



FiTech EFI is the Real Deal

***Everything you always wanted to know about
EFI conversion for our GMC's (and likely
some things you never wanted to know!)***

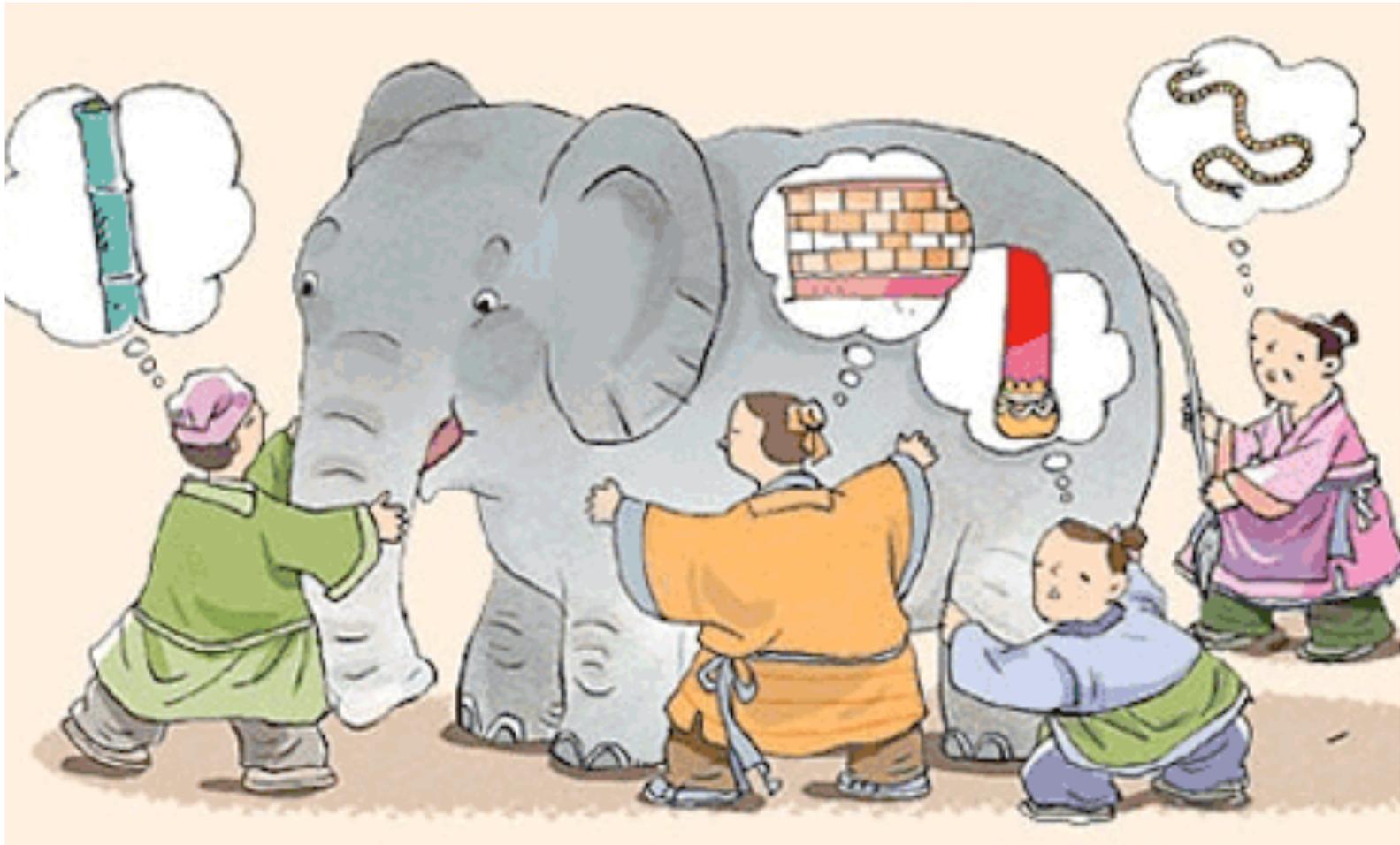
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Display unit provided
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Doing a presentation on fuel injection to this group is a bit like holding a target in front of your face.....

Everyone who has owned a car since the 1970s has direct experience with FI, but not all experiences are the same. There have been many different systems and many advances over the years





Remember the blind man and the elephant story - we all may see the same thing differently

So lets keep our interactions civil and respectful as we delve into this most interesting upgrade for our coaches

A bit of history

- Fuel injection was first developed for diesel engines where there is no air control and power output is determined by how much fuel is introduced into the engine.
- During WWII fuel injection became important for high performance air planes operating at altitudes where a carb simply could not meter fuel effectively



An Antoinette mechanically fuel-injected V8 aviation engine of 1909, mounted in a preserved Antoinette VII monoplane aircraft.

More history

- Following WWII Europe was in shambles and resources were scarce so countries taxed vehicles on the displacement of the engine. Fuel injection there was developed to provide higher performance from small displacement engines.
- In the US, resources were plentiful and power/speed were kings. The easiest way to more power was by larger displacement engines and carbs were simple and easy for the manufacturers to implement on ever larger engines.



Bosch L-Jetronic EFI in an 85 Alfa GTV6

- MB and Peugeot were the dominant diesel players in Europe and they initially adapted their diesel fuel injection for gas engines.
- Bosch also developed fuel injection systems that were widely used.
- Bendix was the big FI player in the US, first with AMC, then Chrysler and GM in the mid 1950s. These systems were fraught with teething problems and hard cold starting, plus the dealers didn't like them because their mechanics couldn't properly service them.
- Bendix finally gave up and licensed their technology to Bosch who came out with a whole line of "Jetronic" systems used by most European car makers clear through the 1990s. First letter designated how the oxygen content of the air was estimated.
- US makers revisited FI beginning in the late 1970s to try to meet ever stricter emission laws.

Let's take a quick look at how FI and EFI systems work

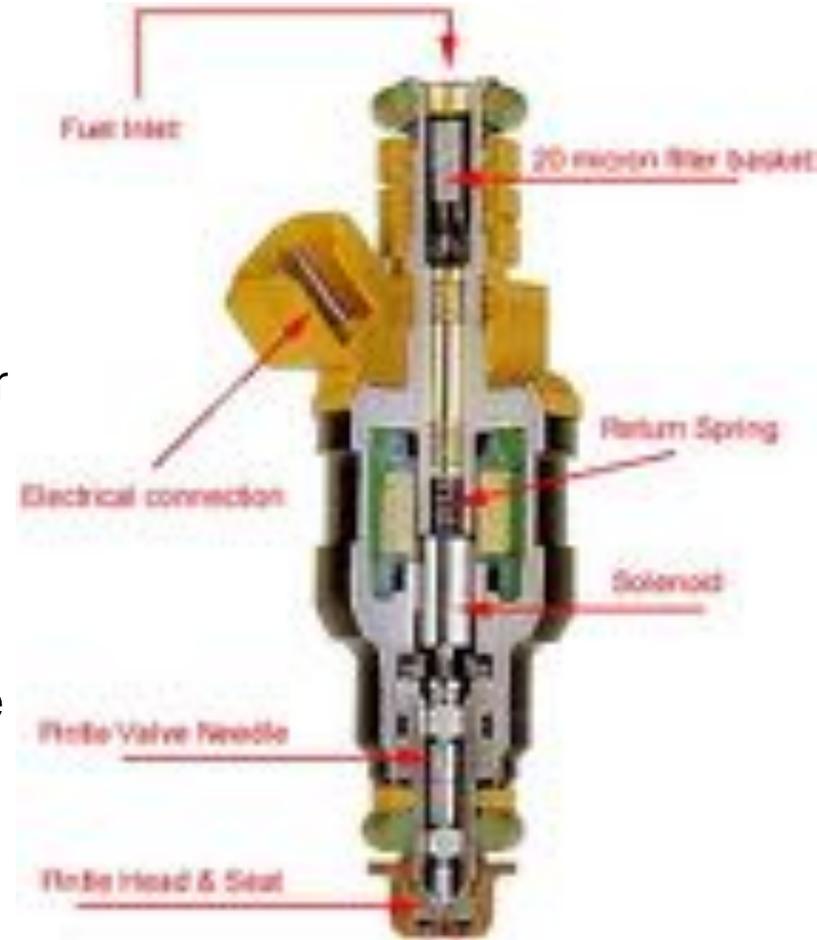
- Some means is used to try to estimate the amount of oxygen in the incoming air - the greater the density of oxygen, the heavier the air is
- Based on that estimate the system tries to determine the power output desired by the driver, the load the engine is under, how hot it is and a bunch of other factors to estimate the proper amount of fuel to introduce into the incoming air stream so the engine will combust the fuel while producing the desired balance between power, fuel economy and exhaust emissions
- In the US, OEM systems were nearly always optimized for low emissions far more than for power, fuel economy, engine life or field maintainability.
- In Europe, OEM systems were usually biased towards performance enhancements for small displacement engines. Fuel economy and field maintainability were usually also priorities.

A lot changed over the years



- Bosch, working with a smaller company, developed a means of measuring the oxygen remaining in the exhaust stream relative to the amount of oxygen in the incoming air stream. At first these sensors could only determine if the O₂ in the exhaust was at, above or below a designed point. Later the sensors became much more discriminating and could say by how much the ratio was above or below the design point. Any, over time, they became much faster.
- These O₂ sensors fed back to the FI system critical information about whether the estimated fuel to be delivered under a given set of conditions was correct or not and by how much the fuel amount should be changed the next time those same conditions were encountered.

- At first the amount of fuel to be delivered was determined by some mechanical means - engine driven pumps for the diesel derived systems and a valve on the end of a lever for many of the gas derived systems.
- A big breakthrough came with the development of a solenoid operated valve (a fuel injector) that could be opened or closed for different periods of time to meter pressurized fuel into the incoming air stream very precisely.
- The early ones were slow so the size of the opening in the injector had to be carefully matched to the demands of the engine. Over time these injectors became much faster so the size of the opening played far less of a role in determining the amount of fuel introduced to the engine. If you wanted more, you pulsed the injector more often, if you wanted less you pulsed the injector less often, so one injector could work for a wide range of engine sizes and performance characteristics.



- Another big break through came with the development of micro processors which could integrate the information coming from a wide variety of sensors to calculate the desired amount of fuel and control the fuel injector.
- Usually these worked off of a table of air/fuel ratios developed by engineers familiar with the characteristics of different engines in different applications - typically engine load on one axis and weight (oxygen content) of the incoming air on the other.
- Additional factors were used as multipliers to modify this basic A/F ratio to account for things like driver input in terms of throttle position, exhaust gas or water temperature, vacuum/manifold pressure, air temperature, feedback from the O₂ sensor, engine RPMs, etc.
- Early microprocessors were slow so could not make very many calculations per unit of time and were prone to failure due to heat and vibration. Early sensors were not all that reliable, either.

- As we moved into the 2000s all these things improved and now very fast, very reliable microprocessors can make many times more and more accurate calculations than they could just a decade or so ago.
- And, they have now become very heat and vibration tolerant to the point they can be placed directly in the throttle body itself instead of needing to be sequestered away at the end of a long, large cable under a seat in the passenger compartment as was the norm not all that long ago.
- Sensors have similarly improved in accuracy and reliability.
- The result is today's EFI systems that can be adapted to our GMC motor coach 455 or 403 engines are a far cry from earlier period fuel injection systems using components now languishing in junk yards around the country.

EFI systems that can be added to our GMCs come in two basic flavors

- In one flavor the target A/F ratio tables and modifiers are determined by the system designer and stored on a memory chip accessed by the microprocessor. In some cases laptop based software is supplied that allows the owner to modify these values if they have the skills to do so.
- The other, newer, types of EFI systems suitable for adding to our GMC coaches are called, “self learning”. They start with a base set of A/F ratio tables and modifiers and then recalculate these values based on feedback from the O2 sensor and the other sensors so over time the values stored in the system - or calculated on the fly - for all the different conditions encountered in real world driving experiences get closer and closer to what the designer considers ideal.

Several self learning options exist in the market

- The most common offerings come from FiTech (the price/value leader at the moment), CompCams Fast-EZ, MSD Atomic, Edelbrock E-Street, QuickFuels QFI, and the Holley Terminator.
- All receive generally favorable reviews and enjoy high reliability.
- They differ in price by about 2x or more, most use off the shelf OEM quality components, all feature proprietary software and they differ in terms of how many external sensors need to be located and wired by the user and where the microprocessor is located.



Our intake manifolds are different so even though the bolt holes line up, you need an adapter between the manifold and the throttle body no matter which of these you use.



- The throttle bodies features four butterfly valves that most commonly open simultaneously. They would hit the web between the primary and secondary openings on our intake manifold, hence the adapter is needed to raise the throttle body up by about 1/2" to allow them to clear the web.
- I used NAPA 735-4930 to install the Fitech throttle body and that worked well for me.

FiTech uniquely also offers a Fuel Command Center that greatly simplifies installation of an EFI system.

- The FCC includes a high pressure, fully submerged fuel pump inside a surge tank that can be located anywhere.
- Also in the FCC is a valve that mimics the float valve in a QJet so you can feed it from any mechanical or low pressure electric fuel pump suitable for a carb.
- The microprocessor controls the output of the high pressure pump to supply only the fuel the engine needs so no liquid fuel return line to the tank is required. You do need to plumb a vapor line from the FCC into one of the vent lines on your coach to catch any liquid fuel should the internal valve fail for any reason.
- The fuel pressure regulator is built into the throttle body so no noise and no extra plumbing required.



Installation is simple

- The first step is to find a place to mount the Fuel Command Center.
- You can use a frame mounted high pressure fuel pump if you wish to plumb your own return lines but this \$400 FCC makes everything so much easier and faster.
- I mounted mine at the upper corner in front of the radiator on the PS to keep it cooled by the ram air coming through the grill.





A UHMW plate is mounted to the stock bracket that holds the AC condenser. The FiTech FCC is mounted to that using the FiTech supplied mounting brackets.



The UHMW plate acts as a baffle to direct air through the radiator. Air that passes to the PS of the FiTech FCC is directed on my Clasco coach through the fan assisted engine oil cooler shown here

With the grill in place you can hardly tell it is there and it has no impact on cooling that I can tell



The next step is to remove the Qjet and bolt on the FiTech throttle body

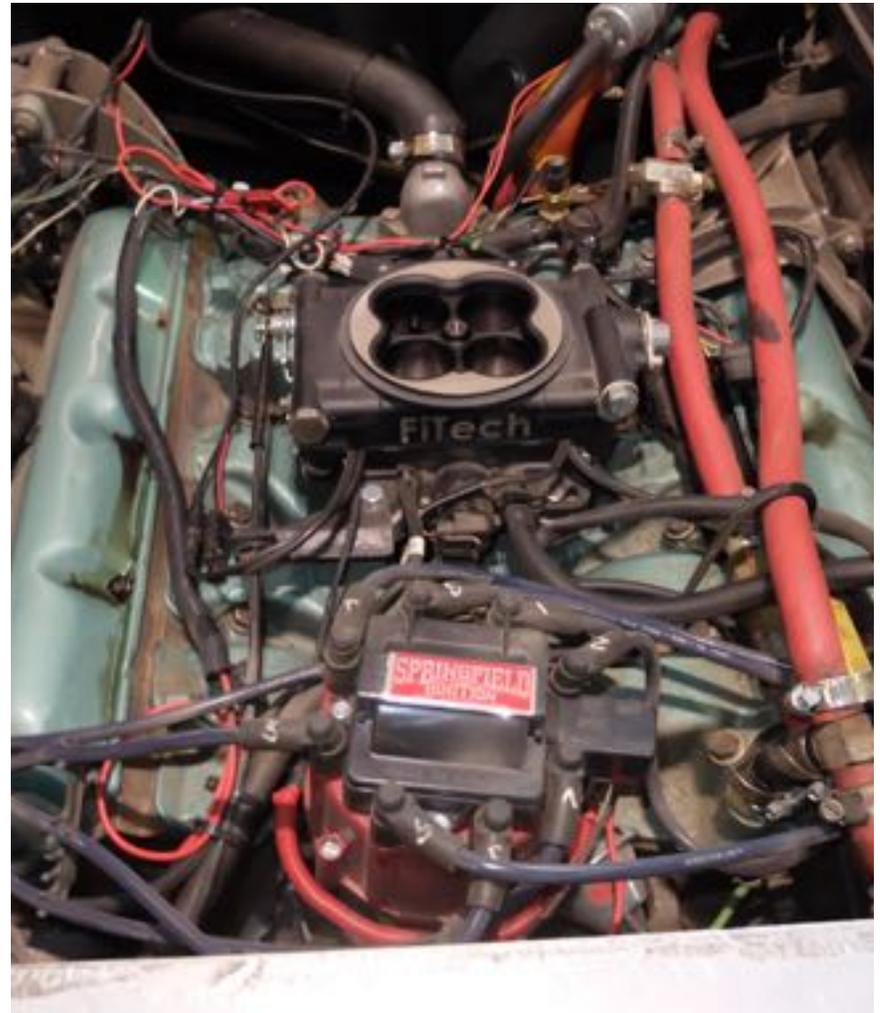
This is where I started - **Bounds QJet and HEI curved for the carb.**



This is where I ended up - **FiTech EFI and Patterson HEI curved for the FiTech system.**

..... remove the QJet and bolt on the FiTech throttle body

- Use an adapter like NAPA 735-4930 so the butterflies don't hit the web
- You will need to cut off the lower part of the FiTech throttle linkage so it doesn't hit our very low intake manifold (pic next page)
- And you need to cut off the QJet throttle cable retainer so it does not interfere with the throttle position sensor on the FiTech throttle body (pic next page)

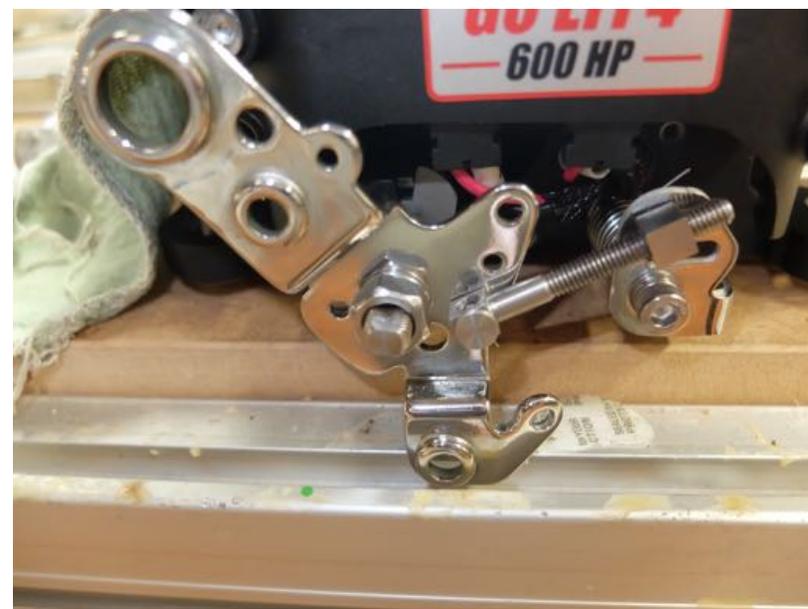


Cut off the lower part of the FiTech throttle linkage so it does not hit the intake manifold as shown at left



Cut off the passenger side of the QJet throttle cable retainer as it would otherwise hit the sensor shown at right

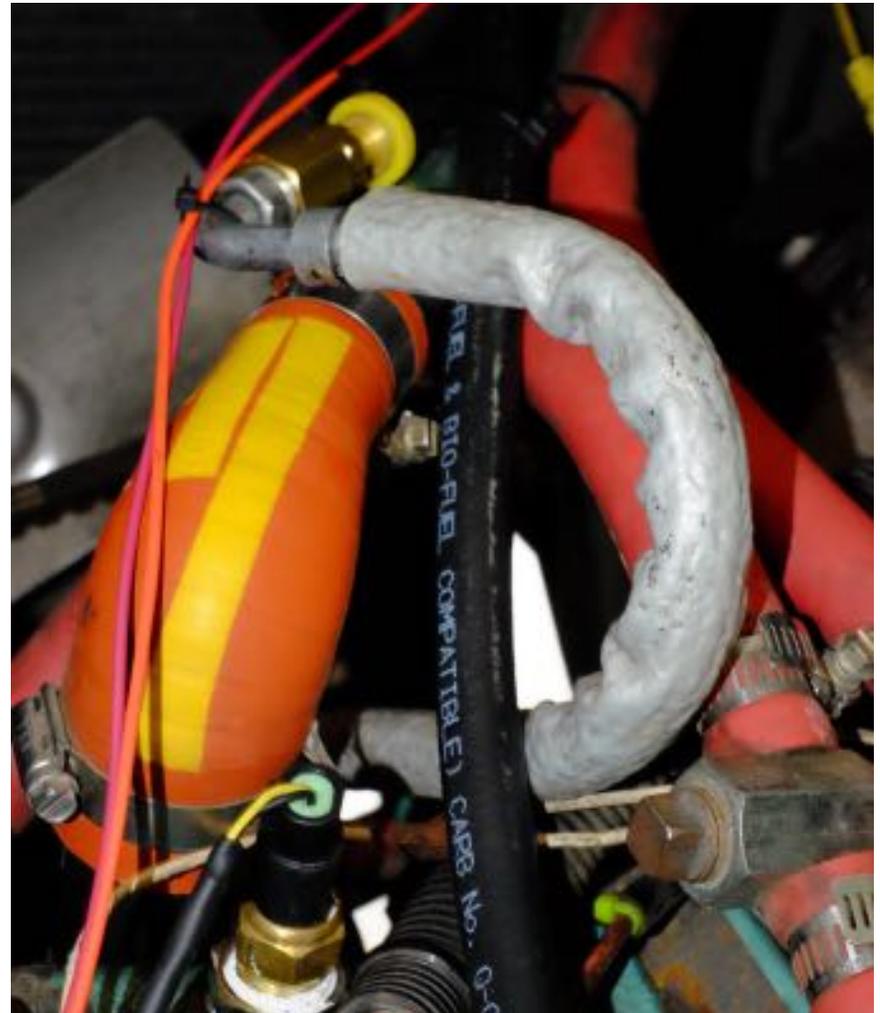




The only other thing you need to do is adapt the throttle cable end to fit the FiTech throttle linkage. I used:
Carb linkage bushing 1/2 to 1/4 - Mr Gasket 6026 from NAPA
Carb linkage stud kit - Holley 20-38 from NAPA.

Next comes plumbing

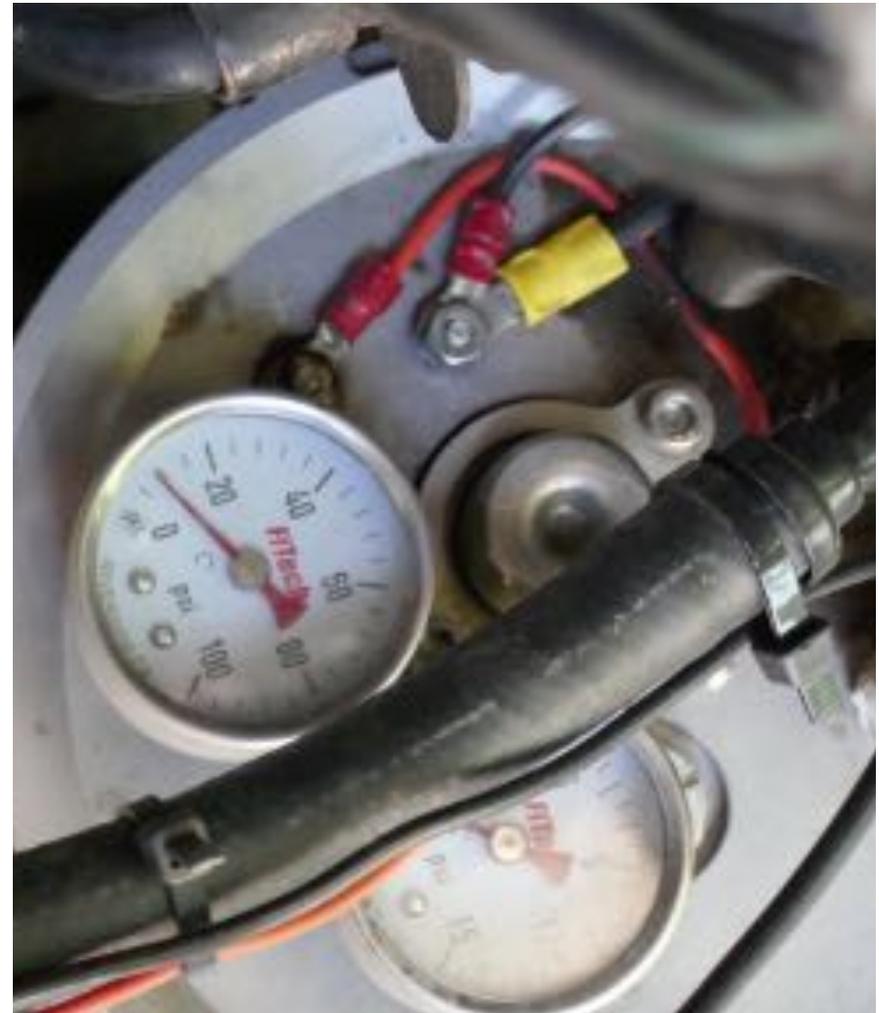
- I already had a small booster pump wired to the tank selector switch so I removed the selector valve and hooked that pump to the aux tank (front) via a metal filter.
- I added a Carter 4070 low pressure electric pump hooked to the rear tank (main) via a metal filter. That is the one I use mainly and that gives me an effective 40+ gallons of fuel.
- I teed those two together through check valves going forward.
- If the Carter ever fails all I need to do is click over to the aux pump via the stock tank selector switch on the dash and run off that pump until I can safely replace the Carter.



- The mechanical fuel pump was removed and blocked off.
- The fuel line coming forward from the two low pressure electric fuel pumps was tied into the existing line that originally ran from the mechanical fuel pump to the QJet. The other end of that line received the hose that goes to the low pressure side of the FiTech FCC.
- The high pressure line supplied by FiTech runs from the FCC to the throttle body.
- Plumbed this way, I can revert back to a carb in less than 20 minutes if I ever experience any kind of EFI issues on the road. All I need to do is remove the FiTech throttle body, bolt the QJet (stored in the pod on top) back on, remove the low pressure FCC line from the low pressure side of the FiTech FCC and screw it back into the nose of the QJet.
- You also need to run a vapor line from the FCC over to a T in the fuel fill vent line on the drivers side of the coach.

All that is left is a bit of wiring, installing the FiTech water temp sensor and the O2 sensor.

- The wire harness supplied with the FiTech unit is long enough to reach everything.
- You supply a wire that is hot when the key is on and also while the starter is engaged. I used the B+ wire going to the HEI but note the change in gauge of that wire from the firewall connector to the distributor.
- You also need an always on + wire and a system ground.
- The micro processor in the throttle body varies the output of the high pressure pump in the FCC according to demand so it stays cool and runs only as hard as it needs to.
- The whole system takes very little power.



- FiTech supplies the O2 sensor with a bung that can either be banded in place with included SS bands and a gasket, or which can be welded in place when you have everything sorted out the way you want it.
- A simple step drill is all you need to drill a hole at least 10 degrees off horizontal where you want the O2 sensor located. With stock manifolds in the Clasco I selected an easily accessible spot on the PS just aft of where the exhaust pipe bolts to the stock manifold.
- The FiTech wire harness was plenty long enough to reach there without issue.



Make sure there is no exhaust leak here or at the manifold to engine block gasket

Follow the very complete installation instructions and your coach will fire right up.

- Using the supplied hand held unit enter basic data about your engine (displacement, type of cam, desired idle speed, etc).
- Pay close attention to how to purge air from the FCC lines and throttle body fuel rail before you start up for the first time.
- Once warmed up, set the idle position of the butterflies to produce 6-10 steps on the idle air controller in the throttle body.
- Use the supplied hand held unit to tell the system you are using the FCC instead of a frame mounted high pressure pump which is the default setting.
- The last thing is to test the clearance between your air cleaner and the hatch cover. I used kids modeling clay to check for interference and then carved away the under side of the hatch cover. If your body pads are squished, you may have to do more extensive work to get the hatch to clear as the air cleaner is about 1/2" higher due to the adapter.



So, what do you gain from adding EFI?

- Your coach will drive and perform like a modern car.
- It will start right up hot or cold without touching the accelerator pedal.
- It will be much crisper on acceleration. It will run smoother and in every way be a more relaxed and enjoyable driving experience.
- Elevation won't matter any more. It will run just as well crossing the Rockies as it does at sea level.
- Fuel consumption will be about the same to begin with and will get a bit better over time as the system learns your driving style.
- If you want to make significant improvements in fuel economy, slow down. You will gain around 0.5 MPG for every 5 MPH you reduce your average speed.
- Using computer controlled spark advance, some users of some EFI systems report a bit better mileage by advancing the spark and leaning out the A/F ratio under light load cruise conditions but that has to be carefully done to avoid damaging the engine from overly hot internal engine temperatures or from pre-ignition.

What about spark control?

- FiTech offers spark control on many of their models via a two wire locked out distributor and external coil. It uses a 3x3 base table (RPM and vacuum) and uses interpolation for all values other than those set in the base table.
- They do not offer or use a knock sensor and appear to to me to prefer to error on the side of protecting the engine from timing or A/F extremes rather than trying to achieving a mile so improvement in MPG. My system appeared to run rich to begin with and gradually has leaned out the more I drive.
- They are high on the stock HEI system for spark control IF the distributor is properly set up and properly functioning. They say that is hard to beat for most street applications.
- Dick Patterson (Springfield Ignition) has talked with their engineers and has developed HEI curves to match their recommendations for use in our GMC coaches. This is what I use.

The included hand held controller is very useful

- The only time you need to use it is when you first input info about your engine and when you decide you want to alter some setting (like telling it you are using the FCC instead of a frame mounted high pressure fuel pump).
- But, you can also mount it inside and use the many dashboard features to display real time as many parameters as you wish to monitor. Most of the time I use the “large gauges” function to display water temp and A/F ratio.





The FiTech display unit has a metal case and color touch screen

You can set any number of things to display while you drive



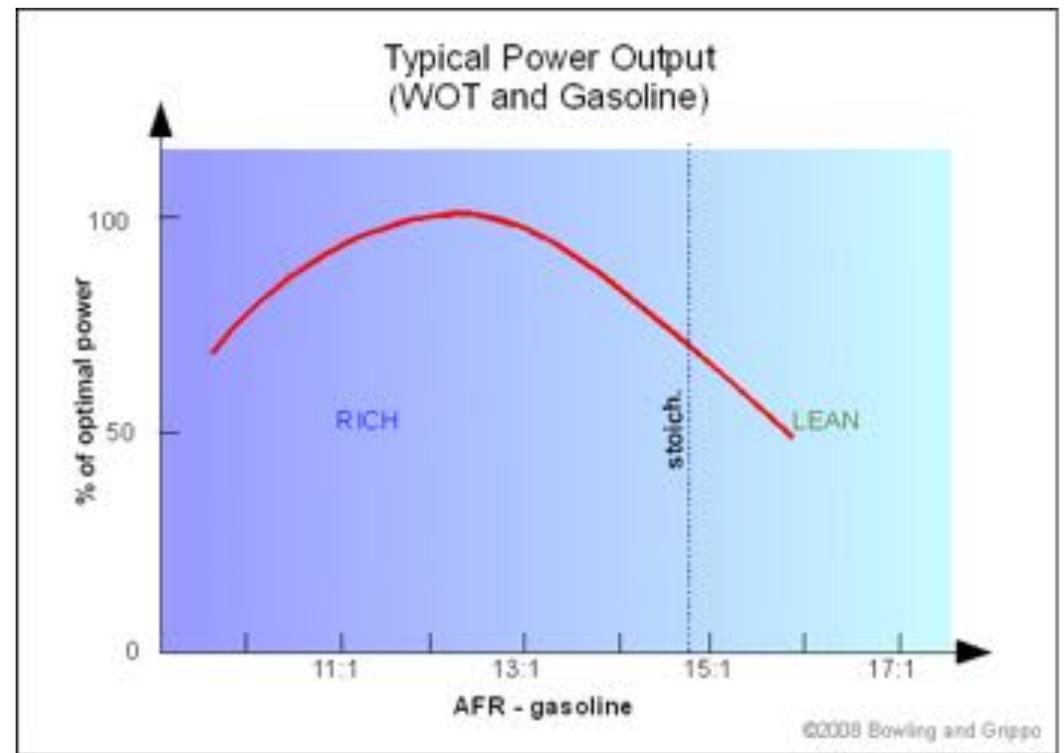
Other things you might want to do.....

- Use the controller to monitor how precisely you have set the butterfly throttle plates static position to produce the best idle and off idle performance for your engine.
- If your engine fires on the second or third crank and you want it to fire on the first, you can use the controller to increase the initial fuel shot. I keep mine set to fire on about the third crank so the engine can build up a little oil pressure before starting.
- If you want it to settle down to your selected idle speed faster, you can use the controller to change how quickly the IAC in the throttle body reacts. I keep mine fairly slow coming to idle.
- You don't need to do anything with the hand held controller, but if you are so inclined you can exercise very precise control over more than 130 parameters to make your coach perform exactly like you want it to under all driving conditions. No laptop needed.

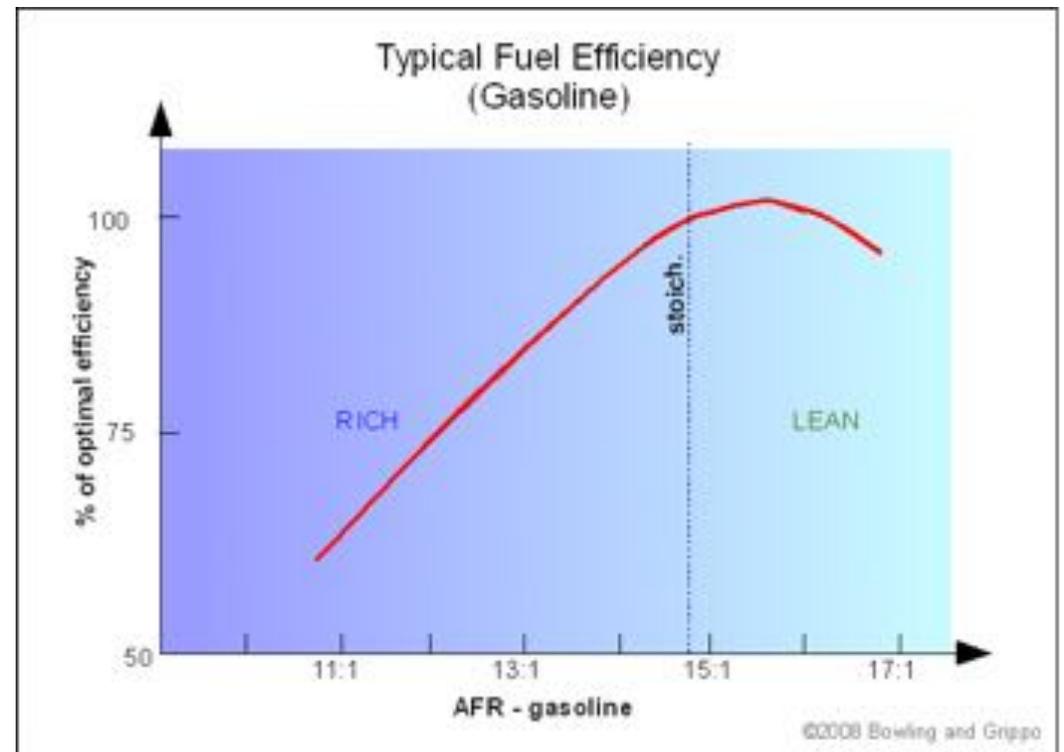
The bottom line

- ***Self learning EFI systems seem ideal for our GMC coaches.*** The FiTech unit is one of the newest designs and also the least expensive at the moment so it appears to be the value leader.
- It costs about half what the competing units cost yet appears to be very well designed and manufactured from very high quality components. Machining and casting looks to be first rate and my experience over more than 5,000 miles suggests it will turn out to be quite reliable as well.
- It installs easily in a day or two.
- If you pay attention to how you do your plumbing you can revert back to a QJet in less than 20 minutes without getting under your coach if you have an EFI issue while on the road. That means you continue your trip under carb power and do all your EFI diagnosis from the comfort of your own garage when you get home.
- It will do all the learning work for you as you drive. It is always updating its information to get better and better at calculating the correct A/F ratio for every given driving condition you experience.
- If you want to “help” it, you can control as many of the parameters as you wish. If you really screw it up, you can go right back to self learning from scratch at the push of a button.
- It will make you smile every time you turn the key!

Engine power is maximized while running richer than stoichiometric



But fuel economy is maximized while running leaner than stoichiometric



Gasoline without adders 14.7

<u>Fuel</u>	<u>Stoich. AFR</u>
Octane (C ₈ H ₁₈)	15.1
Methanol (CH ₃ OH)	6.47
Ethanol (C ₂ H ₅ OH)	9.00
E85 (mix of gasoline and ethanol)	9.87
Propane (C ₃ H ₈)	15.7
Hydrogen (H ₂)	34.3
Methane (CH ₄)	17.2
Benzene (C ₆ H ₆)	13.3
Toluene (C ₆ H ₅ CH ₃)	13.5
LPG (C ₄ H ₁₀)	15.5
Nitromethane (CH ₃ NO ₂)	1.70

Now I will open it up for questions and comments from the floor

Keep it civil and respectful knowing that the other person might have a different fuel injection experience than you have, so what seems so right on to you just might be way off from the POV of their experience.





Justin Brady (theGMCRV.com) supplied the components for the display. Everything is the same as what I installed in our 77 Clasco, showed in this presentation and which will shortly also go into our 78 Royale.