LINDER TECHNICAL SERVICES

Home of the Injector Guru

FUEL INJECTION DIVISION

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FUEL INJECTION DIVISION

LINDER TECHNICAL SERVICES

FUEL INJECTION SERVICES

- FUEL INJECTION SERVICE
- ON & OFF VEHICLE
- TOTAL INJECTOR RECONDITIONING

2005

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This ***“service”*** usually takes approx. one hour for the vehicle to run out of fuel and entire service to be performed. The good thing is that the technician may do other services while this being performed! Some technicians may install a set of plugs, change the fuel filter or perform brake service while the engine is flushing. Charges for this fuel injection service are up to the individual shop but the ***performance gained is absolutely amazing.***

In reality you are restoring the fuel *“system”* to original operations. This is exactly what should be done as a vehicle ages.

Our Associations :

STS

ASE

ATMC
AUTOMOTIVE TRAINING MANAGERS COUNCIL

A.V.I.

iATN

ASA

Council of Advanced Automotive Trainers
CAAT

ON CAR Fuel Injection Service (Cont.)

6. Clean throttle plate area and Idle Air Control passages.
Just this *"service"* alone on most late model engines will *show a manifold vacuum increase* of up to 2. You may stop the engine and clean the areas as needed, but my suggestion is to use a extra hand-held fuel injector hooked in parallel with pressure hose along with a pulser to allow cleaning of throttle plates with the same chemical as injectors are running on. This has proven to work very well as air drawn into IAC passages on a running engine will clean the passages without IAC removal. Neat trick!

Points to Ponder:

- ***A manifold vacuum increase tells the technician that the engine "liked" the service***
- ***Using the hand-held injector will usually lower a GM IAC count from 40 to 15 without touching a thing!! (think about this)***

7. Check Minimum Air Flow Rate and adjust if needed.
Most vehicles that have "stalling" problems are due to a mis-adjusted throttle plate or incorrect minimum air rate. Check service manuals for specifications.

Points to Ponder:

- ***Delco makes a set of small 'tune up" booklets that do a excellent job of covering minimum air rate adjustment procedures.***

8. Relearn the vehicle's On-Board Computer
Some vehicles may have been running in such a poor state of operation that the On-Board Computer may need to be relearned! Consult the OEM suggested relearn procedures for each particular vehicle.

FUEL INJECTION SYSTEM SERVICE IS COMPLETE!!!

FUEL INJECTOR SERVICE (OFF CAR)

Fuel injectors are designed to operate and last for 150,000 + miles. Because of their significance to emissions, some vehicle manufacturers put a warranty of 5 years or 50,000 miles on their injectors. However, over a period of time, harmful deposits can build up around the injector nozzle. Deposits can also build up inside the injector or clog the injector filter basket and reduce the amount of fuel being delivered. When fuel delivery decreases, the injector pulse width will increase, which creates additional heat in the injector. A leading cause of this condition is short drive cycles. Short drive cycles with repeated temperature change creates fuel diffusion. The lighter gasses evaporate and the heavier particles of fuel settle at the tip of the injector. Engine heat then bakes the heavier particles into hard deposits. These deposits can clog an injector and reduce the volume of fuel delivered or distort the spray pattern. When fuel delivery is out of specification, driveability problems exist because the PCM is unable to maintain proper overall air/fuel ratio. Some injectors may be commanded by the PCM to go richer or leaner depending on whether the problem injectors are clogged or leaking.

Until recently, the normally accepted service procedure for clogged or leaking injectors was to use an on-car chemical cleaning (this topic was the focus of our October 1997 Newsletter which is available online at www.lindertech.com) or replace the injector. Replacement, however, can be very expensive. Replacing a single injector or two does not insure a volume or delivery pattern match. This procedure may even need to be repeated again as other injectors fail, which will cost the customer a labor charge again.

WHY PAY FOR NEW FUEL INJECTORS WHEN WE CAN SERVICE THEM FOR A FRACTION OF THE COST?

OFF car fuel injector service offers some additional benefits to fuel system service. When an injector is out of the engine, it can be checked thoroughly by a variety of dynamic testing. A visual inspection can reveal leakage and physical damage at the fuel discharge area.

LTS RECONDITIONING PROCESS:

Linder Technical Services began testing and servicing fuel injectors off car in 1994. Today, LTS is a leader in offering reconditioned fuel injectors to the automotive industry. LTS injectors are reconditioned using a procedure that we have developed by teaching fuel injection for over 20 years, servicing "today's" fuel injected vehicles, and by testing tens of thousands of injectors over the past few years. Flow matched sets of injectors can easily be obtained by servicing a large volume of injectors. LTS offers a number of lifetime replacement injector sets to replace some of the common failing types of injectors.

Cores are a large part of the reconditioning process. LTS buys cores from national core suppliers, salvage yards and service technicians. *We also offer core trade in programs in which technicians have earned credit for training, manuals or tapes.*

The LTS reconditioning process has several steps:

1. CORES are first separated into families by manufacturer and then by application.

2. VISUAL INSPECTION: each injector is carefully examined for broken connectors, broken pintle or any damaged areas.

3. CLEANING AND DEGREASING starts with an air-powered agitated bath of "Simple Green" and water. This removes external grease and oil from the injector and prevents contamination of the cleaning tanks, etc. Fuel injectors that have painted surfaces are glass-beaded to prevent contamination and then repainted during the final stage.

ON CAR Fuel Injection Service (Cont.)

4. Clean Fuel Injectors.

At this point in the *"service"* we start the engine and adjust the output pressure closer to regulator pressure or lower than in the previous steps. Lower pressure will cause the pulse width to open up somewhat longer and *allow the injectors to be cleaned*. Slow speed (idle) position will take a longer time frame and operating temperature will be reached. This is one place where time is required. Ever wonder how a can of injector cleaner could clean the entire fuel injection system in 9 minutes. (It can't!!) Remember not only are you after clean injectors but you also want the chemical to decarbon the engine valves, pistons and O2 sensor.

Points to Ponder:

- ***Time is required to perform this service.***
- ***Internal pintle cleaning is performed during this cycle.***
- ***Fuel control is always in direct response to O2 response.***
  Ex: Slow O2 = Slow fuel control= Poor performance.

5. Decarbon the entire engine.

On most vehicles, the injector spray will help the decarboning process. On others, you may need to *enhance the operation with external addition of mixture thru PCV hose, throttle plates or idle air controls.*

Points to Ponder:

- ***Most technicians (especially very young ones) think carbon is a 90's problem. The older guys (especially the very old ones) remember throwing rice through a flathead at 2500 rpm and watching the blacks specs fly out the exhaust. Carbon is still a problem in the 21st century! We now have lower fuel volatility and in some cases vehicles with high compression may experience a no-start situation.***
- ***Proper compression = 14.6 x compression ratio***

ON CAR Fuel Injection Service (Cont.)

3. Flush entire fuel rail and upper fuel injector screens including the fuel pressure regulator.

We would suggest raising the input pressure to a point above regulator setting to allow a constant flow of fuel thru the inlet pressure side of system, thru the fuel rail and out the open fuel pressure regulator. In most cases the applied pressure is 75-90 psi but will be maintained by the presence of a regulator. At this point, cleaning chemical is added to the fuel at a 5-1 mixture and **allowed to flow thru system for 15 to 30 minutes**. (I have some GM Dealers that use 1 hour per vehicle with great results!) Results are best on a hot engine with the fuel supply looped and the engine NOT running.

Points to Ponder:

- ***This flush is the "fix" most vehicles need to start with. The difference is that you are effectively removing the deposits to a remote tank and filter vs. attempting to soften them and blow them thru the upper screens.***
- ***Most injectors use a 10 micron final filter screen.***
- ***A 25% restriction in the upper screen would increase the injector on-time approx. 25%!***
- ***Injectors have a working "duty cycle" like a welder. Extend the duty cycle=shortened life of the coil or bobbin.***
- ***Each engine has a "pattern failure" in the system Ex: Buick V-6 engines have problems with the injectors located on the end where the rail curves and the injector next to the EGR valve. Those three injectors will always show a restriction first! Cylinder #5 is the pattern failure on 4.9L Ford inline 6's. (Study the rail design and look for the problem areas)***

THE RECONDITIONING PROCESS (CONT.)

4. OHM TEST: although this is a static test, each injector is ohm-tested to manufacturer specifications. This eliminates 30% of core injectors and out of spec injectors are discarded!

5. CURRENT DRAW TEST: each injector is dynamically tested with current applied to load the injector's windings. This test incorporates a current draw scope pattern and is performed at least 4 or 5 times on each injector both hot and cold. This step eliminates another 30% of core injectors and out of spec injectors are discarded!

6. LEAK TEST: injectors are leak-tested hot and cold at manufacturers system pressure. Less than and greater than pressures are also used to help find leaking injectors. Leakage can be at the discharge end, body, or electrical connector.

7. INJECTOR OPERATION AND SPRAY PATTERN: injectors are pulsed at different cycles and visual spray pattern output is observed.

8. INJECTOR FLOW RATE (PRIOR TO CLEANING)... all injectors are flowed at different pulse cycles for delivered fuel quantities.

9. FILTER BASKETS are removed and inspected. O-rings and pintle caps are removed and discarded.

THE RECONDITIONING PROCESS (CONT.)

10. ULTRASONIC CLEANING AND BACK FLUSHING…...the ultrasonic cleaner basin physically shakes the deposits loose using sound at a frequency that resonates with particles, but not with injector bodies. Since the injector solenoids pulse at various frequencies during the cleaning, the cleaning fluid back flushes through the injector and carries the deposit reside back and out.

11. INJECTOR FLOW RATE (AFTER CLEANING)….injectors are again flow bench tested for volume and spray pattern. A dramatic improvement is usually noticed in flow and overall pattern.

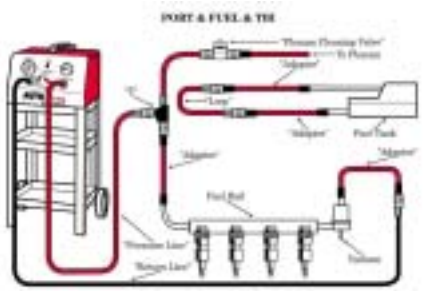
12. MATCHING BALANCED SETS….delivered volume and spray pattern at various pulse cycles is noted in step #11. This information is recorded and then used to match sets of injectors. ***LTS sets are matched within 2%***

13. INJECTOR FILTER BASKETS, END CAPS AND O-RINGS ARE REPLACED. Injectors that were glass-beaded in step #3 are painted.

14. INJECTORS ARE PACKED with a mixture of Marvel Mystery Oil and Kroil to help increase shelf life. Rubber caps are placed over each end to protect during storing and shipping.

ON CAR Fuel Injection Service (Cont.)

1. Check Fuel Pump operating pressure and volume.
The missing link here is *volume!* Most working technicians assume that if the pressure is correct, the volume is OK also! By hooking up a fuel pressure tester to the fuel rail inlet and return, and using the pressure side feed tee'd into the fuel unit tank, we can quickly ***test the fuel pressure*** with engine running while at the same time ***test the volume*** of the pump by stealing fuel into our holding tank. *(1 pint in 30 seconds is the usual specification)* When proper volume is flowed into tank we would shut down the engine and change hose connections to allow machine to be put in control of fuel supply system. A **Two line system** would be attached to the fuel inlet and return on the fuel rail with the vehicle's on-board system being "looped" and returning fuel to the tank. This prevents disabling of the factory unit.



2. Test pressure Regulator for operation and leakage
At this time the fuel pressure *regulator would be tested* for operational pressure and proper regulation including leakage. (this works well as operator has total control of rail pressure with unit control valve)

Points to Ponder !

- ***Good pressure doesn't mean proper volume! Ex: A clogged filter may test OK on pressure but the restriction may not allow proper volume under load!***
- ***It is a good idea to use the vehicle's own gasoline to service the system vs. a can of shop gasoline that has been sitting around for some time!***
- ***Pressure regulators DO fail and a lot more of them don't properly shut off fuel causing higher than normal pump wear.***

ON CAR Fuel Injection Service

After many years of **"Fuel Injection Service**" I feel that some service technicians still misunderstand the *process* of proper Fuel System handling. Much has been said over the years with regard to when and how to perform injector cleaning. Some manufactures have suggested methods of cleaning while others have issued bulletins to disregard any cleaning at all. For this reason, I offer the following on the proper process for injector service on today's vehicles.

All engines using fuel injection **DO,** in fact, require some type of fuel system maintenance! Normal wear and tear with today's under-hood temperatures and changes in gasoline quality contribute to the build up of olefin wax, dirt, water and many other additives. Unique to each engine is an air control design that also may contribute different levels of carbon deposits, such as oil control.

To simplify the approach, I will use the word ***"Service"*** since the words Injector Cleaning can be misleading as to the real function needed to maintain the vehicles of today!

Fuel Injection System Service:

Note the words *system & service* vs. *cleaning*!

1. **Check fuel pump operating pressure and volume.**
2. **Test fuel pressure regulator for operation and leakage.**
3. **Flush entire fuel rail and upper fuel injector screens.**
4. **Clean fuel injectors**
5. **Decarbon engine assembly.**
6. **Clean throttle plate and Idle Air Control passages.**
7. **Check minimum air flow rate and adjust if needed.**
8. **Relearn On-Board Computer**

All of the above steps may be performed using a **"two-line"** fuel injector service unit such as: Carbon Clean, Auto Care, Injector Test, DeCarbon and Motor-Vac.

FUEL INJECTOR SERVICE KITS

These kits contain o-rings, pintle caps, grommets, spacers and other "hard-to-find" injector parts. These kits are a must for shops specializing in engine rebuilding and cylinder head work. They are also nice to have around at 4:30 on a Friday afternoon! Don't waste your time running to the local parts store that can't help you. Save time and money and keep these valuable parts in stock. Additional parts are available that may not be shown in the picture. The "Injector Wizard" will customize injector service kits to meet your needs. Call for more details.

Other hard to find parts available from LTS include:

Throttle Body Injection rebuild kits.
Fuel rail o-ring kits.
Injector harness connectors.
GM Central Port Injection pressure regulator kits.
Injector-to-Fuel rail clips.
Injector harness retainers.
EGR valve carbon trap gaskets.
CPI & CSFI Poppet Valve retainers.

FUEL INJECTOR SERVICE

Linder Technical Services is more then just Chrysler, Ford and General Motors injectors. We stock over 300 Import injector part numbers also. If you have a vehicle that we don't have an exchange set of injectors for we can service yours. Send them to LTS with a note that includes your name, address and phone number along with the vehicle year, make, model and engine size. In most cases we can guarantee a 24 hour turn around time. If you are sending us injectors and the fuel rail is contaminated, send it too, we clean fuel rails.

INJECTOR MANUFACTURERS; Even though we see fuel injectors packaged under many different names, there are primarily only a handful of manufacturers. The manufacturers shown below are some of the more common that we see.

BOSCH INJECTORS

DENSO INJECTORS

MULTEC INJECTORS

SIEMANS INJECTORS

FUELISH TIPS FROM THE "GURU" (CONT.)

- Carbon on throttle plates cause extended crank time on a cold start.
- Ford TBI fuel pumps draw about 3 AMPS, MPFI is about 5 AMPS.
- Carbon on valves will cause hard starting cold.
- Low IAC counts indicate a vacuum leak or misadjusted minimum air rate or low fuel pressure.
- High idle on dual TBI units, suspect the base gasket.
- Wrong PCV valve may cause low IAC counts.
- Always check injector supply voltage cranking and running.
- A shorted injector may cause a problem on another cylinder due to injector pairings in a parallel circuit.
- A shorted injector may run OK under normal electrical loads and poorly under higher voltages. Lower voltage at battery and listen to tailpipe.
- A noid lamp must be used with CAUTION! The computer may show a good noid and have low supply voltage.
- A good MULTEC will draw less than 1 AMP of current, a bank of three must draw less than 3 AMPS.
- If a misfire goes away with propane added, suspect a lean injector.
- All injectors have a final filter (approx. 10 micron) that will restrict over time!
- Fuel pump ground is more critical on high output pumps.
- Defective or hardened injector o-rings can cause hard hot restart.

FUELISH TIPS FROM THE "GURU"

- Shorted MULTECS may cause a hesitation along with low O2 voltage.
- Surge on a GM 3.8 Liter after TCC lockup - suspect the injectors are lean.
- TBI pressure regulator springs will rust at high mileage - REPLACE.
- Ford injectors are more prone to plug & restrict with mileage.
- Fuel pumps need 1/4 tank or more of fuel for correct pump operating temperature.
- Injectors are NOT matched on SOME 4.3L GM for manifold trim.
- GM dual TBI injectors should ohm at 2.2 OHMS @ 150°F.
- On a scope, a plugged injector looks like a vacuum leak with a sloping upward spark line.
- Ford Tempo TBI has an inlet screen (part # E53Z-9F525-A) that will cause a lean mix when restricted.
- Code 42 on GM can be caused by shorted injectors !
- A defective Ford alternator may make injectors run RICH !
- TBI exhaust manifold glows RED, suspect defective injector.
- Leaking injectors may be found by disabling ignition, unhooking all injectors and checking exhaust for hydrocarbons while cranking engine. MAX HC = 300 PPMS.
- Fuel filter has flow direction and if it is installed backwards it may act like a restricted exhaust.

FUEL INJECTOR SPRAY PATTERNS

FUEL INJECTOR SPRAY PATTERNS; Many technicians believe that a fuel injector sprays a conical cone shape pattern, this is not always true. Some injectors spray a straight stream or maybe a stream that is directed to one side. There are also injectors that spray a dual stream. The spray pattern of an injectors is determined by the way it's discharge tip was designed. Here is a picture of eight KNOWN GOOD SPRAY PATTERNS.

Injector identification from left to right:

Toyota (Denso) = Dual intake valve engine.
G.M. (Multec) = 3.4L "X" engine.
Chrysler (Siemens) = 3.8L "L" engine. Injector has a direction spray that is being directed at a 15-degree angle towards picture.
Ford (Bosch) = Deposit Resistant Injector (DRI) with 4-laser cut discharge holes.
BMW (Bosch) = Pintle style discharge tip.
G.M. (Multec) = Stamped Spray Tip design, multi-hole discharge.
G.M. (Multec) = Multi-hole discharge.
G.M. (Multec) = Multi-hole discharge.

ABOUT THE FUEL INJECTION "WIZARD", DOUG GARRIOTT

Doug Garriott started in the automotive business in 1980 working in a service station. He graduated from Lincoln Technical Institute here in Indianapolis, Indiana in 1984. Afterward, Doug worked in the field as a driveability technician for over six years. He later hired on as an instructor for Lincoln Technical Institute. He taught several classes including: Engine Performance, Fuel & Emissions Systems, Advanced Automotive Electronics, Service Shop Management and Service Shop Procedures. During this time, Doug also completed the "Master Instructor Train the Trainer Program".

Doug came on board full time with Linder Technical Services in 1997 as the Injector "Wizard". His main focus is in the injector lab. Doug spends countless hours on research and development each year. He works closely with Jim finding fixes for the "pattern failures" that were discussed on pages 22 and 23. On average, we ship around 700 injectors each week and that number is growing every day!

In addition to his responsibilities in the injector lab, Doug trains 1-2 groups of technicians each year here at our facility in Indianapolis. He also teaches fuel injection seminars at locations both at home and abroad and teaches the fuel injection portion of our one-week "Guru School".

Doug also travels frequently with owner, Jim Linder, to trade shows across the country. They can regularly be seen in Columbus, Ohio, Lexington, Kentucky, Kansas City and Las Vegas. The next time you are at an automotive trade show, look for the Linder Technical Services banner and stop by and say "HI" to the "Wizard"!

RETURNLESS FUEL SYSTEMS (CONT.)

return line. Supply pressure is regulated on the downstream side of the in-line filter to accommodate changing restrictions throughout the filter's service life. This system is limited to constant rail pressure (*CRP) System calibrations, whereas with ERFS, the pressure transducer can be referenced to atmospheric pressure for CRP systems or differentially referenced to intake manifold pressure for constant differential injector pressure (**CIP) systems.

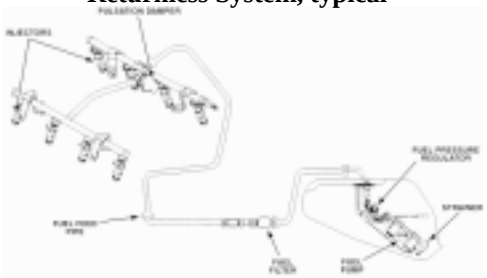
*CRP is referenced to atmospheric pressure, has lower operating pressure and is desirable for calibrations using speed/air density sensing.
**CIP is referenced to manifold pressure, varies rail pressure and is desirable in engines that use mass air-flow sensing.

DEMAND DELIVERY SYSTEM (DDS)

Given the experience with both ERFS and MRFS, a need was recognized to develop new returnless technologies that could combine the speed control and constant injector pressure attributes of ERFS together with the cost-savings, simplicity and reliability of MRFS. This new technology also needed to address pulsation damping/hammering and fuel transient response. DDS system technology was developed. A different form of Demand pressure regulator has been applied to the fuel rail. It mounts at the head or port entry and regulates the pressure downstream at the injectors by admitting the precise quantity of fuel into the rail as consumed by the engine. Having Demand regulation at the rail improves pressure response to flow transients and provides rail pulsation damping. A fuel pump and a low-cost, high performance Bypass regulator are used within the appropriate Fuel sender. They supply a pressure somewhat higher than the required rail set pressure to accommodate dynamic line and filter pressure losses. Electronic pump speed control is accomplished using a Smart regulator as an integral flow sensor. A Pressure Control Valve (PCV) may also be used and can readily reconfigure an existing design fuel sender into a returnless sender. Returnless systems are desirable and are expected to be the "STANDARD" fuel delivery system in most vehicles in the years to come.

RETURNLESS FUEL SYSTEMS

Returnless System, typical



ELECTRONIC RETURNLESS FUEL SYSTEM (ERFS)

This system is unique because it doesn't use a mechanical valve to regulate rail pressure. Fuel pressure at the rail is sensed by a pressure transducer, which sends a low level signal to a controller. The controller contains logic to calculate a signal to the pump power driver. The power driver contains a high current transistor that controls the pump speed using pulsation width modulation (PWM). This transducer can be differentially referenced to manifold pressure for closed-loop feedback correcting and maintaining the pump's output to a desired rail setting. This system is capable of continuously varying rail pressure as a result of engine vacuum, engine fuel demand and fuel temperature (as sensed by an external temperature transducer if necessary). A pressure vent valve (PVV) is employed at the tank to relieve over-pressure due to thermal expansion of fuel. In addition, a supply side bleed, by means of an in-tank reservoir using a supply side jet pump, is necessary for proper pump operation.

MECHANICAL RETURNLESS FUEL SYSTEM (MRFS)

The first production Returnless systems employed the MRFS approach. This system has a bypass regulator to control rail pressure that is located in close proximity to the fuel tank. Fuel is sent by the in-tank pump to a chassis mounted in-line filter with excess fuel returning to the tank through a short return line. The in-line filter may be mounted directly to the tank, thereby eliminating the shortened

MEET OUR INJECTOR LAB CREW

GREG MANKER

Greg started with LTS in September of 2001 part-time and came on board full time in December that same year. His primary function is cleaning and flowing hundreds of injectors each week. Greg also does our Throttle Body Injection re-building.

Greg is a very avid race car fan (as long as Chevy wins) and is extremely knowledgeable with Indy 500 history. He has two cars that he maintains and races, a1983 Monte Carlo, quarter mile car and a 1984 Caprice, roadrunner car. He is a member of the Indy Hi-Winders Car Club.

Greg likes to learn new things and catches on very quickly which has made him an asset to the Fuel Injection portion of the business. Greg travels with the LTS crew from time to time to work the trade show booth.

STAN KRATOWICZ

Stan started helping out part-time in the Fuel Injection Lab in November 2003. At that time, plans were already in the works to expand the Lab which meant producing more fuel injectors and needing more help. Stan proved in a short time that he is not only a quick learner but a very hard worker. Once the expansion was complete, he joined the LTS crew as a full-time employee. Stan works on the "finishing" process of the injectors where they are made ready for shipping.

Just like the rest of the LTS crew, Stan is a "car guy". He is a member of the Indy Hi-Winders Car Club. He owns a 1986 Monte Carlo with a 355 engine and when he's not busy with his three children, he likes to take his Monte to the drag strip.

GM'S CENTRAL PORT INJECTION (CPI) UNIT

The CPI unit is very similar to the old "dribble" system of the late 1950's used on Corvettes. The system is mounted under the intake plenum and uses a single injector with six spray holes feeding a pod with six lines and poppets.

This CPI unit operates the main "maxi" injector at approximately 60 psi and fires all lines with poppets at the same time requiring approximately 43 psi to release final fuel spray.

SYSTEM PRESSURE…...KOEO fuel pressure should be 54 to 64 psi and should not bleed down when the pump stops running. Running pressure may be slightly lower; normally 52-54 psi. Many technicians have been fooled with a no-start at 56-57 psi. This system MUST have 58-60 psi (KOEO) to operate correctly. The reason for this is the difference in actual volume of fuel being delivered at different fuel pressure settings. Note that at 56 psi, the unit sprays approximately 20 mils of fuel. When the unit is at the correct pressure of 60 psi, the unit sprays 28 mils. This is a huge difference in volume (30%**)!**

LEAKING FUEL PRESSURE REGULATOR. The diaphragm in the fuel pressure regulator will rupture and leak fuel into the upper intake. The regulator cannot be purchased separately from a dealer or parts supplier. Until now, the only fix was to buy a whole new unit which is very costly!

LTS is one of the only companies in the country that offer reconditioned CPI units and replacement pressure regulator kits that can be purchased separately! (For more information on this, please refer to page 24.)

INJECTOR SIZING

Most people want to increase the output of fuel to better their engine's performance. Injector sizing can sometimes be a challenge, especially if you don't know what size of injector you are starting with. In most cases, manufacturers publish the rating of injectors, in pounds of fuel per hour (lb/hr). The rate is figured with the injector held open @ 3 bars (43.5psi). An important consideration is that larger flow injectors have a higher minimum flow rating. Here is a formula to figure injector sizing if you are changing the mechanical characteristics of an engine.

$$\text{Flow Rate} = \frac{\text{HP x BSFC}}{\text{\# of Cylinders. X Max. Duty Cycle}}$$

- **HP** is your projected horsepower, be realistic!
- **BSFC** is Brake Specific Fuel Consumption in pounds per horsepower-hour. Calculated values are used for this, 0.4-0.8 lb. In most cases. Start on the low side for naturally aspirated engines and the high side for engines with forced induction.
- **# of cylinders** is actually the number of injectors you are using.
- **Max. Duty Cycle** is considered at 0.8 (80%). Above this, the injector may over-heat, lose it's consistency, or not work at all.

Example: 5.7 Liter V-8

$$\frac{\text{240 hp x 0.65}}{\text{8 Cyl x 0.8}}$$

24.37 Lb/Hr. injectors required

PATTERN FAILURES (CONT.)

1992-1995 GM 4.3 Vortec vin "W". The diaphragm ruptures inside the fuel pressure regulator, which causes it to leak externally into the intake. At this time, we are one of the only companies that we know of that will sell you a ***replacement regulator ONLY!*** The CPI units also have problems with sticking poppet nozzles. A complete reconditioned unit with flow-matched tubes and a new regulator is also available from LTS

Regulator Kit

Complete Reconditioned Unit

LTS offers the General Motors 4.3L service kit. This kit is just what you need for the 1991-95 Vortec engines. It includes an LTS Reconditioned CPI unit with upgraded regulator so you don't have any more worries about a leaking regulator, the fuel supply & return lines which will put your mind at ease when removing those brittle plastic lines from the old unit, an upper plenum gasket and an EGR screen-type gasket to take care of the common problem of carbon getting stuck in the EGR valve.

CPI UNIT (CONTINUED)

STICKING POPPETS have plagued this unit. Poppet nozzles contain a check valve and extension spring that together regulate fuel flow. Fuel flows from the poppet nozzle when pressure exceeds 40 psi.

THE EGR SYSTEM on this engine has been a problem. Carbon gets caught in the EGR valve and holds it open causing a rough or no idle condition. A number of fixes are available for this problem including:

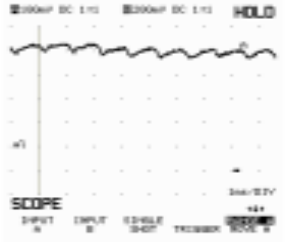
1. An updated PROM that exercises the valve and increases the opening periods at highway speeds. This is available for 1991-1994 vehicles. A new flash programming fix is available for '95 and newer vehicles.

2. An aftermarket screened gasket to prevent this condition from recurring is the TOMCO #2-1357

3. Cleaning kits are available that require chemical to remove and clean out the EGR passages. The utilization of this method has prevented many comebacks and should be looked into as a preventative maintenance service.

THE O2 SENSOR receives voltage from the ignition/gauge fuse for it's heater. There is no code specifically for the heater element. Indicators of heater element failure are sluggish performance and/or odor from the catalytic converter.

CURRENT RAMPING the fuel pump with an amp probe and DSO should show between 7.5-10.5 amps (new pump). One brush and spring is prone to failure due to low fuel level, ethanol or oxygenated fuels, or poor fuel filter service.



CENTRAL SEQUENTIAL FUEL INJECTION

Central Sequential Fuel Injection is used on GM light trucks beginning in 1996. It is similar to the CPI system used on the earlier 4.3L models. Rather than one TBI injector feeding all of the poppet nozzles, there is now one electrical injector for each poppet nozzle. Each is fired sequentially for accuracy and precise metering control.

The CSFI injectors are located in the fuel meter body assembly. Also included in this assembly are the fuel inlet, fuel return, fuel pressure regulator and electrical connector for the injectors. Each injector and poppet nozzle assembly is a single unit and can be serviced individually.

When an injector energizes, the increased fuel pressure pushes the poppet nozzle's ball off of it's seat and fuel is supplied to the cylinder. When the injector de-energizes, spring force overcomes the decreased fuel pressure and the ball seats, cutting off fuel supply at the nozzle.

CSFI SERVICE:

When removing the fuel meter body from an engine, notice that the body is numbered to indicate poppet nozzle order. These numbers must match the injector with the poppet nozzle and cylinder. If the lines are installed incorrectly, a driveability problem could result.

To remove a nozzle, squeeze the locking tabs together while lifting it out of the casting socket. The fuel meter body assembly is removed by releasing the bracket lock tab with a flat tip screwdriver.

PATTERN FAILURES (CONT.)

- **Chrysler 3.5L** The fuel rail in these engines has problems leaking fuel. The dealer will sell you a new fuel rail to fix this problem, but we have an o-ring kit available.

- **GM 7.4L "J"** The most common problem with these injectors is that they get dirty and drip fuel. This will cause the system to lose fuel pressure and create a hard starting condition. We use a Bosch replacement.

- **1990-97 Landrover V-8.** These vehicles use a Disc style injector. When a Disc style injector gets dirty they are very difficult to get clean and achieve the proper spray pattern. We replace the Disc style injectors with Bosch injectors.

- **1989-94 Toyota Truck 6 Cylinder.** These are Denso injectors that leak where the plastic electrical connector meets the metal body. This is due to deterioration of an internal o-ring. We replace these injectors with another Denso injector that is not prone to leaking.

- **1992-97 GM 2.2L.** This a small side feed Multec injector. It will leak fuel into the electrical connector over a period of time. We have NEW injectors to insure a quality repair.

- **Nissan Injectors.** Through the years Nissan injectors have been plagued with a variety of problems. Early models had injectors that leaked externally, later models would short out. Both of these situations make the injectors non-reconditionable. We have NEW OEM injectors to insure a quality repair.

Many of these replacement sets come with a

Lifetime Warranty!

Call Doug for details!

PATTERN FAILURES? WE'VE GOT THE FIX!

Over the last eight years, we have shipped over 300,000 fuel injectors across the country, so we have become very familiar with "pattern failures". We have done extensive work trying to find fixes for these particular problems. Below is a list of some common injector "pattern failure" problems along with the LTS fix for each one.

- **GM 2.8, 3.1 vin "T" and 3.3 up to 1993.** Many of you know that these cars come originally equipped with black Multec injectors which are prone to electrically shorting out. Our fix for these is to replace them with a Bosch DRI (Deposit Resistant Injector).

- **1985-1992 5.7 vin "8" or vin "6" Corvette, Firebird, Camaro.** These vehicles also have Multec injectors which have problems shorting out. We also replace these with Bosch units.

- **1987-1990 4.0 Jeep.** These vehicles may have come with a Siemens, Deka or Bendix injector, but all have problems leaking externally where the body of the injector meets the plastic top. These are replaced with a Bosch unit which does not leak.

- **1990 4.5 vin "3" and 1991-1993 4.9 vin "B" Cadillac.** We have Bosch injectors for both of these engines to replace the problem Multec.

- **1984-1988 GM 3.8 vin "3".** These GM cars were originally equipped with a Bosch injector that had problems leaking externally much like the Jeep injectors we talked about before. We replace them with the newer style Bosch injectors that do not leak.

- **GM TBI.** The springs break in the fuel pressure regulators. We have repair kits available with gaskets, seals, a diaphragm and a spring.

CSFI SERVICE (CONT.)

FUEL PRESSURE TESTING ON THE CSFI SYSTEM:

With the key cycled "ON", the regulator should control fuel pressure to the specification of 60-66 psi with the pump running and the engine "OFF".

Fuel pressure that continues to fall after the engine has been stopped or the ignition has been turned "OFF" could be caused by:

- A leaky injector and poppet assembly
- Damaged o-rings
- A leaking fuel pressure regulator valve
- Partially disconnected fuel pulse damper (known as the pulsator) in the tank.

COMMON FAILURES:

Internal contamination causes a rich condition (poppets are stuck open) OR damaged fuel tubes can cause a lean condition.

GM has issued a bulletin (#87-65-07) addressing the "rough idle after start when vehicle has sat overnight/SCPI poppets sticking (Clean Fuel Injector Using New Procedure)." This bulletin describes the service methods needed when these poppets stick closed using injector balance testing and replacing any and all failing injector units. Once units have been replaced, it is suggested to add a 20-ounce bottle of port fuel injector detergent to the tank. (#12345104)

Caution: these units have been known to leak from the injector upper area into the harness, up through the wiring and into the PCM/VCM unit. The customer complaint is usually the smell of gasoline from the engine compartment. Current GM warranty policy is 3 years/36,000 on this problem with an 8 year/80,000 warranty on the PCM.

REVIEWING GENERAL MOTORS CSFI

We have written many newsletter and magazine articles about the General Motors Central Sequential Fuel Injection (CSFI) system. You know the one; it's used on the 1996 through 2002 4.3L/5.0L & 5.7L that suffers from stuck poppet valves. Many of you have tried to free the poppets as recommended by G.M.s lengthy tech bulletins about unsticking seized poppets and then cleaning these units. Or maybe you have even replaced the injector-poppet for the cylinder(s) that had the misfire. Then you find in a week or two that the vehicle is back in your shop again for another misfire code. You don't know what went wrong, it ran great when it left, but now you are at square one again. Well here's what happening, CSFI is similar to the CPI system used on the previous 4.3L engines. Rather than one maxi injector feeding all the poppets and firing every crankshaft revolution, it uses one injector for each poppet that is fired sequentially. This gives the poppets a hot soak period before they fire again. This makes these units susceptible to tarnish build up on the poppets and causes them to stick. So what is the fix?

LTS now has NEW replacement units that utilize a "Mini-injector" instead of a poppet valve. These units are a direct fit and very cost effective. Get yours today and get that "come-back" out of your shop!

G.M. STAMPED SPRAY TIP CONT.

So what's happening with these injectors? At some point these vehicles probably started with a symptom like the ones mentioned in the TSB. But, nothing was done about it. The carbon, dirt, rust or whatever was restricting the injector was not cleaned out. Now the problem has gotten worse and something has become lodged in the injector or it is so clogged that very little or no fuel is being discharged. A few "taps" on the side of the injector dislodges whatever happens to be stuck inside the injector and it seems to work fine again. This could be related to the use of fuels that do not contain certain detergents or fuel additives and the use of fuel with an improper octane rating. Driving patterns such as short trips with long cool down periods can also accelerate this condition.

So is tapping on the injector a fix? Absolutely not! In most cases the injector will stick again and/or other injector will develop the same problem.

What's the fix?

1. Take a fuel sample and test for fuel contaminates such as: water, sugar, rust, dirt, etc. This may mean you have to leave the sample sit overnight.
2. Flush the fuel rail, lines and tank as needed.
3. Perform an intake cleaning to remove carbon that could possibly clog the new injectors.
4. Replace all injectors with our flow-matched sets.
5. Educate your customer that regular maintenance can reduce their chances of having this problem reoccur in the future. This includes oil changes, PCV valves, fuel system service and intake cleaning to remove carbon. Not only will this make your shop money, but there is much less chance that this vehicle will come back with the problem again.

G.M. STAMPED SPRAY TIP INJECTORS

We've been getting calls regarding fuel injector problems with G.M. Multec injectors with the Stamped (stainless) Spray Tip. General Motors introduced this version of the Multec injector in 1993, it is primarily used on, the 3100 engine (vin M & J), the 3400 (vin S & E) and the 3800 (vin K). Many of the complaints are related to a MIL on and/or a lean condition. It seems that as technicians are checking into these driveability problems, they find that one or more of these injectors doesn't seem to be working at all. However, with a few "taps" on the side of the injector, it comes back to life. Let's explain what is going on.

The injector utilizes a larger discharge bore when compared to the original Multec. This was done to prevent fuel dripping from the discharge area and improve air/fuel mixing. This makes the injectors prone to carbon build up at the discharge end, reducing the amount of fuel flow. This will cause a multitude of problems such as hard starting, hesitation, MIL on and a lean condition. G.M. has published a TSB regarding these particular problems: Bulletin# 99-06-04-005B. Below is an excerpt from the bulletin.

Condition
Some owners may comment on driveability symptoms of long or hard start, chuggle, rough idle and light or intermittent misfire. The MIL may also illuminate.

Cause
Due to various factors, the fuel injectors may become restricted. At this point no specific fuel or engine condition has been identified as causing the restriction. The restriction causes the engine to operate at a lean air/fuel ratio. This may either trigger the MIL to illuminate or the engine to develop various driveability symptoms.

FUEL INJECTOR OPERATION CONFIRMATION

What procedure do you use to confirm injector operation when the injectors are still in the vehicle? Do you have a procedure? Do you check all aspects of an injector's operation?
Maybe the first question should be: How did you determine that the injectors are the problem? Can it be assumed that you did a thorough analysis of the:

- Engines mechanical ability
- Ignition system
- Fuel delivery to the injectors
- Emission control devices
- PCM's ability to control fuel by testing and observing the O2 sensor waveform.

All these systems need to be confirmed as operating properly before you can move on to the injectors.

Checking injectors on the vehicle has changed through the years. Some of the tools and procedures from yesterday are not the tools and procedures of choice today. It is also important to have a good understanding of the type of fuel system and the PCM strategy for the system you are working on.

So, lets start with a good definition of what an injector is. An injector is *an electrical - mechanical device that meters and atomizes fuel*. From this definition, we base our diagnostic procedure.

Electrical - This is a two part analysis. One is the electrical integrity of the injector. The other is the computer's ability to provide a pulse to the injector at the proper time. At one time, a resistance check of the injector was all that was done to confirm its electrical ability. This test was felt to be adequate and some technicians still use it, but a one-time check of an injectors' resistance is not always enough. This is due to the fact that resistance will change with an injectors' temperature. I have seen thousands of injectors that passes a resistance test at room temperature and failed when some heat was added.

INJECTOR OPERATION CONFIRMATION (CONT.)

Many technicians use a noid light to prove a signal from the PCM. You must remember, this test tells us nothing about supply voltage or injector pulse width. A noid light will ONLY tell you if the injector driver in the PCM is going to ground. Is it a good ground? Keep in mind that most noid lights only have a resistance of 3.5 ohms and inserting one into the PCM control circuit changes the circuits' current characteristic.

Today the use of a Digital Storage Oscilloscope (DSO) is a common tool. Many technicians look at an injector's voltage pattern to confirm supply voltage, good ground, inductive kick when the injector is turned off, and a measurement of pulse width. Others use a low amp current probe with their DSO as the preferred method of obtaining a waveform. This allows the technician to confirm the PCM signal, injector pulse width, and injector circuit current usage. DSO patterns can also be helpful in diagnosing mechanical operation by showing the pintle hitting its opening and closing points.

Mechanical - At one time a stethoscope might have been used to listen for a clicking noise coming from an injector. Many times, unless the injectors are being pulsed individually, the vibration of one injector can be carried through the rail and heard at another injector.

Metering - There are many different ways of measuring injector output, depending on the make of the vehicle. Some PCMs have a built-in test for injector balance that can be run through a scan tool or activated through the dash. This allows the injectors to be shut off individually and the difference in their cylinders power contribution to be recorded. Keep in mind that a mechanical problem could cause a cylinder to fail this type of test.

Probably the most common method is the use of a fuel pressure gauge and an injector pulser to determine injector contribution. Injector contribution is calculated by the difference of a before pressure and after pulsing pressure readings. Although this test is widely used, there are no real concrete specs.

INJECTOR OPERATION CONFIRMATION (CONT.)

Most specifications say no more than a 10kPa difference in drop per injector. This is approximately 1.5 psi, which is a small amount of difference if an injector only drops 5 or 6 psi total. Furthermore, there are no specifications telling how much an injector should drop to begin with. General Motors has expanded on this test for their Central Sequential Port Injected engines. The new procedure uses a fuel chamber with spring-loaded diaphragm that connects to the fuel pressure connection valve and a dial indicator. When the injector is pulsed, the dial indicator measures the diaphragm movement, which correlates with the actual amount of fuel delivered.

Hickok Inc. makes a product for Mac Tools called a Scanalizer. It is a multiport fuel injection analyzer that has the capability of testing fuel pump supply, fuel pressure, pressure regulator operation, injector electrical integrity and injector flow.

An injector balance test using an exhaust analyzer (watching HC change) is another method, but most technicians don't want to go through this procedure. Why? Because you must tap into the exhaust system in front of the catalytic converter to get an accurate reading of the hydrocarbon gases. This takes a little time to drill a test port and we know how hot the exhaust can be while we're trying to get this done. There are kits available for this test that have inserts to plug the exhaust when testing is done. You must also have means of killing individual cylinders to perform this test.

Atomization/Spray pattern - I conclude that most technicians have the theory that an injector sprays a conical cone shape spray. This theory is from looking at the spray pattern of a throttle body injector. A port injector may have this type of spray, but some, depending on nozzle design, may spray a straight stream. Some of the newer design injectors have an off center fuel discharge hole. These are directional spray injectors and if you look at their pattern unaware of this, you may condemn it. Anyway, how can atomization and pattern be seen when the injector is in the intake manifold? To make a proper comparison, the injectors will have to be removed.