AUTOMOTIVE TECHNICIAN TRAINING SERVICES

Presents

Diagnosing Fuel Systems

Part 1

1

Your Instructor For This Seminar

"G" Jerry Truglia

- **National Trainer, ASE World Class, Master: Auto, Truck, School Bus, L1, L3, CNG and…**
- **ATTP Master Instructor, New York State, CT and New Jersey**
- **STS (Service Technician Society) 2003 President**
- **TST (Technicians Service Training) Founder and President**
- **Author / Co Author/ Technical adviser on 25 plus books including OBD II and Mode 6, and Understanding and Diagnosing Hybrid Vehicles**
- **Published articles for multiple newsletters, and magazines**
- **Picked as one of the Top Instructors in the country by EPA & SAE**
- **Numerous Radio, TV, Internet, and SAE Video appearances**
- **PTEN, MotorAge and TST Webcast Instructor**
- **Motor Magazine Top 20 award winner**
- **Provider of OBD II Training for 14 states, Ontario Canada and the US EPA**
- **Guest speaker at SAE Congress, IM Solutions and Clean Air Conference**

2

What Will Be Covered:

Fuel Systems Diagnosis

Diagnosing Fuel Injectors

Injector Flow Test

Injector Pressure Transducer Test and HC Per Cylinder

GDI Fuel Systems

And more….

3

SAFETY

We need to protect our bodies with protective clothing and exercise a lot of caution when we work around fuel systems. With newer systems commonly operating at fuel pressures of 60 to over 2900 psi, there is no such thing as a *small* fuel system leak.

No one cares more about your safety than you do.

4

Introduction: CIS Bosch Fuel Injection

• **Fuel delivery is done through a mixture control unit that consists of a fuel distributor, airflow sensor and fuel lines.**

• **As the airflow sensor plate moves, the motion is transferred to the control plunger in the fuel distributor.**

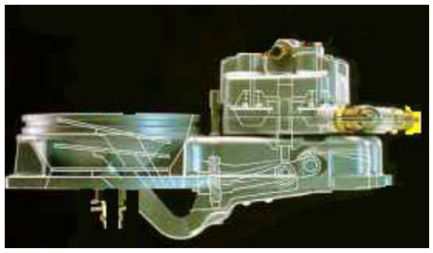
• **To increase fuel delivery pressure is reduced in the lower part of the differential pressure valve this allows for greater fuel flow to the injectors allowing for a rich mixture.**

5

Introduction: CIS Bosch Fuel Injection

• **When the throttle is depressed the plate raises and fuel demand is increases. This action lifts the plunger to deliver a higher volume of fuel to the engine that tries to match the air intake.**

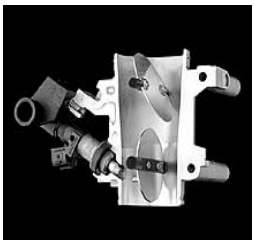
• **Oxygen sensor voltage is sent to the ECM and is used to control fuel delivery only when the system is in closed loop.**



6

Introduction: TBI Fuel Injection

The throttle body assembly usually contains one or two injectors, a TP (throttle position sensor), IAC (idle air control) motor, pressure regulator and a throttle plate. The throttle body injection system was introduced in order to provide a better fuel delivery system and replace the expensive electronic carburetor.



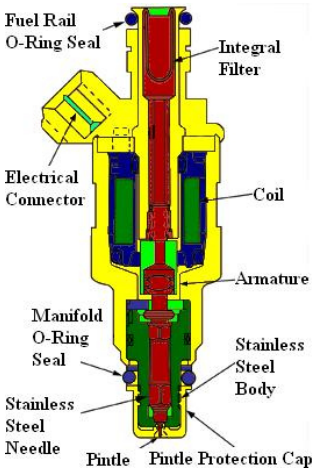
7

EFI Fuel Injection One Injector Per Cylinder

EFI systems utilize one injector per cylinder. Other names for EFI are Ported and/or Sequential.

In EFI systems that use a MAP sensor, the computer is designed to calculate the amount of air entering the engine from the MAP and rpm input signals.

On a MAF system the calculation of air entering the engine is done as air flow through the MAF.



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EFI Different Fuel Injection

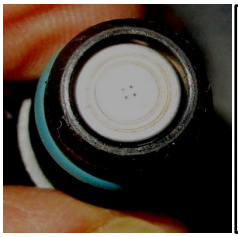


Three different types of EFI injectors that perform the same task. The different designs were for different motor application made by different companies.

9

EFI Different Fuel Injection

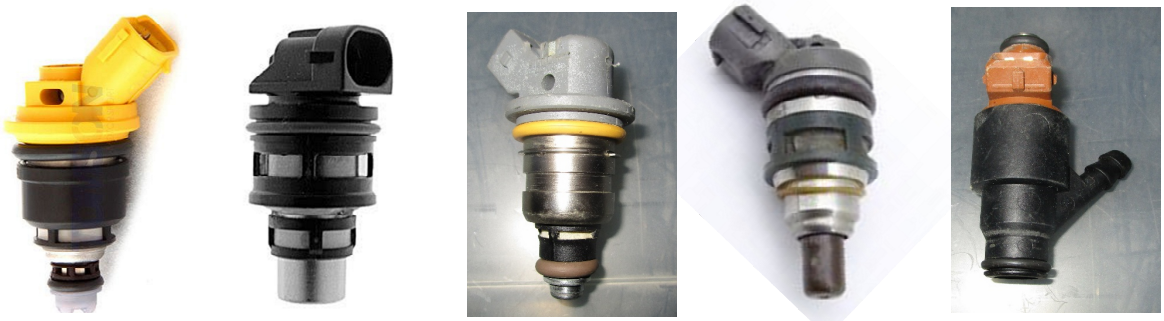


There are different tips designs from a one pintel to 2, 4, 6 tip and a ball type injector. The reason for theses different tips is to atomize the fuel better. Some injectors also spray to one side, right or left.

10

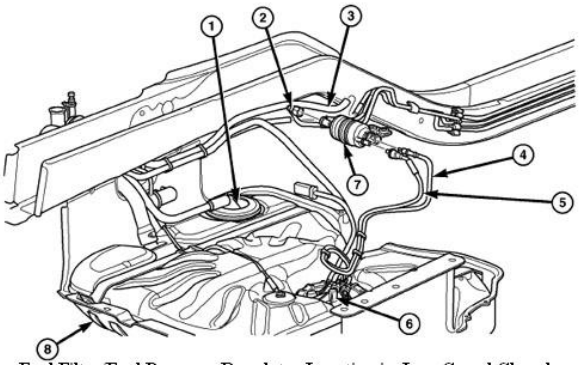
Bottom And Side Feed Port Injectors



Port, bottom and side feed injectors are installed in a plenum that connects to the fuel wells for each injector. Fuel enters the plenum flowing around the bottom and side feed injectors.

11

Pressure Regulators



Fuel Filter/Fuel Pressure Regulator Location in Jeep Grand Cherokee

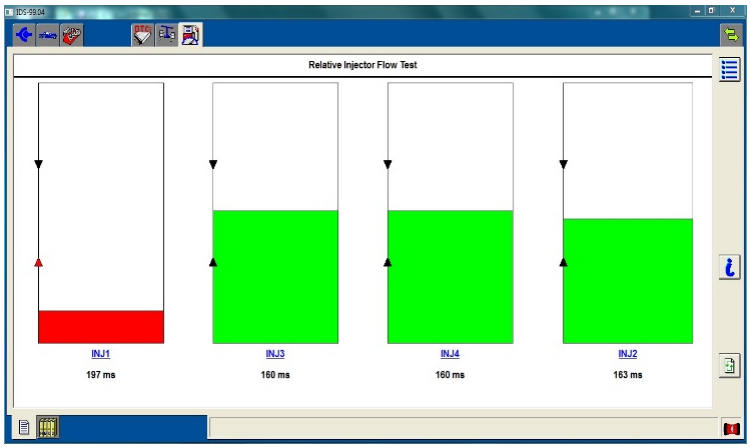
1 - ORVR CONTROL VALVE
2 - FUEL SUPPLY LINE (TO FUEL RAIL)
3 - EVAP LINE
4 - FUEL RETURN LINE (MALE)
5 - FUEL PRESSURE LINE (FEMALE)
6 - FUEL PUMP MODULE ASSEMBLY
7 - FUEL FILTER/PRESSURE REGULATOR
8 - FUEL TANK

Courtesy AllData

12

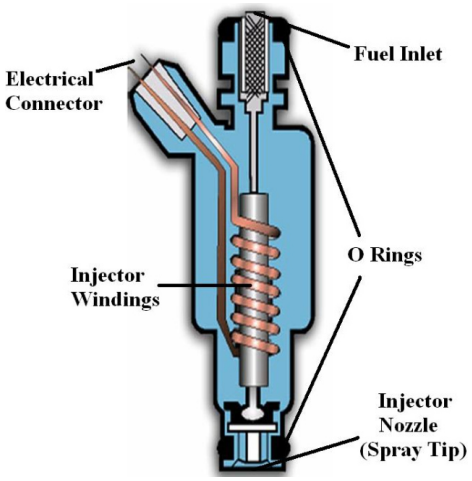
Pressure Regulators

The scan tool screen capture to the right is from the Ford IDS factory scan tool. In this capture off a GDI engine, one injector in cylinder number one is diagnosed using the electronic pressure transducer via the IDS data. Rather than performing any manual testing, this test can be done with a few clicks on the scan tool.



13

Injector Anatomy



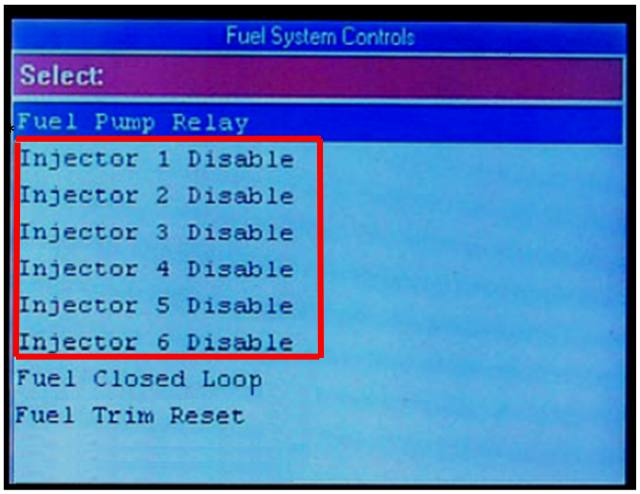
14

GM Vortex Injectors

This system uses mechanical poppet valves that are reminiscent to the Bosch CIS system along with one or two TBI injectors that are electronically controlled by the PCM. This pump supplies 60 to 77 psi when working properly. *The most common problems with this older style Vortec system is the pressure regulator blowing out causing multiple problems* (*no starts, rich running conditions or lean running conditions) and the plastic tubes crack causing a dead cylinder.*

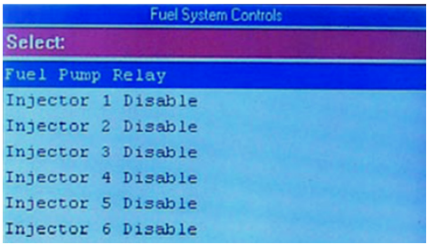
15

Using Your Scan Tool For Fuel Injector Diagnosis



16

Diagnosing Fuel Injectors



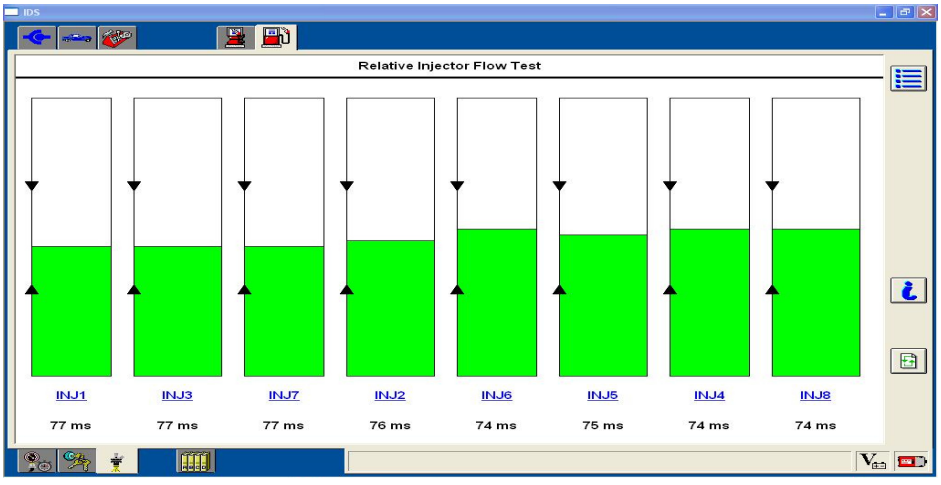
Disable injectors by using bi-directional controls and use an emissions analyzer to do a *Hydrocarbons per Cylinder Test.*

- **When you disable an injector check to see the HC reading on your emissions analyzer.**
- **If, when you disable a particular injector, the HC readings plummet, then you know that there is not a problem with that particular injector.**

17

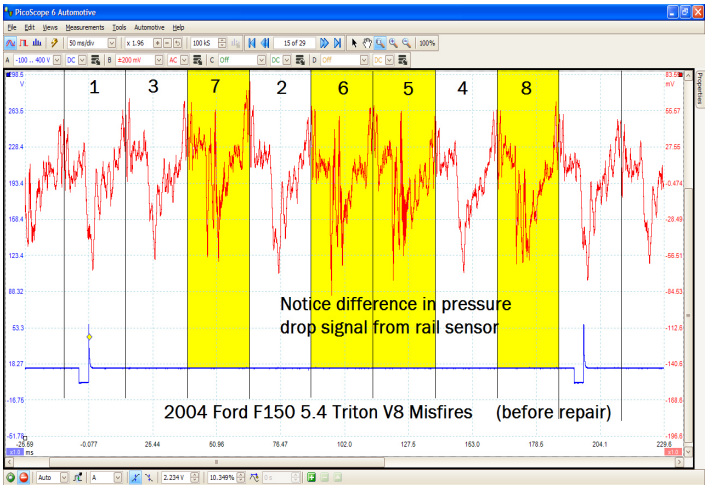
PCM Injector Flow Test

Ford's IDS scan tool allows the technician to perform an electronic Relative Injector Flow Test.



18

Labscope & Pressure Transducer Injector Flow Test – Case Study



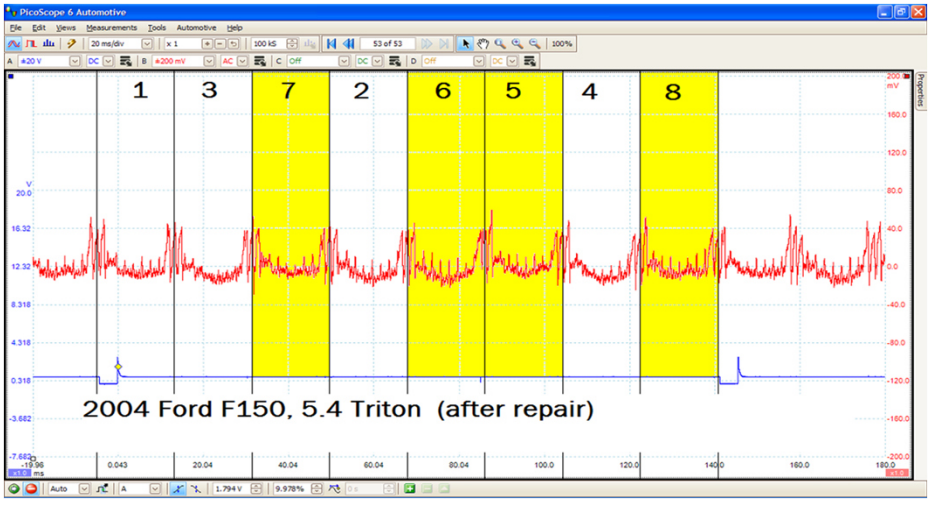
Case study is from Pete Meier of Motor Age Magazine

The labscope waveform in red is the pressure pulses from a transducer that is attached to the fuel rail. The red channel B is coupled to AC voltage while the blue channel A is DC coupled. The injector waveform in blue is the sync so the firing order can ID the proper injector. The injector pressure drop is measure and seen as a mess compared to the waveform on the next slide.

19

19

Labscope & Pressure Transducer Injector Flow Test – Case Study



Case study is from Pete Meier of Motor Age Magazine

The labscope waveform in red is the pressure pulses from a transducer after replacing the injectors.

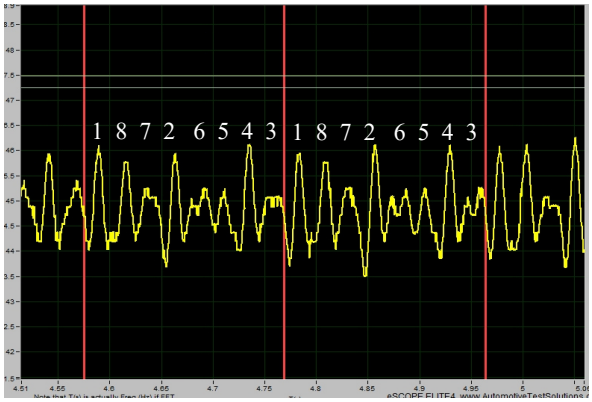
See the difference?

20

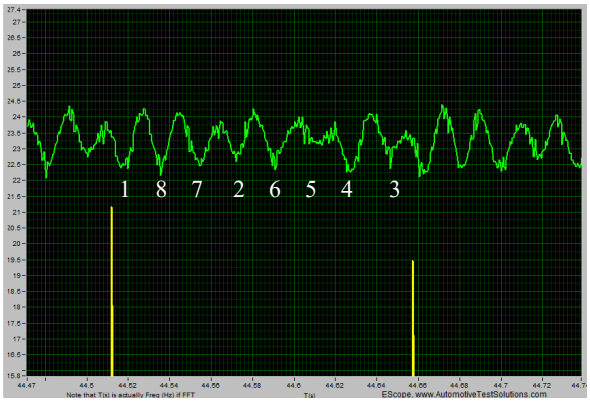
20

Labscope & Pressure Transducer Injector Flow Test – Case Study

Pressure Transducer To Check Fuel On A Chevy 5.3 L



Before Fuel System Cleaner Added To Tank



After Fuel System Cleaner

21

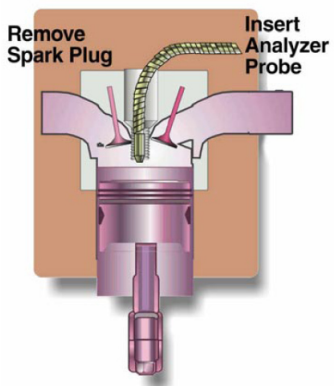
21

Leaky Injectors

Remove the spark plugs and insert the probe from the gas analyzer. The cylinder with the highest HC reading has the leaky injector. *DO NOT CRANK ENGINE*

22

Injector HC Leak Test



Non Leaking Injector

Test each cylinder (engine OFF)

Leaking Injector

23

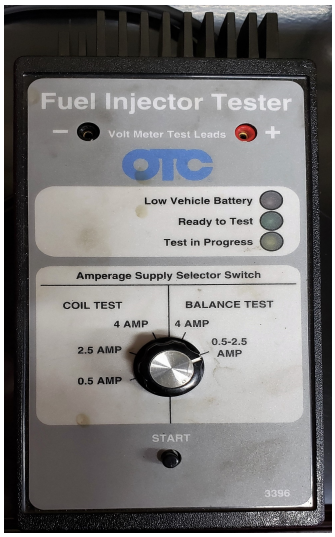
Injector Voltage

QUICK TIPS:

If voltage at both of the injector terminals is equal to system voltage (12 + volts) KOER, then you have an open trigger circuit.

Check for a voltage drop on the feed side of the injector, any reading more than 0.10 (100mv) indicates a problem.

The OTC tester to the right connects to an injector so an Ohmmeter test can be performed for the Coil Test. Voltage reading can also be taking and use for testing purposes.



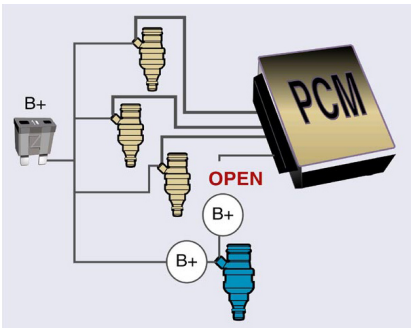
24

Fuel Injectors Balance And Flow Test

Next turn the ignition on and watch the pressure gauge hit 38 lbs (or whatever the specification for the vehicle that is being tested). Afterward, select 1 Pulse/500 mS on the small tool or the Start button on the bigger tester. Press the Activate Injector button once and record the pressure drop. Do this twice for each injector. Be sure to start the engine up between doing the tests on each cylinder to prevent hydrostatic lock.

25

Fuel Injectors Balance Test



QUICK TIP:

If voltage at both of the injector terminals is equal to system voltage KOER, then you have an open trigger circuit. The PCM isn't toggling the circuit to ground or there's an open circuit between the injector and PCM.

26

Injectors Guru Tips

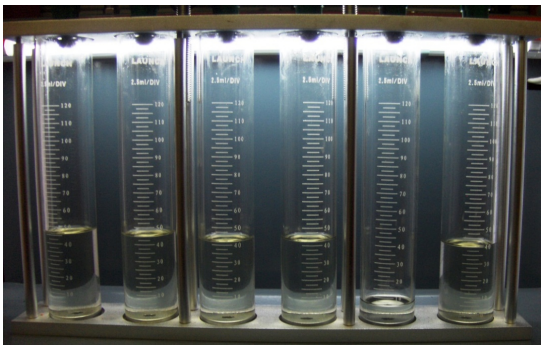
Here are the steps in a thorough fuel system service:

- **Test the fuel pressure (and volume).**
- **Test the fuel pressure regulator for operation and leakage.**
- **Flush the entire injector fuel rail including the injector inlet screens and regulator.**
- **Clean the injectors.**
- **Clean the throttle plate and idle air control valve and passages.**
- **Reset minimum idle air if necessary.**
- **Relearn the PCM.**

27

Injectors Guru Tips

Cleaning Stage One—Flush the rail and regulator with the engine off. Cleaning the injectors in the engine also helps to remove carbon deposits from intake valves, the tops of pistons, and oxygen / air fuel sensors. To clean injectors an ultrasonic cleaner must be used.



28

Direct Fuel Injection

Direct-injection has been around for many years on diesel engines.

Vehicles such as Audi, BMW, Mercedes, GM, Ford, Chrysler and Toyota, just to name a few, are already using this new and better fuel delivery system.

With gasoline direct injection (GDI), the gasoline is injected directly into the combustion chamber. GDI allows for a very lean mixture (as much as 35:1) during cruising.

The direct injection (GDI) fuel system on Audi's is divided into two parts, the low side at 6 (87.02 psi) to 7 bar (101.52 psi) and the high side 110 bar (1595.41 psi). Many newer GDI systems put out over 3000 psi.

29

GM - Bosch GDI System Example

The PCM controls each fuel injector with 65 V. This is controlled by a boost capacitor in the PCM. During the 65 V boost phase, the capacitor is discharged through an injector, allowing for initial injector opening. The injector is then held open with 12 V.

The fuel injector assembly is an electrical magnetic injector. The injector has six precision machined holes that generate a cone shaped oval spray pattern. The fuel injector has a slim extended tip in order to allow a sufficient cooling jacket in the cylinder head.

30

GDI Injector Information

1. When removing GDI injectors carefully clean the manifold or engine bore with a soft brush to remove the carbon build up.
2. GDI fuel injection pulse width or on time is much lower than conventional fuel injection. GDI on time at idle 0.4 to less than 2 mS compared to 3 to 5 mS.
3. GDI injector are low resistance injector about 1 ohm rather than 14 ohms for conventional injectors.
4. GDI injector use 65 volts due to a boost converter (capacitors) that takes 12 volts and boost it to 65 volts.
5. Note: GM recommendations along with some other OEs are to replace the high pressure stainless steel fuel lines once they are loosen to prevent fuel leaks.

31

GDI High Pressure Pump And Camshaft

32

2006 Audi A4 2.0L Turbo GDI Problem

Since there was no way for us to test the high pressure side of the pump, we had to remove the fuel pump and visually inspect the cam follower. Take a look at the worn one we located in the engine verses the new one. The camshaft was also damaged along with the tip of the high pressure fuel pump.

33

GDI Fuel Rails Must Be Torqued And /Or Replaced System

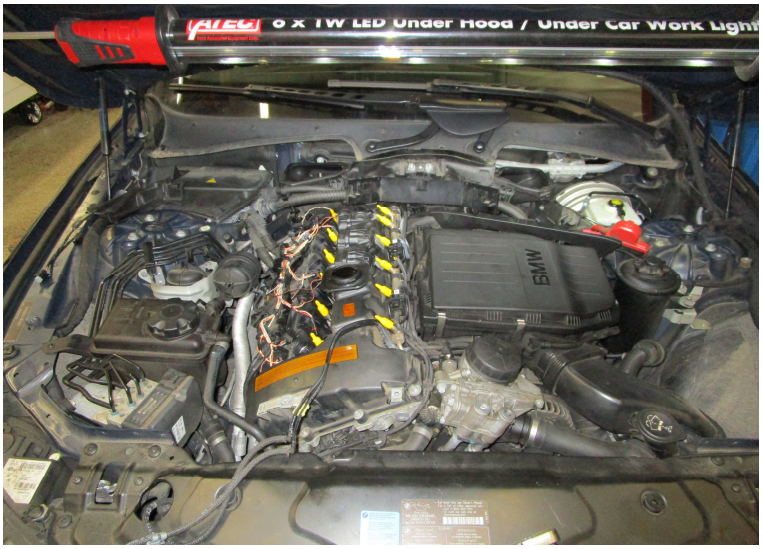
34

GDI Injector Must Be Kept In Order And Covered

These Injectors Must Be Coded or Programed Into The PCM/ECU If Replaced

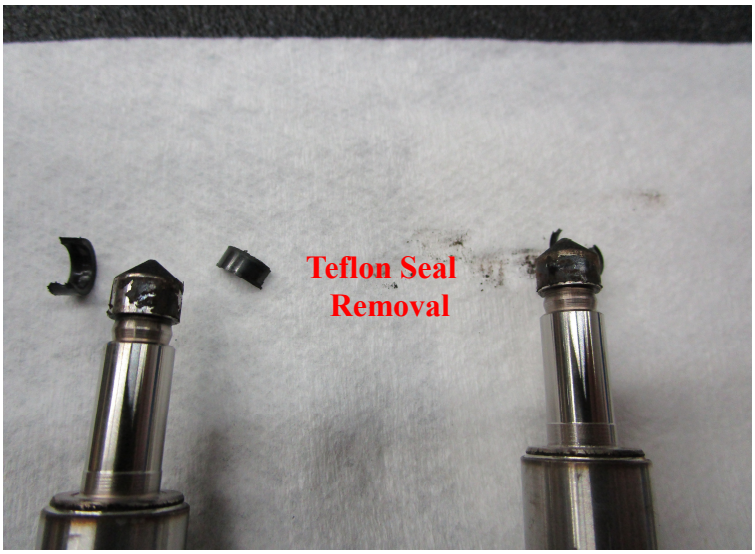
35

GDI Line Opening Covered After Removal Of Injectors



36

GDI Injector Seals Removed – Careful Removing Seals



37

GDI Fuel Injector Installer

Teflon Seal
Installation

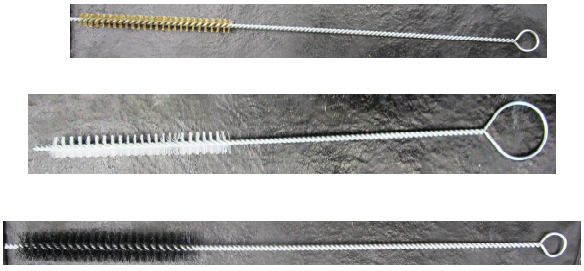
38

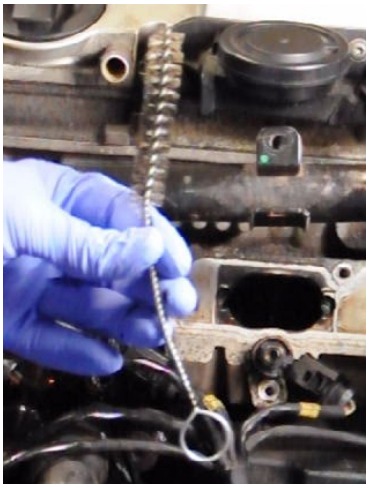
GDI Injector Tools And Caps

39

GDI Brushes To Clean Injector Ports

It is important to clean injector ports that are located in the manifold or head with a soft brush. Leaving any debris behind can damage the injector seals.





40

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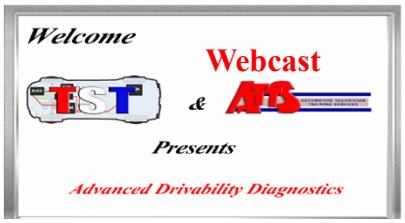

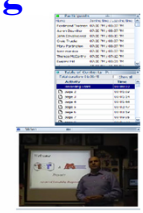

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41

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42