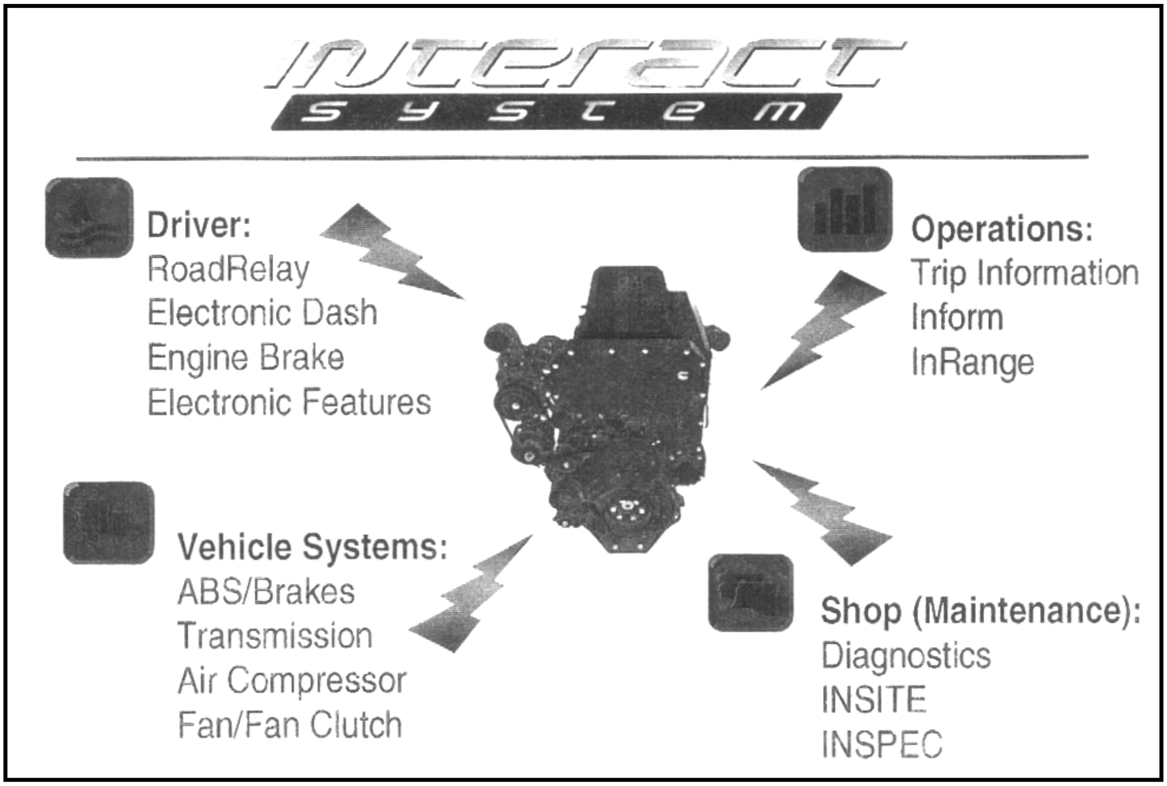
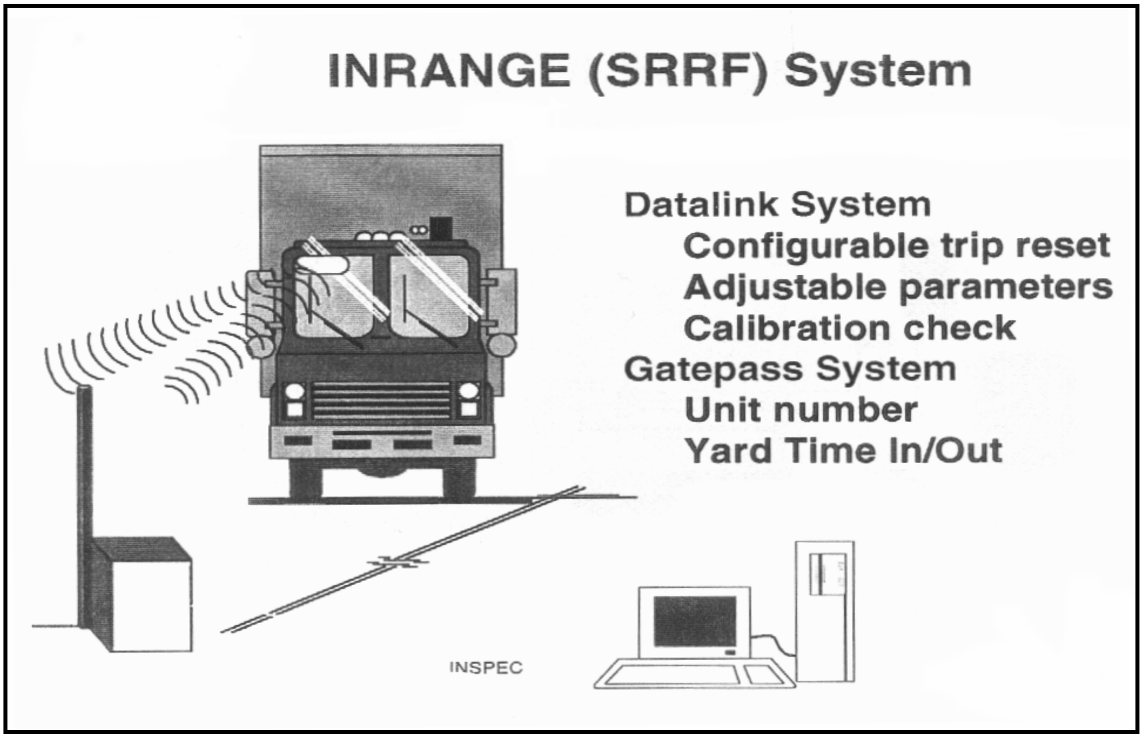
Cummins IS – Interact System & HPI-TP Fuel System

Introduction
Cummins 3rd generation of electronics was introduced in 1997 under the IS management system. ISX CM870 engine control system
The Electronic Control Module is the control center of the system. The ECM processes all of the inputs and sends commands to the fuel system, vehicle, and engine control devices. Because the ECM is the final pathway of integration for all vehicle management systems, it is called interact or IS for short.



IS From Cummins includes some of the following features
- Faster processing speeds and increased memory
- Improved fuel efficiency
- Integrated Centinel Control (no separate module)
- Improved Maintenance Monitor features
- Enhanced PTO programming features/ parameters
- Enhanced engine diagnostics/Prognostics
- Enhanced Security features
- Audit trails
- Enhanced Engine Protection System
- Anti theft protection when used with Road Relay
- Powertrain Protection Features
- J-1939 Network capable
- Enhanced On-Board Trip Information

• Battery Powered ECM clock back-up for real time clock stamping of data.
• Enhanced data reporting features
• Short Range Radio Communication (“Inrange” SRRF) System
• Improved Emission Reduction



Above: “In-range” SRRF System Short-range radio frequency (Cummins “INRANGE” SRRF System) Fault codes can be retrieved, the ECM recalibrated etc. using this tool.

Cummins small medium and large bore engines received this new system after the CELECT system. Instead of the B, C, L, and M engines, their new names are **ISB, ISC, ISL, ISM.ISX** and **Signature**
The N-14 kept Celect Plus system but will not be produced after 2000 model year

CM870 ECM Features

The most significant change from the CELECT system is the new ECM module. It was originally the air cooled CM570. It had a greater number of inputs and output pins than CELECT PLUS - all of which are programmable. Many more features and components can be added to this system which can interface with J-1939 network and PWM outputs.

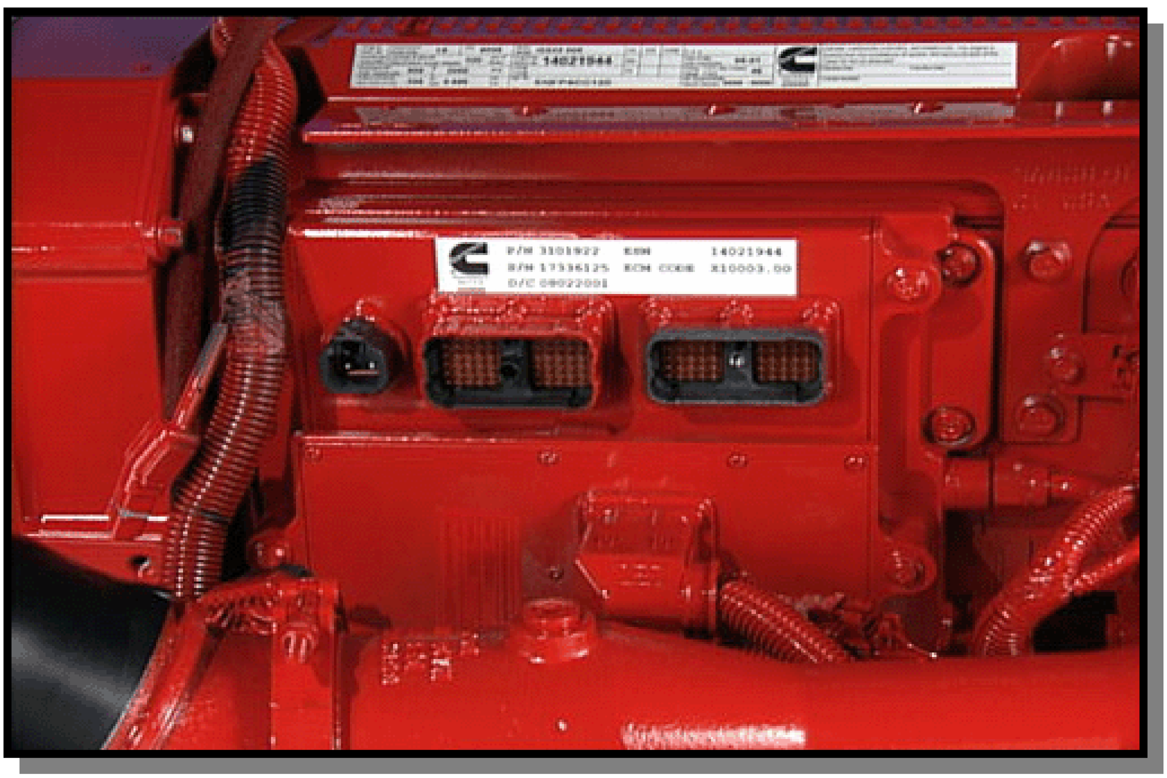
The newest ECM is the CM870 introduced in the ‘02 model year. This system has advanced capabilities to control the EGR system and the variable geometry (VGT) turbocharger
The ECM contains the software code to run the engine and can be powered by either a 12 or 24 volt system.

The ECM also provides the ability to communicate with service tools and contains memory for data storage.

The ECM communicates with service tools and some other vehicle controllers, such as transmissions, braking system, and traction control systems, through an SAE J1939 and the 1708/1587 Datalink.

The ECM determines the power output of individual cylinders by the way the engine speed increases due to a combustion event. The ECM averages this instantaneous power output of a single cylinder over a number of cylinder firings. The ECM then decides what adjustments to make to the fueling on each cylinder to balance the power equally between cylinders.

The ECM is mounted to a cooling plate on the fuel pump side of the engine. Fuel flow through a passage in the cooling plate provides the necessary cooling for the ECM. About 35% of the output of the gear pump is sent through this cooling plate.

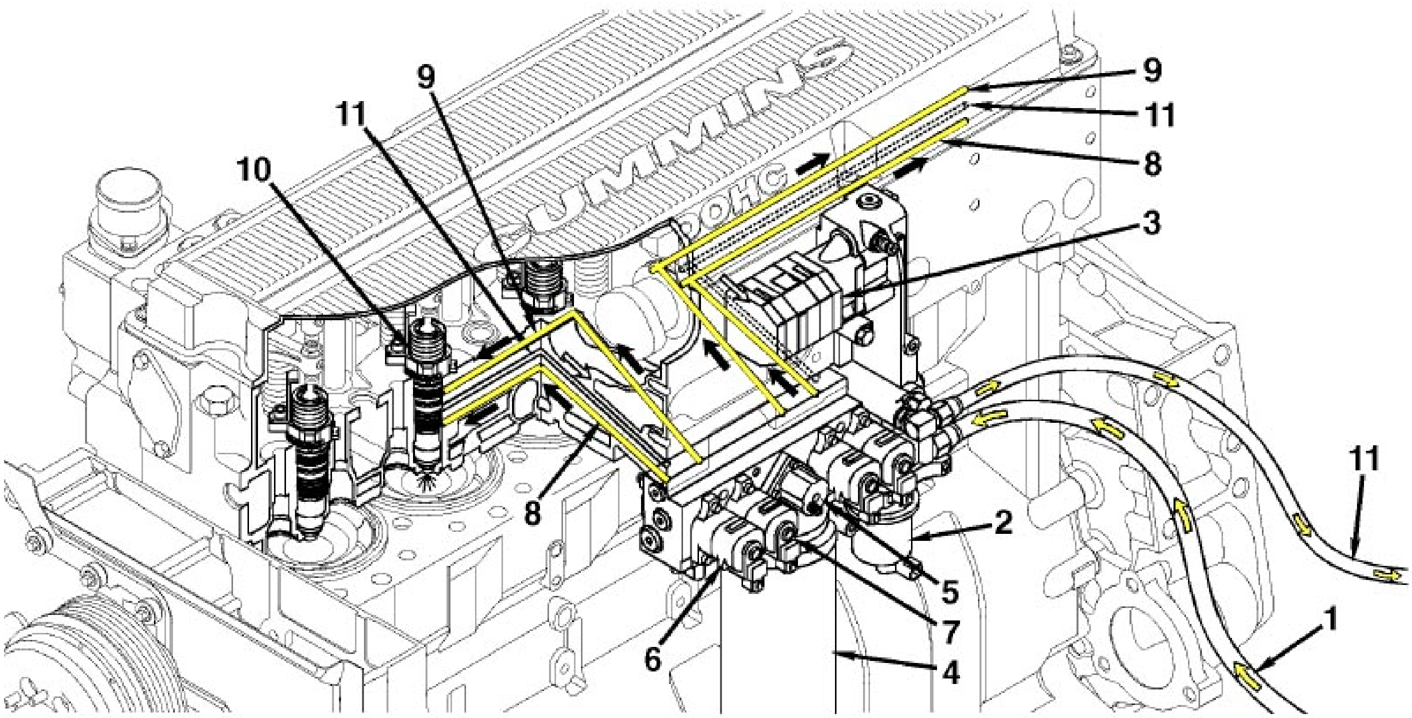


Above: Note ECM cooling plate and connectors

HPI-TP Fuel System

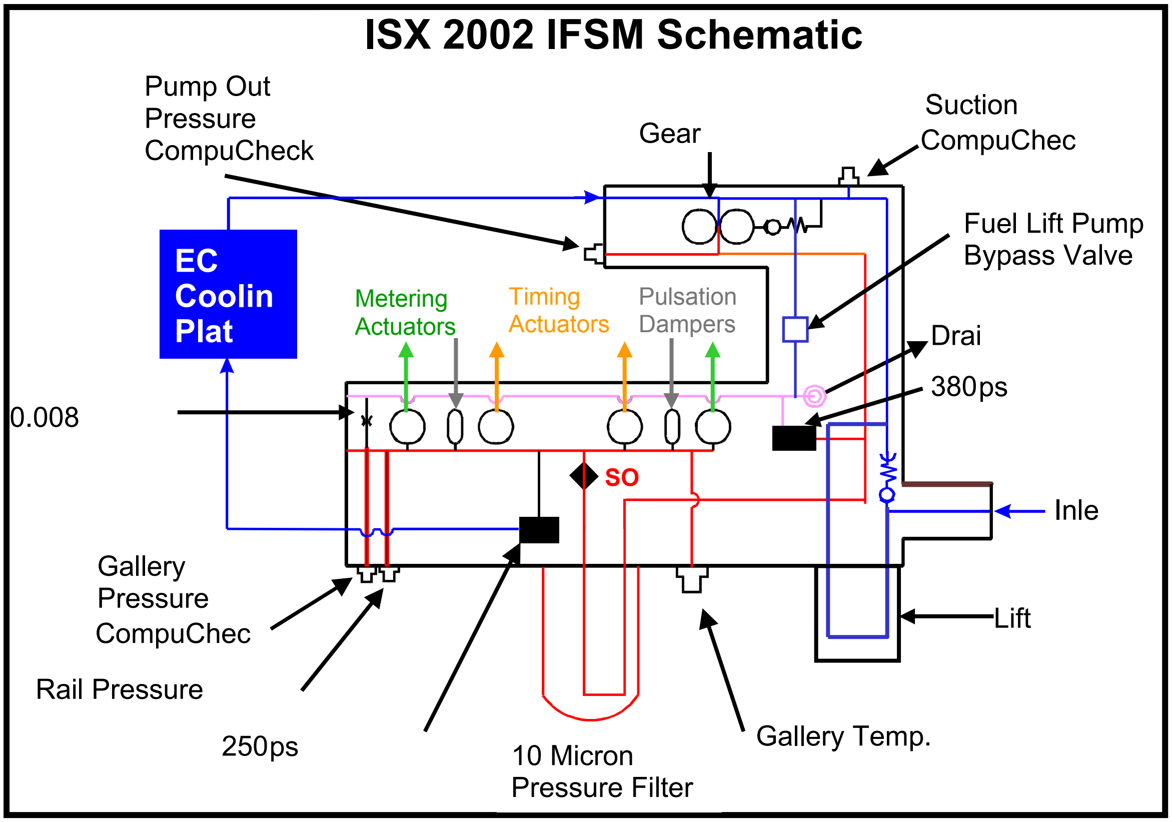
Heavy Duty High Pressure Injection - Time Pressure Fuel System

Cummins ISX/Signature (Signature has a different heavier premium parts system) uses a new fueling system on ISX and Signature 600 engine. The injector uses an open nozzle style of injector used on earlier PT systems. The design of this nozzle maintains that “old PT system sound” to it as a result. (open nozzle do not use a valve closing needle valve but instead allow combustion gases to mix in the injector cup before the plunger pushes the fuel/air mixture out the orifice).
Timing and metering pressure-regulating solenoids/actuators now control hydraulic circuits to the injectors. Metering solenoids control fuel quantity at the timing solenoids control the beginning and end of injection.



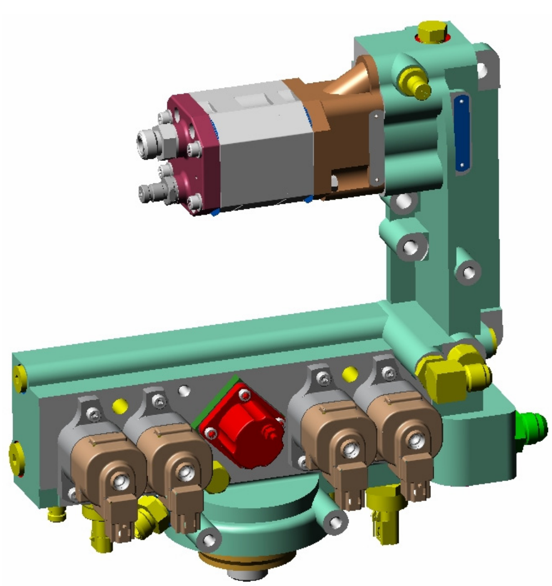
1. Fuel Supply from Tank
2. Fuel Lift Pump
3. Fuel Pump
4. Pressure Fuel Filter
5. Fuel Shutoff Valve
6. Fueling Actuator
7. Timing Actuator
8. Fueling Supply to Injector
9. Timing Fuel Supply to Injector
10. Injector
11. Fuel Drain to Tank.

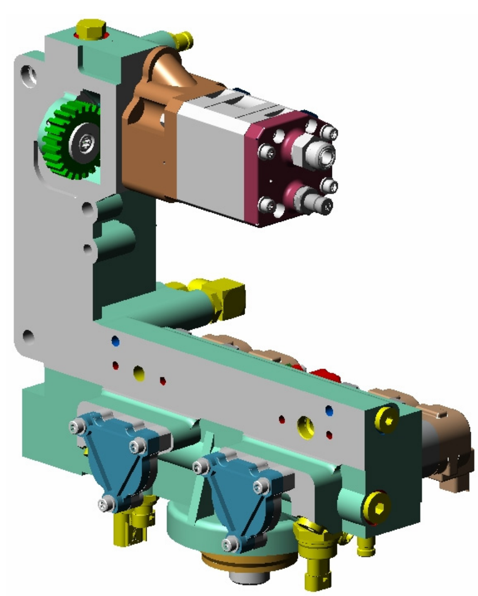
The operation of the centrally located injector is also unique. Metering and timing plungers in the injector are operated hydraulically using fuel supplied to it through separate timing and metering rails located in the cylinder head. Pressurization of the fuel for injection is accomplished by a plunger actuated by an overhead camshaft. ***Note there are no electrical connections or solenoids on the injector.***

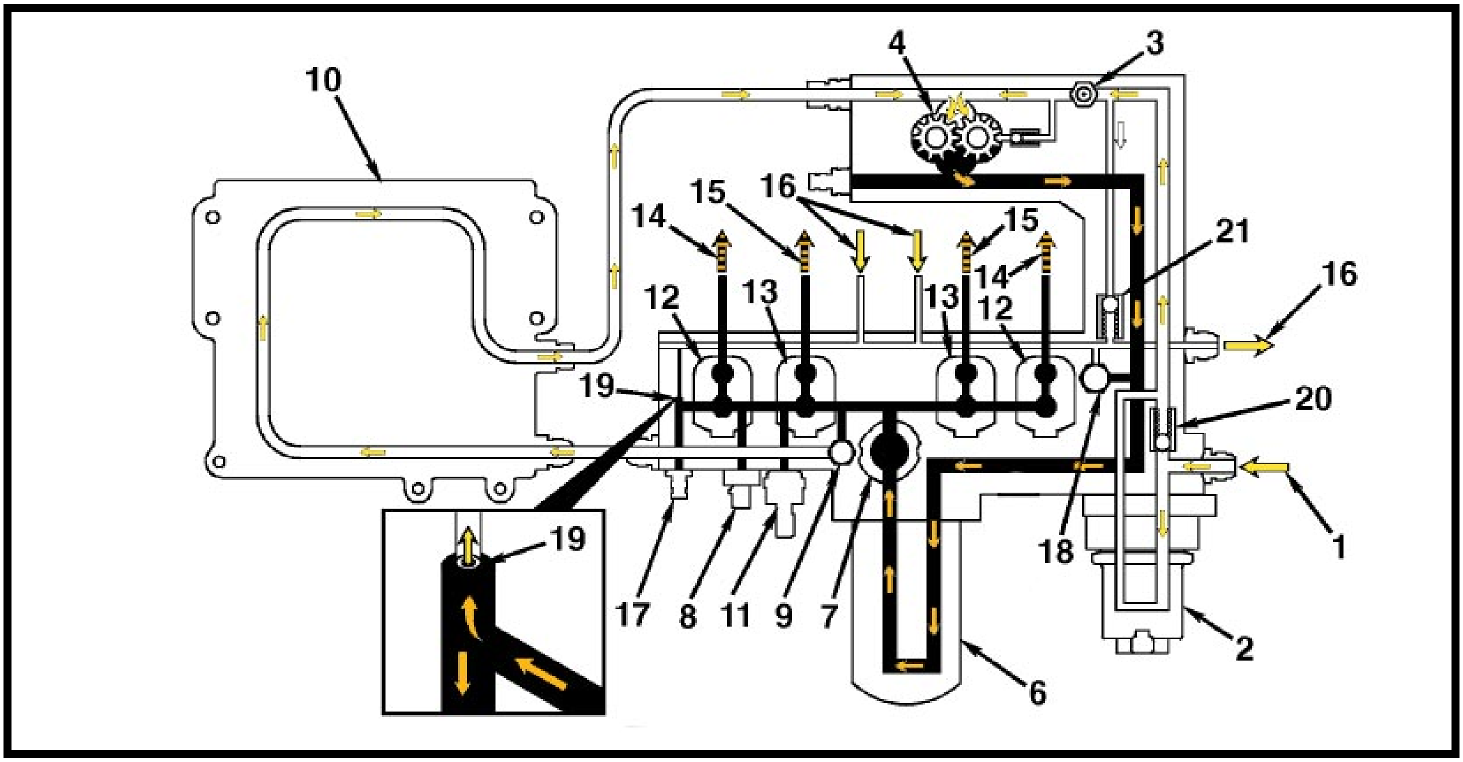


Integrated Fuel System Module (IFSM)

The system consists of six high-pressure unit injectors and an integrated fuel system module (IFSM) containing actuators that provide various fuel pressure for metering and timing control of the injectors. PWM signals to the actuators control injection quantity and injection timing, a pump and regulator for fuel supply pressure, a 10 micron pressure side filter, and various sensors for system monitoring. The system is controlled by an advanced electronic control module (ECM), which makes fueling and timing decisions based on temperature, barometric air pressure, boost pressure, exhaust gas pressure and throttle position.





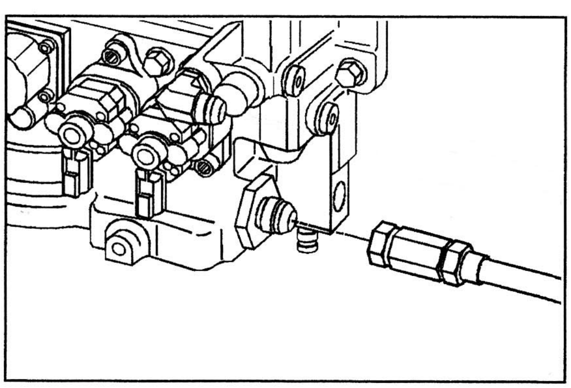


Parts List:

1. Fuel Supply From Tank
2. Fuel Lift Pump
3. Compuchek™ Fitting (Fuel Inlet Restriction)
4. Fuel Pump
6. Pressure Fuel Filter
7. Fuel Shutoff Valve
Fuel Pressure)
8. Engine Fuel Temperature Sensor
9. 250 PSI Regulator
10. ECM Cooling Plate
11. Rail Fuel Pressure Sensor
12. Fueling Actuator
13. Timing Actuator
14. Fueling Supply to Injector
15. Timing Fuel supply to Injector
16. Fuel Drain to Tank
17. Compuchek™ Fitting (Rail
18. 380 PSI Regulator
19. Hot Start / Stall Orifice
20. Anti Drainback Valve
21. Fuel Lift Pump Bypass Valve

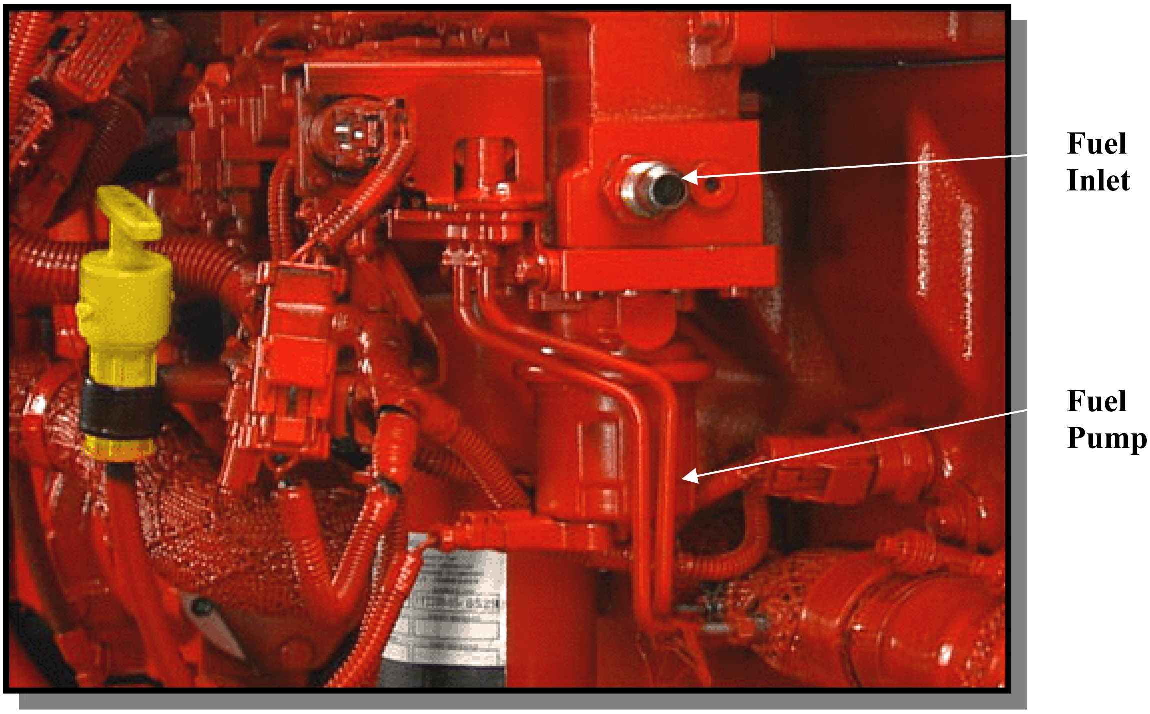
HPI-TP System Fuel Flow

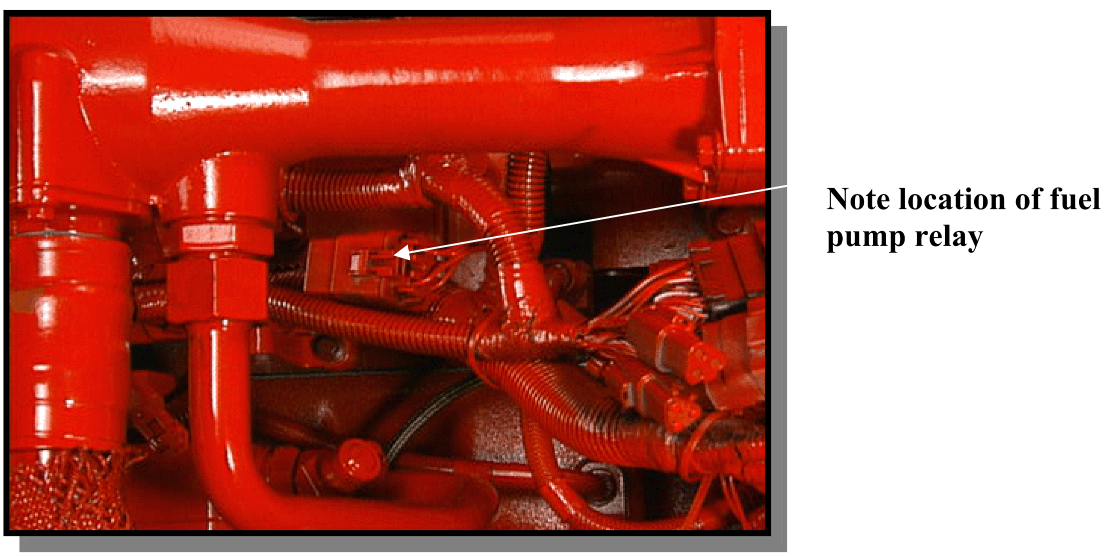
1. The pre-filter is rated at 150 micron and it contains a water-in-fuel sensor and a water drain.



2. Fuel then flows into the inlet fitting of the IFSM.

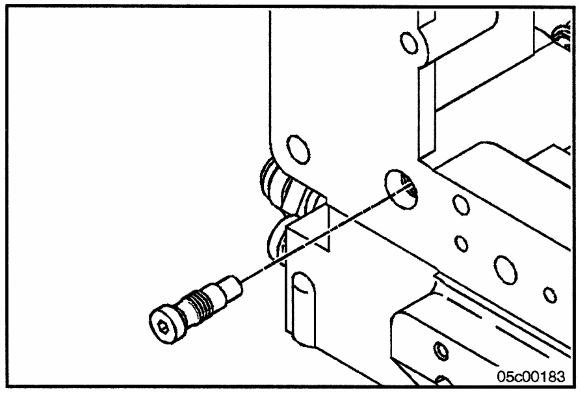
3. Fuel continues into the fuel lift pump. This pump runs for the first two minutes after the key is turned on to insure that fuel gets up to the gear pump quickly for easier starting.



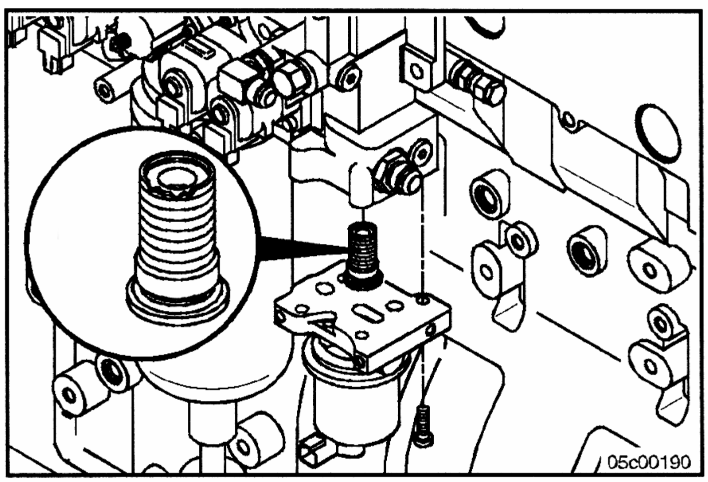


Fuel continues into the fuel lift pump. This pump runs for the first two minutes after the key is turned on to insure that fuel gets up to the gear pump quickly for easier starting.

4. At one psi of pressure a valve in the IFSM housing opens to allow some lift pump output to flow to the drain line. This bypassing of fuel helps to bleed any air from the supply passages



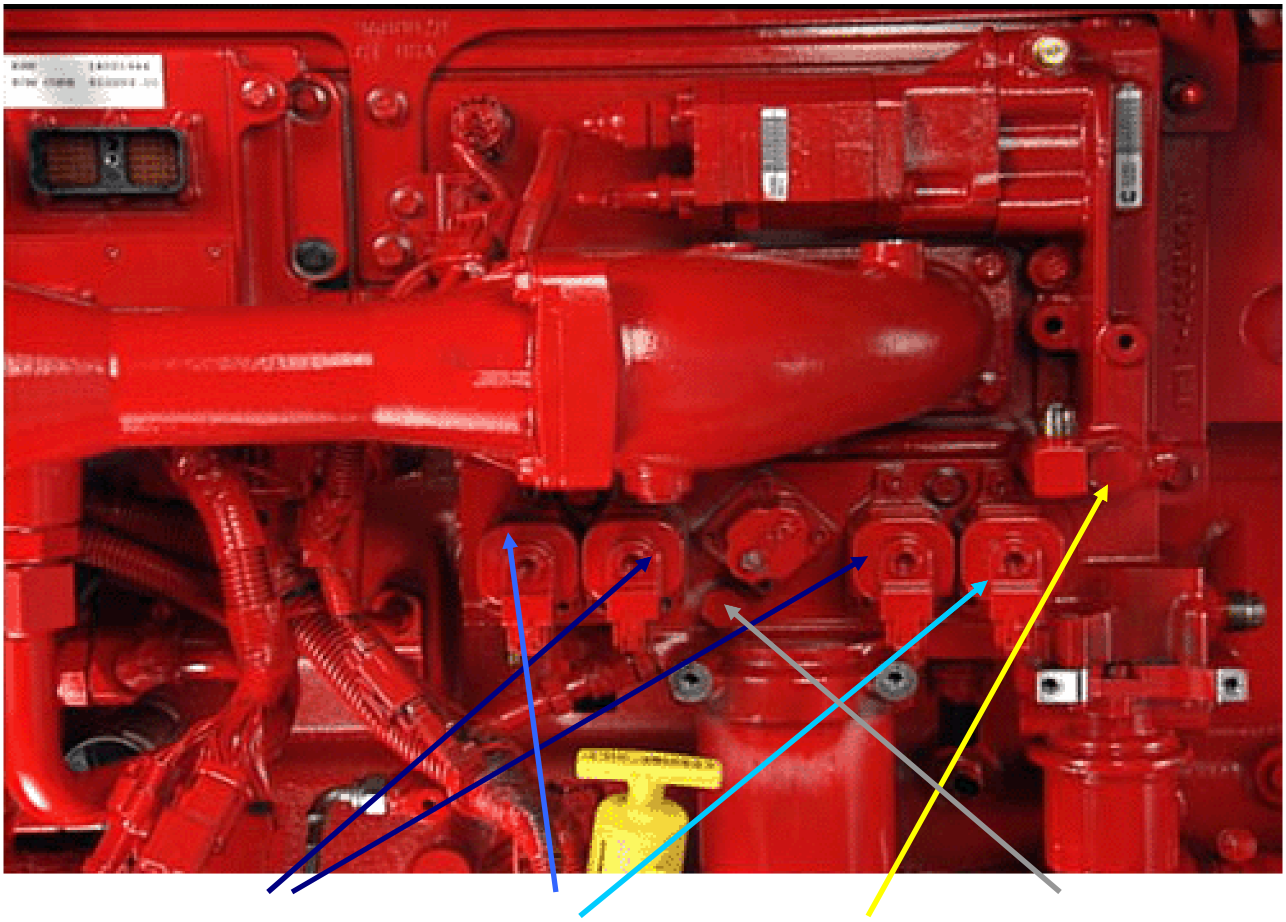
5. When the engine starts, the gear pump then draws the fuel directly from the inlet fitting past the anti-drain-back valve.



6. The gear pump provides the high volume and constant pressure needed by the system for correct metering and timing.

7. A 380 psi high pressure regulator, installed in the IFSM between the gear pump and the filter, is a safety valve to prevent damage in case of a stuck fuel shutoff valve or other blockage in the fuel lines after the gear pump. Any fuel flowing through the high-pressure regulator is dumped back to the drain line in the IFSM and then returned to the fuel tank.

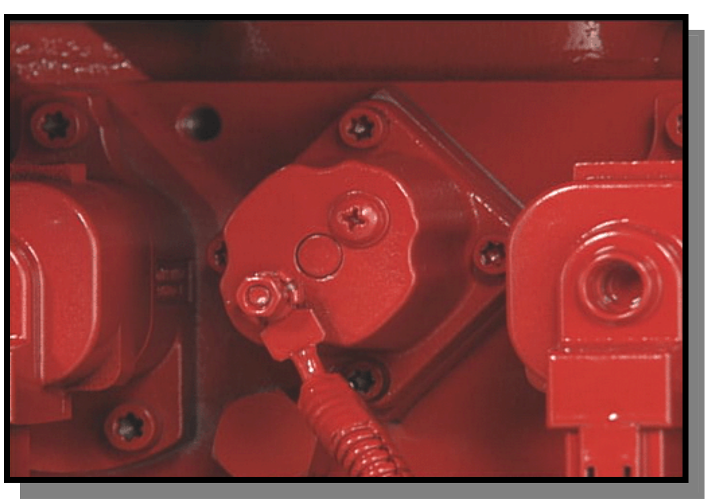
8. Fuel under pressure flows to the secondary fuel filter. This filter is a 98% efficient 15 micron filter.



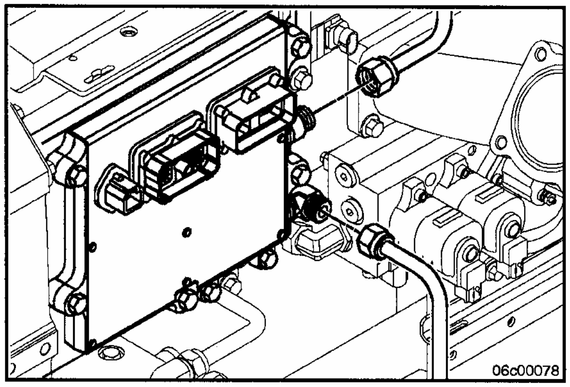
Timing Actuators **Metering Actuators** **350-psi regulator** **250psi regulator**

9. After contaminants are removed, the filtered fuel flows to the rapid restart style shut off valve. This fuel shut-off valve is capable of stopping fuel flow in case of engine overspeed, or other system problems sensed by the ECM.

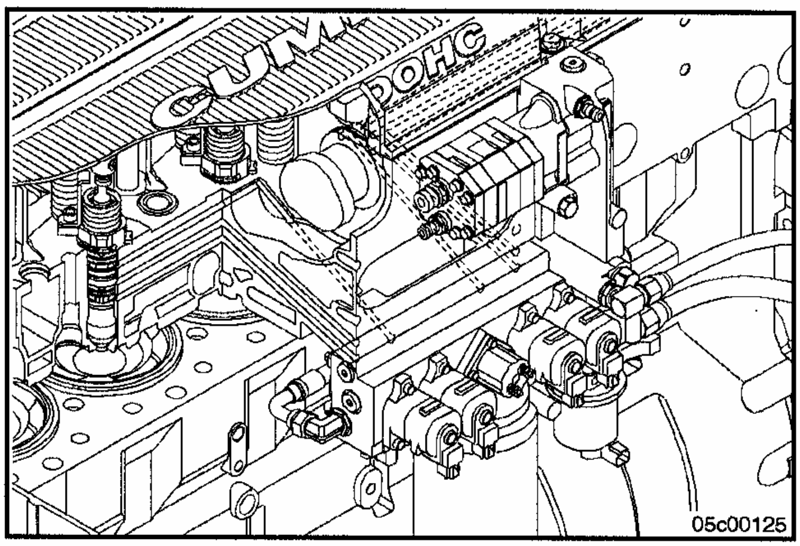
Below: Electric Shut-off valve located between timing actuators



10. The 250 psi fuel system regulator allows excess fuel to flow out of the rail to limit and maintain the pressure within the IFSM fuel rail. The excess fuel from 250 psi regulator flows through external tubing to a passage in the ECM cooling plate before going through return tubing to the inlet side of the fuel pump.

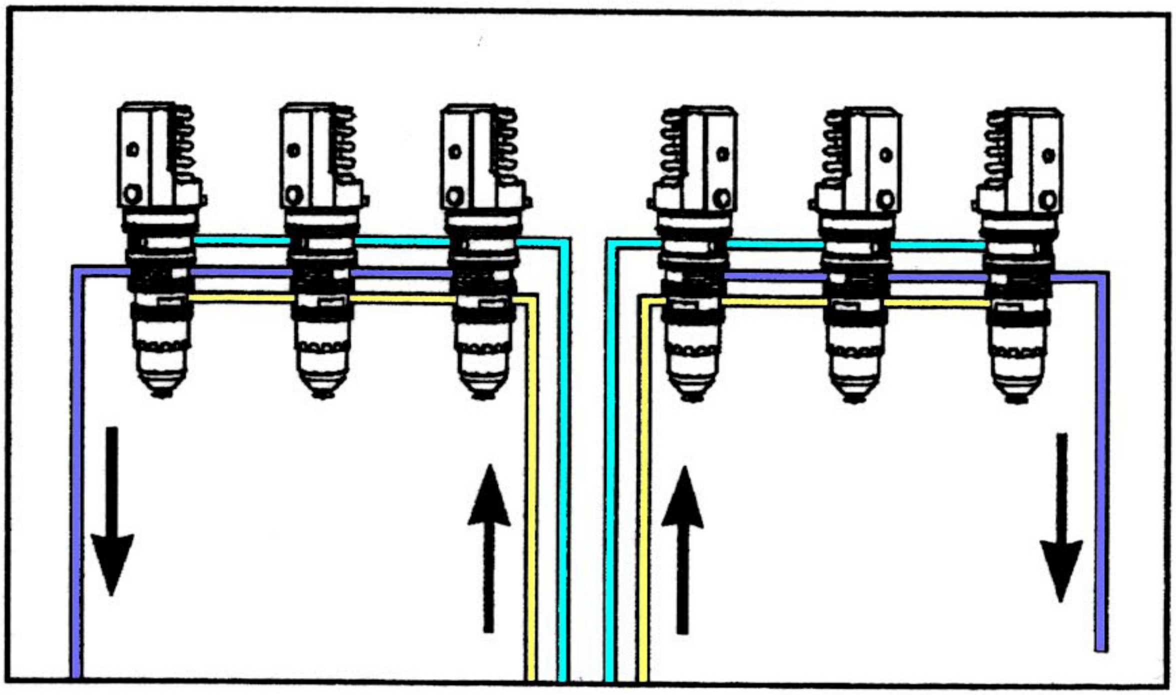


11. With a constant pressure at the actuators the ECM sends signals to the actuators to control the fuel flow to the injectors.
Each of the actuators is a ***normally closed*** ON/OFF device. The actuators open when they receive a signal from the ECM. Opening the actuator allows fuel to flow to its connected timing or metering rail.



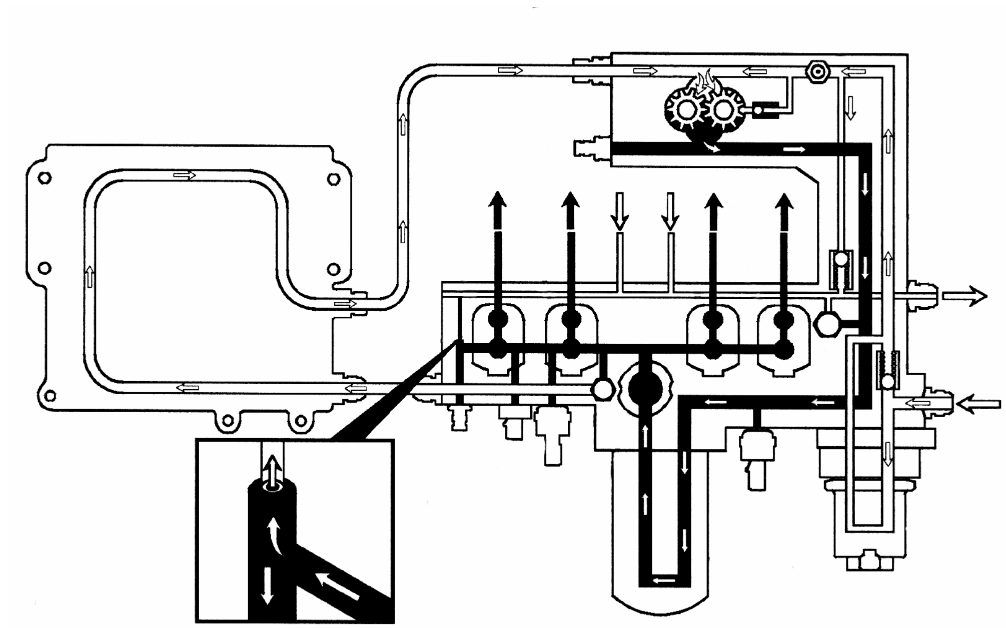
12. Fuel then enters the common supply passage for the front and rear bank metering and timing actuators.
One set of the actuators controls the amount of fuel injected and the other set controls the timing

13. The ECM determines the fueling and timing quantities within a given bank and commands the corresponding fuel pulse widths from the actuators. The actuators meter exact fuel quantities to the unit injectors through fueling and timing manifolds in the engine cylinder head.



Yellow: Timing actuator flow
Blue: Metering actuator flow
Grey: Fuel return

14. The opening of each actuator sends a pulse down a passage connected to each injector within its bank.
Due to the firing order (1-5-3-6-2-4) and following cam position for each cylinder, only one injector within a bank is in position to receive metering and timing fuel.

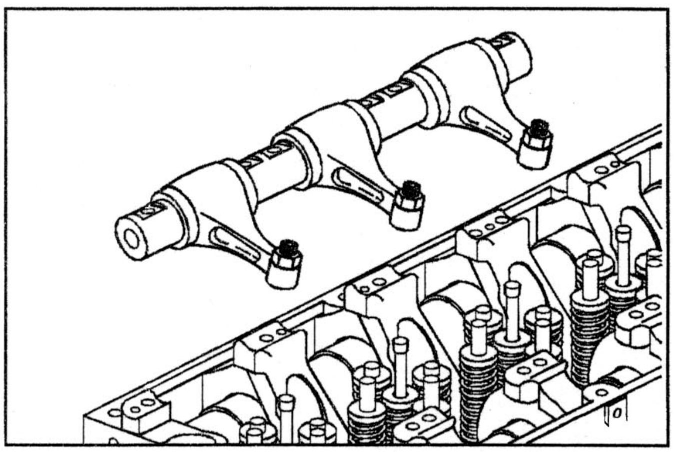


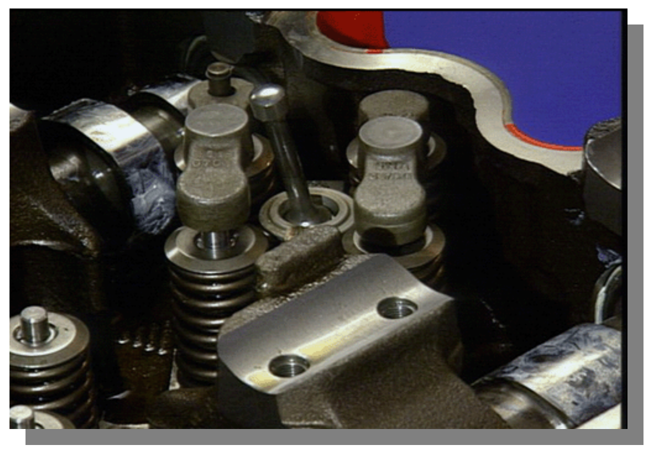
15. With metering and timing complete, the cam drives the plungers downward. Within the descending stroke a solid hydro-mechanical link is formed and injection begins (start of injection). The timing of the linkage formation is based on metered and timing fuel quantify.
The high injection pressure is only generated within the nozzle of the cam-actuated injector.

The end of injection occurs when the lower plunger meets the nozzle seat. The HPI-TP injector has the sharpest end of injection of any injector since the injector plunger bottoms-out in the injector cup at the end of injection.

The fuel used above the timing plunger, to achieve the injection timing, flows into the drain passage in the cylinder head, then into the drain passage in the IFSM.

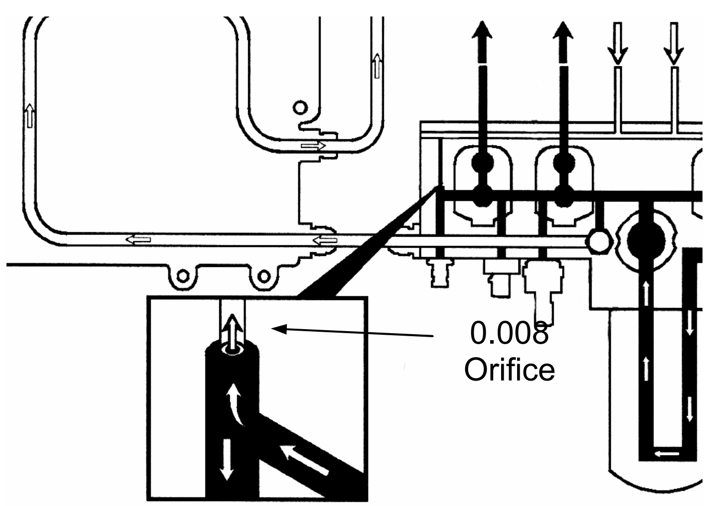
Below: Overhead camshaft and injector plunger



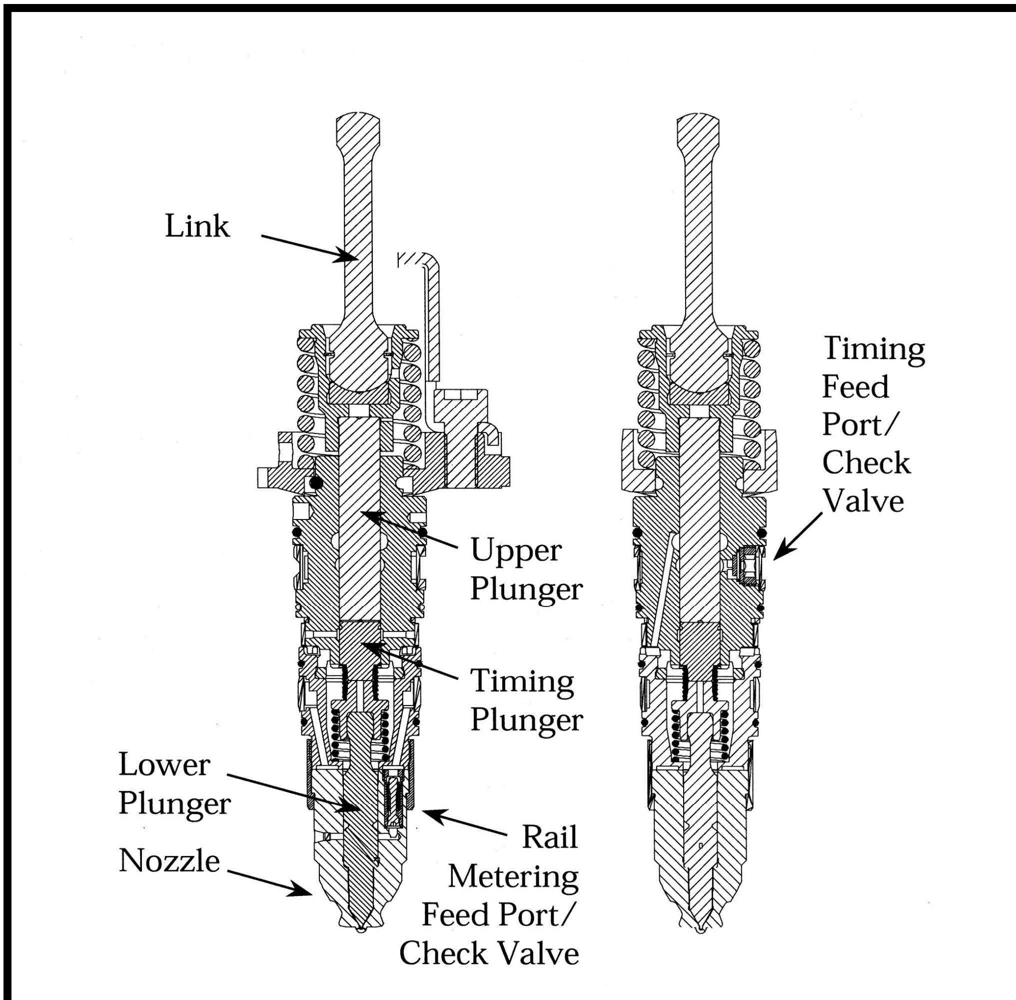


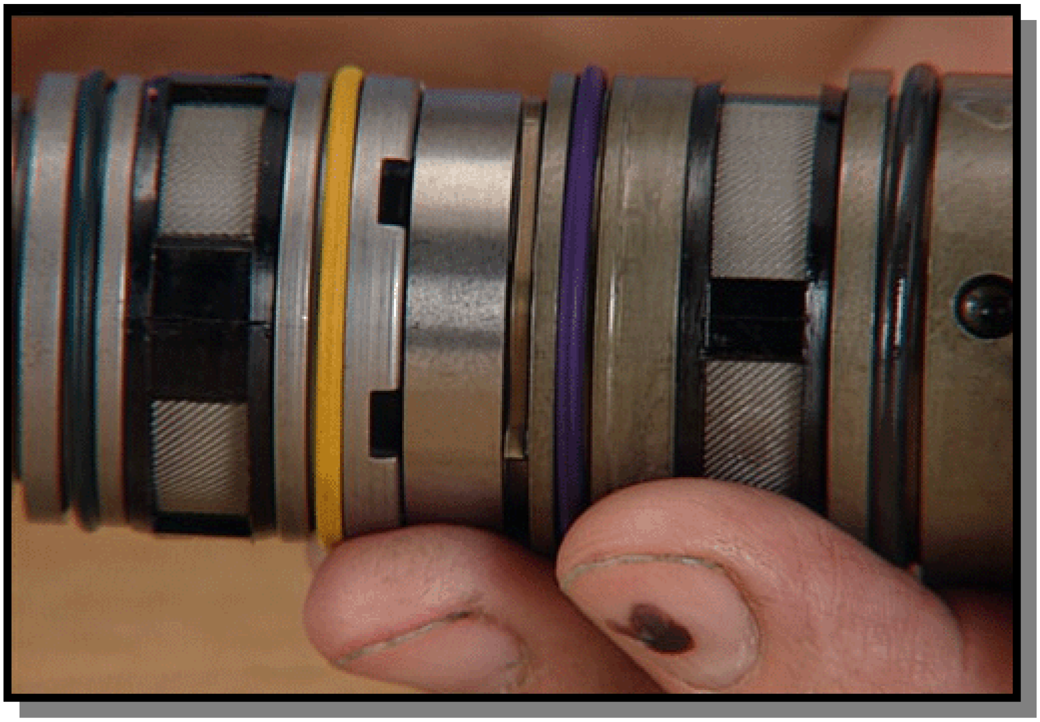
16. Fuel is returned to the fuel tank through the connection on the IFSM.

17. When the engine is shutdown, the fuel trapped between the actuators and the injectors absorbs heat from surrounding engine components. As the temperature of the fuel increases, the fuel expands and increases pressure in the metering supply rails. If allowed to build, this pressure would push fuel through the open injector into the cylinder. This would result in increased cranking resistance and hard starting while the engine is still warm. .A passage drilled between the metering supply rail and the drain passage in the IFSM, along with a check valve mounted in each metering actuator, provides fuel venting to reduce this pressure. An .008 orifice is installed in the drilling to limit fuel flow to the drain passage during normal engine operation.



HPI-TP Injector





Injector Features:

- Time Pressure (TP) metering for improved timing and fueling accuracy and minimal metering delay.
- 28,000 psi injection pressure for emissions control and fuel economy.
- One piece nozzle assembly to eliminate traditional leak paths.
- Fully variable timing for emissions control and fuel economy.
- Titanium nitride coated plungers for wear and scuff resistance.
- Check valve assemblies are calibrated prior to assembly.
- Trapped volume spill and timing spill control for lower unburned hydrocarbons and particulates

The titanium nitride coated injector plungers reduce wear and improve the scuff resistance of the plunger.

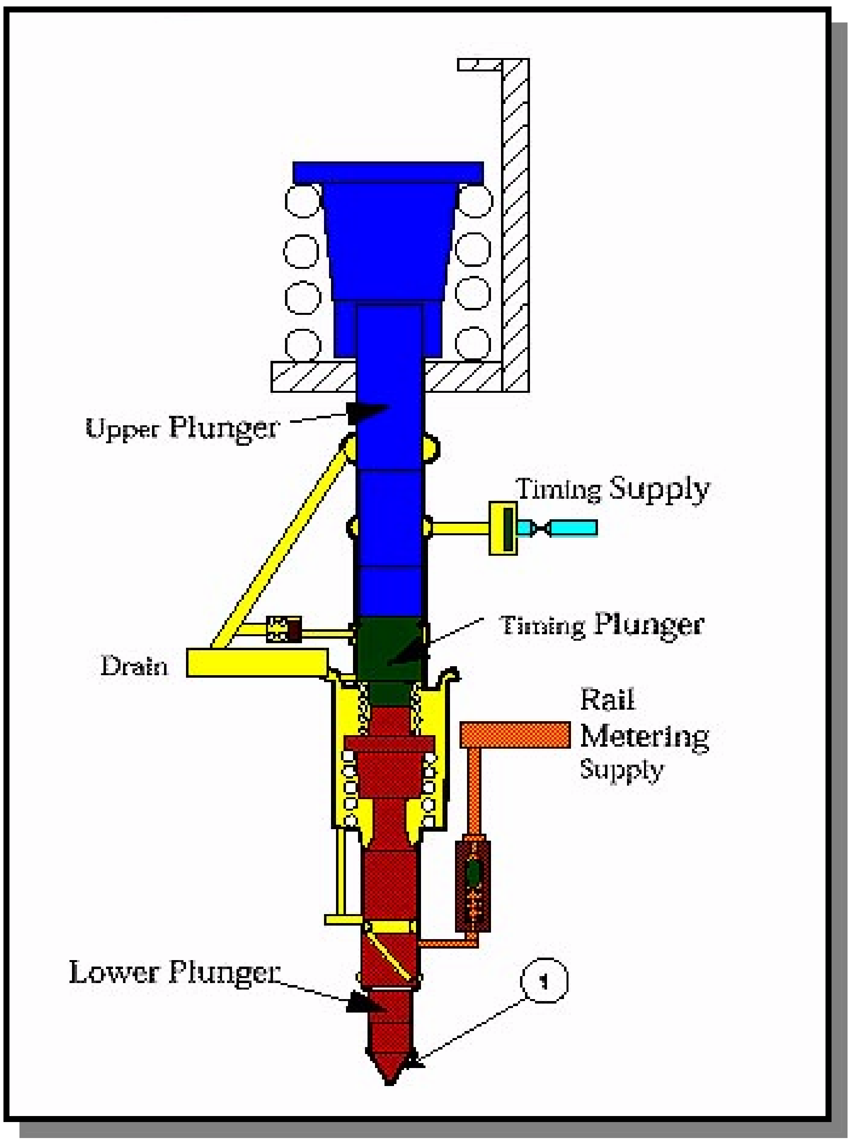
The injector operates under approximately 28,000 psi fuel pressure. However, the injector is designed to withstand 35,000 psi. These higher injection pressures improve emission control and fuel economy.

Four o-ring seals on the injector body separate the fuel timing, metering and drain passages. These o-rings also maintain the separation of the fuel and lubricating oil.

The injector sleeve relies on pressure from the injector to help it seal against the cylinder head. Without the injector installed coolant is likely to leak past the sleeve and into the cylinder. Therefore, before removing injectors the coolant must be drained at least below the injector level. As an alternative to draining the coolant you can use the coolant dam tool #3824319 to hold the coolant in the engine while the injectors are out.

Injector Operation

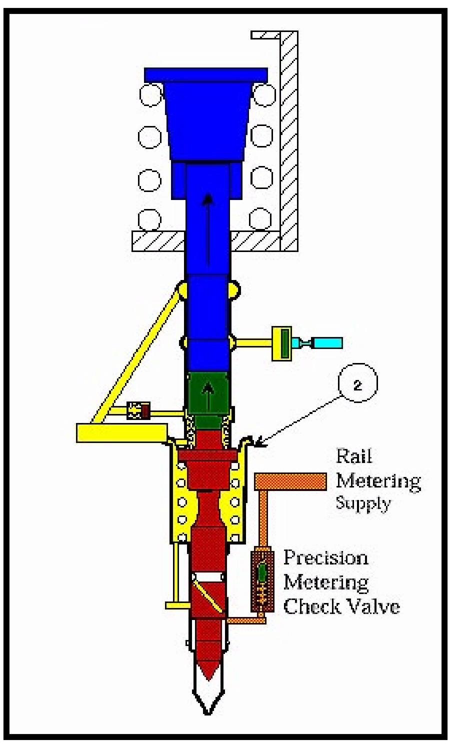
Event One
The injector is mechanically loaded by the drive train causing the Lower plunger to be pressed tightly against the nozzle seat. The Lower plunger is held in this position until the end of the exhaust stroke.

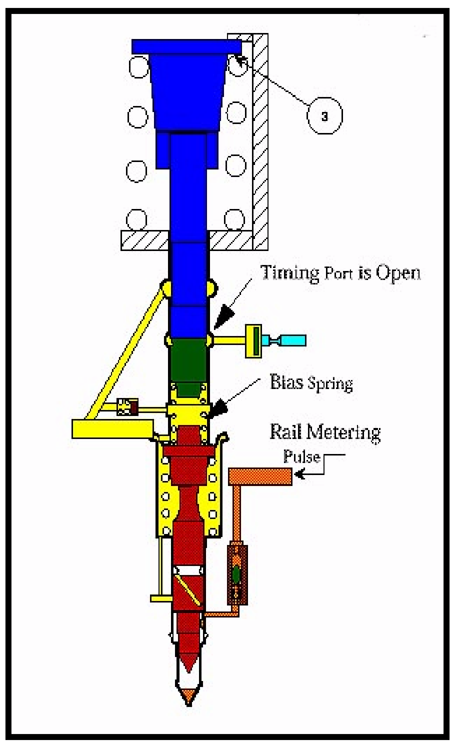


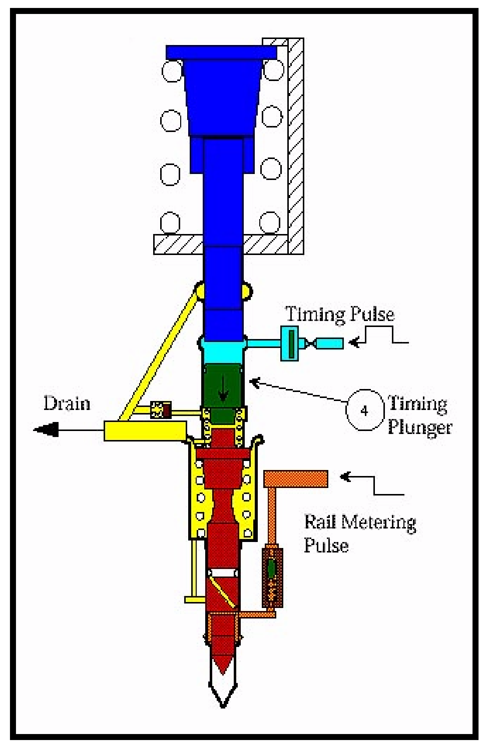
Event Two
The three injector plungers retract together, following the cam retraction profile, until the Lower Plunger contacts its mechanical stop. The Lower plunger spring holds it there. This is the beginning of the Rail metering window. Rail metering will begin when the Metering check valve is opened by a pressure pulse from the Metering Actuator .

Event Three The maximum injector lift is determined by the cam inner base circle or a top stop, as shown. Only one injector is ready for timing and rail fuel along the manifold bank. The rail metering pulse has reached this injector and the rail check valve has opened. Fuel is metered into the nozzle. The constant pressure pulse is sent for a commanded time period.

Event Four The Timing Actuator opens and starts the Timing pulse to the injector. The Timing plunger moves down and the timing advances as long as the Timing pulse lasts. The rail Metering pulse must finish before the Timing plunger closes the rail metering window. In these diagrams, the Timing plunger has stopped prior to reaching the Lower plunger.



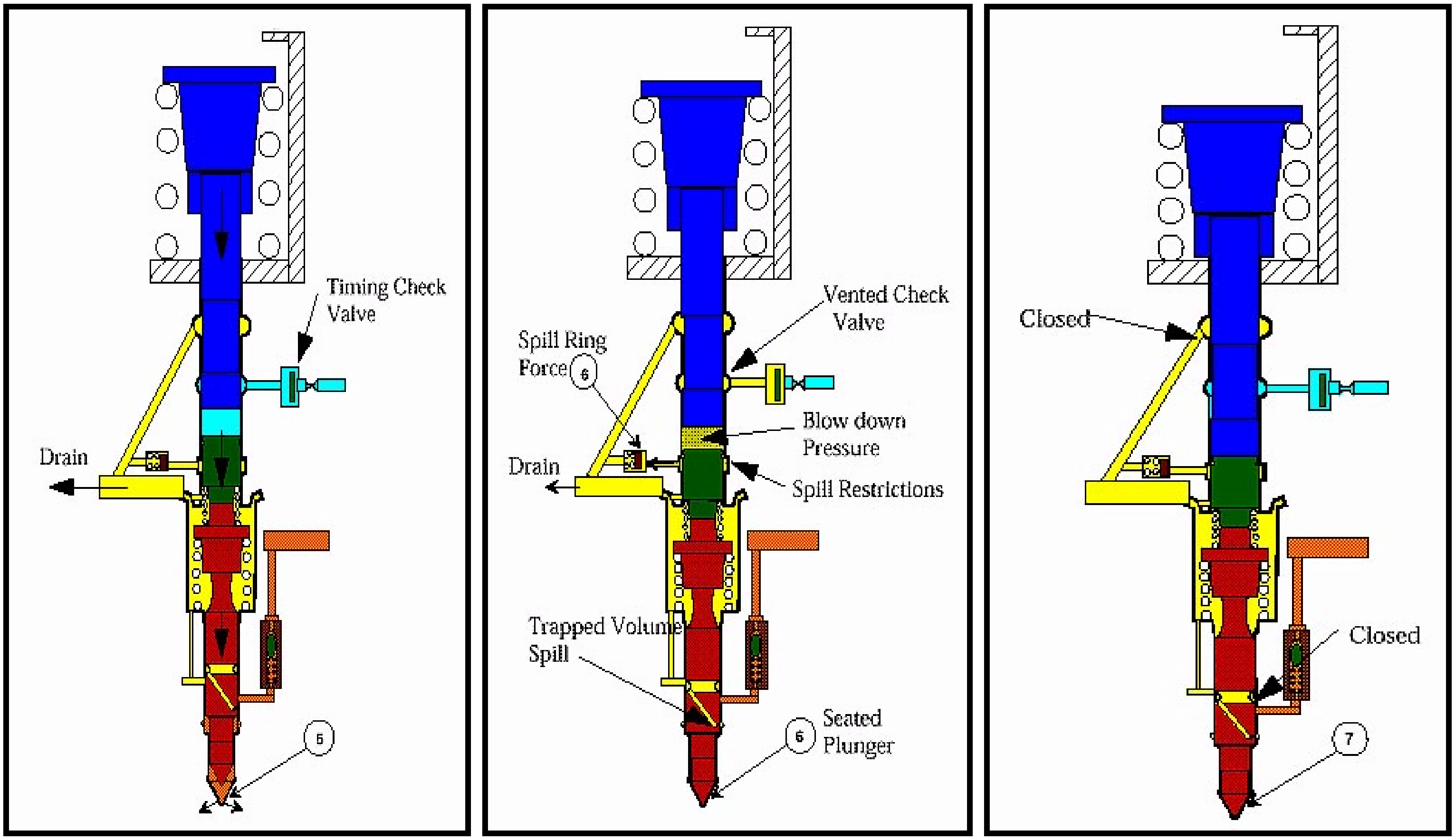


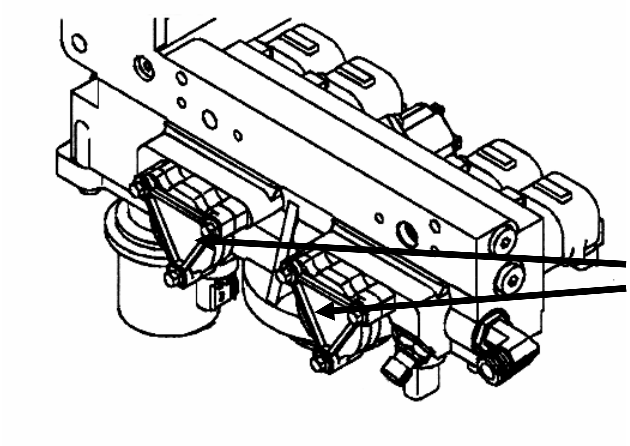


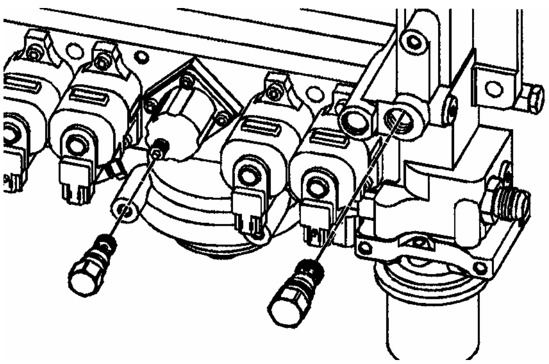
Event Five The cam pushes the Upper plunger down. This closes the Timing check valve. The Timing Plunger is hydraulically pushed down and it contacts the Lower Plunger. All three plungers move together and injection starts when the Lower plunger reaches solid fuel in the nozzle.

Event Six The trapped volume spill (TVS) drilling assists in a crisp end of injection. The Timing check valve is also vented to drain to release any injection pressure. The Lower plunger is held tightly against the nozzle seat by the spill pressure above the timing plunger (blow down). This pressure is controlled by the spill ring spring force, the Timing plunger's annular orifice and the Barrel to Timing plunger spill groove overlap.

Event Seven The Injector is mechanically loaded by the drive train causing the Lower plunger to be pressed tightly against the Nozzle seat. The Timing and Rail Metering windows are closed and will allow the other cylinders in its bank to get their fueling pulses. The Lower plunger is held in this position until the end of its Exhaust stroke .







250 and 380 PSI Regulators