Contents

Note: the table of contents isn't current... I figure it will get updated just prior to finalizing everything else.

Installation and Technical Manual

Introduction

This is a technical manual covering installation, tuning, and trouble shooting of the FFI Platinum Edition conversion system. It is intended that it be used in addition to the Owner's Manual. If you have not familiarized yourself with the contents of the Owner's Manual, please take a few minutes and do so now.

The FFI Platinum Edition conversion system is easy to install and generally requires little or no tuning from the factory preset. However, ethanol conversion can be technically involved and for this reason, the FFI warranty requires the conversion system to be installed either by an authorized installer or an ASE certified mechanic. The purpose for this restriction is to provide assurance that the installation was done properly, the vehicle works correctly with the addition of the kit, and that it can be expected to operate reliably.

The Clean Air Act requires the emission control equipment of vehicles converted to ethanol to operate correctly following conversion and it places shared burden for this upon the manufacturer and the installer. This technical manual provides the installer with the information they will need to insure that the installation of the conversion system has been done properly.

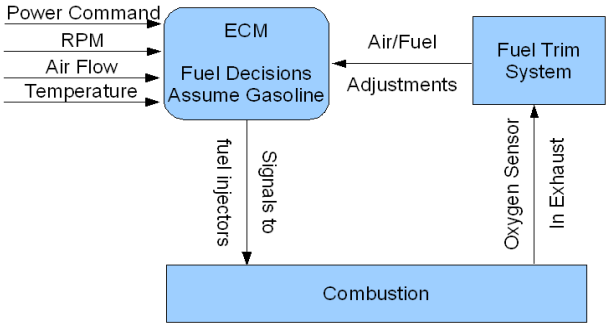
FUEL FLEX INTERNATIONAL.COM

A Brief Review of Fuel Trim

One of the big advantages of fuel injection is that it can be an adaptive system and adjust to changing conditions. All modern vehicles monitor sensors so they can measure the current conditions in which they are operating and make decisions on how to control the engine for those conditions.

Fueling decisions must supply the correct amount of fuel to go with the air being delivered to the engine. Too much fuel and the vehicle will be both wasteful and have excessive emissions. Too little fuel and the engine won't run properly. With the right fuel and air ratio, there will be a small amount of oxygen remaining in the exhaust, but not very much. Oxygen sensors supply information about this residual oxygen and allow the fuel trim system to make the necessary corrections to keep the mix just right.

Here is a simplified diagram of the fuel trim process.



During combustion, the carbon atoms and the hydrogen atoms will need to match up with oxygen atoms from the air, forming CO2 and H2O. The chemistry of gasoline can vary a little bit, the carbon/hydrogen ratio doesn't change much from one gasoline to another. Consequently, the maximum range of adjustment the ECM must handle is moderate.

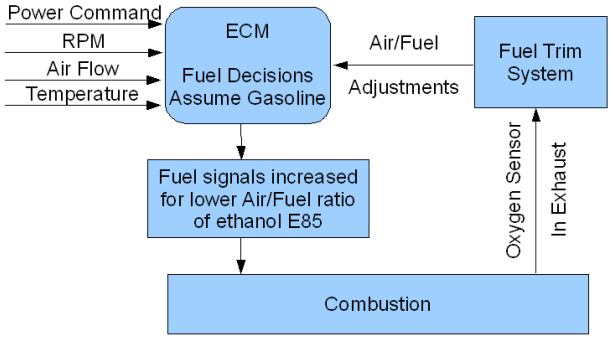
Installation and Technical Manual

Basic Operation of the Converter

Ethanol is a highly oxygenated fuel. Some of the Os needed to match up with the carbons and hydrogens are already present in the fuel. In fact, every molecule of ethanol has an oxygen atom inside. As a result, less air needs to be delivered for the same amount of fuel. But engines regulate air with the throttle and then adjust the fuel to go with the delivered air. As a result, instead of looking at it as needing less air for the same amount of fuel, we need to look at it as needing a bit more fuel to go with the same amount of air.

The vehicle's fuel trim system knows how to watch the oxygen sensors, determine that a higher fuel/air ratio is needed and make adjustments but it wasn't designed with enough adjustment ability for E85.

By intercepting the fuel injector signals, we can monitor the fueling pulses generated by the ECM and add a percentage to them, increasing the fuel delivered. The process diagram now looks like this.



As you can see, all of the sensor inputs and decisions made by the ECM are intact, we have just added some positive fuel trim. The FFI Platinum Edition conversion system does not replace the vehicle's fuel trim system but rather works with and enhances its capabilities.

Injector Saturation

As can be seen in the diagram of the previous section, the FFI conversion system increases the fuel signal, allows the injector to spray fuel for a longer time, and thus delivers the extra fuel needed to correct for the different fuel/air ratio of E85. It is necessary to not be spraying fuel at the back of a closed intake valve, and the FFI Platinum Series converter takes this into account. This determines the maximum amount of fuel that can be delivered.

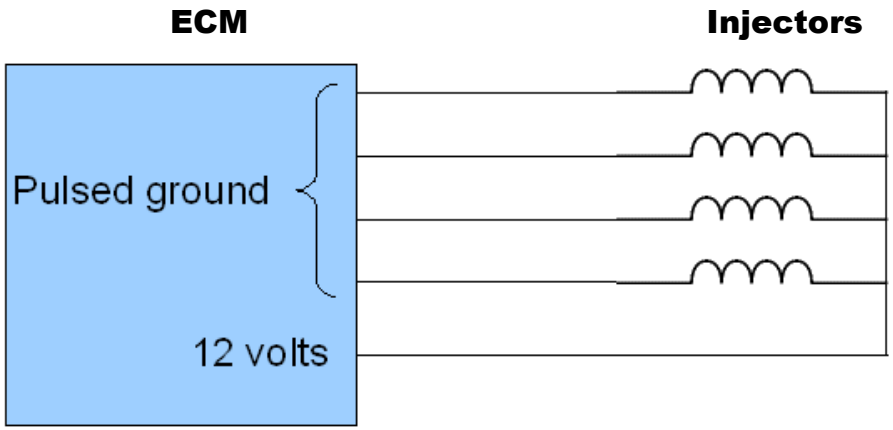
When choosing injectors for an engine, vehicle manufacturers will build in some design margin and choose an injector with a little extra capacity over what would ordinarily be needed. Stretching the fueling signal to the injectors corrects the fuel/air ratio difference between gasoline and E85 and uses this design margin to reliably deliver the fuel needed. There are many after-market products that help engines breath better to increase power and/or efficiency. These products provide extra air to the engine, and extra air requires extra fuel to go along with it. They too rely upon the design margin to operate properly. Separately, each of these techniques can reliably obtain the extra fuel needed from the design margin of the vehicle manufacturer's injector selection. Together, they may require a higher fuel flow rate than the injectors can provide.

One of the best indicators of this is experiencing a lean condition, particularly under power, adjusting the FFI Platinum conversion system to provide additional fuel and not getting the extra fuel needed. Other common signs are a vehicle running fine on a warm afternoon, but early in the morning when the air is chilly, the vehicle runs lean and sets fault code P0171 and/or P0174.

When these events happen, and adjusting the conversion system to supply more fuel does not remedy the problem, make sure the fuel filter is clean and check for adequate fuel pressure and flow. If both of these are OK, then further work will need to be done to determine the limiting factor for the rate of fuel flow. Performance tuning is a very complex subject and beyond the scope of this manual.

Wiring

Electrically, fuel injectors are an inductor. Each injector has a fuel valve and a spring holds this valve in the closed position. The injector also has a coil, and when current passes through the coil, it presses against the spring, opens the valve. The fuel is under pressure and it then flows to a sprayer, misting fuel into the intake air stream. While it would be possible to switch the current on either side of the injector, it is standard practice to supply the injector with 12V and pulse the connection to ground. This then is the basic circuit diagram used to control the fuel in a four cylinder multiport injection system.



The longer the connection to ground, the longer injector will spray fuel. Thus there is a consistent relationship between the length of the grounding pulse and the amount of fuel delivered. The FFI Platinum Series conversion system is inserted into the pulsed ground connection between the injectors and the ECM.

FUEL FLEX INTERNATIONAL.COM

Installation and Technical Manual

Vehicle Evaluation

Ethanol is a great fuel but there are some materials compatibility issues to be aware of prior to installing an ethanol upgrade on a vehicle that was manufactured to only use gasoline.

Rubber and Plastic:

The following materials will break down quickly in the presence of concentrated ethanol: natural rubber, butyl rubber, polyurethane, cork gasket, leather, PVC, polyamides and methyl-methacrylate. If any of these materials are in the pressurized portion of the fuel system, they must be replaced. If you are unsure of a material's composition, you should perform follow-up inspections to check for fuel leaks.

Neoprene, a material that looks much like butyl rubber, polypropylene, Nuna-N, Nitride, Viton, and Teflon have all be reported to tolerate ethanol.

Soft Metals:

Zinc, brass, lead, and uncoated aluminum will corrode and discolor in the presence of ethanol. Research indicates that anodized aluminum often performs much better and may well be fine.

Aluminum is often used for the engine block but you will generally find that the cylinder walls are steel. FFI has an aluminum block engine that has been fueled with pure ethanol for over two years and it has not experienced any issues. There may be long term reliability issues for parts that contain these soft metals but degradation of these parts should not cause catastrophic fuel leaks.

Fiberglass:

Ethanol is not friendly to fiberglass. The most common resin recipes result in a material that is reactive with ethanol. Cars and trucks do not tend to use fiberglass in the fuel system, but it is very common in boating and many bulk storage tanks. If the fuel tank is made of fiberglass, unless the manufacturer has indicated otherwise, it should not be used to hold E85. Not all fiberglass boats use fiberglass fuel tanks. If E85 is spilled into the bilge, it simply needs to be cleaned up; a responsible course of action regardless of the fuel being used. Occasional minor splashing during fueling will evaporate quickly and do not pose a threat to the resin.

Oxygen Sensors:

The primary oxygen sensors are the root cause of most installation difficulties. They should be evaluated for proper operation and responsiveness before installing the converter. OBD2 compliant vehicles will provide the sensor readings with the streaming real time data. Older vehicles may require use of an oscilloscope to the sensor. Sensor output voltage should osculate between approx 0.2 and 0.8 volts. If the sensor signal is not osculating or is slow, the sensor should be replaced.

ALL oxygen sensors should be replaced if they are outside of their recommended mileage, even if they are responding properly. They do wear out and should be replaced on schedule.

Overall mechanical operation:

Converting a vehicle to ethanol does not magically fix existing problems. Evaluate the operation of the vehicle. Is the battery in good condition? Does the charging system work properly? Does the engine run well? Is there a rough idle, balky performance, difficulty starting, or any indication of mechanical trouble? If so, the vehicle is not a good candidate for ethanol conversion until these issues have been corrected.

FUEL FLEX INTERNATIONAL.COM

Installation and Technical Manual

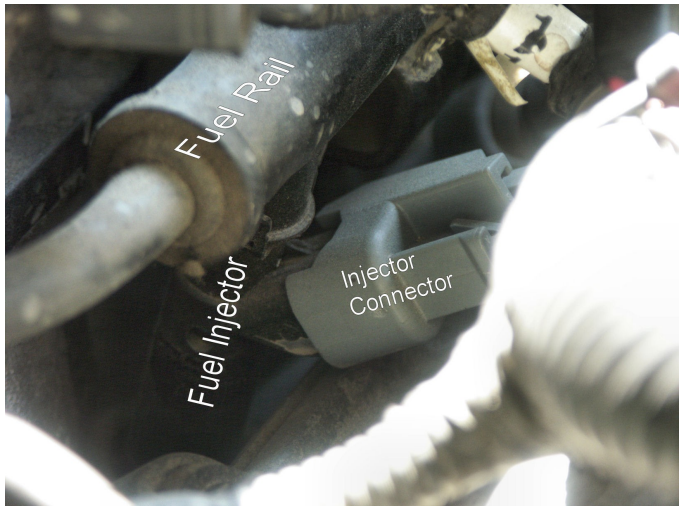
Pre Installation Checklist

The following list should be checked. A full diagnostic test for each item need not be done if the system appears to be working correctly but all items should be evaluated.

- ❑ Battery in good shape.
  - . How much does the voltage drop during cranking?
  - . How old is it? If it is nearing its life expectancy, recommend the owner replace it before it leaves them stranded.
- ❑ Charging system working properly.
- ❑ Engine starts easily.
  - . Difficulty starting on gasoline is a strong indication of a problem. Especially if the engine is warm.
- ❑ Idle is smooth and sounds OK.
- ❑ Engine responsive with smooth reliable power.
- ❑ Oxygen sensors OK.
  - . Evaluate both miles and oscillation rate.
  - . Replace is recommended if questionable.
- ❑ Ignition system
  - . Spark plugs in good shape.
  - . Ignition wires good? Coil packs look OK?
- ❑ Fuel filter clean and fuel pressure good
  - . Generally not a problem if the vehicle runs well and has routine maintenance performed. Investigate more if warranted.
  - . Filter is recommended to be changed following conversion. If the current one is working OK, it should be fine until then.
- ❑ Fuel level. You will need to change to ethanol during the installation. If it is mostly full of gasoline, this is an obstacle. Having ¼ tank or less is ideal.
- ❑ Measure the emissions of the vehicle prior to conversion. This gives a baseline for comparison later. Readings should be taken with the engine at operating temperature.

Installation

The FFI ethanol upgrade system goes into the circuit between the ECM and each injector. On most vehicles, this is easily done by plugging the upgrade kit into the circuit between the vehicle's injector wires and the injector.



The basic steps are then

1. Locate the fuel injectors.
2. Determine connector type and polarity; set harness to match.
3. Determine a good place to mount the upgrade kit.
4. Route the kit's wiring.
5. Unplug the vehicle's injector connector and connect to the kit's male connector. Plug the kit's female connector onto the injector. Repeat for all cylinders.
6. Connect the black wire(s) to any good chassis ground.
7. Secure the kit and the wiring harness.

FUEL FLEX INTERNATIONAL.COM

Installation and Technical Manual

Locating the fuel injectors

Most four cylinder engines are a straight four in a transverse mounted configuration. The injectors will be along the front or along the back. There may be a cover that has to be removed to access the injectors.

A straight six will have the injectors long the side, much like on the four cylinder engines.

A V-6 engine may well have the injectors on the inside of the V under an air plenum. To access these injectors, the plenum will have to be removed and then replaced.

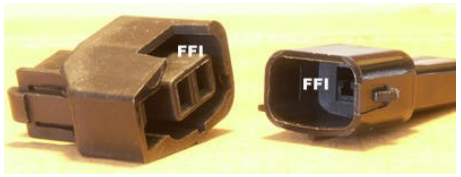
Some V-6 engines and most V-8 engines will have the injectors along the outside of the V and adjacent to the valve covers.

If your injectors are difficult to access, you will want to consider a hard-wire installation. (more on this later)

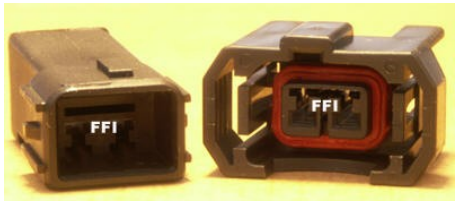
Connector Type

Once the injectors are located, a visual inspection should match to one of the following common types of injectors:

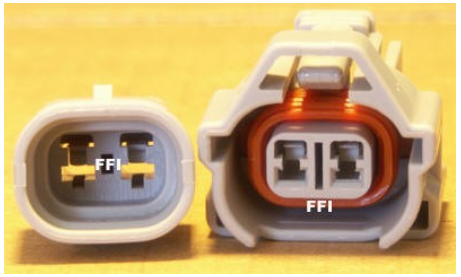
Toyota



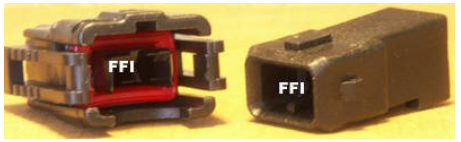
Honda



Nippondenso

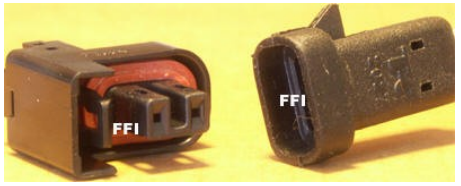


EV1



EV6

Delphi Mini



FUEL FLEX INTERNATIONAL.COM

Installation and Technical Manual

Polarity

Every injector connector will have both power and pulse but they can be on either side. The polarity of the upgrade kit must match the polarity of the vehicle. There are several methods of checking the polarity.

Method 1 – Examine the color codes of the injector wires. All of the pulse wires will have different color codes. Most vehicles have the same color code for all of the power wires.

Method 2 – probe for voltage. Remove one of the injector connectors and turn the key switch to the On position. Most vehicles will at this point have energized the power side of the circuit. A voltage probe or voltmeter will detect which side of the connector has power. A small percentage of vehicles require the vehicle to be running before they energize the power side of the injector.

Caution! Polarity on ALL of the upgrade kit connectors must match! Damage to the ECM could occur if some of the connectors are in one configuration and some are in another. Be sure to double check both male and female connectors.

If the polarity of ALL the upgrade kit connectors is opposite from the vehicle, no harm will occur. The vehicle will simply fail to start.

Pre Installation Checklist

To allow for the conversion system to be installed on vehicles of differing polarity, kits are generally shipped with terminals (the conductor) not inserted into the connectors (the plastic body).

Once polarity of the vehicle is determined, the terminals should be inserted into the back of each connector. Inside the connector are latches that keep the terminal from slipping back out. These latches must engage the latch keyhole in the terminal. The following photographs show the terminals with the latch on top and the corresponding connector oriented with the latch on top. Properly aligned, the terminal should slip in and the latch should engage.

Add pictures here

FUEL FLEX INTERNATIONAL.COM

Installation and Technical Manual

Mounting the kit

The converter should not be located close to high heat sources. Objects like exhaust manifolds, turbochargers, and radiators produce considerable heat.

Secure the converter so that it will not come loose during operation. Every vehicle will present different challenges here. Using the flanges on the converter to secure with screws or bolts works well. Velcro attachment to a flat surface like a fuse box also works well. Many times a tie wrap or two is the best solution.

Routing the Wiring Harness

Be sure to keep the wires located where they will not become tangled with belts, fans, or other equipment. Do not locate the harness so that it is in direct contact with objects hot enough to melt the plastic. Remember that engines will flex around on their mounts a bit as torque levels change. Be sure to allow a little slack in your routing to account for this.

It is best to not secure the wires at this point. The extra slack will make it easier to work with the injector connectors.

Removing and attaching connectors

Injectors tend to be in close quarters. Working on a hot engine is frustrating and will usually get your hands burned. Let the engine cool first. It is safer, and tends to result in better work.

DO NOT PRY THE CONNECTOR FROM THE INJECTOR

The connectors are latched onto the injectors. There will be a release tab that must be pressed to unlatch them. Additionally, many of the connectors will have a locking clip on the release tab. The locking clip will need to be removed for the release tab to be depressed. The locking clips will often break when removed. This will not cause any harm as the primary latch is more than sufficient to keep the connector in place.

Once the locking tab has been removed, the release tab can be pressed to unlatch the connector. Unlatched, it will easily come off of the injector. If it does not remove easily, it is not unlatched. Forcing it will break something.

When mating connectors, press them together until the latch has engaged the mating connector. You should hear a click when they latch into place. If they do not latch, they will be prone to coming loose during operation.

FUEL FLEX INTERNATIONAL.COM

Hardwire Installation

Electrically, a hardwire installation accomplishes the same goal as a normal installation with connectors. Bypassing the connectors and tapping directly into the pulse wires eliminates the need to have matching connectors on the converter. It also simplifies installation for vehicles where the injectors are difficult to access.

There are several reasons why you may wish to opt for a hardwire installation including:

- Unusual injectors on a vehicle
- Inaccessible connectors
- Added reliability for extreme service
- Cost

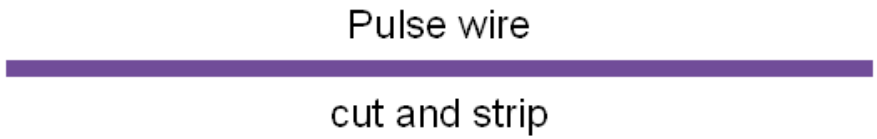
To perform a hardwire installation you will need the following tools:

- Wire cutters
- Wire strippers
- Soldering Iron
- Rosin core solder
- Heat shrink tubing
- Heat gun

The converter uses color coded wires to identify the in and out for each injector. The standard colors used are Blue, Grey, Green, and Brown. The input to the converter (ECM side) will always be a solid color. The output from the converter (injector side) will always have a white stripe. It does not matter which color set goes to which cylinder, but the solid and stripe from each color must go to the same injector wire.

Installation and Technical Manual

First, identify the pulse wires and locate a convenient place to splice into these wires. Double check that you have identified the correct wires, then cut the pulse wire and strip approx ½ inch.



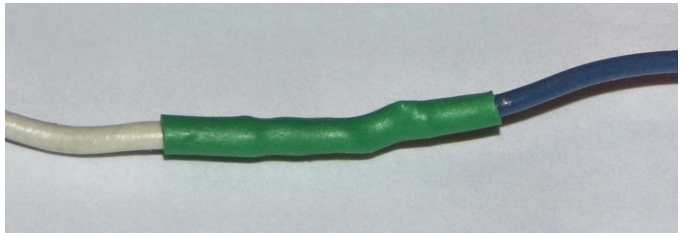
Slip sections of heat shrink onto the cut ends of the injector wires, pushing it back far enough it will not be affected by the heat from the soldering of the wires.

Each injector pulse wire will be joined with the colored pairs from the converter. For example, the blue channel will have a wire that is solid blue and another wire that is blue with a white stripe. The wire pairs to the converter must be joined to the wires for the same injector.

Join the solid colored wire from the converter to the ECM side of the cut. Likewise, the striped wire should be joined to the injector side of the cut.

Join the wires end to end, twisting the strands together. Make sure the strands from both wires are twisted together smoothly and have good overlap, then solder with rosin core solder. It is crucial to achieve a good flow of solder into the joint. It must make a good electrical connection and not be prone to mechanical separation. Dropping a glob of hot solder onto cold wires will not provide a reliable connection. It must also be free of any wire strands or sharp tips of solder as these can poke through the heat shrink and cause shorts.

When the solder joint has cooled, slip the heat shrink tubing back down the wire to cover the bare metal. Center the tubing over the joint and use the heat gun to apply heat to the heat shrink tubing. Do not melt the insulation, but you want to shrink the tubing so it makes a good tight seal over the solder joint. When you are done, it should look much like this one.



Lastly, the red wire from the converter needs to tap into the power wire on the injection circuit. This provides power to the convert. It may be soldered in like the pulse wires. Alternatively, you may also use a T-tap crimp on connector. The only requirement is that the power connection provide a reliable source of power.

Converters for more than four injectors will have multiple wiring harnesses, each with a red wire. It is necessary to only connect one of these to power. The others need not make a connection but should be secured.

Installation and Technical Manual

Testing and Tuning

With all electrical connections made, the wires should be secured. Standard heat tolerant tie wraps work well for this. Start the engine. If it does not start, runs rough, or you get a MIL indication, refer to the troubleshooting section for guidance.

After letting the engine idle for a few minutes, the vehicle should be taken for a short test drive. It need not be miles in length but should be long enough for the oxygen sensors to heat up and provide data to the ECM. The purpose of this test drive is to verify that the vehicle can operate on gasoline. Measure the emissions in the same manner as before. You should see similar readings. If emissions are higher, the converter is adjusted too high for the vehicle. It should be adjusted lower in small increments until comparable emissions are achieved.

The vehicle is now ready for ethanol. Of course there will be some amount of gasoline in the tank. This is not really a problem as any mixture of gasoline and E85 will work fine but you will want to verify that the vehicle can operate properly on straight E85. Ideally, the vehicle will be delivered for conversion with no more than ¼ tank of fuel, in which case filling up with E85 will result in a high enough ethanol content to get a good indication of vehicle operation on E85. Add the fuel and take it on a test drive of sufficient length to consume the fuel in the fuel line and fuel rail. On most vehicles, the extra performance when the ethanol enters the fuel rail is noticeable. Drive the vehicle a bit longer, checking to make sure it idles smoothly, is responsive, and provides smooth power, and the on board diagnostics have not set the MIL.

At this point, take another emissions reading and complete the warranty registration.

FUEL FLEX INTERNATIONAL.COM

Installation and Technical Manual

Returning the vehicle to the owner

So long as the vehicle continues to operate properly, they should avoid filling with gasoline for the next several fuel stops. This does several things. First, it gets the ethanol percentage all the way to full E85 to verify that the engine operates properly on E85. Second, it will complete the cleaning of the olefins from the tank. Once the olefins have been cleaned, the sediments they trap will work their way into the fuel filter. The sooner this occurs, the sooner they will be removed.

They should return if the check engine MIL indicator lights. They should also return for a check up after about 1000 miles. This should clean out the olefins and give the sediments time to be trapped in the filter. It is best to replace the fuel filter at this checkup as a preventative measure.

Make sure they have their Owner's Manual. It contains valuable information which they should be familiar with.

Testing and Troubleshooting

These are the most common problems you might have in an installation. Note that most of them result in poor connections.

Symptom	Probable Cause / Action
Vehicle cranks but won't fire	Converter has opposite polarity from vehicle. Double check polarity of vehicle and switch polarity of converter to match. Make sure to change ALL connectors to match vehicle.
No lights on the converter	If the converter has NO lights when the key switch is ON, either the red power wire is not getting voltage or the black wire is not grounded.
Vehicle runs rough	This is generally caused by one or more connectors not being fully seated to the mating connector. OBD will often identify the misfiring cylinder. Re seat the connectors making sure all connectors click and lock into place.
Check Engine Light	Read diagnostic codes from the ECM
OBD lean	Vehicle is not getting enough fuel. Adjust converter to a higher number, clear the codes and retest.
OBD rich	Vehicle is getting too much fuel. Adjust converter to a lower number, clear the codes and retest.
Vehicle runs fine until ethanol goes over 50%	Oxygen sensors may be dirty or inoperative. Check for proper operation and replace if necessary.

FUEL FLEX INTERNATIONAL.COM

Installation and Technical Manual

Diagnosing a troublesome converter

It is rare, but occasionally there is a bad harness or converter. If you have a two board converter, swapping the cables between boards will help determine if the problem is with the converter or with the cable. If the misfiring cylinder moves, then the trouble is with the circuit board. If the trouble stays on the same cylinder, then the trouble is with the cable.

If you have a single board converter (4 cylinder, motorcycle, ATV), then swapping for a new converter is the best practice. If the problem persists, the converter is probably OK. If the problem only occurs with one converter, it is defective.

If you suspect a cable of having a broken connection, an ohm meter can check continuity from the converter to the connectors.

Common Questions About Ethanol

Will ethanol harm the fuel system?

Rubber reacts to ethanol and will quickly degrade. Rubber was engineered out of fuel systems in the 1980s. If you are going to convert an older vehicle to ethanol, you will need to replace any rubber parts.

Does ethanol burn hotter? Will it melt my engine?

Ethanol, at the same power level, actually burns cooler.

Is ethanol corrosive?

Everything is corrosive so something. Most of the corrosive problems that were being experienced with ethanol were actually due to contaminants in the fuel and not the ethanol itself. Most fuel suppliers add corrosion inhibitors to the fuel and most engines can safely use ethanol.

Is ethanol poisonous?

Ethanol is the same alcohol that is used in beverages like beer and wine. It is biodegradable, and once diluted, will break down in the environment and become harmless.

Can I use pure alcohol in my vehicle?

That mostly depends upon your local laws about pure alcohol. Most jurisdictions will require it to be denatured. E98 is a mixture of 2 percent gasoline to denature the fuel and 98% ethanol. It has approximately 120 octane and results in very high performance. Most vehicles can use this with the FFI converter.