ISUZU E-Learning System

Module 2: Engine Fundamentals

Table of Contents

Table of Contents

Operating Principles of Internal Combustion Engines

Operating Principles of Internal Combustion Engines

Automobile Engines – engines designed to produce power and propel automobiles to be able to go from point a to point b.

Gasoline Engines

- Engines which uses gasoline fuels. Small-sized, high speed, high powered and light weight and are widely used for passenger cars, commercial vehicles and small trucks.

Diesel Engines

- Engines which uses light oil called diesel as fuel. Used in commercial vehicles like trucks and buses due to fuel economy and high thermal efficiency compared to gasoline engines.

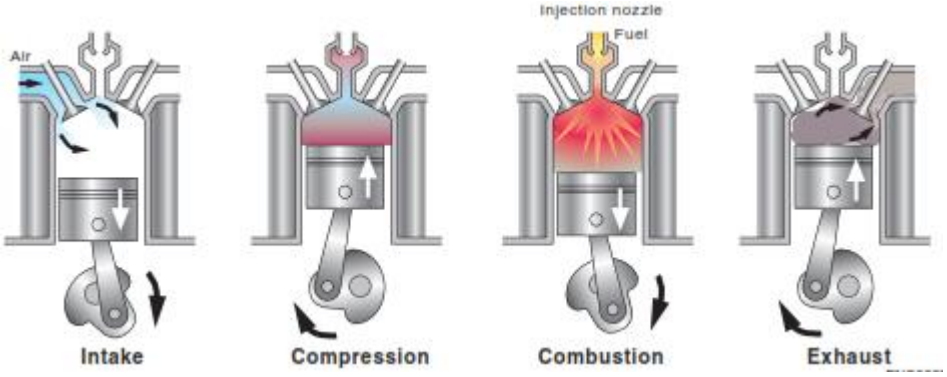
Operating Principles of Internal Combustion Engines

Fundamentals of Diesel Engines

- Designed by Rudolf Diesel in 1897, provides advantages of low fuel consumption and long durability.

Features of Diesel Engines

- It draws only air during intake stroke.
- There is no ignition system



Diesel Engine Operation

Intake Stroke - Air enters the engine as the piston goes down to BDC and Intake Valves open.

Compression Stroke – Air is being compressed as the piston goes up to TDC. Temperature and pressure of air increases as the volume of the cylinder decreases.

Combustion Stroke – fuel is injected into the combustion chamber and ignites as it mixes with the compressed and heated air, increases further its pressure and forces the piston to go down and rotates the crankshaft, providing power.

Exhaust Stroke – as the piston goes up again, exhaust valves open and exhaust gas exits the cylinder and out to exhaust pipe.

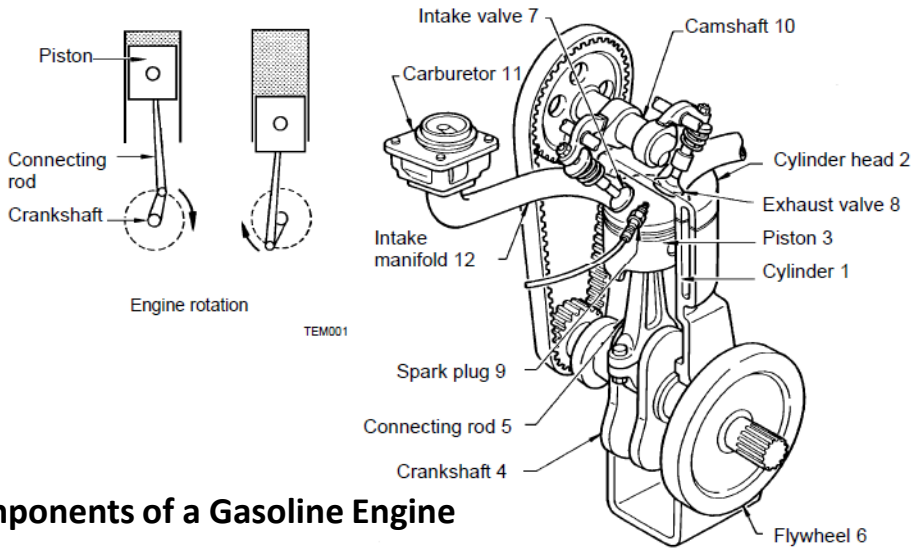
Operating Principles of Internal Combustion Engines

Fundamentals of Gasoline Engines

- The first practical gasoline engine was designed by Nikolaus August Otto in Germany in 1876. These engines use gasoline for fuel and have the following characteristics:
  - ✓ Small in size
  - ✓ High engine speed
  - ✓ High powered
  - ✓ Light weight

Features of Gasoline Engines

- Air and Fuel mixed during Intake Stroke
- Requires Spark Plug to ignite Air Fuel Mixture
- Has low compression ratio to avoid knocking



Basic Components of a Gasoline Engine

Operating Principles of Internal Combustion Engines

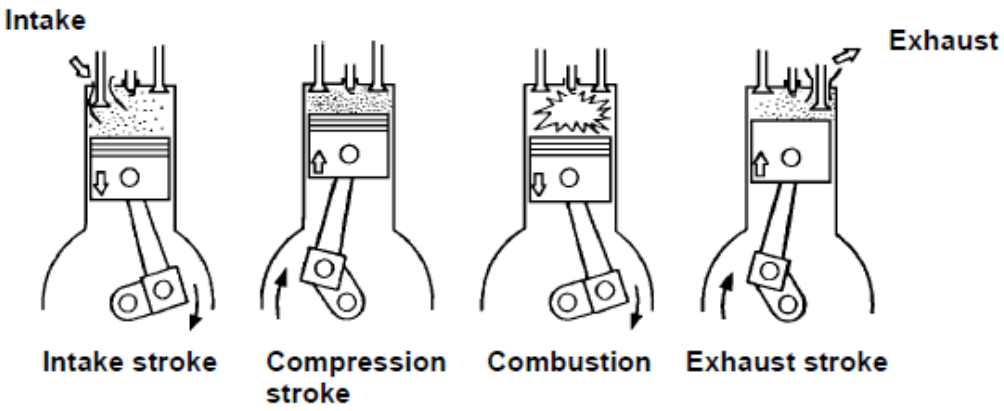
Gasoline Engine Operation

Intake Stroke – The Intake Valve is open while the piston moves down and the air-fuel mixture is sucked into the cylinder.

Compression Stroke – As the piston begins to move-up, the intake valve closes to seal the combustion chamber and the air-fuel mixture is compressed, increasing its pressure and temperature.

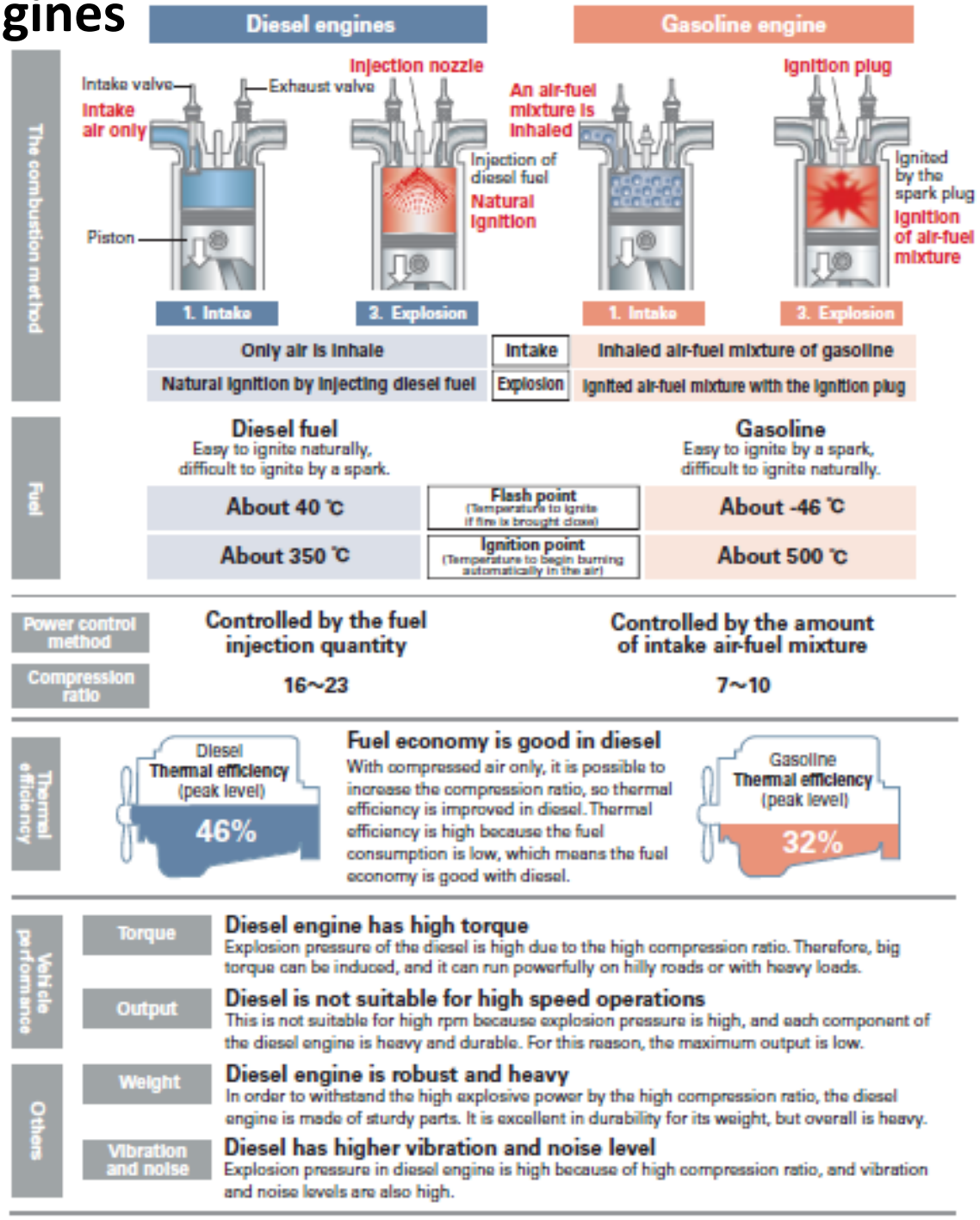
Combustion Stroke – After compression of air-fuel mixture, it is then ignited using spark plug. The mixture explodes producing a much higher pressure and temperature, pushing the piston downward as the mixture expands.

Exhaust Stroke – as the piston approaches BDC after combustion, the exhaust valves open and piston starts to move upward pushing the exhaust gas out of the cylinder and into the exhaust manifold.



Operating Principles of Internal Combustion Engines

Comparison between Diesel and Gasoline Engines

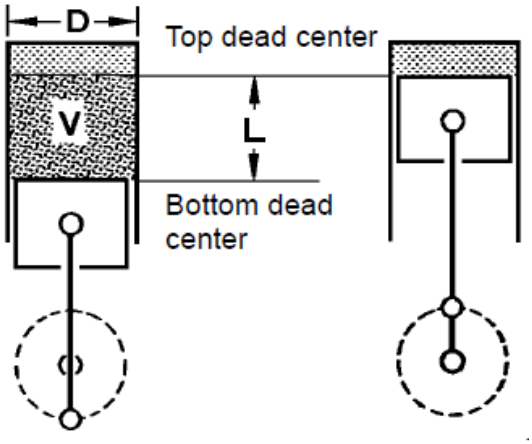


Engine Performance

Engine Performance

Piston Displacement

- It is the volume discharged when the piston moves from bottom dead center to top dead center. Engine displacement is that volume multiplied by the number of cylinders



Piston displacement

Formula for Engine Displacement:

$$\text{E. D.} = \frac{\pi}{4} \times (\text{Bore})^2 \times \text{Stroke} \times \#\text{ of Cylinders}$$

Where:

BORE = Diameter and STROKE = Height ; $\pi = 3.141593$

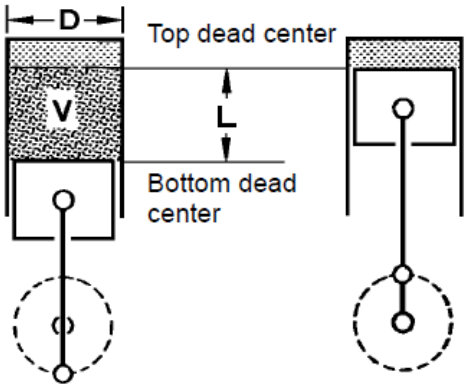
$$V_{cylinder} = \frac{\pi}{4} \times (\text{Bore})^2 \times \text{Stroke}$$

Engine Performance

Piston Displacement

Engine Displacement for 4JJ1 3.0L Diesel Engine

Given:
Bore = 95.4 mm or 9.54 cm
Stroke = 104.9 mm or 10.49 cm
No. of Cylinders = 4 cylinders
1 L = 1000 cm^3
1 cm = 10 mm



Piston displacement

Solution:

$$E.D. = \frac{\pi}{4} \times (Bore)^2 \times \text{Stroke} \times No.\,of\ Cylinders$$

$$E.D. = \frac{3.141593}{4} \times (9.54\ cm)^2 \times 10.49\ \text{cm} \times 4\ Cylinders$$

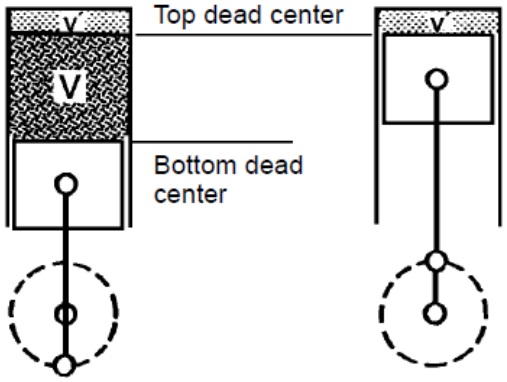
$$E.D. = 2{,}999.32\ cm^3 \times \frac{1\ L}{1000\ cm^3}$$

$$E.D. = 2.999\ L \approx 3.0\ L$$

Engine Performance

Compression Ratio

- It is the ratio of the volume above the piston when the piston is at bottom dead center to the volume above the piston when it is at top dead center



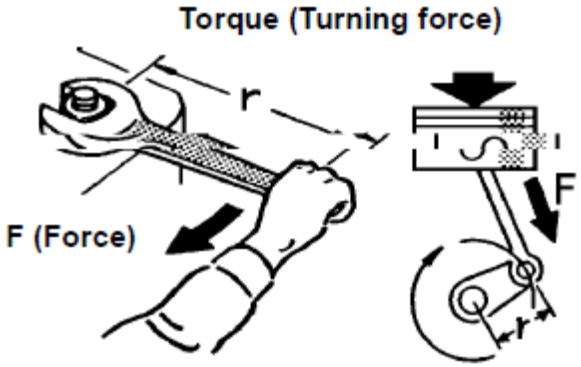
Compression ratio

$$\text{C. R.} = \frac{(V_{cylinder}) + (V_{chamber}) \text{ @ Bottom dead center}}{(V_{chamber}) \text{ @ Top dead center}}$$

Engine Performance

Torque

- It is the ability to cause something to rotate or turning force.



Torque = Force (F) x Distance (R)

Power

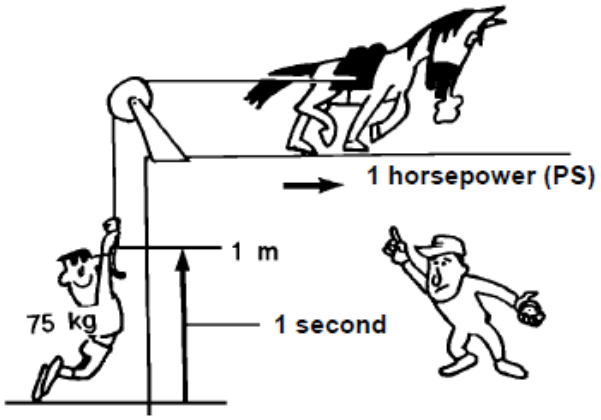
- Power or Output is the work volume and speed required to do the work or work volume per unit of time. Engines are rated in Horsepower.
- 1HP = 745.7 Watts
- 1HP = 1.0143 PS

For output of 4JJ1-TCX:

177 KW

130 PS

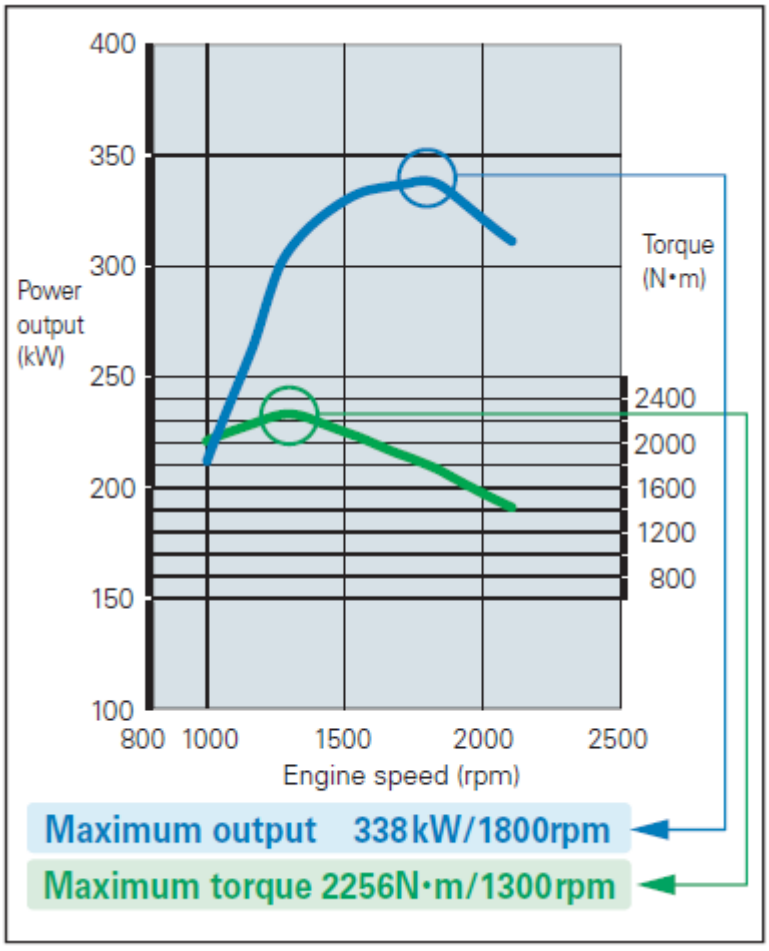
128.17 HP



Engine Performance

Engine Performance Curve

- This curve or graph shows the power and torque according to ranges of engine speed. It indicates the characteristics of the engine depending on the RPM.



Engine Structure

Engine Structure

Description

- Both Diesel and Gasoline engines are similar in construction as both engines have cylinder blocks, cylinder heads, crankshafts, pistons etc. The only difference is that diesel engines are heavier and stronger than gasoline as diesels have a higher operating pressure than gasoline.

Diesel

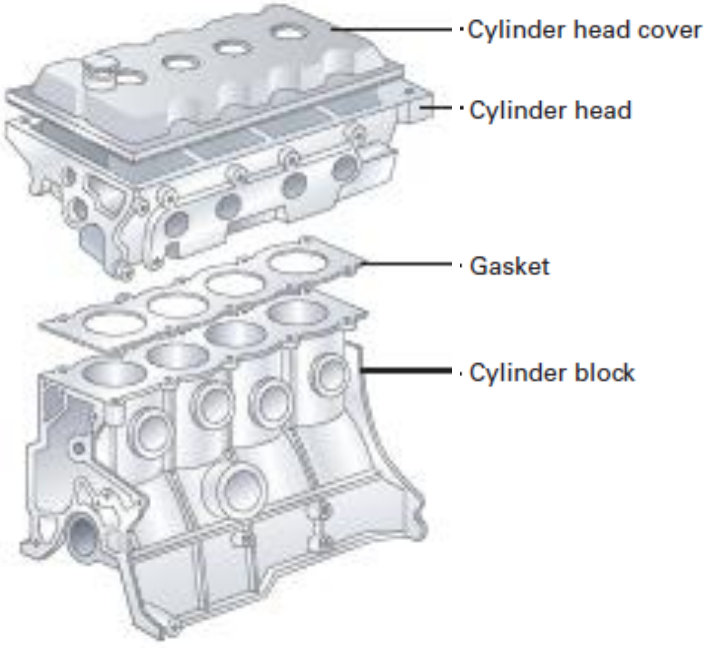
Gasoline

Engine Structure

Cylinder and Cylinder Block

- The block is the foundation of the engine in which all of the parts of the engine is attached to it. Usually made of cast iron for strength and durability particularly for diesel engines due to higher operating pressure.

- Power is produced inside the block as pistons move up and down to perform its role.



Types of Cylinders

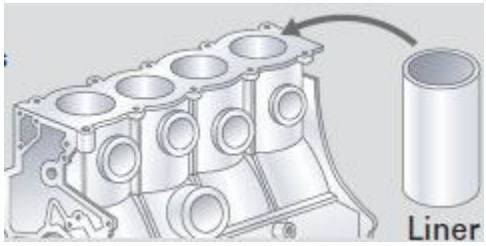
There are two types of cylinders:

Integrated Cylinders:

cylinders are machined in the block (Liner Less).

Liner-Type Cylinders:

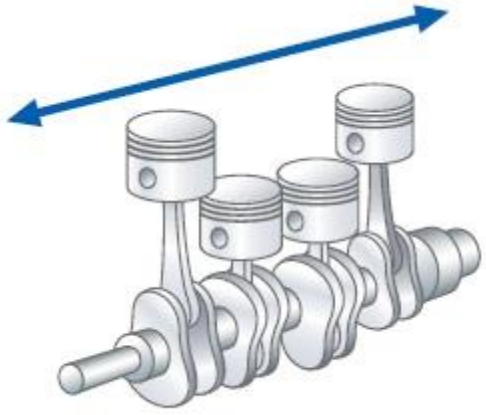
A “liner” is inserted or press fitted inside the cylinder block and is usually made of strong metal and are resistant to abrasion.



Engine Structure

Types of Cylinder Arrangement

In-Line type:

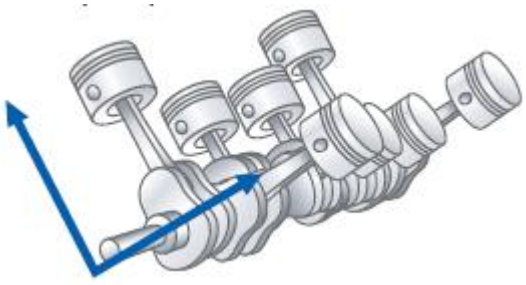


Cylinders are lined up in straight line (in-line) and is mechanically simple. It has good balance and vibration characteristics.

Advantage: Simple Configuration

Disadvantage: Engine will be longer if many cylinders are integrated.

V-Type:



Cylinders are arranged in a V configuration. Engine can be made short and compact and is usually used for passenger cars.

Advantage: Easy to form with multi-cylinders since it is small and compact.

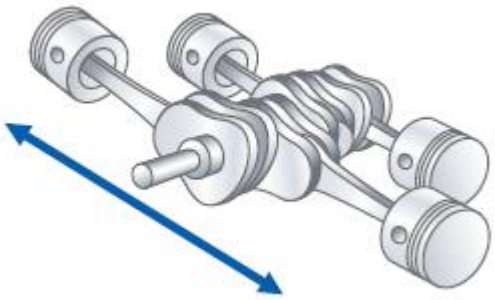
Disadvantage: It has a complicated design.

Engine Structure

Types of Cylinder Arrangement

Horizontally Opposed:

It is arranged flat or horizontal and pistons are opposed to each other. Overall height of the engine can be low.



Advantage: Height of engine hood can be low.

Disadvantage: Design is complicated.

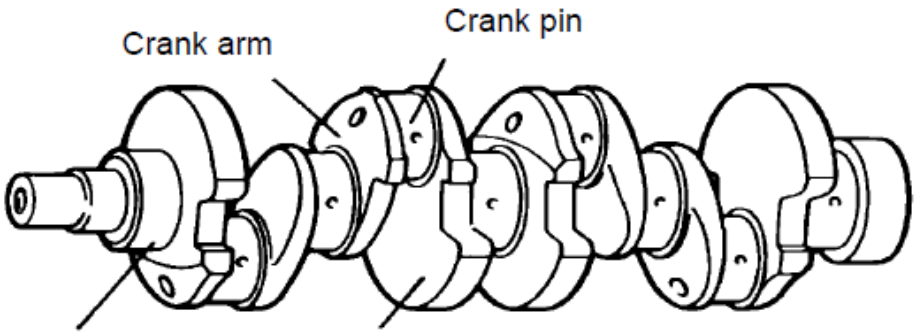
Cylinder Head

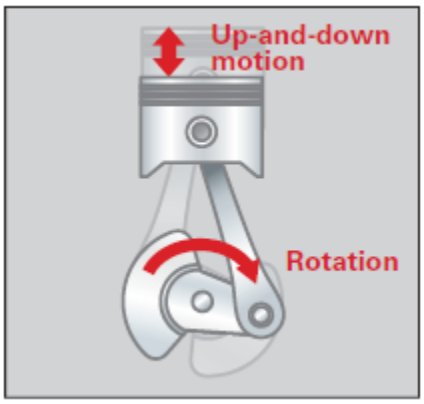
- It sits above the cylinder block and closes the top cylinder forming the combustion chamber and is sealed by a head gasket.
- In most engines, it provides space for passages that feed air and fuel to the cylinder as well as exhaust for spent gasses as well as passages for cooling and lubrication.

Engine Structure

Crankshaft

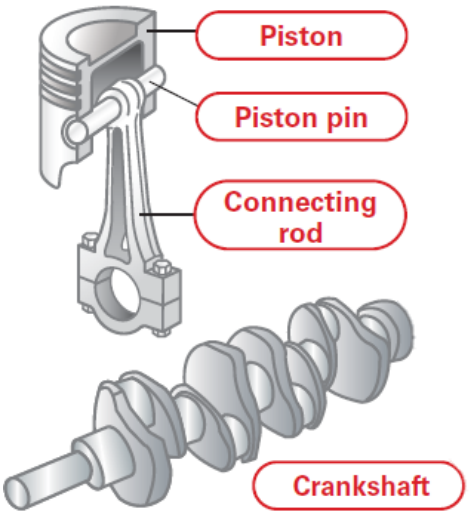
- It receives combustion pressure via piston and connecting rod, and converts the reciprocating motion of the piston to a rotary motion.





Piston and Connecting Rod

- The piston is an inner cylinder which moves up and down in an outer cylinder. The piston head received the force from the expanding gas during combustion and forces the piston to go down during combustion stroke. The connecting rod connects the piston to the crankshaft via piston pin and crankshaft journal.

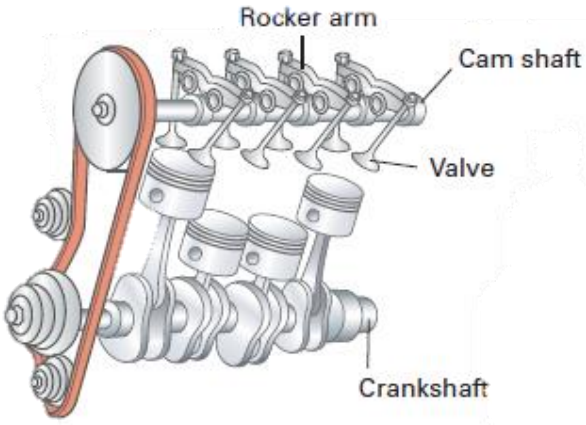


Engine Systems

Engine Systems

Valve Mechanism

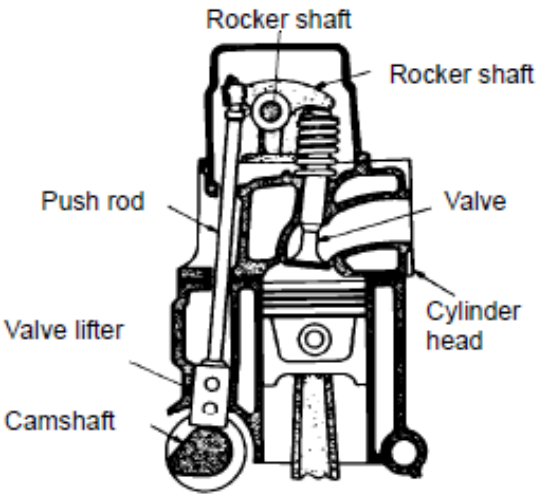
- Valves direct flow of intake and exhaust gases to and from the engine and are part of the combustion chamber.
- They are operated using a camshaft with cam grooves that equal the amount of valves for both intake and exhaust which open and close depending on cycle of the engine.



Valve Configuration

Overhead Valve (OHV):

- Intake and exhaust valves are located above the piston while the camshaft is located inside the engine block. As the camshaft rotate, valves are pushed using pushrods and rocker arms.
- Number of valves are limited to two due to space occupied by the valve train.



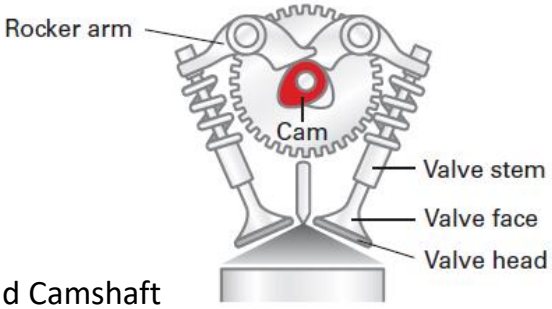
OHV type

Engine Systems

Valve Configuration

Single Overhead Camshaft (SOHC):

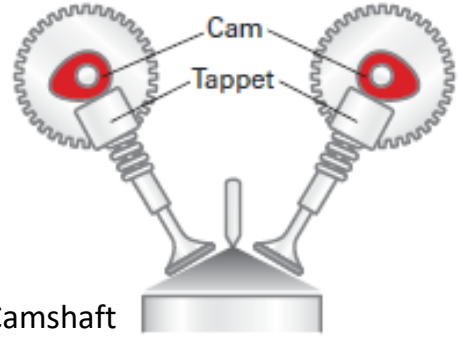
- Intake and exhaust valves are still located at the cylinder head on top of the cylinders and is operated by a single camshaft.



Single Overhead Camshaft

Double Overhead Camshaft (SOHC):

- Two camshafts are used to operate the intake and exhaust valves, one camshaft directly controls the intake valves while another camshaft for the exhaust.
- It improves valve-response, increase engine speed as well as flexibility in the valve layout.



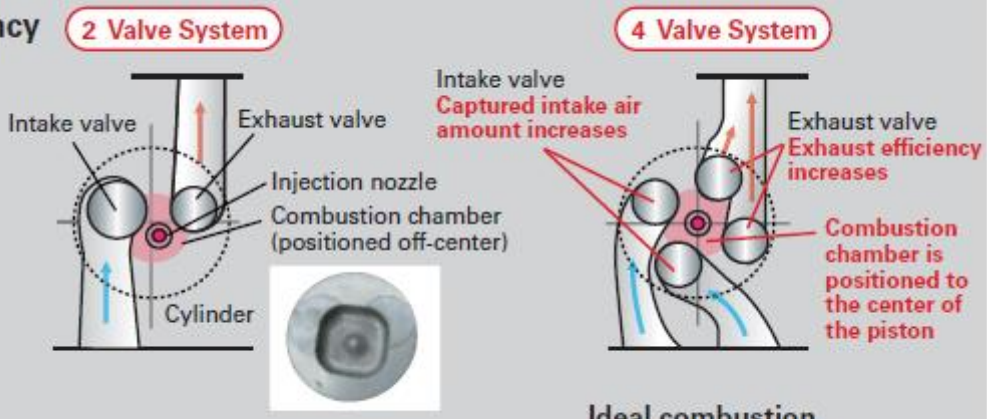
Double Overhead Camshaft

Engine Systems

Effect of Multiple Valves

Combustion efficiency is varied by the number of valves

Two-valve system has an intake and exhaust valve. Four-valve system has two valves for intake and exhaust respectively.



<Effect of 4-valves>

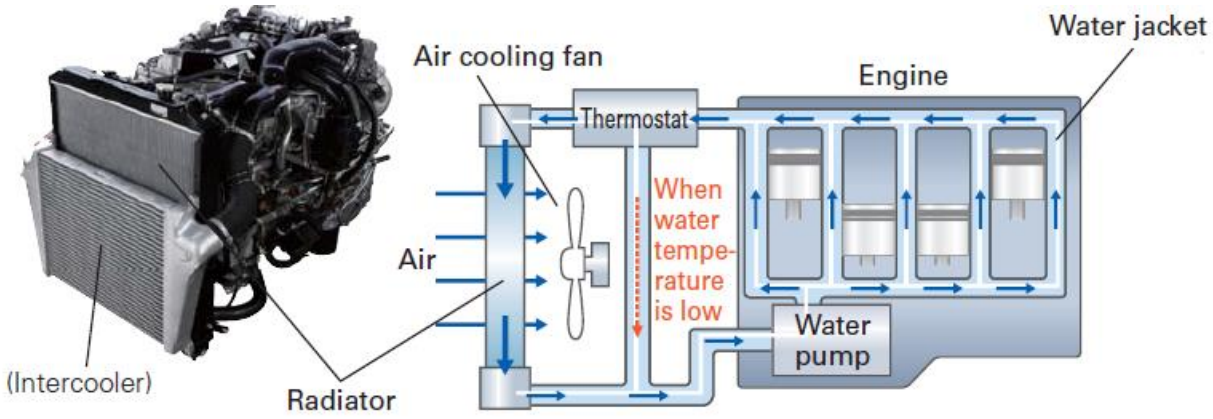
1. **Intake and exhaust efficiency can be improved**
   Intake air volume in the cylinder increases
   Exhaust is smooth
2. **Combustion chamber can be installed in the center of the piston**
   It is possible to position the combustion chamber in the center, as the size of each intake port can be made smaller. This allows homogeneous fuel injection and air fuel mixture.

Ideal combustion condition is provided

- Higher power
- Reduction of PM and black smoke
- Improved fuel efficiency

Engine Systems

Cooling System



Purpose of Cooling System to Engines

- Engines heat up during operation in which 30% of it is caused by combustion of fuel.
- If not controlled, this will result to engine wear and worst seizure of parts as engine oil will breakdown and lose its lubricating capacity.
- Cooling system provides this control as it maintains the optimum engine temperature.

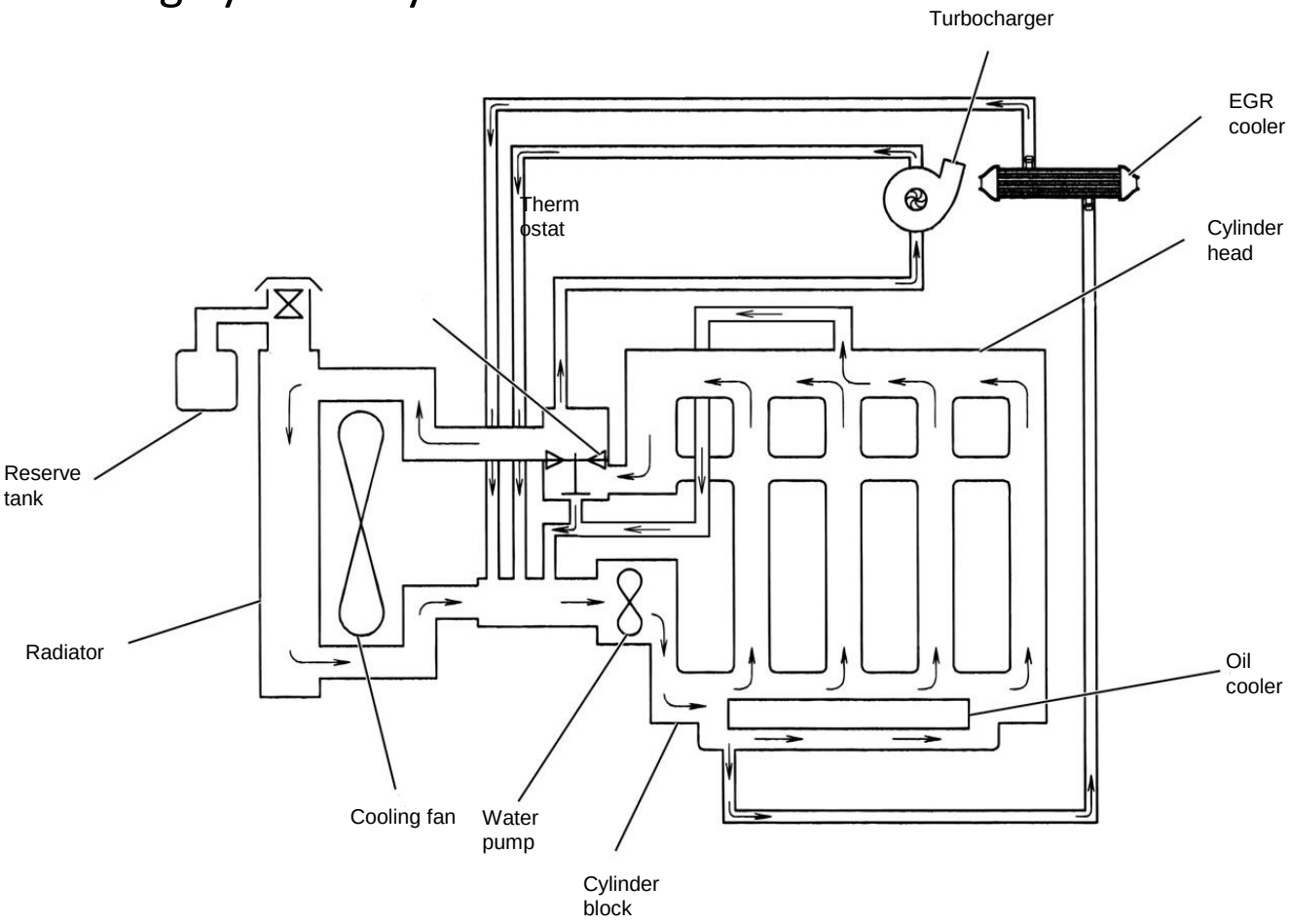
Components:

- Radiator
- Water Pump
- Fan
- Thermostat
- Radiator Cap
- Coolant

Engine Systems

Cooling System

Cooling System Layout

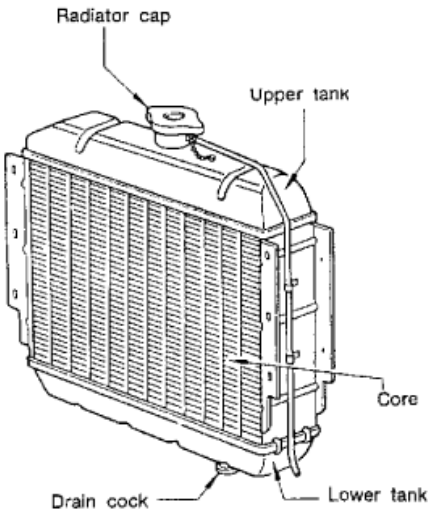


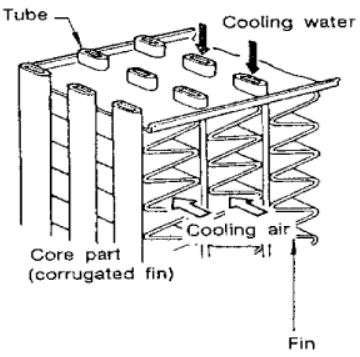
Engine Systems

Cooling System

Radiator

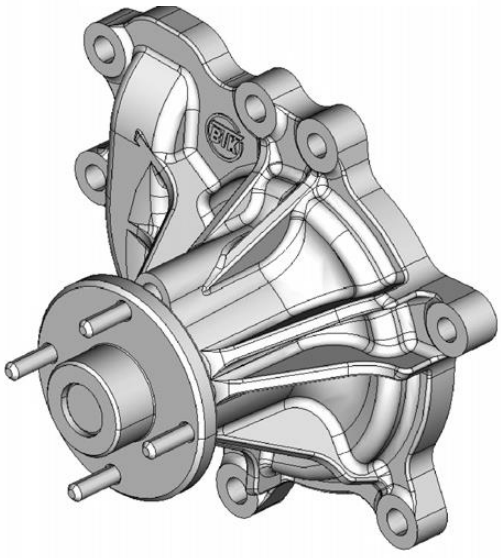
- It is a heat exchanger having two sets of passages, one for coolant and the other for air.
- As the hot coolant from the engine flows through one of its passages, it loses its heat as the air that passes through it takes it away.





Water Pump

- It draws coolant from the radiator and feeds it through the engine. It promotes circulation of the coolant in the engine and return to the radiator in order to cool it.

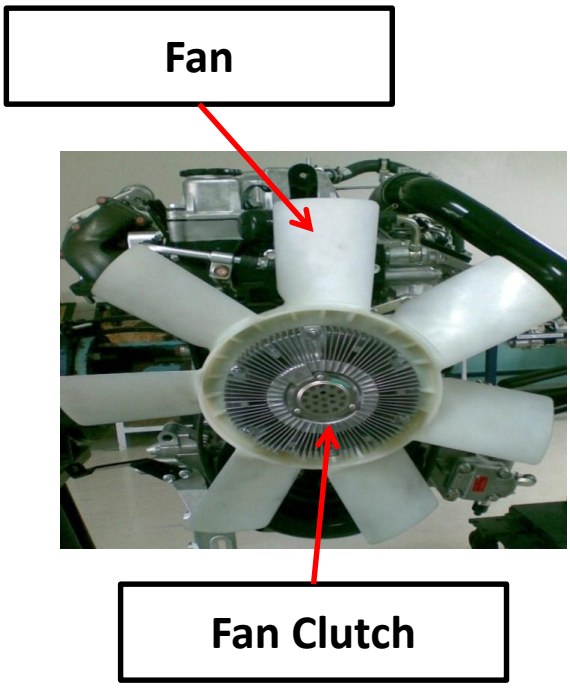


Engine Systems

Cooling System

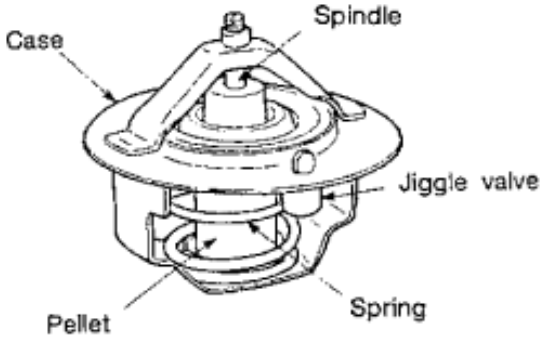
Cooling Fan

- It pulls the air from the surrounding towards the radiator in order to improve engine cooling specially at idle and low vehicle speed.
- It has a fan clutch which contains silicone oil which acts as a liquid clutch which engages when it is heated and releases when it is cooled.



Thermostat

- A heat operated valve that regulates coolant flow and temperature at a certain level.
- Coolant flow is controlled by allowing to circulate in the engine if the coolant is cool. If the coolant's temperature is high, thermostat will open and lets it flow through the radiator to cool before returning to the engine.

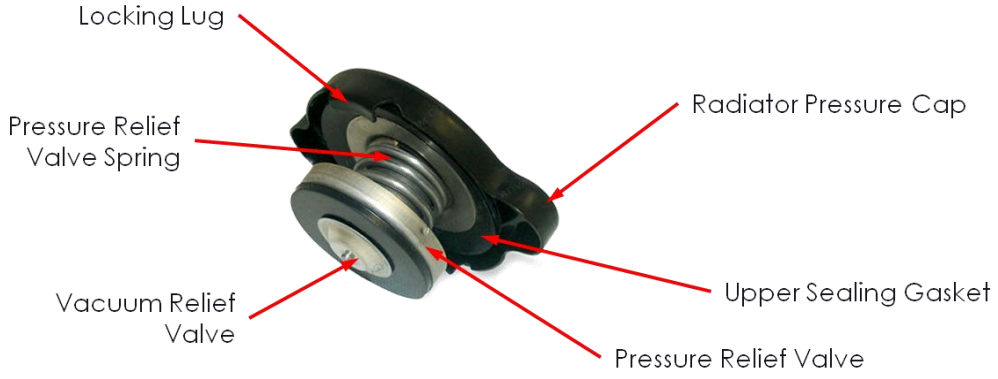


Engine Systems

Cooling System

Radiator Cap

- Aside from sealing the cooling system, it holds the coolant to a predetermined amount of pressure in order to raise further its heat absorbing capacity.
- It serves also as a valve as it directs coolant flow from radiator to the surge tank at high pressure, and returns it when the radiator is cooled.



Engine Systems

Cooling System

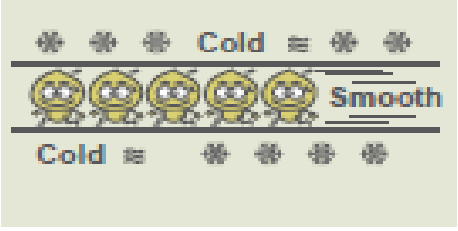
Coolant

- A mixture used as a heat transfer medium having a cryoprotective and rust prevention performance.

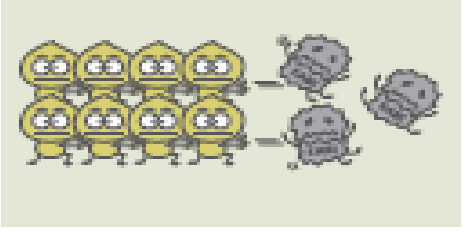
It has the following functions:

- Cooling Action
  - It cools the engine system to prevent overheating.

- Cryoprotective Action
  - It lowers the freezing point of the engine coolant.



- Rust Prevention
  - It helps protect the cooling system from metal deposits and corrosion.

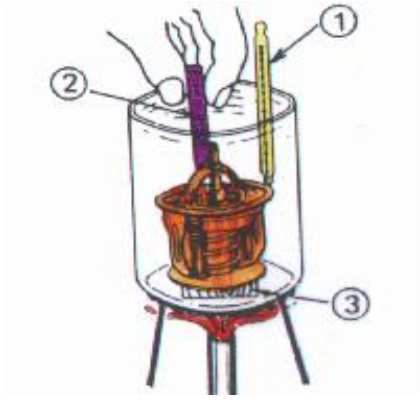


Engine Systems

Cooling System

Inspection points for Cooling System

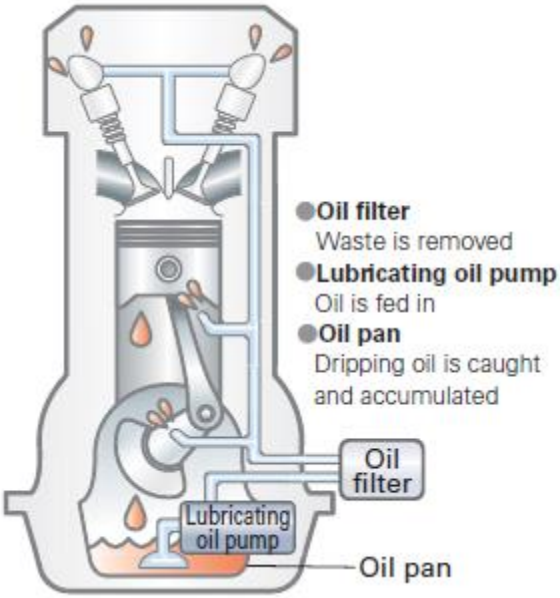
- Inspect coolant level and concentration.
- Check fan belt tension and condition.
- Check condition of water pump for any damages.
- Check all pipes, hoses and connections for leaks or any damages.
- Check condition of radiator for leaks and any damages. Remove any foreign objects caught in the fins of the radiator.
- For inspection of thermostat: Place the thermostat in water and heat it. Stir the water and check its temperature during Initial Valve Opening, Full-open and amount of valve lift.



Engine Systems

Lubrication System

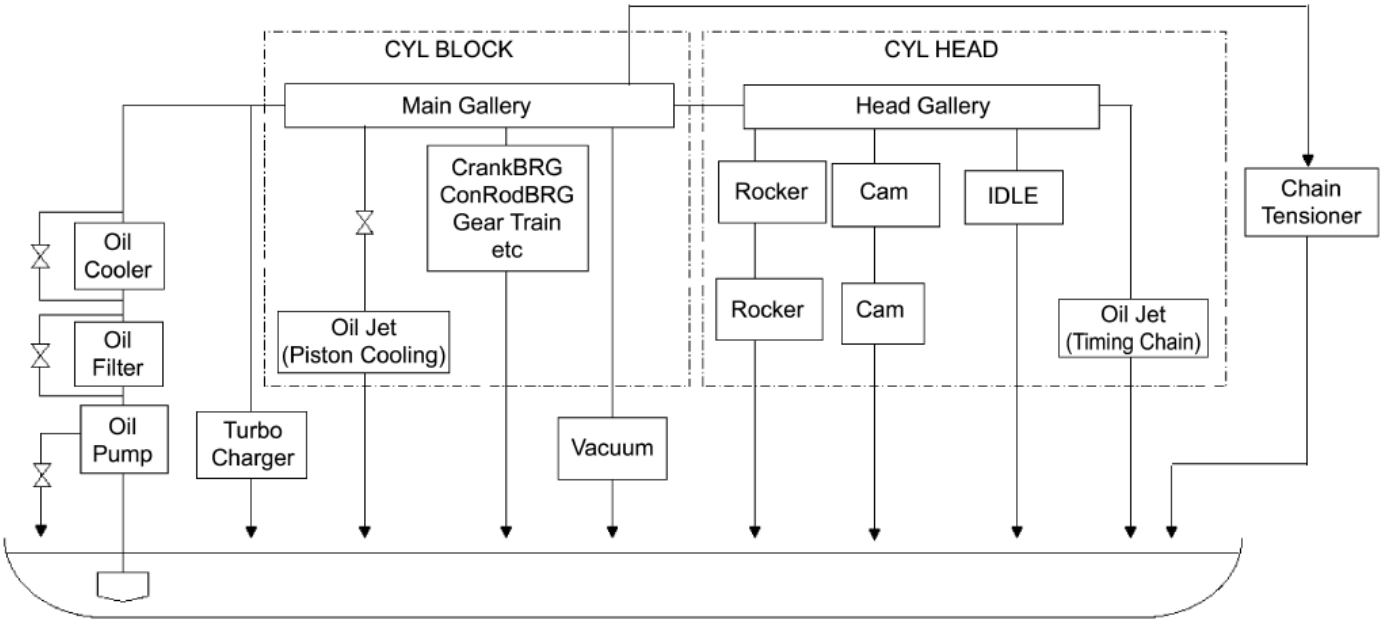
- Our engines are made up of many moving parts like gears, pistons, valves, cams, etc. As these parts move, they interact with each other and produce heat due to friction. Friction causes damages to these moving parts. For this reason, a lubrication system is needed to form an oil film on the sliding surface of the metal preventing friction.



Engine Systems

Lubrication System

Lubrication Circuit:



Engine Systems

Lubrication System

Engine Oil

- Engine oil serves as lubrication for various engine components as well as being able to absorb some of the engine heat as it circulates inside the engine.

Functions of Engine Oil:

Function	Purpose
Lubrication	Suppresses metal friction and prevents wear.
Anti-rust Action	Restricts air and humidity from reaching the surface of the metal, in order to prevent rust.
Sealing Action	Seals the crevice between a piston and a cylinder with oil film.
Purifying Action	Carries carbon and sludge to the filter in granular form.
Cooling Effect	Cools the heat which arises from combustion and metal friction.
Acid Neutralization	The action which neutralizes the oxidizing gas which arises from combustion, and prevents metal corrosion.
Antioxidant Action Effect	Prevents the oxidation of oil by air.

Engine Systems

Lubrication System

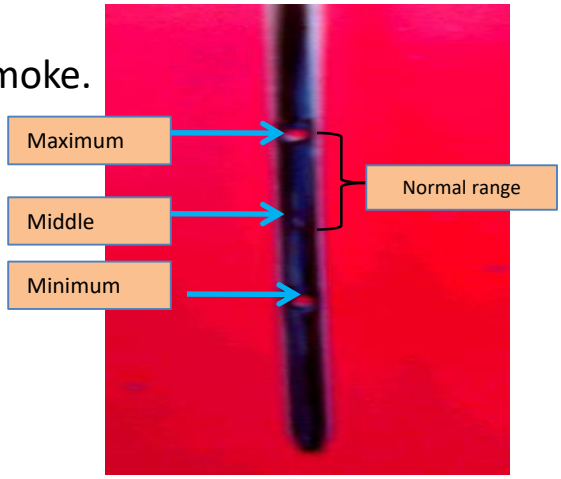
Engine Oil

Why must engine oil be changed?

- Oil is oxidized by heat, and its performance degrades.
- Impurities accumulate in the oil, and the oil does not circulate normally particularly for diesel engines as they contain a lot of soot.

Does overfilling oil cause any malfunctions?

- Overfilling causes bubbles when the engine oil is stirred in the oil pan and may cause the following malfunctions:
  - Bubbles spill over from the oil level gauge.
  - The oil pump cannot suck enough oil, and this causes the engine to seize up.
  - Oxidation of oil is accelerated.
  - The oil burns and generates white smoke.



Engine Systems

Lubrication System

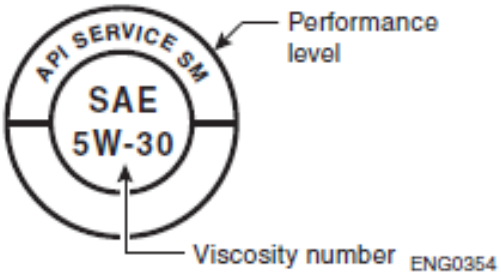
Difference between Diesel and Gasoline Engine Oils

- Diesel engines generate a lot of soot, sludge and acid components which must be cleaned and neutralized.
- Gasoline engine uses three-way catalyst for exhaust emission control, oils for gasoline engines have measures to protect the catalyst.

Classification of Engine Oil

American Petroleum Institute (API)

- establishes quality of applicable oil to engine increasing efficiency. It is classified by deposit, oxidation stability, friction resisting, corrosion protection, consumption of oil, improvement of mileage etc.



Engine	API Rating
Gasoline (S, or Service)	SN, SM, SL, SJ, SH, SG, SF, SE, SD, SC, SB, SA
Diesel (C, or Compression)	CJ-4, CI-4, CH-4, CG-4, CF-4, CF-2, CF, CE, CD-II, CD, CC, CB, CA

Engine Systems

Lubrication System

Engine Oil Viscosity

- The standard of Society of Automotive Engineers generally used for classification criteria of viscosity.

Example: SAE 5W-40 / SAE 10W-30 / SAE 15W-40
Note: **W** means winter

Engine Oil Viscosity Grade

SAE **10W** **30**

Oil viscosity code at high temperature

Oil viscosity code at cold temperature

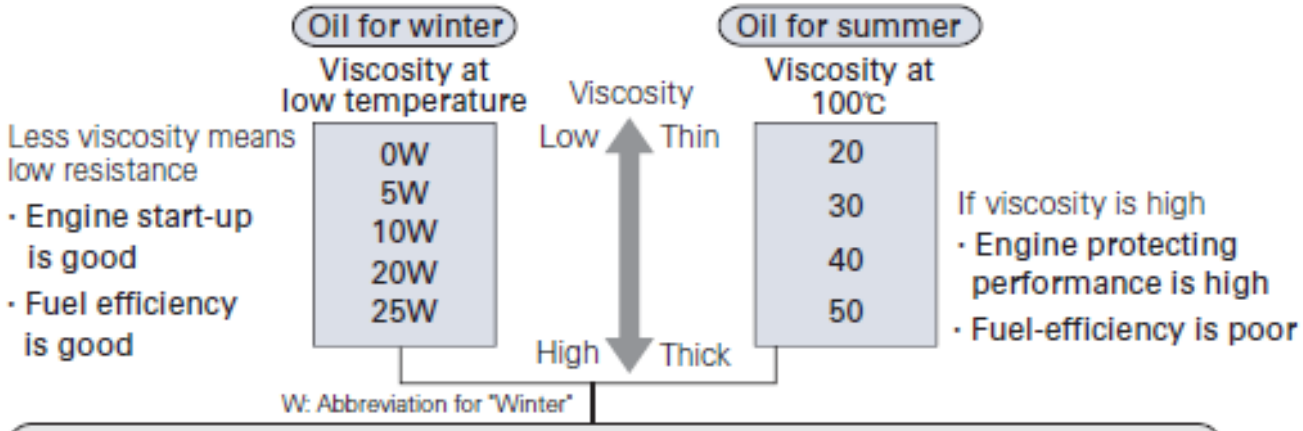
Society of Automotive Engineers

Engine Systems

Lubrication System

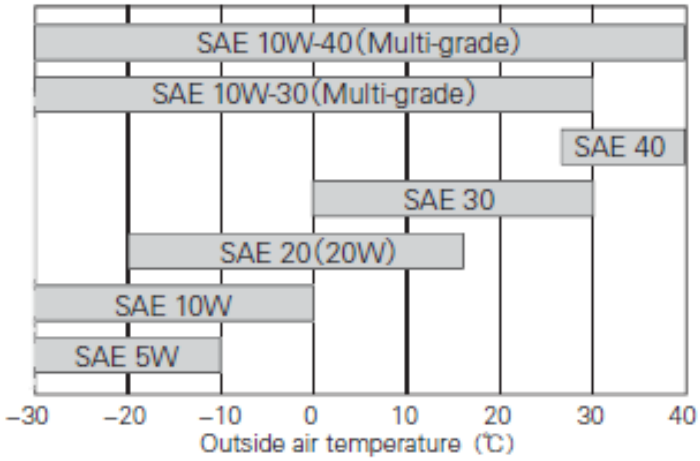
Engine Oil Viscosity

Classification of engine oil viscosity (SAE specifications)



- Multi-grade has combined properties usable for both seasons, for summer and winter (Example: 10W-30)
- Single grade has the properties of one or the other of the seasonal oils (Example: SAE30)

Outside air temperature and oil viscosity adjustment

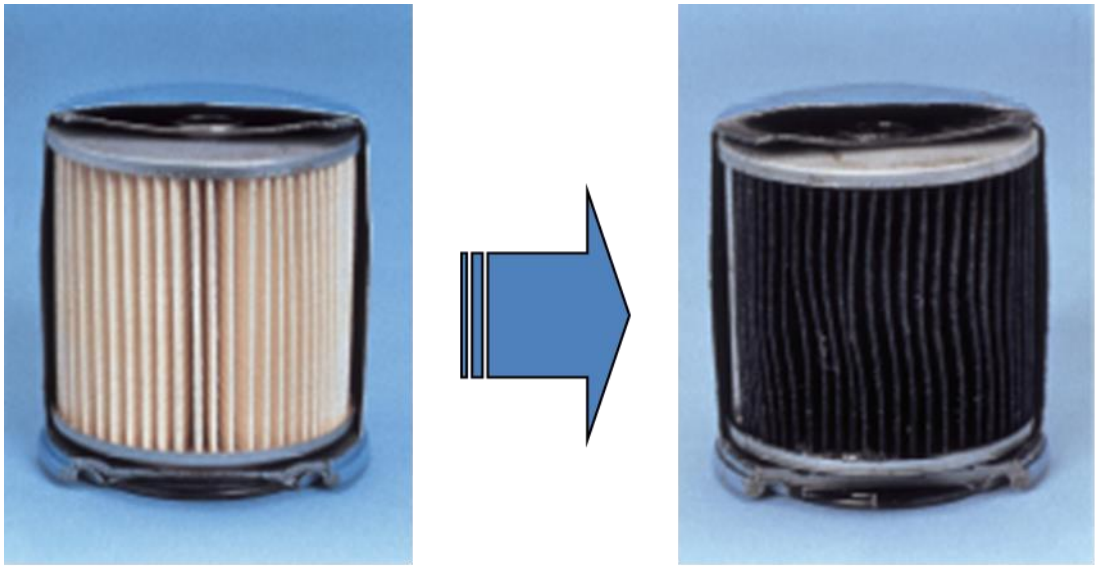


Engine Systems

Lubrication System

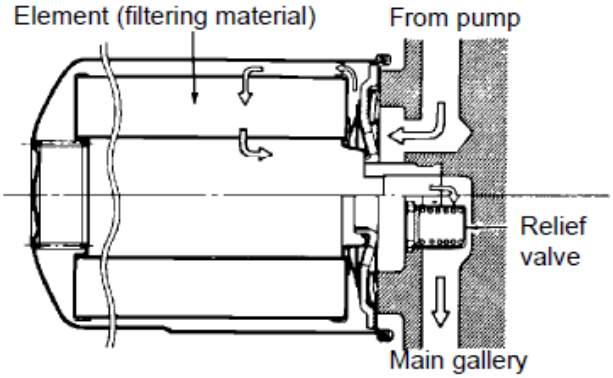
Oil Filter

- It prevents seizure of moving parts by filtering out dust, metal particles, sludge and other harmful contaminants from the engine oil.

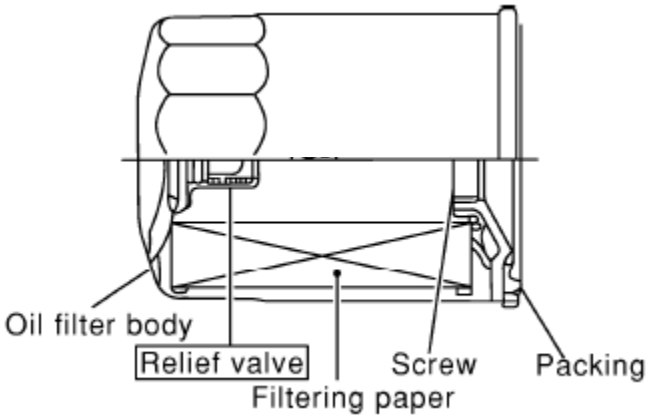


NEW

AFTER 5,000 KMS USE



OIL FILTER (CARTRIDGE TYPE)

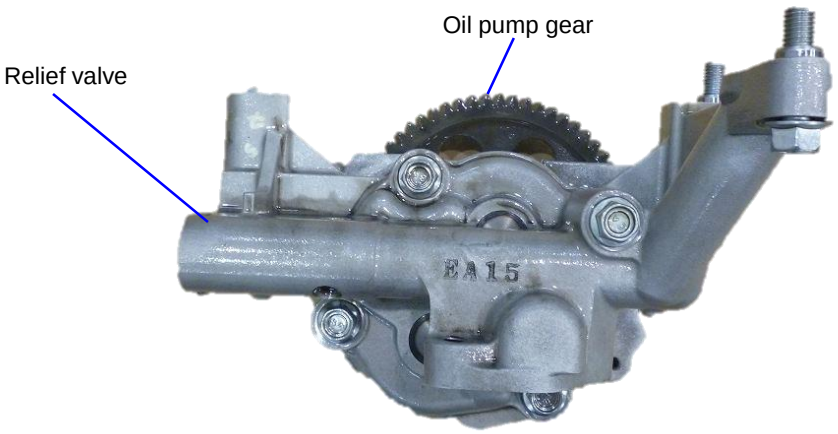


Engine Systems

Lubrication System

Oil Pump

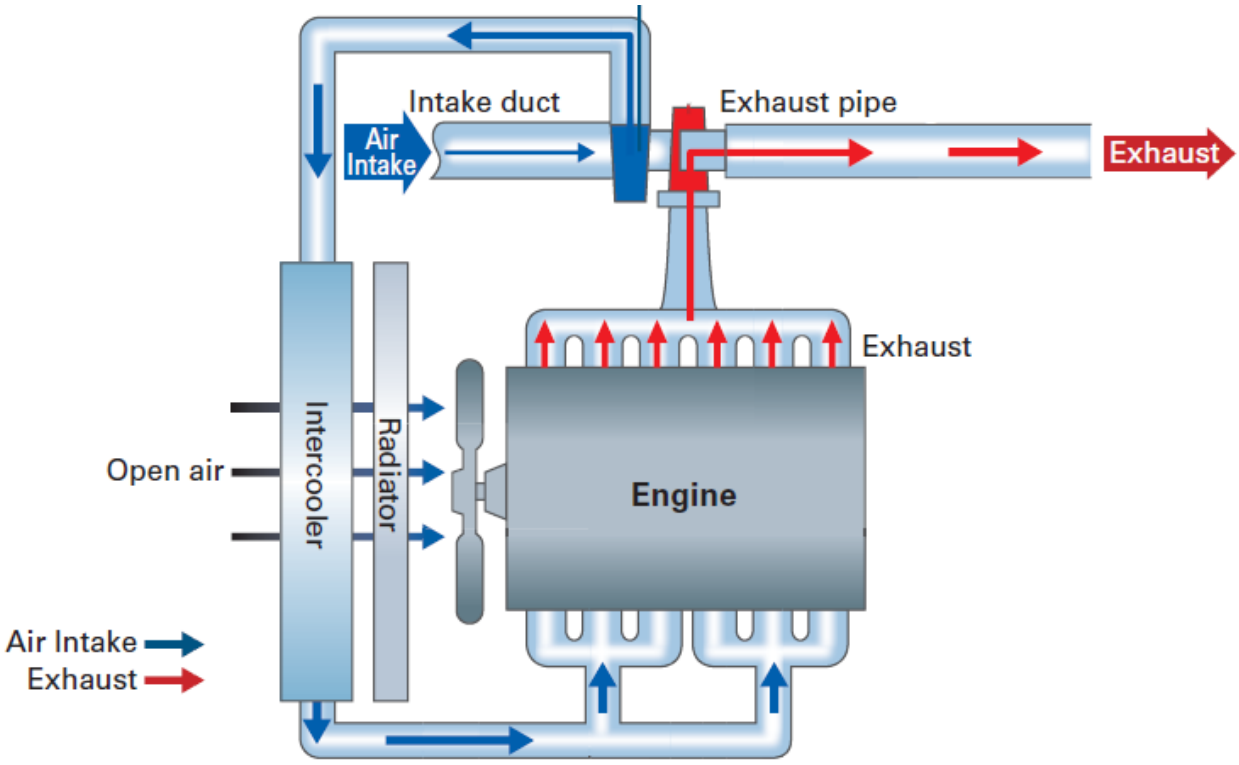
- It promotes circulation of engine oil through out the lubrication circuit.



Engine Systems

Intake & Exhaust System

- These two system are responsible of providing the needed air for combustion and filters out pollutants from exhaust gases that may cause air pollution.

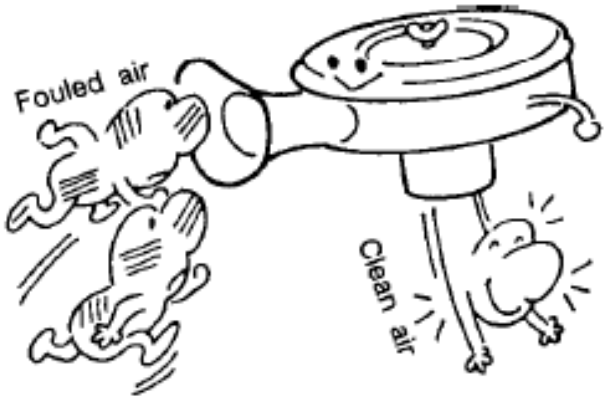


Engine Systems

Intake & Exhaust System

Intake System

Air Filter – it is attached to the air inlet and it removes dust and particles from air before going into the engine during intake.



Isuzu D-Max

Isuzu N-Series

Engine Systems

Intake & Exhaust System

Intake System

Types of Air Filter:

- Dry Type – It consists of an element and body which contains the element. Foreign matter in the intake air is absorbed by the element and cannot pass through.

- Wet Type (Viscous Type) – It is identical in structure to the dry type filter, but the surface of the is coated with special viscous oil or adhesive that collects dust.

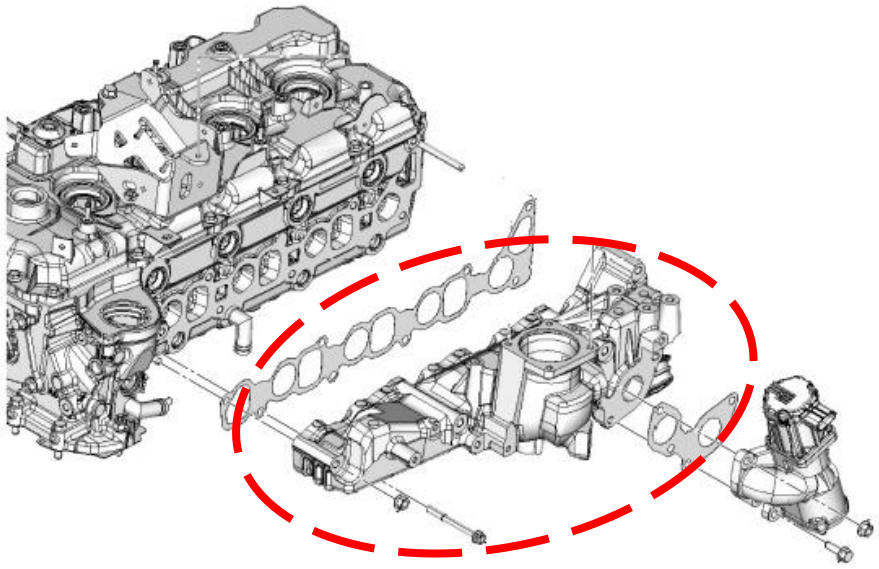
Engine Systems

Intake & Exhaust System

Intake System

Intake Manifold

- It is a set of branch tubes that evenly distributes air into each intake port in the cylinder head.
- It also serves as mounting point for throttle and EGR valves and other components related to intake system.



Engine Systems

Intake & Exhaust System

Intake System

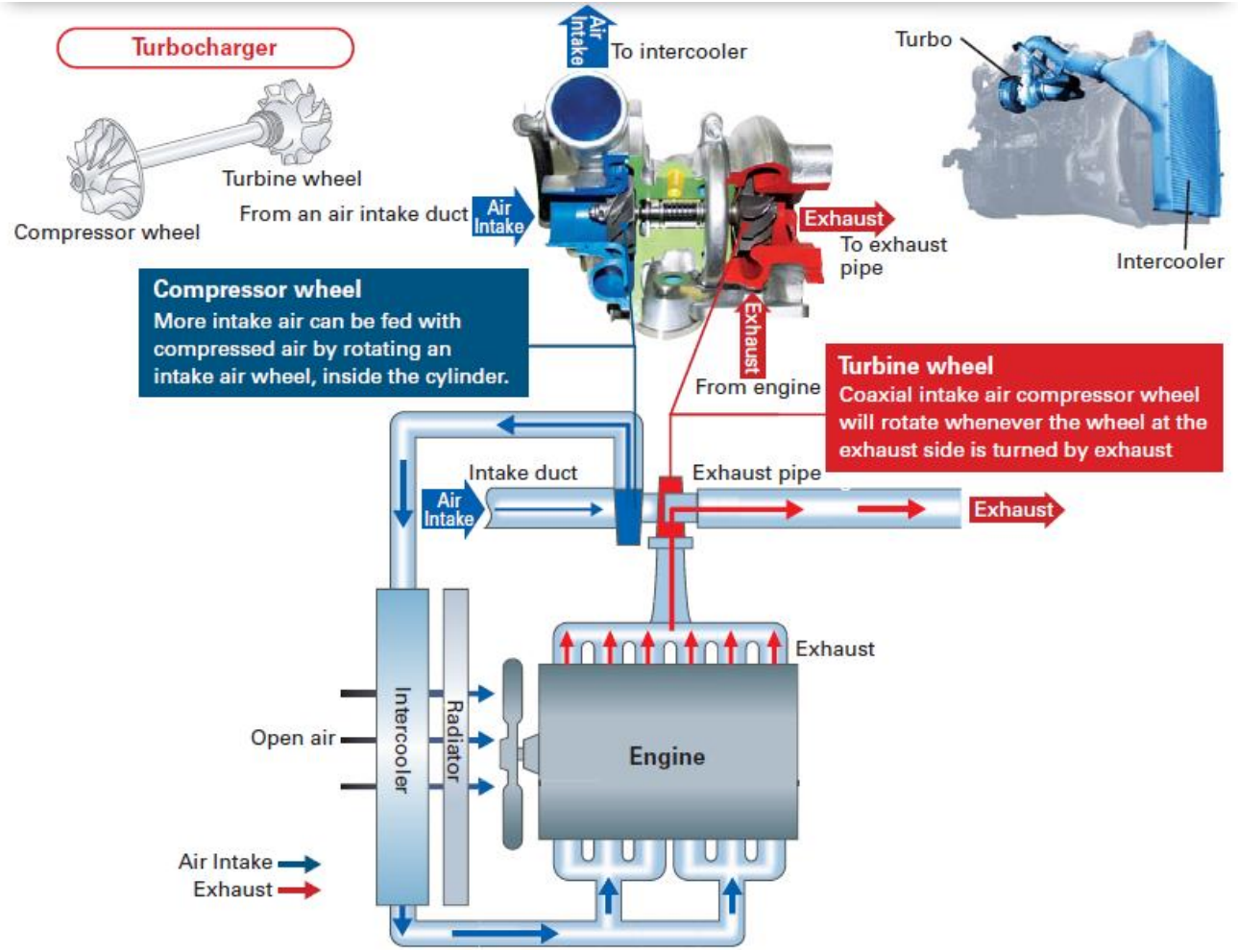
Turbocharger

- It is a type of forced induction system where in intake air is forced into the combustion chamber to improve engine performance.

Engine Systems

Intake & Exhaust System

How It Works



- The system utilizes the energy from exhaust gas to rotate the turbine of the turbocharger to suck air and increase its pressure before it enters the engine. Increased amount of air in the intake increase also fuel during injection and thus increase torque output.

Engine Systems

Intake & Exhaust System

Types of Turbocharger

Conventional Turbocharger

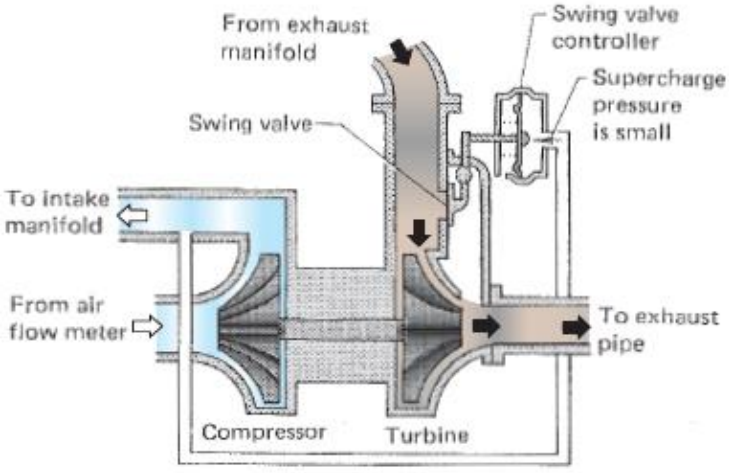


Figure A

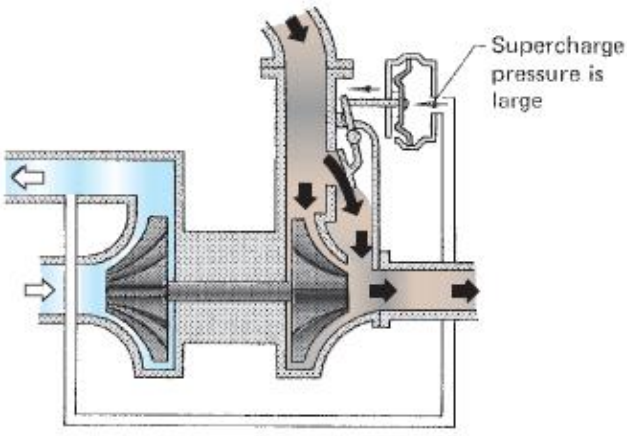


Figure B

- This type of turbocharger relies only on the speed of the exhaust gas to compress intake air at the compressor. High intake pressure or boost pressure can only be achieved at higher exhaust gas speed or higher engine speed and low boost pressure on low engine speed.

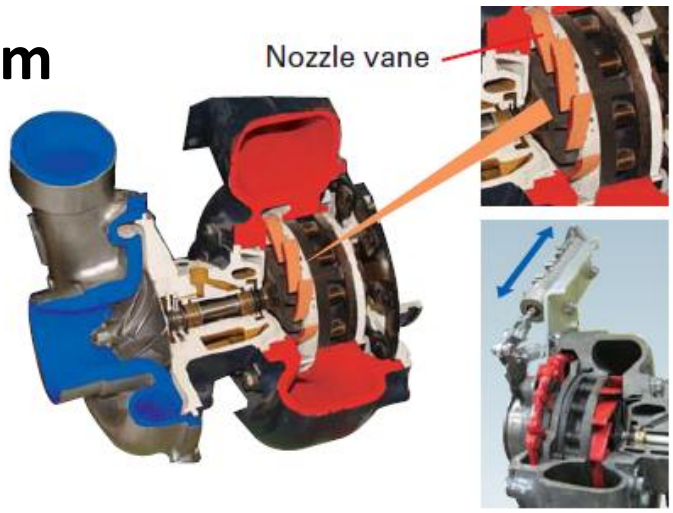
- The disadvantage, however, is that you need to have engine speed to achieve boost to increase power. This causes delay in power increase which is called “turbo lag”.

Engine Systems

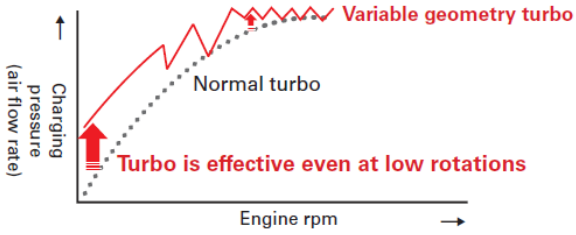
Intake & Exhaust System

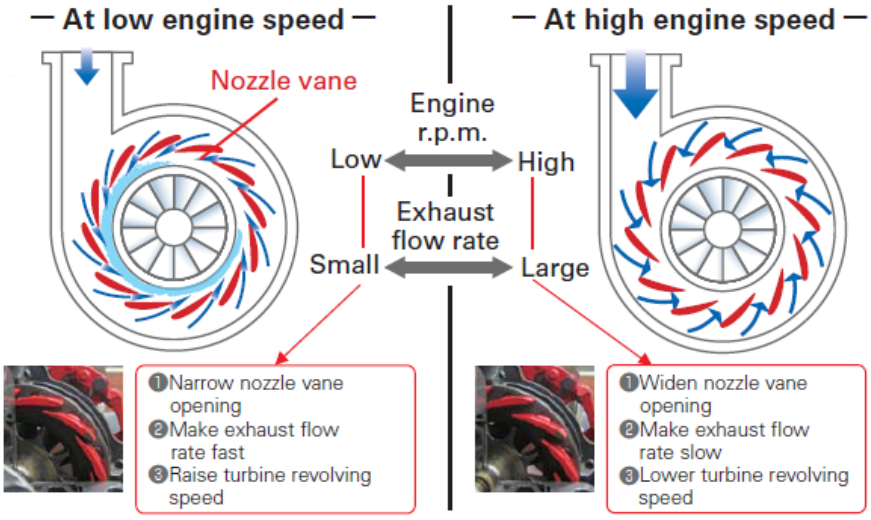
Types of Turbocharger

Variable Geometry System



- It is similar with the conventional turbocharger in terms of design. However, there are nozzle vane at the turbine side which controls the velocity of exhaust gas. This increases or decreases exhaust gas velocity to maintain the ideal boost pressure regardless of engine load.

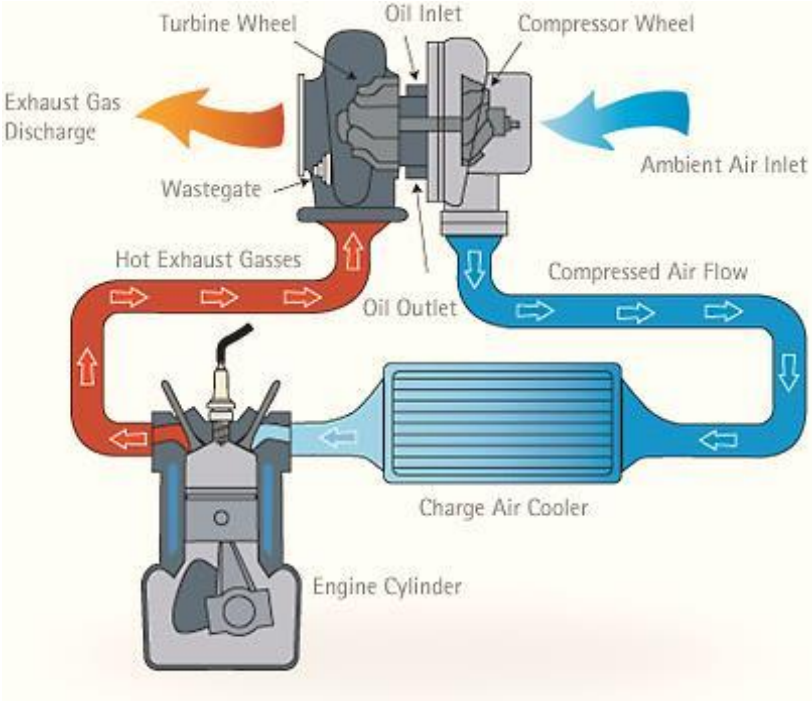




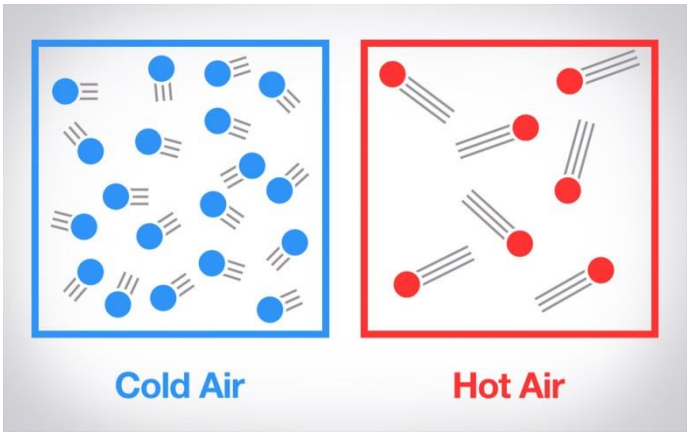
Engine Systems

Intake & Exhaust System

Intercooler



- In theory, compressed air is hotter and less dense than cold air. Intercooler increases charge air density by cooling it before entering the engine. This packs oxygen molecules tightly together and thus increasing its density which also increase power during combustion.



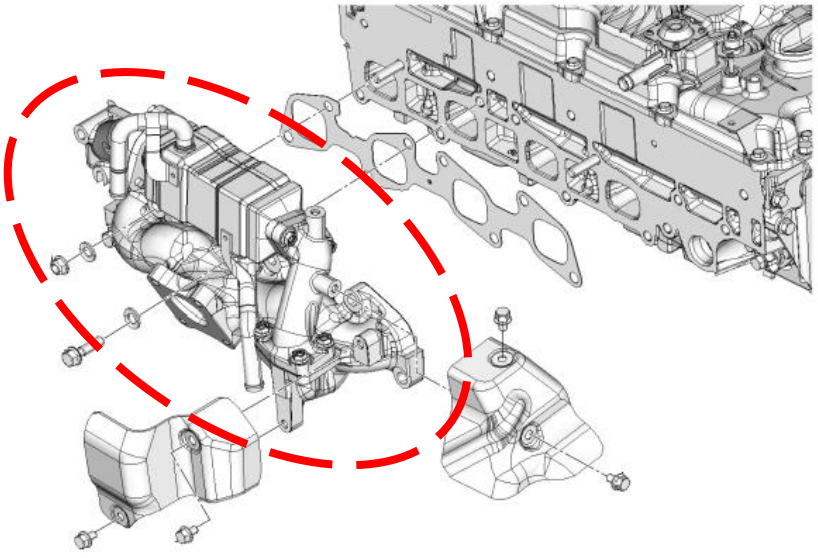
Engine Systems

Intake & Exhaust System

Exhaust System

Exhaust Manifold

- It collects exhaust gases from each cylinder and passes them to the exhaust pipe with minimal resistance.
- It is designed so that exhaust gases from each cylinder do not interfere with one another.
- Serves as mounting point for turbocharger as it uses exhaust gas to rotate the compressor.



Engine Systems

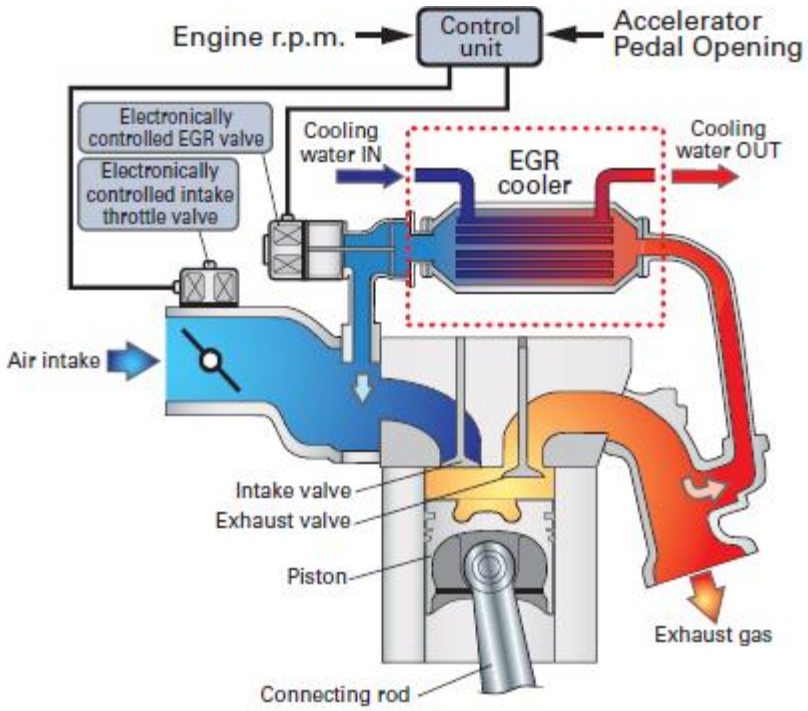
Intake & Exhaust System

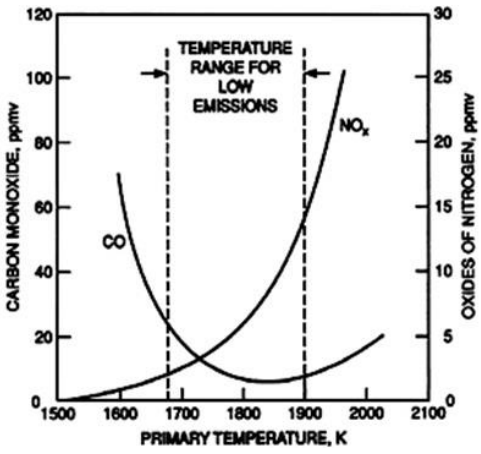
Exhaust System

EGR and After Treatment of Exhaust Gas

Exhaust Gas Recirculation

> It is a device used to lower Nitrogen Oxide (NOx) emission by recirculating a portion of exhaust gas back to the intake manifold during intake stroke in order to lower combustion temperature.





Engine Systems

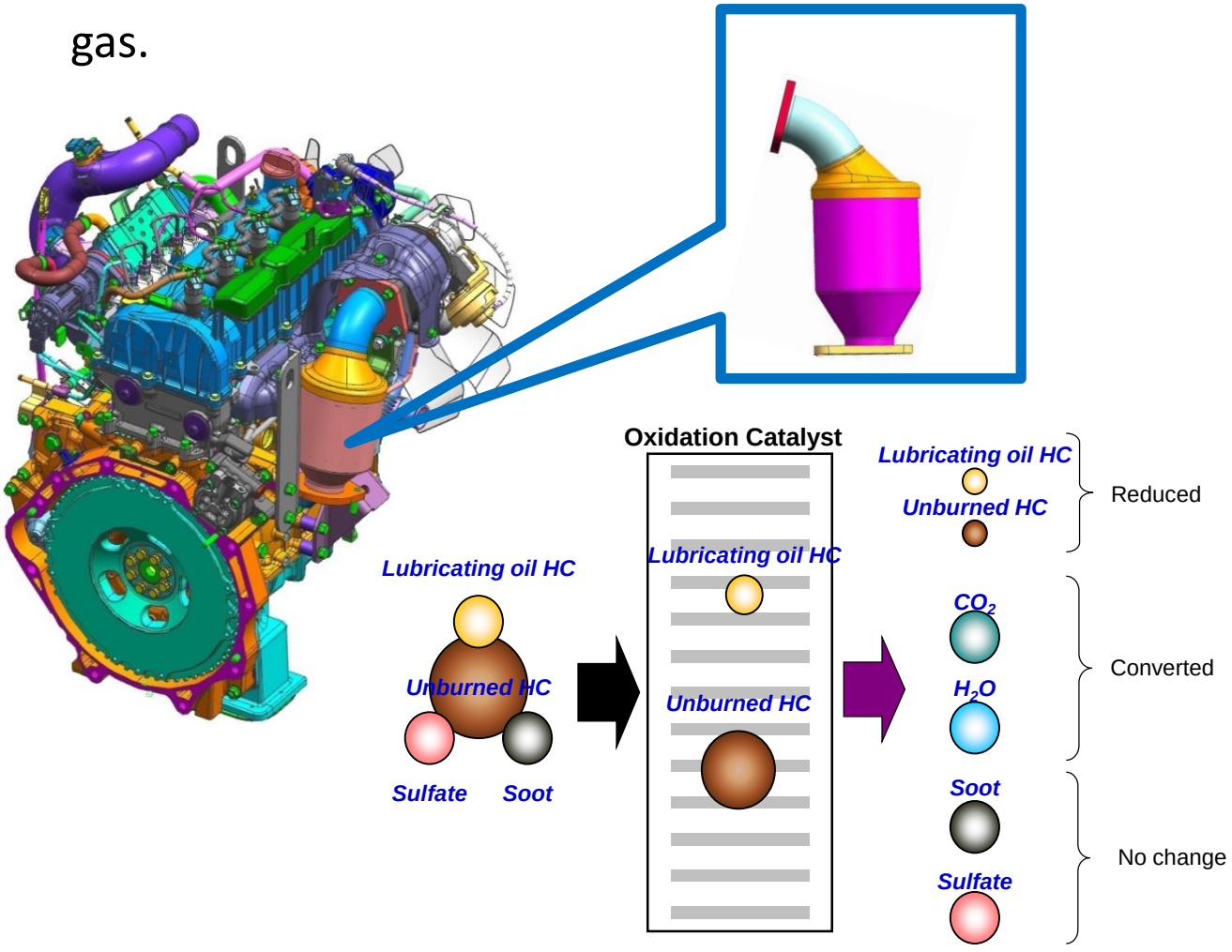
Intake & Exhaust System

Exhaust System

EGR and After Treatment of Exhaust Gas

Diesel Oxidation Catalyst

- It converts HC (unburnt fuel) to CO2 and H2O in order to reduce harmful contaminants in the exhaust gas.

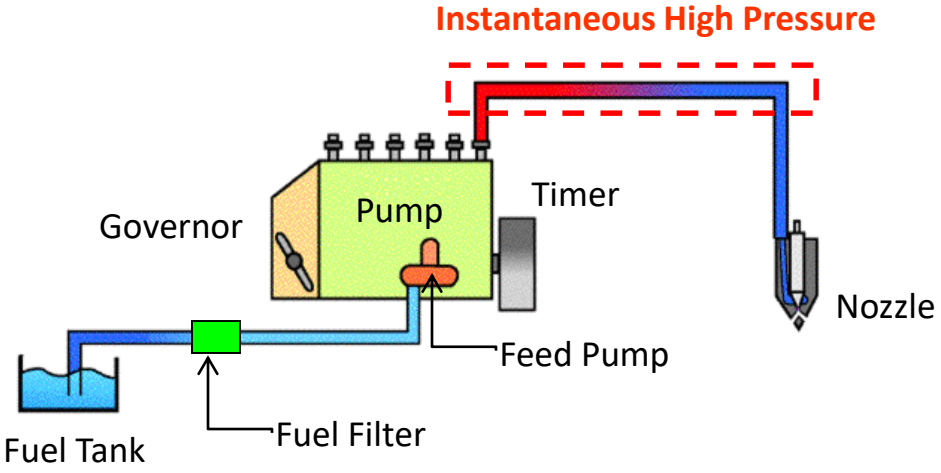


Engine Systems

Fuel System

Conventional Fuel Injection System

- This system injects fuel at high pressure and temperature so that mixture of fuel and air is obtained for complete combustion. It consists of Injection Pump, Injection Nozzles, Fuel Tank, Fuel Filter and Fuel Lines.



Types of Injection Pumps:

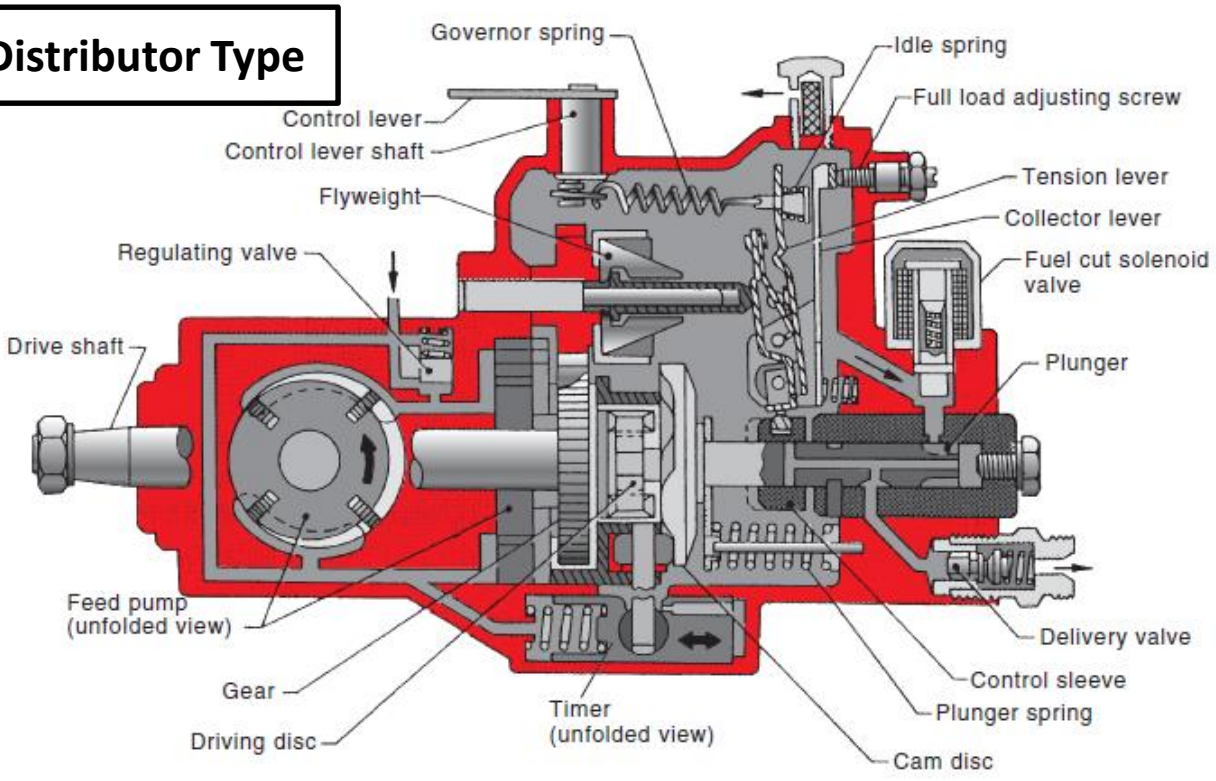
- Distributor/Rotary Type – Has a rotor that sends fuel to the injection nozzle in the cylinders as it rotates.
- In-line Injection Pump – Has a barrel and plunger assembly for each cylinder.

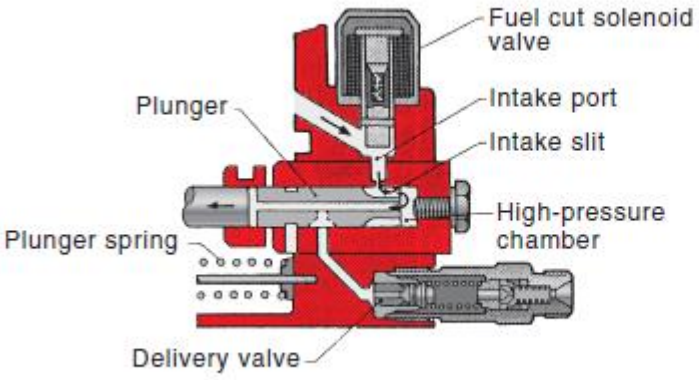
Engine Systems

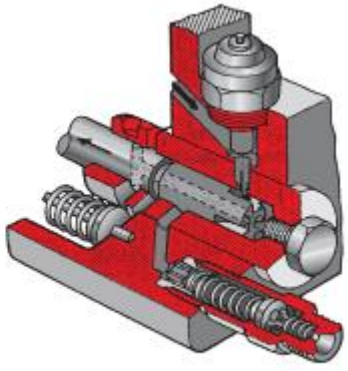
Fuel System

Injection Pumps

Distributor Type





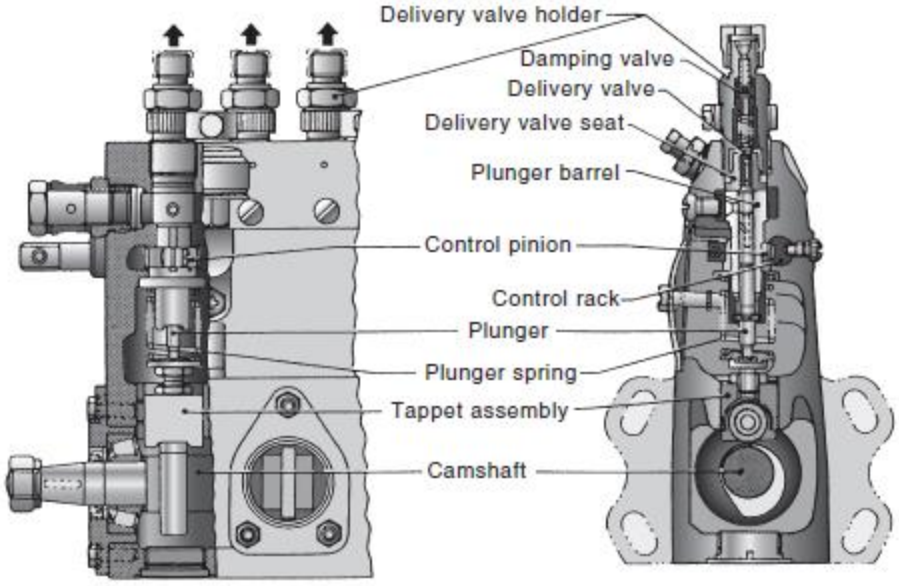


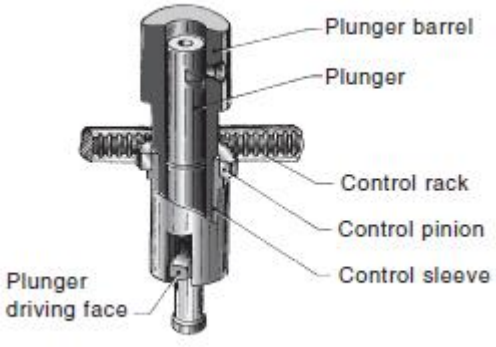
Engine Systems

Fuel System

Injection Pumps

In-Line Type





Engine Systems

Fuel System

Injection Nozzles

- The role of the fuel injector is to inject pressurized fuel from the injection pump into the combustion chamber.

Important factors for injection nozzles:

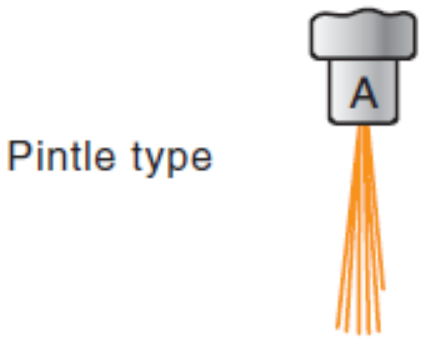
✓ Spray Pattern

✓ Initial Injection Pressure

✓ Injection Timing (via injection pump)

Type of Injection Nozzles

Pintle Type: - it has a single hole usually used for indirect injection engines in orde create swirling effect with compressed air during injection.

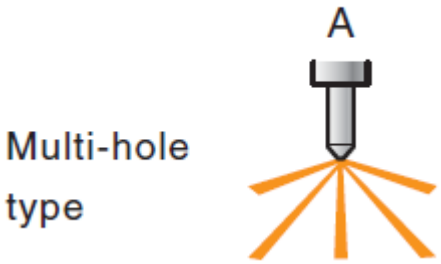


Engine Systems

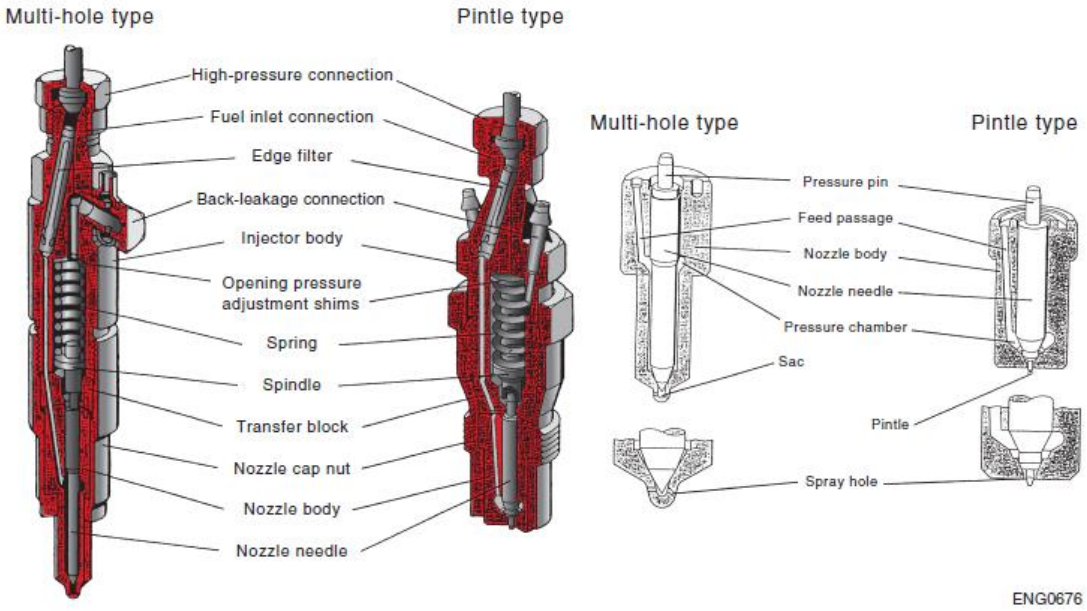
Fuel System

Type of Injection Nozzles

Multi-Hole Type: - It has multiple holes which may vary upto 0.2 to 0.4 mm in diameter with pressures up to 300 kg/cm2. it is used for direct injection engines which spread the injection spray to mix with compressed air during injection.



Parts of Injection Nozzles

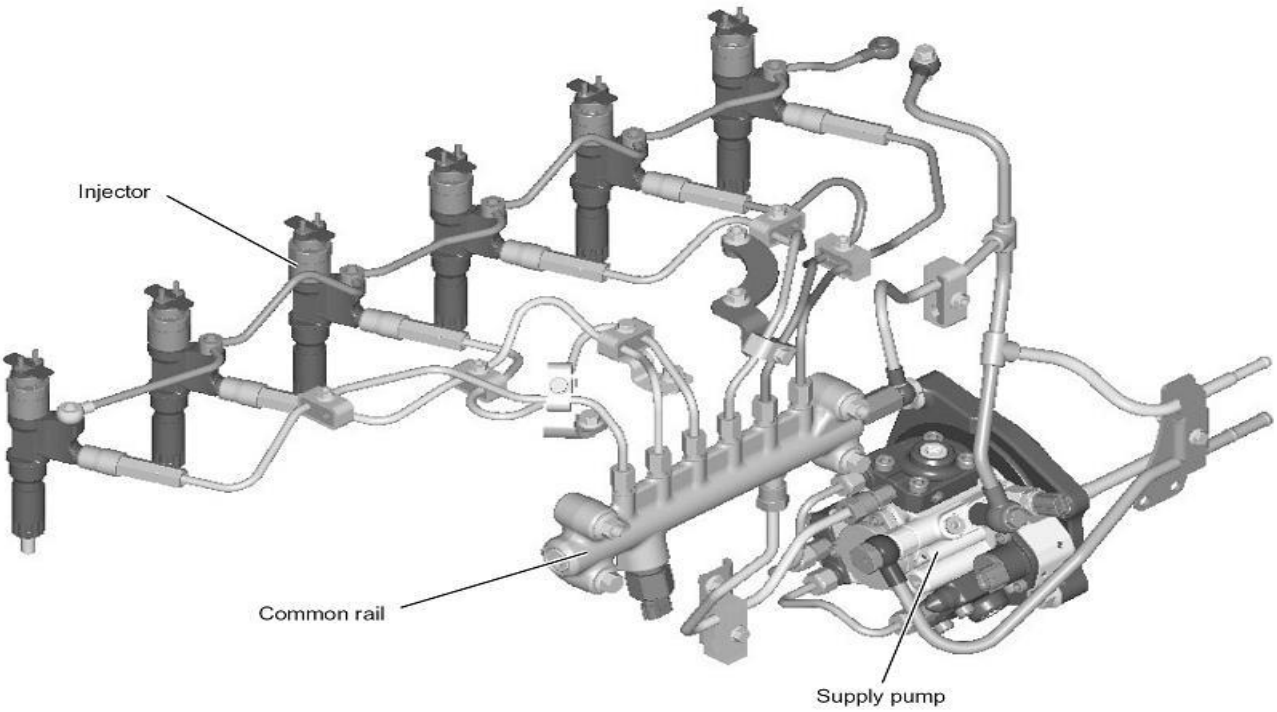


Engine Systems

Fuel System

Common Rail Direct Injection System

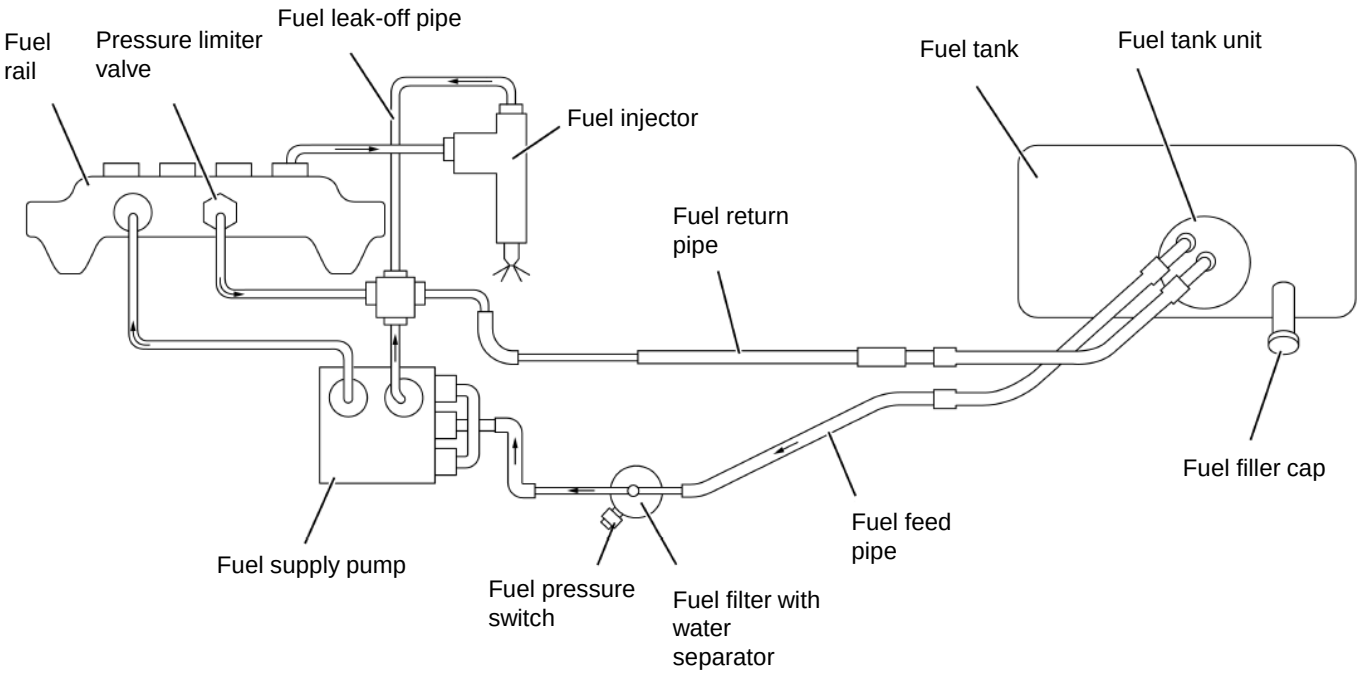
- Fuel is stored in a chamber called “Common Rail” by pressures reaching up to 180 Mpa. It is called a common rail since all injectors are connected in a single fuel rail. This system maintains the high fuel pressure regardless of the engine condition thus improving further the performance of diesel engines compared to previous fuel systems.



Engine Systems

Fuel System

Common Rail Direct Injection System Lay-out



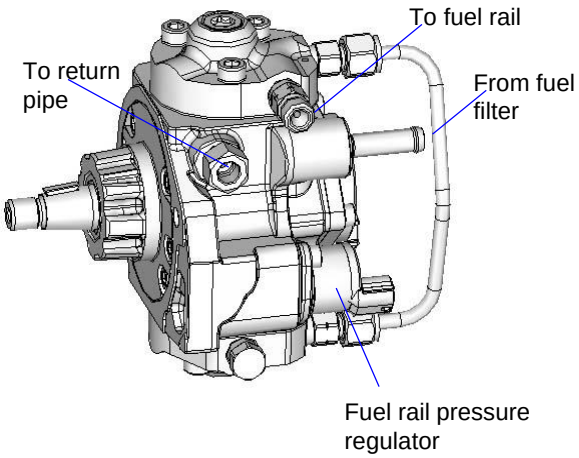
Engine Systems

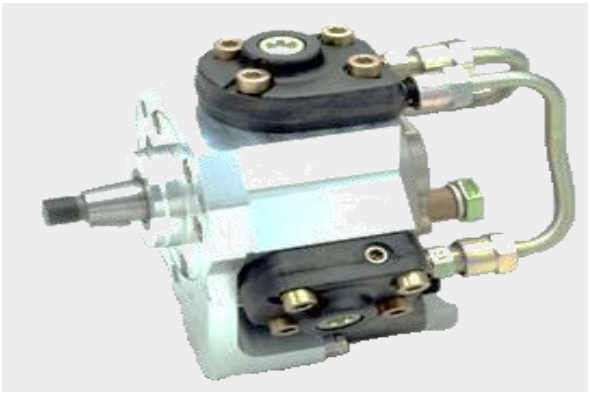
Fuel System

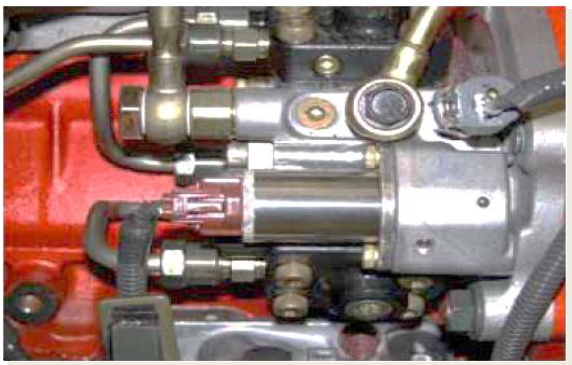
Basic Parts of the Common Rail Direct Injection System

Supply Pump

- It is the heart of the common rail direct injection system (CRDI) in which it draws fuel from the tank and pressurizes it at a higher pressure to be delivered to the fuel rail. It is controlled by the ECM in terms of Fuel Quantity and Fuel Pressure.







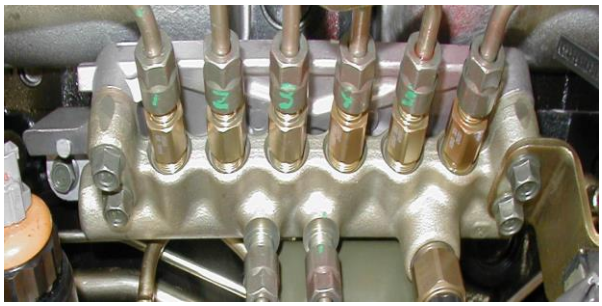
Engine Systems

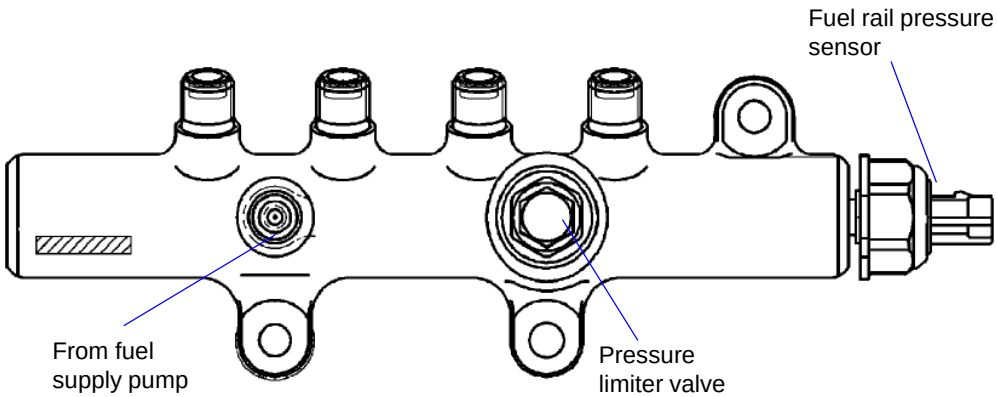
Fuel System

Basic Parts of the Common Rail Direct Injection System

Fuel Rail

- It is also called the common rail and is used to store high pressure fuel from supply pump and acts as a reservoir for fuel injectors. It has a sensor called Fuel Rail Pressure Sensor which detects pressure of the rail and sends it to the ECM for Fuel Pressure Control. Pressure is limited via Pressure Limiter to avoid over pressure which may lead to failure of the fuel rail.





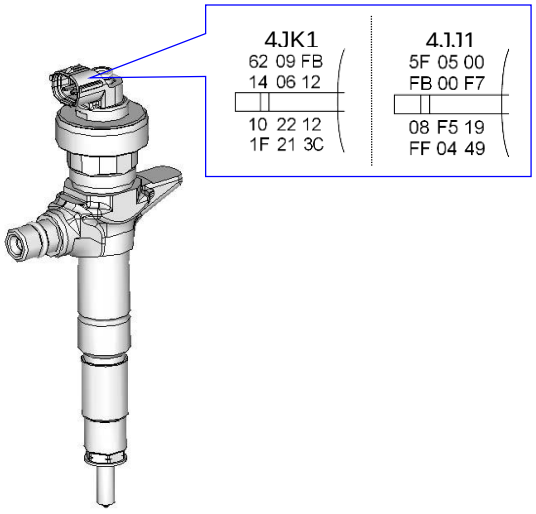
Engine Systems

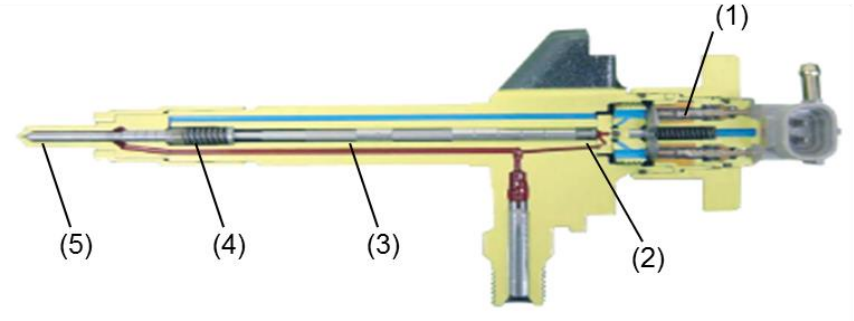
Fuel System

Basic Parts of the Common Rail Direct Injection System

Fuel Injector

- It is electronically controlled injector controlled by the ECM. Control parameters include:
  - ❖ Injection Timing
  - ❖ Injection Quantity
  - ❖ Injection Rate
- It has ID Codes which displays various injector characteristics in 24 Alphanumeric figures. Each injector in an engine has a unique ID Code and should be programmed to the ECM during replacement.





(1) Solenoid
(2) Outlet orifice
(3) Command piston
(4) Nozzle spring
(5) Nozzle

Engine Systems

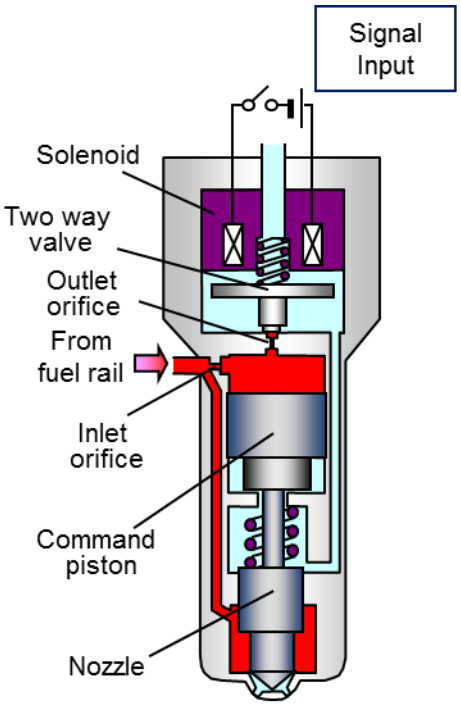
Fuel System

Basic Parts of the Common Rail Direct Injection System

Fuel Injector Operation

1. Non-Injection State

- The two way valve (TWV) closes the outlet orifice by means of a spring force, when no current is supplied from the ECM to the solenoid. At this time, the fuel pressure applied to the nozzle leading end is equal to the fuel pressure applied to the control chamber through the inlet orifice. As for the force competition in this state, the pressure on the command piston upper surface + nozzle spring force defeat the pressure on the nozzle leading end, and consequently the nozzle is pushed downward to close the injection holes.



Non-Injection State

Engine Systems

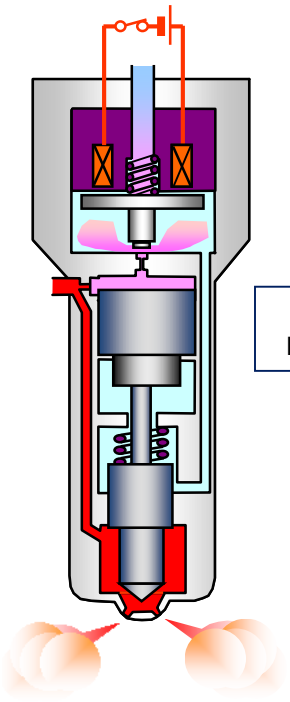
Fuel System

Basic Parts of the Common Rail Direct Injection System

Fuel Injector Operation

2. Injection Start

- The TWV is pulled up to open the outlet orifice, and thus the fuel leaks toward the return port, when the current is supplied from the ECM to the solenoid. As a result, the nozzle is pushed up together with the command piston by the fuel pressure applied to the nozzle leading end, and then the nozzle injection holes open to inject the fuel.



Engine Systems

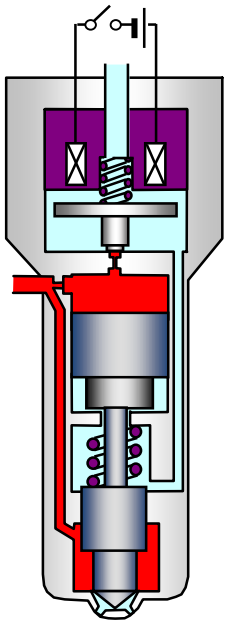
Fuel System

Basic Parts of the Common Rail Direct Injection System

Fuel Injector Operation

3. Injection End

- The TWV lowers to close the outlet orifice, when the ECM shuts off a current supply to the solenoid. As a result, the fuel cannot leak from the control chamber, and thus the fuel pressure in the control chamber rises abruptly and then the nozzle is pushed down by the command piston to close the nozzle injection holes, resulting in the end of fuel injection.



Injection Finish

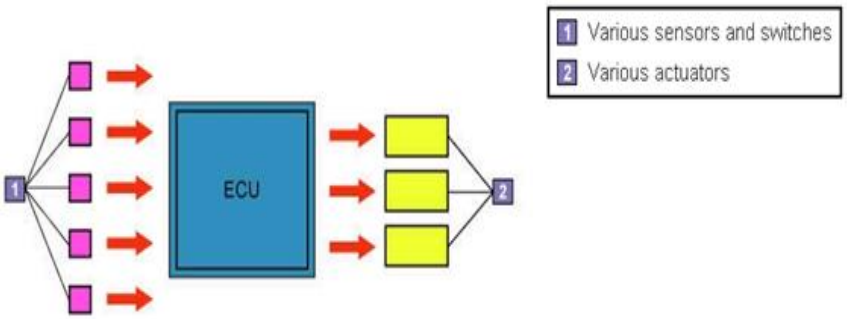
Engine Systems

Fuel System

Basic Parts of the Common Rail Direct Injection System

Electronic Control Module (ECM)

The ECM controls the fuel injection system and the engine overall. It receives signal from various sensors in order to determine operating conditions of the engine and perform control via actuators to realize optimal engine operation at all times.



Engine Model Line-up

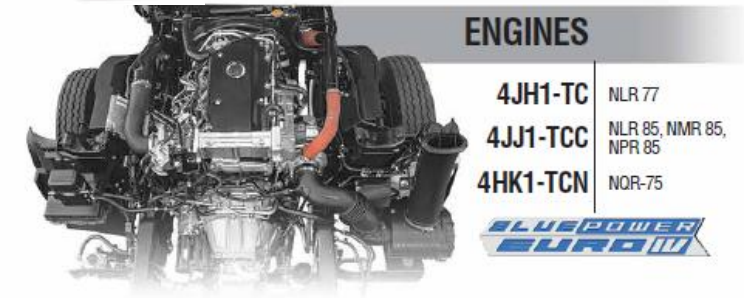
Engine Model Line-up

Isuzu D-Max & Isuzu mu-X

Engine Model	4JJ1-TCX
Type	4 Cylinder In-line Blue Power Diesel Engine with Turbo Intercooler
Bore and Stroke, mm	95.4 x 104.9
Displacement, liters	3.0
Max. Output, Ps@rpm	177 @ 3,550-3,650
Max. Torque, N-m@rpm	380 @ 1,800-2,800
Engine Oil Cap., liters	7.5
Emission Rating	Euro 4

Engine Model Line-up

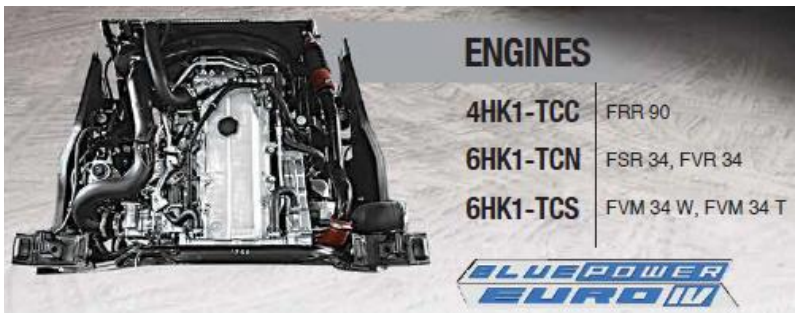
Isuzu N-Series



Engine Model	4JJ1-TCC	4JH1-TC	4HK1-TCN
Type	4-Cylinder, Turbo-Intecooler, DOHC, Common-Rail Direct Injection, Blue Power Diesel Engine	4-Cylinder, Turbo-Intercooler, Common-Rail Direct Injection, Blue Power Diesel Engine	4-Cylinder, Tubro-Intercooler, Common-Rail Direct Injection, Blue Power Diesel Engine
Bore and Stroke, mm	95.4 x 104.9	95.4 x 104.9	115 x 125
Displacement, liters	3.0	3.0	5.2
Max. Output, Ps@rpm	124 @ 2,600	106 @ 3,200	155 @ 2,600
Max. Torque, N-m@rpm	354 @ 1,500	230 @ 1,400-3,200	419 @ 1,600-2,600
Engine Oil Cap., liters	8.0	8.0	11
Emission Rating	Euro IV	Euro IV	Euro IV

Engine Model Line-up

Isuzu F-Series



Engine Model	4HK1-TCC	6HK1-TCN	6HK1-TCS
Type	4-Cylinder In-line, Turbo-Intercooler, Common-Rail Direct Injection, Blue Power Diesel Engine	6-Cylinder In-line, Turbo-Intercooler, Common-Rail Direct Injection, Blue Power Diesel Engine	6-Cylinder In-line, Turbo-Intercooler, Common-Rail Direct Injection, Blue Power Diesel Engine
Bore and Stroke, mm	115 x 125	115 x 125	115 x 125
Displacement, liters	5.2	7.8	7.8
Max. Output, Ps@rpm	190 @ 2,600	240	280
Max. Torque, N-m@rpm	510 @ 1,600-2,600	706	882
Engine Oil Cap., liters	11	19.5	19.5
Emission Rating	Euro IV	Euro IV	Euro IV

Engine Model Line-up

Isuzu C & E - Series

CYH 52

EXR 52

CYZ 52

EXZ 52

Engine Model	6WG1-TCR
Type	6-Cylinder In-line, Turbo-Intercooler, Common-Rail Direct Injection, Blue Power Diesel Engine
Bore and Stroke, mm	147 x 154
Displacement, liters	15.7
Max. Output, Ps@rpm	400
Max. Torque, N-m@rpm	1863
Engine Oil Cap., liters	28
Emission Rating	Euro V

Engine Model Line-up

Isuzu EXR and EXZQL Euro V

EXRQL418W1

EXZQL425W1

Engine Model	6WG1-TCR
Type	6-Cylinder In-line, Turbo-Intercooler, Common-Rail Direct Injection, Blue Power Diesel Engine
Bore and Stroke, mm	147 x 154
Displacement, liters	15.7
Max. Output, Ps@rpm	420
Max. Torque, N-m@rpm	2,060
Engine Oil Cap., liters	29
Emission Rating	Euro V

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu D-Max

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (4JJ1-TCX)	BESCO GENUINE (10W-30)	1884057460	GALLONS	7.5
		IGMO MULTI Z+ (10W-30)	570670459		
		IGMO "XTRM" (15W-40)	570671459		
2	TRANSFER CASE	BESCO TRANSAXLE (5W-30)	1884057520	PAIL	2.0
3	A/T TRANSMISSION (TB50LS)	MOBIL ATF AT3309	SOTFR00070L	PAIL	3.0
4	M/T TRANSMISSION (MUA OR MUX)	BESCO TRANSAXLE (5W-30)	1884057520	PAIL	3.0
5	FRONT DIFFERENTIAL	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	2.0
6	REAR DIFFERENTIAL				3.0
7	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	1.0
8	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	8.0
9	BRAKE/CLUTCH FLUID	DOT 3	5106620IL	500 mL	1.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu mu-X

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (4JJ1-TCX)	BESCO GENUINE (10W-30)	1884057460	GALLONS	7.5
		IGMO MULTI Z+ (10W-30)	570670459		
		IGMO "XTRM" (15W-40)	570671459		
2	TRANSFER CASE	BESCO TRANSAXLE (5W-30)	1884057520	PAIL	2.0
3	A/T TRANSMISSION (AWR6B45)	ENEOS (JX NWS-9638)	5877030010	LITERS	3.0
4	FRONT DIFFERENTIAL	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	2.0
5	REAR DIFFERENTIAL				3.0
6	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	1.0
7	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	8.0
8	BRAKE FLUID	DOT 3	5106620IL	500 mL	1.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu NLR77

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (4JH1-TC)	IGMO MULTI Z+ (10W-30)	570670459	GALLONS	8.0
		IGMO "XTRM" (15W-40)	570671459		
2	M/T TRANSMISSION (MSB5S)	IGMO "XTRM" (15W-40)	570671459	LITERS	2.7
		BESCO TRANSAXLE (5W-30)	1884057520	PAIL	
3	REAR DIFFERENTIAL	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	2.7
4	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	1.0
5	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	11.0
6	BRAKE/CLUTCH FLUID	DOT 3	5106620IL	mL	1.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu NLR85, NMR 85, NPR 85

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (4JJ1-TC)	IGMO MULTI Z+ (10W-30)	570670459	GALLONS	8.0
		IGMO "XTRM" (15W-40)	570671459		
2	M/T TRANSMISSION (MYY5M)	IGMO "XTRM" (15W-40)	570671459	LITERS	2.8
		BESCO TRANSAXLE (5W-30)	1884057520	PAIL	
3	REAR DIFFERENTIAL	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	3.4
4	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	1.0
5	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	11.0
6	BRAKE/CLUTCH FLUID	DOT 3	5106620IL	mL	1.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu NQR75

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (4HK1-TCN)	IGMO MULTI Z+ (10W-30)	570670459	GALLONS	11.0
		IGMO "XTRM" (15W-40)	570671459		
2	M/T TRANSMISSION (MYY6S)	IGMO "XTRM" (15W-40)	570671459	LITERS	4.4
		BESCO TRANSAXLE (5W-30)	1884057520	PAIL	
3	REAR DIFFERENTIAL	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	4.3
4	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	2.0
5	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	18.0
6	BRAKE/CLUTCH FLUID	DOT 3	5106620IL	mL	1.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu FRR90

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (4HK1-TCC)	IGMO MULTI Z+ (10W-30)	570670459	GALLONS	11.0
		IGMO "XTRM" (15W-40)	570671459		
2	M/T TRANSMISSION (MZZ6W)	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	4.4
3	REAR DIFFERENTIAL				6.5
4	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	3.0
5	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	18.0
6	BRAKE/CLUTCH FLUID	DOT 3	5106620IL	mL	3.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu FSR34, FVR34

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (6HK1-TCN)	IGMO MULTI Z+ (10W-30)	570670459	GALLONS	19.5
		IGMO "XTRM" (15W-40)	570671459		
2	M/T TRANSMISSION (MZW6P)	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	5.3
3	REAR DIFFERENTIAL				6.5
4	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	3.0
5	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	28.0
6	BRAKE/CLUTCH FLUID	DOT 3	5106620IL	mL	3.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu FVM34

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (6HK1-TCS)	IGMO MULTI Z+ (10W-30)	570670459	GALLONS	19.5
		IGMO "XTRM" (15W-40)	570671459		
2	M/T TRANSMISSION (FULLER ES11109)	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	8.5
3	REAR DIFFERENTIAL (TANDEM AXLE)				14.0
4	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	3.0
5	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	28.0
6	BRAKE/CLUTCH FLUID	DOT 3	5106620IL	mL	3.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu CYZ52, CYH52, EXR52, EXZ52

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (6WG1-TCR)	IGMO MULTI Z+ (10W-30)	570670459	GALLONS	28.5
		IGMO "XTRM" (15W-40)	570671459		
2	M/T TRANSMISSION (MJT7S)	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	17.0
3	M/T TRANSMISSION (MJX16)				19.0
4	FRONT DIFFERENTIAL				18.0
5	REAR DIFFERENTIAL				12.0
6	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	6.0
7	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	47.4
8	BRAKE/CLUTCH FLUID	DOT 3	5106620IL	mL	1.0

Engine Model Line-up

Standard Fluids and Lubricants – Isuzu EXRQL418W1 and EXZQL425W1

	SYSTEM	BRAND / SPECIFICATION	PART NO.	SUPPLY FORM	CAPACITY (L)
1	ENGINE OIL (6WG1-TCG52)	IGMO MULTI Z (10W-30)	570670459	GALLONS	29
		IGMO "XTRM" (15W-40)	570671459		
2	M/T TRANSMISSION (ZF16S2230TO)	ZF-ECOFLUID M	0671090383 (4L) 0671090384 (18L)	LITERS/PAIL	16
3	FRONT DIFFERENTIAL (EXZQL ONLY)	DELO GL-5 EP (80W-90), (85W-140)	510411HRK/ 510412HRK	PAIL	18.0
4	REAR DIFFERENTIAL				12.0
5	POWER STEERING	TEXAMATIC 1888	510134NJL	LITERS	6.0
6	ENGINE COOLANT	ISUZU LLC PREMIX	570622NFE	LITERS	40
7	CLUTCH FLUID	DOT 3	5106620IL	mL	1.0

Troubleshooting

Lubrication System

Troubleshooting

Problem: Excessive Oil Consumption

Checkpoint	Trouble Cause	Countermeasures
Engine Oil	Engine oil unsuitable / Too much engine oil	Replace engine oil / Correct volume of engine oil
Oil seal and gasket	Oil leakage from oil seal / gasket	Replace oil seal and/or gasket
Air Breather	Clogged air breather	Clean air breather
Intake and exhaust valve	Worn valve stems and valve guides	Replace intake and exhaust valves / valve guides
Turbocharger oil seal	Leakage	Replace turbocharger oil seal

Troubleshooting

Lubrication System

Troubleshooting

Problem: Inaccurate Oil Pressure

Checkpoint	Trouble Cause	Countermeasures
Engine Oil	Improper viscosity / Insufficient engine oil	Correct oil viscosity / volume of engine oil
Oil pressure gauge/ indicator light	Defective oil pressure gauge/or indicator light	Repair or replace oil pressure gauge/or indicator light
Oil Filter	Clogged oil filter	Replace oil filter element
Relief valve / Bypass valve	Relief valve sticking / weakened bypass valve spring	Replace relief valve / or bypass valve
Oil Pump	Clogged oil pump strainer / worn oil pump related parts	Clean oil pump strainer / replace oil pump related parts

Troubleshooting

Cooling System

Troubleshooting

Problem: Engine Overheating

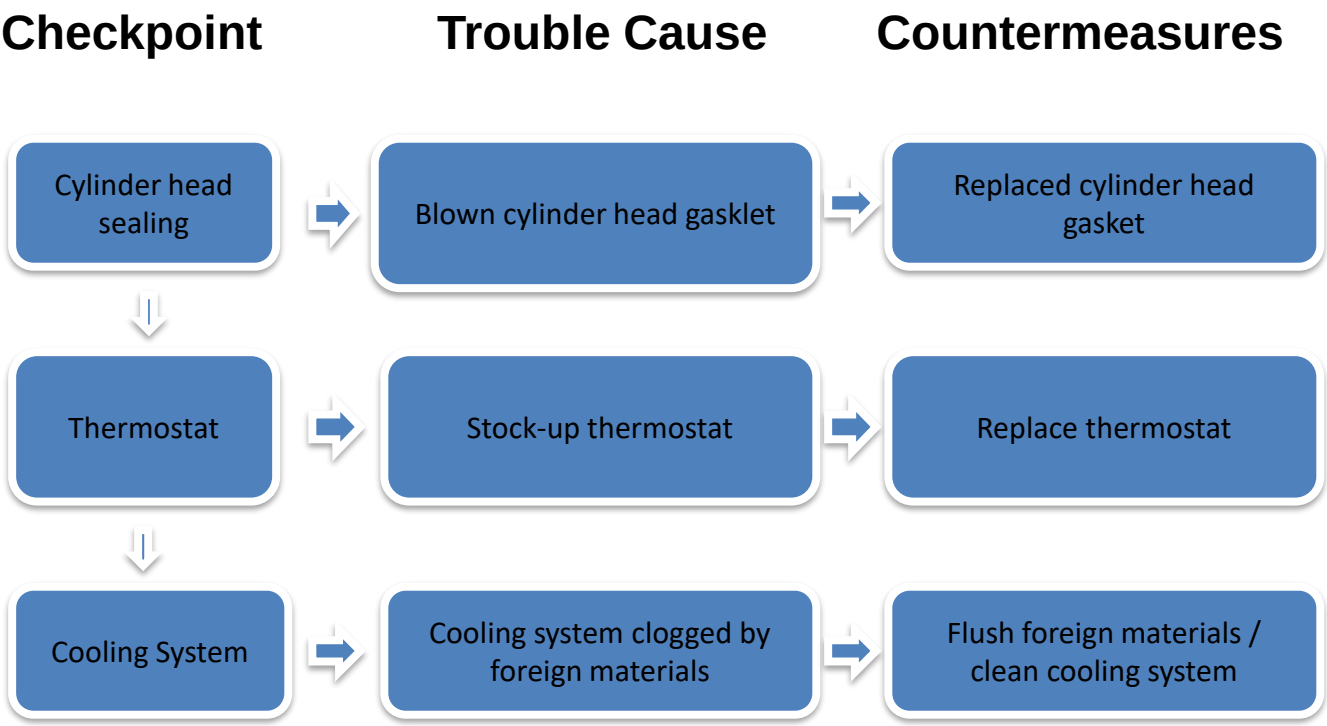
Checkpoint	Trouble Cause	Countermeasures
Cooling Water	Insufficient cooling water	Replenish cooling water / or coolant
Fan Coupling (if equipped)	Oil leakage from fan coupling / inadequate oil	Replace fan coupling / replenish oil
Fan Belt	Broken fan belt / worn belt causing slippage	Replace fan belt
Radiator	Clogged radiator cores / defective radiator cap	Clean radiator / replace radiator cap
Water Pump	Worn water pump seals / or bearings	Repair / or replace water pump

Troubleshooting

Cooling System

Troubleshooting

Problem: Engine Overheating

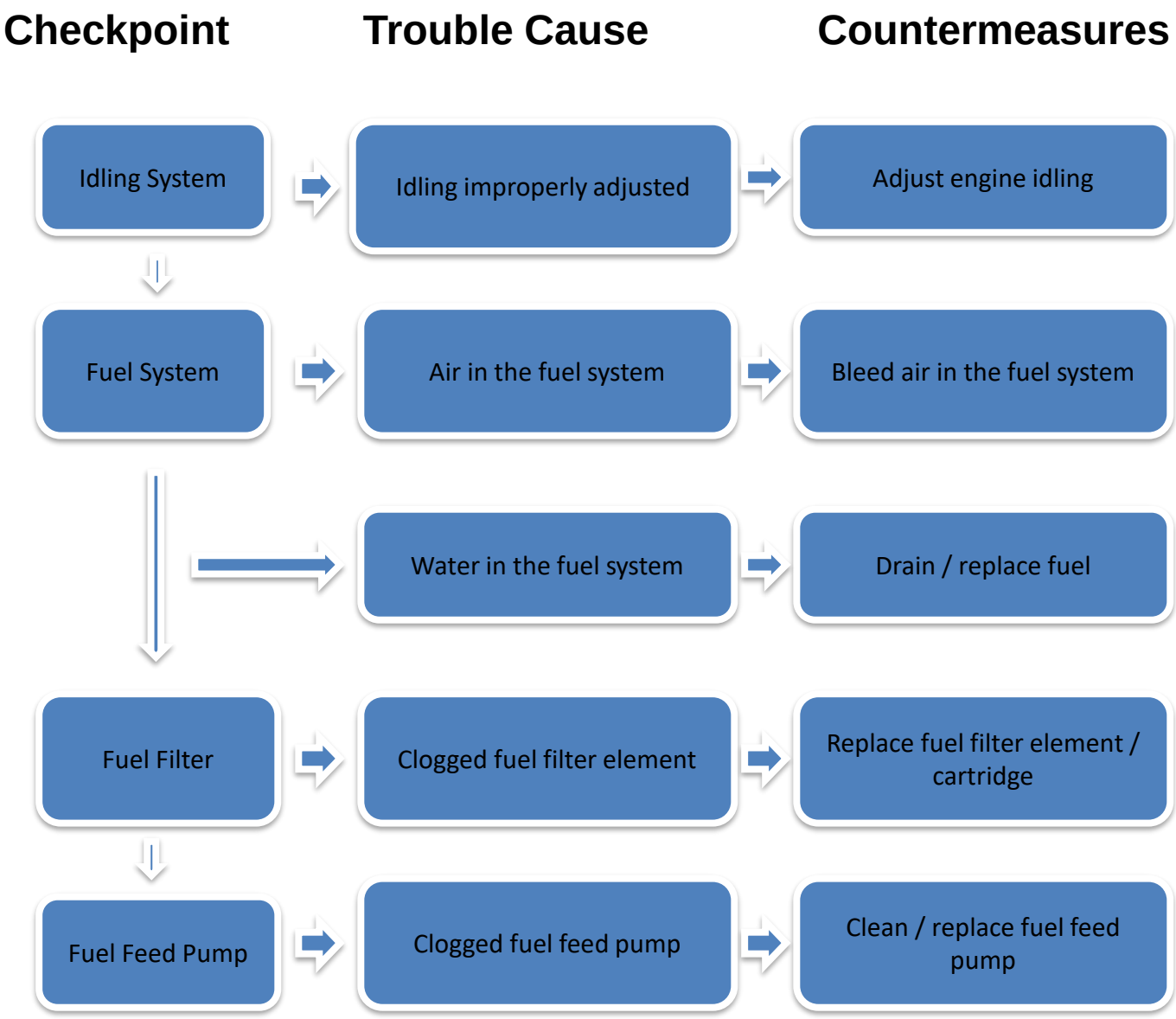


Troubleshooting

Fuel System

Troubleshooting

Problem: Unstable Engine Idling

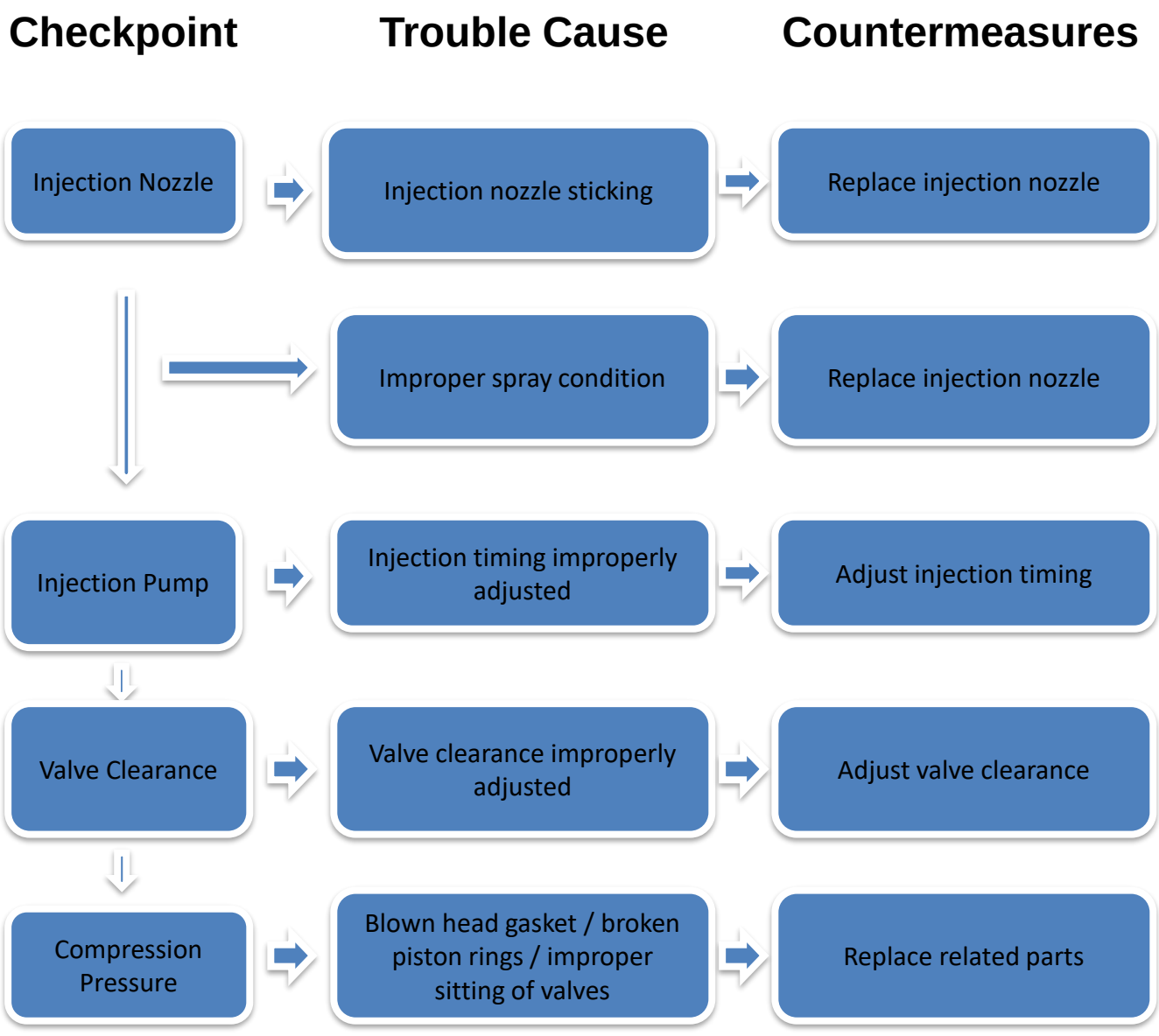


Troubleshooting

Fuel System

Troubleshooting

Problem: Unstable Engine Idling

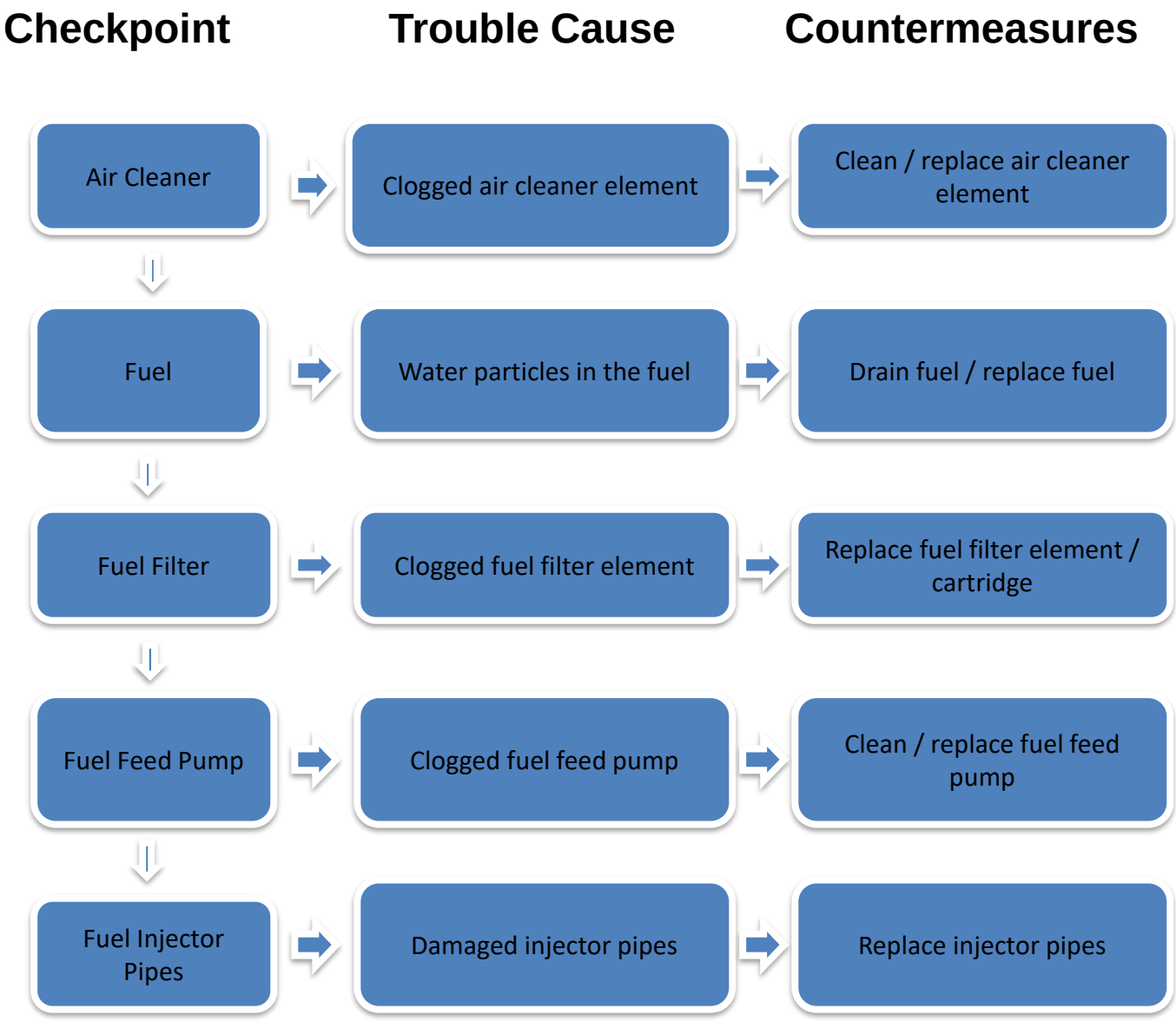


Troubleshooting

Fuel System

Troubleshooting

Problem: Insufficient Power

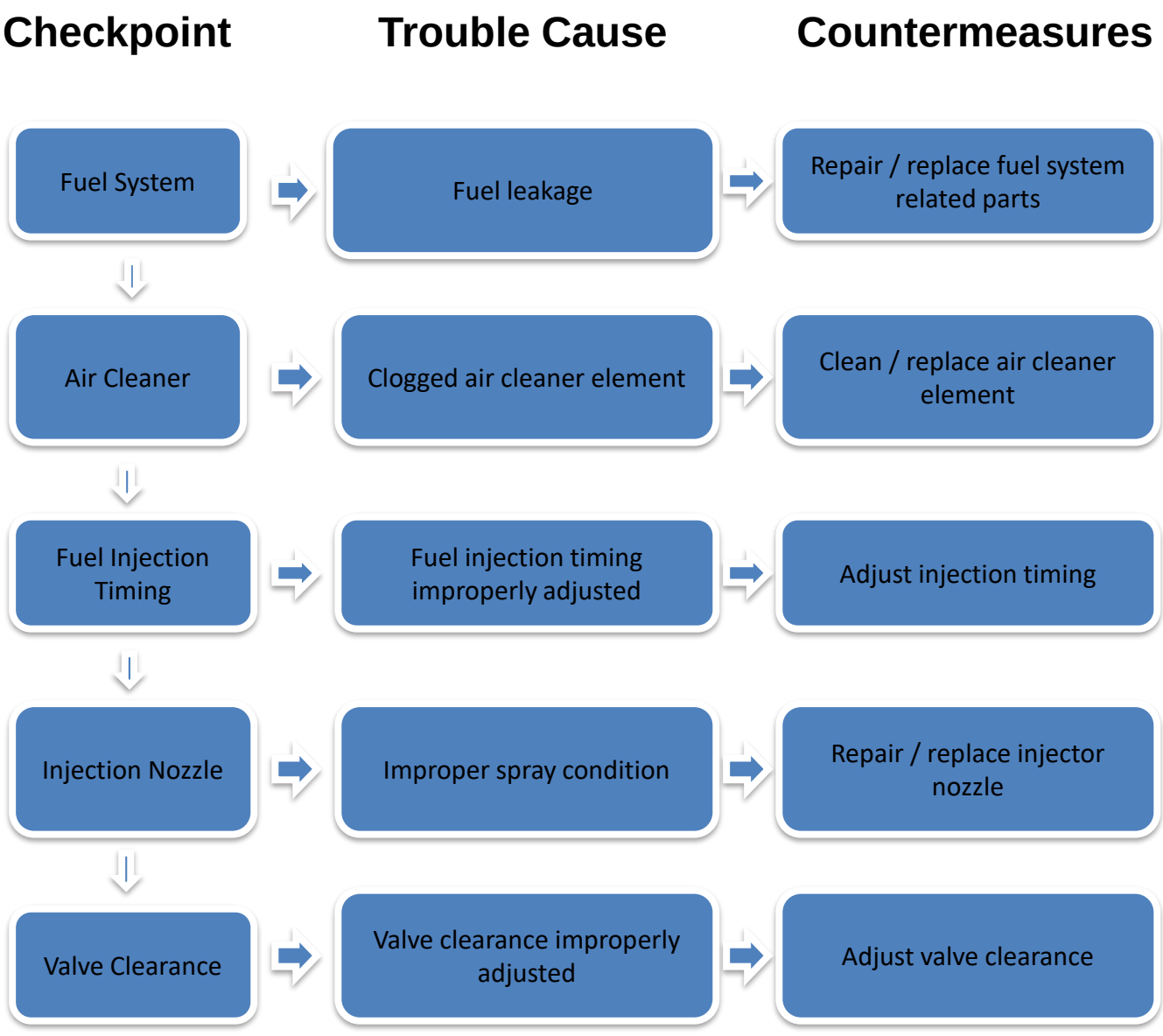


Troubleshooting

Fuel System

Troubleshooting

Problem: Excessive Fuel Consumption



The End