INSTALLATION:

PLANNING

Because of the many differences between the TBI and the aircraft's original fuel metering system, it is very important to carefully plan the routing of all linkages, plumbing, and ducting components before beginning the permanent installation.

Like other diaphragm fuel metering systems, the TBI will experience momentary power loss when momentary interruptions in fuel flow occur. This can result from the formation of vapour or the ingestion of air from leaks in the fuel system.

Below is a list of potential vapour or air leak sources that should be considered during the planning phase of any TBI installation.

1. Boost pump, gascolator, fuel filter, and fuel valve should preferably be located outside the engine compartment or mounted together and blast cooled.

2. Boost pump should be located below the level of the fuel in the tanks.

3. Engine driven fuel pump should be shrouded and blast cooled.

4. Fuel lines in the engine compartment should be insulated by fire sleeve and protected from radiant heat sources (exhaust pipes) by reflecting baffles.

5. Minimize the number of fuel line fittings, especially 90 degree elbows, and limit the length of the fuel line, especially in the engine compartment.

6. Maintain constant upward slope of fuel line from the boost pump (i.e. avoid high points or loops where air bubbles can accumulate).

7. On aircraft with improperly baffled fuel tanks, the fuel tank fuel line. In such cases, long slips and sharp taxi turns before takeoff should be avoided while operating with low fuel tank levels.

8. Avoid fuel system complications which invite errors in fuel management.

9. Loose fittings, defective O rings, split flares, or improperly installed components such as primer pumps and gascolator seals, can be a troublesome source of air leaks and are usually difficult to identify.

INSTALLATION REQUIREMENTS

In order for the Rotec TBI to perform satisfactorily and dependably, the finished installation must include the following features:

A. Inlet air filter

B. Induction air system

C. Cockpit throttle stops, open and closed

D. Cockpit mixture control stops, rich and lean

E. Fuel filter, 40 micron or finer

F. Fuel pressure requirements:
All Models require 0.5 to 15 psi.

G. The aircraft fuel system, up to the point of connection to the TBI, including lines, filters, pumps, valves, and fuel flow sensors, must demonstrate the capability of flowing 150% of the rated power fuel requirements of the engine when operating on the last gallon of fuel in the tank. This flow capacity must exist when the aircraft is at the pitch attitude yielding minimum fuel head and with the fuel boost pump operating.

H. Fuel tank vents in all tanks

MOUNTING

Because the Rotec TBI uses a diaphragm in lieu of a float chamber, the unit may be mounted in any position. There are a few positions which should be avoided if possible.

On Continental and Lycoming engines, the TBI must be mounted in an orientation that places the spray bar tube in a horizontal plane. If the metering tube is not in a horizontal plane, positive or negative “G” forces acting on the diaphragm will alter fuel metering. Avoid orientations in which the throttle slide moves fore and aft (parallel to the crankshaft), especially in Lycoming engines. The best performance will be obtained when the throttle slide moves in a spanwise direction.

EXISTING FUEL PRIMING SYSTEMS

It is mandatory that the TBI priming system be employed and made functional regardless of whether or not the aircraft has a preexisting priming system. The TBI is used for priming the engine and in emergency situations where fuel is urgently required to keep the engine running. In this instance the engagement of the TBI primer will override the metering flow valve and inject fuel directly into the engine.

INSTALLATION: FUEL

FUEL INLET FITTING

On all TBI models the fuel inlet filter is a 150 mesh finger screen which is quite fragile and must be handled with care if removed. Great care should also be exercised to avoid the introduction of contaminants when removing and re-placing the inlet screen or the plug on the opposite end of the filter chamber. Because the fuel inlet screen is a "last chance" filter, the aircraft fuel system must include a primary filter of 40 micron rating or finer.

The body castings of these models incorporate a double ended fuel inlet chamber which has a 9/16 - 18 female thread at each end. The fuel inlet filter may be installed in either end of this chamber. The opposite end contains a plug. The TBI fuel inlet filter is compatible with standard 3/8 inch flared tube fittings found in most aircraft fuel systems.

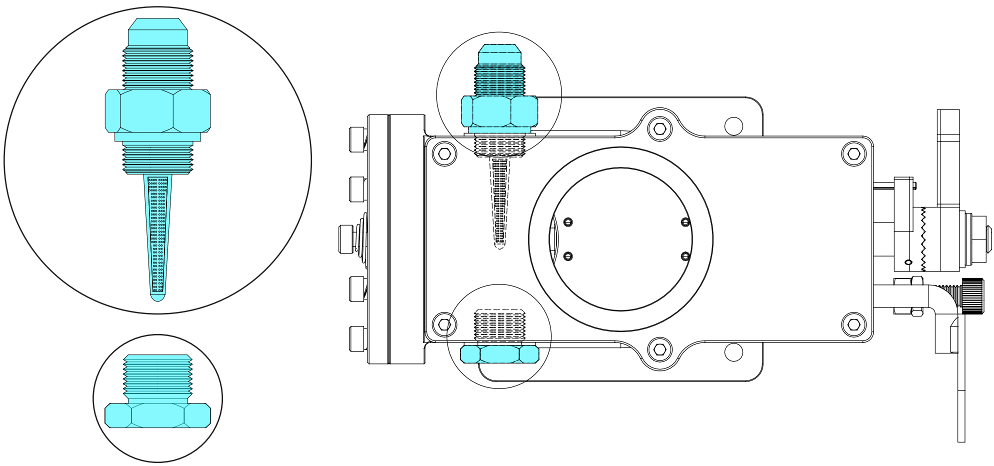

Figure # 6

NOTE

If contaminants are found inside the TBI inlet filter screen, then a failure of the main airframe filter has occurred and must be corrected.

CAUTION

Do not use thread sealing compounds or tape. All fitting joints use a flared tube seat and, if properly installed, require no additional sealing material.

FUEL FILTRATION

The Rotec TBI Fuel System requires the air frame have its own fuel filtration up stream. The fuel filter used with the prior carburettor can be used with the TBI. An automotive fuel filter or gascolator can be added if a fuel filter wasn't present previously. This can be placed anywhere along the fuel line, while keeling in mind the heating of the fuel should be minimised to prevent vapour lock.

The TBI comes standard with a "last chance" filter integral with the TBI body fuel fitting. The filter consists of a very fine 40 micron (0.0016") gauze mesh, designed to stop debris from blocking the TBI spray bar jets, which are holes 0.3 mm (0.01") in diameter.

The TBI "last chance" filter should be inspected and cleaned every 100 hours. Use a 3/4" wrench to remove the fuel fitting housing the "last chance" filter.

Replacement/spare filters are available to purchase individually from Rotec.

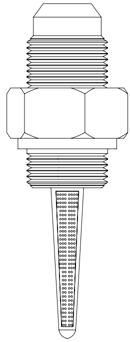

Figure # 7

FUEL SUPPLY

The Rotec TBI Fuel System runs at a broad range of fuel pressures. Typical fuel pressures range between 0.5 - 15 psi. The TBI has been tested with fuel pressures as high as 15 psi. These are not fuel pressure requirements, but instead are recommended provision for adequate fuel flow.

Engines have specific fuel flow requirements. Appropriate fuel flow must be available to the TBI at all times for the engine to run. Engines using the TBI can run with very low fuel pressures where there is adequate fuel flow. Therefore the recommended minimum (0.5 psi) is to allow provisions for flight maneuvers that could disrupt fuel flow.

GRAVITY FEED

Gravity fed fuel tanks work provided there is adequate fuel flow, even when the fuel tank is almost empty. If gravity fuel feed worked originally, then it will work with the TBI.

It is recommended that the ground tests are conducted at low fuel tank levels and high power settings to confirm whether adequate fuel is supplied at all fuel tank levels.

Upon engine shutdown, the TBI metering regulator will cut off fuel flow, however it is not the sole intension of the TBI metering regulator to perform this duty. For that reason it is highly recommended that airframe fuel shut off tap be used to positively shut fuel supply off to the TBI.

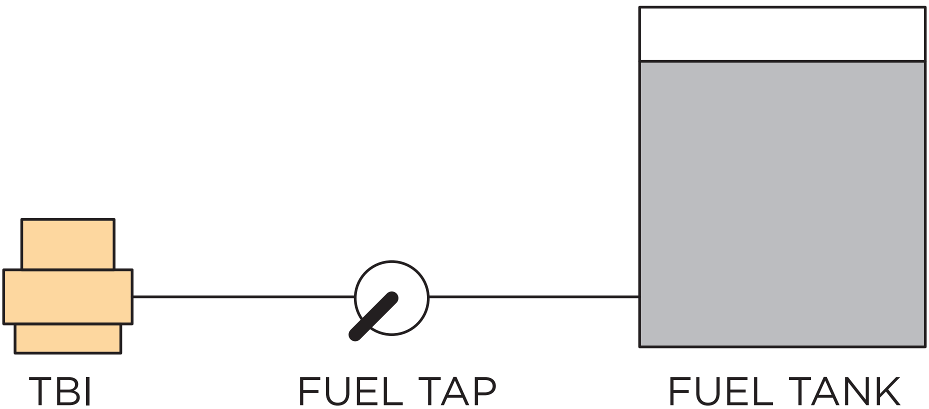

Figure # 8

NOTE

The TBI regulator must always be used, even when using gravity feed. This dynamic metering device alters fuel flow depending on engine demand and is a critical part of TBI function.

ELECTRIC PUMP

The Electric Fuel Pump offers more provision for aerobatics due to the constant fuel pressure supplied. Typical fuel pumps used on piston aircraft engine will fall within correct specification.

Fuel tanks positioned lower than the TBI require a fuel pump.

You should consider the inclusion of a restricted return line for provision against vapour lock.

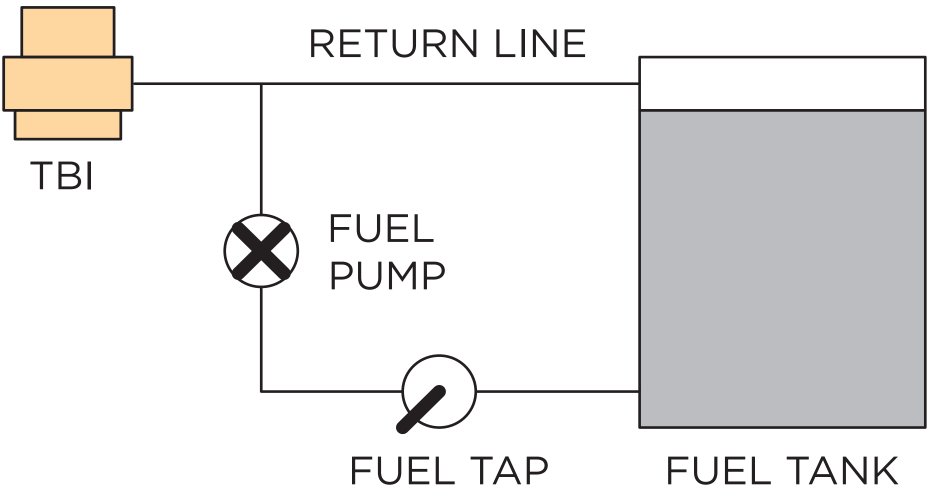

Figure # 9

FUEL DRAIN FITTING

Following engine shutdown, approximately half of the fuel trapped in the regulator (about one teaspoon) will drain out through the spray bar tube and out the intake flange. Provision must be made in the engine compartment to allow this fuel to exit the cowling without creating a fire hazard.

INSTALLATION: THROTTLE

THROTTLE INTRODUCTION

The Rotec TBI Fuel System uses a throttle slide to limit airflow to the engine.

COCKPIT CONTROL

Up to three cables are required to control the throttle slide, mixture arm and primer from the cockpit. Two options are available for controlling the throttle with bowden cables:

<table>
<tr><th>Option</th><th>Where cable (inner) is fixed on the TBI (spacer washer location):</th><th>Moving at TBI:</th><th>Where sleeve (outer) is fixed on the TBI:</th><th>Moving at throttle lever:</th><th>Fixed at throttle lever:</th></tr>
<tr><td>1</td><td>Support bracket</td><td>Sleeve (outer)</td><td>Throttle arm</td><td rowspan="2">Cable (inner)</td><td rowspan="2">Sleeve (outer)</td></tr>
<tr><td>2</td><td>Throttle arm</td><td>Cable (inner)</td><td>Support Bracket</td></tr>
</table>

THROTTLE SETTING

The idle stop is used to set the idle speed (RPM)

The WOT (Wide Open Throttle) stop position of the TBI should be set to stop on the throttle quadrant and not rely on the TBI body. This is to avoid force applied to the roll pin that secures the throttle slide lever to the throttle slide. If a stop on the cockpit throttle quadrant is not used, the user risks damaging the throttle arm by applying excess force when already in the WOT position. You will not need to limit the WOT position of the TBI, unless it is oversized for the engine.

THROTTLE CONTROL SETUP

During engine operation at less than full throttle, a substantial pressure difference exists between the two ends of the throttle slide. This pressure gradient causes a strong buoyancy force acting to close the throttle. This force is greatest at idle and diminishes at increased throttle openings.

Because of the higher throttle friction associated with the TBI, linkage installations utilizing a pull cable in only one direction with spring return in the opposite direction are not satisfactory.

Throttle linkage connection to the TBI throttle control arm must provide movement which is parallel to the throttle control arm within plus or minus 5 degrees. This requirement may be met using a bell crank arrangement or a push-pull cable or rod.

The force required to move the throttle lever should **NOT** exceed 20 N (4.5 lbf), once operating under normal conditions. A levered throttle quadrant is used to operate the throttle slide from the cockpit.

The linear action of the throttle arm has a maximum range of:

<table>
<tr><th>TBI Throat Diameter</th><th>Maximum Linear Throttle Range</th></tr>
<tr><td>34mm*</td><td rowspan="2">40mm</td></tr>
<tr><td>40mm</td></tr>
<tr><td>48mm</td><td>48mm</td></tr>
<tr><td colspan="2">*Able to open beyond the point of full throttle, as it uses the same slide found on units with a 40mm throat. Therefore, the effective throttle range is 34mm. This has no effect on performance.</td></tr>
</table>

The throttle should be operated between power settings progressively.

An aircraft engine with a propeller creates significant load, much like being in high gear in a car. Rapid changes in throttle position, for example from idle to WOT, could see an engine cease operation. This is caused by a rapid change in demand for air. With any increase in throttle, the air velocity at the spray bar is not feeding the required amount of fuel to speed up the engine. This situation is present on any throttle system that limits airflow and is dealt with in a number of ways.

NOTE

Rotec do not offer brackets, linkages or cabling. For linkages or cabling, online aircraft part stores can be helpful in sourcing the desired components.

If rapid throttle operation is required, throttle up from low idle RPM to a higher idle RPM, increasing the provision for rapid throttling.

NOTE

Maximum throttle control arm extension at Wide Open Throttle from Idle for the various models is as follows:

TBI-MKII	Idle Length	WOT Length	Extension
34 Series	169	206	37mm [1.46in]
40 Series	169	206	37mm [1.46in]
48 Model	182	227	45mm [1.77in]

Additional allowance must be made for engine movement on mounts to assure no interference with other parts of the engine or airframe components.

Following installation and hook up of the throttle linkage to the TBI throttle control arm, the cockpit mounted "open throttle" stop must be adjusted so that the cockpit throttle control contacts the stop concurrent with, or prior to, the slide reaching its full open position. This stop is required to prevent excessive pilot force being applied to the throttle control arm.

Adjustment of the "throttle closed" stop will be described in Mixture Setup (p.40) of this manual.

MIXTURE CONTROL INTRODUCTION

The Mixture Control Arm on the TBI is a simple aluminium lever that can be positioned at different angles about the Spray Bar tube's axis. Full travel of the Mixture Control Arm requires that the arm be able to swing 90 degrees of arc in going from Full Rich to Full Lean as seen in Figure # 10 . The Full Rich mixture position occurs when the metering holes in the Spray Bar are orientated perpendicular to the airflow. Full Lean occurs when the metering holes look directly into the airflow.

The Mixture Arm Base is permanently pinned in place limiting the tube rotation angle to 90 degrees to ensure these settings. To avoid excessive overhang moments, the control element connected to the mixture arm must be a lightweight bowden wire or the equivalent. For installation flexibility, the Mixture Arm Lever may be orientated at any angle that does not obstruct the Throttle Control Rod for compatibility with the engine it is being installed in.

MIXTURE CONTROL SETUP

The Rotec TBI Fuel System has the most efficient means of adjusting fuel mixture. Rather that using a crude flow valve, it uses a fuel delivery spray bar with many tiny holes along its length, rotating through a smooth and consistent 90° arc.

Mixture	Full Lean	Maximum Rich
Turn Mixture Arm:	Clockwise	Counter Clockwise
Spray Bar Hole Orientation to Airflow:	Parallel*	Perpendicular

NOTE

***Spray bar holes face the incoming air stream. If the orientation were reversed, the spray bar would have no way of leaning the mixture.**

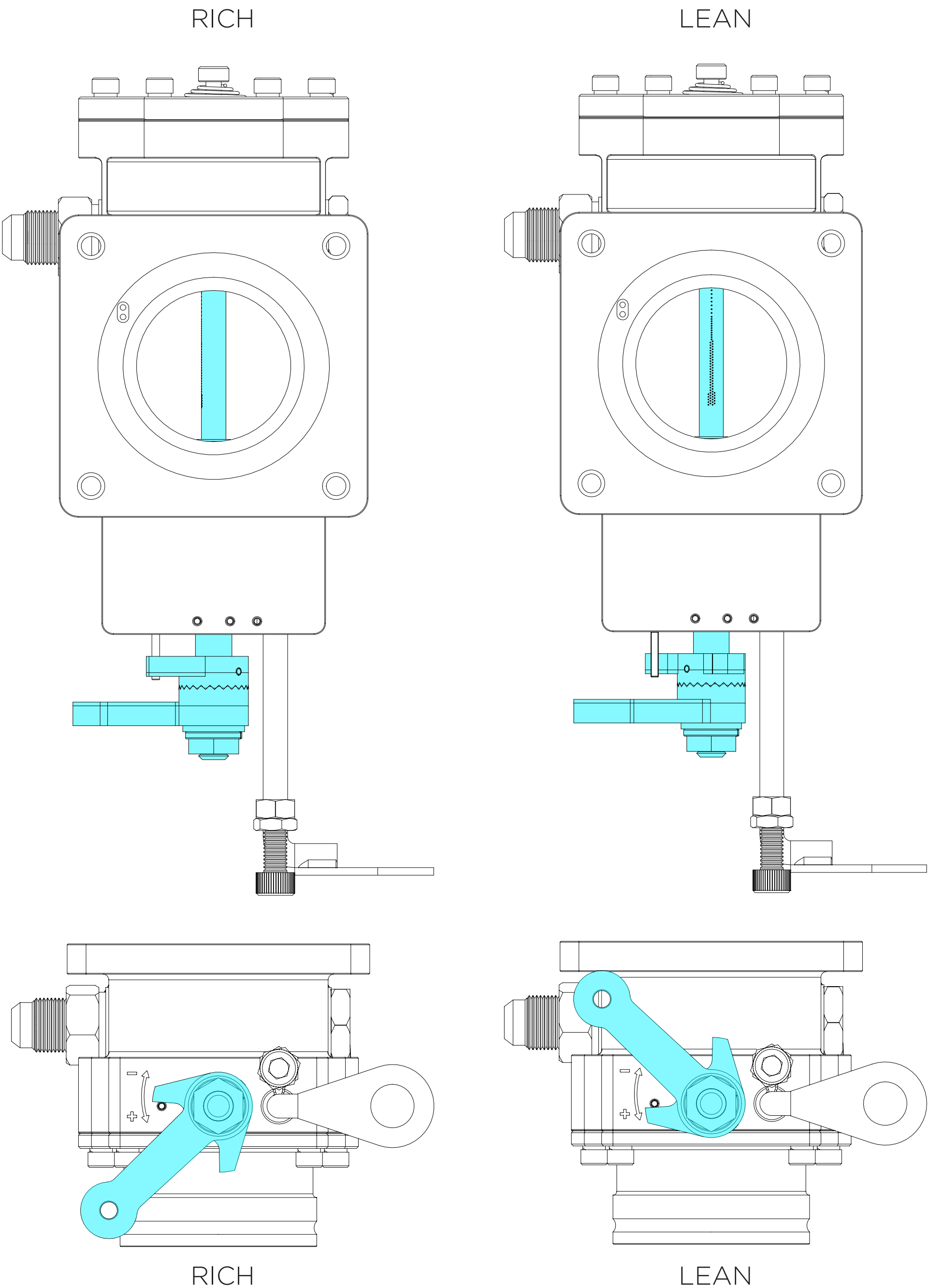

Figure # 10
Mixture Operation

INSTALLATION: MIXTURE

MIXTURE ARM ADJUSTMENT

The mixture arm position can be adjusted for better access by the cockpit controls. To make an adjustment, undo the M8 lock nut with a 13mm wrench an adjust accordingly.

Be careful not to orientate the mixture arm with respect to the throttle control rod, so that it does not interfere with the throttle control rod stop. It is possible to have the arm prevent the throttle slide fully closing. This must be avoided.

COCKPIT CONTROL

Up to 3 bowden cables are required to control the throttle slide, mixture arm and primer from cockpit.

The mixture lever arm can be re-positioned on the mixture arm base ratchet. To do this loosen the M8 lock nut with a 13mm wrench and reposition as desired.

WARNING

Do not hang heavy unsupported cables on the mixture arm, as this can result in the damage to the mixture lever or base of the spray bar.

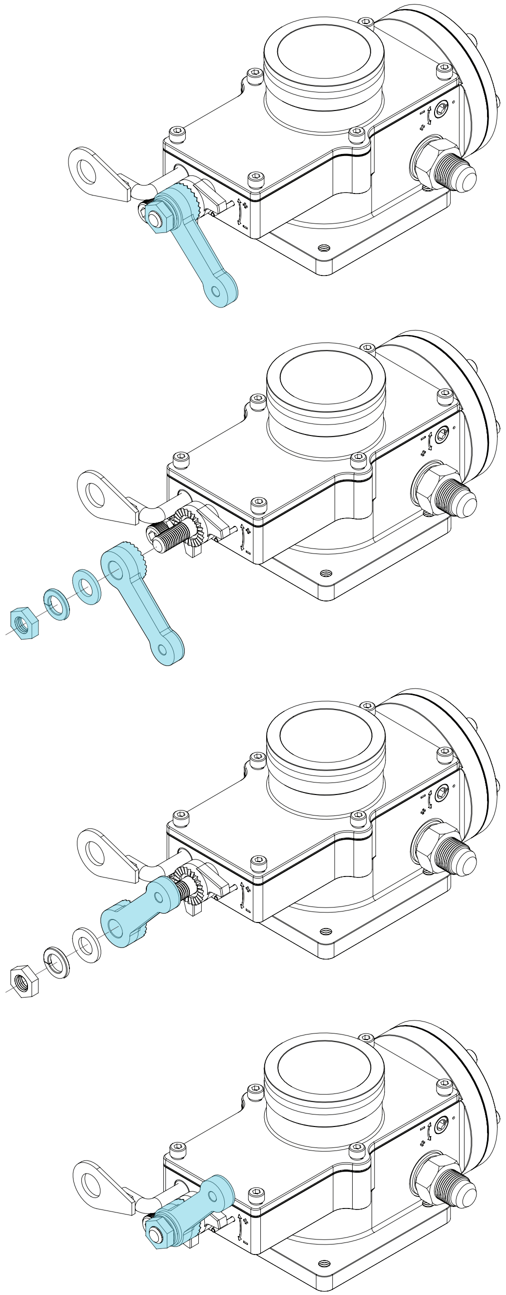

Figure # 11

INSTALLATION: PRIMER

REGULATOR OVERRIDE SETUP

The Rotec TBI Fuel System offers priming, a unique feature not found on the other fuel systems. When pressed, the function of the regulator is temporarily over ridden and fuel flows freely from the spray bar for engine cold starting.

The inclusion of a cockpit controlled primer lever is mandatory in the unlikely encounter of vapour lock or other possible fuel starvation anomaly. The primer can be used to recover a failed engine.

Located in the center of the fuel pressure regulator the primer button can be controlled from the cockpit via a push or pull slide cable, much the same as the mixture arm or throttle cable. Support brackets can be fabricated using sheet aluminium, a simple task for recreational aircraft users.

NOTE

Use on-line aircraft part stores for sourcing desired linkages, cabling and throttles. We do not supply these, as customer requirements differ vastly between projects.

CONFIGURATIONS

The primer can be activated using a pushing or pulling action, depending on how you choose to set it up.. This could even involve a mechanism where the mixture level position beyond full rich is used for primer control. The primer can be activated using a pulling action, allowing the use of a friction throttle for control. See the MK.I examples below where the regulator is separate entity to the body.

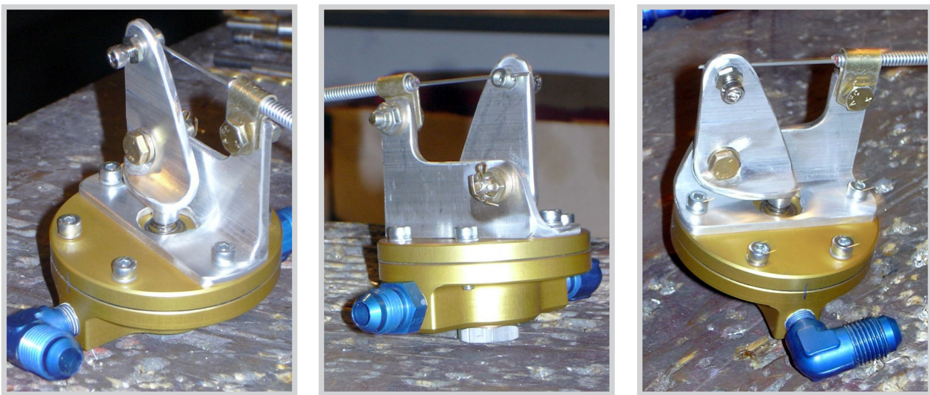

Figure # 12

Figure # 13

Example of custom made bracket design

ELECTRONIC CONTROL

While a regulator primer button activated by electronic control has been done, it is not ideal. In order to counteract vapour lock or other fuel starvation anomalies, such as air bubbles in the fuel lines, rapid pressing or continual depression may be required. Simple electronic control does not allow this, where manual control does. Furthermore, an electronic solenoid used to engage the TBI primer system could be prone to failure. A simple mechanical lever, operated by a cable, is less complicated and more reliable due to the absence of any electronics or electrical systems.

INSTALLATION: HEAT

PROTECTION FROM ENGINE HEAT

Air temperatures in the engine compartment downstream of the cylinders are usually about the same as the engine's oil temperature. Fuel system components such as filters, gascolators, boost pumps etc, can easily heat the fuel to its boiling temperature when located in this high temperature environment. While float carburetors separate vapour and discharge it through the float bowl vent, the TBI, like other diaphragm controlled fuel metering devices, pass this vapour on to the engine, resulting in roughness, power loss or power instability.

Vapor problems can be avoided by:

1. Locating filters, gascolators and boost pumps outside of the engine compartment,

2. Insulating engine compartment fuel line with fire sleeve

3. Blast cooling the engine driven fuel pump. If it is not possible to mount these components remotely, then they should be enclosed together in a box or shroud and blast cooled.

CARBURETTOR HEAT

A carburettor heat system is recommended when using the Rotec TBI fuel system. Although some customers choose not to install one to simplify their installation. Any carburettor or throttle body that restricts manifold pressure to control power output will by nature greatly reduce the local temperature at its throttle opening. Therefore the slide throttle can potentially be impeded from ice build up,if no carburettor heat system is present.

Inclusion of a carburettor heat system is at the discretion of the user.

Carburettor heat system can be used on demand or constantly depending on the desired setup.

INDUCTION AIR INLET

Fuel metering in the Rotec Throttle Body Injector is accomplished by sensing both the direction and velocity of air flowing past the spray bar tube. This means that engine performance can be adversely affected if air entering the Throttle Body Injector is extremely turbulent or is delivered from only one side of the inlet bell mouth.

In general, the efficiency of the induction air inlet can be judged by engine smoothness at full throttle and the extent to which the engine can be leaned at cruise power. An inlet with good flow characteristics will allow an engine equipped with a fixed pitch propeller to run smoothly with the mixture leaned 200 RPM below peak power when operating at or below 75% power. An engine equipped with a constant speed propeller should demonstrate smooth operation when leaned to peak exhaust gas temperature while operating at or below 75% power.

CAUTION

Severe engine damage can result from operation above 75% power with an excessively lean mixture. At a pressure altitude of 7000 feet, the engine produces only about 75% power at full throttle and can tolerate leaner mixtures. Consult the engine manufacturer’s operating manual for proper leaning procedures for fuel injected engines.

Engines operating with poorly designed air inlets may demonstrate engine roughness at wide open throttle, inability to tolerate lean mixtures, and substantial variation in cylinder to cylinder head temperature or exhaust gas temperature.

Appendix D illustrates examples of good and bad inlet configurations. Good inlet configurations promote good cylinder to cylinder fuel distribution, because air enters the Throttle Body Injector inlet uniformly from 360 degrees around the inlet centerline.

Bad inlet configurations such as the examples shown in Appendix D, require intake air to undergo a sharp 90 degree bend while entering the Throttle Body Injector, causing some of the metered fuel to be deflected against the throat wall. Full throttle operation will be rough due to poor fuel distribution, and the engine will have little tolerance for operation on lean mixtures at cruise power settings.

Some configurations which do allow 360 degree air delivery like the one shown in Appendix D, may experience problems at full throttle due to the short vertical distance between the Throttle Body injector and the opposite air filter flange.

This configuration promotes the formation of a standing vortex in the inlet bell mouth, reducing the airflow capacity of the Throttle Body Injector with resulting full throttle roughness and loss of power.

The performance of engines with bending inlet flow-paths can be improved by increasing the bend radius or by providing a straight section of duct between the Throttle Body Injector and the bend. Alternatively, a 90 degree change in airflow direction can be accommodated by feeding the Throttle Body Injector from a relatively large volume plenum chamber as shown in Appendix D. Dimensions shown in these illustrations should be considered as the minimum. Increasing any of the dimensions will result in improved fuel distribution.

If a Throttle Body Injector is to be installed utilizing intake ducting from an earlier carburetor installation, ground tests should be conducted to determine whether any performance deficiencies exist. If any adverse symptoms are noted, the information contained herein should be used as the basis for designing a new inlet configuration.

AIR SUPPLY

The Rotec TBI Fuel Syetem relies on fine air filtration, as unwanted debris and dirt are not only bad for your engine, but also can impede the movement of the slide throttle. Such debris can accidentally be introduced when using sealant, compounds or tapes.

Depending on the users installation requirements, air cleaners/filters or plenum boxes can be easily attached to the TBI. Many users choose to fabricate a simple spigot from fiber glass. Others choose to fabricate a mount from aluminum or steel. There is no off the shelf industry standard mount for air cleaners/filter or a plenum box. All installations are unique.

NOTE

It is a good idea to make the internal diameter of the spigot flare match the full radius of the TBI trumpet. All TBI models come with the same air box flange, 4 x 1/4” UNC threads arranged in a 63.5mm (2.5”) square bolt pattern.

Check the external TBI dimensions, including the bolt pattern as the air cleaner/filter or plenum box must connect to here.

Large masses mounted to the TBI should be supported, especially for spigot type engine mounts as the rubber coupling could be pried off it if enough force is applied.

INSTALLATION: AIR

INDUCTION DESIGN

Good incoming air is critical for proper TBI performance. The following can negatively bias the airflow across the spray bar and have an adverse affect on performance:

- Scat hose or duct tubing with sharp bends

- Small air boxes or plenum's that supply inadequate air volume

A plenum box attached to a 30mm stand off works well. Plenum's act as a static air reservoir for the TBI to draw from, rather than pulling from a length of scat hose, which can often have dynamic air fluffing about its length.

If sharp bends are required as space is limited, you will need to use an air straightener or add a plenum chamber that the feed hose can attach to at any angle, even 90 degrees. The plenum in this instance serves as an air feeding chamber and the 90 degree feeder tube only has to replenish the plenum of air.

ISOLATION TEST

Try test running the engine without any induction system. If isolating the TBI from the induction system results in a change in performance, then a re-design of the air induction system will be required. The attachment of a well designed air induction system should cause no decrease in performance. See Appendix C for examples.

RAM AIR

Specific Ram air induction system should be avoided as the incoming ram pressure can disturbed the delicate pressure drop at the spray bar, if the pressure drop at the spray bar neutralized or even become positive then no fuel will flow, and at best the engine may become excessively lean in mixture.

WARNING

Ram air should be avoided as the increase in induction pressure can unsettle the delicate negative pressure across the spray tube. This could result in less than ideal engine performance and rough running. Ram Air becomes more powerful in flight so ground testing may not be a true indicator of total performance.