid valve via a quick disconnect connector.
4. Do not by-pass the gas solenoid valve during start unless you are instructed from PST reps to do so. **Incorrect manual metering of the gas may cause internal damage and flame coming out of tail cone.**
5. Before start, open the external gas tank valve.
6. After start, close the valve and disconnect the external gas tank.

### C. One-way Valve



One-way valve "IN" direction is from the silver shaded side. Use this valve for filling the gas canister.


### D. Quick Disconnect Connector





This can be used for both kerosene and gas. It allows easy connection and disconnection of tubing and can also be used to make loop of kerosene and gas lines to prevent any leakage during storage.

## Accessories





### A. Battery

	<ol style="list-style-type: none"> <li>1. Use good 6-cell battery pack for the ECU.</li> <li>2. Use at least 1700mAh capacity Ni-Cad batteries</li> <li>3. The supplied battery pack is Sanyo 1800 mAh</li> </ol>
---	---

### B. Fuel & Gas Filters

	
<p style="text-align: center;">Gas and Kerosene "<u>last chance</u>" filters are already fitted inside the front cover</p>	<p style="text-align: center;">Extra protection is required with <u>additional</u> external filters</p>

### C. Glow Plug

			
<p style="text-align: center;">Glow Plug &amp; Needle</p>	<p style="text-align: center;">Pull Out the coil</p>	<p style="text-align: center;">Coil pulled out 2mm</p>	<p style="text-align: center;">Glow Plug Cap</p>

1. Use OS glow plug or similar threaded plug. Higher resistance or colder glow plug may require higher glow voltage and this is programmable via the GDT.
2. The coil needs to be pulled out. We recommend using a needle for this job. Be careful when pulling out the coil as not to break the filament. For new glow plug, heating the filament prior to pulling out the coil will greatly reduce the change of breakage.
3. The coil must be pulled out about 2mm.
4. Replace the glow plug carefully and tighten firmly.
5. The red glow plug cap goes over the plug. Pull the red spring-loaded wire and place the cap over the glow plug then release to grab the glow plug head.
6. Make sure that the cap fits firmly and will not come loose during operation. Safely tie the wiring to prevent any possibility of the cap entering the turbine if it comes loose.

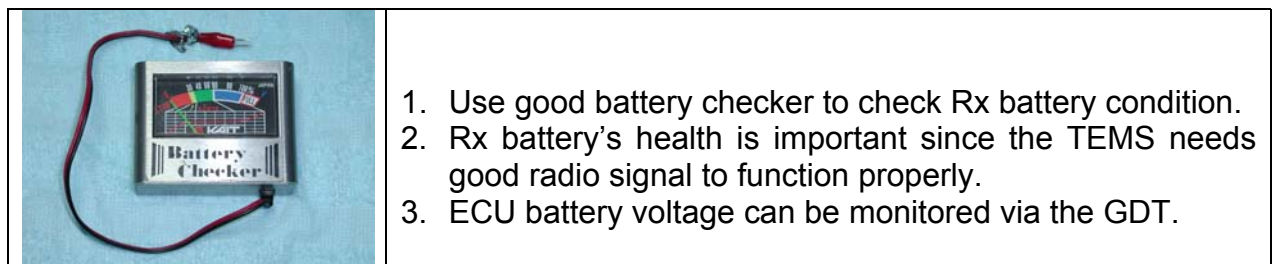
## Accessories (cont)

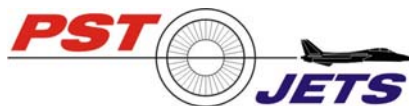
### D. Chargers



1. Use good charger that has good charging, discharging, and conditioning features. Computer and digital types are recommended.
2. Supplied battery can be quick or slow charged.
3. Automatic charging is highly recommended.
4. Charge the battery directly with good wire and connector.

### E. Battery Checker





## J600 Instruction Manual

### PST TEMS - Turbine Engine Management System

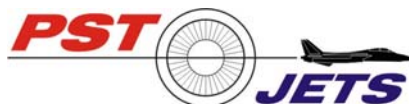
The PST TEMS is a highly sophisticated electronic turbine controller that is simple to operate. It incorporates the highest standard in computer program coding, written specifically for the J600. Your J600 will perform at its optimum performance under the control of the PST TEMS.

#### **System Components**



Your system consists of the following:

1. GDT (Ground Display Terminal) – handheld terminal for programming, operating, and monitoring the TEMS.
2. TEMS – engine controller unit which gather data from connected sensors and manipulate them for optimum commanded performance.
3. Fuel Pump – supply pressured fuel to the engine as directed by the TEMS.
4. Gas Solenoid Valve (SMC) – automatically turn on and off starting gas as directed by the TEMS during auto start sequence.
5. Internal Gas Canister – self-contained remote starting gas.
6. Fuel Shutoff (Ball) Valve – manually shut down the engine and provide fuel cutoff to the engine during fueling.
7. EGT Probe – K-type temperature sensor
8. Hall Effect Speed Sensor – located in the engine front cover to pick up revolution information.
9. Battery – main power for the TEMS and electric starter, 7.2V, 6-cells, 1800mAh Ni-Cad.
10. ECU Power Switch with 15A Slow Blow fuse in case.



## J600 Instruction Manual

### PST TEMS (Cont)

#### Feature of the TEMS

The TEMS is designed to monitor various parameters of the J600. It has full auto-start capability when coupled with the electric starter and solenoid gas valve. The parameters monitored while the turbine is running are: Turbine speed, Exhaust Gas Temperature, battery voltage, pump voltage, and radio signal validity. Loss of R/C signal (PPM/FM) for 1 second will cause shutdown. For PCM, this must be set in the radio's Fail Safe setup. Basically, the TEMS will perform full auto start sequences and ramp the J600 up to calibrated idle speed. First time run will require max speed calibration and this process will be discussed in more details later.

#### Software Version



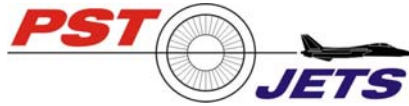
As of January 2003, the software version is V2.33 for TEMS and V2.21u for GDT. Please monitor our website for any available upgrades to higher version.

#### Installation of the TEMS

##### Important:

1. The TEMS and radio receiver must be placed as far away from each other as possible.
2. The TEMS battery pack and the receiver battery pack must be placed as far away from each other as possible. At least, the batteries must not be placed side-by-side, but end-to-end. This is to eliminate the chances of R/F cross talk between the units which may affect the operation of your radio equipment.
3. Avoid placing servos, solenoid valves, pump, or magnetic objects inline with the engine front cover to minimize the chances of interference to the Hall Effect rpm sensor.
4. When plugging the TEMS into the receiver, extreme care must be taken with the polarity of the receiver. The TEMS has JR type connectors. This will plug into Futaba and other "positive middle" type radios but care must be taken not to reverse the polarity. Other "middle negative" system may be used but the polarity of the TEMS plug will need to be changed.





## J600 Instruction Manual

### PST TEMS (Cont)

5. Extreme care must be taken not to reverse the polarity of the battery to the TEMS. Incorrect polarity can destroy the TEMS and will not be covered by the warranty.
6. TEMS is protected by 15-amp slow blow fuse and must only be replaced with the same rating fuse.
7. Use the supplied fuel pump only. For any other fuel pump, please contact us for recommendations.

Wiring of the TEMS to the radio and accessories is quite simple and straight forward. The wires are marked where they exit the TEMS.



**Battery** – Black-Negative ; **Red-Positive**

**Pump** – **Blue-Negative** ; **Red-Positive**

**Glow** – Black-Negative (engine case) ; **Green-Positive** (glow plug head)

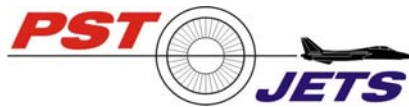
**Starter** – Black-Negative ; **Red-Positive**

**GDT** – Remote connector for Ground Display Terminal

**EGT** – For connection to Temperature Probe sensor

**Revs/RC** – Three-wires cable: Revs (RPM sensor) plug is the male pins and the R/C plug is standard JR servo plug which connect to Rx throttle channel

**GAS** – not labeled here but it has distinctive connector (blue color) that will connect to the solenoid valve (two-wires cable)



## J600 Instruction Manual

### PST TEMS (Cont)

#### GDT (Ground Display Terminal)



The PST GDT has three control press-in buttons. The UP and DOWN buttons are used to scroll between menu pages and to set programming values. The ENTER button is used for selecting the menu page feature and to store the input values into the TEMS unit. When you first turn on the system, the software version page will be displayed momentarily then switch to the first default screen. By pressing UP, the menu will change thru the main menu pages each time the key is pressed. Sub-menus can be accessed by ENTER key then use the UP and DOWN to scroll thru the sub-menu pages. Menu Pages are in the following sequence:

#### **Start Up First screen**

#### **Start Enable**

#### **Show Shutdown Data**

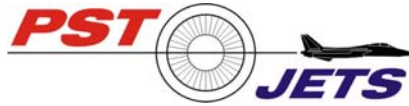
#### **Prime Pump**

#### **Ramping Values**

- Ramp Switch – Lo
- Ramp Switch – Hi
- Ramp Up – Lo
- Ramp Down – Lo
- Ramp Up – Mid
- Ramp Down – Mid
- Ramp Up – Hi
- Ramp Down – Hi

#### **Physical Adjusts**

- View Runtime & Start
- Adjust Glow Driver
- Learn R/C Parameters
- Adjust Start Ramp
- Adjust Idle Revs
- Adjust Max Revs
- Reset To Default



## J600 Instruction Manual

### PST TEMS (Cont)

#### **Programming Features**

##### **Start Enable**

Press UP until you see this page displayed. This page is used for initiating the auto start from the GDT. Press UP to start the turbine. Another option for starting the turbine is from the transmitter. By cycling the throttle and trim to minimum, trim to max and stick to max then stick back to min. The start sequence should initiate if the stick/trim movement are done within 5 seconds. More details of start in the Auto Start section.

##### **Show Shutdown Data**

Press UP until you see this page displayed. Press ENTER to select the page. The page is a freeze frame of the turbine condition at the point of shutdown. The displayed values are showing what the TEMS was reading at the time of shutdown. You can see what caused the shutdown, and also what the other readings were at the time. "\*" is displayed beside the cause of shutdown. (see the GDT Diagnostics Display Interpretation section for details). The data will be retained even if the TEMS is switched off and on again until the next shutdown.

To exit back to the main menu, press UP or wait for ten seconds.

##### **Prime Pump Feature**

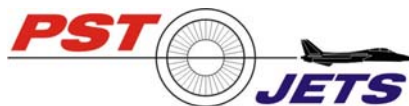
To ensure a successful auto start, the pump and fuel lines should have fuel in them right up to the engine inlet. This is achieved by running the pump to fill the lines. Caution not to over prime the engine as this can cause hot start. After first setup of the system, the fuel pump may be dry and before priming, the pump needs to be feed with initial fuel. Use pressure to initiate the flow of fuel to the pump before priming. It is advisable to disconnect the delivery line to the turbine and redirect it to an external fuel container. Run the pump a few seconds to circulate the system then reconnect the fuel line.

Press UP until you see this page displayed. Press ENTER to select the function. Press the UP button will start the pump running at an idle. To stop the pump, press UP again. The display will return to menu page automatically. To perform priming function again, repeat the sequence.

##### **Setting of Ramping Values**

This option is open to the user but the default parameters are recommended. Use the values as set from factory as shown on data sheet at the end of this manual. The numbers can be simply interpreted as time (fraction of second) required for ramping. The higher the number, the longer it takes to ramp thus slower ramping. This feature is useful for fine tuning the J600 at different atmospheric conditions.





## J600 Instruction Manual

### PST TEMS (Cont)

#### **Physical Adjusts**

Press UP until you see this page displayed. Press ENTER to access the sub-menus below:

##### **- View Runtime & Start**

From this menu, press ENTER to display the turbine runtime and number of starts. These values can only be reset by factory representatives after engine service.

##### **- Adjust Glow Driver**

Press ENTER from this menu to activate glow plug voltage setting. The default value is set at 180 meaning 1.80V. Use UP or DOWN to adjust the value to the desired level. Different glow plug with higher resistance will require higher voltage to sustain the glow during start. Range can be from 180 to as high as 270.

##### **- Learn R/C Parameters**

This allows the TEMS to memorize and store your radio's throttle settings for Shutdown, Idle, and Full thrust positions. This has to be done only once unless the radio is worked on or replaced. Setting the transmitter as described below:

JR: Throttle ATV (Travel Adjust): -100/+100 ; Throttle Trim Rate: 50% ; Normal  
(On PCM 10X, remove all MIX and SLOW functions on throttle channel)

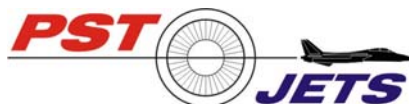
Futaba: Throttle ATV: -100/+100 ; Reversed

On Futaba FF8, 8UAPS, 9ZAP, etc. with digital trim the following is recommended:  
Set the "Throttle cut " to 40% and assign to switch "E". Trim to be set at midpoint. With switch toward you, is "trim min" ; switch in mid position is "trim max". To shut motor down, with stick at min, move the switch E to the "trim min" position.

First switch the radio and receiver on, set the throttle trim and stick position to minimum. Press UP until the "Physical Adjusts" menu displays, then press ENTER and UP button until "Learn R/C Parameters" menu displays. Press ENTER and follow the instructions displayed on the screen. Once finish, the information is saved into the TEMS.

##### **- Adjust Start Ramp**

This is the ramping from zero to Idle point. Default value is 45. Higher the number, the longer the ramping time. Not recommended to go below 45. You may increase this value as the fuel pump becomes more free flowing to avoid flame during start. The value can go as high as 100 for strong pump.



## J600 Instruction Manual

### PST TEMS (Cont)

#### - Adjust Idle Revs

Use this function to increase default idle value above 55,000 rpm. You may need to adjust this value to higher rpm (57-60k) if flameout is experienced at low throttle setting.

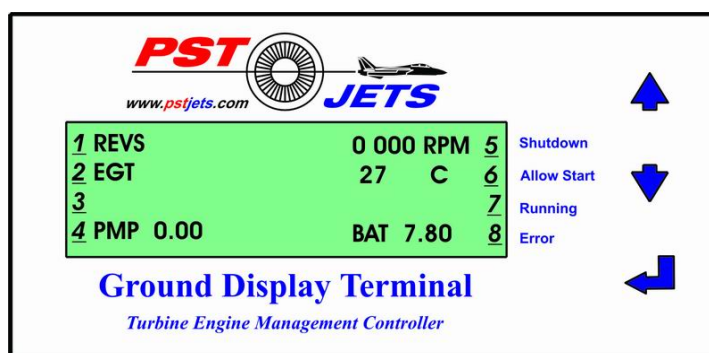
#### - Adjust Max Revs

Use this function to derate the engine. Maximum revolution is 160,000.

#### - Reset to Default

Use this page to reprogram the TEMS to default value settings.

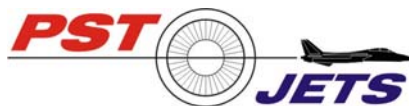
### GDT Diagnostics Display Interpretation



The number 1-8 is not part of the display but they are where the \* will be displayed to mean something. The list below indicates via the numbers in the place of \* above.

#### - Prior to and during start:

- 1 Revs are below allowable start RPM.
- 2 EGT is below allowable start EGT.
- 3 Not used.
- 4 Throttle stick is not at stick min and trim is not at max position.
- 5 TEMS is in shutdown mode – No start is possible.
- 6 R/C signal and conditions are ok to allow start. Only active after “Start Enable” has been pressed or throttle stick/trim cycled as described earlier.
- 7 Once this comes on, the pump will start ramping and the turbine is considered running.
- 8 If on, indicates an error in the TEMS software. The user is warned that the unit should be re-programmed by PST Jets authorized service center, even if all appears to be working correctly. The TEMS will not allow a start and message **"Start Not Ready"** will be displayed. If flashing, indicates a fault while reading values from the processor chip. \*\* CHECK ALL VALUES AND VERIFY AGAINST THE DEFAULT VALUES \*\*



## J600 Instruction Manual

### PST TEMS (Cont)

#### - While running:

- 1 Flashing indicates the turbine is exceeding Min or Max RPM and the TEMS is holding the pump to keep within limits.
- 2 Flashing indicates the turbine is exceeding Max EGT and the TEMS is holding the pump to keep the EGT within limits.
- 3 The RPM signals has fallen away and the TEMS is filtering the reading to allow the RPM signal to restore itself.
- 4 Not used while running, except to indicate, at shutdown, if the user shut the turbine down.

#### - After Shutdown:

- 1 Shutdown caused by revolution, check more detail at "Show Shutdown Data".
- 2 Shutdown caused by EGT, check more detail at "Show Shutdown Data".
- 3 Not used.
- 4 Shutdown caused by user shutting down, or on R/C signals loss.
- 5 Indicates the TEMS is in shutdown mode
- 6 Same as during start
- 7 Same as during start
- 8 Same as during start

### TEMS Trouble Shooting

After plugging in the GDT, please observe that the following messages are **not** displayed. The message indicates some type of fault with the installation.

#### Messages:

**"No Comms"** – There is a communication error between the GDT and the TEMS. In this case, try switching off the power to the TEMS for 5 seconds and then switch on again. If this persists, contact us or PST service center.

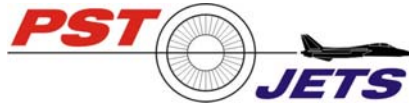
**"No R/C"** – Your radio is not on

**"R/C Rev"** – Throttle channel is reversed. Change the action of your throttle and repeat the "Learn R/C Parameters".

**"R/C Invalid"** – The R/C signal is not within the specification of the TEMS. Try resetting the TEMS and your radio. If this persists, contact us or PST service center.

**"Glow Fail"** – The glow plug filament is broken or the wiring to the plug is open. Check the wiring and replace the glow plug as described in previous section.

**"Start Not Ready"** – CPU error or if R/C is off or any other condition not healthy for start. In this case, try switching off the power to the TEMS for 5 seconds and then switch on again. If this persists, contact us or PST service center.



## J600 Instruction Manual

### PST TEMS (Cont)

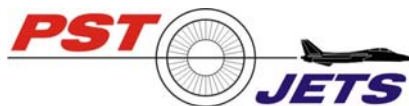
Additional indications can be observed if there are other faults with the setup.

1. Pump starts running and then shuts down on "Pmp" – Flat battery pack or radiated interference between TEMS and receiver. Move TEMS and receiver away from each other. Move TEMS battery and receiver battery away from each other.
2. Pump will not increment or decrement while adjusting idle and full speed – Check that the throttle stick is at minimum while decreasing idle and at full throttle position while increasing rpm.
3. TEMS "hangs up" while setting radio limits – This happens if you try to set the radio throttle settings and the receiver is off or somehow the TEMS is not seeing the R/C signal. Switch TEMS off and on again and switch R/C on and do setting again. Verify correct R/C operation by putting a servo in the throttle channel.
4. Pump surging – Check for proper ventilation and try circulating the motor with fuel for about 10-15 minutes.
5. Idle rpm drops below 55K – If the idle rpm swings down too much and sometimes causes flameout at idle, idle revolution needs to be increased thru Adjust Idle Revs function. Raise the idle to 57-60K. Differentiation between Idle thrust at 55K and 60K is almost unnoticeable.
6. No throttle response between 0-25% throttle (JR) – Set throttle trim rate to 50%.

### Auto Start Sequences

This is how your TEMS system works. The TEMS will start and ramp the turbine up to idle speed then release the control over to the transmitter. The basic description of the auto start sequence and shutdown is as followed.

1. Turbine spins momentarily to 7000 rpm to verify the battery and starter motor capability. Note: If the turbine does not reach 7000 rpm within 10 seconds, the TEMS will abort the start and report "**Step Fail**" on the GDT.
2. Turbine is allow to spool down while opening gas and switching glow on.
3. At 2000 rpm, spool back up to 7000 rpm then allow to spool down again.
4. At 2000 rpm, spool back up to 7000 rpm.
5. When the gas ignites, glow will be switched off and the starter re-engages. Note: If no ignition takes place after 4 attempts, the start will be aborted and the TEMS will report "**Start Fail**" on the GDT. To restart, just reset the TEMS and repeat the auto start cycle.
6. When 7000 rpm is reached and EGT is above 110 C, the pump will start.
7. At 30,000 rpm, the starter will disengage ("M" indicates starter motor is on).
8. At 40,000 rpm, the gas will be switched off ("G" indicates gas is on).
9. The turbine is self-sustaining and will continue to ramp up to 65,000 rpm.
10. "Idle Adjust" will be displayed and the turbine speed will be reduced to 55,000 rpm.



## J600 Instruction Manual

### PST TEMS (Cont)

11. You can now calibrate the J600 for maximum full speed (or desired derated speed) and higher idle speed as described in the Calibrating MIN and MAX rpm section.
12. The turbine can be shutdown by moving the throttle stick to idle and the trim lever to minimum.
13. After shutdown, the TEMS will cool the turbine by spooling between 2000 and 7000 rpm until the EGT is below 120 C. **“COOLING”** will be displayed during this period. GDT programming function is inactive during the cooling cycle. Note: You may switch the radio transmitter and receiver off during the cooling period but the TEMS power must be left on.

You can monitor the start sequence via messages displayed on the GDT. The messages are as followed:

1. **M Glow On** - M=Motor Start ; Glow On=glow plug is powered
2. **G Glow On** - G=Gas open ; Glow On=glow plug is powered
3. **MG Glow On** - Motor and Gas on
4. **Step Fail** - Shutdown step due to faults
5. **MG Ramp** - Turbine is between start and 15,000 rpm
6. **M Ramp** - Turbine is between 15,000 and 30,000 rpm
7. **M Ramp** - Turbine is between 30,000 and 40,000 rpm
8. **Ramp** - Turbine is accelerating with fuel to 65,000 rpm
9. **Idle Adjust** - TEMS is calibrating idle speed to 55,000 rpm
10. **Idle** - Turbine is self sustained, control is released to user

### **Calibrating MIN and MAX rpm**

This feature is available after the engine is running and need to be done only once on first run after installation. To calibrate the Min and Max speed, press UP to access the calibration menus and use ENTER to activate the function. **Safety:** Use ears and eyes protection with fire extinguisher ready.

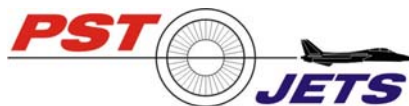
- **Adjust Idle Speed** – With throttle stick at minimum position, use UP and DOWN keys to adjust Min speed. Minimum speed is default at 55,000 rpm.
- **Adjust Full Speed** – With throttle stick at maximum position, use UP and DOWN keys to adjust Max speed. Maximum speed is 160,000 rpm. You can use this feature to derate the thrust in case maximum thrust is not required.
- **Auto Set Full Speed** – Use this feature to automatically set the Max or Full speed. With throttle stick raise to about 25% above minimum position, use UP key to activate the calibration process. The TEMS will increase and calibrate the turbine to max full speed of 160,000 rpm then reduce to set throttle position once the calibration is completed. This feature calibrates the TEMS to the voltage required by the fuel pump at maximum thrust. It is strongly recommended to use this feature to calibrate full speed at the first run of flying session.

## Mounting and Installation

1. Carefully insert the mounting straps under the EGT probe as shown in the pictures.
2. Take good care that the EGT probe will not bend out of shape and that the end remains securely inserted into the exhaust nozzle.
3. **Important:** EGT probe end must be inserted not more than 2mm into the tail cone.
4. Mounting straps must be securely fastened with the supplied lock nuts and bolts.
5. Mount the turbine securely to test bench or airframe as shown. Bench start is recommended for familiarization with the turbine and the PST TEMS.
6. Tail pipe is needed for airframe internal installation. Please e-mail us for recommended sizes appropriate to your aircraft.

		
<b>Securely mount the turbine</b>	<b>Mounting strap goes under the EGT probe</b>	<b>Tail pipe &amp; Mounting</b>
		
<b>Bench starting</b>	<b>Mounting straps securely fastened</b>	<b>EGT probe inserted not more than 2mm in tail cone</b>





## J600 Instruction Manual

### Before Start

1. Study TEMS section thoroughly for start and operation of the auto start feature.
2. TEMS parameters were factory set but your transmitter needs to be calibrated. Please review the TEMS section for setup and calibration of your radio.

Check that the system retains the following parameters:

Ramping Values: default parameters

Start Ramp = 45 (We recommend that you start with value of 47 on your first few starts then reduce this value to 45 later if the startup becomes too slow)

Setting the Transmitter: (same as described in the TEMS section)

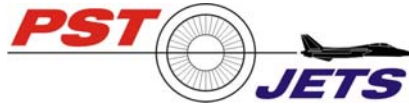
JR: Throttle ATV (Travel Adjust): -100/+100 ; **Throttle Trim Rate: 50%** ; Normal  
(On PCM 10X, remove all mix and slow for throttle channel)

Futaba: ATV: -100/+100 ; Reversed

Set the "Throttle cut " to 40% and assign to switch "E". Trim to be set at midpoint. With switch toward you, is "trim min" ; switch in mid position is "trim max". To shut motor down, with stick at min, move the switch E to the "trim min" position.

### Notes:

1. JR and Futaba throttle reversing is different, please check direction carefully.
2. Turbine models are big investment; please use good quality radio and servos for your model. Seek expert advices for radio / turbine installations.
3. We also recommend that external Rx antenna is used for good reception and to avoid any interference from installed turbine and electronics.
4. Avoid installing the receiver close to fuel pump as the pump motor produces certain frequency that can cause interference to the radio receiver.
5. It is a good practice (also a GTBA requirement) to use manual or servo operated fuel shutoff valve as a last resource to shutdown the engine in case of ECU failure. We recommend and have included the 4mm Festo ball valve.
6. PST TEMS is simple to use but understanding the setup and operation sequences is critical. Please study this manual carefully.



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### Starting



**Bench start and blower for added safety and extra cooling**

Recommendation: We recommend that you start the engine on an outdoor test stand prior to installation into airframe.

Notes: If the air in the fuel line is not removed completely, auto start attempt may not be successful.

Safety: Eyes and ears protection. Fire extinguisher must be in ready position.

**IMPORTANT:** Although the TEMS is designed to automate the start-up sequence and to take proper actions for any abnormalities, the operator must still be aware of what actions are to be taken in the event of unforeseen problems. Manual fuel shutoff valve must be accessible for immediate manual shutdown and fire extinguisher must be ready at all times. Servo controlled mechanism can be installed to control the manual shutoff valve.

#### Auto Start Procedure

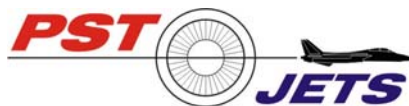
1. Check that TEMS battery is properly charged to full capacity. Note: Limit one full charge to two flights or approximately 25 minutes of running time. Do not use uncharged or low voltage battery pack to run the TEMS as this can cause ECU "hanging up"
2. Make sure fuel line is connected and the fuel pump will not run dry.
3. Open manual fuel and gas shutoff valves, if installed.
4. Make sure that the frequency channel is cleared. Turn on the Rx and Tx.
5. Connect the GDT and turn on TEMS switch. Observe proper GDT display.
6. Prime engine as described in the TEMS section.
7. **Fuel line going into engine must be filled for successful auto start.**
8. Initiate start sequence thru the GDT or thru transmitter throttle stick and trim lever. By cycling the throttle and trim to minimum, trim to max and stick to full then move throttle stick back to min. The start sequence should initiate if the stick / trim movement is done within 5 seconds.
9. Observe the auto start sequence. LED on gas solenoid valve comes on to indicate that the valve is open.
10. "Idle" displays on the GDT indicate that the start is successful.
11. Check that the engine idles at 55,000 rpm and full thrust is set at required speed. (maximum rpm is 160,000) You can calibrate to full 160,000 rpm using the "Auto Set Full Speed" feature as described earlier in the TEMS section.
12. Enjoy flying....



## Maintenance

1. After each run, make sure that the compressor and turbine wheels spin freely and no sign of any physical defects or unusual noises. The turbine assembly will turn and come to a stop with little braking action confirming that the pre-load on the bearings is still good.
2. Re-cycle the TEMS battery often. Preferably after each flying session or about 10 quick charges.
3. After about 20 starts, check the electric starter O-ring for dirt and clean it as appropriate.
4. To clean the O-ring, the front motor may need to be removed. The starter front case can be removed by turning counter-clockwise. When installing the front case back, care must be taken to ensure that the Bendix is not too close to the spinner nut. The Bendix should be about 0.5mm passed the rear case end. There is a stopper in the rear case to ensure correct positioning.
5. Check that the EGT probe is still in good condition and no breakage at the point shown in the picture below.
6. If the glow plug needs to be replaced, follow the steps outlined earlier. Make sure that the filament extends out about 2mm.
7. External filters should be checked and cleaned regularly. Disassemble the filters and clean them as needed. Internal filters (last chance filters) should not need any cleaning if good external filters are used. Avoid opening the front case. Improper removal can cause damage to the turbine thus voiding the warranty.
8. After 150 starts, the turbine needs to be checked and serviced by PST or authorized service agencies. Failure to do so will void the warranty.

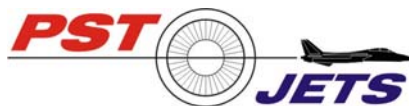
		
<b>Clutch O-ring</b>	<b>Removing the front motor</b>	<b>Clean O-ring as necessary</b>
		
<b>Front motor assembly</b>	<b>External filters recommended</b>	<b>Handle the EGT probe carefully. Shown is the easy break point</b>



## J600 Instruction Manual

### J600 Trouble Shooting

<u>Symptoms</u>	<u>Causes</u> & Fixes
1. Engine shut down due to high or low revolution	<ol style="list-style-type: none"> <li>1. <u>TEMS battery may be weak or has memory effect.</u> Re-cycle and recharge the battery pack. Again recalibrate the TEMS.</li> <li>2. <u>Sticky fuel pump.</u> Pump may need to be run-in more. Remove the fuel pump and run fuel thru the pump continuously for about 15 minutes.</li> </ol>
2. No gas light up during start	<ol style="list-style-type: none"> <li>1. <u>Gas canister is empty.</u> Fill the canister.</li> <li>2. <u>Gas solenoid valve is not connected properly, or installed gas shutoff valve is closed.</u> Check and open valve.</li> <li>3. <u>Solenoid valve locked close due to high pressure gas (100% propane).</u> Use max 70/30 propane/butane mix gas.</li> <li>4. <u>Glow plug is bad (GDT will indicate this).</u> Replace glow plug.</li> <li>5. <u>Glow plug voltage is too low.</u> Increase plug voltage thru GDT (as high as 280 may be required)</li> <li>6. <u>Low battery capacity.</u> Recharge TEMS battery.</li> </ol>
3. Engine does not accelerate to maximum set rpm	<ol style="list-style-type: none"> <li>1. <u>Insufficient fuel or air bubble is entering the engine during initial start.</u> Prime the engine so the fuel line is filled and no air bubbles are present.</li> <li>2. <u>Low battery capacity.</u> Recharge TEMS battery.</li> <li>3. <u>EGT Probe is not installed properly.</u> Check that the probe is inserted 2mm into the tail cone.</li> </ol>
4. Engine flameout during rolls and inverted maneuvers	<ol style="list-style-type: none"> <li>1. <u>Air bubbles in the fuel system.</u> Check tanks installation and make sure that no air bubbles are present in the header tank. Use bubble-elimination device for bubble free fuel.</li> </ol>
5. EGT is too high (above 750 C)	<ol style="list-style-type: none"> <li>1. <u>EGT probe is not inserted correctly.</u> Make sure that the EGT probe end is not more than 2mm into the tail cone.</li> </ol>

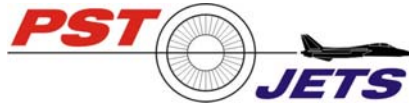


## J600 Instruction Manual

### J600 Trouble Shooting (cont)

<u>Symptoms</u>	<u>Causes</u> & <u>Fixes</u>
6. Motor start not turning	<ol style="list-style-type: none"><li>1. <u>Loose wiring or connection to TEMS.</u> Check motor start wiring and connections.</li><li>2. <u>Motor is bad. Motor life exceeds expected 200 starts cycle.</u> Contact us for replacement starter motor.</li></ol>
7. Strong vibration and unusual noises	<ol style="list-style-type: none"><li>1. <u>Foreign materials may have entered the turbine and damaged the compressor wheels, and/or dirt or small particles may have entered the engine bearing tube, causing damage to the bearings.</u> The engine must be sent to PST Jets or authorized service center for inspection and repair.</li></ol>
8. Flame shooting out during start	<ol style="list-style-type: none"><li>1. <u>Excessive fuel in the engine or liquid propane is entering the turbine.</u> Blow excess fuel out of the turbine or initiate start sequence with the gas and fuel valves closed. Clean and wipe off excessive fuel from the exhaust area and tail pipe before next start attempt. Make sure that the gas canister is standing upright.</li><li>2. <u>Start Up Ramp is too quick.</u> Increase start up ramp to value higher than 45.</li></ol>

\*\* More trouble shooting regarding the TEMS can be found in the TEMS section \*\*



## J600 Instruction Manual

### J600 Specifications

**Dimensions:** Outer diameter: 89mm; Length: 168mm (238mm with starter)

**Weight:** 900 grams (1000 grams with motor start)

**Output:** Maximum thrust 5.5 kg @ 160,000 rpm (recommend 155,000 rpm for normal operation); Idle thrust 0.2 kg at 50,000 rpm \*

**Diffuser:** 7075 Aluminum

**Combustion chamber:** 316 Stainless steel with Inconel vaporizing tubes

**Bearings:** GRW Ceramic angular contact cageless bearing

**Shaft:** EN 24 grade steel

**NGV:** WREN vacuum cast stainless steel

**Turbine:** WREN MW54 vacuum cast Inconel 713, AMS-STD-2175 Grade B

**Compressor:** Garrett, High-grade aluminum alloy

**Motor Start:** Aluminum casing, copper clutch assembly, ball-bearing 280 motor

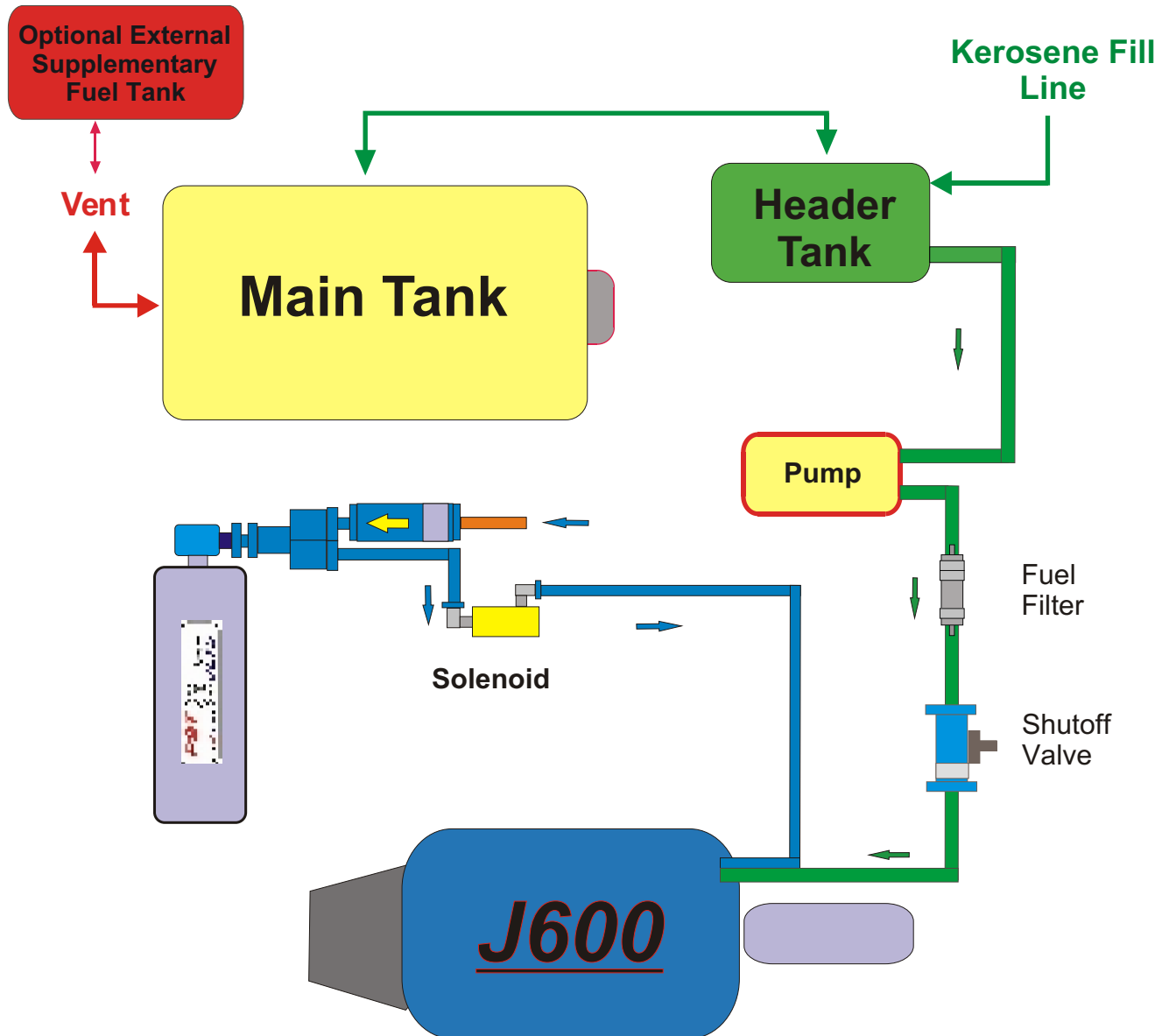
**Technology:** CAD/CAM & CNC Milling and Lathe; Digital & Infrared balancing

**Other components:** High-grade stainless steel

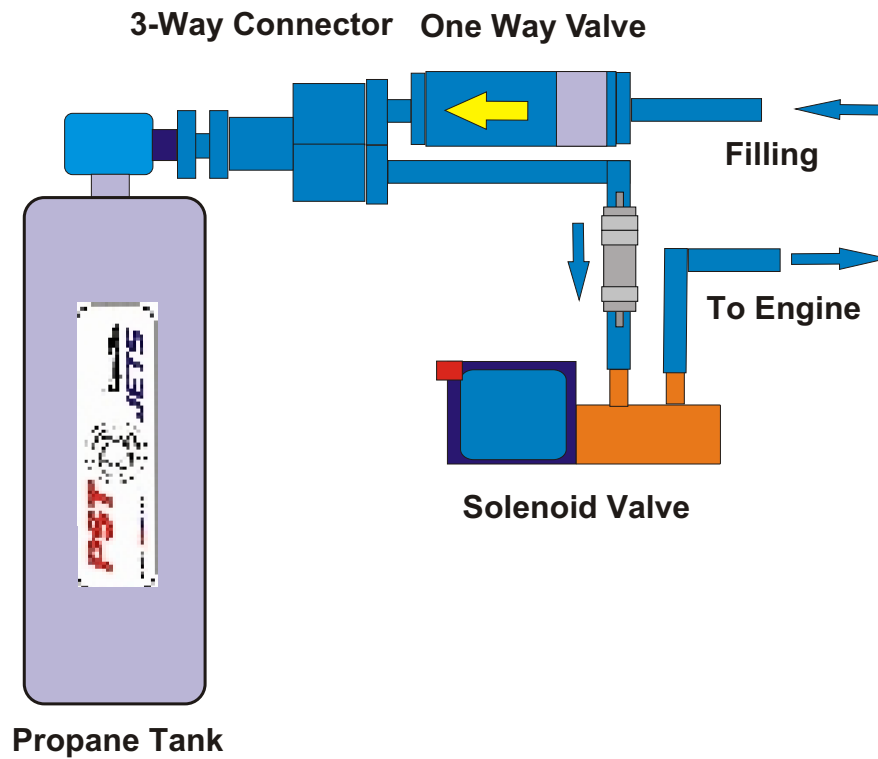
**Accessories:** Stainless steel anodized front casing & engine mounts, high grade gas/fuel tubing & filters, and silicon electrical wiring with gold plated connectors

\* Outside temp 30C (86F); 1013 HPa Barometric pressure; Sea level

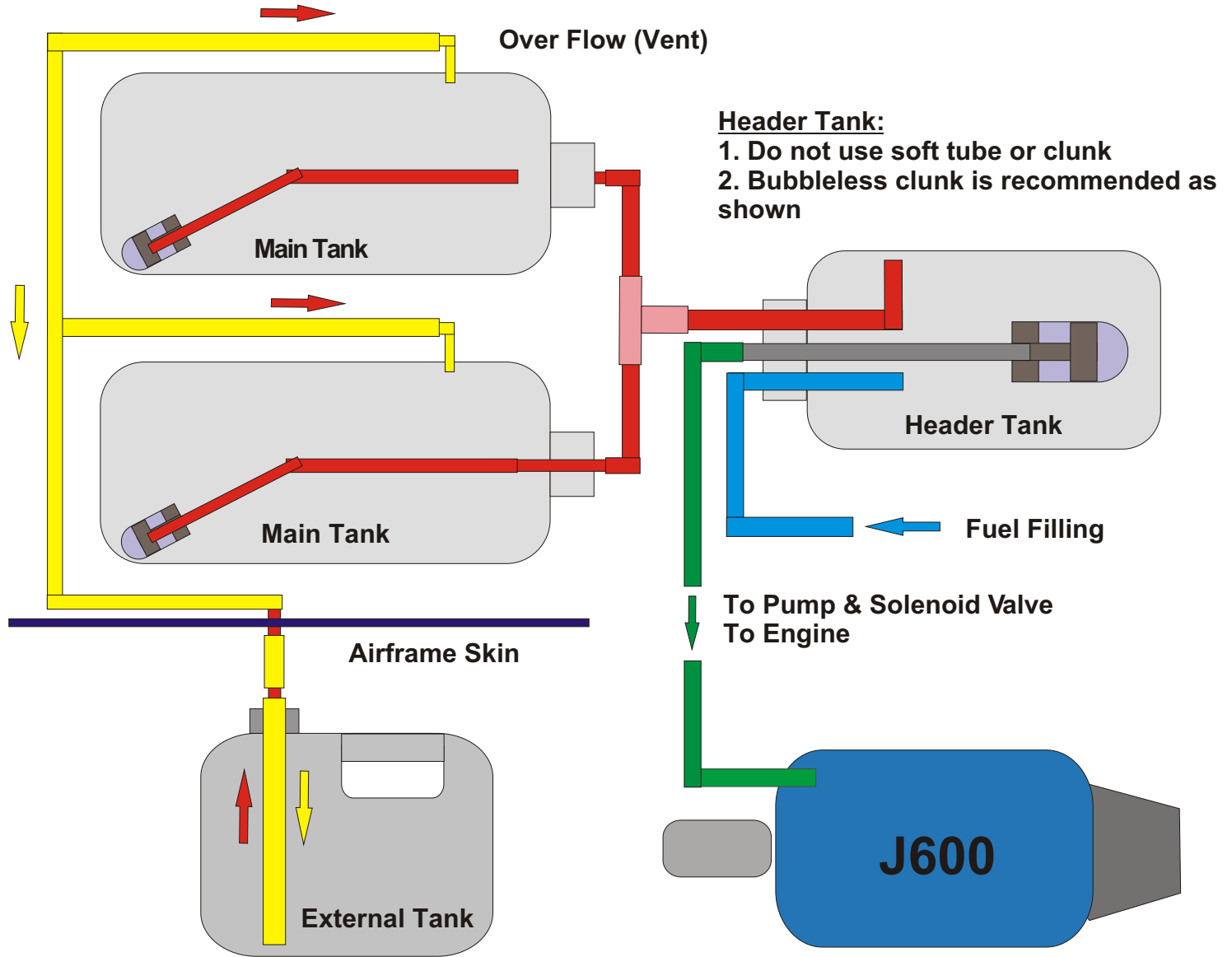
## Diagram A - Fuel & Propane Connection



## Diagram B: Internal Propane Tank



## Diagram C: Main & Header Tank Setup



### Header Tank:

1. Do not use soft tube or clunk
2. Bubbleless clunk is recommended as shown





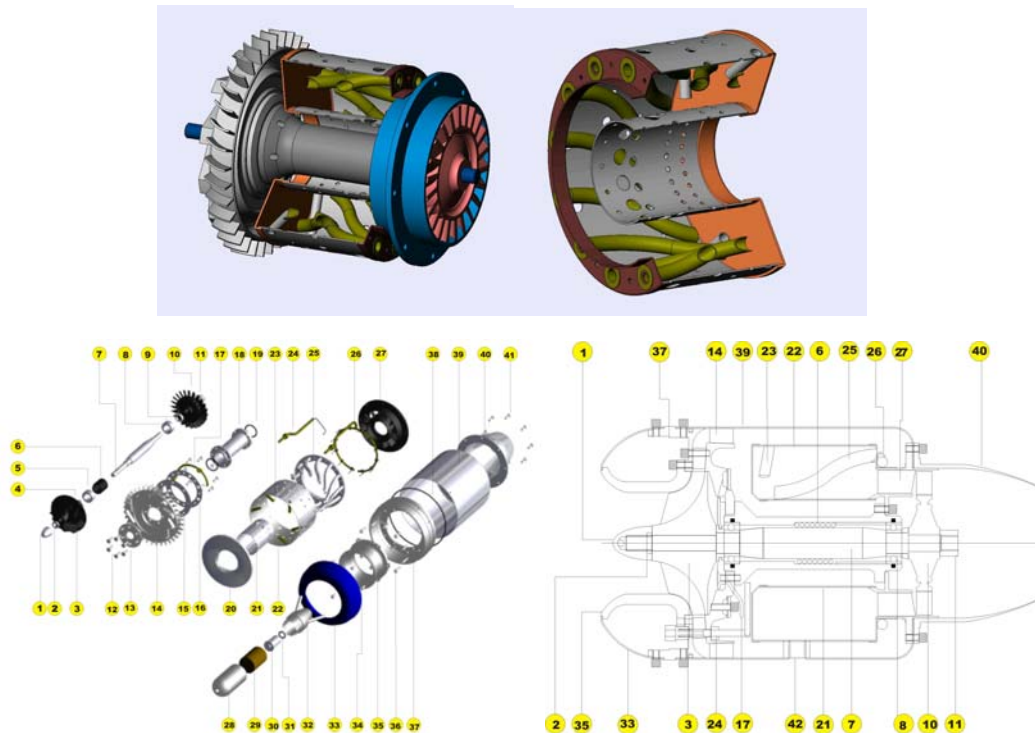
-  Fuel overflows from Vent Line
-  Fuel returns to Main Tank after engine start
-  Fuel fills line
-  Fuel feeds to engine

Diagram D: J600 Sectional View



J600 Parts list

Item #	Description	Item #	Description
1	Spinner Nut	21	Combuster Inner
2	Magnet Ring	22	Combuster Outer
3	Compressor Wheel	23	Swirl Jets
4	Front Spacer	24	Gas Line
5	Front Bearing	25	Vaporizer/Combuster Rear
6	Preload Spring	26	Fuel Injectors
7	Rotor Shaft	27	NGV (Nozzle Guide Vane)
8	Rear Bearing	28	Starter Case Front
9	Rear Spacer	29	Electric Motor
10	Turbine Wheel	30	Clutch
11	Turbine Nut	31	Clutch O-ring
12	Bolts	32	Starter Case Rear
13	Shaft Seal	33	Engine Front Cover
14	Diffuser	34	Bolts
15	Filter Mesh	35	Bell mount Intake
16	Filter Cover	36	Bolts
17	Lubrication Line	37	Diffuser Cover
18	Bearing Tube	38	Case O-ring
19	O-ring	39	Case Outer
20	Combuster Front	40	Exhaust Cone
		41	Bolts
		42	Glow Plug Mount





Owner: \_\_\_\_\_ Serial Number: \_\_\_\_\_ Purchase Date: \_\_\_\_\_

[illegible]



Owner: \_\_\_\_\_ Serial Number: \_\_\_\_\_ Purchase Date: \_\_\_\_\_

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