Research Name:

COMMON RAIL DIESEL INJECTION SYSTEM

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2016

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No.3993 on 24/8/1997

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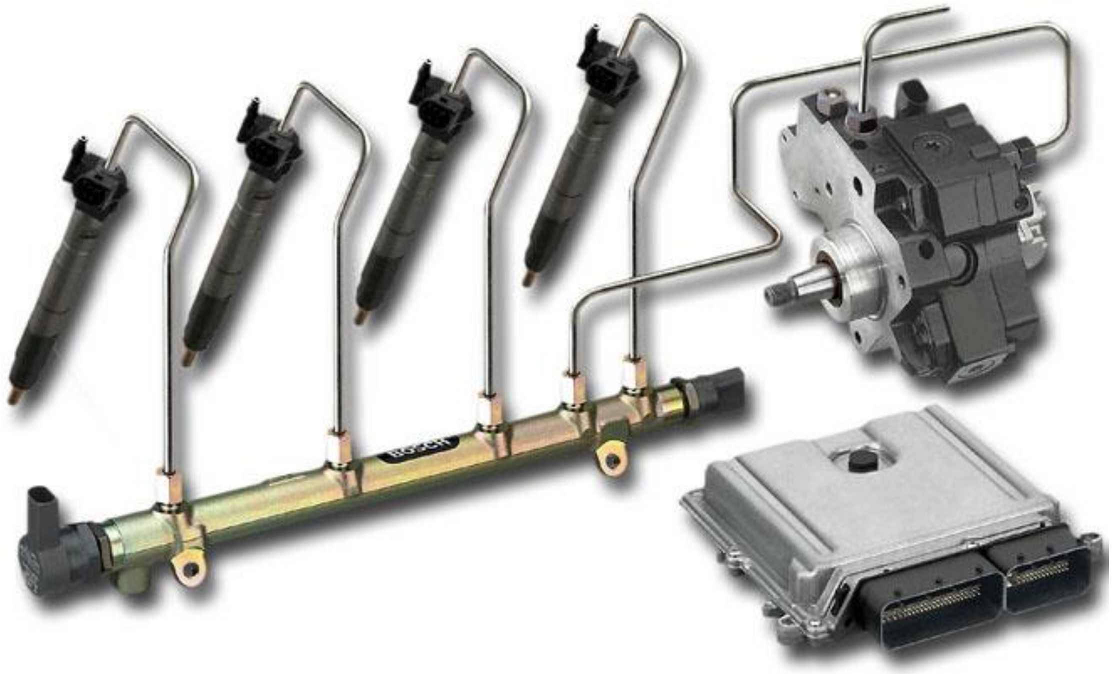
1-The Common Rail Diesel Injection System Explained:

In recent years, more and more drivers have been drawn to diesel-powered vehicles. Bosch has played a major role in this European diesel boom. The modern high-pressure injection systems VP44 distributor-pump, Unit Injector and Common Rail have transformed the ponderous, smoke-belching of yesterday into the sporty, fuel-efficient and clean automobiles of today.

Common rail diesel system



Common rail diesel Engine

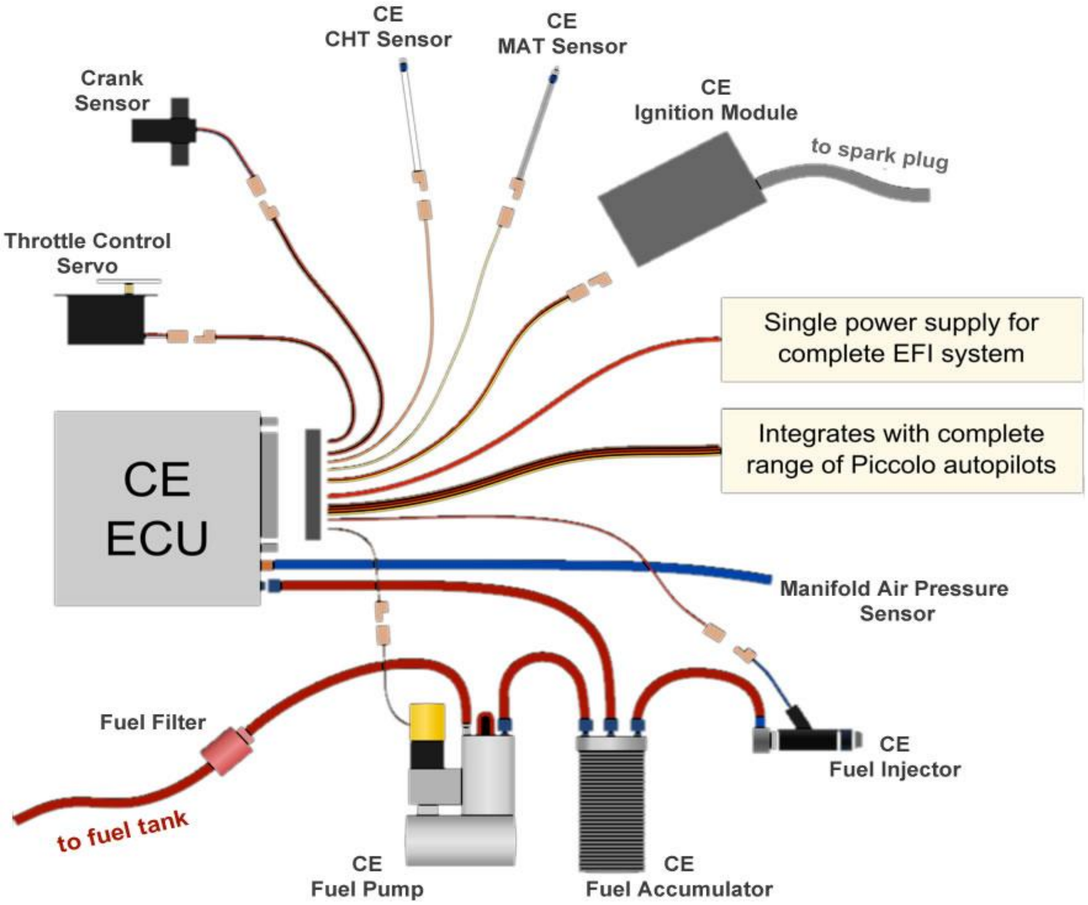
The more common rail system prototype was developed along at the late 1960s by Robert Huber of Switzerland and also the technology further developed by Dr. Marco Ganser in conjunction with the Swiss Federal Institute of Technology in Zurich (University in Zürich, Switzerland) .

The very first successful usage in production vehicle began in Japan by way of the mid-1990s. Dr. Shohei Itoh and Masahiko Miyaki associated with the Denso Corporation, a Japanese automotive parts manufacturer, developed the most popular rail fuel system for heavy duty vehicles and turned it into practical use on their ECD-U2 common-rail system that come with the Hino Rising Ranger truck and sold for general use in 1995. Denso claims the first commercial high pressure common rail system in 1995.

Modern common rail systems, whilst anterior to the same principle, are governed by an electric train engine control unit (ECU) which opens each injector electronically in lieu of mechanically. I thought this was extensively prototyped inside of the 1990s with collaboration between

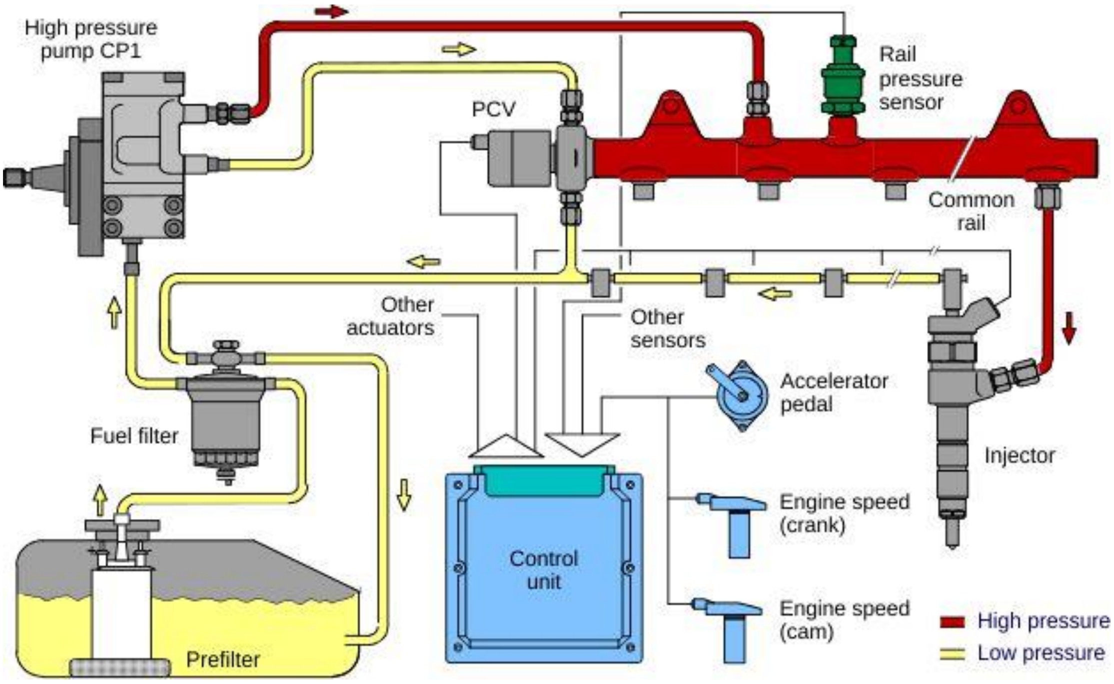
Magneti Marelli, Centro Ricerche Fiat and Elasis. After development and research next to the Fiat Group, the design was acquired due to the fact.

engine control unit (ECU)



German company Robert Bosch GmbH for completion of development and refinement for mass-production. In hindsight the sale seemed to be a tactical error for Fiat mainly because the new technology turned out to be highly profitable. The business enterprise had little choice but to dispose of, however, given that it what food was in a poor financial state when and lacked the resources to try and do development on its own. In 1997 they extended its use for passenger cars. The most important passenger car that used the common rail system was the 1997 model Alfa Romeo 156 2.4 JTD(uniJet Turbo Diesel) , and later on during that year Mercedes-Benz C 220 CDI.

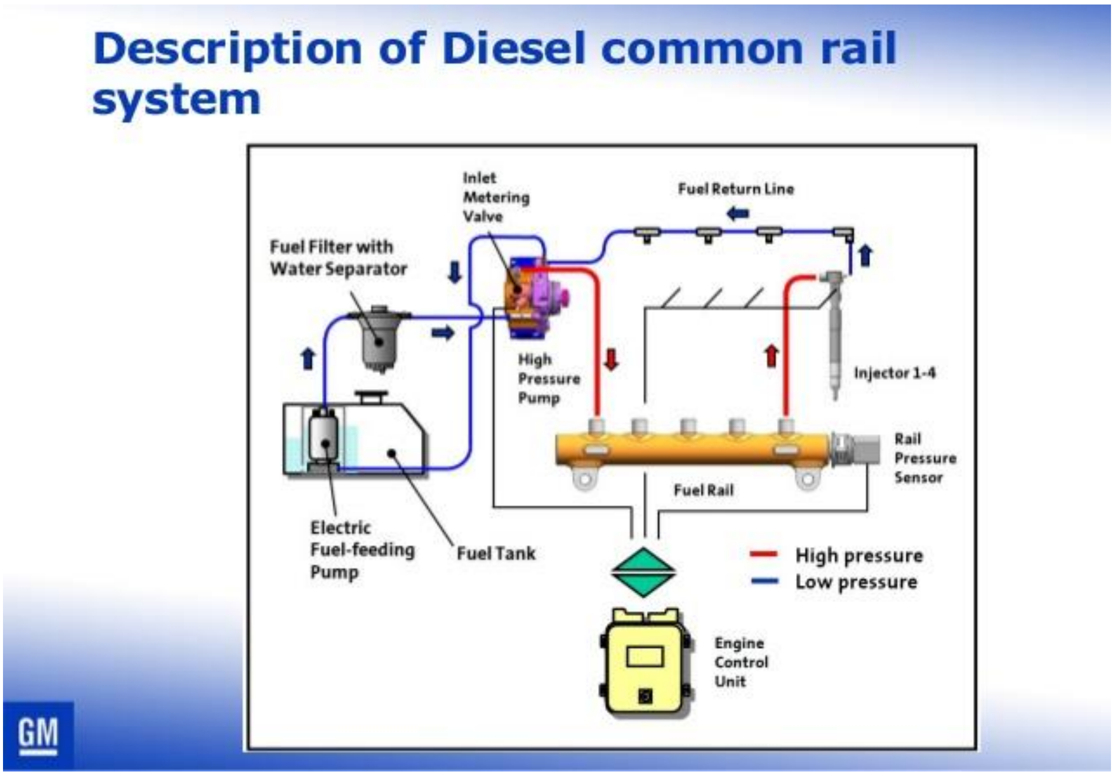
Common rail diesel injection system

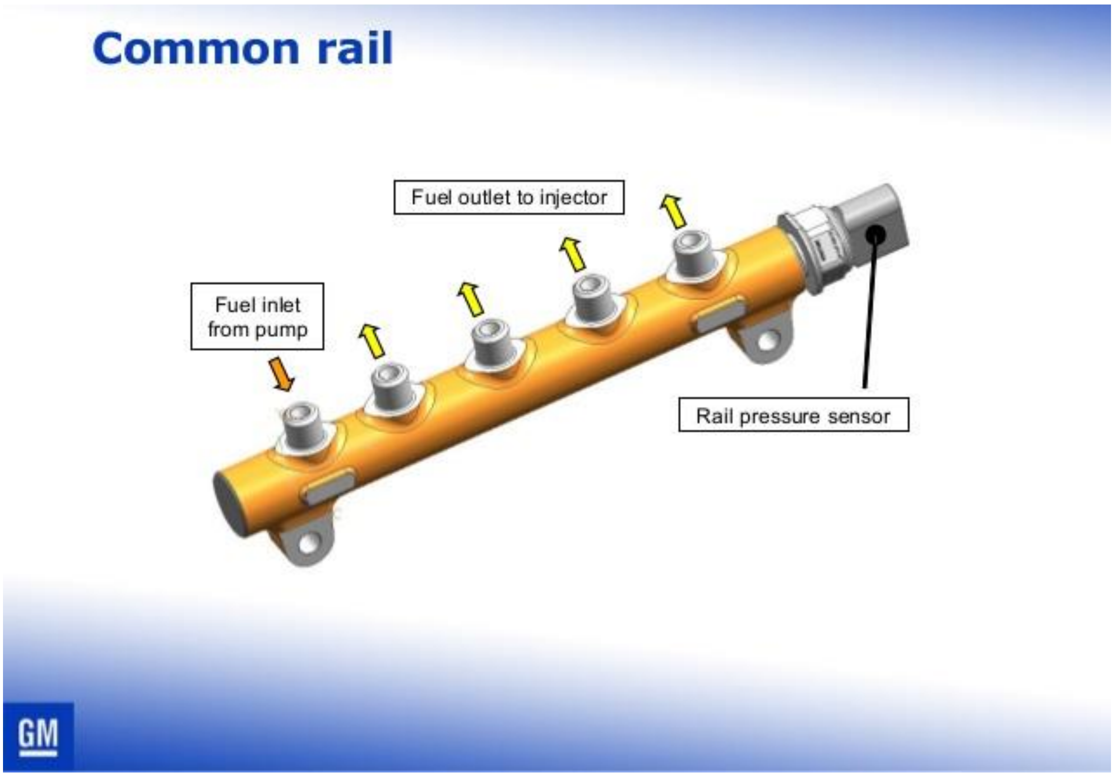


The Common Rail system in particular gives engine developers the freedom they need to reduce exhaust emissions even further, and especially to lower engine noise. The particular design of Common Rail, with its flexible division of injection into several pre-, main and post-injections, allows the engine and the injection system to be matched to each other in the best possible way. In the Common Rail accumulator injection system, the generation of the injection pressure is separate from the injection itself. A high-pressure pump generates in an accumulator – the rail – a pressure of up to 1,600 bar (determined by the injection pressure setting in the engine control unit), independently of the engine speed and the quantity of fuel injected.

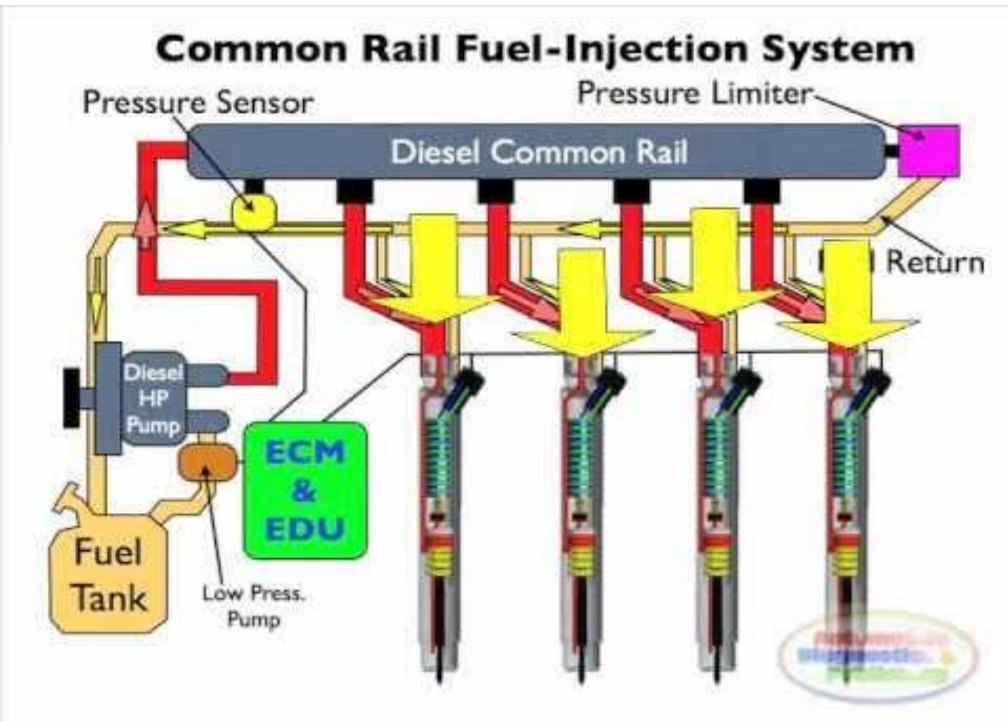
VP44 distributor-pump VP44 distributor-pump

The fuel is fed through rigid pipes to the injectors, which inject the correct amount of fuel in a fine spray into the combustion chambers. The Electronic Diesel Control (EDC): is a diesel engine fuel injection control system for the precise metering and delivery of fuel into the combustion chamber of modern diesel engines used in trucks and cars) , controls extremely precisely all the injection parameters – such as the pressure in the Rail and the timing and duration of injection as well as performing other engine functions.





In the 1st and 2nd generation of Bosch's Common Rail, the injection process is controlled by a magnetic solenoid on the injectors. The hydraulic force used to open and close the injectors is trans-mitted to the jet needle by a piston rod. In the 3rd generation of Common Rail for passenger cars, the injector actuators consist of several hundred thin piezo crystal wafers. Piezo crystals have the special characteristic of expanding rapidly when an electric field is applied to them. In a piezo inline injector, the actuator is built into the injector body very close to the jet needle. The movement of the piezo packet is transmitted friction-free, using no mechanical parts, to the rapidly switching jet needles. The advantages over the earlier magnetic and current conventional piezo injectors are a more precise metering of the amount of fuel injected and an improved atomization of the fuel in the cylinders. The rapid speed at which the injectors can switch makes it possible to reduce the intervals between injections and split the quantity of fuel delivered into a large number of separate injections for each combustion stroke. Diesel engines become even quieter, more fuel efficient, cleaner and more powerful.



For its 4th generation of Common Rail for passenger cars Bosch is currently exploring designs using even higher injection pressures of more than 2,000 bar, as well as injectors with variable injection geometry .

Milestones of development :

1997

First Common Rail system in the world for passenger cars.

Injection pressure: 1,350 bar .

First production use: Alfa Romeo and Mercedes-Benz .

1999

Common Rail system for trucks .

Injection pressure: 1,400 bar .

(First production use: Renault (RVI) .

2001

and generation Common Rail for passenger cars makes diesel engines even more economical, cleaner, quieter and more powerful. Injection pressure: 1,600 bar.

First production use: Volvo and BMW.

2002

and generation Common Rail for trucks gives lower emissions, improved fuel consumption and more power .

Injection pressure: 1,600 bar .

First production use: MAN .

2003

Generation Common Rail with rapid-switch piezo inline injectors for cars

Advantages: up to 20 % lower emissions or up to 5 % more power or up to 3 % lower fuel consumption or up to 3 dB(A) less engine noise.

Injection pressure: 1,600 bar .

First production use: Audi .

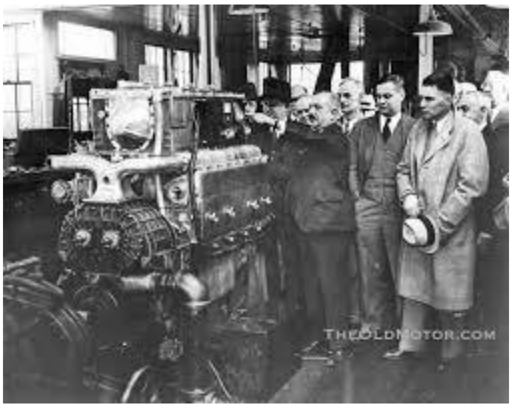
The 3rd generation Common Rail from Bosch is characterized by rapid-switch, compact piezo-inline-injectors. The innovative injection system provides for low exhaust emissions in the new V6 diesel engine of the Audi A8 .

Advantages: up to 20 % lower emissions or up to 5 % more power or up to 3 % lower fuel consumption or up to 3 dB(A) less engine noise .

Abstract: In the common rail system, fuel is distributed to the injectors from a high pressure accumulator, called the rail. The rail is fed by a high pressure fuel pump. The pressure in the rail, as well as the start and end of the signal that activates the injector for each cylinder are electronically controlled. Advantages of the common rail system include flexibility in controlling both the injection timing and injection rate.

The merits of the common rail fuel injection system architecture have been recognized since the development of the diesel engine. Early researchers, including Rudolf Diesel, worked with fuel systems that contained some of the essential features of modern common rail diesel fuel injection systems. For example, in 1913, a patent for a common rail fuel injection system with mechanically actuated injectors was issued to Vickers Ltd. of Great Britain. Around the same time, another patent was issued in the United States to Thomas Gaff for a fuel system for a direct cylinder injection spark ignition engine using electrically actuated solenoid valves. The fuel was metered by controlling the length of time the valves were open . The idea of using an electrically actuated injection valve on a diesel engine with a common rail fuel system was developed by Brooks Walker and Harry Kennedy in the late 1920s and applied to a diesel engine by Atlas-Imperial Diesel Engine Company of California in the early 1930s.

Work on modern day common rail fuel injection systems was pioneered in the 1960s by the Societe des Procedes Modernes D'Injection (SOPROMI). However, it would still take 2-3 decades before regulatory pressure would further development and the technology would mature to be commercially viable. The SOPROMI technology was evaluated by CAV Ltd. in the early 1970s and was found to provide little benefit over existing P-L-N systems in use at the time. Considerable work was still required to improve the precision and capability of solenoid actuators.



Further development of diesel common rail systems began in earnest in the 1980s. By 1985, Industrieverband Fahrzeugbau (IFA) of the former East Germany developed a common rail injection system for their W50 truck, but the prototype never entered series production and the project was abandoned a couple of years later . Around the same time, General Motors was also developing a common rail system for application to their light-duty IDI engines. However, with the cancellation of their light-duty diesel program in the mid-1980s, further development was stopped.

Industrieverband Fahrzeugbau (IFA) - W50

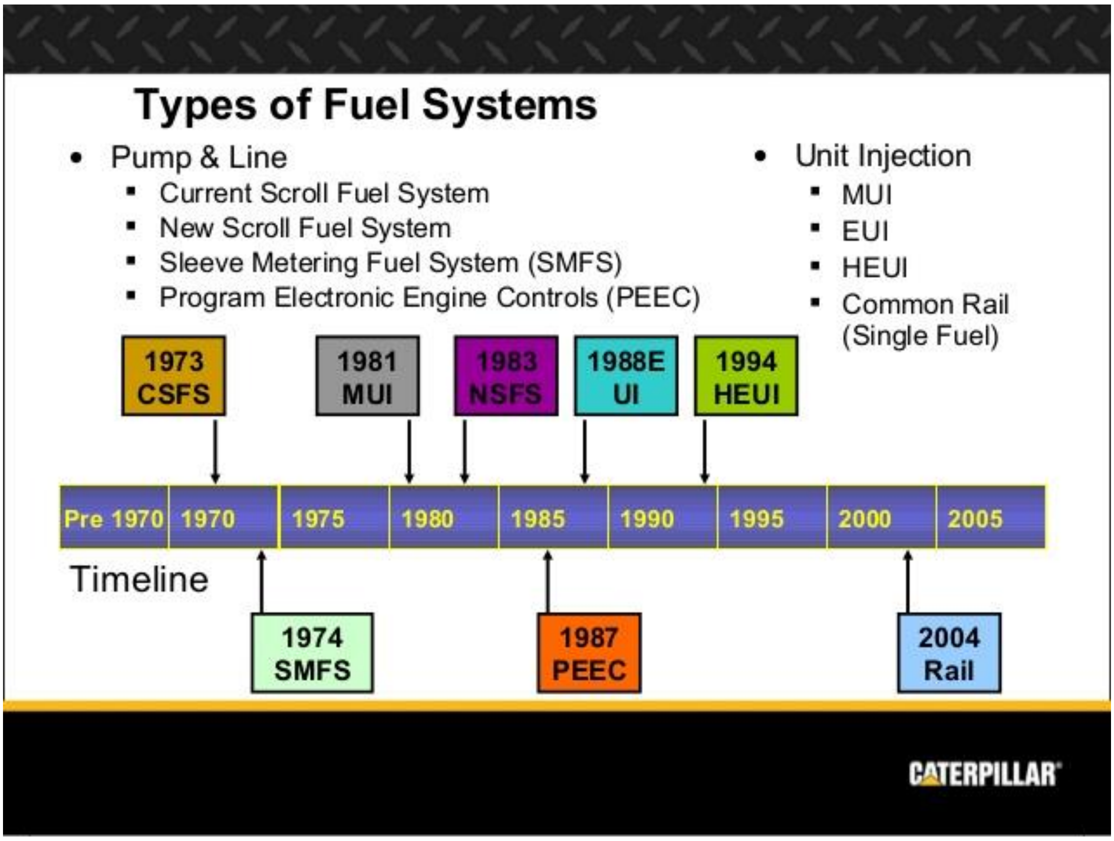
A few years later, in the late 1980s and early 1990s, a number of development projects were initiated by engine OEMs (Original equipment manufacturer) and later taken up by fuel injection equipment manufacturers.

Nippondenso further developed a common rail system for commercial vehicles that they acquired from Renault and that was introduced into production in 1995 in Hino Rising Ranger trucks.

In 1993, Bosch—perhaps due to some pressure by Daimler-Benz(was a German manufacturer of automobiles, motor vehicles, and internal combustion engines; founded in 1926) —acquired the UNIJET technology initially developed by the efforts of Fiat and Elasis (a Fiat subsidiary) for further development and production. Bosch's passenger car common rail system was introduced into production in 1997 for the 1998 model year Alfa Romeo 156 and C-Class Mercedes-Benz.

Shortly afterward, Lucas announced common rail contracts with Ford, Renault and Kia with production starting in 2000.

In 2003, Fiat introduced a next generation common rail system capable of 3-5 injections/engine cycles for the Multi jet Euro 4 engine.



The aim of these development programs started in the late 1980s/early 1990s was to develop a fuel system for the future diesel powered passenger car. Early on in these efforts, it was apparent that future diesel cars would utilize a direct injection combustion system due to the clear advantage in fuel economy and power density relative to the then prevalent indirect injection combustion system. The objectives of the developments included driving comfort comparable to that of gasoline fueled cars, compliance with future emission limits and improved fuel economy. Three groups of fuel system architectures were under consideration:

(1) An electronically controlled distributor pump.

(2) An electronically controlled unit injector (EUI or pump-nozzle unit).

(3) A common rail (CR) injection system. While the efforts around each of these approaches lead to commercial fuel systems for production vehicles, the common rail system provided a number of advantages and

would eventually come to dominate as the primary fuel system used in light-duty vehicles. These advantages included:

Fuel pressure independent of engine speed and load conditions. This allows for flexibility in controlling both the fuel injection quantity and injection timing and enables better spray penetration and mixing even at low engine speeds and loads. This feature differentiates the common rail system from other injection systems, where injection pressure increases with engine speed. This characteristic also allows engines to produce higher torque at low engine speed—especially if a variable geometry turbocharger (VGT) is used. It should be noted that while common rail systems could operate with maximum rail pressure held constant over a wide range of engine speeds and loads, this is rarely done. As is discussed elsewhere, fuel pressure in common rail systems can be controlled as a function of engine speed and load to optimize emissions and performance while ensuring engine durability is not compromised.

Lower fuel pump peak torque requirements . As high speed direct injection (HSDI- high speed direct injection -) engines developed, more of the energy to mix the air with fuel came from the fuel spray momentum as opposed to the swirl mechanisms employed in older, IDI- undirected Injection Diesel - combustion systems. Only high pressure fuel injection systems were able to provide the mixing energy and good spray preparation needed for low PM - particulate matter- and HC- hydrocarbon- emissions. To generate the energy required to inject the fuel in approximately 1 millisecond, the conventional distributor pump would have to provide nearly 1 kW of hydraulic power in four (in a 4-cylinder engine) 1 MS bursts per pump revolution, thus placing considerable strain on the drive shaft. One of the reasons behind the trend toward common rail systems was to minimize the maximum pump torque requirement. While the power and average torque requirements of the common rail pump were similar, high pressure fuel delivery is to an accumulator and thus the peak flow rate (and peak torque required to drive the pump) does not have to coincide with the injection event as is the case with the distributor pump. Pump discharge flow can be spread out over a longer portion of the engine cycle to keep pump torque demand more even.

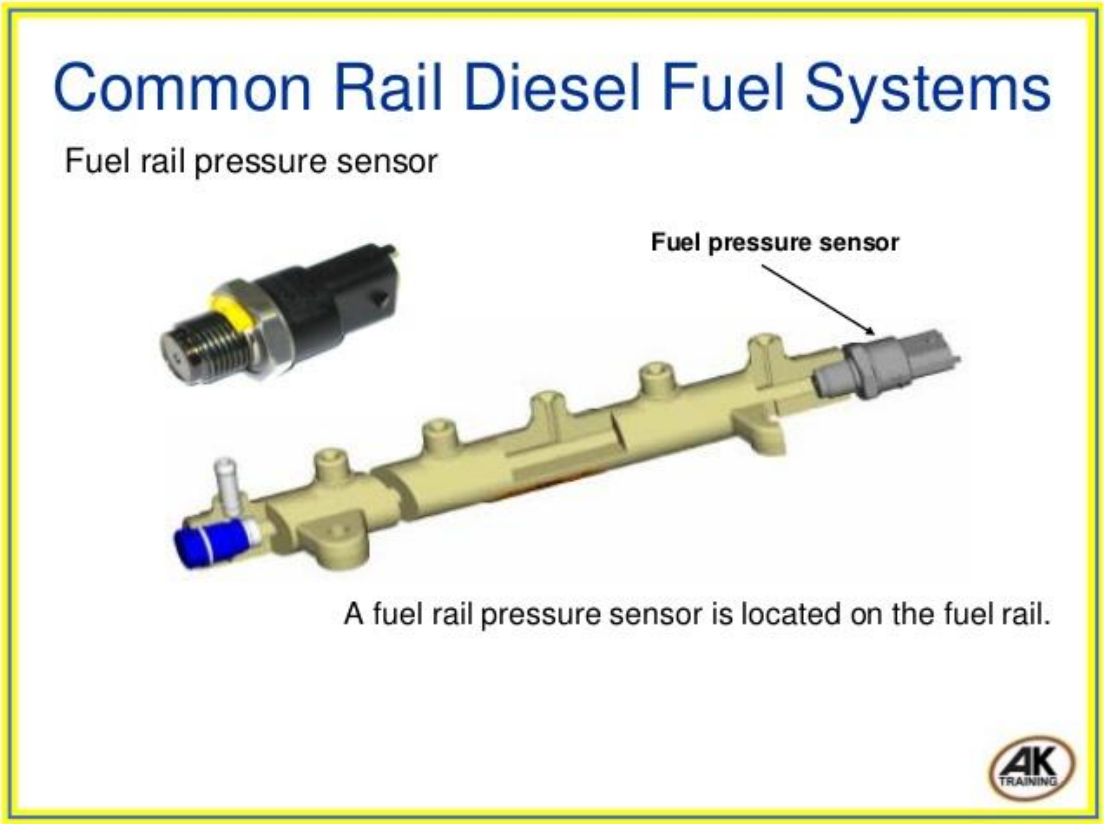
Improved noise quality . DI engines are characterized by higher peak combustion pressures and, thus, by higher noise than IDI engines, It was found that improved noise and low NOx emissions were best achieved by introducing pilot injection(s). This was most easily realized in the common rail system, which was capable of stable deliveries of small pilot

Fuel quantities over the entire load/speed range of the engine.

2- Common rail

Diesel fuel injector as installed in a MAN V8 Diesel engine:

Common rail direct fuel injection is a direct fuel injection system for petrol and diesel engines.



On diesel engines, it features a high-pressure (over 1,000 bar or 100 MPa or 15,000 psi) fuel rail feeding individual solenoid valves, as opposed to a low-pressure fuel pump feeding unit injectors (or pump nozzles). Third-generation common rail diesels now feature piezoelectric injectors for increased precision, with fuel pressures up to 3,000 bar (300 MPa; 44,000 psi).

3- Common rail fuel system on a Volvo truck engine:

The common rail system prototype was developed in the late 1960s by Robert Huber of Switzerland and the technology further developed by Dr. Marco Gesner at the Swiss Federal Institute of Technology in Zurich.

Common rail engines have been used in marine and locomotive applications for some time. The **Cooper-Bessemer** GN-8 is an example of a hydraulically operated common rail diesel engine, also known as a modified common rail.

The common rail system is suitable for all types of road cars with diesel engines, ranging from city cars (such as the Fiat Panda) to executive saloons (such as the Audi A8). The main suppliers of modern common rail systems are Robert Bosch GmbH, Delphi, Denso, and Siemens VDO .

The automotive manufacturers refer to their common rail engines by their own brand names:

BMW: D also used in the Land Rover Freelander as TD4.

Chevrolet: VCDi licensed from VM Motori.

Cummins and Scania: XPI developed under joint venture.

Cummins: CCR Cummins pump with Bosch injectors.

Daimler: CDI and on Chrysler's Jeep vehicles simply as CRD.

Fiat Group Fiat, Alfa Romeo and Lancia: JTD also branded as MultiJet,. JTDm, and by supplied manufacturers as CDTi, TiD, TTiD, DDiS and Quadra-Jet).

JTD, uni Jet Turbo Diesel, is Fiat Group's term for its current common rail turbo diesel engine range. The Multi Jet name is used in the second generation JTD common rail units. Most of the Fiat, Alfa Romeo and Lancia range has JTD engines. Ownership of some Fiat JTD designs is shared with General Motors as part of a settlement of the failed merger between the two auto conglomerates. GM Powertrain Torino group in Turin, Italy manages their interest in these engines. Some PSA Peugeot Citroën diesel engines are also rebadged JTD units.

A new generation JTD engine, MultiJet II was introduced in Fiat Punto Evo in 2009.

(Ford Motor Company: TDCi Duratorq and Powerstroke

Honda: i-CTDi and i-DTEC

Hyundai and Kia: CRDi

IKCO: EFD

Isuzu: iTEQ

Jeep: CRD

Komatsu: Tier3, Tier4, 4D95 and higher HPCR-series

Mahindra: CRDe, DiCR, m2DiCR

Mazda: MZR-CD and Skyactiv-D are manufactured by the Ford and PSA Peugeot Citroen joint venture and earlier DiTD

Mitsubishi: DI-D mainly on the recently developed 4N1 engine family

Nissan: dCi Infiniti uses dCi engines, but not branded as dCi

Opel: CDTI

Proton: SCDi

PSA Peugeot Citroën: HDI or HDi (developed under joint venture with Ford) – See PSA HDi engine

(Renault: dCi (joint venture with Nissan

(SsangYong: XDi (most of these engines are manufactured by Daimler AG

Subaru: TD or D (as of Jan 2008)

Tata: DICOR and CR4

Toyota: D-4D and D-Cat

Volkswagen Group (Volkswagen, Audi, Seat and Skoda): TDI (more recent models use common rail, as opposed to the earlier unit injector (engines

Volvo: D and D5 engines (some are manufactured by Ford and PSA Peugeot Citroen), Volvo Penta D-series engines

4- Diagram of the common rail system:

Solenoid or piezoelectric valves make possible fine electronic control over the fuel injection time and quantity, and the higher pressure that the common rail technology makes available provides better fuel atomization. To lower engine noise, the engine's electronic control unit can inject a small amount of diesel just before the main injection event ("pilot" injection), thus reducing its explosiveness and vibration, as well as optimizing injection timing and quantity for variations in fuel quality, cold starting and so on. Some advanced common rail fuel systems perform as many as five injections per stroke.

Common rail engines require a very short (< 10 seconds) to no heating-up time, depending on ambient temperature, and produce lower engine noise and emissions than older systems.

Diesel engines have historically used various forms of fuel injection. Two common types include the unit injection system and the distributor/inline pump systems. While these older systems provided accurate fuel quantity and injection timing control, they were limited by several factors:

They were cam driven, and injection pressure was proportional to engine speed. This typically meant that the highest injection pressure could only be achieved at the highest engine speed and the maximum achievable injection pressure decreased as engine speed decreased. This relationship is true with all pumps, even those used on common rail systems. With unit or distributor systems, the injection pressure is tied to the instantaneous pressure of a single pumping event with no accumulator, and thus the relationship is more prominent and troublesome.

They were limited in the number and timing of injection events that could be commanded during a single combustion event. While multiple injection events are possible with these older systems, it is much more difficult and costly to achieve.

For the typical distributor/inline system, the start of injection occurred at a pre-determined pressure (often referred to as: pop pressure) and ended at a pre-determined pressure. This characteristic resulted from injectors in the cylinder head which opened and closed at pressures determined by the spring preload applied to the plunger in the injector. Once the pressure in the injector reached a pre-determined level, the plunger would lift and injection would start.

In common rail systems a high-pressure pump stores a reservoir of fuel at high pressure — up to and above 2,000 bars (200 MPa; 29,000 psi). The term "common rail" refers to the fact that all of the fuel injectors are supplied by a common fuel rail which is nothing more than a pressure accumulator where the fuel is stored at high pressure. This accumulator supplies multiple fuel injectors with high-pressure fuel. This simplifies the purpose of the high-pressure pump in that it only needs to maintain a commanded pressure at a target (either mechanically or electronically controlled). The fuel injectors are typically ECU-controlled. When the fuel injectors are electrically activated, a hydraulic valve (consisting of a nozzle and plunger) is mechanically or hydraulically opened and fuel is sprayed into the cylinders at the desired pressure. Since the fuel pressure energy is stored remotely and the injectors are electrically actuated, the injection pressure at the start and end of injection is very near the pressure in the accumulator (rail), thus producing a square injection rate. If the accumulator, pump and plumbing are sized properly, the injection pressure and rate will be the same for each of the multiple injection events.

5- Common rail injection

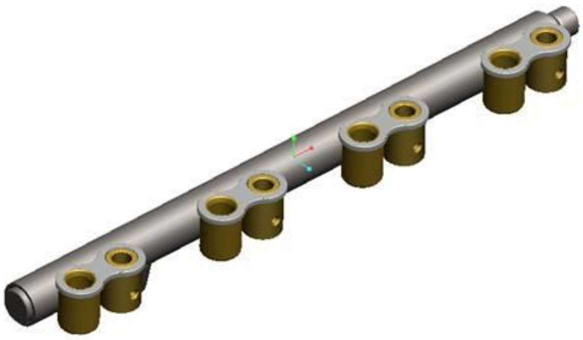
Advanced technology for diesel engines:

Bosch launched the first common rail system in 1997. The system is named after the shared high-pressure reservoir (common rail) that supplies all the cylinders with fuel. With conventional diesel injection systems, the fuel pressure has to be generated individually for each injection. With the common rail system, however, pressure generation and injection are separate, meaning that the fuel is constantly available at the required pressure for injection

6- Common rail diesel injection system:

In the Common Rail system, an accumulator, or rail, is used to create a common reservoir of fuel under a consistent controlled pressure that is separate from the fuel injection points.

A high-pressure pump increases the fuel pressure in the accumulator up to 1,600 bar or 23,200 PSI. The pressure is set by the engine control unit and is independent of the engine speed and quantity of fuel being injected into any of the cylinders. The fuel is then transferred through rigid pipes to the fuel injectors, which inject the correct amount of fuel into the combustion chambers.



rigid pipes - Common Rail

The injectors used in Common Rail systems are triggered externally by an Electronic Diesel Control, or EDC unit, which controls all the engine injection parameters including the pressure in the fuel rail and the timing and duration of injection.

Diesel fuel injectors used in Common Rail injection systems operate differently to conventional fuel injectors used in the jerk pump system, where the plungers are controlled by the camshaft position and speed. Some common rail injectors are controlled by a magnetic solenoid on the injector. Hydraulic force from the pressure in the system is used to open and close the injector, but the available pressure is controlled by the solenoid triggered by the Electronic Diesel Control unit.

Some injectors use Piezo crystal wafers to actuate the injectors. These crystals expand rapidly when connected to an electric field. In a Piezo inline injector, the actuator is built into the injector body very close to the jet needle and uses no mechanical parts to switch injector needles.

7- The common rail system:

Common rail systems have a modular design. Each system consists of a high-pressure pump, injectors, a rail, and an electronic control unit.

8- Mode of operation:

With conventional diesel injection systems, the fuel pressure has to be generated individually for each injection. With the common rail system, however, pressure generation and injection are separate, meaning that the fuel is constantly available at the required pressure for injection. Pressure generation takes place in the high-pressure pump. The pump compresses the fuel and feeds it via a high-pressure pipe to the inlet of the rail, which acts as a shared high-pressure reservoir for all injectors – hence the name "common rail". From there, the fuel is distributed to the individual injectors, which inject it into the cylinder's combustion chamber.

9- Broad range of solution:

Bosch offers common rail systems for all vehicle models from micro cars to heavy luxury limousines. The high-pressure pumps operate at pressures between 1,100 and 2,200 bar. Systems with individual pumps are also available (plug-in pumps). The injectors use either solenoid valve or Piezo technology.

10- Advantages:

Clean and highly efficient fuel injection due to extremely short spraying distances and multiple injections.

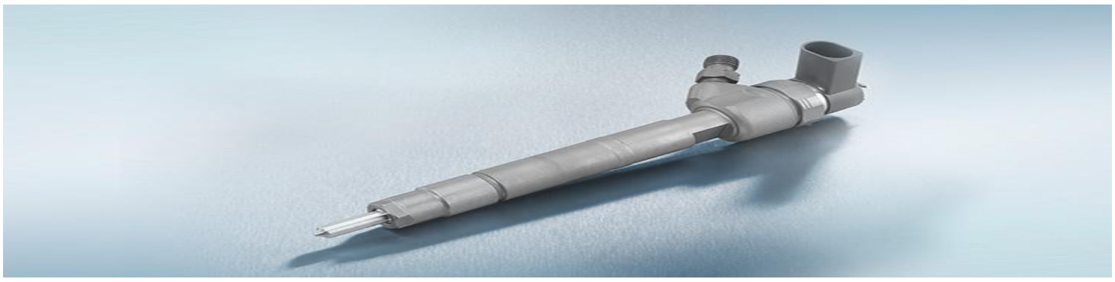
High engine power and smooth running with low consumption and emissions.

Can be used with all vehicle models due to modular design.

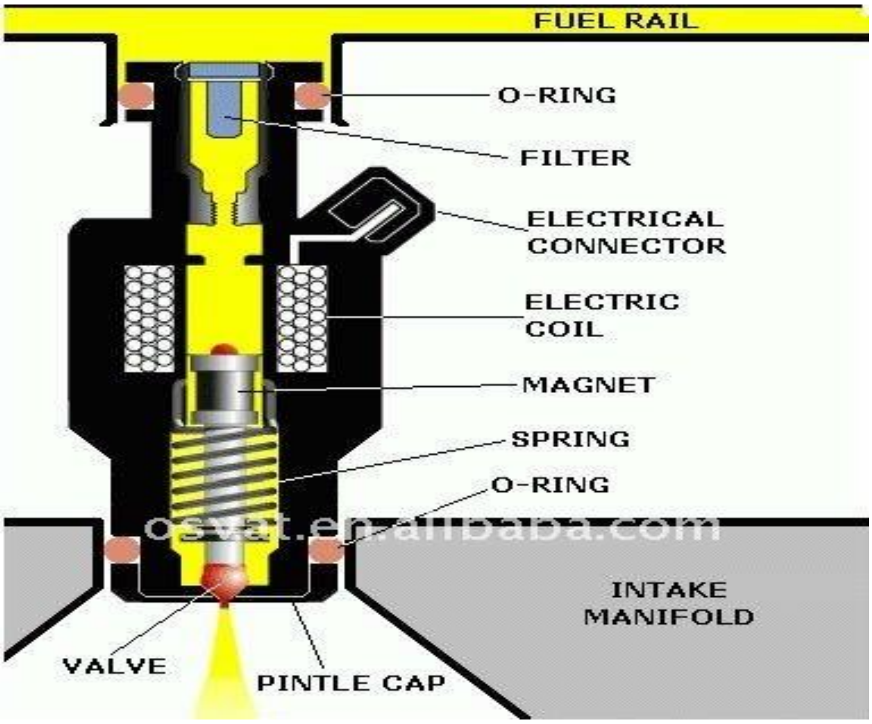
11- High-pressure pumps:

The high-pressure pump compresses the fuel and supplies it in the required quantity. It constantly feeds fuel to the high-pressure reservoir (rail), thereby maintaining the system pressure. The required pressure is available even at low engine speeds, as pressure generation is not linked to the engine speed. Most common rail systems are equipped with radial piston pumps. Compact cars also use systems with individual pumps which operate at a low system pressure.

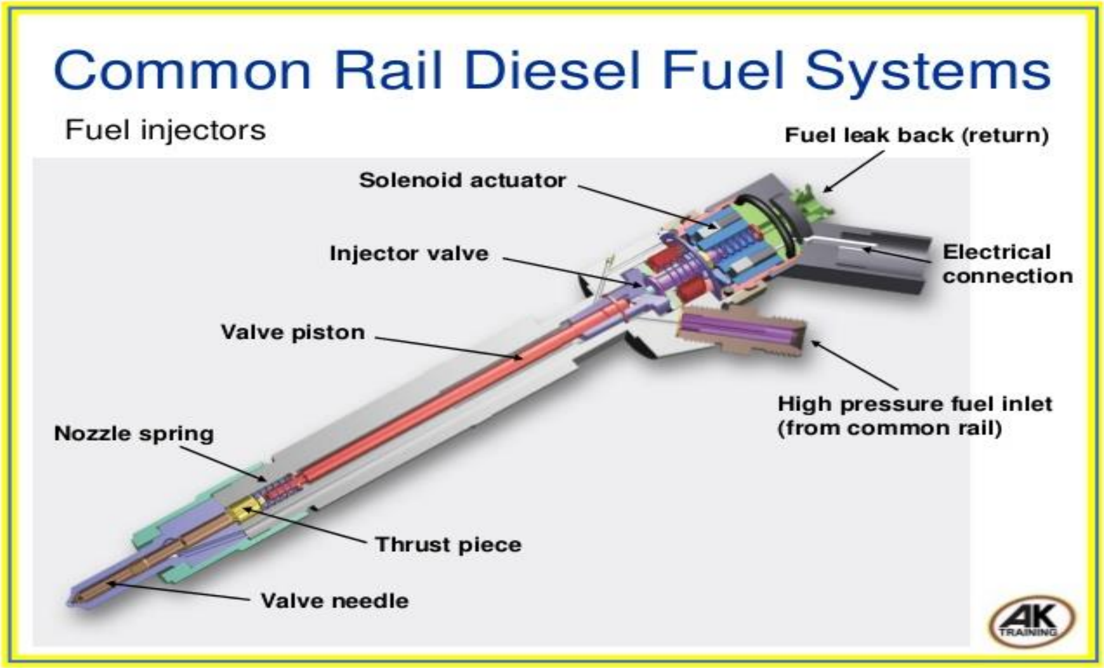
12- Injectors:



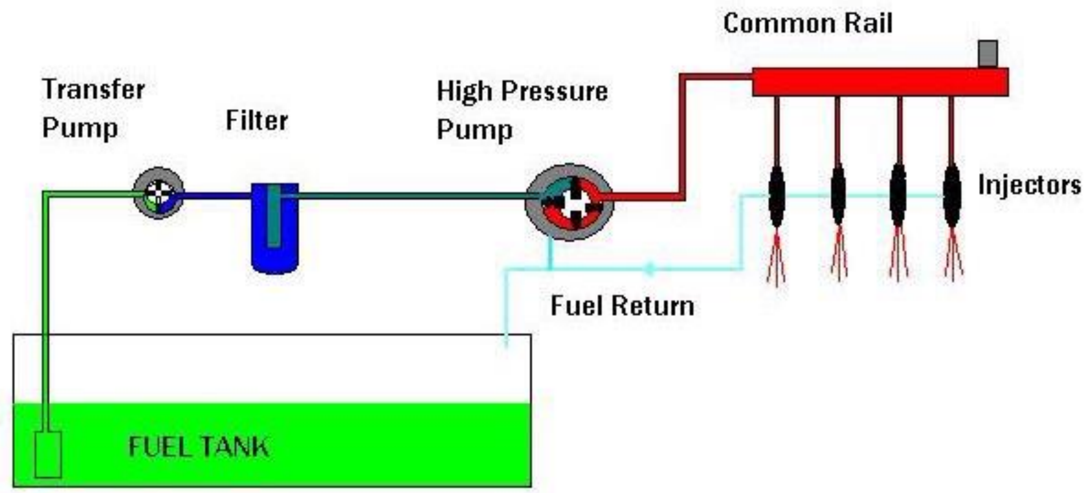
The injector in a common rail system consists of the nozzle, an actuator for Piezo injectors or a solenoid valve for solenoid valve injectors, as well as hydraulic and electrical connections for actuation of the nozzle needle.



It is installed in each engine cylinder and connected to the rail via a short high-pressure pipe. The injector is controlled by the Electronic Diesel Control (EDC). This ensures that the nozzle needle is opened or closed by the actuator, be it solenoid valve or Piezo. Injectors with Piezo actuators are somewhat narrower and operate at a particularly low noise level. Both variants demonstrate similarly short switching times and enable pre-injection, main injection and secondary injection to ensure clean and efficient fuel combustion at every operating point.

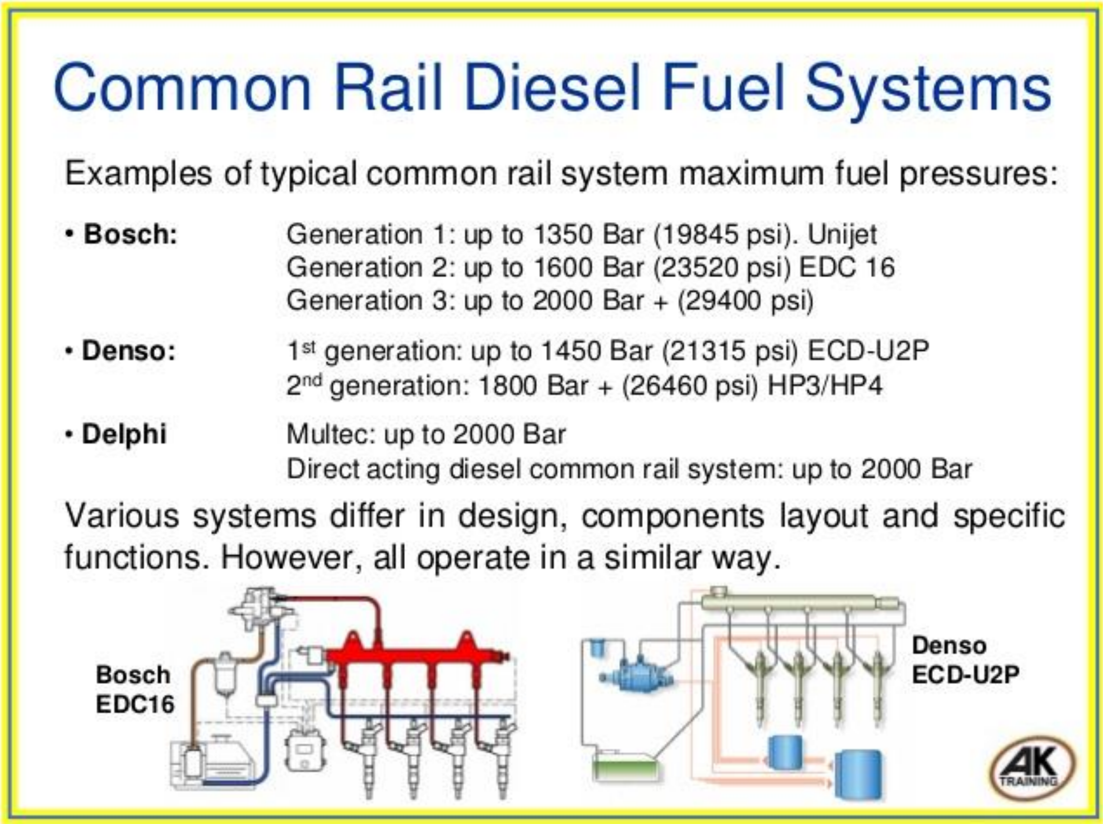


13- Common Rail Injectors Explained



Increased government regulation and the push to lessen greenhouse gas emissions in recent years, has led to the modern high-pressure injection systems. Unit Injector and Common Rail design have transformed the plodding, black smoking, and inefficient diesels of yesterday into the sporty, fuel-efficient and clean diesel vehicles of today. This is the New Clean Diesel.

The Common Rail system in particular gives engine developers the freedom they need to reduce exhaust emissions even further, and especially to lower engine noise. The particular design of Common Rail, with its flexible division of injection into several pre, main and post-injections, allows the engine and the injection system to be matched to each other in the best possible way. In the Common Rail accumulator injection system, the generation of the injection pressure is separate from the injection itself.



Diesel fuel is drawn from the fuel tank by a fuel transfer pump. After the transfer pump draws the fuel from the tank it will pass through at least one primary fuel filter. A high-pressure pump generates in an accumulator – the rail – a pressure of up to 1,600 bar (determined by the injection pressure setting in the engine control unit), independently of the engine speed and the quantity of fuel injected. The fuel is fed through rigid pipes to the injectors, which inject the correct amount of fuel in a fine spray into the combustion chambers. The Electronic Diesel Control (EDC) controls extremely precisely all the injection parameters – such as the pressure in the Rail and the timing and duration of injection – as well as performing other engine functions.

Electronic Diesel Control (EDC)

14-Advantages of the Common Rail Diesel System:

The electronically controlled common rail system has many advantages:

Increased Performance more torque at low engine speeds.

Reduced fuel consumption.

Less exhaust and emissions.

Quieter running engine.

15- WARNING:

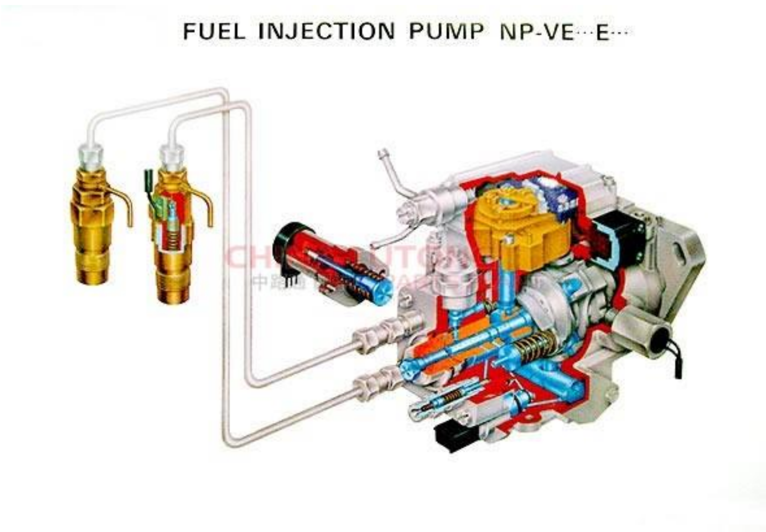
Common rail diesel fuel systems operate at very high pressure and can cause severe injury. Fuel pressures of up to 2000bar may be present. Never attempt to service or repair any Common Rail or pressurized fuel system without the proper equipment and training.

16- Electronic Common Rail Direct Injection (CRD):

Modern diesels owe their resurgence in popularity to advances in fuel delivery and engine management systems that allow the engines to return power, performance and emissions equivalent to their gasoline counterparts, while simultaneously producing superior fuel economy.

Electronic Control Unit:

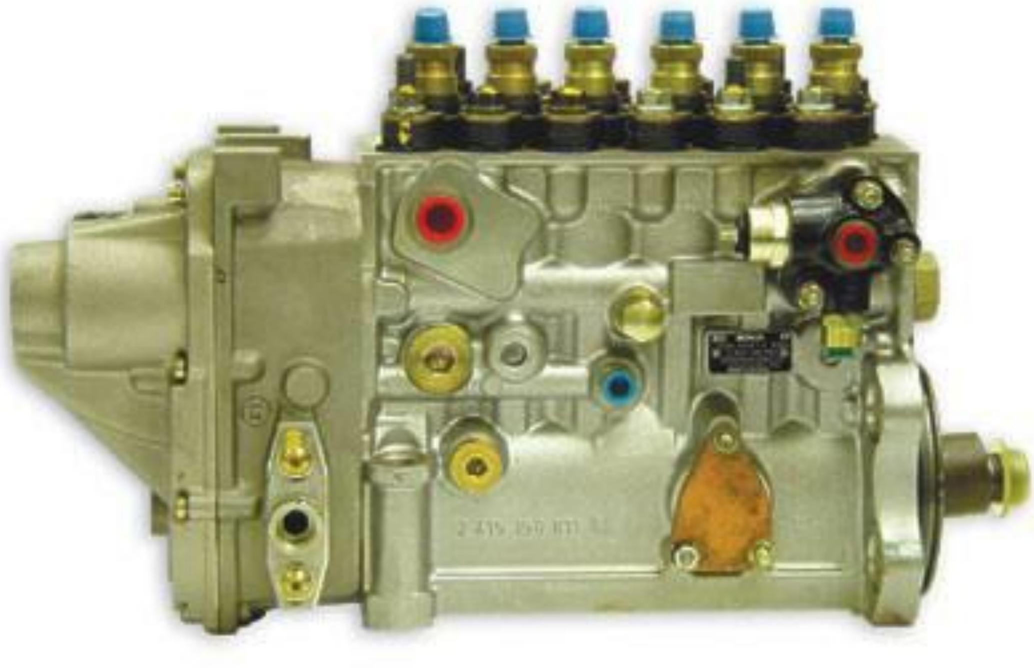
The ECU collects and processes signals from various on-board sensors. An ECU electronic module contains microprocessors, memory units, analog to digital converters and output interface units. Depending upon the parameters, a number of different maps can be stored in the onboard memory. This allows the ECU to be tailored to the specific engine and vehicle requirements, depending on the application. The operating software of the ECU can be adapted for a wide variety of engines and vehicles without the necessity of hardware modification. The ECU is usually located in the cab or in certain cases, in a suitable position in the engine bay where additional environmental conditions might require cooling of the ECU as well as a requirement for better dust, heat and vibrations insulation.



The high-pressure pump

It's the high pressure fuel rail and the computer controlled electronic injectors that make all the difference. In the common rail system, the fuel pump charges the fuel rail at a pressure of up to 25,000 psi--but unlike indirect injection pumps--it is not involved in fuel discharge.

Under the control of the onboard computer, this fuel quantity and pressure accumulates in the rail independently of engine speed and load.



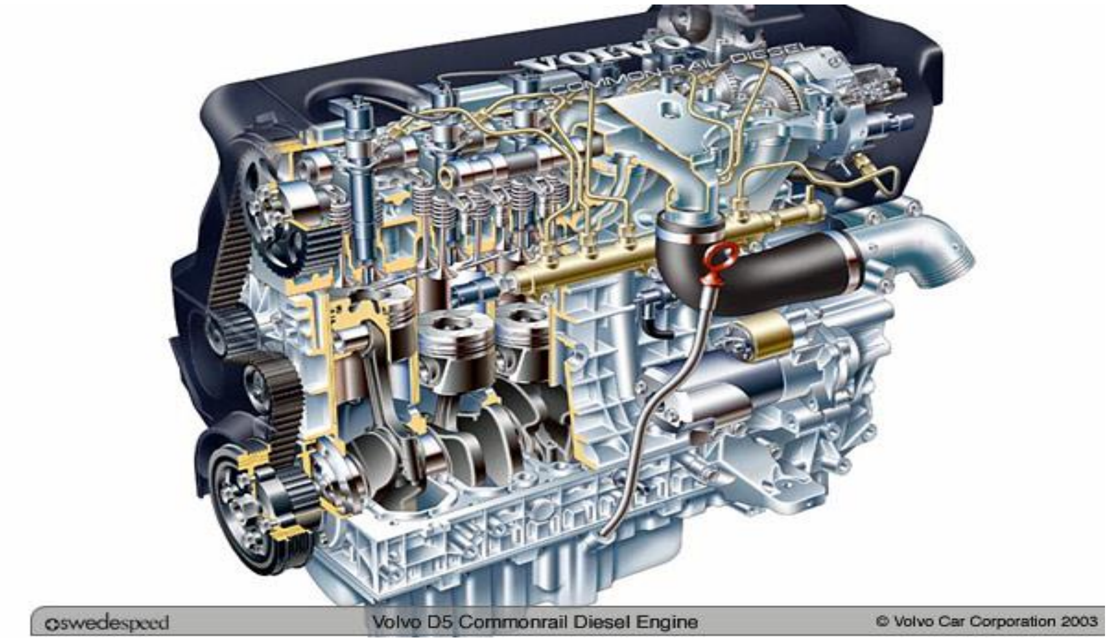
Indirect injection pump (Normal Diesel pump)

Each fuel injector is mounted directly above the piston within the cylinder head (there is no pre-chamber) and is connected to the fuel rail by rigid steel lines that can withstand the high pressure. This high pressure allows for a very fine injector orifice that completely atomizes the fuel and precludes the need for a pre-chamber. The actuation of the injectors comes via a stack of piezo electric crystal wafers that move the jet needle in tiny increments allowing for the spray of fuel. Piezo crystals function by expanding rapidly when an electric charge is applied to them. Like the fuel pump, the injectors are also controlled by the engine computer and can be fired in rapid succession several times during the injection cycle. With this precise control over injector firings, smaller, staggered quantities of fuel delivery (5 or more) can be timed over the course of the power stroke to promote complete and accurate combustion. In addition to timing control, the short duration, high pressure injections allow a finer and more accurate spray pattern that also supports better and more complete atomization and combustion.

Through these developments and improvements, the modern common rail direct injection diesel engine is quieter, more fuel efficient, cleaner, and more powerful than the indirect mechanical injection units they have replaced.

Modern diesels owe their resurgence in popularity to advances in fuel delivery and engine management systems that allow the engines to return power, performance and emissions equivalent to their gasoline counterparts, while simultaneously producing superior fuel economy.

Diesel Engine



©swedespeed Volvo D5 Commonrail Diesel Engine © Volvo Car Corporation 2003

Each fuel injector is mounted directly above the piston within the cylinder head (there is no pre-chamber) and is connected to the fuel rail by rigid steel lines that can withstand the high pressure.

rigid steel lines that can withstand the high pressure-common Rail

17- System health check

After checking that the engine oil level was satisfactory, I decided to carry out my quick health check of the fuel system. This test takes just a few minutes using nothing more than the graphing function of a diagnostic scan tool to evaluate fuel rail pressure against engine speed. The purpose of the test is to establish what rail pressure the system is capable of producing during engine cranking, at engine idle speed and during a snap acceleration. The system produces a characteristic pressure waveform which is displayed nicely as a graph.

I have found this health check extremely useful for highlighting a variety of problems; from low pressure fuel supply to transfer pump failure and excessive leak back from injectors. Knowing what to expect is the key to the test.

No expensive equipment is required, just a thorough understanding of the system and how to manipulate it to conduct the required test. Based upon test results, further tests can then be carried out tailored to the system variant whether it be metering control, two point rail controls, with or without electric lift pump in tank etc.

The quick health check is also a good way of establishing a healthy common rail diesel fuel system, thereby enabling it to be quickly eliminated as the cause of the problem. In this case, my quick health check did indeed show the system to be healthy.

18- HDi (high diesel injection) Technology:

Citroën's HDi diesel engines use common rail technology, in which just one rail supplies all the injectors with fuel at very high pressure.

19- Common Rail Diesel engine problems:

Common Rail Diesel (CRD, CD, CDI) problems can be incredibly expensive to fix!

CRD engines have been recently developed to meet the latest stringent diesel exhaust emission standards and diesel fuel sulphur levels are now very low for the same reason.

Lubricity is the measure of the reduction in friction of a lubricant. At a time when CRD pumps and injectors rely even more on diesel fuel for lubrication, lubricity has actually been reduced! Diesel fuel, without a small biodiesel component, requires lubricity improving additives to prevent excessive engine wear, especially with CRD. Most CRD engines have strict factory limits of 5% or 20% biodiesel component.

CRD injection systems are currently internationally associated with widespread problems, including engine rattles, expensive injector and fuel pump failures, injector sticking, engine stalling problems and rapid piston and liner wear. Problems have been documented across a wide range of engine suppliers. Some reports are on engines with way less than 60,000km on the clock.

CRD injectors and fuel pumps run with incredibly fine tolerances and are highly stressed due to enormous pressures often over 200,000kPa (29,000psi), which causes higher diesel fuel temperatures. These high temperatures can degrade diesel fuel resulting in fouling deposits within pumps and injectors. This risk reportedly increases with biodiesel blends, since biodiesel by nature, degrades faster than diesel.

CRD operating pressures also cause higher loadings on equipment, which places a huge demand on the diesel fuel lubricity. Compared to older technology diesel fuel systems, CRD are totally unforgiving when it comes to fuel contamination. Very small amounts of water or other contaminants in the diesel will wreck CRD pumps and injectors, which are pretty much non-repairable, so it often means new components.

Injector rattle can sound like noisy valve tappets, or rapid machine gun fire. The injector could be fouled by contaminant, or is seizing due to inadequate lubrication. Excessive fueling could be causing detonation inside the combustion chamber, instead of smooth combustion. Sometimes a rattle or pinging noise occurs under acceleration from cold, but will disappear after a km or two.

CRD engines are designed with much finer tolerances than older technology, not only within pumps and injectors, but also in piston to liner clearances, making CRD engines much more susceptible to deposits, or the presence of any water or other contamination in the fuel or oil.

Beware of CRD engine rattle at any time .. treat any injector rattle as a very serious alarm bell!

We have recently introduced CRD Fuel ENHANCER a lubricity improving fuel additive, which also has anti-rust and deposit removal properties that will likely solve CRD engine rattles and help stop component failures, CRD Fuel Enhancer .. diesel fuel lubricant, deposit remover and anti-rust additive for CRD injectors and systems to prolong their life and avoid diesel engine failures .

20- What causes common rail diesel engine problems?

The Common Rail Diesel (CRD) injection system is the most recent development to achieve ever more stringent diesel exhaust emission standards, but it is currently associated with several problems, including engine rattles, expensive injector and fuel pump failures, injector sticking, stalling problems and rapid piston and liner wear.

The newer (D4D= Direct-injection 'common rail' diesel engine) and other common rail engines constantly have injection failure and fuel pump problems. I wanted to share some information with you in order to make us understand the quality of fuel that we use on daily basis and have our engines face these problems which lead to very costly repairs.

Common rail is a very good technology that produces more horse power and gives better fuel economy. The only reason that these engines fail is the quality of fuel and filtration technology we use. These engines run on regular diesel but there are a few things we should keep in mind to make these engines run without problems. First we need to know a few things about diesel fuel.

The fresh diesel from the refinery is actually very good; things start to happen after it is transferred from there to the storage or equipment tank. Here, the stability of diesel starts to change as quickly as after three months. The process of oxidation starts and diesel starts to become darker in color as dark and heavy particles starts to form. They can gum up and plug fuel filters and causes low power and poor.

Water is another problem as it enters fuel through condensation and poor handling along with dirt. Water causes severe damage to fuel injection systems causing poor running and reduced performance and even valves and piston rings are affected.

Another thing is fuel degradation caused by heat and it occurs when fuel comes in contact with extreme heat in high pressure injection systems.

The bottom line is that our diesel is not handled properly. It is stored for long periods and the storage tanks are not regularly cleaned. These newer engines are sensitive and cannot take bad diesel. Therefore, I suggest that the fuel tanks should be cleaned and polished frequently by the oil companies and fuel stations.

The search for cleaner emissions has driven the manufacturers to design common rail systems with higher and higher pressures and tighter tolerances, demanding cleaner fuel to operate. This need to filter out smaller particles and more of the water out of the fuel makes the design and maintenance of the filtration system critical to avoiding common rail diesel problems related to the injection and combustion system.

We all know that the most critical step in maintaining your common rail vehicle is ensuring that the fuel that goes into the system is properly filtered at each step of the injection process. Can the right filtration set-up avoid problems when you receive a really bad dose of fuel? The answer is no. But it can make the problems easier, and less expensive, to deal with and repair.

Please remember that one of the most important parts of the filtration system is a proper water separator on the delivery rail. If there is any chance of water entering the fuel system, it must be eliminated.

21- Common Rail Diesel:

Common rail direct fuel injection system is a really modern variant of direct fuel injection for petrol and diesel engines.

On diesel engines, it possesses a high-pressure (over 1,000 bar/15,000 psi) fuel rail feeding individual solenoid valves, dissimilar to low-pressure fuel pump feeding unit injectors. Third-generation common rail diesels now feature piezoelectric injectors for increased precision, with fuel pressures as long as 1,800 bar/26,000 psi.

Today the most popular rail system has brought in terms of a revolution in diesel engine technology. Robert Bosch GmbH, Delphi Automotive Systems, Denso Corporation, and Siemens VDO (now owned by

Continental AG) is going to be main suppliers of modern common rail systems. The motor car makers make reference to their common rail engines by their own individual brand names.

Solenoid or piezoelectric valves make possible fine electronic control over the fuel injection system serious amounts of quantity as well as the higher pressure that the common rail technology makes available provides better fuel atomization. For you to lower engine noise, the engine's electronic control unit can inject a small amount of diesel prior to when area of the injection event ("pilot" injection), thus reducing its explosiveness and vibration, and how optimizing injection timing and quantity for variations in fuel quality, cold starting and similar matters. Some advanced common rail fuel systems perform as much as five injections per stroke.

Common rail engines require very short (< 1 s) or no heating up time in any respect and produce lower engine noise and emissions than older systems.

Diesel engines have historically used various different types of fuel injection system. Two common types include the gps device injection system and therefore the distributor/inline pump systems. While these older systems provided accurate fuel quantity and injection timing control, we were holding limited by a number of factors:

We were looking at cam driven and injection pressure was proportional to engine speed. This typically meant that the new highest injection pressure could only be achieved at all the highest engine speed as well as maximum achievable injection pressure decreased as engine speed decreased. This relationship is true with all pumps, even those used on common rail systems; along with the unit or distributor systems, however, the injection pressure is stuck just using the instantaneous pressure of a single pumping event with no accumulator as well as the relationship is a lot more prominent and troublesome.

For all the typical distributor/inline system, the start of injection occurred in a very pre-determined pressure (also known as as: pop pressure) and ended at about a pre-determined pressure. This characteristic resulted from injectors active in the cylinder head which closed and opened at pressures determined by way of spring preload applied to the plunger in to the injector. As soon as the pressure in a very injector reached a pre-determined level, the plunger would lift and injection would start.

In common rail systems, a high pressure pump stores a reservoir of fuel at high pressure – up to and above 2,000 bars (29,000 psi). The concept of a "common rail" means indisputable fact that every single fuel injectors are made available from a common fuel rail which can be just a pressure accumulator the spot that the fuel is stored at high pressure. This accumulator supplies multiple fuel injectors with high pressure fuel. The fuel injectors can even be ECU-controlled. When the fuel injectors are electrically activated, a hydraulic valve (consisting of a nozzle and plunger) is mechanically or hydraulically opened and fuel is sprayed back into the cylinders at the desired pressure. Ever since the fuel pressure energy is stored remotely along with the injectors are electrically actuated, the injection pressure at the start and end of injection can be quite close to the pressure while in the accumulator (rail), thus producing a square injection rate. In most cases accumulator, pump and plumbing are sized properly, the injection pressure and rate is the same for every one of the multiple injection events.

22- Summery (Conclusion) :

1-Three groups of fuel system architectures were under consideration:

(1) an electronically controlled distributor pump.

(2) an electronically controlled unit injector (EUI or pump-nozzle unit) .

(3) a common rail (CR) injection system.

While the efforts around each of these approaches lead to commercial fuel systems for production vehicles, the common rail system provided a number of advantages and would eventually come to dominate as the primary fuel system used in light-duty vehicles.

2- The electronic diesel control unit precisely meters the amount of fuel injected, and improves atomization of the fuel by controlling the injector pulsations. This results in quieter, more fuel efficient engines; cleaner operation; and more power.

3- Through these developments and improvements, the modern common rail direct injection diesel engine is quieter, more fuel efficient, cleaner, and more powerful than the indirect mechanical injection units they have replaced.

4- This electronically controlled system optimizes the air-fuel mix in all conditions of use, significantly reducing both fuel consumption and CO_2 emissions. The latest-generation common rail system sets even higher standards in precision and efficiency. HDi diesel engines stand apart for their recognized qualities, including: reliability, acoustic comfort, low fuel consumption and reduced CO_2 emissions.

5-The Common Rail Diesel Injection System delivers a more controlled quantity of atomized fuel, which leads to better fuel economy; a reduction in exhaust emissions; and a significant decrease in engine noise during operation.

6- The Common Rail Diesel Injection System delivers a more controlled quantity of atomized fuel, which leads to better fuel economy; a reduction in exhaust emissions; and a significant decrease in engine noise during operation.

7- and generation Common Rail for passenger cars makes diesel engines even more economical, cleaner, quieter and more powerful.

8- Advantages of the common rail system include flexibility in controlling both the injection timing and injection rate.

The Common Rail system in particular gives engine developers the freedom they need to reduce exhaust emissions even further, and especially to lower engine noise

Diesel engines become even quieter, more fuel efficient, cleaner and more powerful.

and generation Common Rail for trucks gives lower emissions, improved fuel consumption and more power .

Abstract: In the common rail system, fuel is distributed to the injectors from a high pressure accumulator, called the rail. The rail is fed by a high pressure fuel pump. The pressure in the rail, as well as the start and end of the signal that activates the injector for each cylinder are electronically controlled. Advantages of the common rail system include flexibility in controlling both the injection timing and injection rate.

This characteristic also allows engines to produce higher torque at low engine speed—especially if a variable geometry turbocharger (VGT) is used .

It should be noted that while common rail systems could operate with maximum rail pressure held constant over a wide range of engine speeds and loads, this is rarely done.

The electronically controlled common rail system has many advantages:

Increased Performance more torque at low engine speeds.

Reduced fuel consumption.

Less exhaust and emissions.

Quieter running engine.

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Feb. 2016
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