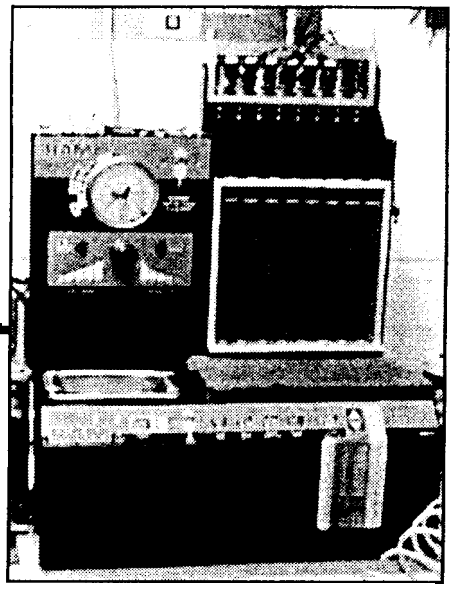
The Official Newsletter of LINDER TECHNICAL SERVICES

LTS IN CONTROL WITH LINDER TECHNICAL SERVICES

Networking

FUEL INJECTOR SERVICE

(OFF CAR)



Fuel injectors are manufactured to operate properly and last for 150,000 miles. Because of their significance on emissions they are warranted in most cases for 5 years or 50,000 miles by the vehicle manufacturer. 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. A leading cause of this is short drive cycles. Short drives with repeated temperature change creates fuel diffusion. This allows heavy particles to settle at the tip of the injector. Injectors should hold a constant spray pattern and a delivery volume within three percent for a given engine's set. When delivery is out of spec, driveability problem exist because the ECM is unable to maintain the proper air/fuel ratio overall causing some injectors richer or leaner depending on if the injectors are clogged or leaking.

A pressure drop test is valid for determining a reduction in volume passing through an injector, such as would occur in the event of injector plugging. BUT a partial buildup, such as would be displayed as a *poor spray pattern,* will have a minimal affect on the injector's flow rate and may not show up during a pressure drop test. Another way and probably more effect is to do a *cylinder balance test with gases.* This test is most accurate when taken in front of the catalytic converter. Do to that fact, it is the least used by technicians because they must tap into the vehicle's exhaust, which takes time, or they don't have a working exhaust analyzer.

Until recently, the normally accepted service procedures for clogged or leaking injectors was to use an on-car chemical cleaning (this topic was the focus of our October 1997 Newsletter) or injector replacement. Replacement, however, is the most expensive way and many customers don't take this kind of news very well. Replacing a single injector or two doesn't 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?

TESTIMONIALS

Doug,
Thanks for shipping the injectors so promptly. You wouldn't believe the difference the made in driveability. No more stumble off the id/e! You folks at Linder Technical Service can count on a glowing reference from me. Thanks again for your help.
Sincerely,
Bob Smith

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To Whom It may Concern:
We are enclosing the core for the CPi assembly we received. Also, I spoke to Doug and he said to just deduct the core charge from the invoice amount. We did and enclosed you will find our check along with the core CPI unit. We were very pleased with the price and performance of the part Thank you for the added information you sent. I'm sure you'll be hearing from us again sometime.
Sincerely,
Ron May, Jr.
Ronnie's Service Center
Wilkes- Barre, PA

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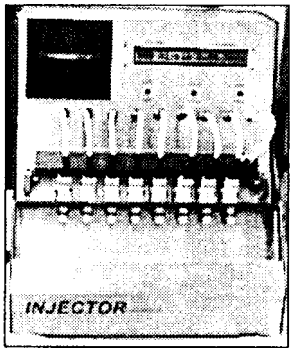
Thank you! Your product is excellent. Also the service.
Steve
Auto Service House
Denver, Colorado

• • • • • • • • • • • • •

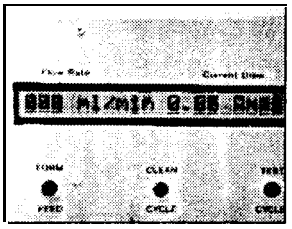
These injectors, as I told Peggy, are plugged with mothball residue. The customer had been told, by a jet mechanic, that mothball would make his car go faster! Maybe if it had wings, it would have. But all it did was plug up the injectors and the pressure regulator.

Hope you can resurrect these injectors. I have to drop the tank and flush the system. Let me know if there's any problem with the injectors. Also, could you please get an injector o-ring kit. If not, let me know, so I can start looking for one.

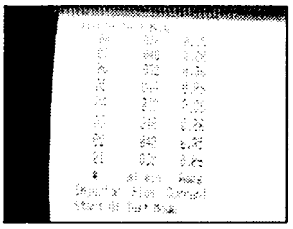
Am including some local coffee for your pleasure,
Aloha,
Jim
Ocean View Auto & Elect.
Ocean View, Hawaii



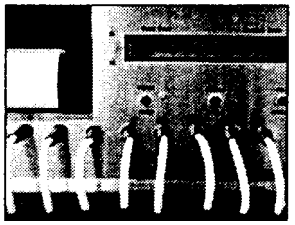
OFF CAR fuel injector service offers some additional benefits. A visual flow at various pulse rates can reveal mechanical binding of the pintle or pulse ranges when the injector may not function at all. Distorted spray patterns or dribbles that may not show up during an on car pressure drop test can easily be spotted. *Mostly,* it gives a visual flow rate. And by doing a relatively large volume we can mix and match injectors into sets with the correct spray pattern and an even volume of delivery.



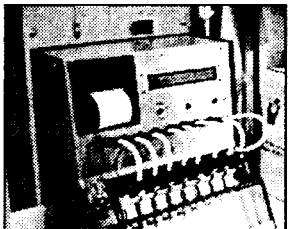
Our injectors are reconditioned using a procedure that we have developed by teaching fuel injection for over 20 years, servicing today's fuel injected vehicles and by testing tens of thousands of injectors over the past few years. This procedure uses both conventional and specialized computer test equipment. **The steps are as follows:**



1. 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!



2. 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 the injector hot and cold. This step eliminates another 30% of core injectors and out of spec injectors are discarded!



3. 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 leakers.

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

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

6. 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. The cleaning fluid backflushes through the injector and carries the deposit residue back and out.

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

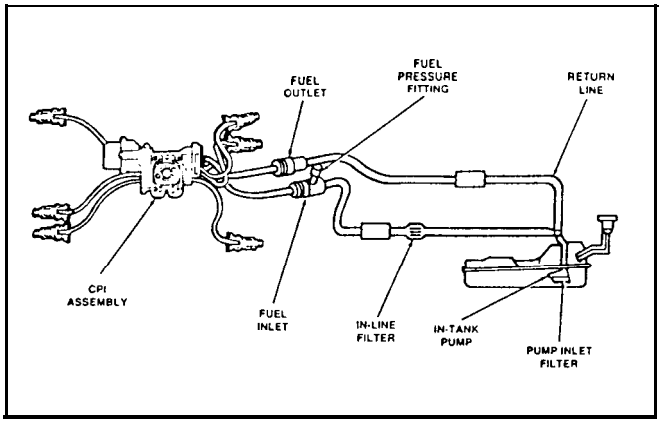
8. MATCHING BALANCED SETS...delivered volume and spray pattern at various pulse cycles is noted in step #7. This information is used to mach sets of injectors.

9. INJECTOR SCREENS, END CAPS, AND "0"-RINGS ARE REPLACED.

WHAT A YEAR IT'S BEEN!

By Doug Garriott "The Injector Wizard"

At the beginning of 1997 I came onboard at LTS full time in the injector room. At that time I thought I knew alot about fuel injection having taught and servicing it for many years. *Well,* I didn't know as much as I thought I did. One of the responsibilities I was given was to assist in **Hotline Phone call.** Did this ever shed some light on the subject. Here are some of the common topic asked:



1. GM'S 4.3 L (L35) **Vortec, Central Port Injection (CPI) Fuel System.**

SYSTEM PRESSURE... KOEO should be 54-64 psi and should not bleed down when the pump stops running. In most cases the pressure regular will open and allow fuel to return at 60 psi. Running pressure may be slightly lower **BUT SHOULDN'T GO LOWER THAN** 57 **psi.** Normal pressure will be 59-61 psi, at 56 psi there is 30% fuel delivery loss which can cause HARD STARTING AND DRIVEABILITY problems. The poppet nozzles contain a check valve and extension spring that together regulate fuel flow. Fuel flows from the poppet nozzle when pressure exceed 37-43 psi. (on the flow bench I see this shut down at 40 psi).

Watch for leaks at the injector electrical connectors and the pressure regulator, these are very common.

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 typical to fail due to low fuel level, ethanol or oxygenated fuels, or poor fuel filter service.

The upper intake plenum gasket in the front is also known for sucking in. This causes a vacuum leak and creates a high idle, sometimes setting an intermittent SES light with a code 35 (IAC) stored.

Carbon on the EGR pintle will cause driveability problems too.

Beware, the HEGO is an air tight unit and receives its external air source through the wire. Use a jumper when tested so the wire is not damaged.

The 02 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.

Fuel tank straps should be tightened to spec (26 to 31 Ibs. per foot) whenever tank has been lowered. If not, the return line could be pinched, causing the fuel pressure to increase.

2. **INJECTOR RESISTANCE...** This is a book within itself (and one should always be used when possible). BUT due to the fact that not everyone has a book or is willing to use it, I have put together some common injector resistance tables.

We **are finding that Current Ramping injectors is a much more effective and an efficient way of dynamically testing the injector's coil windings.**

CHRYSLER:

TBI low pressure systems (most)	1.3 ohms
TBI high pressure systems (most)	0.7 ohms
MFI early years through 1992 (most)	2.4 ohms
MFI later years after 1992 (most).	14.5 ohms

FORD:

TBI low pressure	1.9L	1987-90	1.0 - 2.0 ohms
TBI low pressure	2.3L	198587	1.0 - 2.0 ohms
TBI low pressure	2.5L	1986-90	1.0 - 2.0 ohms
TBI high pressure	3.8L	1984-87	1.5 - 2.5 ohms
TBI high pressure	5.0L	1981-85	1.5 - 3.5 ohms
MFI	1.6L	1985	2.0 - 2.7 ohms
MFI	1.6L	1983-85	15.0 - 19.0 ohms
MFI	2.3L T/C	1983-88	2.0 - 2.7 ohms
MFI	2.3L	1989-94	15.0 - 18.0 ohms
MFI	2.3L Tk	1985-94.	15.0 - 18.0 ohms
MFI	3.0L	1986-90	15.0 - 18.0 ohms
MFI	4.9L	1987-88	15.0 - 18.0 ohms
MFI	5.0L	1985-84	15.0 - 18.0 ohms
MFI	7.4L	1987-94	15.0 - 18.0 ohms

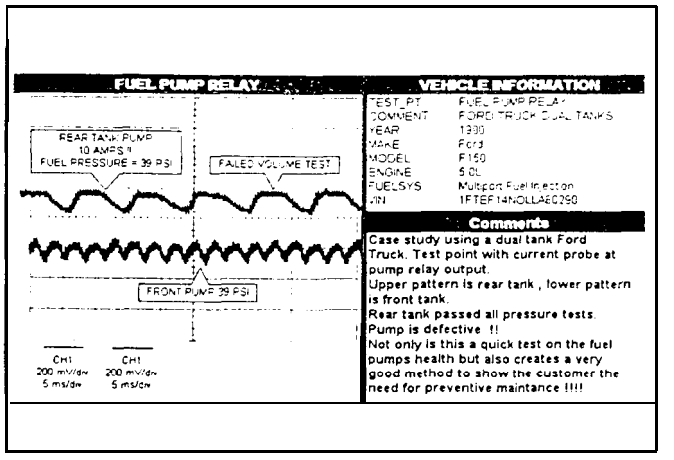
*In 1991 Ford started using a DRI (Deposit Resistant Injector) in their MFI systems. This injector has a lower resistance value, normally 13-l 6 ohms.

GENERAL MOTORS

TBI 220 series 2.8 / 3.1 / 4.3 / 5.0 / 5.7 / 7.4 liter.	1.16 - 1.36 ohms
TBI 295 series 4.3 / 6.0 / 7.0 liter.	1.42 - 1.62 ohms
TBI 700 series 2.0 / 2.2 / 2.5 liter.	1.42 - 1.62 ohms
CPI vortec 4.3 liter 1.50 ±.2 ohms	
MFI Bosch style injector (1985-89) 2.8 liter	15.95 - 16.35 ohms
MFI Black Multec injector 2.8 / 3.1 / 3.3 / 3.4 liter.	11.8 - 12.6 ohms
MFI 3800 eng.	14.3 - 14.7 ohms
MFI 3.8 / 5.0 / 5.7 liter.	15.8 - 16.6 ohms
MFI 5.7 LT5-ZR1	11.8 - 12.6 ohms
Quad 4	1.95 - 2.15 ohms

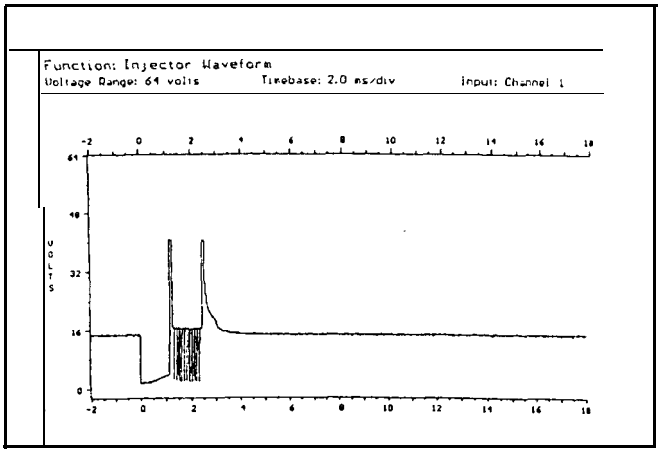
3. FUEL PUMP PRESSURE AND VOLUME...

Although system pressure varies alot from manufacturer to manufacturer, system to system, volume can be check by using a universal spec...1/2 pint in 15 seconds. We recommend Current Ramping the power supply to the pump. This is a good indicator of the overall pump condition.



4. **JEEP PEAK AND HOLD INJECTOR...**

The question has been asked about what appears to be “injector ringing” on Jeep Peak and Hold injectors. This is normal on this type of system. It is nice to know that technicians are looking at this, as it is abnormal to have this “ringing” appear on a GM TBI Peak and Hold. The fix for GM, is to put a .1 MFD capacitor across the injector harness.

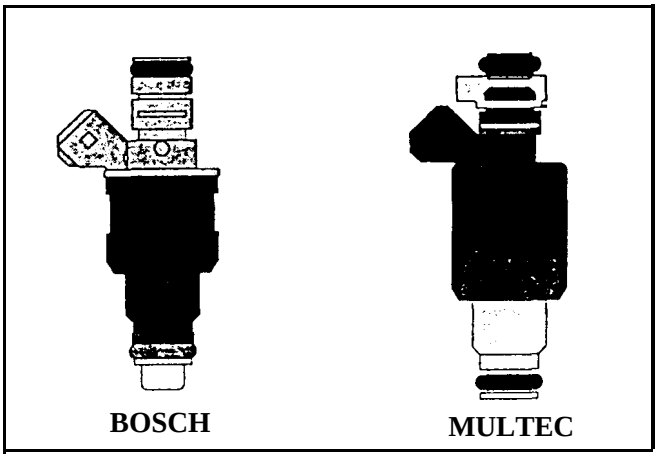


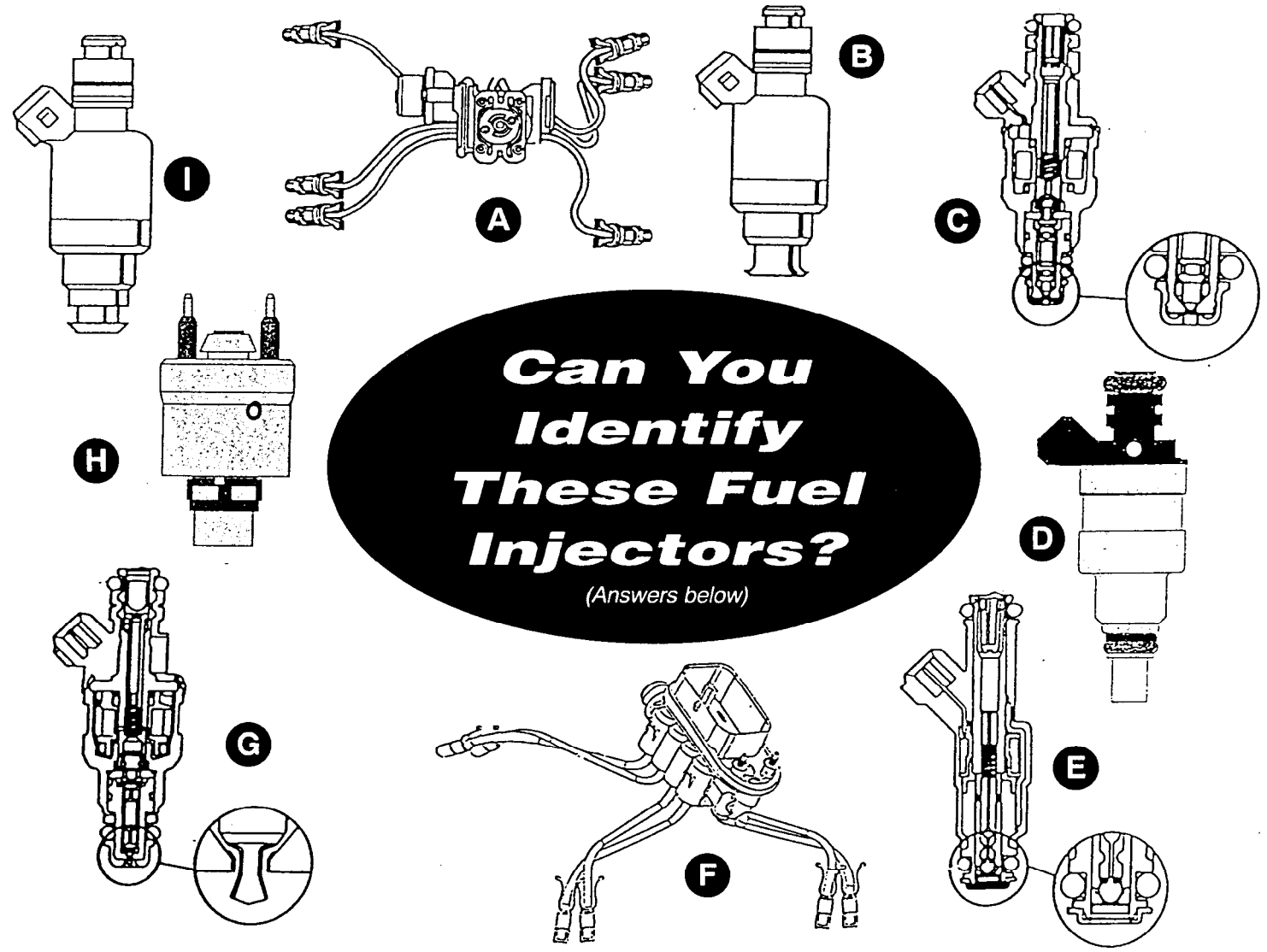
5. DIFFERENCE IN INJECTORS...

Sometimes it is necessary to ask if a GM vehicle is equipped with Bosch or Multec injector. here is an illustration of both. The next question is usually “what type of problems do they each have?”

Bosch injectors over a period of time have a tendency to leak externally near the connector.

Multec injectors are more prone to coil shorting, loosing their resistance. It should also be noted that the connector color on a Bosch injector is used in identifying application. i.e. Black, Blue, Green, Grey, White, Yellow.





Returnless Fuel System **(RFS)**

By Doug Garriott

Returnless fuel delivery systems are being used to assist vehicle manufacturers meet lower emissions requirements for evaporative hydrocarbons from the vehicle. Because the fuel return line contributes to much of this vapor formation, it's elimination is desirable, (any fuel flowing through a return type system absorbs heat energy from the rail in the engine compartment, this fuel is allowed to depressurize to essentially atmospheric pressure in the return line, and to raise the bulk fuel temperature in the tank).

Returnless fuel systems usually have the following differences compared to return type system:

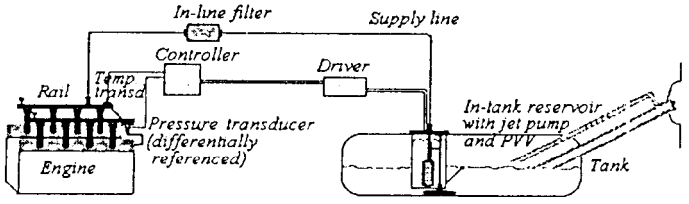
- No return line from the rail (rail operated dead-headed).
- No bypass regulator on the rail (a bypass regulator must function with a return line).
- Only engine consumption fuel flows in the supply line (average flow rate is reduced). Therefore, all fuel flows through the supply line and rail passes through the injectors, including vapor.
- Higher rail pressure maybe required to meet fuel hot handling criteria and prevent vaporing.
- Rails and injectors operate at a higher temperature. (Since average flow rate is reduced, supply fuel spends more time in transit to absorb heat of the engine compartment).

Injector I.D.

A = GM Central Port Injection (CPI)
B = GM Multec Stamped Spray Tip
C = Ford Bosch Cap
D = Chrysler Bosch Pencil or GM Chimney
E = Ford Bosch Disc
F = GM Central Sequential Fuel Injection (CSFI)
G = Ford Denso
H = GM TBI Maxi
I = GM Multec

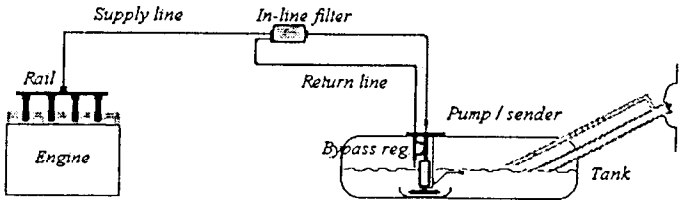
TYPES:

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 which controls the pump speed using pulsation width modulation (PWM). This transducer, which can be differentially referenced to manifold pressure for closed-loop feedback correcting and maintaining the pump's output to a desired rail setting. The system is capable of continuously varying rail pressure as functions 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 do 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.



Electronic returnless system

MECHANICAL RETURNLESS FUEL SYSTEM (MRFS) – The first production returnless systems employ the MRFS approach. This system has a bypass regulator to control rail pressure 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 eliminating the shortened return line). Supply pressure is regulated on the downstream side of the in-line filter to accommodate changing restrictions through-out 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.



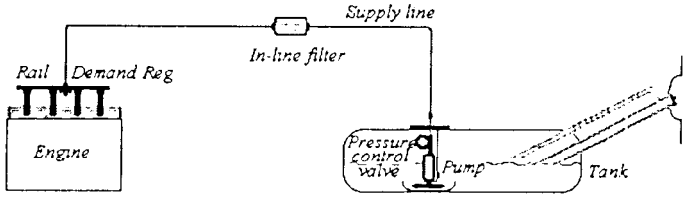
Mechanical returnless using in-tank regulation

**CRP is referenced to atmospheric pressure, have 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.*

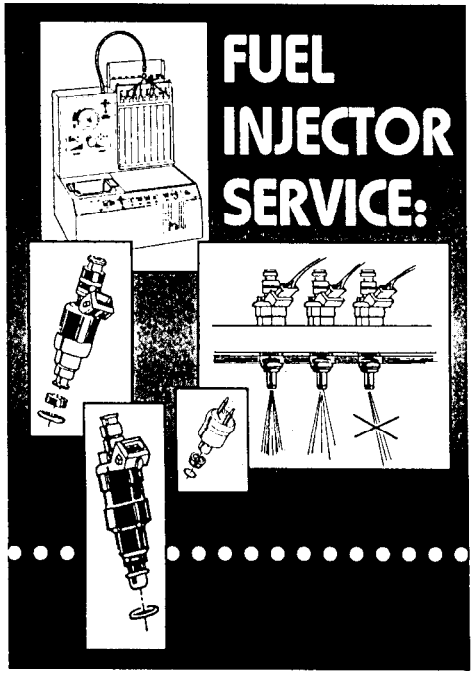
DEMAND DELIVERY SYSTEM (DDS) – Given the experience with both ERFS and MRFS, a need was recognized to develop new returnless system technologies, which could combine the speed control and constant injector pressure attributes of ERFS, together with the cost-savings, simplicity, and reliability of MRFS. 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 a 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 most vehicles by the year 2000.



Typical DDS fuel system schematic

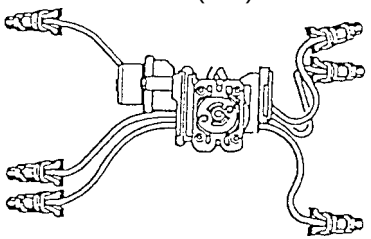
FUEL INJECTOR SERVICE



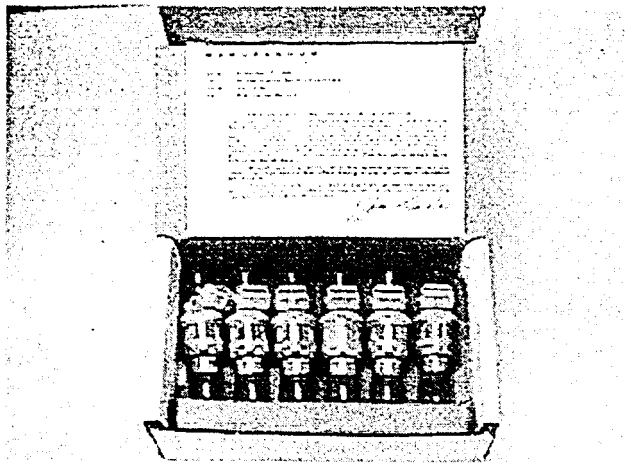
All injectors serviced will carry a 90 day (replacement only) warranty. Labor to install or other services are not included.

Did You Know?

LTS Fuel Injection Service now does 4.3L Vortec (CPI) units.



CALL DOUG FOR DETAILS.



PRICING: *RECONDITIONED*

SINGLE TBI INJECTOR	$24.95 each
MULTIPORT FUEL INJECTOR	$24.95 each
CORE CHARGE	$3.00 each
CPI CORE	$50.00 each

6 DRI's [Multec replacements] "LIFETIME WARRANTY" ..... $199.90 set

GM CPI units ..... $ 189.90

Our *ad as seen in Motor Service Magazine*

Matched Flow Rate Injectors?

When replacing fuel injectors, they should be replaced in matched sets as per picture above. Our testing has shown that 5 used injectors combined with one new injector the flow rates may vary from 10 to 25 % per set! Even with an off the shelf (new) set the flow rate may be very different!

All Linder Technical Services fuel injectors are matched + or - *3 %* with performance applications matched + or - 0%!