Bolt-On Fuel Injection

A sophisticated single-point system from AirSensors substantially improves throttle response

by BILL ESTES

Only a few years ago, electronic fuel injection (EFI) was a lofty automotive concept applied only to exotic vehicles. It appeared to be years away from practical use on the average family car, truck or van.

Nevertheless EFI has virtually replaced the carburetor. All engines of most manufacturers have been converted to fuel injection as a direct result of improved technology, reduced production costs and ever-tightening emissions standards. The only notable omissions are in motorhome chassis with weight ratings of over 10,000 pounds.

Why the changeover? Manufacturers found that more precise management of fuel was necessary to meet emissions rules, and they wanted to utilize more sophisticated fuel-management systems for better performance and fuel economy.

EFI systems used at the original equipment manufacturer (OEM) level have created quite a bit of interest among owners of vehicles equipped with carburetors—especially carburetors that have been troublesome. There was an obvious opportunity for an aftermarket company to produce a fuel-injection system that could be retrofitted to a variety of carbureted engines.

AirSensors of Seattle, Washington, recognized the opportunity more than 10 years ago and has produced a system that is currently marketed throughout the United States. It can be fitted to a variety of engines, including all the V-8s popular with RV owners. The system is very sophisticated, which should be no surprise in view of the fact that it has been under active development so long, culminating in sales about four years ago.

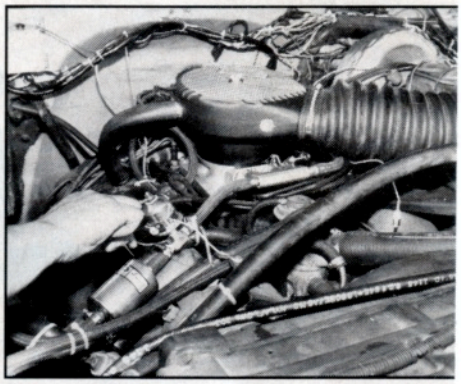
While EFI systems installed at factories on passenger cars, light trucks and vans have not been universally successful in producing what most RV owners want—improved fuel economy and performance—notable success stories have occurred. Probably the most dramatic is the 5-liter (302-cid) Ford V-8. Known as a wimpy and sometimes troublesome performer throughout the 1970s and early 1980s, the 302 came out slugging in 1985 with EFI and has been a favored choice among trailerists ever since. Likewise, the GM 5.7-liter (350-cid) and Ford 5.8-liter (351-cid) engines appeared to have fared well in 1988 when fitted with EFI, showing noticeably higher performance and throttle response.

On the other hand, GM's 7.4-liter (454-cid) and Ford's 7.5-liter (460-cid) V-8s didn't benefit substantially in fuel economy or performance with the addition of EFI in 1988. Variances in results are attributed, at least in part, to how much of the inherent benefit of EFI is applied to meeting emissions rules rather than to boosting performance and fuel economy.

Results also have varied between types of EFI systems: throttle-body injection and port injection. GM so far utilizes all throttle-body systems in trucks and vans, while Ford uses ported systems. The port systems have a theoretical advantage in that they inject fuel directly into the cylinders, whereas a throttle-body system injects fuel into the intake manifold.

photo by Derek Hamaguchi

The AirSensors system, suitable for a variety of engines, was installed on a Chevy 454 (right) for evaluation. System relies on air-mass sensor and electronic control to correctly meter fuel.



Control of emissions was a factor in development of the throttle-body-type AirSensors EFI system because an add-on product must meet emissions rules in various states; the most stringent are in California, where AirSensors is limited to vehicles with weight ratings of over 8500 pounds. Applicability of the system is not restricted in any other states, according to the manufacturer.

The obvious goals for AirSensors were performance and fuel-economy improvement since the system must substantially outstrip the carburetor to justify its $1399 price (plus approximately $400 for installation). AirSensors advertises the system as "The Power of Tomorrow Today" with technology that delivers "more power, better mileage and fewer exhaust emissions than any normally carbureted engine intake system." The manufacturer claims as much as 35 percent increase in torque and as much as 20 percent increase in horsepower.

Certainly a well-designed EFI system should make a difference, and the AirSensors system appears very well designed.

Our test installation, on a 454 V-8 engine in a 1976 Chevrolet Suburban, was performed by a very competent AirSensors dealer, R & E Racing in Lancaster, California. The installation is not highly complicated, but should be handled by a shop equipped with at least an exhaust-gas analyzer to help with air-fuel ratio settings, although the AirSensors manual includes specific instructions on how to make the adjustments based on road performance.

The key to the varied benefits of the AirSensors system is a sophisticated air-mass sensor that monitors air density, enabling the electronic brain of the system to make rapid fuel-flow adjustments in response to changes in air density that result from varying temperature, humidity and altitude. Other components include an engine-speed sensor, which monitors rpm, a temperature sensor, a spark-plug firing sensor and an analog computer inside the control unit, which offers five different air-fuel ratio program adjustments: master air-fuel, cold start, idle, load and acceleration. A fuel-pump shutoff switch is used to prevent fuel leakage and flooding in the event the vehicle doesn't start. Also, there is a "drive home" mode to allow limp-home capability if the system malfunctions. With the easy adjustment capability of this system, the driver can adjust air-fuel ratios as the vehicle cruises along the highway if he chooses. It's one of the more interesting aspects of this system.

All EFI systems, including this one, operate on higher fuel pressures than are typical of carburetion. AirSensors includes a 12-volt DC pump and fuel regulator that maintain pressure at 30 to 40 psi, in addition to a line that returns fuel to the tank. Most late-model vehicles already have such a line; it must be added to earlier models. The fuel return tends to help prevent vapor lock. The system requires a conventional 12-volt DC booster pump at the tank to move fuel to the high-pressure pump under the hood, and this pump is not part of the AirSensors kit, although it should be wired in parallel with the AirSensors pump, which shuts off after a few seconds if the engine doesn't start.

The theory behind a single-point (throttle-body) system such as the AirSensors is that its four nozzles

AirSensors Electronic Fuel Injection Performance

	Stock Carb	*AirSensors EFI*
0-60 mph	19.6 sec	18.8 sec
40-60 mph	10.6 sec	10.4 sec
Uphill speed on 5% grade, full throttle*	59 mph	63 mph
Manifold vacuum at 60 mph while towing**	5"	6"
Manifold vacuum at 55 mph solo	11-12"	12-13"
Fuel consumption while towing at 55 mph***	8.63 mpg	8.60 mpg
Fuel consumption solo at 55 mph	12.5 mpg	12.9 mpg

**Third gear, gross combined weight 11,500 pounds.*
***Throttle adjusted to maintain 60 mph; manifold vacuum readings indicate differing throttle needed to maintain that speed.*
****Terrain consisting of about 50 percent low hills and 50 percent level highway, 800 feet elevation, third gear, axle ratio 4.10:1.*

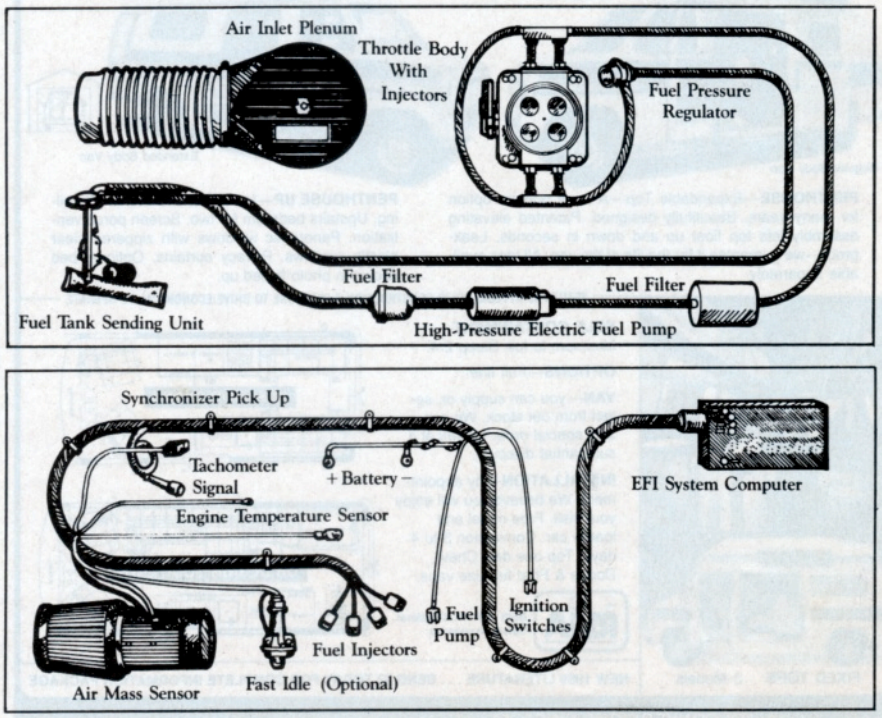


illustration by Robert Lamarche

Fuel system (top) includes high-pressure pump, return line to tank for fuel unused by the engine. EFI computer receives input from air mass sensor, other sources.

spray fuel into the intake manifold, as opposed to the venturi action (air velocity) required to draw fuel from a conventional carburetor. The EFI system meters fuel more precisely and creates better atomization for more complete combustion.

Our evaluation began with baseline road tests to establish several road-performance and fuel-consumption statistics (see accompanying table). In addition, we arranged for a comparison (carburetor vs. EFI) rear-wheel horsepower test on a chassis dynomometer at an independent shop (see accompanying graph).

The EFI installation required the better part of a day by the technicians at R & E, who utilized the stock intake manifold and all emissions equipment except the hot-air intake for the stock air cleaner, which was discarded. The high-pressure fuel pump was mounted on the fender well and was assisted by an electric fuel pump already in use, installed near the fuel tank. R & E ran the vehicle on their dynomometer and adjusted the Air-Sensors control for the target air-fuel ratios, explaining to us that the settings were subject to adjustment based on road performance and mileage results.

Says Ed Bailes of R & E, "We set the ratios up where we like to see them, but on the highway if the engine is not happy, the settings should be changed. Every engine is different and will tell you if air-fuel ratios are undesirable by surging, stalling, backfiring or detonating if it's too lean. Being too rich will cause hesitation and loss of mileage."

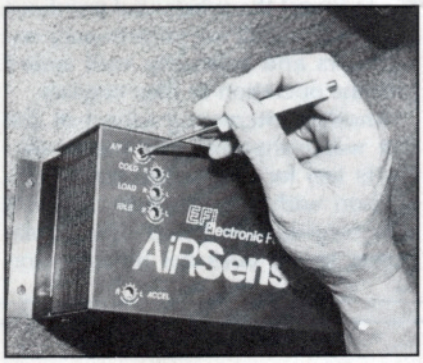
We didn't have to wait long for initial test results. Before we even got out of R & E's driveway, it was obvious that throttle response was improved considerably, even though the engine used for the test was no slouch in stock condition. With EFI in place, the engine ran more smoothly and easily, showing higher manifold vacuum readings under a variety of throttle conditions, including light-throttle cruising.

Then we hitched the Suburban to a 30-foot, 5500-pound trailer (11,500 pounds gross combined weight) for the tests listed in the accompanying specifications table. Our seat-of-the-pants results were very favorable even while towing the heavy trailer; throttle response and overall performance still seemed noticeably improved until we approached 4000

rpm. Performance in the 2500- to 3000-rpm range, which is where most trailering is done, was very impressive. The engine pulled better, and the vehicle was more fun to drive.

However, our initial fuel-economy runs proved that we were paying for the improvement. The Suburban went to 8.63 miles on each gallon with a carburetor and dropped to 7.81 with installation of the EFI. So we moved the air-fuel ratio setting one notch leaner. The result: 8.23. Yet another notch leaner brought it up to 8.60, approximately our mileage figure with the carburetor, while we noticed very little reduction in performance. Going beyond that point appeared to noticeably soften performance.

The air-fuel-ratio screw controls air-fuel mix in all operating ranges, while the adjustment for load affects only heavy-throttle ratios—similar to operation of the secondary venturi of a four-barrel carburetor. We found it relatively easy to determine the settings that made this engine perform best; it was a simple matter of moving the adjusting screw up or down while maintaining a specific operating condition (cruise, hill-climb, etc.) until the engine performed best. When we went too lean, power would decrease and we would begin to hear detonation (ping). Going too rich affected performance less dramatically, although it undoubtedly caused the engine to suck up a lot more fuel. We adjusted toward the lean side and then moved the screw back just enough to create best performance. We mounted the control unit in our test vehicle near the driver's right leg.



AirSensors control unit permits on-the-road adjustment of air-fuel ratios in various operational ranges.

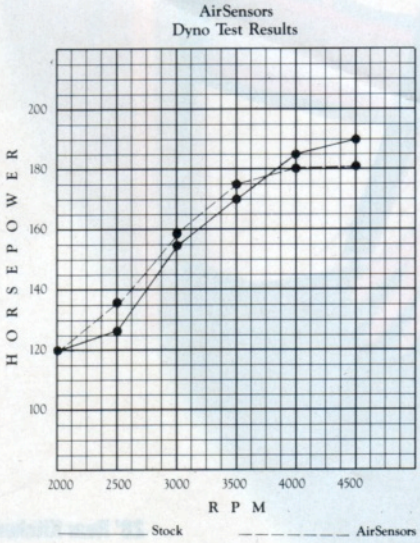
For anyone who has ever tried to judge the effect of changing jets or metering rods in a carburetor, the AirSensors system is quite a revelation.

The effects of a small change in carburetor jet size is much more difficult to gauge because at least a limited amount of time elapses between tests, whereas with the AirSensors the effect of repeated on-the-road adjustments is readily apparent. It's possible to repeat the adjustments as many times as the driver feels is necessary.

The idea of encouraging vehicle owners, some of whom are not very mechanically oriented, to fiddle with air-fuel ratios appears to present the opportunity for engine damage. If, for example, an owner uses an air-fuel setting that is too lean, causing the engine to ping continuously, significant damage to valves, piston rings and pistons can occur. An excessively rich setting could cause accelerated wear due to gasoline dilution of cylinder-wall lubrication. But AirSensors as well as R & E say they have not encountered problems because it is not difficult to know when the engine is "happy" with the air-fuel ratios being dialed into the control unit. It may also be true that people who are willing to invest the substantial purchase price of this unit are performance enthusiasts and relatively well tuned into the operation of their engines.

Another interesting aspect of the test was comparing our seat-of-the-pants feel for the performance comparison with our numbers. The feel was considerably better. The horsepower graph does not indicate dra-

matic improvement, but does indicate the best gain at around 2500 rpm, which coincides with where we felt the most improvement in usable power and in throttle response. Neither do the acceleration results set any new records. We upshifted at 4000 rpm during acceleration runs, even though the carbureted engine gained power beyond that point. With EFI, the engine did not approach 4000 rpm as willingly as it did with the Quadrajet carburetor and was flat after 4000. However, this is of little consequence from a practical standpoint because most RV owners rarely see 4000 rpm.



Rear-wheel horsepower was measured on chassis dynomometer before and after installation of fuel-injection system.

Hill-climb results with the trailer show that the engine was strong in stock condition, maintaining 59 mph under full throttle in third gear on a 5-percent grade with the carburetor and somewhat stronger with EFI: 63 mph. That's more of an achievement than it may seem because wind drag with a conventional box-style trailer multiplies rapidly above 50 mph. A part-throttle test during which we drove in second gear with overdrive (3200 rpm) and adjusted the throttle to hold speed at 60 mph resulted in 5 inches manifold vacuum with the carbureted engine and 6 inches with EFI, a slight improvement owing either to improved fuel atomization and distribution or simply to use of more fuel in that throttle range—or both.

While cruising on flat highways, manifold vacuum usually was in the area of 11 to 12 inches with the carburetor and 12 to 13 inches with EFI,

apparently in this case showing that the engine could cruise with smaller throttle openings due to improved fuel distribution and atomization. Speaking of manifold vacuum readings, a vacuum gauge still is valuable with this EFI system because the system includes a load-start point at which air-fuel ratios go from cruise to enriched ratios. The installer can set this point wherever the vehicle owner feels is appropriate based on vehicle use and driving conditions. If typical driving conditions produce vacuum readings upwards of 8 to 10 inches, a load-start point around 6 inches is appropriate.

The only problem we encountered with the system was a tendency to balk during cold starts. It was necessary to turn the key on and off two or three times to activate and reactivate the high-pressure fuel pump before the engine would start. When it fired, the engine would blubber for a couple of seconds. Thereafter, operation was exceptionally smooth.

We did not have the opportunity to test this system in cold weather. It is necessary for the driver to control fast-idle when the engine is cold, because the AirSensors system does not include this capability. AirSensors has an optional $183 fast-idle air-bypass valve, but they say owners who feel the need usually opt to install an anti-dieseling solenoid that they can control manually with a switch under the dash.

Service is handled by approximately 70 AirSensors dealers located throughout the nation, and AirSensors will send parts by overnight air either to dealers or to owners of the systems who encounter problems in areas where there is no dealer. The company promotes a spare-parts kit ($250) that includes replacement fuel filters, a fuel pump, air-mass sensor, air cleaner and temperature sensor.

AirSensors has done an excellent job with this EFI system. It does not require major modification of the vehicle and appears to have a good reputation for reliability. Whether it's worth $1800 must be answered on an individual basis, but it definitely increases the enjoyment of driving. **TL**

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