

**TSIO-520-L & LB  
WB**

**CONTINENTAL® AIRCRAFT ENGINE**

# **OPERATOR'S MANUAL**



**Continental Motors, Inc.**

**FAA APPROVED**

## Supersedure Notice

This manual revision replaces the front cover and list of effective pages for Publication Part No. X30505, dated December 1978. Previous editions are obsolete upon release of this manual.

## Effective Changes for this Manual

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# INTRODUCTION

The operating instructions outlined in this manual have been developed from comprehensive evaluation of the engine performance in relation to its installation in an aircraft. Recommendations, cautions and warnings regarding operation of this engine are not intended to impose undue restrictions on operation of the aircraft, but are inserted to enable the pilot to obtain maximum performance from the engine commensurate with safety and efficiency. Abuse, misuse, or neglect of any piece of equipment can cause eventual failure. Failure to observe the instructions contained in this manual constitutes unauthorized operation in areas unexplored during development of the engine, or in areas in which experience has proved to be undesirable or detrimental.

**WARNING . . .** In order to properly use this engine, the user must comply with all instructions contained herein. Failure to so comply will be deemed misuse, relieving the engine manufacturer of any responsibility. This manual contains no warranties, either expressed or implied. The purpose of the data presented is instruction, information and safety.

Notes, Cautions and Warnings are included throughout this manual. Application is as follows:

**NOTE:** Special interest information which may facilitate the operation of equipment.

***CAUTION:** Information issued to emphasize certain instructions or to prevent possible damage to engine or accessories.*

**WARNING . . .** Information which, if disregarded, may result in severe damage to or destruction of the engine or endangerment to personnel.

Users are advised to keep up with the latest information by means of service bulletins, which are available for study at any approved Teledyne Continental Distributor or Dealer, or which are obtainable on an annual subscription basis. Subscription forms are available from the Distributor or from Teledyne Continental Motors, P. O. Box 90, Mobile, Alabama 36601, Attention: Publications Department.

**WARNING . . .** This engine must be install in accordance with all requirements and limitations listed in the Detail Specifications for Teledyne Continental Aircraft Engines. Any deviations caused by installation, or operation, such as acrobatic maneuvers will be deemed as misuse and Teledyne Continental Motors shall be relieved of any further responsibility.

# SECTION I

## OPERATING SPECIFICATIONS AND LIMITS

When increasing power, first increase the RPM with the propeller control and then increase manifold pressure with throttle. When decreasing power, throttle back to desired manifold pressure and then adjust to the desired RPM. Readjust manifold pressure after final RPM setting.

*CAUTION . . . Cylinder head and oil temperatures must never be allowed to exceed the limitations specified. Near-maximum temperatures should occur only when operating under adverse conditions, such as high power settings, low airspeed, extreme ambient temperature, etc. If excessive temperatures are noted, and cannot reasonably be explained, or if abnormal cowl flap and/or mixture settings are required to maintain temperatures, then an inspection should be performed to determine the cause. Possible causes of high temperatures may include broken or missing baffles, inoperative cowl flaps, sticking oil temperature control unit, or restricted fuel nozzles (resulting in lean-running cylinders). Faulty instruments or thermocouples may cause erroneously high (or low) temperature indications. Refer to Section VIII of this manual and/or the aircraft overhaul manual for trouble shooting procedures.*

**WARNING . . . Do not use any propeller that is not certificated and specifically designed for operation on this engine.**

## DETAILED SPECIFICATIONS

This specification is for the TSIO-520-L, -LB and -WB Aircraft Engines which have:

FAA Type Certificate Number . . . . . E8CE

**RATINGS:**

|  | <u>-L, -LB</u> | <u>-WB</u> |
|--|----------------|------------|
| Maximum Continuous BHP (-0, +5%)                 | 310            | 325        |
| Maximum Continuous RPM                           | 2700           | 2700       |
| Maximum Continuous Manifold<br>Pressure, In. HG. | 38.0           | 39.5       |

**CYLINDER DATA:**

|                             |             |
|-----------------------------|-------------|
| Number of Cylinders         | .6          |
| Displacement (Cubic Inches) | .520        |
| Bore and Stroke (Inches)    | 5.25 x 4.00 |
| Compression Ratio           | 7.5:1       |

**PROPELLER DRIVE DATA:**

|                                   |                           |
|-----------------------------------|---------------------------|
| Type                              | ARP 502                   |
| Direction of Rotation             | Clockwise                 |
| Ratio (To Crankshaft)             | 1:1                       |
| Vibration Dampers, Number & Order | Two 6th, One 5th, One 4th |

**FUEL SYSTEM**

|   |                                |
|---|--------------------------------|
| Type  | Continuous Flow Fuel Injection |
| Make and Model  | Bendix RSA7DA1                 |
| Fuel - (Min. Grade Aviation Gasoline<br>Conforming to ASTM-D410-46) | 100 or 100LL                   |

**LUBRICATION SYSTEM**

|                                      |              |
|--------------------------------------|--------------|
| Specification                        | MHS-24B      |
| Grade (SAE)                          |              |
| Above 40° F. Ambient Air (Sea Level) | .50          |
| Below 40° F Ambient Air (Sea Level)  | 30 or 10W-30 |
| Pump Capacity, Quarts Maximum        | .12          |
| Usable Oil Quarts 26° Nose Up        | 6.1          |
| Usable Oil Quarts 13.5° Nose Down    | 6.1          |
| Filter                               | Full Flow    |



**ACCESSORIES:**

|   |   |
|---|---|
| Magnetos .....                                  | Bendix 1200 Series                            |
| Ignition Harness .....                          | 5MM Shielded (.750-20 Thd. Connection)        |
| Spark Plugs . . .                               | 18MM x .750-20 Thd. Connection (FAA Approved) |
| Turbosupercharger with Integral Wastegate ..... | AiResearch                                    |
| Oil Cooler (Decongealing) .....                 | Modine  |
| Alternator-24V, 100A .....                      | Teledyne                                      |
| Solenoid - Starter .....                        | Prestolite                                    |
| Starter - 24V .....                             | Prestolite                                    |
| Overboost Valve .....                           | AiResearch                                    |
| Variable Controller .....                       | AiResearch                                    |
| Sonic Venturi                                   |   |
| Intercooler and Miscellaneous Parts             |   |
| Freon Compressor Drive                          |   |

**BASIC ENGINE WEIGHT NOT INCLUDING**

|                          |               |
|--------------------------|---------------|
| <b>ACCESSORIES .....</b> | <b>416.10</b> |
|--------------------------|---------------|

**TOTAL ENGINE DRY WEIGHT WITH ACCESSORIES**  
**(SUBJECT TO PRODUCTION VARIATION OF ±2.5%) 539.60**

# **OPERATING SPECIFICATIONS** **TSIO-520-L, -LB, -WB**

| OPERATION                           | MAXIMUM HORSEPOWER |              | PERFM. CLIMB | MAX. REC. CLIMB | RECM. CLIMB | MAX. ALLOW. CRUISE | RECM. CRUISE | RECM. CRUISE | ECONOMY CRUISE | IDLE | RUN UP  |
|-------------------------------------|--------------------|--------------|--------------|-----------------|-------------|--------------------|--------------|--------------|----------------|------|---------|
|                                     | -L, -LB<br>2700    | -W/B<br>2700 |              |                 |             |                    |              |              |                |      |         |
| RPM                                 | 2700               | 2700         | 2700         | 2400            | 2400        | 2400               | 2400         | 2200         | 2200           | —    | 2000    |
| MANIFOLD PRESSURE                   | 38"                | 39.5"        | 38"          | 34"             | 32"         | 33"                | 30"          | 30"          | 26"            | —    | —       |
| MIXTURE                             | RICH               | RICH         | RICH         | RICH            | RICH        | LEAN               | LEAN         | LEAN         | LEAN           | RICH | RICH    |
| FUEL FLOW (PPH)<br>AT SEA LEVEL (1) | 180-190            | 190-200      | 180-190      | 152-162         | 143-152     | 111                | 97           | 83           | 69             | —    | —       |
| CYLINDER HEAD<br>TEMPERATURE (F°)   |                    |              |              |                 |             |                    |              |              |                |      |         |
| MINIMUM                             | 240                | 240          | 240          | 240             | 240         | 240                | 240          | 240          | 240            | —    | 200     |
| NORMAL (2)                          | 300-420            | 300-420      | 300-420      | 300-420         | 300-420     | 300-420            | 300-420      | 300-420      | 300-420        | —    | 200-250 |
| MAXIMUM                             | 460                | 460          | 460          | 460             | 460         | 420                | 420          | 420          | 420            | —    | —       |
| OIL TEMPERATURE (F°)                |                    |              |              |                 |             |                    |              |              |                |      |         |
| MINIMUM                             | 100                | 100          | 100          | 100             | 100         | 100                | 100          | 100          | 100            | —    | 75      |
| NORMAL (3)                          | 100-200            | 100-200      | 160-180      | 160-180         | 160-180     | 160-180            | 160-180      | 160-180      | 160-180        | —    | 75-100  |
| MAXIMUM                             | 240                | 240          | 240          | 240             | 240         | 240                | 240          | 240          | 240            | —    | —       |
| OIL PRESSURE (PSI)                  |                    |              |              |                 |             |                    |              |              |                |      |         |
| MINIMUM                             | 30                 | 30           | 30           | 30              | 30          | 30                 | 30           | 30           | 30             | 10   | 30      |
| NORMAL                              | 40-60              | 40-60        | 40-60        | 40-60           | 40-60       | 40-60              | 40-60        | 40-60        | 40-60          | —    | 40-60   |
| MAXIMUM                             | 80                 | 80           | 80           | 80              | 80          | 80                 | 80           | 80           | 80             | —    | 100 (4) |

- (1) Fuel flows shown are ref only and will vary from engine to engine and with forward speed - lean using TIT.
- (2) Where practical, cylinder head temperatures should be held between 350-380°F for maximum engine life.
- (3) Cruise temperatures above this range should be avoided. Constant engine operation above this level should be investigated for possible oil system malfunction.
- (4) With cold oil only.

## SECTION II

### NORMAL OPERATING PROCEDURE

*CAUTION . . . This section pertains to operation under average climatic conditions. The pilot should thoroughly familiarize himself with Section V, Part 1, Abnormal Operating Conditions. Whenever such abnormal conditions are encountered or anticipated, the procedures and techniques for normal operation should be tailored accordingly. For example, if the aircraft is to be temporarily operated in extreme cold or hot weather, consideration should be given to an early oil change and/or a routine inspection servicing.*

#### GENERAL.

The life of your engine is determined by the care it receives. Follow the instructions contained in this manual carefully.

The engine receives a run-in operation before leaving the factory. Therefore, no break-in schedule need be followed. Straight mineral oil (MIL-C-6529 Type II) should be used for the first oil change period (25 hours).

The minimum grade aviation fuel for this engine is 100LL (Blue) or 100 (Green). In case the grade required is not available, use a higher rating. Never use a lower rated fuel.

**WARNING . . .** The use of a lower octane rated fuel can cause pre-ignition and/or detonation which can damage an engine the first time high power is applied. This most likely occur on takeoff. If the aircraft is inadvertently serviced with the wrong grade of fuel, then the fuel must be completely drained and the tank properly serviced.

## **PRESTARTING.**

Before each flight the engine and propeller should be examined for damage, oil leaks, security and proper servicing.

1. Position the ignition switch to the "OFF" position.
2. Operate all controls and check for binding and full range of travel.
3. Assure that fuel tanks contain proper type and quantity of fuel. (100LL - Blue, or 100 - Green)
4. Drain a quantity of fuel from all sumps and strainers into a clean container. If water or foreign matter is noted, continue draining until only clean fuel appears.
5. Check oil level in sump. (12 Quarts)
6. Check cowling for security.

## **STARTING.**

1. Propeller Controls - HIGH RPM
2. Mixture Controls - IDLE CUT-OFF
3. Battery Switch - ON

NOTE . . . If external power is used start right engine first.

4. Boost Pumps - ON
5. Start Engines

NOTE . . . Initial starting ignition is provided by a special high voltage circuit operated by the starter switch, which fires the spark plugs and retards the ignition timing. Starting will be facilitated if

the starter is released as soon as the engine starts so that normal ignition is provided by the magnetos.

*CAUTION . . . Do not engage the starter when the engine is running as this will damage the starter.*

*CAUTION . . . If difficulty in starting is experienced, do not crank for longer than thirty seconds at a time as the starter motor may overheat. If the engine does not start after thirty seconds of cranking, allow a 3 to 5 minute cooling period before continued attempts.*

## **COLD STARTS**

- a. Throttle - 1/2 OPEN
- b. Mixture control FULL RICH for 2 to 3 seconds to prime then to IDLE CUT-OFF
- c. Throttle - 1/2 INCH OPEN
- d. Magneto/Start Switch - START
- e. When engine starts, return the Magneto/Start switch to BOTH. Slowly advance the mixture control to FULL RICH.

## **FLOODED ENGINE**

- a. Mixture Control - IDLE CUT-OFF
- b. Throttle - 1/2 OPEN
- c. Magneto/Start Switch - START
- d. When engine starts, return the Magneto/Start switch to BOTH. Retard the throttle and slowly advance the mixture control to FULL RICH position.

## **HOT STARTS.**

- a. Throttle - APPROXIMATELY 1 INCH OPEN
- b. Mixture Controls - FULL FORWARD for 1 to 2 seconds then to IDLE CUT-OFF
- c. Magneto/Start Switch - START
- d. When engine starts, return the Magneto/Start switch to BOTH. Slowly advance the mixture control to FULL RICH.
6. Throttle 1000 to 1500 rpm
7. Oil pressure - ABOVE RED RADIAL WITHIN 30 SECONDS.
8. Alternator Switch - ON
9. External Power (if used) - Disconnect
10. Loadmeters - CHECK FOR BATTERY CHARGE
11. Use the same procedure to start other engine

NOTE . . . Continuous use of the fuel boost pumps is recommended for ground operation in ambient temperatures of 90°F (32°C) or above.

## **GROUND RUNNING; WARM-UP.**

Teledyne Continental aircraft engines are aircooled and therefore dependent on the forward speed of the aircraft for cooling. To prevent overheating, it is important that the following rules be observed.

1. Head the aircraft into the wind.

2. Operate the engine on the ground with the propeller in “Full Increase” RPM position.
3. Avoid prolonged idling at low RPM. Fouled spark plugs can result from this practice.
4. Leave mixture in “Full Rich”. (See “Ground Operation at High Altitude Airports”, Section I, for exceptions.)
5. Warm-up 900-1000 RPM.

## PRE-TAKEOFF CHECK

1. Maintain engine speed at approximately 1000 to 1500 RPM for at least one minute in warm weather, and as required during cold weather to prevent cavitation in the oil pump and to assure adequate lubrication.
2. Advance throttle slowly until tachometer indicates an engine speed of approximately 1200 RPM. Allow additional warm-up time at this speed depending on ambient temperature. This time may be used for taxiing to takeoff position. The minimum allowable oil temperature for run-up is 75° F.

*CAUTION . . . Do not operate the engine at run-up speed unless oil temperature is 75° F. minimum.*

3. Perform all ground operations with cowlings flaps, if installed full open, with mixture control in “FULL RICH” position and propeller control set for maximum RPM (except for brief testing of propeller governor).
4. Restrict ground operations to the time necessary for warm-up and testing.
5. Increase engine speed to 2000 RPM only long enough to perform the following checks:

a. Check Magnetos: Move the ignition switch first to "R" position and note engine RPM, then move switch back to "BOTH" position to clear the other set of spark plugs. Then move the switch to "L" position and note RPM. The difference between the two magnetos operated individually should not differ more than 50 RPM with a maximum drop for either magneto of 150 RPM. Observe engine for excessive roughness during this check.

If no drop in RPM is observed when operating on either magneto alone, the switch circuit should be inspected.

**WARNING . . .** Absence of RPM drop when checking magnetos may indicate a malfunction in the ignition circuit. Should the propeller be moved by hand (as during preflight) the engine may start and cause injury to personnel. This type of malfunction should be corrected prior to continued operation of the engine.

*CAUTION . . . Do not underestimate the importance of a pre-takeoff magneto check. When operating on single ignition, some RPM drop should be noted. Normal indications are 25-75 RPM drop and slight engine roughness as each magneto is switched off. Absence of a magneto drop may be indicative of an open switch circuit or improperly timed magneto. An RPM drop in excess of 150 RPM may indicate a faulty magneto or fouled spark plugs.*

Minor spark plug fouling can usually be cleared as follows:

1. Magnetos - Both On.
2. Throttle - 2200 RPM.
3. Mixture - Move toward idle cutoff until RPM peaks and hold for ten seconds. Return mixture to full rich.



#### 4. Magnetos - Recheck.

If the engine is not operating within specified limits, it should be inspected and repaired prior to continued operational service.

Avoid prolonged single magneto operation to preclude fouling of the spark plugs.

##### b. Check throttle and propeller operation

(1) Move propeller governor control toward low RPM position and observe tachometer. Engine speed should decrease to minimum governing speed (200-300 RPM drop). Return governor control to high speed position. Repeat this procedure two or three times to circulate warm oil into the propeller hub.

(2) Move propeller to “feather” position. Observe for 300 RPM drop below minimum governing RPM, then return control to “full increase” RPM position.

*CAUTION . . . Do not operate the engine at a speed in excess of 2000 RPM longer than necessary to test operation and observe engine instruments. Proper engine cooling depends upon forward speed of the aircraft. Discontinue testing if temperature or pressure limits are approached.*

#### 6. Instrument Indications.

a. Oil Pressure: The oil pressure relief valve will maintain pressure within the specified limits if the oil temperature is within the specified limits and if the engine is not excessively worn or dirty. Fluctuating or low pressure may be due to dirt in the oil pressure relief valve or congealed oil in the system.

b. Oil Temperatures: The oil cooler and oil temperature control valve will maintain oil temperature within the specified range unless the cooler oil passages or air channels are obstructed. Oil temperature above the prescribed limit may cause a drop in oil pressure, leading to rapid wear of moving parts in the engine.

c. **Cylinder Head Temperature:** Any temperature in excess of the specified limit may cause cylinder or piston damage. Cooling of cylinders depends on cylinder baffles being properly positioned on the cylinder heads and barrels, and other joints in the pressure compartment being tight so as to force air between the cylinder fins. Proper cooling also depends on operation practices. Fuel and air mixture ratio will affect cylinder temperature. Excessively lean mixture causes overheating even when the cooling system is in good condition. High power and low air speed, or any slow speed flight operation, may cause overheating by reducing the cooling air flow. The engine depends on the ram air flow developed by the forward motion of the aircraft for adequate cooling.

d. **Battery Charging:** The ammeter should indicate a positive charging rate until the power used for starting has been replaced by the battery charging circuit, unless the electrical load on the alternator is heavy enough to require its full output. The ammeter reading should return to the positive side as soon as the load is reduced. A low charging rate is normal after the initial recharging of the battery. A zero reading or negative reading with no battery load indicates a malfunction in the alternator or regulator system.

*CAUTION . . . The turbocharger has no oil temperature indicator. The oil temperature to the turbocharger is the same as indicated by the engine oil temperature gauge. The main shaft in this unit is lubricated by engine oil from the engine oil pressure system. The oil pressure to the turbocharger is higher than that indicated by the engine oil pressure gauge. The engine oil must be warm, at least 100° F, before take off to assure proper turbocharger operation. The engine must not be operated at high power until the oil has reached this temperature.*

## **TAKEOFF.**

- a. Position mixture to "FULL RICH". Where installed, cowl flaps should be positioned as specified by aircraft manufacturer.
- b. Position fuel boost pump switch as instructed by aircraft manufacturer.
- c. Slowly advance the throttle to FULL OPEN position, carefully monitoring manifold pressure. For standard day temperatures and normal engine oil operating temperatures, manifold pressure will not exceed the rated value when the throttle is FULL OPEN. However, when taking off full throttle with a minimum engine oil temperature of 100°F., an increase in manifold pressure above the rated value will occur due to the effect of cold oil upon the turbocharger control system. Under these conditions, a 1.0 -2.0 inches Hg increase in manifold pressure above the rated value is allowed for 2 - 3 minutes duration and need not be considered as detrimental to the engine. Do not continue to advance the throttle if it is apparent that overboost will occur beyond the limits allowed above.

An increase in manifold pressure beyond the limits allowed above indicates a need to have the turbocharger controller readjusted. The controller is to be adjusted to provide rated manifold pressure at 2700 RPM full throttle with an engine oil temperature of 160°F - 180°F.

In cold weather, the wastegate valve may not open unless the oil is warm.

*CAUTION . . . Avoid rapid throttle operation.*

## **CLIMB.**

- a. Climb must be done at a "FULL RICH" mixture setting, with cowl flaps, if provided, set to maintain desired temperature.

b. During climb (immediately after takeoff) observe manifold pressure and, if necessary, retard throttle to stay below rated maximum manifold pressure setting (red line).

**WARNING . . . Overboosting will damage the engine and be cause for engine inspection.**

c. Reduce to climb power.

**NOTE . . .** Although this engine is approved for continuous operation at 100% of Rated Power, it is seldom necessary or desirable to do so for long periods of time. Generally, when the aircraft has been configured for climbout, engine power should be reduced. Recommended power for normal climb is 2400 RPM, 34 MAP with a FULL RICH mixture setting. If power settings greater than 2400 RPM, 34 MAP must be used, particular attention should be given to cylinder head, EGT, and oil temperatures, and mixture must be "FULL RICH".

**WARNING . . .** At power settings above 2400 RPM, 34 MAP, do not use the E.G.T. gauge as an aid to mixture adjustment. If you attempt to determine the "peak" E.G.T. while the engine is operating at high power, burned valves, detonation, and possible engine failure can occur.

## **CRUISE.**

1. Set manifold pressure and RPM for cruise power selected.
2. After engine temperatures have stabilized at cruise condition (usually within 5 minutes of operation), adjust mixture to lean cruise condition according to Section IV of this manual.

**NOTE . . .** During high ambient temperature, a very low fluctuation in fuel flow may appear in the early flight stages, which is caused by excess vapor. If this occurs, operate the fuel boost pump.

3. When a cruise lean mixture setting is used, and increased power is desired, the mixture control must be returned to "FULL RICH" before changing the throttle or propeller setting. When reducing power, retard throttle, then adjust RPM and mixture.

NOTE . . . If an exhaust gas temperature gauge is used to monitor cruise fuel flow, the minimum cruise fuel mixture should not exceed 1650°F EGT.

NOTE . . . Rapid throttle movements may cause undershooting or overshooting the desired manifold pressure and a subsequent adjustment will be required after the turbocharger has stabilized for the new power setting. Gradual throttle movement will permit the turbocharger to keep pace with the change in power. On pressurized aircraft, slower manifold pressure adjustment will prevent sudden "spikes" in cabin altitude. At high altitude, large reductions in manifold pressure may cause some reduction of cabin pressure.

## DESCENT.

Descent from high altitude is to be accomplished at cruise power settings and mixture control positioned accordingly. A minimum of 20 in. Hg and 2200 RPM is required to maintain cabin pressurization.

*CAUTION . . . Rapid descents at a high RPM and idle manifold pressure setting are to be avoided.*

During descent, monitor cylinder and oil temperatures.

NOTE . . . Avoid long descents at low manifold pressure as the engine can cool excessively and may not accelerate satisfactorily when power is reapplied. If power must be reduced for long periods, adjust propeller to minimum governing RPM and set manifold pressure no lower than necessary to obtain desired

performance. If the outside air is extremely cold, it may be desirable to add drag to the aircraft in order to maintain engine power without gaining excess airspeed. Do not permit cylinder temperature to drop below 300°F. for periods exceeding five (5) minutes.

## LANDING.

1. In anticipation of a go around and need for high power settings, the mixture control should be set in "FULL RICH" position before landing.

NOTE . . . Advance mixture slowly toward "FULL RICH". If engine roughness occurs, as may happen at very low throttle settings and high RPM, it may be desirable to leave the mixture control approximately 3/4 open until the throttles are advanced above 15 inches of manifold pressure.

2. Operate the boost pump as instructed by aircraft manufacturer.

## STOPPING ENGINE.

1. If boost fuel pump has been on for landing, turn to "OFF".
2. Operate the engine at idle for approximately five minutes to allow the turbochargers to cool off and slow down.

NOTE . . . Taxi time after landing may be considered part of five minutes.

The turbochargers will generally spin from 1 to 2 minutes after the engines have shut down. If the engines are shut down too soon, and the turbochargers are still turning at high speed, the shaft bearings could become starved of lubrication. This can cause bearing damage.

3. Place mixture control in "IDLE CUTOFF".
4. Turn magnetos "OFF".

# **SECTION III**

## **IN-FLIGHT EMERGENCY PROCEDURES**

If a malfunction should occur in flight, certain remedial actions may eliminate or reduce the problem. Some malfunctions which might conceivably occur are listed in this section. Recommended corrective action is also included; however, it should be recognized that no single procedure will necessarily be applicable to every situation.

A thorough knowledge of the aircraft and engine systems will be an invaluable asset to the pilot in assessing a given situation and dealing with it accordingly.

### **ENGINE ROUGHNESS.**

Observe engine for visible damage or evidence of smoke or flame. Extreme roughness may be indicative of propeller blade failure. If any of these characteristics are noted, follow aircraft manufacturer's instructions.

1. Engine Instruments - Check. If abnormal indications appear, proceed according to Abnormal Engine Instrument Indications (this section).
2. Mixture - Adjust as appropriate to power setting being used. Do not arbitrarily go to Full Rich as the roughness may be caused by overrich mixture.
3. Magnetos - Check On.

If engine roughness does not disappear after the above, the following steps should be taken to evaluate the ignition system.

1. Throttle - Reduce power until roughness becomes minimal.

2. Magnetos - Turn Off, then On, one at a time. If engine smooths out while running on single ignition, adjust power as necessary and continue. Do not operate the engine in this manner any longer than absolutely necessary. The airplane should be landed as soon as practical and the engine repaired.

If no improvement in engine operation is noted while operating on either magneto alone, return all magneto switches to On.

*CAUTION . . . The engine may quit completely when one magneto is switched off, if the other magneto is faulty. If this happens, close throttle to idle and move mixture to idle cutoff before turning magnetos on. This will prevent a severe backfire. When magnetos have been turned back on, advance mixture and throttle to previous settings.*

**WARNING . . .** If roughness is severe or if the cause cannot be determined, engine failure may be imminent. In this case, it is recommended that the aircraft manufacturer's emergency procedure be employed. In any event, further damage may be minimized by operating at a reduced power setting.

## **TURBOCHARGER FAILURE.**

Turbocharger failure will be evidenced by inability of the engine to develop manifold pressure above ambient pressure. The engine will revert to "normally aspirated" and can be operated, but will produce less than its rated horsepower.

Readjust mixture as necessary to obtain fuel flow appropriate for observed manifold pressure and RPM.

**WARNING . . .** If turbocharger failure is a result of a loose, disconnected or burned-through exhaust, then a serious fire hazard exists. The first choice should be to



follow the aircraft manufacturer's emergency instructions. If turbocharger failure occurs before takeoff, DO NOT fly the aircraft. If failure occurs in flight, and the choice is made to continue operating the engine, proceed as follows:

1. Mixture - Idle Cutoff.
2. Throttle - Normal Cruise.
3. Propeller Control - Normal Cruise RPM.
4. Mixture - Advance slowly. When the proper mixture ratio is reached, the engine will start. Continue to adjust the mixture control unit until the correct fuel flow for the manifold pressure and RPM is obtained.

NOTE . . . An interruption in fuel flow to the engine can cause engine failure due to turbocharger "run-down". At high altitude, merely restoring fuel flow may not cause the engine to restart, because the mixture will be excessively rich. If the engine does not restart, there will be insufficient mass flow through the exhaust to turn the turbine. This condition may give indications similar to a turbocharger failure. If a power loss is experienced followed by surging of RPM, fuel flow, and manifold pressure, the following steps are recommended:

1. Mixture Control - Idle Cutoff.
2. Fuel Selector - Position so as to permit use of auxiliary fuel pumps (boost pumps).
3. Auxiliary Fuel Pump - On.
4. Throttle - Set to normal cruise position.

5. Propeller - Adjust normal cruise RPM.
6. Mixture - Enrich slowly from idle cutoff. Engine starting will be apparent by a surge of power. As the turbocharger begins to operate, manifold pressure will increase and mixture can be adjusted accordingly.
7. Fuel Boost Pump - Positioned according to aircraft manufacturer's instructions.
8. Mixture - Readjust if necessary.

NOTE . . . If this procedure does not effect a restart, descend below 18,000 feet and repeat. If the engine still will not start, the problem is likely other than fuel starvation or turbocharger failure.

## **ABNORMAL ENGINE INSTRUMENT INDICATIONS**

### **HIGH CYLINDER HEAD TEMPERATURE.**

1. Mixture - Adjust to proper fuel flow for power being used.
2. Cowl Flaps - Open.
3. Airspeed - Increase.

If temperature cannot be maintained within limits, reduce power and have the engine inspected before further flight.

### **HIGH OIL TEMPERATURE.**

NOTE . . . Prolonged high oil temperature indications will usually be accompanied by a drop in oil pressure. If oil pressure remains normal, then a high temperature indication may be caused by a faulty gauge or thermocouple. If the oil pressure drops as temperature increases, proceed as follows:

1. Cowl Flaps - Open.
2. Airspeed - Increase to normal climb or cruise speed.
3. Power - Reduce if steps 1 and 2 do not lower oil temperature.

*CAUTION . . . If these steps do not restore oil temperature to normal, an engine failure or severe damage can result. In this case it is recommended that the aircraft manufacturer's emergency instructions be followed.*

## **LOW OIL PRESSURE.**

If the oil pressure drops unexplainably from the normal indication of 30 to 60 psi, monitor temperature and pressure closely and have the engine inspected at termination of the flight. If oil pressure drops below 30 psi, an engine failure should be anticipated and the aircraft manufacturer's instructions for such should be followed.

## **IN-FLIGHT RESTARTING.**

*CAUTION . . . Do not attempt to start the engine above an altitude of 20,000 feet using the starter, due to possibility of magneto distributor block corrosion or burning.*

*CAUTION . . . Actual shutdown of an engine for practice or training purposes should be minimized. Whenever engine failure is to be simulated, it should be done by reducing power. The turbocharger can reach speeds of 80,500 RPM and must receive lubricating oil pressure from the engine driven oil pump. A sudden decrease of oil pressure to the turbocharger bearings will cause excessive wear or possible failure.*

Whenever a turbocharged engine is shutdown in flight, or when fuel flow is interrupted, the turbocharger will "run down" due to

lack of mass flow through the exhaust system. If the mixture is placed in "FULL RICH" during restart attempts at high altitude, the fuel flow may be excessive and the engine may fail to start due to overrich mixture. The degree of overrichness will depend primarily on altitude.

The key point in restarting is to increase fuel flow gradually from idle cutoff so the engine will start when a proper mixture is reached. As the mass flow through the exhaust system increases, the turbocharger will spin up and provide increased manifold pressure. The mixture may then be increased and power adjusted as desired.

*CAUTION... A few minutes exposure to temperatures and airspeed at flight altitudes can have the same effect on an inoperative engine as hours of cold-soak in sub-Arctic conditions. If the engine must be restarted, consideration should be given to descending to warmer air. Closely monitor for excessive oil pressure as the propeller is unfeathered. Allow the engine to warm up at minimum governing RPM and 15 inch of manifold pressure.*

The following procedure is recommended for in-flight restarting:

1. Mixture - IDLE CUT-OFF
2. Fuel Selector Valve - ON
3. Fuel Boost Pump - ON
4. Magneto/Start Switches - ON BOTH
5. Throttle - NORMAL START POSITION (1/2 open)
6. Primer - MIXTURE FULL RICH THEN IDLE CUT-OFF
7. Propeller:

## **WITHOUT UNFEATHERING ACCUMULATORS:**

- a. Cabin Press Air Shut-off Valve - PULL CLOSED
- b. Propeller Control - MOVE FORWARD OF THE FEATHERING DETENT TO MID-RANGE
- c. Magneto/Start Switch - START
- d. Mixture - FORWARD AS ENGINE STARTS
- e. Cabin Press Air Shut-off Valve - PUSH OPEN (After engine is running smoothly)

## **WITH UNFEATHERING ACCUMULATORS:**

- a. Propeller Control - FORWARD OF FEATHERING DETENT UNTIL ENGINE ATTAINS 600 RPM; THEN BACK TO DETENT
- b. Oil Pressure - STABILIZED

NOTE . . . If propeller does not unfeather or the engine does not turn, return the propeller control to the feather position and secure the engine.

- c. Mixture - FULL RICH AT 1000 RPM
- 8. Throttle - AS NECESSARY TO PREVENT OVERSPEED;  
Warm up at 15 in. Hg manifold pressure
- 9. Oil Pressure, Oil and Cylinder Head Temperatures -  
NORMAL INDICATION
- 10. Alternator Switch - ON
- 11. Power - AS REQUIRED



# SECTION IV

## ENGINE PERFORMANCE AND CRUISE CONTROL

The performance curves in this section are provided as a reference in establishing power conditions for takeoff, climb and cruise operation. Refer to aircraft manufacturer's flight manual for recommended power settings and tabular climb and cruise data.

### CRUISE CONTROL BY E.G.T.

Exhaust gas temperature on the TSIO-520-L, -LB and -WB engines is measured at the turbocharger turbine inlet and is commonly referred to as TIT (Turbine Inlet Temperature).

To establish cruise lean mixture, proceed as follows:

1. Adjust manifold pressure and RPM for desired cruise setting.
2. Lean the mixture to peak E.G.T. or 1650°F. whichever occurs first.

### CAUTION

Do not continue to lean mixture beyond than necessary to establish peak temperature or 1650°F. whichever occurs first. If E.G.T. reaches 1650°F., lean no further!

3. Set mixture to full rich for changes in altitude and power setting which will require the E.G.T. to be rechecked and the mixture to be reset.

*CAUTION . . . Do not attempt to adjust mixture by use of E.G.T. at power settings above maximum recommended cruise. Also, remember that engine power will change with ambient conditions. Changes in altitude or outside air temperature will require adjustments in manifold pressure and fuel flow.*

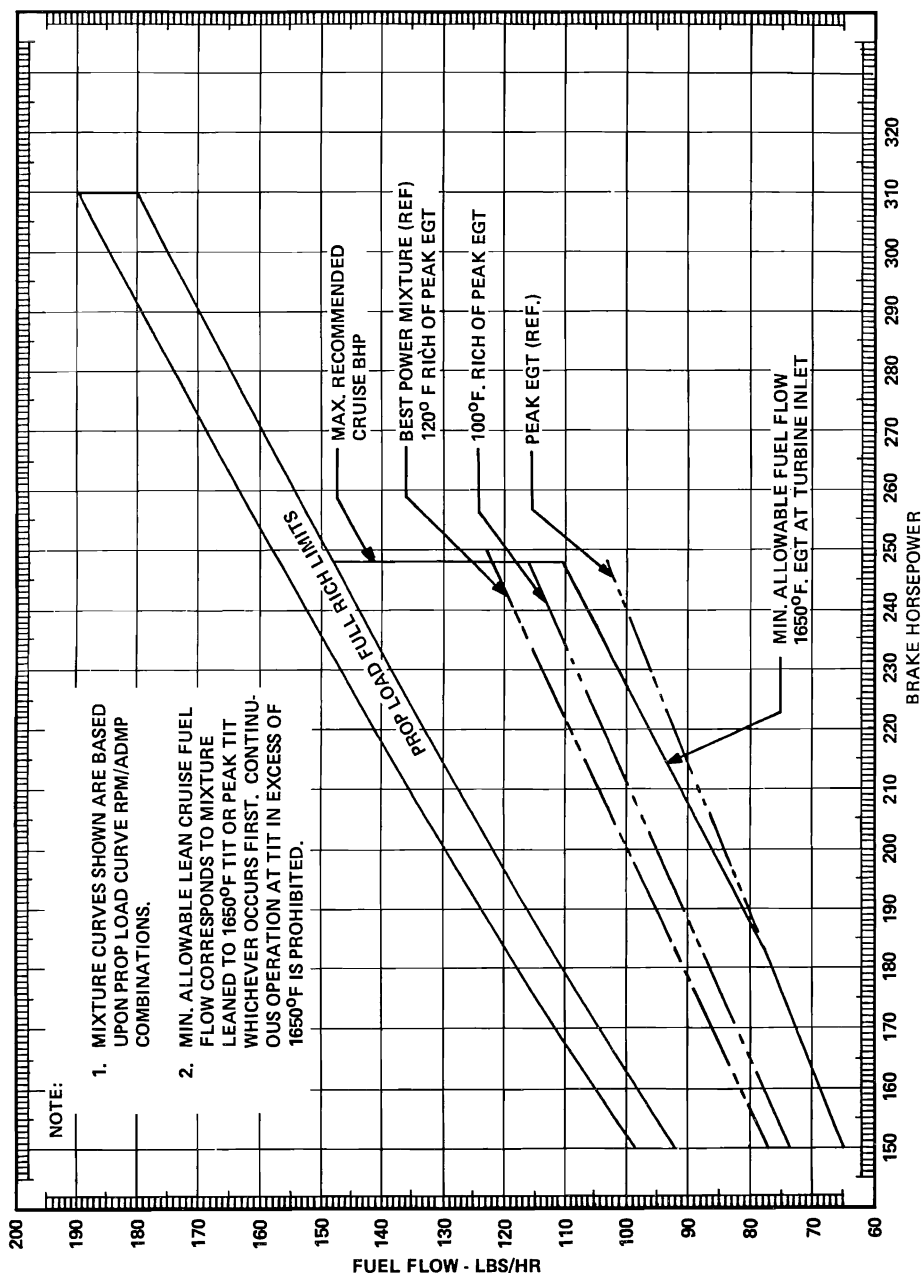


FIGURE 1. FUEL FLOW VS. BRAKE HORSEPOWER, TSIO-520-L, -LB



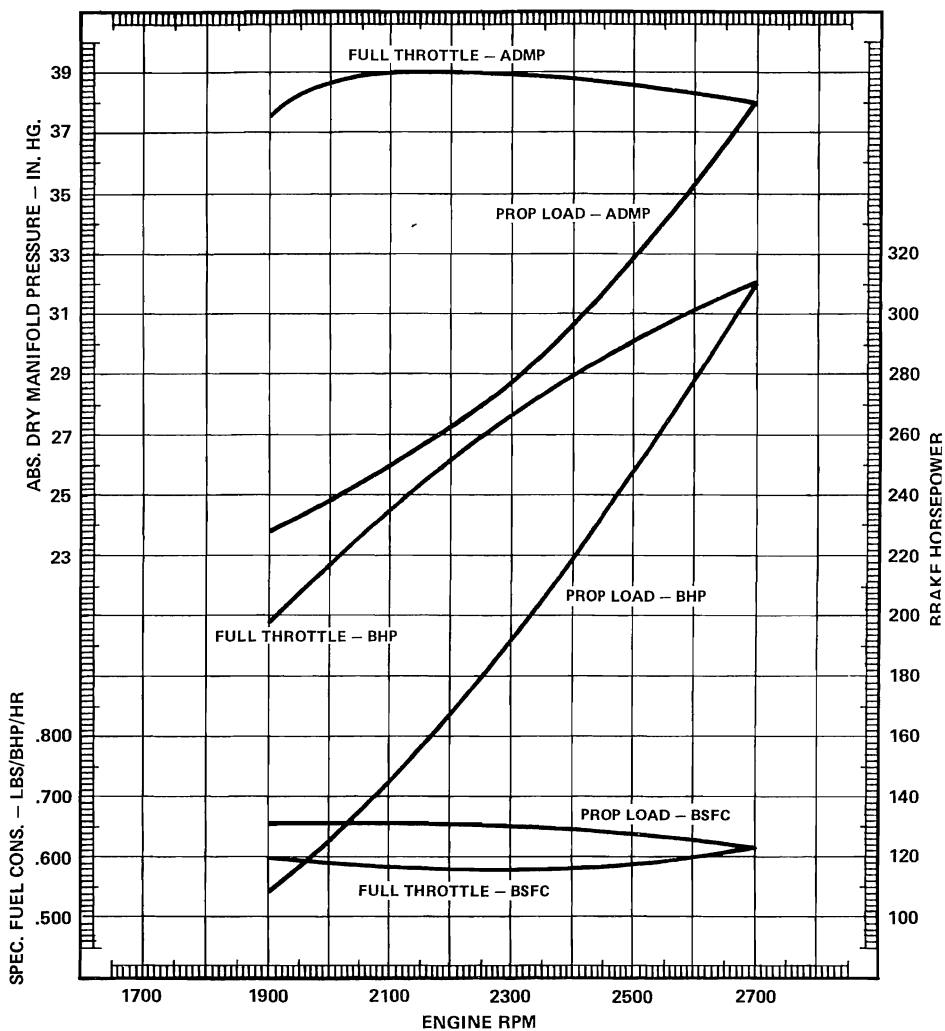
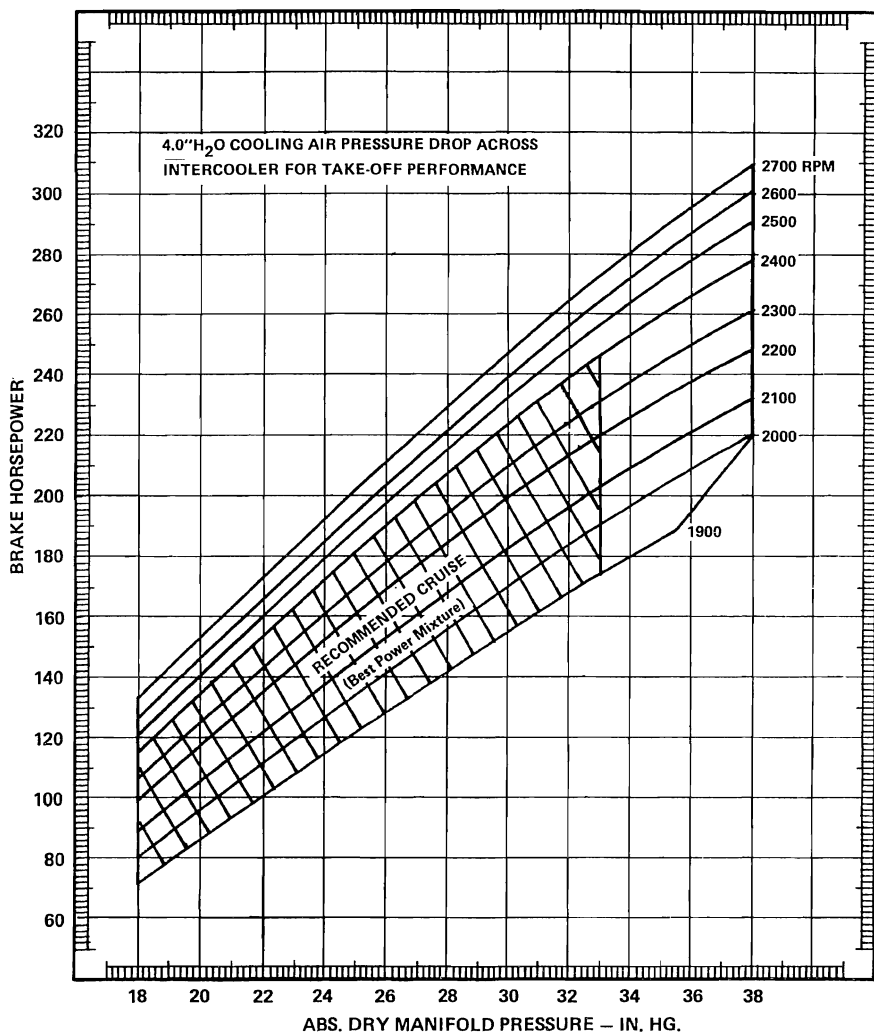


FIGURE 2. SEA LEVEL PERFORMANCE, TSIO-520-L, -LB



**FIGURE 3. BRAKE HORSEPOWER VS. MANIFOLD PRESSURE**  
**TSIO-520-L, -LB**

**40°F H<sub>2</sub>O COOLING AIR PRESSURE DROP ACROSS INTERCOOLER FOR TAKE-OFF PERFORMANCE**

**TO DETERMINE ACTUAL HP AT ALTITUDE**

1. Determine  $P_a$  or  $P_a$  known  $P_a$  in. Hg. and RPM (P, A).
2. Obtain  $P_a$  by correcting  $P_a$  at P, A.
  - a) Add 1% for each 6"  $P_a$  below  $P_a$ .
  - b) Subtract 1% for each 6"  $P_a$  above  $P_a$ .
3. Transfer  $P_a$  to  $P_a$  in. Hg. and read actual HP.

**ABS. DRY MANIFOLD PRESSURE IN. HG.**

**MAY 1962**

**SPECIFIED FULL RICH FUEL FLOW FOR  
34-.38" HG. MIXTURE LEANED TO 100°F.  
RICH OF PEAK EGT FOR 20-.35" HG.**

**ABS. DRY MANIFOLD PRESSURE - IN. HG.**

**BRAKE HORSEPOWER**

**60°F H<sub>2</sub>O COOLING AIR PRESSURE DROP ACROSS  
INTERCOOLER FOR INFLIGHT PERFORMANCE**

**TURBOCHARGER - AID MODEL TH08A-68  
FUEL INJECTOR - BENDIX ISATDA1**

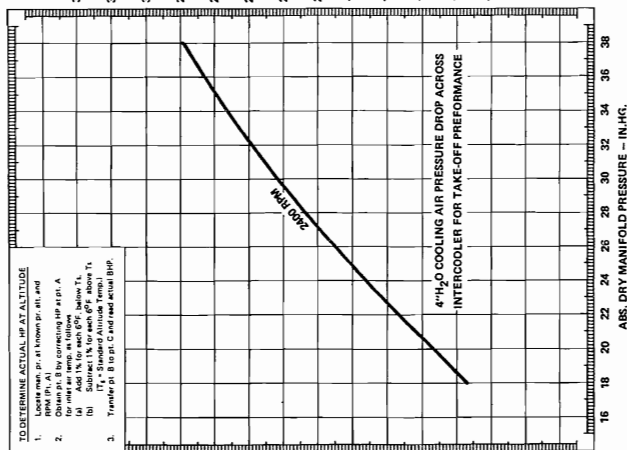
**SEA ALT. TIME  $P_{0.75}$  100**

**PRESSURE ALTITUDE IN THOUSANDS - FEET**

Points A, B, and C are marked on the graph. Point A is at approximately 10,000 feet altitude and 28 in. Hg manifold pressure. Point B is at approximately 10,000 feet altitude and 30 in. Hg manifold pressure. Point C is at approximately 10,000 feet altitude and 32 in. Hg manifold pressure.

**FIGURE 4. ALTITUDE PERFORMANCE, TSIO-520-L, -LB (2200 RPM)**

# SEA LEVEL PERFORMANCE



# ALTITUDE PERFORMANCE

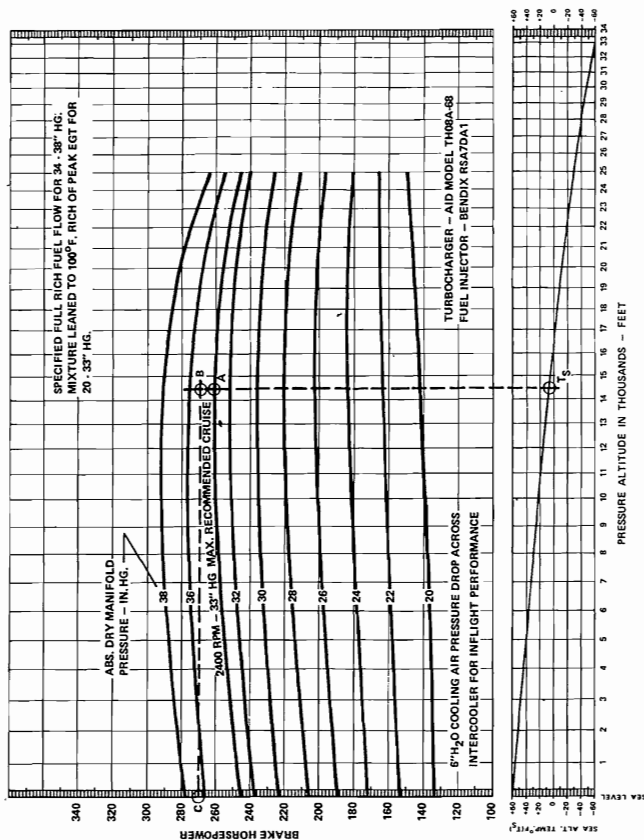
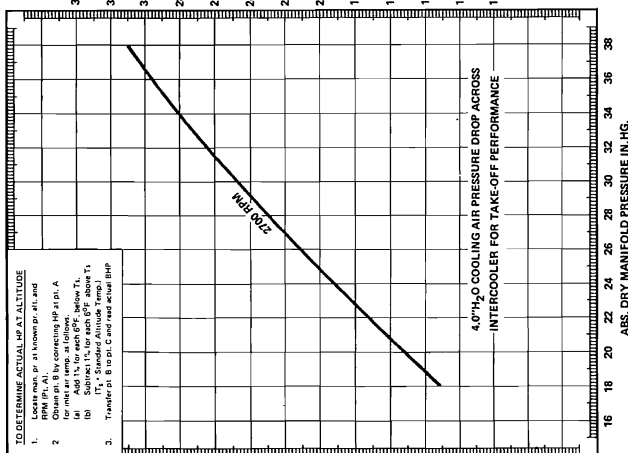


FIGURE 5. ALTITUDE PERFORMANCE, TSIO-520-L, -LB (2400 RPM)

# SEA LEVEL PERFORMANCE



# ALTITUDE PERFORMANCE

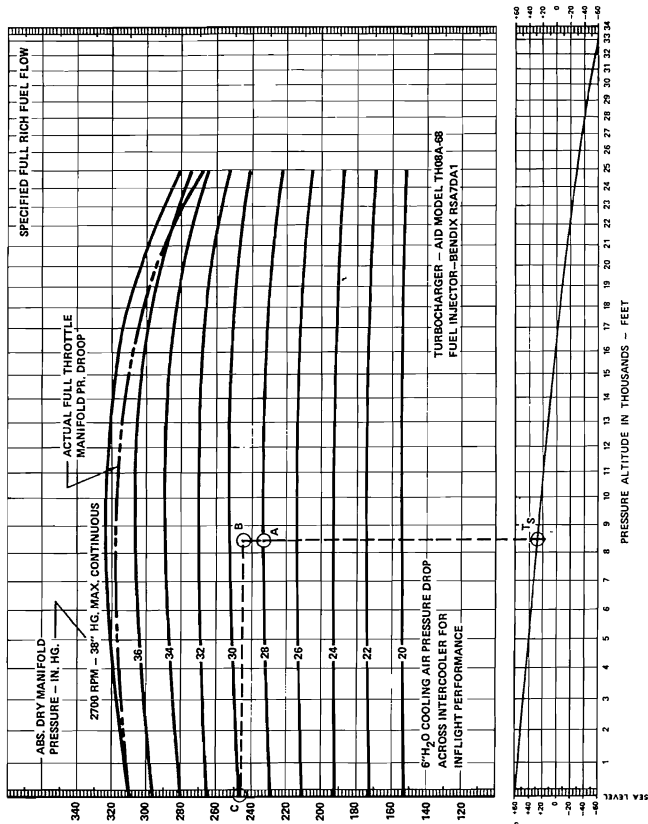


FIGURE 6. ALTITUDE PERFORMANCE, TSIO-520-L, LB (2700 RPM)

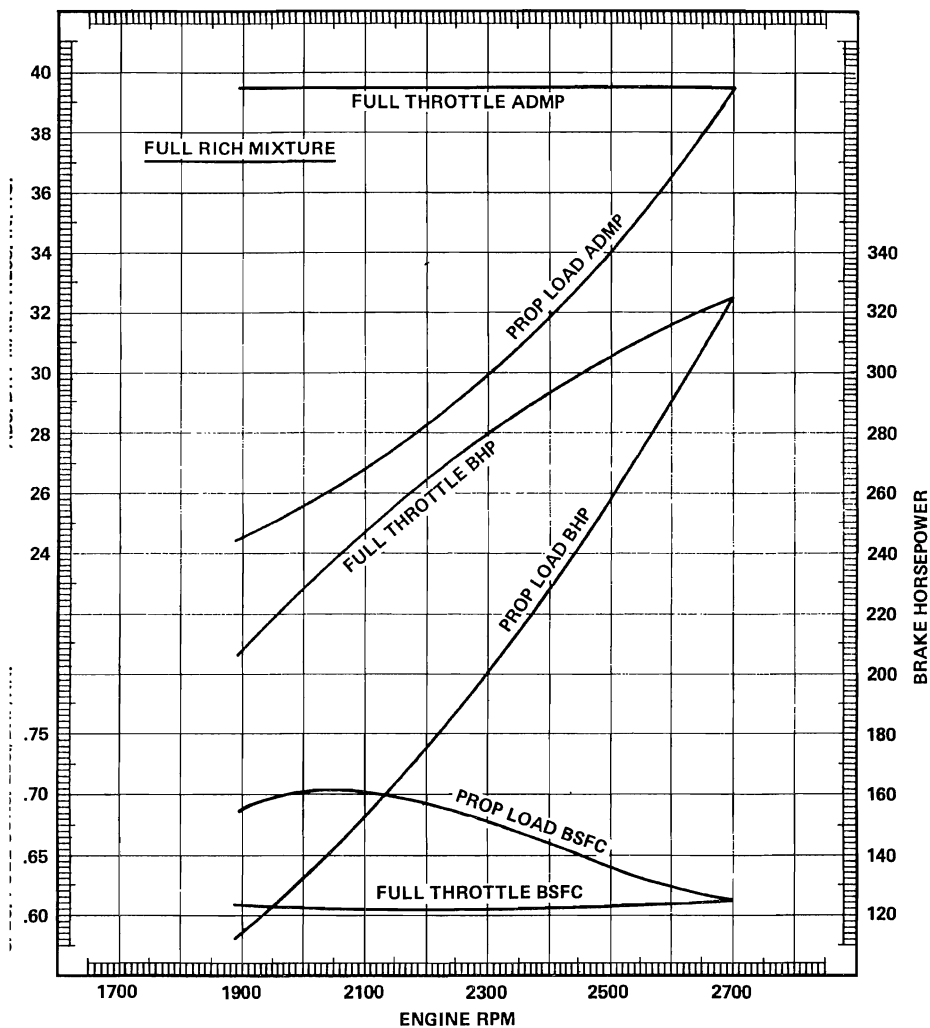
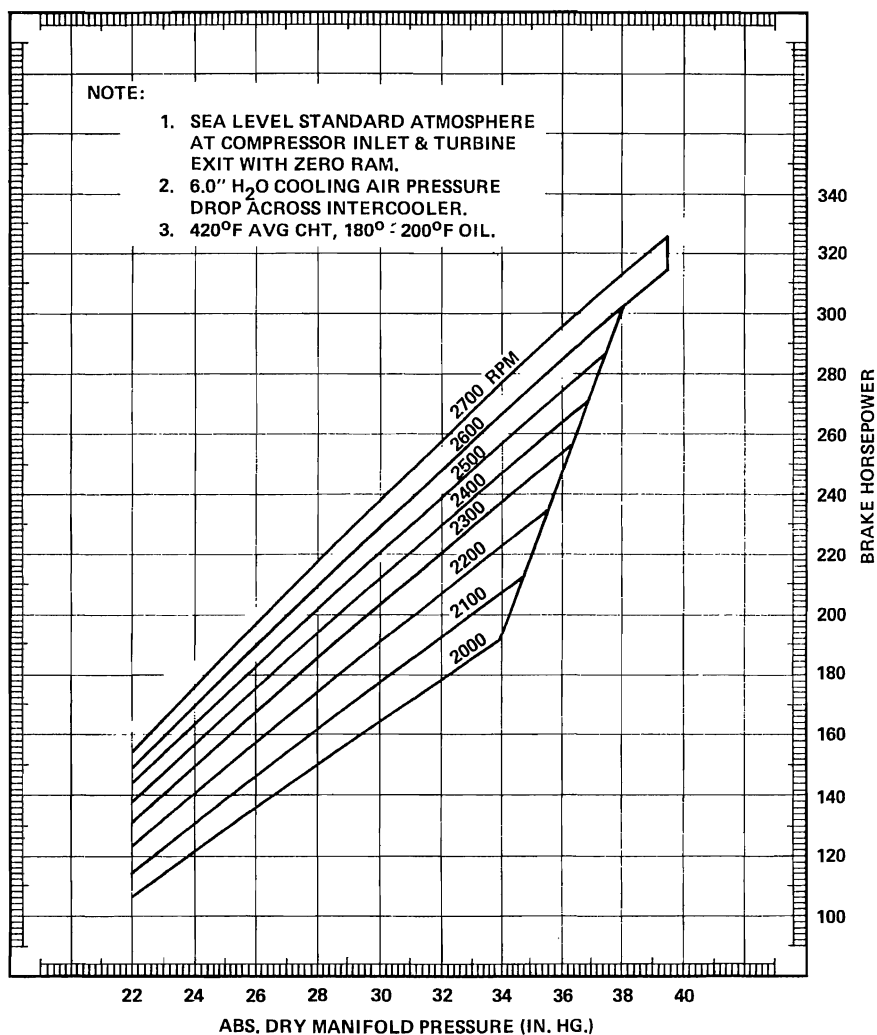


FIGURE 7. SEA LEVEL PERFORMANCE, TSIO-520-WB



**FIGURE 8. SEA LEVEL PERFORMANCE, TSIO-520-WB  
FULL RICH MIXTURE**

NOTE:

1. SEA LEVEL STANDARD ATMOSPHERE AT COMPRESSOR INLET & TURBINE EXIT WITH ZERO RAM.
2. 6.0" H<sub>2</sub>O COOLING AIR PRESSURE DROP ACROSS INTERCOOLER.
3. 420°F AVG CHT, 180° - 200°F OIL.
4. OPERATION AT BEST POWER MIXTURE PROHIBITED ABOVE 248 BHP.

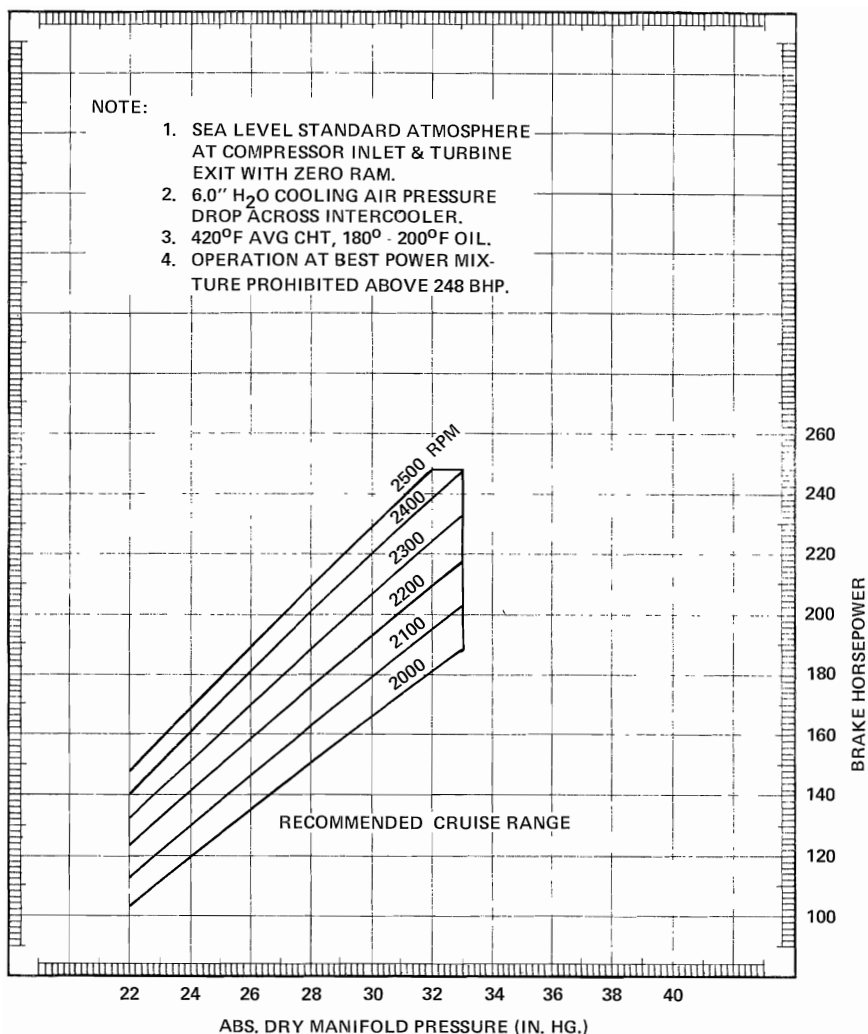


FIGURE 9. SEA LEVEL PERFORMANCE, TSIO-520-WB  
BEST POWER MIXTURE



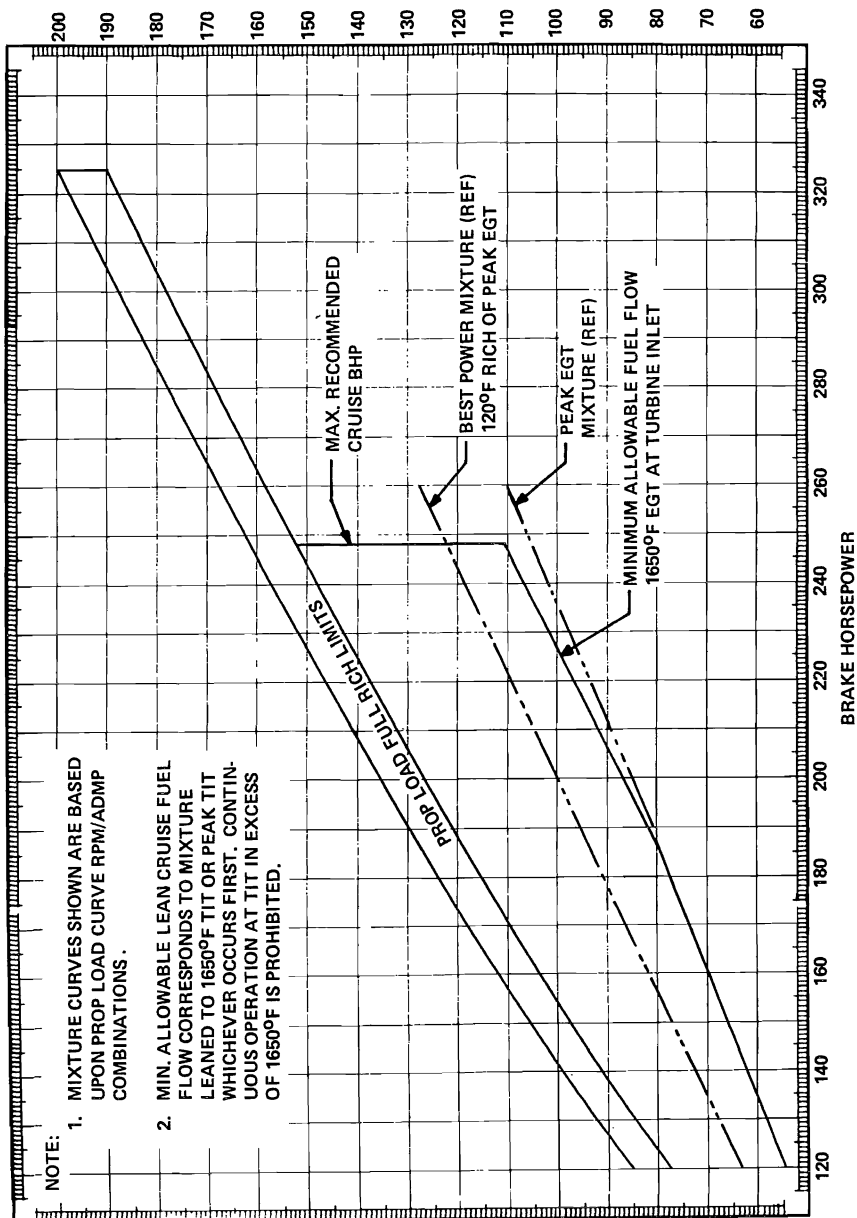
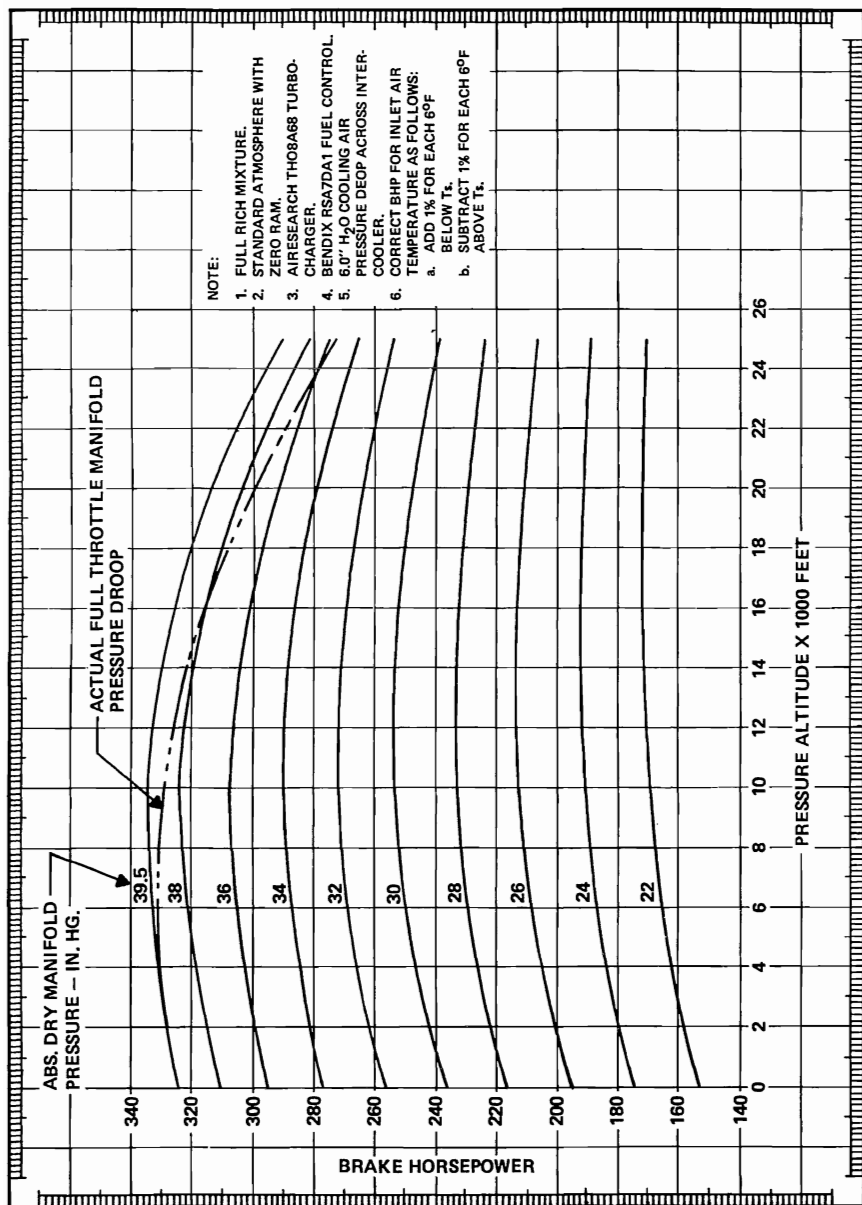


FIGURE 10. FUEL FLOW VS. BRAKE HORSEPOWER, TSIO-520-WB



**FIGURE 11. ALTITUDE PERFORMANCE, TSIO-520-WB (2700 RPM)**

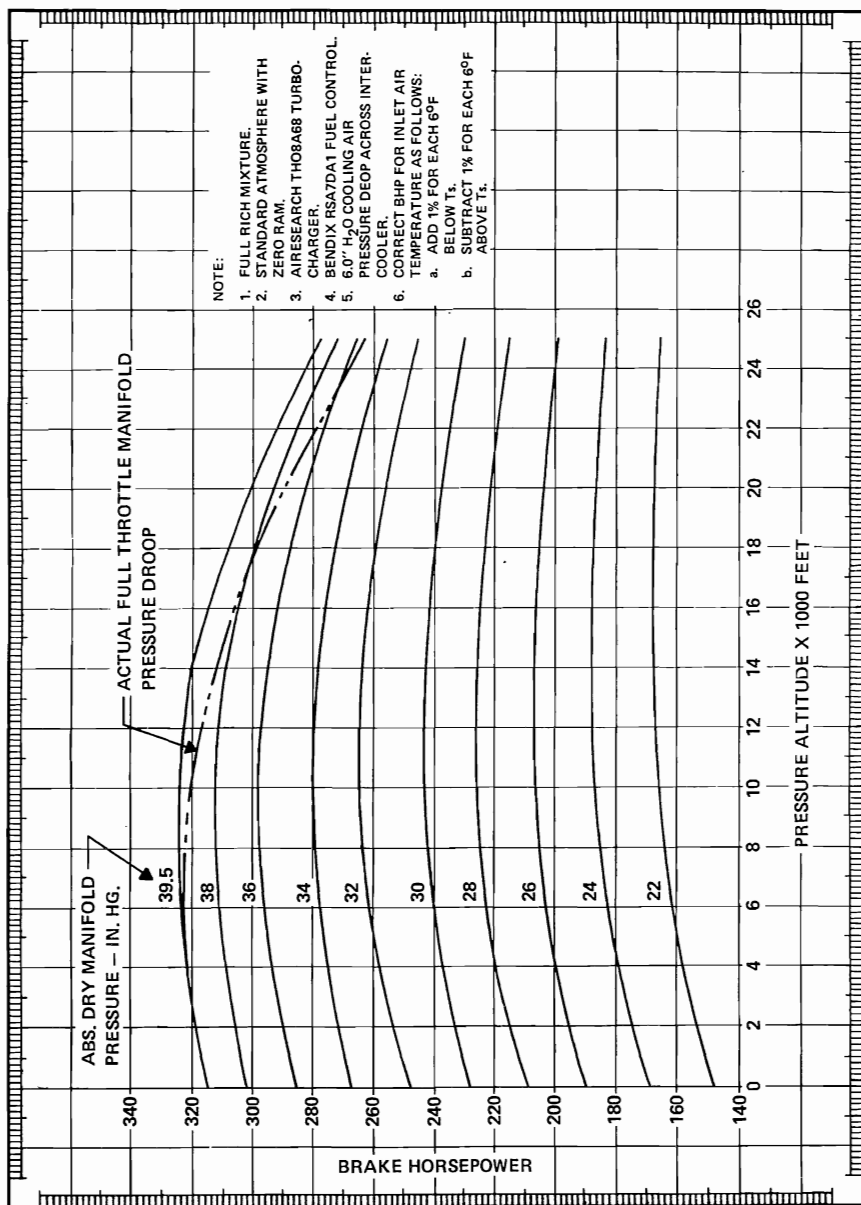


FIGURE 12. ALTITUDE PERFORMANCE, TSIO-520-WB (2600 RPM)

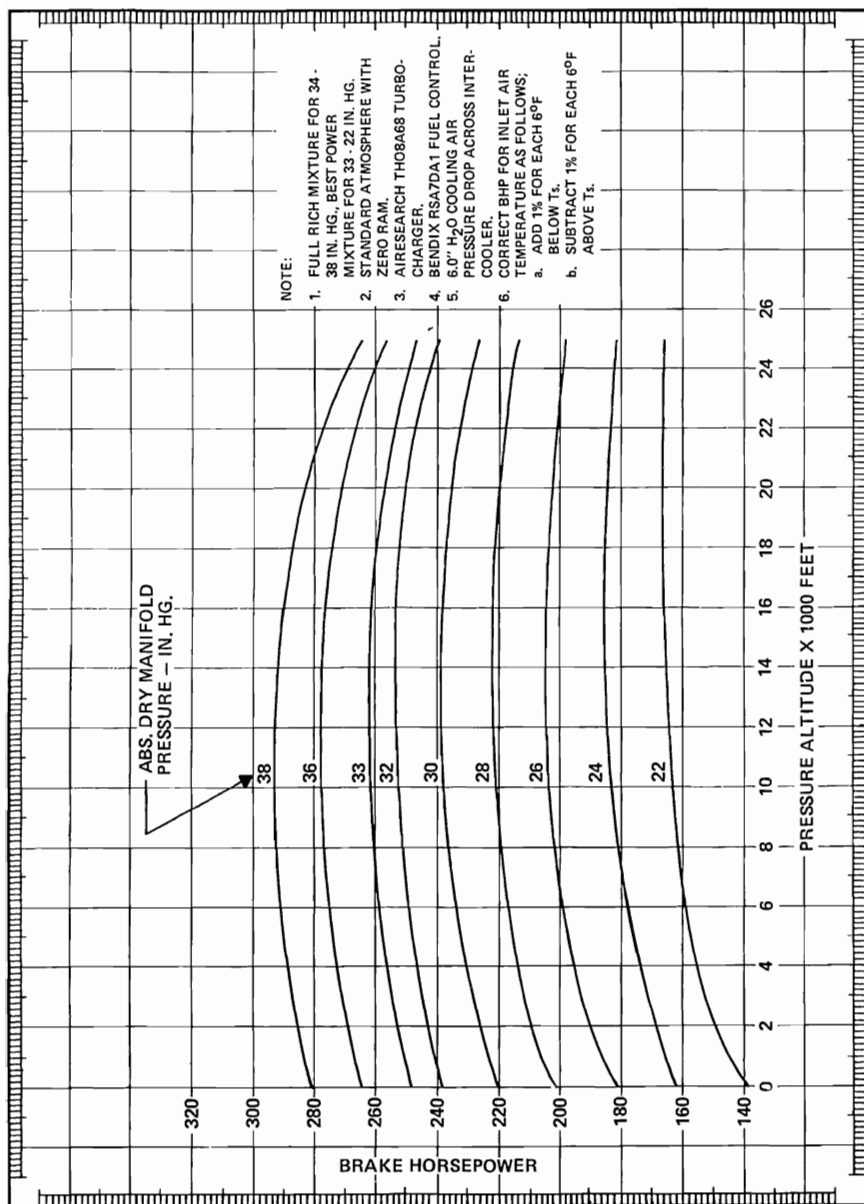


FIGURE 13. ALTITUDE PERFORMANCE, TSIO-520-WB (2400 RPM)

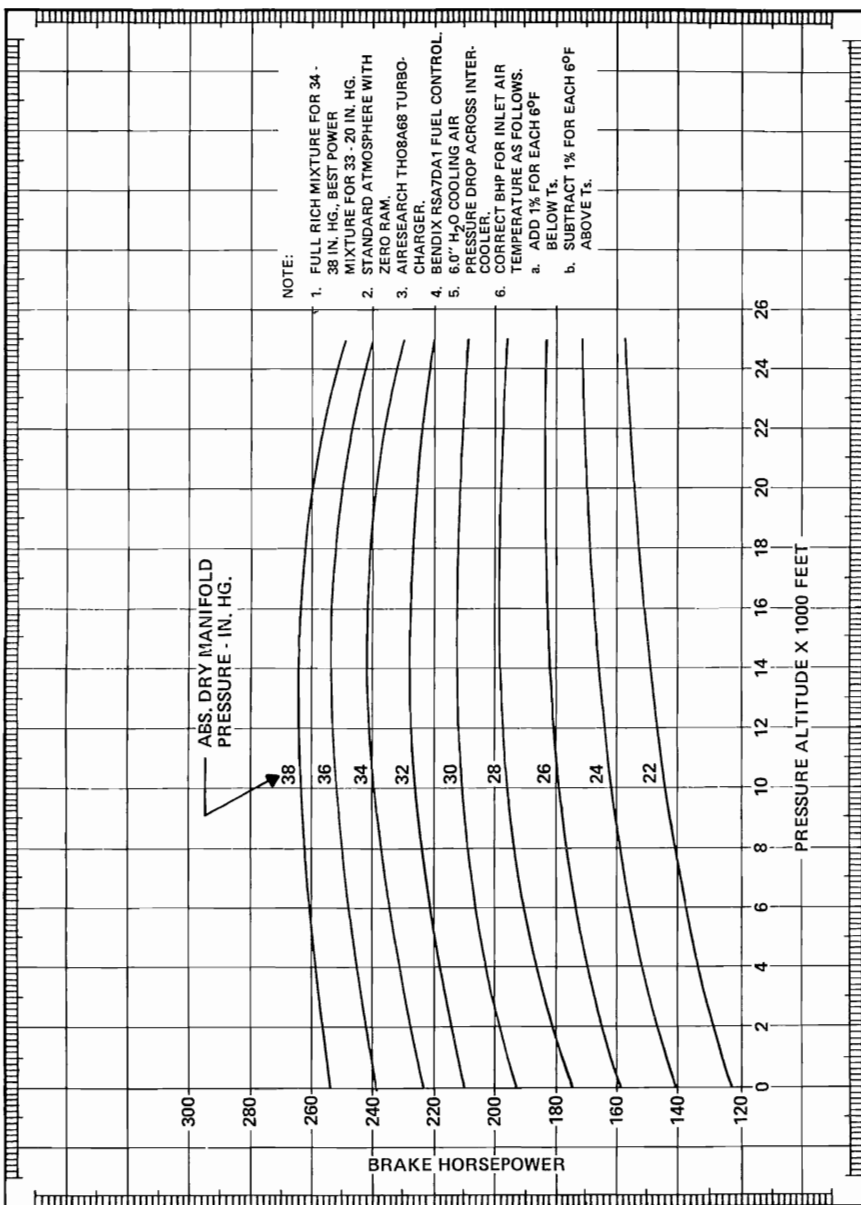


FIGURE 14. ALTITUDE PERFORMANCE, TSIO-520-WB (2200 RPM)



# SECTION V

## ABNORMAL ENVIRONMENTAL CONDITIONS

Three areas of operation may require special attention. These are (a) extreme cold weather, (b) extreme hot weather and (c) high altitude ground operation. The following may be helpful to the operator in obtaining satisfactory engine performance under adverse conditions.

### COLD WEATHER OPERATION (Ambient Temperature Below Freezing).

NOTE . . . Prior to operation and/or storage in cold weather assure engine oil viscosity is SAE 30 or SAE 10W30. In the event of temporary cold weather operation, not justifying an oil change to SAE 30, consideration should be given to hanging the aircraft between flights.

Engine starting during extreme cold weather is generally more difficult than during temperate conditions. Cold soaking causes the oil to become heavier (more viscous), making it more difficult for the battery to turn the engine over. This results in a slow cranking speed and an abnormal drain on the battery capacity. At low temperatures, gasoline does not vaporize readily, further complicating the starting problem.

False starting (failure to continue running after starting) often results in the formation of moisture on the spark plugs due to condensation. This moisture can freeze and must be eliminated, either by applying heat to the engine or removing and cleaning the plugs.

### PREHEATING.

The use of preheat and auxiliary power (battery cart) will facilitate starting during cold weather and is recommended when the engine has been cold soaked at temperatures of 10°F. and below in excess of two hours. Successful starts without these aids can be expected at temperatures below normal, provided the

aircraft battery is in good condition and the ignition and fuel systems are properly maintained.

The following procedures are recommended for preheating, starting, warm-up, run-up and takeoff.

1. Select a high volume hot air heater. Small electric heaters which are inserted into the cowling “bug eye” do not appreciably warm the oil and may result in superficial preheating.

**WARNING . . . Superficial application of preheat to a cold-soaked engine can have disastrous results.**

A minimum of preheat application may warm the engine enough to permit starting but will not de-congeal oil in the sump, lines, cooler, filter, etc. Typically, heat is applied to the upper portion of the engine for a few minutes after which the engine is started and normal operation is commenced. The operator may be given a false sense of security by indications of oil and cylinder temperatures as a result of preheat. Extremely hot air flowing over the cylinders and oil temperature thermocouples may lead one to believe the engine is quite warm; however, oil in the sump and filter are relatively remote and will not warm as rapidly as a cylinder, for example, even when heat is applied directly, oil lines are usually “lagged” with material which does an excellent job of insulating.

Congeaed oil in such lines may require considerable preheat. The engine may start and apparently run satisfactorily, but can be damaged from lack of lubrication due to congealed oil in various parts of the system. The amount of damage will vary and may not become evident for many hours. On the other hand, the engine may be severely damaged and could fail shortly following application of high power. Improper or insufficient application of preheat and the resulting oil and cylinder temperature indications may encourage the pilot to expedite his ground operation and commence a takeoff prematurely. This procedure only compounds an already bad situation.



Proper procedures require thorough application of preheat to all parts of the engine. Hot air should be applied directly to the oil sump and external oil lines as well as the cylinders, air intake and oil cooler. Excessively hot air can damage non-metallic components such as seals, hoses and drive belts, so do not attempt to hasten the preheat process.

Before starting is attempted, turn the engine by hand or starter until it rotates freely. After starting, observe carefully for high or low oil pressure and continue the warm-up until the engine operates smoothly and all controls can be moved freely. Do not close the cowl flaps to facilitate warm-up as hot spots may develop and damage ignition wiring and other components.

2. Hot air should be applied primarily to the oil sump and filter area. The oil drain plug door or panel may provide access to these areas. Continue to apply heat for 15 to 30 minutes and turn the propeller, by hand, through 6 or 8 revolutions at 5 or 10 minute intervals.

3. Periodically feel the top of the engine and, when some warmth is noted, apply heat directly to the upper portion of the engine for approximately five minutes. This will provide sufficient heating of the cylinders and fuel lines to promote better vaporization for starting. If enough heater hoses are available, continue heating the sump area. Otherwise, it will suffice to transfer the source of heat from the sump to the upper part of the engine.

4. Start the engine immediately after completion of the preheating process. Since the engine will be warm, use normal starting procedure.

NOTE . . . Since the oil in the oil pressure gauge line may be congealed, as much as 60 seconds may elapse before oil pressure is indicated. If oil pressure is not indicated within one minute, shut the engine down and determine the cause.

5. Operate the engine at 1000 RPM until some oil temperature is indicated. Monitor oil pressure closely during this time and be alert for a sudden increase or decrease. Retard throttles, if necessary, to maintain oil pressure below 100 psi. If oil pressure drops suddenly to less than 30 psi, shut down the engine and inspect the lubrication system. If no damage or leaks are noted, preheat the engine for an additional 10 to 15 minutes before restarting.

6. Before takeoff, run up the engine to 1700 RPM. If necessary, approach this RPM in increments to prevent oil pressure from exceeding 100 PSI.

At 1700 RPM, adjust the propeller control to Full Decrease RPM until minimum governing RPM is observed, then return the control to Full Increase RPM. Repeat this procedure three or four times to circulate warm oil into the propeller dome. If the aircraft manufacturer recommends checking the propeller feathering system, move the control to the Feather position but do not allow the RPM to drop more than 300 RPM below minimum governing speed.

NOTE . . . Continually monitor oil pressure during run up.

7. Check magnetos in the normal manner.

8. When the oil temperature has reached 100°F. and oil pressure does not exceed 80 PSI at 1700 RPM, the engine has been warmed sufficiently to accept full rated power.

*CAUTION . . . Do not close cowl flaps in attempt to hasten engine warm-up.*

NOTE . . . Fuel flow will likely be on the high limit; however, this is normal and desirable since the engine will be developing more horsepower at substandard ambient temperatures.

If preheat is not used, employ the following start procedure:

1. Fuel Selector - Main tank or as instructed by aircraft manufacturer.
2. Battery Switch - On.
3. Mixture - Rich.
4. Throttle - Open.
5. Primer - Operate until fuel flow or fuel pressure shows maximum reading.
6. Throttle - Positioned to approximate 1000 - 1200 RPM position.
7. Starter - Engage.
8. Primer - Operate as necessary to indicate firing. Continue to prime as necessary to sustain engine operation.
9. Throttle - Gradually retard to 800 - 1000 RPM for warm-up.

Observe oil pressure for indication and warm-up engine at 1000 RPM. Ground operation and run up require no special techniques other than warming the engine sufficiently to maintain oil temperature and oil pressure within limits when full RPM is applied.

NOTE . . . Before applying power for takeoff, check that oil pressure, oil temperature and cylinder temperature are well within the normal operating range. When full power is applied for takeoff, insure that oil pressure is within limits and steady. Surging

or overshooting of manifold pressure, RPM or fuel flow may indicate the engine is not satisfactorily warmed up.

*CAUTION . . . Any of the following engine reactions should be cause for concern, and are justification to discontinue the takeoff.*

- a. Excessive manifold pressure other than momentary overboost of 1 or 2 inches.
- b. Low, high or surging RPM.
- c. Fuel flow excessively high or low.
- d. Any oil pressure indication other than steady and within limits.
- e. Engine roughness.

#### **HOT WEATHER OPERATION (Ambient Temperature in Excess of 90°F.)**

*CAUTION . . . When operating in hot weather areas, be alert for higher than normal levels of dust, dirt or sand in the air. Inspect air filters frequently and be prepared to clean or replace them if necessary. Weather conditions can lift damaging levels of dust and sand high above the ground. In the event the aircraft should be flown through such conditions, an oil change is recommended as soon as is practical. Do not intentionally operate the engines in dust and/or sand storms. The use of dust covers on the cowling will afford additional protection for a parked aircraft.*

In-flight operation during hot weather usually presents no problem since ambient temperatures at flight altitudes are seldom high enough to overcome the cooling system used in modern aircraft design. There are, however, three areas of hot weather operation which will require special attention on the part of the operator. These are: (1) Starting a hot engine, (2) Ground operation under high ambient temperature conditions and (3) Takeoff and initial climbout.

1. Starting a Hot Engine. After an engine is shutdown, the temperature of its various components will begin to stabilize; that is, the hotter parts such as cylinders and oil will cool, while other parts will begin to heat up due to lack of air flow, heat conduction, and heat radiation from those parts of the engine which are cooling. At some time period following engine shutdown the entire unit will stabilize near the ambient temperature. This time period will be determined by temperature and wind conditions and may be as much as several hours. This heat soaking is generally at the worst from 30 minutes to one hour following shutdown. During this time, the fuel system will heat up causing the fuel in the pump and lines to "boil" or vaporize. During subsequent starting attempts, the fuel pump will initially be pumping some combination of fuel and fuel vapor. At the same time, the injection nozzle lines will be filled with varying amounts of fuel and vapor. Until the entire fuel system becomes filled with liquid fuel, difficult starting and unstable engine operation will be experienced.

Another variable affecting this fuel vapor condition is the state of the fuel itself. Fresh fuel contains a concentration of volatile ingredients. The higher this concentration is, the more readily the fuel will vaporize and the more severe will be the problems associated with vapor in the fuel system. Time, heat or exposure to altitude will "age" aviation gasoline; that is, these volatile ingredients tend to dissipate. This reduces the tendency of fuel to vaporize and, up to a point, will result in reduced starting problems associated with fuel vapor. If the volatile condition reaches a low enough level, starting may become difficult due to poor vaporization at the fuel nozzles, since the fuel must vaporize in order to combine with oxygen in the combustion process.

The operator, by being cognizant of these conditions, can take certain steps to cope with problems associated with hot weather/hot engine starting. The primary objective should be that of permitting the system to cool. Low power settings during the landing approach will allow some cooling prior to the next start attempt. Ground operation tends to heat up the engine, therefore,

minimizing this will be beneficial. Cowl flaps should be opened fully while taxiing. The aircraft should be parked so as to face into the wind to take advantage of the cooling effect. Restarting attempts will be the most difficult during the 30 minutes to one hour following that interval, the fuel vapor will be less pronounced and normally will present less of a restart problem.

Normal starting procedure should be used except that the throttle should be opened more while cranking.

2. Ground Operation Under High Ambient Temperature Conditions. Oil and cylinder temperatures should be monitored closely during taxiing and engine run up. Operate with cowl flaps full open. Do not operate the engines at high RPM except for necessary operational checking. If takeoff is not to be made immediately following engine run up, the aircraft should be faced into the wind and the engine idled at 900 - 1000 RPM. It may be desirable to operate the fuel boost pumps to assist in suppressing fuel vapor and provide more stable fuel pressure during taxiing and engine run up.

3. Takeoff and Initial Climbout. Do not operate at maximum power any longer than necessary to establish the climb configuration recommended by the aircraft manufacturer. Temperatures should be closely monitored and sufficient airspeed maintained to provide adequate cooling of the engine.

## **GROUND OPERATION AT HIGH ALTITUDE AIRPORTS.**

Idle fuel mixture will be rich at high density altitudes. Under extreme conditions it may be necessary to manually lean the mixture in order to sustain engine operation at low RPM. When practical, operate the engines at higher idling speed.

# SECTION VI

## ENGINE DESCRIPTION

The designation TSIO-520-L, -LB, -WB describes this engine as follows:

TS: Denotes "turbocharged".

I: Denotes "fuel injected".

O: Denotes "opposed", and refers to the horizontally-opposed cylinder arrangement.

520: Denotes piston displacement in cubic inches.

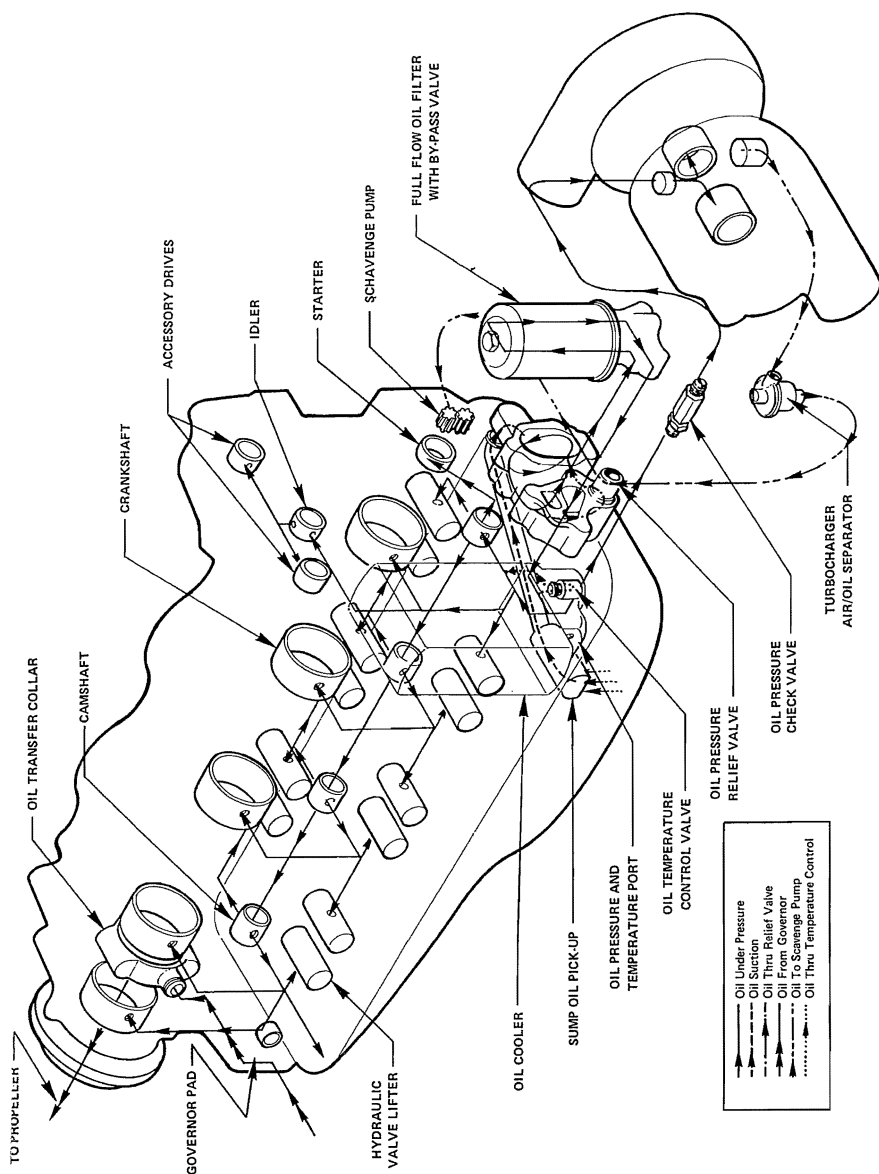
L, LB

or WB: Denotes "specific engine model and configuration".

### OIL SYSTEM. (Figure 15)

The oil supply is contained in a 12-quart, wet sump which is attached to the bottom of the crankcase. A conventional dipstick is provided for determining the oil quantity.

When the crankshaft is turning, oil is drawn through a screen and pick up tube which extends from the sump to a port in the crankcase. It then passes to the inlet of the gear-type, engine-driven oil pump and is forced under pressure through the pump outlet. A pressure relief valve incorporated in the oil pump prevents excessive oil pressure by allowing excess oil to be returned to the suction side of the pump. After exiting the pump, the oil (now under pressure), enters a full-flow filter and is passed on to the oil cooler. If the filter element becomes blocked, a bypass relief valve will open to permit unfiltered oil to flow to the engine. As the oil enters the oil cooler, it will flow in one of two directions: (a) When the oil is cold, an oil temperature control unit will open and most of the oil will bypass the cooler. Some oil always flows through the cooler to prevent congealing in cold weather. (b) As the oil warms, the oil temperature control unit actuates to close off the cooler bypass forcing the oil to flow through the cooler core. In operation, the oil temperature control



**FIGURE 15. OIL LUBRICATION SYSTEM SCHEMATIC**



unit modulates to maintain oil temperature in the normal range of approximately 170°F.

After leaving the cooler, the oil enters the crankcase where the various channels and passageways direct it to the bearing surfaces and other areas requiring lubrication and cooling. The propeller governor boosts engine oil pressure for operation of the propeller. It controls oil pressure going to the propeller hub to maintain or change propeller blade angles. This oil flows through the propeller shaft to reach the hub.

Other areas within the engine receiving oil include the valve lifters, inner piston domes and lower cylinder walls. A tap in the oil cooler supplies oil pressure for lubrication of the turbocharger bearings. This oil is carried to the turbocharger through an external line. A pressure check valve, located in the turbocharger oil supply line, prevents siphoning of oil into the turbocharger after engine shutdown. After lubricating the turbocharger bearings, it is drawn into a scavenge pump and returned to the oil sump. Oil within the engine drains, by gravity, back into the sump.

NOTE . . . In addition to the oil pressure port located in the base of the oil cooler, alternate pick-up ports are located at the forward ends of the 2-4-6 and 1-3-5 main oil galleries. Refer to the airframe owners manual to determine the exact location of the oil pressure probe.

## **FUEL SYSTEM.**

All RSA type fuel injection systems are based on the principle of measuring engine air consumption by use of a venturi and using the airflow forces to control fuel flow to the engine. Fuel distribution to the individual cylinders is obtained by the use of a flow divider and air bleed nozzles in the RSA-7DA1 system. The venturi used in the RSA-7DA1 control is not the conventional type of venturi with a restricted barrel. The venturi in the RSA-7DA1 is located in the center of the barrel, with air flowing

around rather than through the venturi. Refer to the schematic diagram. This venturi arrangement incorporates a pressure pickup for impact pressure, venturi throat pressure and the density compensating bellows assembly.

## **GENERAL DESCRIPTION.**

The following is a description of the operation of the injection system.

## **AIRFLOW SECTION.**

A measure of the airflow consumption of the engine is accomplished by sensing inlet air pressure and venturi throat pressure in the throttle body. These pressures are vented to the two sides of the air diaphragm and are connected by an air channel in which the automatic mixture control needle is located. By movement of the throttle valve, a change in engine air consumption occurs that will change the velocity of air through the venturi; this will reflect an immediate change in the air differential pressure. The air pressure is the induction housing pressure.

## **REGULATOR SECTION.**

The regulator system consists of a fuel diaphragm, which opposes the force of the air diaphragm; this force is transmitted through a regulator stem. The fuel pressure shown on the ball side of the fuel diaphragm is the pressure after the fuel has passed through the fuel strainer, manual mixture control rotary plate, main metering (cruise) jet and the rotary idle plate; and is referred to as metered fuel pressure. Fuel inlet pressure is applied to the opposite side of the fuel diaphragm. Immediately upon movement of the throttle, three of the four pressures involved in the regulator (namely, impact air, venturi throat, inlet fuel pressure) become fixed, the fourth pressure (metered fuel pressure) must vary to keep the regulator in balance. This is accomplished by the ball valve controlling the orifice opening.

# BENDIX FUEL INJECTION SYSTEM

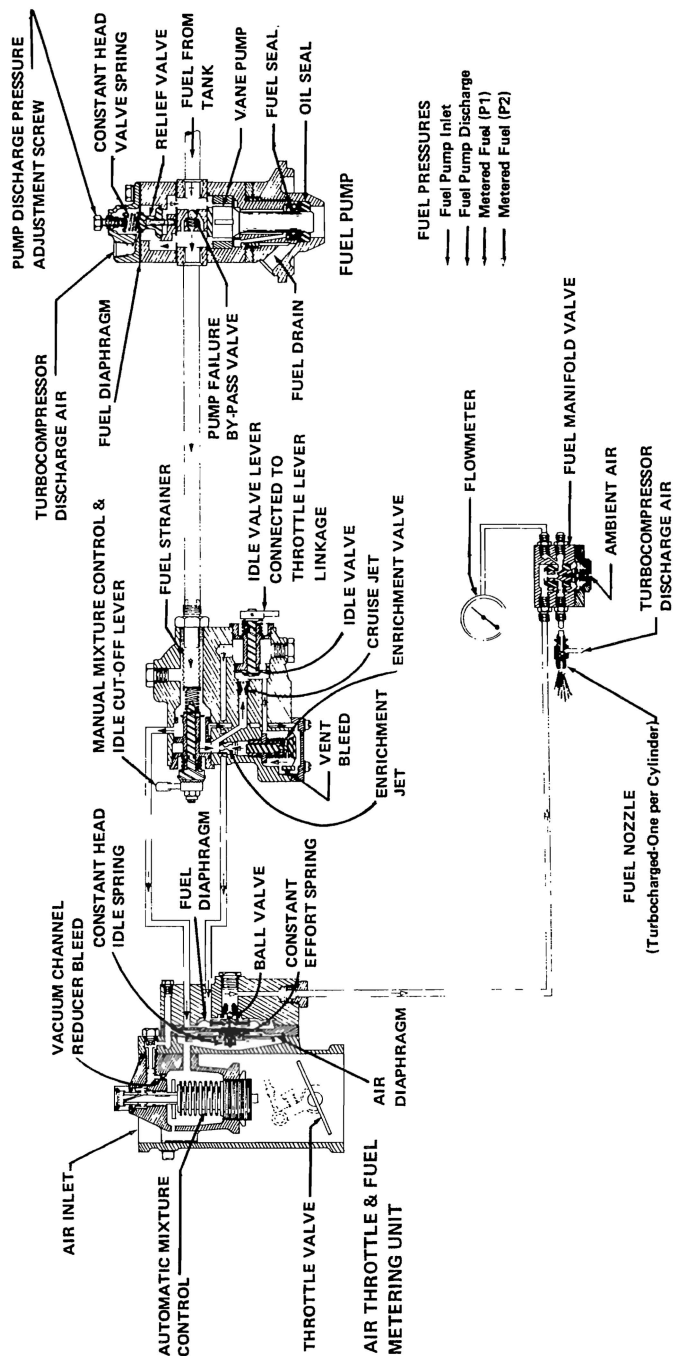


FIGURE 16. FUEL INJECTION SYSTEM SCHEMATIC

Since the air differential pressure across the air diaphragm is a function of mass airflow into the engine, and the fuel differential pressure across the fuel diaphragm (and fuel jet) is proportional to the air differential pressure (when the regulator is in balance), the correct fuel-to-air ratio is always maintained with this system, regardless of the quantity of air being consumed by the engine. Requirement changes in engine fuel/air ratio are accomplished by the selection of fuel jet size.

Consideration has been made for the low air forces experienced in the idle range by the incorporation of the constant head idle spring. This spring applies a force necessary to provide adequate fuel supply for the idle range. As the air metering forces increase, the spring compresses until the spring retainer touches the air diaphragm and acts as a solid member.

## **FUEL CONTROL SYSTEM.**

The manual mixture control valve produces a full rich condition when the lever is against the rich stop, and a progressively leaner mixture as the lever is moved toward idle cutoff.

Both idle speed (closed throttle position) and idle mixture (relationship between throttle position and idle valve position) may be readily adjusted externally to meet individual engine requirements.

## **FLOW DIVIDER.**

The metered fuel is delivered from the fuel control unit to a pressurized flow divider. This unit keeps metered fuel under pressure, divides fuel to the various cylinders at idle and off idle, and shuts off the individual nozzle lines when the control is placed in "idle cutoff." Referring to the schematic diagram, metered fuel pressure enters the flow divider through a channel that permits fuel to pass through the ID of the flow divider needle. At idle the fuel pressure from the regulator must build up to overcome the spring force applied to the diaphragm and valve assembly. This

moves the valve upward until fuel can pass out through the OD annulus of the valve to the fuel nozzle. Since the regulator meters and delivers a fixed amount of fuel to the flow divider, the valve will only open as far as necessary to pass this amount to the nozzles. At idle the opening required is very small, and the nozzle discharge pressure is negligible, thus the fuel is divided for the individual cylinders at this point by the flow divider. As fuel flow through the regulator is increased above idle requirements, fuel pressure builds up in the nozzle lines, fully opens the low divider valve, and fuel distribution to the engine becomes a function of the discharge nozzles. Idle range fuel distribution in installation without a flow divider is a function of the air bleed nozzles.

#### **AIR BLEED NOZZLES.**

The fuel discharge nozzles for the individual cylinders are the air bleed configuration. Each nozzle incorporates a calibrated jet, the size of which is determined by: (1) fuel inlet pressure available, and (2) the maximum fuel flow required by the engine. All nozzles are calibrated to flow alike (within  $\pm 2$  percent) and are interchangeable between engines and cylinders.

Fuel pressure, before the individual nozzles, is in direct proportion to fuel flow; therefore, a simple pressure gauge can be calibrated to fuel flow, gallons per hour, and be employed as a flowmeter.

On this engine, the nozzle fuel air chamber is vented to the top deck of the throttle body as this is turbocharger outlet pressure; turbocharger outlet pressure is always greater than manifold pressure. Whenever an engine is turbocharged, it is necessary to vent the nozzles to a common air pressure greater than manifold pressure, or the manifold pressure will blow the fuel in the nozzle fuel/air chamber through the vent and into the engine nacelle.

#### **AUTOMATIC MIXTURE CONTROL UNIT.**

This unit provides a variable orifice between impact pressure and venturi throat pressure. It is responsive to both changes in air

temperature and pressure (density) and will keep the differential air pressure between the two air chambers constant for any airflow, regardless of changes in the air inlet density.

The automatic mixture control (AMC) consists of a contoured needle that is moved in or out of an orifice by a bellows assembly. The sealed bellows contains helium gas to sense density variations and also a small quantity of inert oil to help damp vibrations. Under high density conditions, the bellows is contracted and positions the needle in the orifice so that the flow of impact pressure into venturi throat pressure is at a minimum. As density decreases, due to either a decrease in pressure or an increase in temperature, the bellows elongates and repositions the needle in the orifice so there is a greater flow of impact pressure to venturi pressure, which decreases the air metering forces to maintain a constant fuel/air ratio.

## **INDUCTION SYSTEM.**

The induction system components include the aircraft filter/alternate air door, turbocharger compressor, throttle, intercooler, runner manifold and cylinder intake ports. Air flows through these components in the order they are listed.

The filter normally accepts all incoming air from the aircraft intake scoop. Should the filter become blocked for any reason, the alternate air door will open to preclude engine stoppage.

The turbocharger compressor is a high volume air pump connected to the opposite end of the turbocharger turbine (see Turbocharger System). It increases the volume and pressure of air admitted to the cylinder for combustion. At high compressor discharge pressures, considerable heating of the induction air occurs, due to compression.

The intercooler is a heat exchanger which lowers the temperature of the compressor discharge air to permit more efficient engine and turbocharger operation. The induction air passes through the

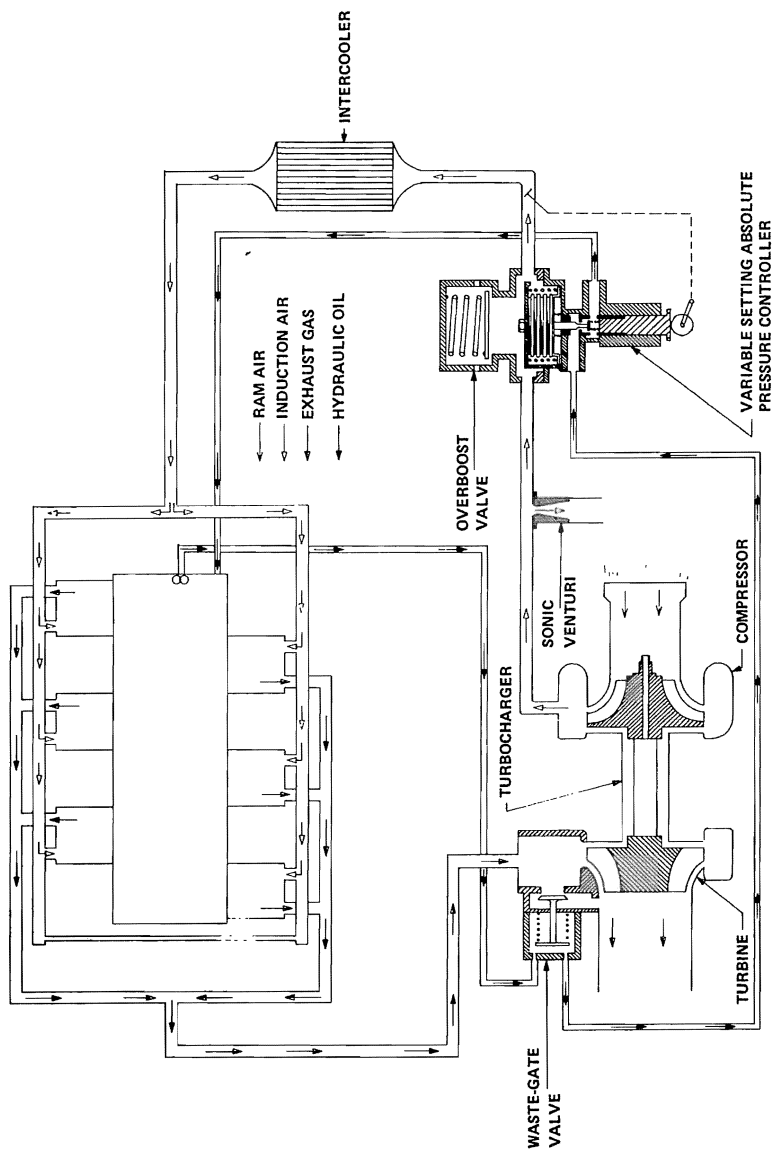


FIGURE 17. INDUCTION/EXHAUST SYSTEM SCHEMATIC

core of the intercooler and transfers some of its heat to the cooling fins which are exposed to the relatively cooler ram air.

The runner manifold is an air distribution system mounted beneath the engine. It serves to carry induction air to the individual cylinder intake ports.

The cylinder intake ports are cast into the cylinder head assembly. Air from the runner manifold is carried into the intake ports, mixed with fuel from the injector nozzles, and enters the cylinder as a combustible mixture when the intake valve opens.

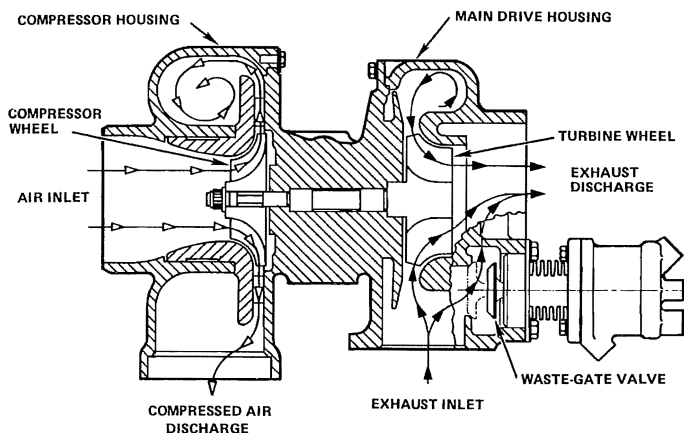
Overboost protection is provided by a pressure relief valve located between the compressor and the throttle. In the event of a wastegate or controller malfunction resulting in excessive discharge pressures, the relief valve will open to prevent excessive manifold pressure.

## **TURBOCHARGER.**

The complete turbocharger system consists of a turbine and compressor assembly, wastegate assembly, a variable pressure controller, a sonic venturi, and necessary hose, linkage and ducting required for a functional installation.

The variable pressure controller links the throttle to the wastegate actuator through a cam, spring and aneroid arrangement. When the throttle is opened, the cam on the controller rotates to compress the spring. This action closes a valve within the controller allowing oil pressure in the wastegate actuator to increase, which drives the wastegate toward the closed position. This action causes more exhaust gas to flow through the turbine assembly, increasing its speed and resulting in more output of induction air from the compressor, since it is connected to the opposite end of the turbine shaft. Now, as the compressor output increases, manifold pressure increases. The aneroid unit on the controller senses compressor discharge pressure and its action opposes the force of the spring, that is, it tends to open the valve, relieving oil pressure





**FIGURE 18. TURBOCHARGER SECTIONAL**

in the wastegate actuator which allows the wastegate to move toward open. In operation, the forces between the spring and the aneroid are balanced and the controller serves to maintain constant compressor discharge pressure as selected by the throttle and therefore maintains a constant manifold pressure. When the throttle is repositioned the cam, spring, aneroid and wastegate are displaced until the forces are again in balance for the new compressor discharge pressure.

The wastegate assembly consists of a poppet type valve and actuator. When open, the valve allows exhaust gas to bypass the turbine and flow directly overboard. In the closed position, the wastegate valve diverts the exhaust gases into the turbine. The valve is held open by a spring, and is closed by the oil pressure operated actuator. In operation, the wastegate normally modulates in intermediate position according to demands of the controller assembly until engine reaches its critical altitude. At critical altitude and higher, the wastegate is fully closed.

A sonic venturi permits the restricted flow of compressor air for aircraft cabin pressurization. When air flow through this unit reaches approximately 6 pounds per minute, it becomes critical; that is, 6 pounds per minute is the maximum flow the sonic venturi will permit regardless of pressure at the inlet.

## CYLINDERS.

Before assembly the aluminum cylinder heads are heated and screwed on to the steel alloy barrels. The valve guides and seats are pressed into the hot cylinder head. When the entire unit has cooled, a permanent cylinder assembly results. Replaceable helical coil inserts are installed in the spark plug ports.

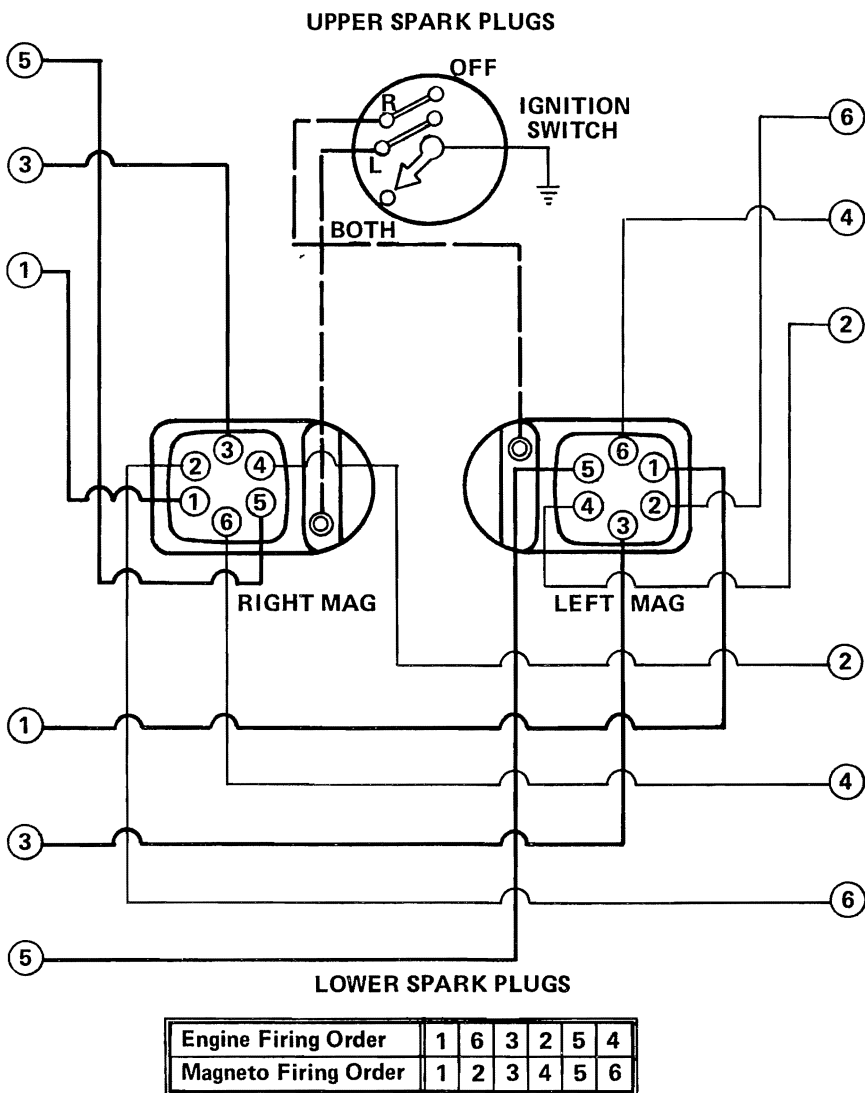
## VALVES.

Exhaust valves are faced with a special heat and corrosion-resistant material and the valve stems are chromed for wear resistance. Oil fed to the hydraulic valve lifters, under pressure from the main galleries, lubricates the lifter guide surfaces and fills the reservoirs inside the lifters. Oil from the lifters which reaches the pushrod ends flows through the pushrods to the rocker arms. Each rocker directs a portion of its oil through a nozzle towards the respective valve stem. Oil is returned to the crankcase through the pushrod housings, which are sealed to the cylinder head and crankcase by rubber seals. Drain holes in the lifter guides direct returning oil to the sump.

## IGNITION SYSTEM.

During normal operation, high voltage to the spark plugs is produced by two magnetos, each of which fires one of the two spark plugs in each cylinder. This dual ignition system serves two purposes. As a safety feature, ignition will occur even if one complete magneto system should fail. Also, due to combustion chamber design and other considerations, more efficient burning of the fuel/air mixture is realized and the engine develops more power.

The left magneto features a retard breaker consisting of a second set of contact points connected to a special circuit to facilitate engine starting. At cranking speeds the normal magneto timing is too much advanced for smooth starting and the spark may be too weak for proper ignition. The special starting circuit is designed to overcome these deficiencies, and operates as follows:



**FIGURE 19. IGNITION SYSTEM**

(a) When the aircraft starter switch is operated, the left and right magneto primary breaker points are grounded to prevent the magnetos from producing ignition at the normal advanced timing causing the engine to kick back. Only the retard breaker points are functioning.

(b) The starter switch also energizes a battery-powered starting vibrator which supplies pulsating voltage to the retard breaker.

(c) As the engine turns during cranking, the retard breaker points open, and cause a “shower of sparks” at the left magneto spark plugs. This high intensity ignition occurs later than would normal ignition and promotes smoother engine starting.

(d) When the engine starts and the switch is placed in the “Both” position, the primary breakers are ungrounded, the starting vibrator circuit is broken and dual ignition is provided.

# SECTION VII

## SERVICING AND INSPECTION

### SERVICING.

Maximum efficiency and engine service life can be expected when a sound inspection program is followed. Poor maintenance results in faulty engine performance and reduced service life. Efficient engine operation demands careful attention to cleanliness of air, fuel, oil and maintaining operating oil temperatures within the required limits.

Good common sense is still the rule, but certain basic maintenance and operational requirements, that we find widely disregarded, do determine, to a large degree, the service life of the modern aircraft engine.

Fuel (Min. Grade)

Aviation Grade 100 or 100LL

**WARNING . . .** The use of a lower octane rated fuel can result in destruction of an engine the first time high power is applied. This would most likely occur on takeoff. If the aircraft is inadvertently serviced with the wrong grade of fuel, then the fuel must be completely drained and the tank properly serviced.

Oil: (First 25 hours operation)

Mineral (non-Detergent) oil or  
Corrosion Preventive oil

Corresponding to MIL-C-6529 Type II

Normal Service

SAE 50 (Above 40°F)  
SAE 30 (Below 40°F)  
or 10W - 30

Oil Sump Capacity:

12.0 U.S. Quarts

Oil Change Interval:

50 hours

NOTE . . . The use of multi-viscosity oil is approved.

*CAUTION . . . Use only oils conforming to Teledyne Continental Motors Specification MHS-24B after break-in period.*

The marketers of the aviation lubricating oil listed below have supplied data to Teledyne Continental Motors indicating their products conform to all the requirements of TCM Specification MHS-24B, Lubricating Oil, Ashless Dispersant.

In listing the product names, TCM makes no claim of verification of marketer's statements or claims. Listing is made in the order in which the data was received by TCM, and is provided only for the convenience of the users.

## APPROVED PRODUCTS

| Supplier                           | Brand Name                            |
|------------------------------------|---------------------------------------|
| BP Oil Corporation                 | BP Aero Oil D65/80                    |
| Castrol Limited (Australia)        | Castrolaero AD Oil                    |
| Continental Oil                    | Conoco Aero S 10W-30 Oil              |
| Delta Petroleum Company            | Delta Avoil Oil                       |
| Humble Oil & Refining Company      | Exxon Aviation Oil                    |
| Pennzoil Company                   | Pennzoil Aircraft Engine Oil          |
| Phillips Petroleum Company         | Phillips 66 Aviation Oil, Type A      |
| Quaker State Oil<br>& Refining Co. | Quaker State AD Aviation Engine Oil   |
| Socony-Mobil                       | Mobil Aero Oil                        |
| Shell Oil Company                  | Aeroshell Oil W                       |
| Sinclair Oil Company               | Sinclair Avoil 20W-40 Oil             |
| Texaco, Inc.                       | Texaco Aircraft Engine Oil Premium AD |
| Union Oil Company of California    | Union Aircraft Engine Oil HD          |

## INSPECTIONS.

The following procedures and schedules are recommended for engines which are subjected to normal operation. If the aircraft is exposed to severe conditions, such as training, extreme weather, or

infrequent operation, inspections should be more comprehensive and the hourly intervals decreased.

### DAILY INSPECTION (PREFLIGHT).

Before each flight the engine and propeller should be examined for damage, oil leaks, proper servicing and security. Ordinarily the cowling need not be opened for a daily inspection.

### 50 HOUR INSPECTION.

Detailed information regarding adjustments, repair and replacement of components may be found in the appropriate Overhaul Manual. The following items should be checked during normal inspections:

- |                       |                               |       |
|-----------------------|-------------------------------|-------|
| 1. Engine Conditions: | Magneto RPM drop:             | Check |
|                       | Full Power RPM:               | Check |
|                       | Full Power Manifold Pressure: | Check |
|                       | Full Power Fuel Flow:         | Check |
|                       | Idle RPM:                     | Check |

Record any values not conforming to engine specifications so that necessary repair or adjustment can be made.

- |                        |  |
|------------------------|--|
| 2. Oil Filter:         | Replace filter.  |
| 3. Air Filter:         | Inspect and clean to replace as necessary.                   |
| 4. High Tension Leads: | Inspect for chafing and deterioration.                       |
| 5. Magnetos:           | Check and adjust only if discrepancies were noted in Step 1. |

6. General: Check hoses, lines, wiring, fittings, baffles, etc. for general condition.
7. Adjustments & Repairs: Perform service as required on any items found defective.
8. Engine Condition: Run up and check as necessary for any items serviced in Step 6. Check engine for oil leaks before returning to service.

## 100 HOUR INSPECTION.

Perform all items listed under 50 Hour inspection, and add the following:

1. Oil: Drain while engine is warm. Refill sump.
2. Valves/Cylinders: Check compression (Refer to Service Bulletin M73-19).
3. Cylinders, Fins, Baffles: Inspect.
4. Control Connections: Inspect and lubricate.
5. Fuel and Oil Hoses and Lines: Inspect for deterioration, leaks, chafing.
6. Fuel Nozzles: Inspect nozzles and vent manifold for leaks or damage.
7. Turbocharger: Check freedom of rotation.
8. Exhaust: Check all joints for condition and leaks.
9. Wastegate: Check operation and condition.
10. Alternate Air Door: Check operation.



11. Spark Plugs: Inspect, clean, regap (if necessary) and reinstall. Rotate plugs from upper to lower positions and vice versa to lengthen plug life.
12. Oil Filter: Replace.
13. Magnetos: Check. Adjust points and timing if necessary.

NOTE . . . Minor changes in magneto timing can be expected during normal engine service. The time and effort required to check and adjust the magnetos to specifications is slight and the operator will be rewarded with longer contact point and spark plug life, smoother engine operation and less corrective maintenance between routing inspections.

14. Oil Pressure Relief Valve: Inspect and clean.
15. Oil Temperature Control Unit: Inspect and clean.
16. Fuel Metering Unit Inlet Screen: Inspect and clean.
17. Throttle Shaft and Linkage: Inspect for wear and lubricate.
18. High & Low Fuel Pump Outlet Pressure: Check. Adjust if necessary.
19. Adjustments & Repairs: Perform service as required on any items found defective.
20. Engine Condition: Perform complete run up. Check engine for fuel or oil leaks before returning to service.

NOTE . . . Refer to TSIO-520 Overhaul Manual for proper procedures and limits.



## **SECTION VIII**

**WARNING... Do not attempt to use this manual as a guide for performing repair or overhaul of the engine. The Engine Overhaul Manual must be consulted for such operations.**

### **TROUBLESHOOTING**

The trouble shooting chart which follows, discusses symptoms which can be diagnosed and interprets the results in terms of probable causes and the appropriate corrective action to be taken.

For additional information on more specific trouble shooting procedures, refer to Maintenance and Overhaul Manual.

All engine maintenance should be performed by a qualified mechanic. Any attempt by unqualified personnel to adjust, repair or replace any parts, may result in damage to the engine.

**WARNING... Operation of a defective engine without a preliminary examination can cause further damage to a disabled component and possible injury to personnel. By careful inspection and trouble shooting, such damage and injury can be avoided and, in addition, the causes of faulty operation can be determined without excessive disassembly.**

This troubleshooting chart is provided as a guide. Review all probable causes given, check other listings of troubles with similar symptoms. Items are presented in sequence of the approximate ease of checking, not necessarily in order of probability.

| TROUBLESHOOTING CHART                       |   |   |
|---|---|---|
| TROUBLE                                     | PROBABLE CAUSE                                    | CORRECTIVE ACTION   |
| 1. Engine will not start.                   | a. No fuel flow indications- No fuel to engine    | a. Check fuel control for proper position, boost pump “ON” and operating, feed valves open. Fuel filters open, and tank fuel level.   |
|   | b. Have fuel flow indication - Engine flooded.    | b. Turn off boost pump and ignition switch, set throttle to “FULL OPEN” and fuel control to “IDLE CUTOFF”, and crank engine to clear cylinders of excess fuel. Repeat starting procedure. |
|   | c. Have fuel flow indication - No fuel to engine. | c. Check for bent or loose fuel lines.  |
| 2. Engine starts but fails to keep running. | a. Inadequate fuel to fuel manifold valve.        | a. Set fuel control in “FULL RICH” position, turn auxiliary pump to “ON,” check to be sure feed line and filters are not restricted. Clean or replace defective components.               |

## TROUBLESHOOTING CHART

| <b>TROUBLE</b>                  | <b>PROBABLE CAUSE</b>   | <b>CORRECTIVE ACTION</b>  |
|---------------------------------|---|---|
|                                 | b. Faulty ignition system.  | b. Check accessible ignition cables and connections. Tighten loose connections. Replace defective spark plugs.  |
| 3. Engine runs rough at idle.   | a. Improper idle mixture adjustment.<br>b. Fouled spark plugs.                            | a. Readjust idle setting.<br>b. Remove and clean plugs, adjust gaps. Replace faulty spark plugs.  |
|                                 | c. Discharge nozzle air vent manifold restricted or faulty.                               | c. Check for bent or loose connections. Tighten loose connections. Check for restrictions and replace faulty components.  |
|                                 | d. Restricted nozzle.   | d. Remove and clean all nozzles.  |
| 4. Engine has poor acceleration | a. Idle mixture too lean.<br>b. Incorrect fuel/air mixture.<br>c. faulty ignition system. | a. Readjust idle setting.<br>b. Tighten loose connections, replace worn elements of linkage. Service air cleaner<br>c. Check accessible ignition cables and connections. Tighten loose connections. Replace faulty spark plugs. |

## TROUBLESHOOTING CHART

| <b>TROUBLE</b>  | <b>PROBABLE CAUSE</b>  | <b>CORRECTIVE ACTION</b>  |
|---|--|---|
|   | d. Malfunctioning turbocharger.  | d. Check operation, listen for unusual noise. Check operation of wastegate valve, and for exhaust system defects. Tighten loose connections.  |
| 5. Engine runs rough at speeds above idle.  | a. Improper fuel/air mixture.  | a. Check manifold connections for leaks. Tighten loose connections. Check fuel control and linkage for setting and adjustment. Check fuel filters and screens for dirt. Check for proper pump pressure, and replace pump if faulty. |
|   | b. Restricted fuel nozzle.   | b. Remove and clean all nozzles.  |
|   | c. Faulty ignition system and/or spark plugs.                                    | c. Clean and re-gap spark plugs. Check ignition cables for defects. Replace faulty components.  |
| 6. Engine lacks power, reduction in maximum manifold pressure or critical altitude. | a. Incorrectly adjusted throttle control, “sticky” linkage or dirty air cleaner. | a. Check movement of linkage by moving throttle control, control from idle to full throttle. Make proper adjustments and replace worn dirty air cleaner. components. Service air cleaner.   |

## TROUBLESHOOTING CHART

| TROUBLE | PROBABLE CAUSE                      | CORRECTIVE ACTION  |
|---------|-------------------------------------|--|
|         | b. faulty ignition system.          | b. Inspect spark plugs for fouled electrodes, heavy carbon deposits, erosion of electrodes, improperly adjusted electrode gaps or cracked porcelain. Test plugs for regular firing under pressure. Replace damaged or misfiring plugs. Spark plug gap to be 0.015 to 0.019 inch. |
|         | c. Malfunctioning wastegate         | c. Check for full travel of wastegate valve.   |
|         | d. Low oil pressure                 | d. Adjust oil pressure relief valve to maintain 30-60 psi limit.   |
|         | e. Loose or damaged exhaust system. | e. Inspect entire exhaust system to turbocharger for cracks and leaking connections. Inspect gaskets at cylinder exhaust ports, and gasket at turbine inlet flange. Tighten connections and replace damaged parts.   |

## TROUBLESHOOTING CHART

| TROUBLE           | PROBABLE CAUSE                             | CORRECTIVE ACTION  |
|-------------------|--|--|
|                   | f. Loose or damaged manifolding            | f. Inspect entire manifold system for possible leakage at connections. Replace damaged components, tighten all connections and clamps.   |
|                   | g. Fuel nozzles faulty.                    | g. Inspect fuel nozzle vent manifold for leaking connections. Tighten and repair as required. Check for restricted nozzles and lines and clean and replace as necessary.   |
|                   | h. Malfunctioning turbocharger.            | h. Check for unusual noise in turbocharger. If malfunction is suspected remove exhaust and/or air inlet connections and check rotor assembly for possible rubbing in housing, damaged rotor or faulty bearings. Replace turbocharger if damage is noted. |
| 7. Low fuel flow. | a. Restricted flow to fuel metering valve. | a. Check mixture control for full travel. Check for restrictions in fuel filters and lines, adjust control and clean filters. Replace damaged parts.   |



## **TROUBLESHOOTING CHART**

| <b>TROUBLE</b> | <b>PROBABLE CAUSE</b>   | <b>CORRECTIVE ACTION</b>  |
|----------------|---|---|
|                | b. Fuel nozzle vent system faulty causing improper pressure regulation. | b. Check venting system for leaks at connections and other defects. Tighten connections and replace faulty parts. |
|                | c. Improper rigging of aircraft linkage.                                | c. Adjust.  |
|                | d. Incorrect fuel injection pump adjustment and operation.              | d. Check and adjust using appropriate equipment. Replace faulty pumps.  |
|                | e. faulty fuel injector pump relief valve.                              | e. Clean or replace pump.   |
|                | f. Air leakage in fuel pump pressurization line.                        | f. Locate cause of leakage and correct.   |
|                | g. Injector fuel inlet strainer plugged.                                | g. Remove strainer and clean in a suitable solvent. Acetone or MEK is recommended                                 |
|                | h. Injector out of adjustment.  | h. Replace injector.  |

## TROUBLESHOOTING CHART

| <b>TROUBLE</b>     | <b>PROBABLE CAUSE</b>   | <b>CORRECTIVE ACTION</b>   |
|--------------------|---|--|
|                    | i. Faulty fuel flow gauge.  | i. In a twin engine installation, criss-cross gauges. Replace as necessary. Single engine, change gauge. |
| 8. High fuel flow. | a. Loose lines or fittings.   | a. Tighten all connections and check for fuel stains.  |
|                    | b. Damaged nozzle if high fuel flow is accompanied by loss of power and roughness | b. Remove and check.   |
|                    | c. Faulty fuel flow gauge.  | c. Replace if necessary.   |
|                    | d. Injector out of adjustment.  | d. Replace injector.   |
|                    | e. High fuel pressure.  | e. Check boost pump and engine fuel pump outlet pressure.  |
|                    | f. Air leakage in fuel gauge vent pressurization line.                            | f. Locate cause of leakage and eliminate.  |

## TROUBLESHOOTING CHART

| <b>TROUBLE</b>                        | <b>PROBABLE CAUSE</b>   | <b>CORRECTIVE ACTION</b>  |
|---------------------------------------|---|---|
| 9. Fluctuating fuel flow.             | a. Vapor in fuel system, excess fuel temperature.   | a. Normally operating the boost pump will clear system. Operate boost pump and purge system.  |
| 10. Low oil pressure on engine gauge. | a. Insufficient oil in oil sump, oil dilution or using improper grade oil for prevailing ambient temperature.<br>b. High oil temperature.<br>c. Leaking, damaged or loose oil line connections - Restricted screens and filter. | a. Add oil or change oil to proper viscosity<br><br>b. faulty oil temperature control unit in oil cooler restriction. Replace valve or clean oil cooler.<br>c. Check for restricted lines and loose connections, partially plugged oil filter and screens. Clean parts, tighten connections and replace faulty parts. |

## TROUBLESHOOTING CHART

| <b>TROUBLE</b>               | <b>PROBABLE CAUSE</b>                                       | <b>CORRECTIVE ACTION</b>  |
|------------------------------|---|---|
| 11. Poor engine idle cutoff. | a. Engine getting fuel.                                     | a. Check fuel control for being in full "IDLE CUTOFF" position. Check boost pump for being "OFF". Check for leaking fuel manifold valve. Replace faulty components. |
|                              | b. Improper rigging of aircraft linkage to mixture control. | b. Adjust.  |
| 12. White smoke exhaust.     | a. turbo coking, oil forced through seal turbine housing.   | a. Clean or replace turbocharger.   |
| 13. High fuel flow.          | a. Nozzle vent system.                                      | a. Air check for leaks, tighten or replace defective parts.   |
|                              | b. Defective fuel control.                                  | b. Change fuel control.   |
| 14. Low fuel flow.           | a. Fuel pump vent system leaking air.                       | a. Air check for leaks, tighten or replace defective parts.   |
|                              | b. Defective fuel control.                                  | b. Change fuel control.   |

# **SECTION IX**

## **STORAGE AND REMOVAL FROM STORAGE**

### **A. FLYABLE STORAGE (7 to 30 DAYS).**

1. **Preparation for Storage.** If an aircraft, which has been in operation, is to be stored much longer than a week under normal climatic conditions, and if periodic running to circulate the oil will not be carried out, it is advisable to prepare the engine for storage in the following manner:

a. Operate the engine until the oil temperature reaches the normal range. Drain the oil supply from the sump as completely as possible, and replace the drain plug.

b. Fill the sump to the full mark on the dipstick gauge with MIL-C-6529 Type II oil which will mix with normal oil, which is suitable as a lubricant, and will provide protection against corrosion.

c. Run the engine at least five minutes at a speed between 1000 and 1200 RPM with the oil temperature and cylinder head temperature in the normal operating range.

### **2. During Flyable Storage.**

a. Each seven days during flyable storage, the propeller shall be rotated by hand without running the engine. After rotating the engine six revolutions, stop the propeller 45° to 90° from the position it was in.

b. If at the end of thirty (30) days the aircraft will not be removed from storage, the engine shall be started and run. The preferred method will be to fly the aircraft for thirty (30) minutes. If flying is impractical, a ground run shall be made of thirty (30) minute duration, and up to, but not exceeding normal oil and cylinder temperatures.

### **3. Preparation for Service.**

a. If the engine has a total time of more than twenty-five (25) hours, the MIL-C-6529 oil shall be drained after a ground warm-up. Install the TCM recommended oil before flight. It should be noted that MIL-C-6529 Type II is the TCM recommended oil for the first twenty-five (25) hours of flight.

### **B. TEMPORARY STORAGE (UP TO 90 DAYS).**

#### **1. Preparation for Storage.**

a. Remove top and bottom spark plugs and atomize spray preservative oil, (Lubrication Oil-Contact and Volatile, Corrosion-Inhibited, MIL-L-46002, Grade 1) (221° - 250°) through upper spark plug hole of each cylinder with the piston in the down position. Rotate crankshaft as each pair of cylinders is sprayed. Stop crankshaft with no piston at top position.

NOTE . . . Shown below are some approved preservative oils recommended for use in Teledyne Continental engines for temporary storage.

MIL-L-46002, Grade 1 Oils:

|                   |   |
|-------------------|---|
| Nucle Oil 105     | - Daubert Chemical Co.<br>4700 S. Central Avenue<br>Chicago, Illinois           |
| Petrotect VA      | - Pennsylvania Refining Co.<br>Butler, Pennsylvania                             |
| Ferro-Gard 1009-G | - Ranco Laboratories, Inc.<br>3617 Brownsville Road<br>Pittsburgh, Pennsylvania |

b. Re-spray each cylinder without rotating crank. To thoroughly cover all surfaces of the cylinder interior, move the

nozzle or the spray gun from the top to the bottom of the cylinder.

c. Reinstall spark plugs.

d. Apply preservative to engine interior by spraying the above specified oil (approximately 2 ounces) through the oil filler tube.

e. Seal all engine openings exposed to the atmosphere using suitable plugs, or non-hygroscopic tape, and attach red streamers at each point.

f. Engines, with propellers installed, that are preserved for storage in accordance with this section should have a tag affixed to the propeller in a conspicuous place with the following notation on the tag: "DO NOT TURN PROPELLER — ENGINE PRESERVED".

## **2. Preparation for Service.**

a. Remove seals, tape, paper and streamers from all openings.

b. With bottom plugs removed, hand turn propeller several revolutions to clear excess preservative oil, then reinstall plugs.

c. Conduct normal start up procedure.

d. Give the aircraft a thorough cleaning, visual inspection and test flight.





# SECTION X

## GLOSSARY

**ADMP**—Absolute dry manifold pressure. It is used in establishing base-line standards of engine performance. Manifold pressure is the absolute pressure in the intake manifold; it is expressed in inches of mercury (" Hg).

**AMBIENT**—A term used to denote a condition of the surrounding atmosphere at a particular time. For example: Ambient Temperature or Ambient Pressure.

**BHP**—Brake Horsepower. The power actually delivered to the engine propeller shaft. It is so called because it was formerly measured by applying a brake to the power shaft of an engine. The required effort to brake the engine could be converted to horsepower—hence: "brake" horsepower.

**BSFC**—Brake Specific Fuel Consumption. Fuel consumption stated in pounds per hour per brake horsepower. For example, an engine developing 200 horsepower while burning 100 pounds of fuel per hours, has a BSFC of .5.

$$\frac{\text{Fuel consumption in PPH}}{\text{Brake horsepower}} = \frac{100}{200} = .5$$

**COLD SOAKING**—Prolonged exposure of an object to cold temperatures so that its temperature throughout approaches that of ambient.

**CRITICAL ALTITUDE**—The maximum altitude at which a component can operate at 100% capacity. For example, an engine

with a critical altitude of 16,000 feet cannot produce 100% of its rated manifold pressure above 16,000 feet.

**DENSITY ALTITUDE**—The effective altitude, based on prevailing temperature and pressure, equivalent to some standard pressure altitude.

**DYNAMIC CONDITION**—A term referring to properties of a body in motion.

**E.G.T.** — Exhaust Gas Temperature. Measurement of this gas temperature is sometimes used as an aid to fuel management.

**EXHAUST BACK PRESSURE**—Opposition to the flow of exhaust gas, primarily caused by the size and shape of the exhaust system. Atmospheric pressure also affects back pressure.

**FOUR CYCLE**—Short for “Four Stroke Cycle”. It refers to the four strokes of the piston in completing a cycle of engine operation (Intake, Compression, Power and Exhaust).

**FUEL INJECTION**—A process of metering fuel into an engine by means other than a carburetor.

**GALLERY**—A passageway in an engine or component. Especially one through which oil is flowed.

**Hg**—“Inches of Mercury”. A standard for measuring pressure, especially atmospheric pressure or manifold pressure.

**HUMIDITY**—Moisture in the atmosphere. Relative humidity, expressed in percent, is the amount of moisture (water vapor) in the air compared with the maximum amount of moisture the air could contain at a given temperature.

**LEAN LIMIT MIXTURE**—The leanest mixture permitted for any given power condition. It is not necessarily the leanest mixture at which the engine will run.

**MANIFOLD PRESSURE**—Absolute pressure as measured in the intake manifold. Usually measured in inches of mercury.

**MIXTURE**—Mixture Ratio. The proportion of fuel to air used for combustion.

**NORMALLY ASPIRATED (ENGINE)**—A term used to describe an engine which obtains induction air by drawing it directly from the atmosphere into the cylinder. A non-supercharged engine.

**NRP**—Normal Rated Power.

**OCTANE NUMBER**—A rating which describes relative anti-knock (detonation) characteristics of fuel. Fuels with greater detonation resistance than 100 octane are given Performance Ratings.

**OIL TEMPERATURE CONTROL UNIT**—A thermostatic unit used to divert oil through or around the oil cooler, as necessary, to maintain oil temperature within desired limits.

**OVERBOOST VALVE**—A safety device used on some turbocharged engines to relieve excessive manifold pressure in event of a malfunction.

**OVERHEAD VALVES**—An engine configuration in which the valves are located in the cylinder head itself.

**PERFORMANCE RATING**—A rating system used to describe the ability of fuel to withstand heat and pressure of combustion as compared with 100 octane fuel. For example, an engine with high compression and high temperature needs a higher Performance Rated fuel than a low compression engine. A rating of 100/130 denotes performance characteristics of lean (100) and rich (130) mixtures respectively.

**PRESSURE ALTITUDE** — Altitude, usually expressed in feet, (using absolute pressure [static] as a reference) equivalent to altitude above the standard sea level reference plane (29.92" Hg).

**PROPELLER LOAD CURVE**—A plot of horsepower, fuel flow, or manifold pressure versus RPM through the full power range of one engine using a fixed pitch propeller or a constant speed propeller running on the low pitch stops. This curve is established or determined during design and development of the engine.

**PROPELLER PITCH**—The angle between the mean chord of the propeller and the plane of rotation.

**RAM**—Increased air pressure due to forward speed.

**RATED POWER**—The maximum horsepower at which an engine is approved for operation. Rated power may be expressed in horsepower or percent.

**RETARD BREAKER**—A device used in magnetos to delay ignition during cranking. It is used to facilitate starting.

**RICH LIMIT**—The richest fuel/air ratio permitted for any given power condition. It is not necessarily the richest condition at which the engine will run.

**ROCKER ARM**—A mechanical device used to transfer motion from the pushrod to the valve.

**SCAVENGE PUMP**—A pump (especially an oil pump) to prevent accumulation of liquid in some particular area.

**SONIC VENTURI**—A restriction, especially in cabin pressurization systems, to limit the flow of air through a duct.

**STANDARD DAY**—By general acceptance, a condition of the atmosphere wherein specific amounts of temperature, pressure, humidity, etc. exist.

**STATIC CONDITION**—A term referring to properties of a body at rest.

**SUMP**—The lowest part of a system. The main oil sump on a wet sump engine contains the oil supply.

**TBO**—Time Between Overhauls. Usually expressed in operating hours.

**T.D.C.**—Top Dead Center. The position in which the piston has reached the top of its travel. A line drawn between the crankshaft rotational axis, through the connecting rod end axis and the piston pin center would be a straight line. Ignition and valve timing are stated in terms of degrees before or after TDC.

**THERMAL EFFICIENCY**—Regarding engines, the percent of total heat generated which is converted into useful power.

**TORQUE**—Twisting moment, or leverage, stated in pounds-foot (or pounds-inch).

**TURBOCHARGER**—A device used to supply increased amounts of air to an engine induction system. In operation, a turbine is driven by engine exhaust gas. In turn, the turbine directly drives a compressor which pumps air into the engine intake.

**VAPOR LOCK**—A condition in which the proper flow of a liquid through a system is disturbed by the formation of vapor. Any liquid will turn to vapor if heated sufficiently. The amount of heat required for vaporization will depend on the pressure exerted on the liquid.

**VARIABLE PRESSURE CONTROLLER**—A device used to control the speed, and thus the output of the turbocharger. It does so by operating the wastegate which diverts, more or less, exhaust gas over the turbine.

**VISCOSITY**—The characteristic of a liquid to resist flowing. Regarding oil, high viscosity refers to thicker or “heavier” oil while low viscosity oil is thinner. Relative viscosity is indicated by the specified “weight” of the oil such as 30 “weight” or 50

“weight”. Some oils are specified as multiple-viscosity such as 10W30. In such cases, this oil is more stable and resists the tendency to thin when heated or thicken when it becomes cold.

**VOLATILITY**—The tendency of a liquid to vaporize.

**VOLUMETRIC EFFICIENCY**—The ability of an engine to fill its cylinders with air compared to their capacity for air under static conditions. A “normally aspirated” engine will always have a volumetric efficiency of slightly less than 100%, whereas superchargers permit volumetric efficiencies in excess of 100%.

**WASTEGATE VALVE**—A unit, used on turbocharged engines, to divert exhaust gas through or around the turbine, as necessary, to maintain turbine speed. As more air is demanded by the engine, due to throttle operation, the compressor must work harder. In order to maintain compressor and turbine speed, more exhaust must be flowed through the turbine. The wastegate valve closes and causes gas, which would go directly overboard, to pass through the turbine. The wastegate is usually operated by an actuator which gets necessary signals from the turbocharger controller.



