



airmotive**engineering**corp.

AE MECHANICAL FUEL INJECTION SYSTEM

MODEL AE400 through AE900

Installation and Operation Manual

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SAFETY INFORMATION

The following special attention notices are used in this Manual to notify and advise the installer and user of the Airmotive Engineering Corp. (AE) Fuel Injection System that certain actions or procedures may be dangerous to the user or result in damage to the product.

NOTE

Notes are used to notify of installation, operation or maintenance information that is important but not safety related.

CAUTION

Caution is used to indicate the presence of a hazard which will or can cause minor injury or property damage if the notice is ignored.

WARNING

Warning advises that a potential hazard exists and denotes actions and procedures that must be followed exactly to either eliminate or reduce the hazard and to avoid serious personal injury or prevent future safety problems with the product.

DANGER

Danger is used to indicate the presence of a hazard that will result in severe personal injury, death or property damage if the notice is ignored.

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SECTION I – DESCRIPTION

1.1 General Description

The Mechanical, Multi-Nozzle, Continuous Flow Fuel Injection System developed by Airmotive Engineering Corporation (AE) for aircraft engines has been shown to be a reliable and economical fuel system that is well suited for application to the general aviation environment. The AE fuel injection system is a simple, low-pressure system that injects fuel into the intake valve port in the cylinder head. It is designed for ready adaptation to engines of widely varying power ratings, displacement and number of cylinders.

1.2 System Designations

1.2.1 The AE Fuel Injection System carries a basic model designation that identifies the number of cylinders that the system can service, e.g. AE400 is for a four cylinder engine, AE600 is for a six cylinder engine, AE700 is for a seven cylinder engine, etc.

1.2.2 The Model used on a specific engine will carry a “dash” after the model description (see paragraph 1.2.1 above) followed by alphanumeric characters. The first two characters denote a specific cam profile in the Air Throttle Body & Fuel Metering Unit Assembly which determines the flow. This cam profile is designed by AEC to meet the fuel flow performance vs. horsepower requirements of a specific engine as supplied by the engine manufacturer. The third and fourth characters denote a specific Bill of Materials which contains all of the components of the system for a specific engine configuration, i.e. fuel distribution line lengths, fuel injection nozzle assembly sizes, brackets, etc. For example, Model AE400-3N7C would be for a 4 cylinder engine that had a specific fuel flow performance (3N) and a specific Bill of Materials as contained in an Illustrated Parts List (7C).

NOTE

The Performance Data and Bill of Materials (Illustrated Parts List) for a specific Model of Fuel Injection System is not contained in this Manual but is published in a TECHNICAL DATA SHEET for each specific Model. Therefore, the appropriate TECHNICAL DATA SHEET is an integral part of this

INSTALLATION AND OPERATING MANUAL and the two documents must be used together.

1.3 AE Fuel Injection System Schematic

Figures 1 and 2 are schematic flow diagrams of the AE Fuel Injection System. The system contains five major components:

1. Fuel Pump and Vapor Separator Assembly
2. Air Throttle Body and Fuel Metering Unit Assembly
3. Fuel Manifold Valve Assembly
4. Fuel Distribution Lines
5. Fuel Injection Nozzle Assemblies

1.3.1 Fuel Pump and Vapor Separator

Assembly: The fuel pump is a positive displacement rotary vane type pump. The pump is engine driven through an AN spline and attaches to the engine by means of an AN style pad as defined in Air Force-Navy Aeronautical Design Standard AND20003, a copy of which is included at the end of this Manual as Figure 7. The fuel pump draws fuel from the fuel delivery lines and increases the fuel pressure. The fuel pump output flow is considerably beyond the engine needs, and the fuel not needed by the engine is by-passed in the fuel pump assembly. Additionally, fuel entering the pump assembly passes through a swirl chamber where fuel vapors are separated. The by-pass fuel from the pump passes through a venturi at the swirl chamber and draws off the fuel vapors and returns the by-pass fuel and vapors to the fuel tank. The swirl chamber ensures that the fuel pump draws only liquid fuel which prevents surging or other abnormal operation.

1.3.2 Air Throttle Body and Fuel Metering

Unit Assembly: The air throttle body contains the butterfly valve that controls the flow of air to the engine as positioned by the cockpit throttle control lever. The throttle body has a flange that attaches to a mating flange on the intake plenum of the engine. The throttle body can be mounted in any position available on the engine.

DESCRIPTION

The throttle body has a machined boss for attachment of the fuel metering unit housing and a bushed bore through which the throttle shaft passes. The fuel metering cam is attached to the throttle shaft so the butterfly valve and the fuel metering cam move in unison.

There are two fuel lines attached to the fuel metering unit. One line is un-metered fuel input to the fuel metering unit and the second line is metered fuel output to the fuel manifold valve.

Metered fuel flow is a function of un-metered fuel pressure, throttle angle and mixture control position. Proper metering is accomplished by a computer generated cam that is mathematically designed for a specific engine requirement.

1.3.3 Fuel Manifold Valve Assembly: The fuel manifold valve distributes fuel equally to all engine cylinders by dividing the metered fuel flow equally among the number of nozzles in the system. The length and shape of individual fuel lines could cause fuel flow to the cylinders to be

uneven. However, uneven flow can be minimized by selection of proper fuel injection nozzle sizes and by avoiding sharp bends or kinks in the fuel injection lines.

The fuel manifold valve contains one input fuel line from the fuel metering unit and as many output lines to the fuel injection nozzles as there are cylinders on the engine.

1.3.4 Fuel Distribution Line Assemblies: These stainless steel tubes convey the metered fuel from the Fuel Manifold Valve Assembly to the Fuel Injection Nozzle Assemblies which are inserted into each cylinder intake port near and directed at the back side of the intake valves.

1.3.5 Fuel Injection Nozzle Assemblies: The function of the fuel injection nozzle is to atomize and subsequently vaporize the metered fuel. The nozzle sprays fuel continuously into the intake port of each cylinder head where it mixes with induction air.

Figure 1: Model AE400 Fuel Injection System

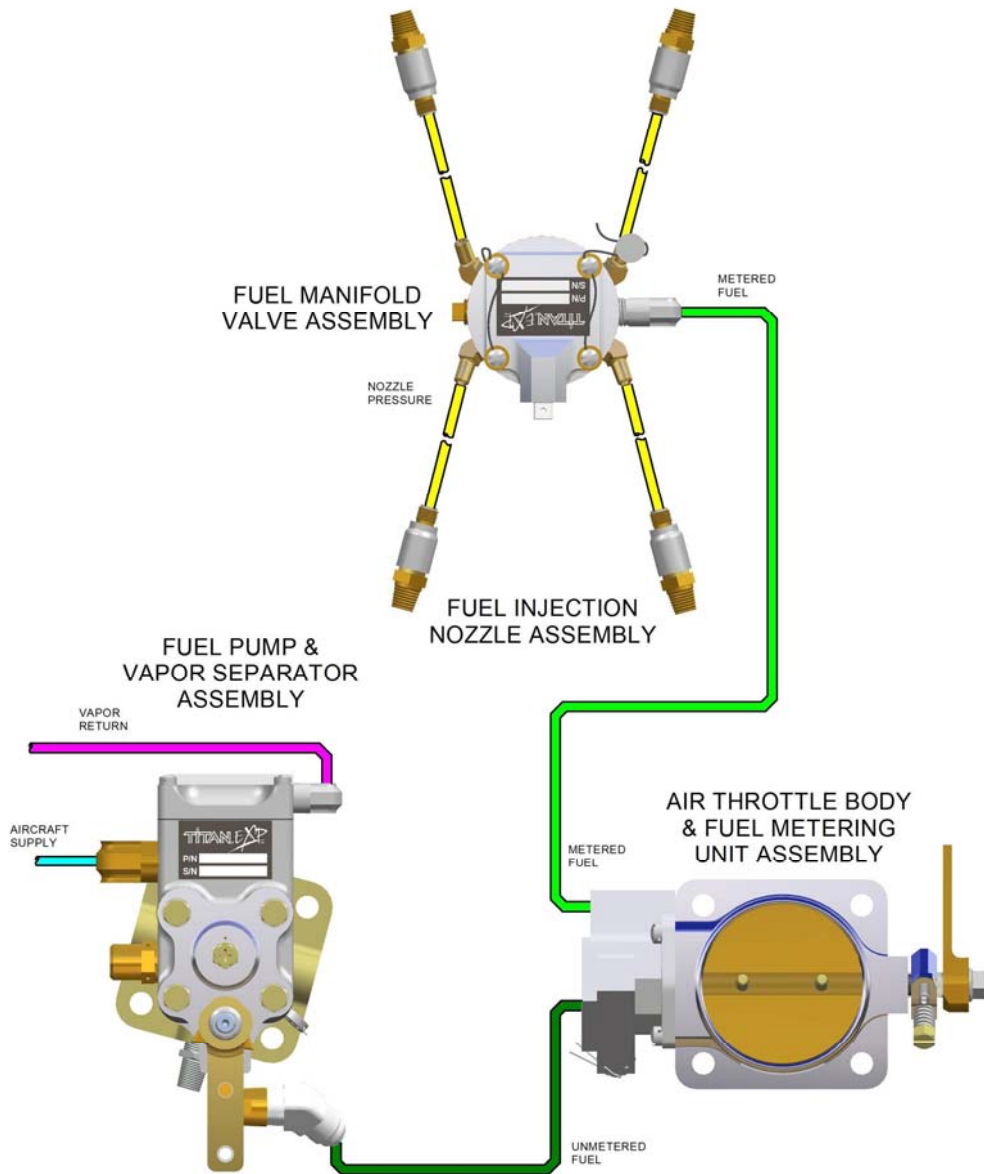


Figure 2: Model AE600 Fuel Injection System Schematic

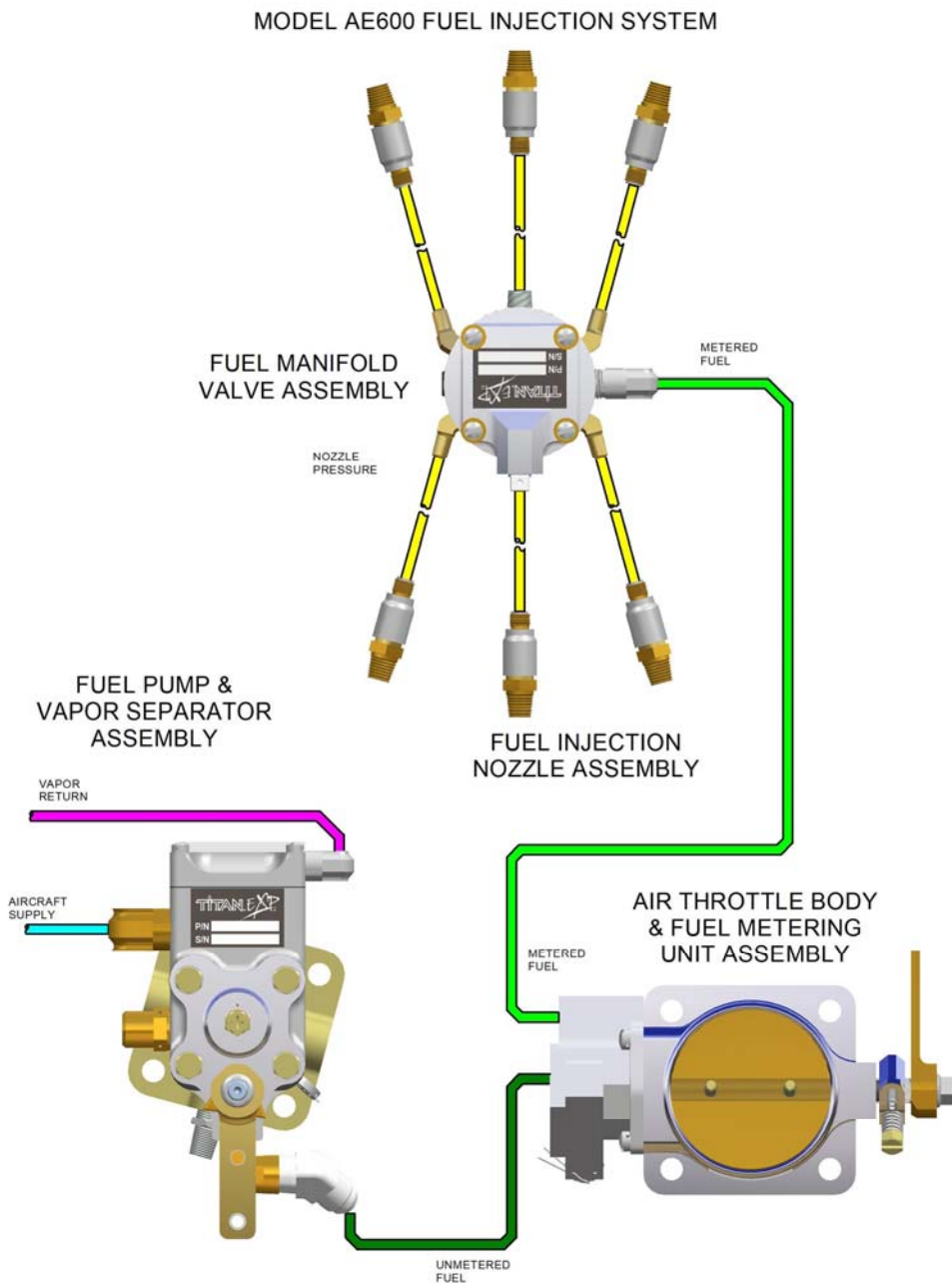


FIGURE 2

SECTION
II – PERFORMANCE ADVANTAGES WITH THE AE
MECHANICAL FUEL INJECTION SYSTEM

2.1 Provides Equal Distribution of Fuel to all Engine Cylinders

2.1.1 On engines with carburetors, the fuel (vapor and droplets) is carried to the cylinders by the intake air. The quantity of fuel actually admitted to the cylinders is determined by the induction system, and impingement and condensation of the gasoline vapor on the walls of the induction pipes affects the distribution of the fuel. Fuel that is not in vapor form in the combustion chamber is wasted.

2.1.2 The design of the AE Fuel Injection System incorporates an engine driven vane pump and vapor separator that produces more fuel flow than is required by the engine. A recirculation path for excess fuel carries unwanted vapor back to the fuel tank. By inserting a calibrated adjustable orifice and relief valve into the recirculation path, fuel pressure and delivery are controlled for all engine operating speeds. Measured fuel output is equally divided among the cylinders by a manifold valve and sent through individual fuel lines to fuel nozzles that spray the fuel into the intake ports. Since the fuel is delivered at the intake valve, there is no fuel loss in the induction system.

2.2 Positively Eliminates Carburetor or Manifold Icing

2.2.1 The velocity and mass of the air as it passes through the ordinary float type carburetor venturi produces a low pressure area that is utilized to draw an emulsion of gasoline and air from a nozzle inserted into this air stream. This emulsion is then distributed by the induction system to the various engine cylinders. The gasoline must be supplied to the carburetor in liquid form and, as it mixes with carburetor bleed air and then passes into the air stream, a vapor is formed.

2.2.2 To change a liquid to a vapor requires the addition of heat as is demonstrated every day when we boil water and steam escapes from the spout of the tea kettle. In a like manner, heat must be added to the liquid gasoline at the venturi to change it to a vapor for mixing with the air inducted into the engine cylinders. Most of this heat must come from the air as it passes

through the carburetor and manifold, and the act of extracting the heat lowers the temperature of the air and surrounding materials.

2.2.3 Although it cannot generally be seen, all air contains water vapor and the maximum amount of water vapor it can hold is determined by its temperature. As the temperature becomes lower, the ability of the air to hold water vapor decreases. The formation of frost on windows during the winter months is caused by warm air containing water vapor coming into contact with the cold window which chills the air below the point where it can continue to hold all the water in a vapor form. In other words, because its temperature is reduced, the relative humidity of the air next to the window increases until it exceeds 100 percent and condensation then takes place. When the relative humidity of air cooled by fuel vaporization in a carburetor exceeds 100%, condensed water impinges on the throttle walls and butterfly valve. The temperature of these surfaces has also been reduced and may be sufficiently low to form ice. Since the carburetor is usually situated at a position where it cannot readily utilize engine heat to prevent ice formation, the addition of a device to pre-warm the air before it enters the carburetor is required.

2.2.4 Heat is not required with the AE Fuel Injection System because liquid gasoline is pumped to atomizing nozzles located in the manifold just ahead of the intake valve where engine heat is available and the temperature is always well above the freezing point. Since the induction system then distributes air only to the engine cylinders, there is no refrigeration process accompanied by condensation and freezing.

2.3 Reduces Cylinder Temperatures and Increases Engine Life

2.3.1 When the fuel is introduced to the air in an atomized form at the intake ports, vaporization takes place as the mixture passes into the cylinder. The vaporizing fuel passing into the combustion chamber helps to cool the intake valve and engine cylinder. By providing equal fuel distribution, fuel injection eliminates lean cylinders and associated high temperatures which can result when using a

PERFORMANCE ADVANTAGES WITH THE AE MECHANICAL FUEL INJECTION SYSTEM

carburetor and induction system that draws the fuel/air mixture through the hot oil sump. Injecting fuel directly at the intake port of the cylinder also eliminates precipitation of the fuel before it reaches the cylinder. By keeping the pistons, rings, and valves at a lower temperature, failure of these parts is less likely to occur and engine life as a whole is increased.

2.4 Reduces Gasoline Consumption

2.4.1 Gasoline consumption of conventional carbureted engines is dependent upon sufficient fuel delivery to prevent the lean cylinders from overheating. The equal distribution of fuel assured with the AE Fuel Injection System minimizes the fuel waste which would otherwise occur in the rich cylinders.

2.4.2 The more uniform fuel distribution obtained with fuel injection, therefore, permits engine operation with more uniform and generally leaner mixtures without danger of overheating individual cylinders.

2.5 Improves Engine Idling

2.5.1 Any aircraft engine with a wide valve overlap idles unevenly when compared with an automotive engine. However, with uniform fuel distribution and the introduction of atomized fuel directly at the intake port, idling is improved.

2.6 Eliminates Danger of Engine Stall During Glide

2.6.1 During a glide an air cooled engine becomes relatively cold and the induction system in particular becomes so cold that the gasoline from a conventional carburetor system precipitates on the inner surfaces of the induction pipes instead of reaching the cylinders. Liquid fuel will pool at various points in the induction system, and erratic operation and even engine stoppage can occur. At partial to wide-open throttle settings, the liquid fuel film on the interior of the induction pipes is not the same as during idle. Consequently, after a prolonged glide, excess fuel in the induction system will be picked up by increased flow that accompanies an opened throttle, and that fuel will be ingested. This ingestion of raw fuel requires time to clear and is a cause for "throttle lag". The practice of occasionally opening the throttle during a glide with a carbureted engine prevents raw fuel from

pooling too much, thereby keeping the induction system in condition for additional power when it is required.

2.7 Improves Engine Acceleration

2.7.1 Since the nozzles in the AE Fuel Injection System are located at the port close to the intake valve, the induction system is divorced from the fuel system; and its sole function is to distribute equal amounts of air to all cylinders.

Consequently, idling is improved and is subject to fewer variables, the danger of engine stall is eliminated; and acceleration of the engine is improved. Further improvement in acceleration comes from the fact that when the throttle is suddenly opened, the injection pump instantly delivers to the engine cylinders the increased quantity of fuel determined by the new throttle position. This causes a momentarily rich mixture in preparation for the larger quantity of air which follows.

2.8 Increases Engine Power

2.8.1 Increased engine power is obtained in several ways. Fuel vaporized within the engine cylinder rather than in the induction system lowers the temperature of the residual gas from the previous combustion event causing it to contract. This cooling effect permits a slightly larger volume of air to be drawn into the cylinder. The maximum power which can be developed by a given engine cylinder depends, among other things, on the mass of air inducted into the cylinder. If the air is warm, the mass of the inducted air is less than would occur if cold air were made available. Thus, fuel injection eliminates the loss of power resulting from the use of carburetor heat to pre-warm the induction air. Elimination of de-icing equipment also makes possible an air intake leading directly forward through the air filter which is ideal for inheriting ram air in flight. ,

Loss of power is also sometimes caused by "flat spots" in a carburetor system. A "flat spot" is a small speed range wherein the proper fuel-air ratio is not obtained and the maximum power is consequently not developed. "Flat spots" are eliminated with the AE Fuel Injection System which provides the proper fuel-air ratio throughout the entire operational range of the engine.

PERFORMANCE ADVANTAGES WITH THE AE MECHANICAL FUEL INJECTION SYSTEM

2.8.2 Unlike carburetors and servo type fuel injection systems, the AE Fuel Injection System does not incorporate a venturi in the inlet air passage. By eliminating the air restriction caused by the venturi, an increase in manifold pressure (> 1") may be experienced (subject to intake efficiency) which adds to the heavier charge of air inducted into the cylinders.

The unrestricted air passage also enhances the beneficial effects produced by ram air. As a rule of thumb, an increase of 1" of manifold pressure equates to a 2 to 3% increase horsepower. Also, an increase of 1" of manifold pressure equates to an increase of 1000' of critical altitude which, with the same horsepower, produces 2.5 knots of increased speed.

2.8.3 For engines that are fitted with a carburetor, a common method for enhancing fuel vaporization is to route the induction air through pipes in the oil sump. While this improves vaporization, the trade off is that it also reduces the density of the air charge entering the cylinders. Fuel injection allows the use of "cold induction" oil sumps that have the air intake plenum separate from the oil sump.

2.9 Reduces Engine Roughness

2.9.1 Roughness is usually attributed to unequal explosions of improper fuel-air mixtures. Equal distribution of fuel, the proper fuel-air ratio, and the slower burning of the colder charge as prepared by the vaporization of the fuel within the combustion chamber prevent roughness in fuel injected engines.

2.10 Permits Higher Airspeeds

2.10.1 Since carburetor heat is not required on fuel injected engines, no heat transfer jacket or exhaust muff with connecting hot-air tubing is needed. Periodic inspection of this equipment is also eliminated. The air throttle body and metering assembly can be mounted in any convenient position on the engine that permits adequate routing of the throttle cable and fuel hoses. This feature permits the use of an induction system design requiring less depth than with a carburetor requiring vertical inlet sump design. With the air intake so placed as to inherit ram air in flight and with no pre-warming of the induction air necessary, maximum power is always available. These advantages, combined with the use of a more streamlined engine cowl to reduce drag, enable higher airspeeds to be obtained.

2.11 Makes Flying Safer and Easier

2.11.1 Flying is safe only if you know what to do under any emergency before the emergency presents itself. In the case of applying manifold heat to prevent icing, the heat should be applied before the need becomes apparent. Failure to do so may cause the engine to lose power and even stall, thus killing the source of the heat necessary to counteract the icing. The separation of the air induction and fuel systems eliminates the possibility of backfiring and reduces the hazard of fire. Elimination of the danger of engine stall during a glide and the satisfaction of knowing that instant power is available when needed makes flying with a fuel injected engine safer. Flying becomes easier and more pleasurable since the problems described above do not exist to distract the pilot.

SECTION
III – INSTALLATION INSTRUCTIONS

3.1 General

Installation instructions for the AE Fuel Injection System are specific to each engine type and configuration. AE publishes installation instructions in the TECHNICAL DATA SHEET that pertains to a specific engine model and establishes application eligibility for a specific Fuel Injection System part number for that engine. Therefore, consult the appropriate TECHNICAL DATA SHEET for installation instructions before beginning the installation.

WARNING

If an AE Fuel Injection System is installed on an engine application for which there is no published TECHNICAL DATA SHEET, the installer assumes all risk of installation and

the consequences arising from the unapproved installation. AE strongly recommends that they be consulted before any system is installed on an engine for which installation instructions have not been published.

3.2 Weight and Balance

If an AE Fuel Injection System is being retrofitted to an engine that had a carburetor or servo fuel injection system, a new weight and balance calculation should be made before flying the airplane.

WARNING

Changes to weight and balance may seriously affect the stability of the aircraft.

SECTION IV – OPERATING INSTRUCTIONS

4.1 General

There are two basic fuel systems used on aircraft engines: carburetors and fuel injection. Furthermore, there are two types of fuel injection systems: servo and mechanical. Each fuel system has its own starting peculiarities which, when understood, offer no undue challenge to the pilot. To assist the pilot who has not had experience with an AE Mechanical Fuel Injection System, the following engine starting procedure is offered.

4.2 Boost Pump(s)

The AE fuel injection system requires the use of at least one boost pump. The primary requirement is that the boost pump must produce between 18-22 psi fuel pressure for emergencies if there is a loss of pressure from the engine driven fuel pump. Similar fuel injection systems used in certificated airplanes also employ a low pressure fuel pump (3-5 psi) for take-off and high altitude operation.

4.3 Plumbing and Gascolators

Fuel lines should be at least 3/8 inch (No. 6) tubing size. All fuel lines must be routed so that there are no low areas where water can be trapped. There must be drains in the low points of the fuel line plumbing. For many of the Van's airplanes, this point is the inboard area of the fuel tank. The builder must be careful to ensure that the fuel lines do not descend and then rise, which creates an area where water can be trapped with no drain.

A properly sized gascolator having a 70 micron filter is normally used, but AEC has identified high gasoline temperatures from gascolators in the vicinity of the exhaust system. If a gascolator is not used, an inspectable and cleanable fuel screen/filter must be installed in the fuel system supply system.

WARNING

A free flowing path (pump bypass) for the fuel to flow to the engine driven fuel pump is absolutely essential so that fuel will flow unimpeded to the engine driven pump when the boost pump(s) are turned off.

4.4 Starting the Engine

This procedure is recommended for both cold and hot starts:

DANGER

Make sure that the propeller is clear and that no personnel are in the immediate vicinity.

- 1) Open the throttle approximately 1 inch, and move the mixture control to the full-rich position.
- 2) Turn on the airframe boost pump on high pressure for one to five (1-5) seconds and turn it back off.
- 3) Immediately start cranking the engine over until it starts.
- 4) As the engine starts to accelerate in RPM, smoothly move the throttle towards the idle position to prevent the engine from running into a high RPM condition.

NOTE

Operating the airframe boost pump on high setting will purge the fuel lines of any air or vapors and will prime the induction port area with fuel. The length of time the airframe boost pump is operated can vary depending on the atmospheric conditions such as air temperature, air density and altitude. Engine temperature (i.e. hot or cold) is a variable to be considered. In most cases, 1-3 seconds should be sufficient.

CAUTION

Excessive operation of the high boost pump will cause the engine to flood. Operation with low boost at intermediate power settings may require the engine to be leaned slightly to provide smooth operation.

4.5 Flying the Airplane

Before test flying the airplane, perform a pre-flight run-up in accordance with the airframe manufacturer's instructions and engine break-in

instructions which are contained in the booklet entitled “Engine Break-in Instructions and Oil Management” (#M101) published by Engine Components, Inc. (ECi). The ECi booklet is available on the web at www.eci.aero.

AE recommends using low boost pressure for take-off. Low boost can also smooth out engine acceleration when the engine is cold.

SECTION V – GENERAL SERVICE INSTRUCTIONS

5.1 Field Inspection and Service

CAUTION

Engine performance, service life and reliability will be compromised if the AE Fuel Injection System is neglected and/or not subjected to periodic inspection.

5.1.1 50-Hour Inspection: Visually inspect all fuel system components for any evidence of fuel staining. Pay particular attention to fuel line connections that may be leaking. Also, look for physical damage to fuel system components including evidence of rubbing wear caused by relative motion between system components.

WARNING

All fuel lines and hoses must show no visual signs of distress, bending or collapse. Steel fuel injection lines must be properly clamped and supported to prevent vibration and fatigue. Flexible fuel hoses must be properly clamped and supported to prevent excess flexing and/or contact with electrical wires, the exhaust system, or other parts that could cause chafing or failure. Clamps must be placed in such a way that normal movement of the engine on the flexible engine mounts does not transmit improper loads to either the flexible hoses or the fittings to which they are attached.

5.1.2 100-Hour Inspection: Perform all inspection requirements contained in paragraph 5.1.1 above. In addition, the fuel nozzles must be removed, cleaned and visually inspected. The nozzles must be cleaned by soaking in lacquer thinner, MEK or acetone for several hours. Blow dry with compressed air before re-installation in the cylinder using procedures described in Section III.

WARNING

Never clean nozzles with wire or other similar object. If nozzle jet is plugged and blockage cannot be removed by solvent action, REPLACE THE NOZZLE with a nozzle of equal flow characteristics.

Inspect the operation of each engine related control including the throttle, mixture, propeller and alternate air controls. Make certain that each

control has full limit of travel and that no binding or excessive play caused by worn parts or improper installation is evident. Inspect control cables and linkage levers in accordance with the aircraft manufacturer's instructions.

WARNING

Failure to comply with the above inspection can result in fuel system linkage and/or related component damage and subsequent loss of engine power.

Inspect all engine control cables for proper routing and security in accordance with the airframe manufacturer's instructions. Inspect all engine control cables for signs of damage or wear caused by chafing and heat distress in accordance with the airframe manufacturer's instructions.

To insure proper operation and prevent accelerated wear, all fuel control linkage rods must be inspected for excessive play which can cause lost motion and breakage of parts. Inspect the pivot points of levers and linkages for debris, old grease and oil. Clean pivot point areas thoroughly using clean solvent. After cleaning, dry each area using compressed air.

Worn or corroded linkage, attaching hardware, levers or lever bushings must be replaced. After cleaning, inspection and repair (as necessary) has been accomplished, each pivot point must be lubricated using LPS2, Permatex "Maintain®" Lubricant. If levers, link rods or bushings have been replaced or reassembled, initial lubrication must be accomplished using Shell #5 grease or Lubriplate #630AA or equivalent. Lubrication of levers, link rods or bushings must be performed.

Consult the airframe manufacturer and/or their current published instructions concerning aircraft engine control cable attach point inspection, cleaning, repair, installation and lubrication.

After the above procedures have been accomplished verify that each control has full limit of travel, the required safeties are in place, that no binding of levers or linkages is occurring and that control movement is unrestricted by contact with other parts or components that are located in close proximity.

GENERAL SERVICE INSTRUCTIONS

WARNING

Connections requiring torqued fasteners must not exhibit any movement or motion between components. Such movement may cause abnormal wear resulting in component malfunction or failure and subsequent loss of power.

Measure and record idle and full power fuel pressure and flows. Compare recorded measurements with data contained in the current AE Technical Data Sheet published for the fuel system that is being inspected.

NOTE

Fuel pressures must be checked using external, calibrated instrumentation connected to the fuel system as described in Paragraph 5.3. Do not use airframe cockpit gages when checking fuel pressures.

NOTE

The fuel system must be adjusted to meet the requirements contained in the AE Technical Data Sheet.

If the fuel injection system is found to be in good physical condition and operational inspection readings conform with the specified flows and pressures, the engine fuel system can be approved for return to service.

If the fuel system is not functioning properly, proceed to Section VI "Trouble Shooting" to determine the probable cause and remedy.

5.2 System Lubrication

Except as required in Paragraph 5.1, Field Inspection and Service, the AE Fuel Injection System requires no separate attention.

5.3 Adjustment and Test

5.3.1 General: Fuel injection system components and assemblies manufactured by AE are adjusted and calibrated at the factory to meet engineering specifications. This insures operation of the system within those specifications throughout the full range of operation.

When engines are installed in aircraft, they are subjected to different induction systems, fuel

supply systems and operating environments. These variables necessitate checking and adjusting the fuel injection system after installation on an engine and in an airframe before flight in order to insure that the fuel system settings are correct for the installation.

Operational verification of the engine fuel system is required when any one of the following circumstances occurs:

- Engine installation
- Airplane inspection (but no less frequently than once per year)
- Whenever a system component is adjusted or replaced

The following adjustment procedures are presented in a sequential format that must be followed to ensure proper fuel system adjustment for an installed engine. Refer to the appropriate AE Technical Data Sheet (TDS) for specifications and requirements for a specific engine. Any fuel system that cannot be adjusted to meet the specified values will require repair or replacement of the affected components prior to further engine operation.

5.3.2 Pre-Adjustment Procedures:

1. Flush the aircraft fuel system. Remove the aircraft supply fuel hose at the fuel pump inlet and direct the hose into a suitable container. Operate the aircraft boost pump and allow a minimum of one gallon of fuel to flow through the system.

If contamination is present, locate and correct the source, then repeat this step before proceeding. Verify that the fuel is 100LL.

CAUTION

Remove all potential sources of ignition prior to flushing the aircraft fuel system.

2. Prior to any checks or adjustments, verify the accuracy of the aircraft tachometer, manifold pressure gauge and fuel flow gauge. Any gauge found to be inaccurate must be repaired or replaced prior to adjusting the fuel system.

WARNING

Use of inaccurate gauges may result in incorrect adjustment of the AE Fuel Injection

GENERAL SERVICE INSTRUCTIONS

System, pre-ignition, detonation, loss of power and severe engine damage.

3. Ensure that all fuel system components are of the correct part number and properly installed. Correct as necessary.
4. Inspect fuel screen. Clean as necessary.
5. Inspect the aircraft induction air filter and alternate air system for condition, operation and cleanliness. Repair or replace any component that is not airworthy.
6. Inspect the aircraft vapor return system for proper operation. Correct as necessary.
7. Ensure the fuel manifold valve vent and fuel pump drain lines are properly installed, open and free of obstruction. Correct as necessary.
8. Inspect all engine control rod ends for freedom of movement, proper installation and security. Correct as necessary.
9. Ensure that all engine controls operate freely throughout their full range of travel and are properly adjusted. In particular, ensure that the butterfly valve in the throttle body reaches the fully open position before the cockpit throttle control reaches its full-open stop. In addition, inspect the mixture control lever on the fuel injection pump to verify that there is full travel from idle cutoff to full-rich as with the throttle control. Correct as necessary.
10. Lubricate all control rod ends and fuel system components.

WARNING

Failure to correctly install and maintain engine controls can result in loss of system control and subsequent engine power.

11. Inspect the exhaust and induction systems for proper installation, security and leaks. Correct as necessary.
12. Inspect all lines, hoses and wire bundles for chafing, loose connections, leaks and stains. Correct as necessary.
13. Install Fuel Pressure Test Gauge using suitable fittings and hoses. AE recommends using the AE Fuel Injection System Calibration Kit, p/n AE115, which is sold by ECi.

14. Bleed all air that was introduced into the fuel system during installation of the Fuel Pressure Test Gauge in accordance with procedures contained in the instructions provided with the kit. Position the throttle control in the FULL OPEN position and push the mixture control to FULL RICH. Turn on the aircraft high boost pump but operate it only long enough to allow purging of air from the system. Verify that all fuel lines, hoses and fittings are secured and torqued to their proper values as defined in the Technical Data Sheet and that no fuel leaks exist before proceeding. Ensure that test hoses have been routed clear of the exhaust system and are supported their entire length to preclude inaccurate gauge readings.

5.3.3 Adjustment and Test Procedures:

WARNING

Before starting the engine, ensure that the aircraft wheels are chocked, the brakes are set and the prop is clear. Verify that all fuel has drained from the induction system prior to attempting to start the engine. Failure to do so could cause hydraulic lock and subsequent engine failure. If the airplane is a taildragger, ensure that the tail is securely tied down to prevent the tail from rising during FULL THROTTLE operations.

CAUTION

Prolonged engine operation at high power without a cooling shroud can cause engine damage. This is particularly true for new engines when piston rings are not fully seated. However, short runs to measure and adjust fuel pressures can be safely accomplished. The most important considerations for a new engine are to ensure that the engine receives sufficient fuel at full power in order to avoid overheating or detonation and that the engine idles reliably without stalling. In any event, final checks and adjustments to the fuel system should be made after engine break-in is complete.

1. Install the engine cowling or cooling shroud during ground operation.
2. On a suitable piece of paper, record the applicable IDLE and FULL THROTTLE adjustment points (i.e. RPM, fuel pressure, fuel flows, manifold pressure and EGT).

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This information is contained in the AE Technical Data Sheet for the specific fuel system model that is being adjusted.

NOTE

To insure optimum cooling during FULL THROTTLE operations, the FULL THROTTLE fuel flow should be set to the top of the requirements limit.

3. Prepare the aircraft for ground run and start the engine in accordance with the aircraft manufacturer's instructions. Advance the throttle to 1500 to 1800 RPM. While monitoring all engine gauges, operate the engine in this speed range until the engine temperatures and pressures have stabilized within their normal operating range.
4. The Idle Speed Stop Screw on the Air Throttle Body and Fuel Metering Unit Assembly (See Figure 5), should be turned in a CCW direction until it does not contact the stop. Use the throttle control to hold idle RPM.
5. Establish idle RPM at 750-800 with mixture lever in FULL RICH position (See Figure 3). Turn the Fuel Pressure Test Gauge selector valve to the hose that is connected to the fuel pump outlet or fuel metering unit inlet which will allow reading of un-metered fuel pressure. Observe the Fuel Pressure Test Gauge and record the reading. If the reading is outside of the applicable requirements, adjust the IDLE un-metered fuel pressure using the Low Pressure Relief Valve adjusting screw on the Fuel Pump and Vapor Separator (See Figure 3).

CAUTION

The IDLE un-metered fuel pressure adjustment must be accomplished prior to any other fuel system adjustment. After each adjustment, increase engine RPM to 1500 to 1800 RPM for 10 seconds to clear the engine.

6. Return to idle RPM. Now the idle mixture must be checked and adjusted. Slowly move the mixture control from FULL RICH to the IDLE cut-off position. Observe the tachometer for an RPM increase of 25 to 50 RPM before dropping off to zero.

NOTE

The RPM reading is influenced by barometric pressure so allowance will have to be made if readings are taken above sea level.

- a. If the rise in RPM is greater than 50, turn the Idle Mixture Adjustment Screw on the Throttle Body (See Figure 5) CW in 180° increments. Reposition the throttle to re-establish idle RPM at 750-800 and repeat Step 6 above.
- b. If there is no change in RPM observed during Step 6 above or the change is less than 25 RPM, this indicates that the mixture is too lean. To enrich the mixture, turn the Idle Mixture Adjustment Screw on the Throttle Body CCW in 180° increments, repeating this adjustment until the requirements are met.

WARNING

Make all adjustments with the engine stopped and the ignition and master switches in the off position.

NOTE

Any adjustment of idle un-metered fuel pressure or idle mixture will affect the other reading. Therefore, continue to adjust and cross check until both readings are within the requirements before proceeding to Step 7.

7. After completing Steps 1 thru 6 above, the FULL THROTTLE fuel flow adjustments must be made. Turn the Calibration Fuel Pressure Test Gauge Selector Valve to the hose that is connected to the fuel metering unit outlet or the manifold valve fuel inlet. This will allow measurement of the metered nozzle pressure. Advance the RPM to 2700 +/- 50 and record the fuel pressure. In addition observe fuel flow and EGT and record the readings.
8. Compare metered nozzle pressure, fuel flow and EGT readings with the requirements. If the readings do not fall within the requirements, first verify that the gauges are functioning properly. When the three measurements are considered in context of the conditions under which a specific engine is being adjusted, a determination can be made as to the need to adjust metered nozzle

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pressure. If it is determined that metered nozzle pressure should be adjusted, adjust pressure using the Adjustable Orifice Screw on the Fuel Pump and Vapor Separator Assembly (Figure 3). Turn clockwise to increase fuel pressure and counterclockwise to decrease pressure.

WARNING

Do not allow cylinder head temperatures to exceed 420°F and oil temperatures to exceed 210°F during FULL THROTTLE operations.

9. After the metered (nozzle) pressure is properly adjusted, reduce engine speed to IDLE RPM. Recheck un-metered IDLE pressure in accordance with procedures stated in Step 5 above, record and compare to requirements. If the observed reading does not meet the requirements, it must be readjusted. If readjustment is performed, the full throttle readings, i.e. fuel pressure, fuel flow and EGT, will have to be rechecked. Continue to adjust and cross check un-metered IDLE and metered nozzle pressure readings until all observed readings meet the requirements.
10. If fuel system adjustments cannot be properly made, it is very likely that a fuel system component may be malfunctioning. Consult Section VI "Troubleshooting" of this manual for help.

NOTE

Due to the air intake and induction system design of some aircraft it may not be possible to obtain rated static RPM until the airplane is in the take-off roll configuration. When this situation occurs, set the FULL THROTTLE fuel settings to provide proper values when rated RPM is achieved during take-off.

11. Next, set the IDLE speed adjustment on the engine. First, start the engine and warm to operating temperatures and pressures. Adjust the throttle to maintain 750 – 800 RPM. Rotate the Idle Speed Stop Screw on the Air Throttle Body and Fuel Metering Unit Assembly (Figure 5) until contact is made with the Throttle Arm stop. Increase engine RPM to 1500 – 1800 RPM for 10 seconds to clear the engine. Return to IDLE and recheck IDLE un-metered fuel pressure, IDLE mixture and IDLE speed.

CAUTION

After final idle mixture adjustment is accomplished, torque the jam nut on the Idle Mixture Adjustment Screw to 25 - 30 in. lbs. DO NOT EXCEED LOCK NUT TORQUE LIMITS. OVER-TORQUING OF LOCK NUT WILL RESULT IN DAMAGE TO THE THROTTLE BODY HOUSING THREADS AND SUBSEQUENT LOSS OF ADJUSTMENT. Apply torque paint and safety wire the nut to the housing.

12. After all ground adjustments and checks are made and the AE Fuel Injection System meets the requirements, disconnect the fuel pressure gauge and related hardware. If using the AE Fuel Injection System Calibration Kit, drain all fuel from the lines and fittings and return the components to the fiberglass case that is supplied with the kit.

WARNING

Verify that all fuel lines and fittings are correctly installed, properly torqued to values established in the Technical Data Sheet and all safety wire is applied as required.

13. Before flying the airplane, read Section 4.3, including the materials that are referenced in the paragraph.
- 5.4 Overhaul
 - 5.4.1 Time Between Overhaul (TBO): The recommended TBO for the AE Fuel Injection System is 2000 hours or the TBO of the engine on which the fuel system is installed, whichever comes first.
 - 5.4.2 Field Overhaul: The AE Fuel Injection System has been designed with a minimum number of parts. Because of its simplicity, the few working parts must be made accurately and assembled with precision fits and clearances. Consequently, AE does not publish overhaul data and provides no support for field overhaul other than services defined in paragraph 5.1 and minor field repairs such as stopping leaks around connections and fittings, replacement of gaskets, etc. Therefore, only a limited number of replacement parts are available from the manufacturer. These part numbers are listed in the Technical Data Sheet which accompanies each specific model.
 - 5.5 Factory Exchange

A prompt and cost effective exchange service is provided through the factory or through authorized engine builders making it possible to exchange the AE Fuel Injection System components for factory reconditioned units.

Figure 3: AE Fuel Pump and Vapor Separator Assembly

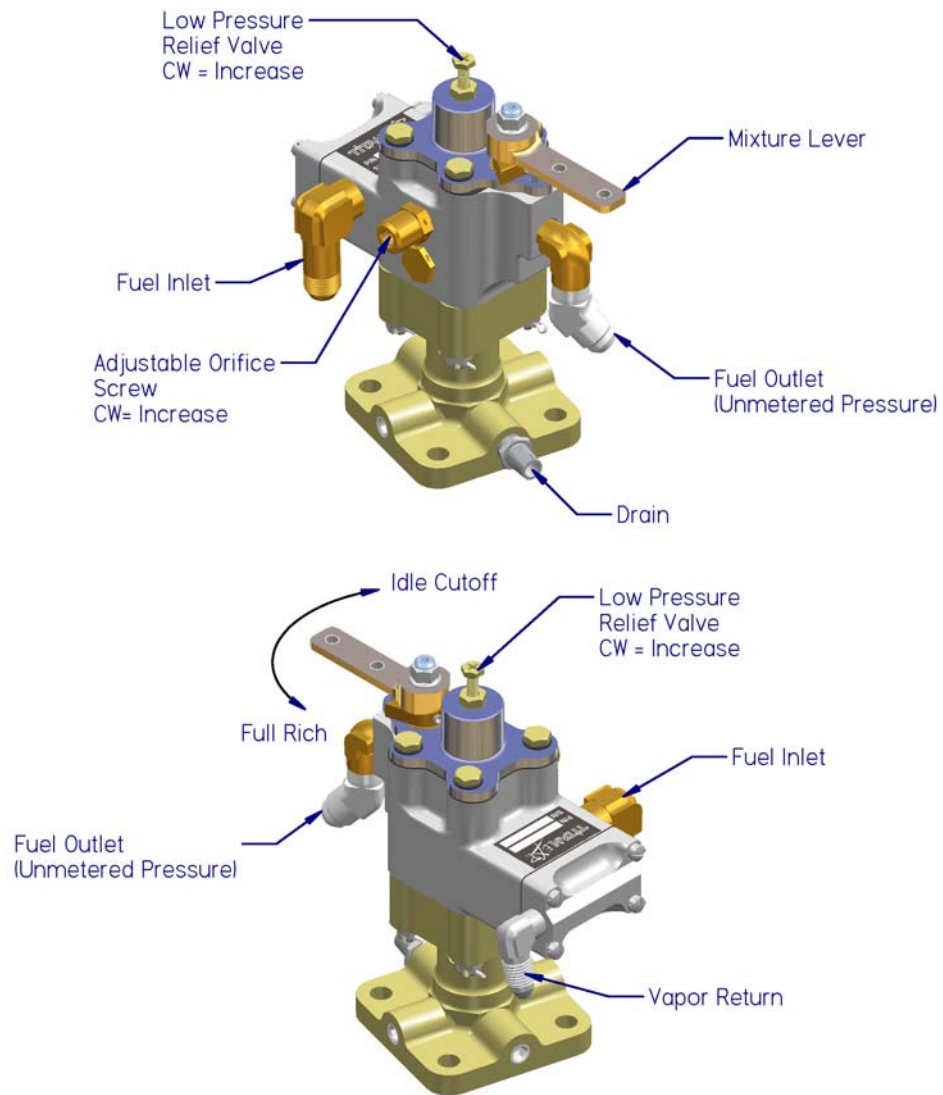


Figure 4: AE Fuel Manifold Valve Assembly

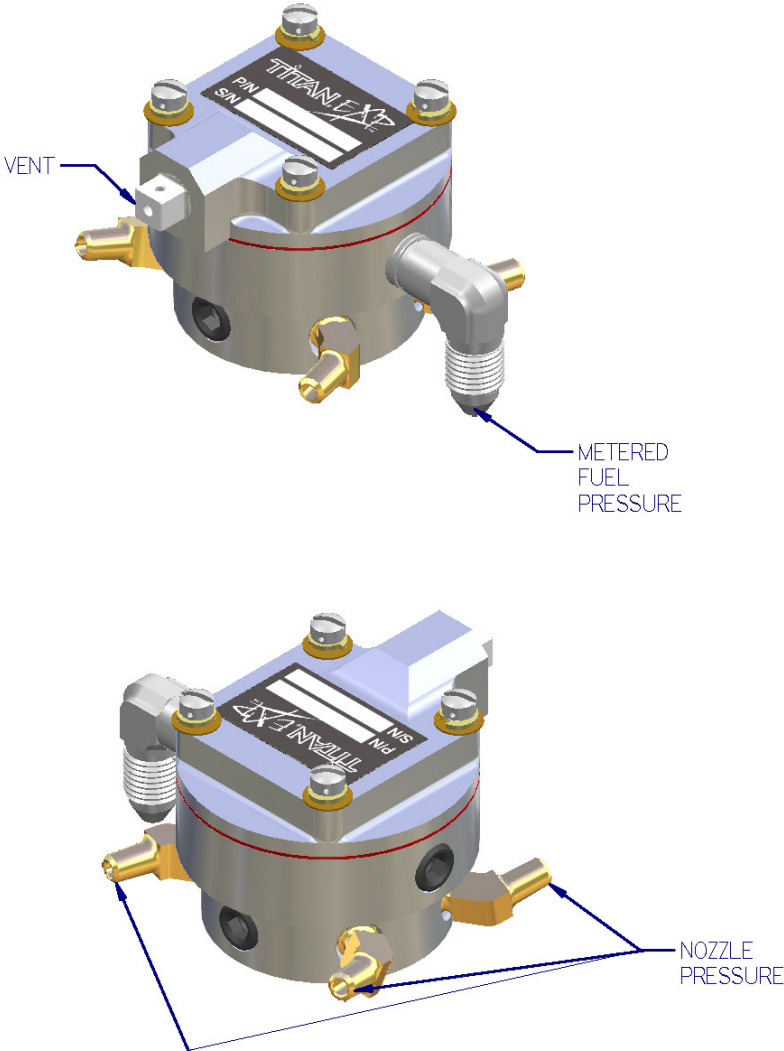


Figure 5: AE Air Throttle Body and Fuel Metering Unit Assembly

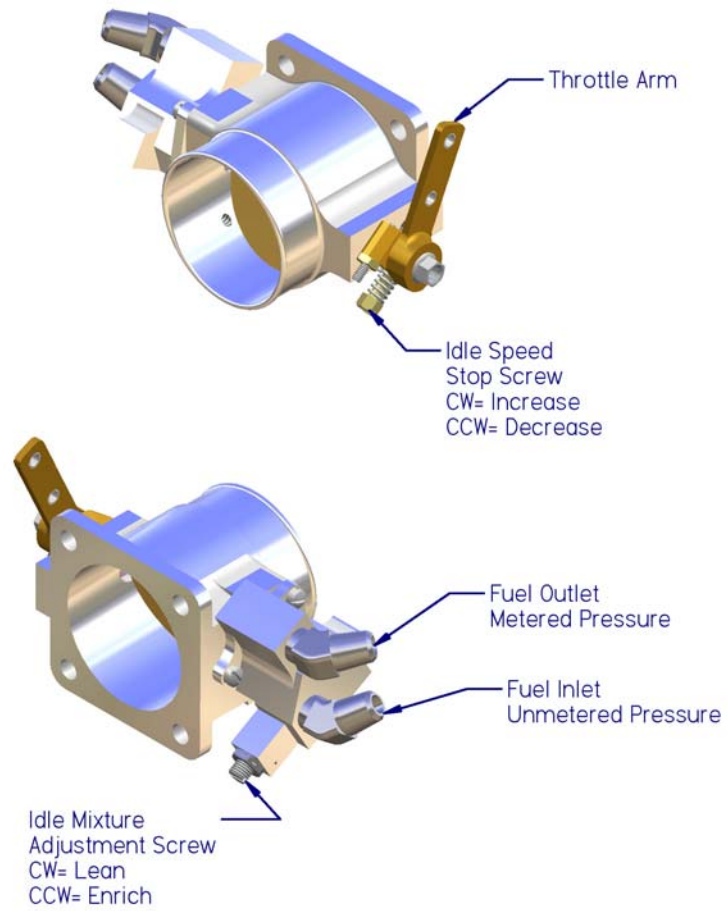
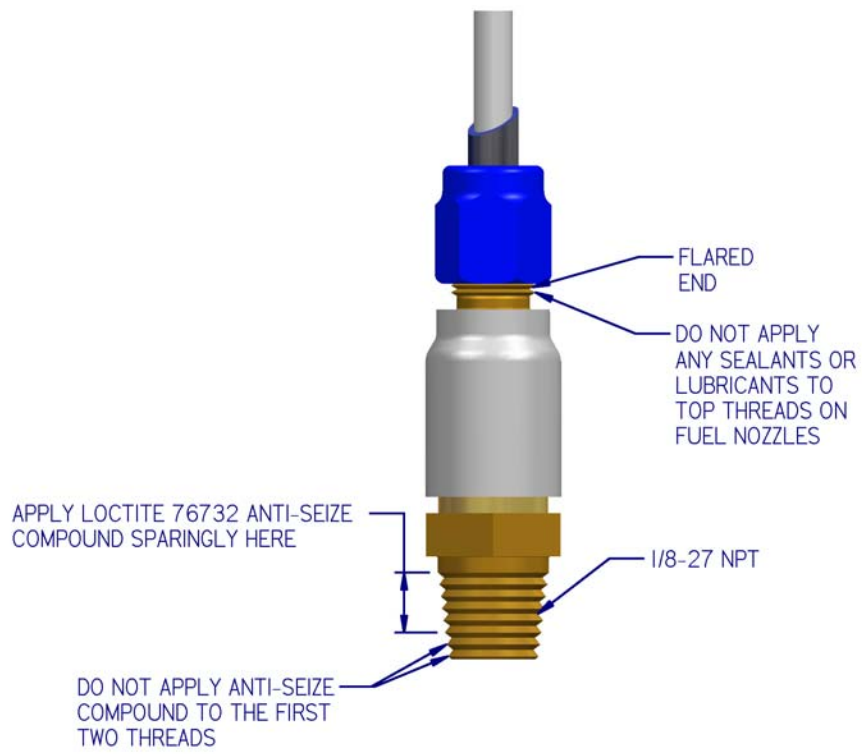


Figure 6: AE Fuel Injector Nozzle



SECTION VI – TROUBLE SHOOTING

6.1 General

The following Table applies only to the fuel injection system and not to the powerplant as a whole. Be sure that the engine trouble is not the result of a faulty ignition system or poor compression caused by defective valves, stuck

rings or scored cylinders. The types of unsatisfactory engine performance listed below may be caused by the fuel injection system, but do not make any adjustments or changes until it is definitely known that the trouble is not caused by the engine or other accessories.

6.2 Table

TROUBLE	PROBABLE CAUSE	REMEDY
Engine will not start	Fuel tank empty	Fill fuel tank.
	Fuel selector valve in wrong position	Turn on selector valve to main tank.
	Ignition not turned on	Turn on ignition.
	Fuel system not primed	See Section 4.2.
	Faulty Manifold Valve	Loosen one fuel line at nozzle. If no fuel flows, replace fuel manifold valve.
	Engine flooded	Allow all fuel to drain from intake system. WARNING: Starting an engine with a flooded intake system will result in hydrostatic lock and subsequent engine malfunction or failure.
	Mixture control improperly rigged	See the airframe manufacturers' instructions.
Rough idle	Engine idle speed too low	See Section 5.3.3
	Improper idle mixture	See Section 5.3.3
	Restricted nozzle jet	See Section 5.1.2
Poor acceleration or engine overheats	Fuel/air mixture too lean resulting from improper adjustment of control linkage	See Section 5.3
	Improper idle mixture	See Section 5.3.3
	Un-metered fuel pressure too high	Lower un-metered fuel pressure. See Section 5.3.3
Rough running engine	Restricted nozzle jet	Remove and clean all nozzles. See Section 5.1.2
	Improper mixture	Adjust engine driven fuel pump in accordance with Section 5.3.3
Low power	Air throttle body not wide open	Inspect throttle body for interference or damage. (Butterfly should be fully parallel to the axis of the throttle bore at full throttle.)
	Obstruction in fuel supply system	Check fuel supply system and strainer for obstruction and leaks and repair as necessary.
Poor idle cut-off	Fuel continues to flow	Check mixture controls in full idle cut-off. Insure auxiliary fuel pump is OFF. Replace manifold valve if necessary.

SECTION
VII – WARRANTY AND RETURN PROCEDURES

7.1 Limited Warranty

Airmotive Engineering Corporation (AE) warrants to the original purchaser of its mechanical fuel injection system (the “Purchaser”) that such products will be free from defects in material and workmanship appearing within one (1) year from its date of first operation. The date of first operation must not exceed one (1) year from the date of shipment from AE and the first date of engine operation on an airframe must not exceed six (6) months from date of engine installation.

AE’s obligation under this warranty shall be limited to its choice of repair or replacement, on an exchange basis, of the component/part when AE has determined that the component/part is defective in material or workmanship. Any component/part exchanged will be warranted for the remainder of the original warranty period.

AE will not assume any responsibility for any labor or transportation costs in connection with the repair or replacement of any part or component under this warranty.

Claims for warranty must be accompanied by adequate proof of elapsed hours and be filed with AE no later than 15 days after discovery of defect. No warranty claim will be allowed if, in the opinion of AE, the part, product or system was improperly adjusted, stored, handled, installed, altered, overhauled or operated contrary to the operating instructions of the manufacturer or was subject to misuse, neglect or accident subsequent to shipment from the AE factory; or if the defect or problem giving rise to the claim resulted from the use of auto gas. AE will not process or honor warranty claims on delinquent accounts.

AE’s warranty does not cover normal maintenance expenses or consumable items. The obligations on the part of AE set forth above are claimant’s exclusive remedy and the exclusive liability of AE. This warranty allocates the risk of product failure between claimant and AE, as permitted by applicable law.

AE reserves the right at any time to change the construction of AE parts and/or products without

incurring any obligation to incorporate such alterations in parts and/or products previously sold by AE.

THIS WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES AND REPRESENTATIONS, EXPRESS OR IMPLIED OR STATUTORY, WHETHER WRITTEN OR ORAL, INCLUDING BUT NOT LIMITED TO ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE, AND ANY IMPLIED WARRANTY ARISING FROM ANY COURSE OR PERFORMANCE OR DEALING OR TRADE USAGE. THIS WARRANTY IS ALSO IN LIEU OF ANY OTHER OBLIGATION, LIABILITY, RIGHT OR CLAIM, WHETHER IN CONTRACT OR IN TORT, INCLUDING ANY RIGHT IN STRICT LIABILITY IN TORT OR ANY RIGHT ARISING FROM NEGLIGENCE ON THE PART OF AE, AND AE’S LIABILITY ON SUCH CLAIM SHALL IN NO CASE EXCEED THE PRICE ALLOCABLE TO THE PART WHICH GIVES RISE TO THE CLAIM.

IN NO EVENT, WHETHER AS A RESULT OF A BREACH OF WARRANTY, CONTRACT OR ALLEGED NEGLIGENCE, SHALL AE BE LIABLE FOR SPECIAL OR CONSEQUENTIAL OR ANY OTHER DAMAGES, INCLUDING BUT NOT LIMITED TO LOSS OF PROFITS OR REVENUES, LOSS OF USE OF THE AIRPLANE OR COST OF A REPLACEMENT.

7.2 Return Procedures

7.2.1 For assistance with installation, adjustment, service and warranty matters relating to the AE Mechanical Fuel Injection System, please contact ECI at:

Phone: 800-ECi-2FLY (800-324-2359) or
210-820-8101
E-mail: sales-service@eci.aero
Fax: 210-820-8102

WARRANTY AND RETURN PROCEDURES

Please make available all pertinent information such as, but not limited, to the following:

- Model number of system
- P/N appearing on the component(s)
- Date and from whom the fuel system was purchased
- Date installed on the engine
- Make and model of the engine

7.2.2 Contact an ECI Territory Manager at 800-324-2359 to obtain a Return Material Authorization (RMA) before sending the product. The RMA form may be downloaded at www.eci.aero/services. All products returned for warranty work must be sent shipping charges prepaid to:

Engine Components, Inc.
Attn: RMA (RMA#, (Customer RMA#))
9503 Middlex
San Antonio, TX 78217

CAUTION

All products *MUST* be flushed of *ALL* fuel residue and all fluid fittings should be covered with clean, tight-fitting plugs or caps before shipping to AE for service or warranty consideration. Shipper assumes all responsibility for complying with OSHA Hazardous Material regulations.

Figure7: AND20003, Air Force-Navy Aeronautical Design Standard

NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility, nor any obligation, whatsoever; and it is the duty of the contractor to make such arrangements as may be required by law to protect its interests in any manner including the holder of any other patent or copyright, or securing any rights of protection in inventions, etc., or all any possible invention that may in any way be related thereto.

NOTE: This drawing was approved by joint action of the Air Force and Navy Departments as the Air Force Navy standard design for this type of drive. This drawing represents the minimum area requirement, and is not to be used for other than the minimum area of approved design.

