



Generator Set Operation and Maintenance Training

Agenda

- **Safety and warning label**
- **Engine System**
 - Operation
 - Preventive Maintenance
 - Common Problems and Troubleshooting
- **Generator Set**
 - System Operation
 - Generator Set Maintenance
 - Generator Set Troubleshooting /Diagnostics

Learning Objective

- **To provide fundamental knowledge and information in Generator Set System.**
- Safety and identify hazards in operating Generator Set;
- Explain the functions of Generator Set systems and components;
- Perform basic troubleshooting in the Generator Set;
- Proper operation of Genset BEFORE, DURING and AFTER Engine stopped;



Safety and Accident Prevention

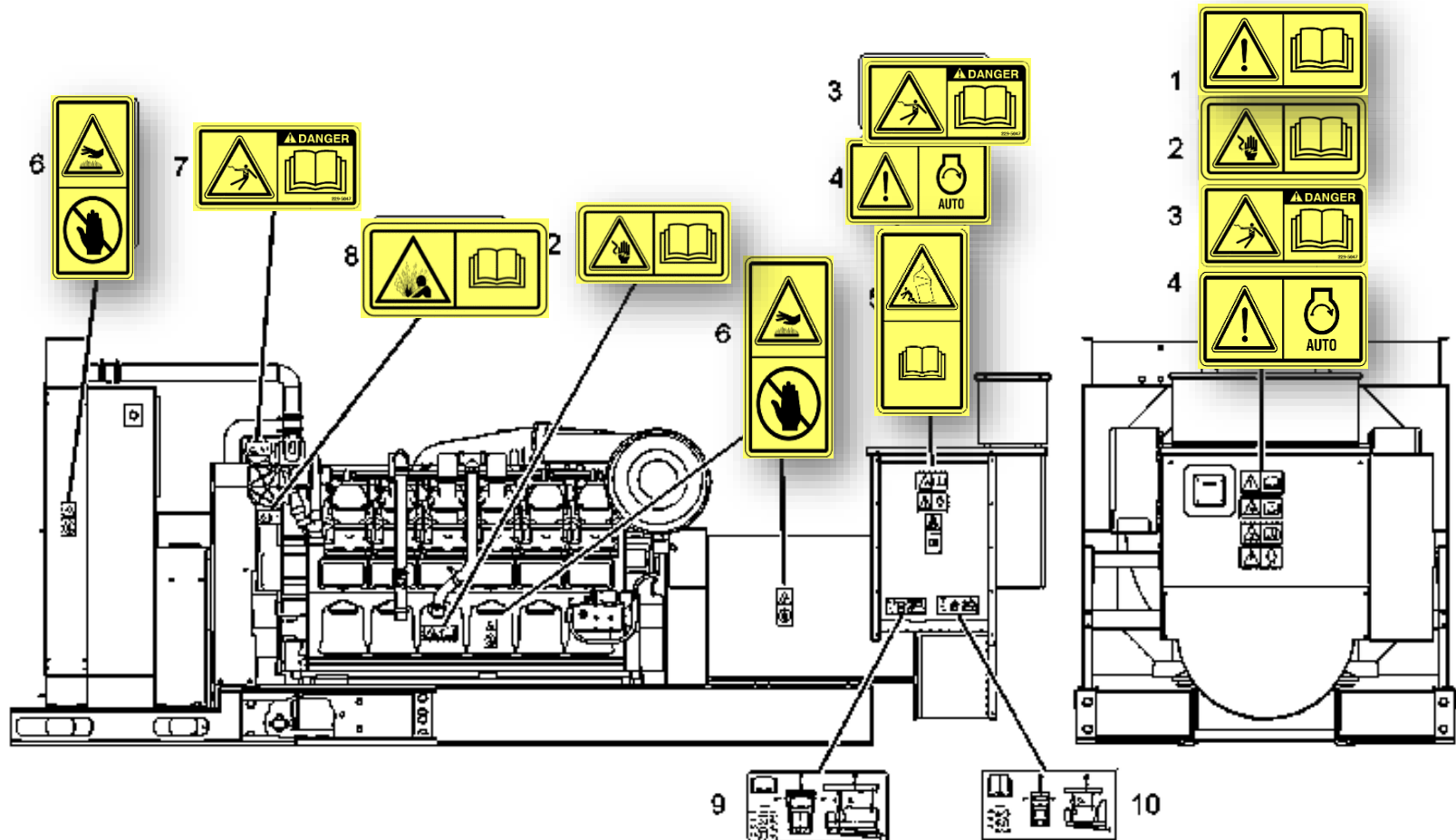
Personal Safety and Protection

Basic PPE's

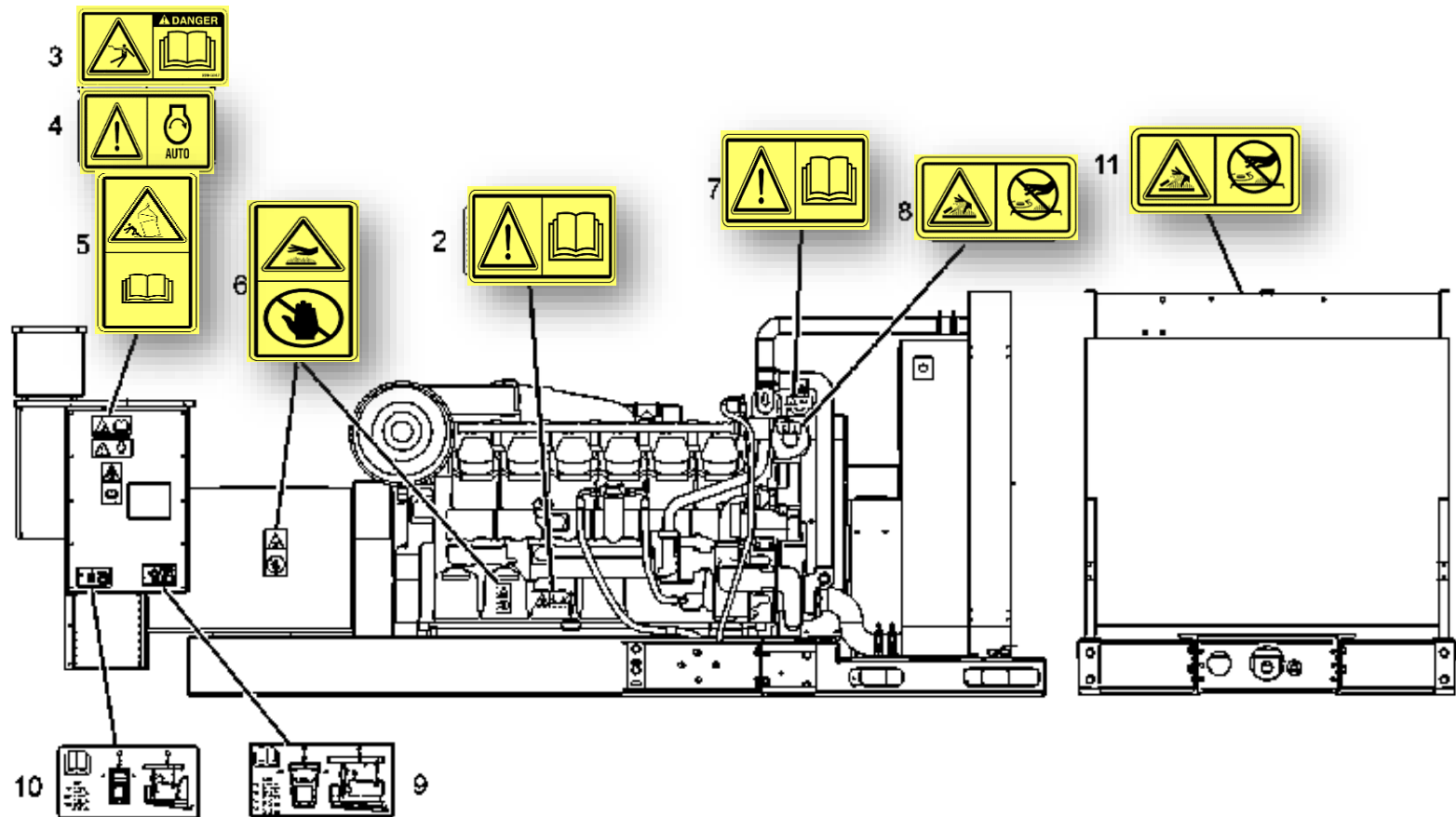
1. Hard Hat
2. Gloves
3. Safety Shoes
4. Arc Flash Protection
5. Hearing Protection



Safety /Warning Label



Safety /Warning Label



Warning label on the Genset



Caterpillar



MTU



Mitsubishi



Cummins



Perkins



Safety /Warning Label Messages



Universal Warning

Do not operate or work on this Engine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could result in injury or death. Contact any manufacturer for replacement manuals. Proper care is your responsibility.



Automatic Starting

When the Engine is in the AUTOMATIC mode, the Engine can start at any moment. To avoid personal injury, always remain clear of the Engine when the Engine is in the AUTOMATIC mode.

Safety /Warning Label Messages



Hot Surface

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.



Lifting the Genset

Crushing Hazard! Improper lifting could cause serious injury or death. Follow the lifting instructions in the Operation and Maintenance Manual for safe lifting procedures.

Safety /Warning Label Messages



Hot Fluid Under Pressure

Pressurized system! Hot coolant can cause serious burns, injury or death. To open the cooling system filler cap, stop the Engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.



Electrical Shock

WARNING! Shock /Electrocution Hazard! Read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could cause serious injury or death.

Safety /Warning Label Messages

Electrocution

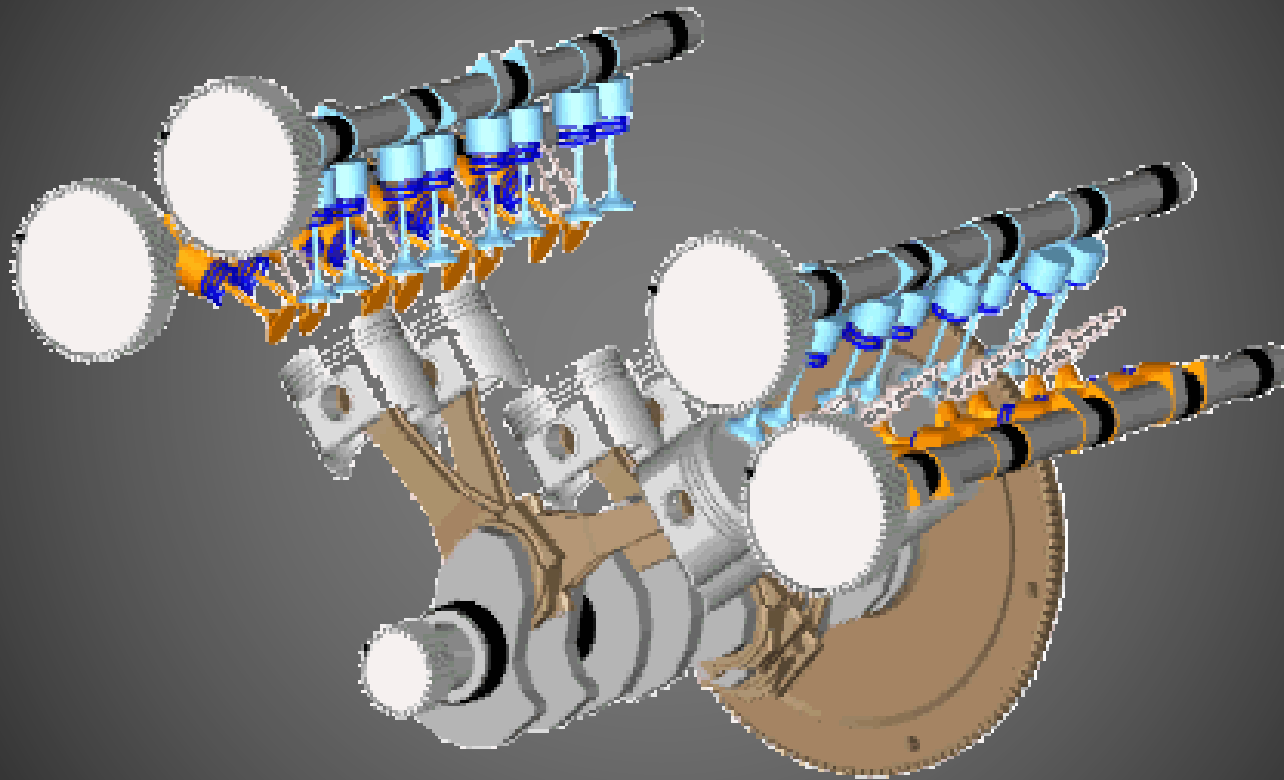


DANGER: Shock /Electrocution Hazard – Do not operate this equipment or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings will result in serious injury or death.



Vapor Explosion (Oil and Fuel Filters)

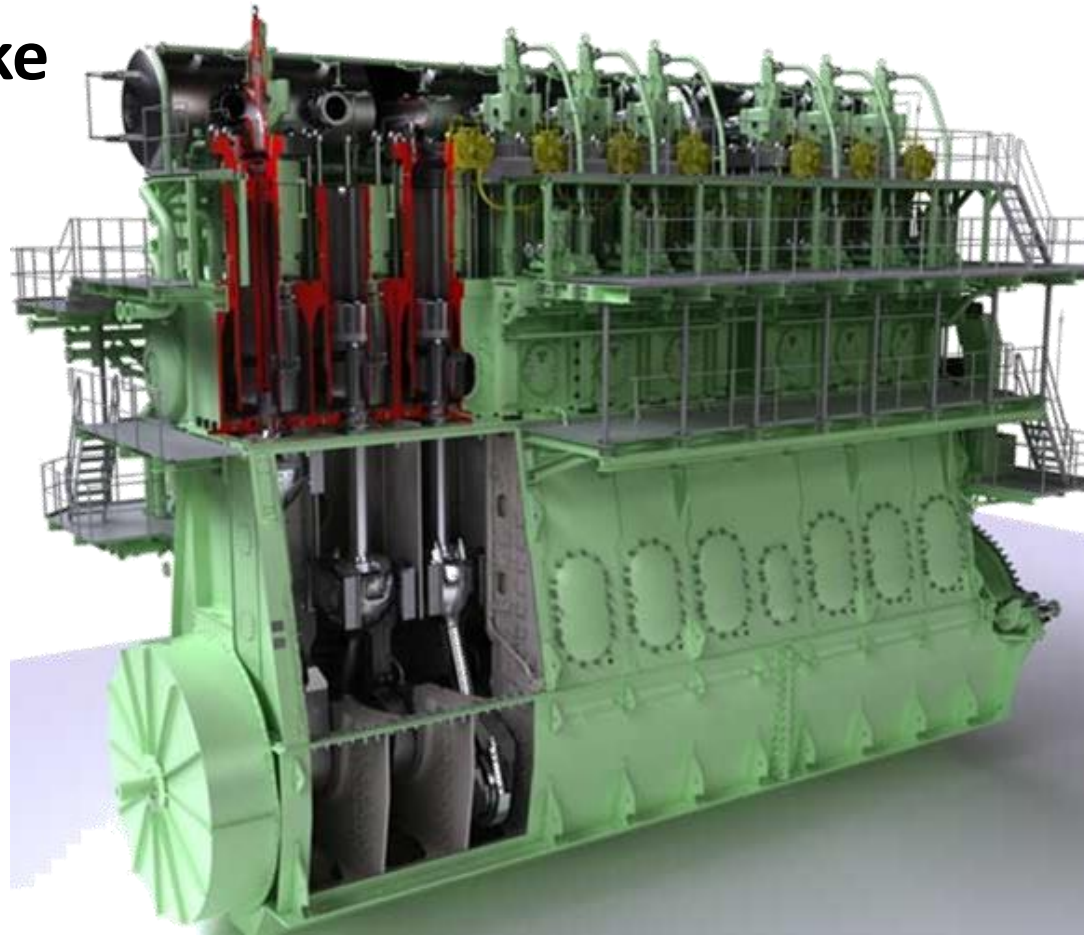
WARNING: Vapor Explosion. Could cause serious injury or death. Read the Operation and Maintenance Manual before conducting any maintenance on the duplex oil or fuel Filters.



Engine System

Designed and Major Systems

- Common Engine Terms
- Combustion and 4 stroke
- Engine Works & Wears
 - Wear and Tear
 - Combustion Process
- Emission Regulation

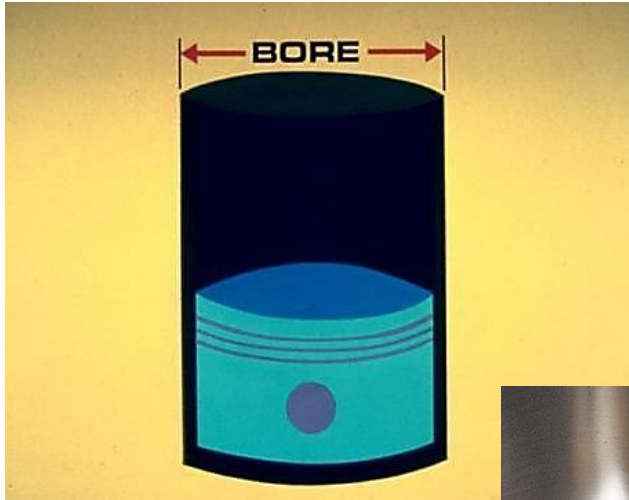


Common Engine Terms

- Bore
- Stroke
- Compression Ratio
- Displacement
- Horsepower



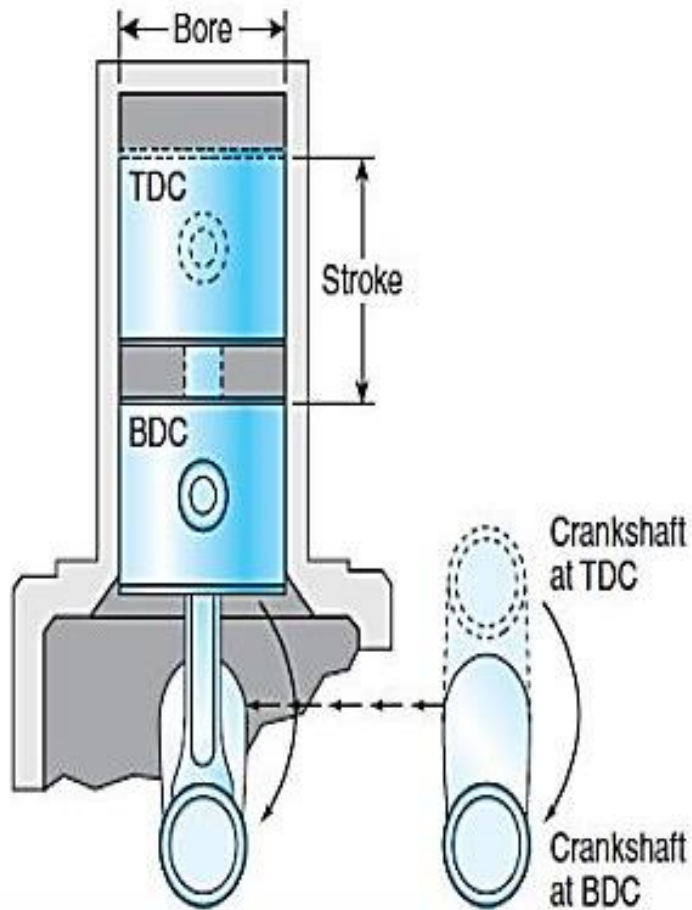
Bore Size



- The diameter of the cylinder
- Measured in inches or millimeters

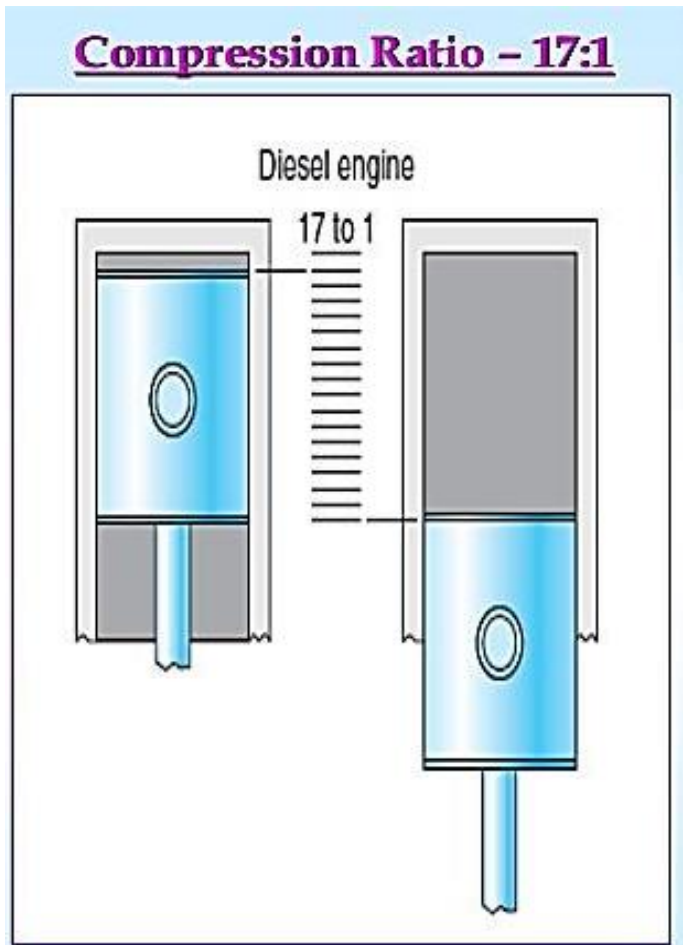


Stroke



- Movement of piston from TDC-BDC
- How far the piston moves from TDC to BDC
- Equal to twice the crank radius

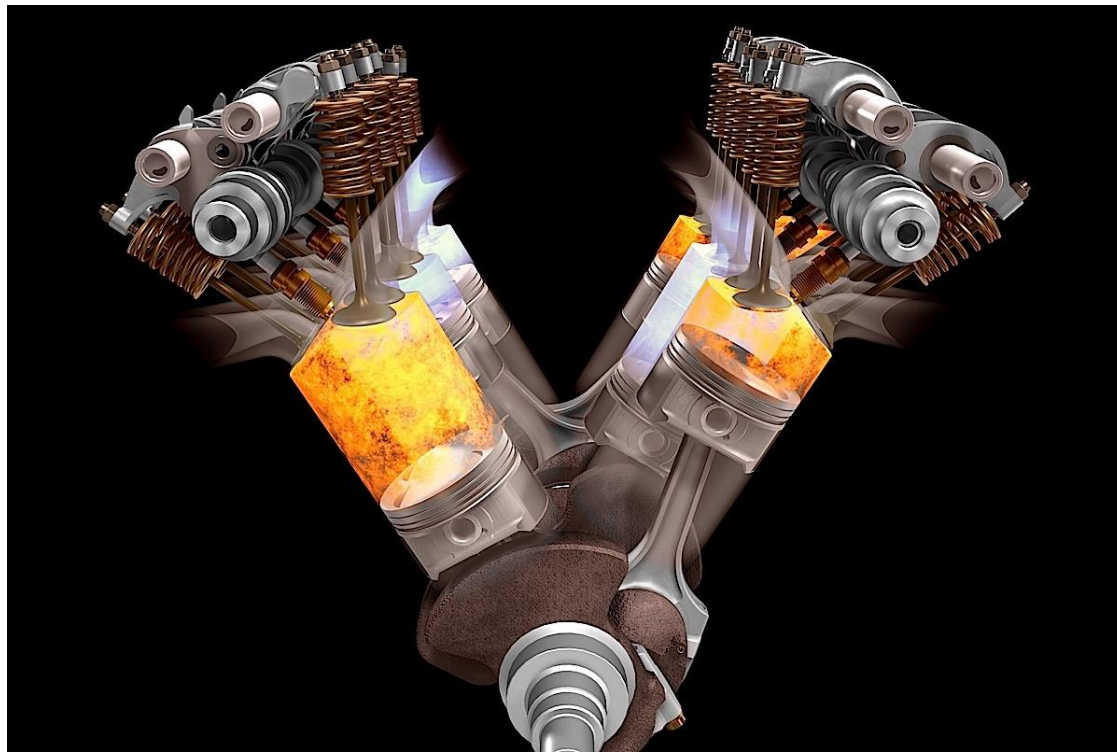
Compression Ratio



- Ratio between the cylinder volume with the piston at BDC and the volume with the piston at TDC
- Compression ratio of our engines are approximately a 14:1 (MECHANICAL) and 17:1 (ELECTRONIC)

Displacement

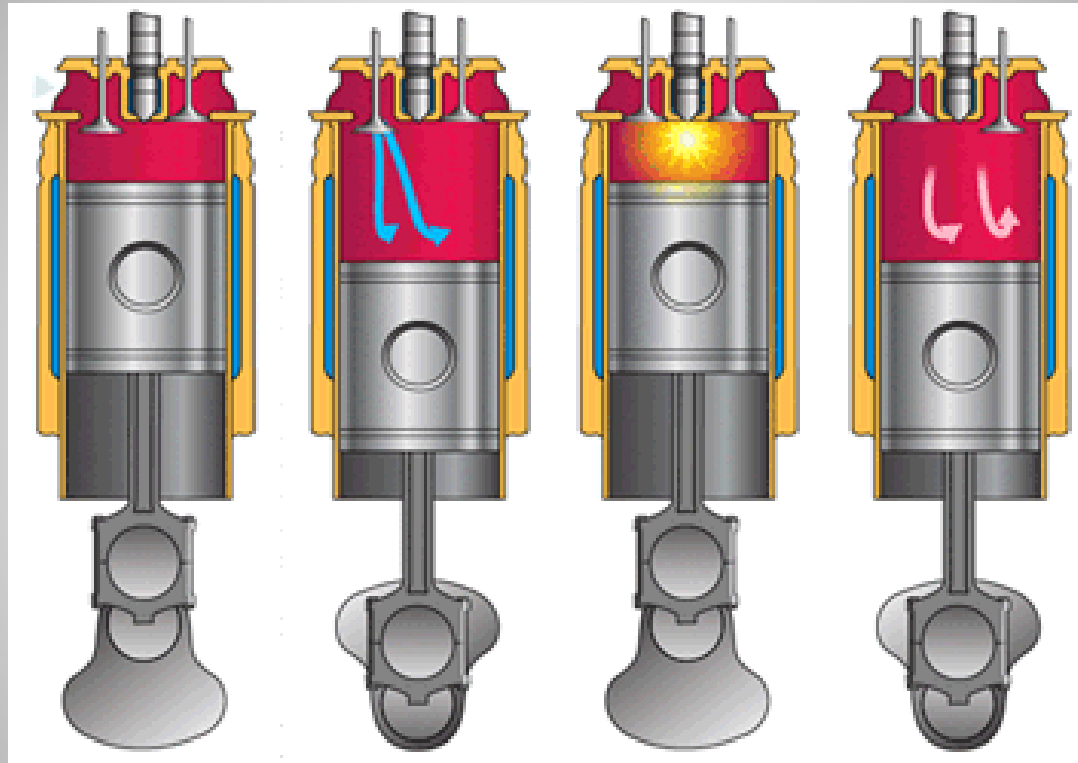
is the swept volume of all the pistons inside the cylinders of a reciprocating **engine** in a single movement from top dead center (TDC) to bottom dead Centre (BDC)



Horsepower

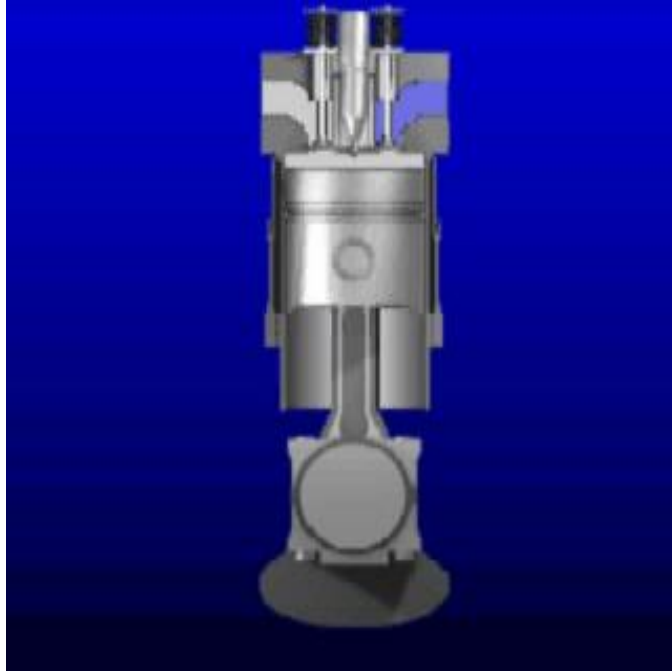
- Horsepower is the **RATE OF DOING WORK** (how quickly a force is applied through a distance)
- Horsepower can be expressed in pound feet per second
- 1 horsepower = 550 lb/ft per second
= 33,000 lb/ft per minute



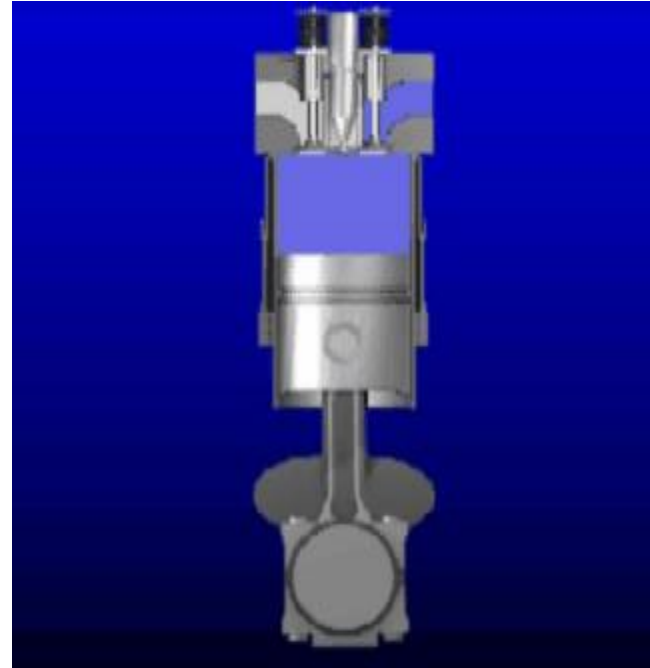


Engine Combustion Process

The Combustion Process – 4 Stroke Cycle

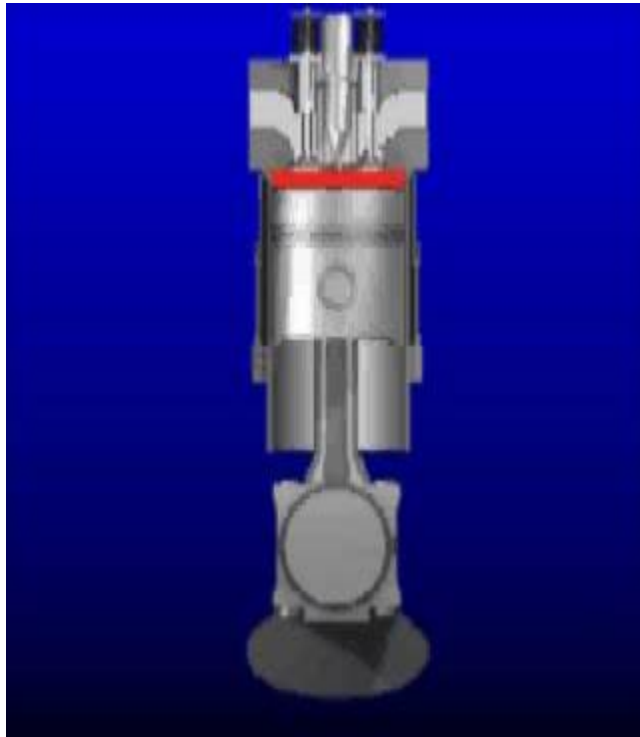


Intake

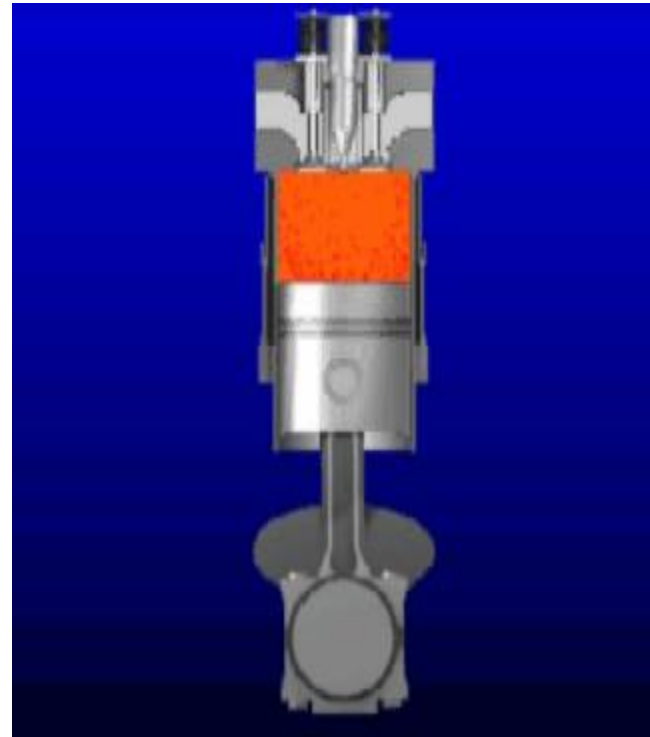


Compression

The Combustion Process – 4 Stroke Cycle

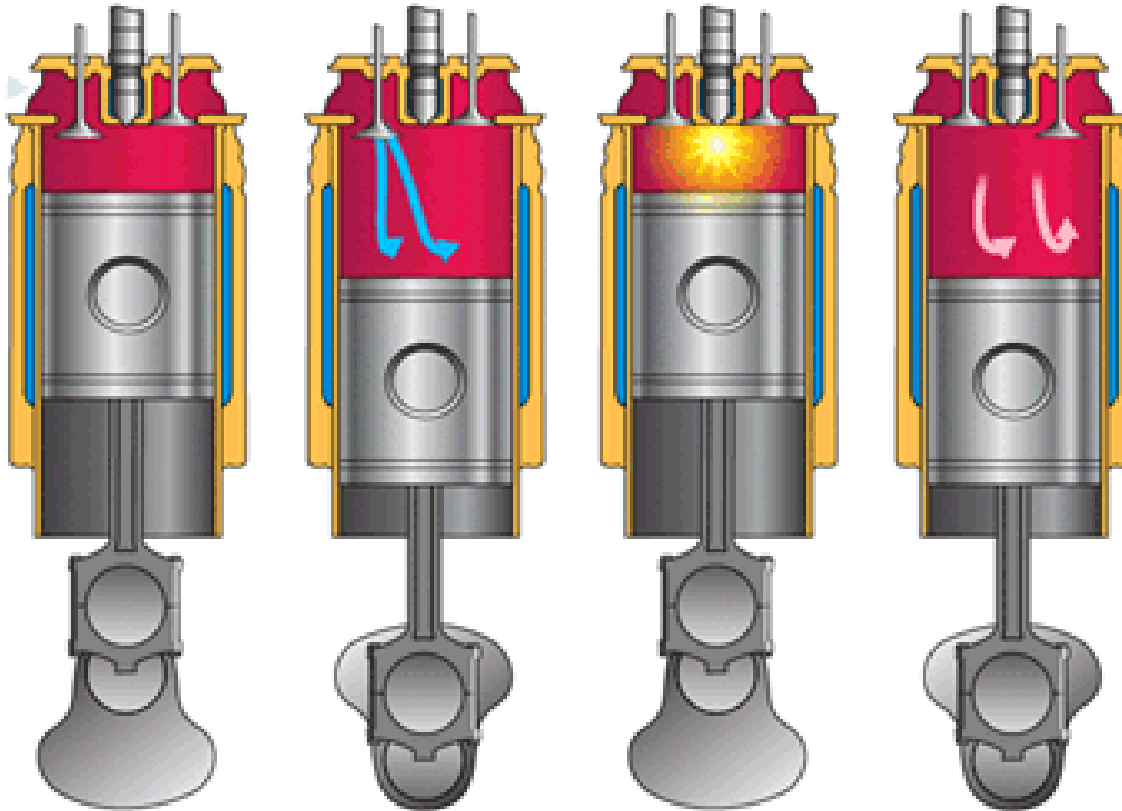


Power



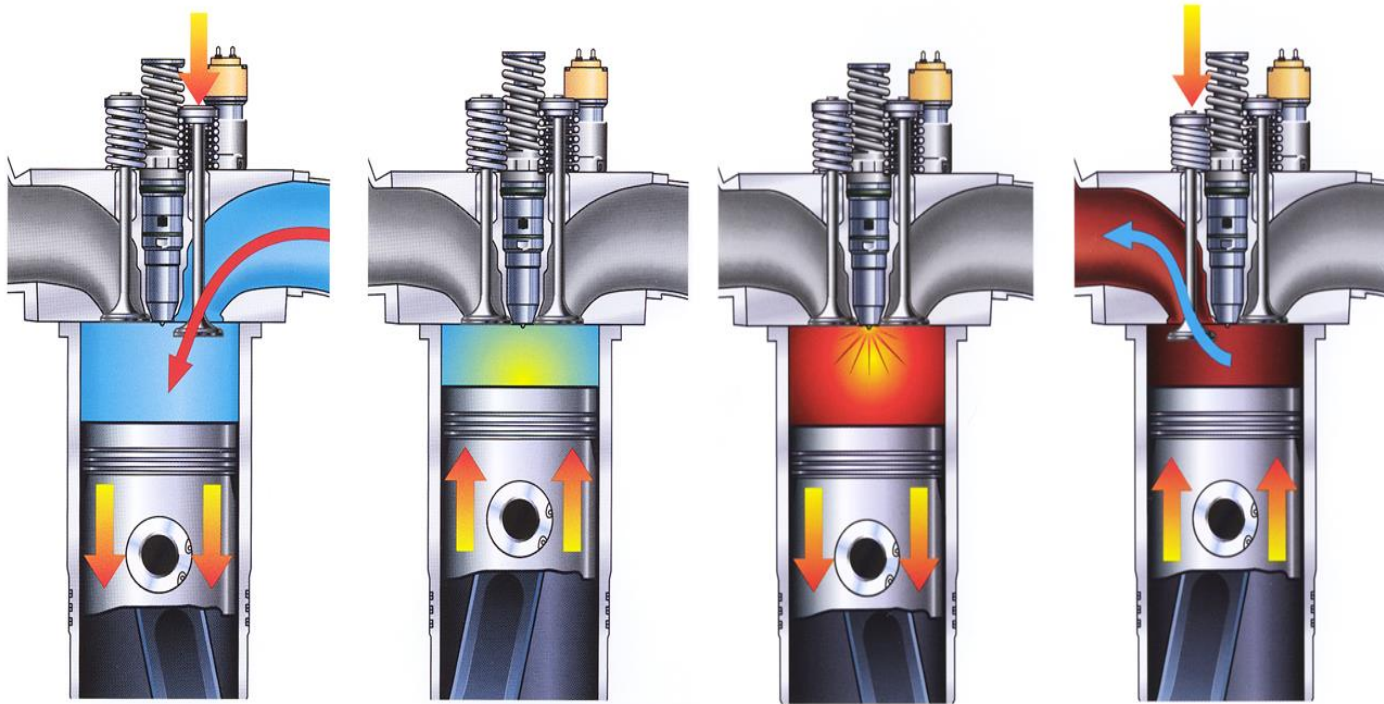
Exhaust

4 Stroke Cycle

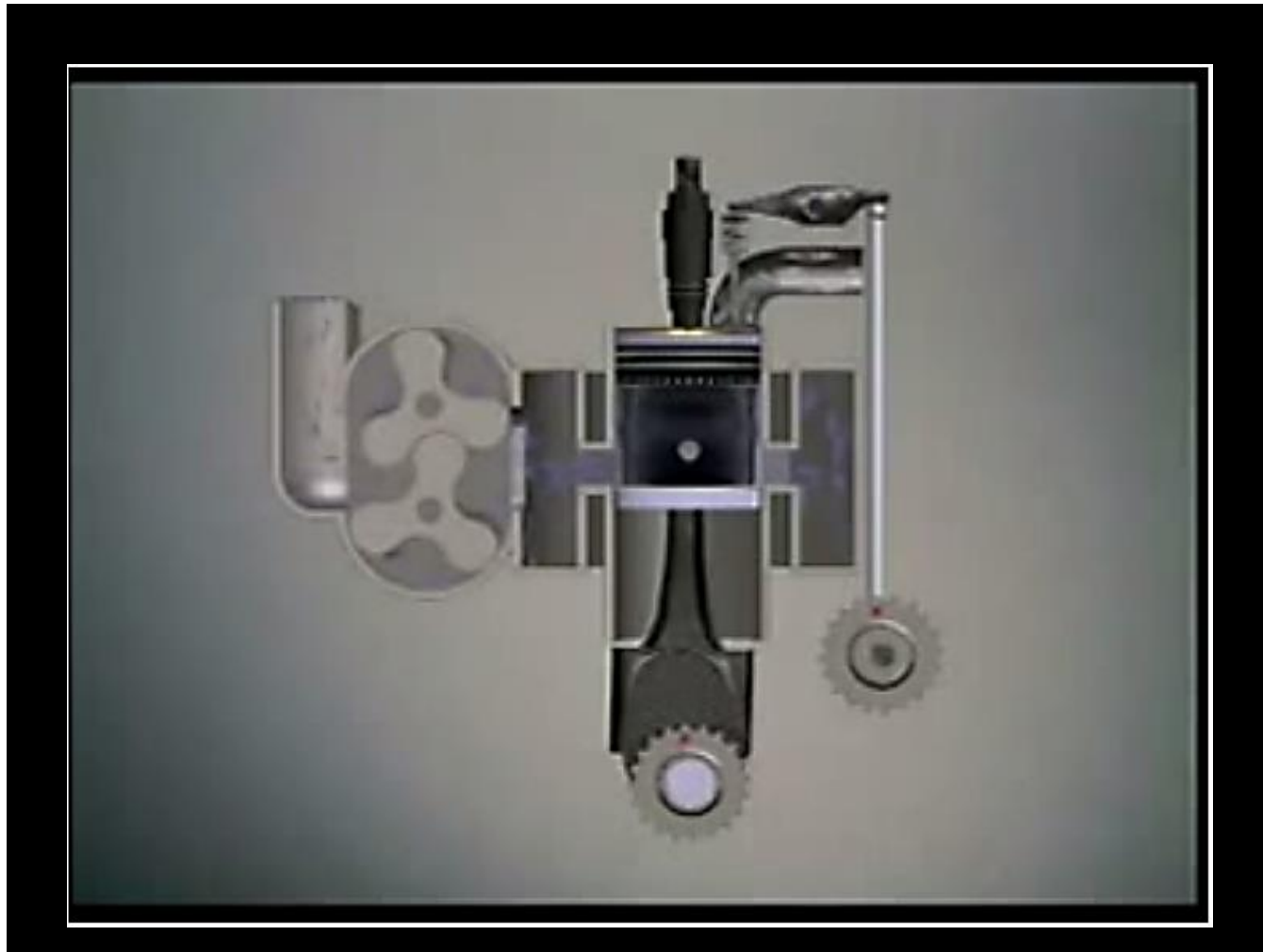


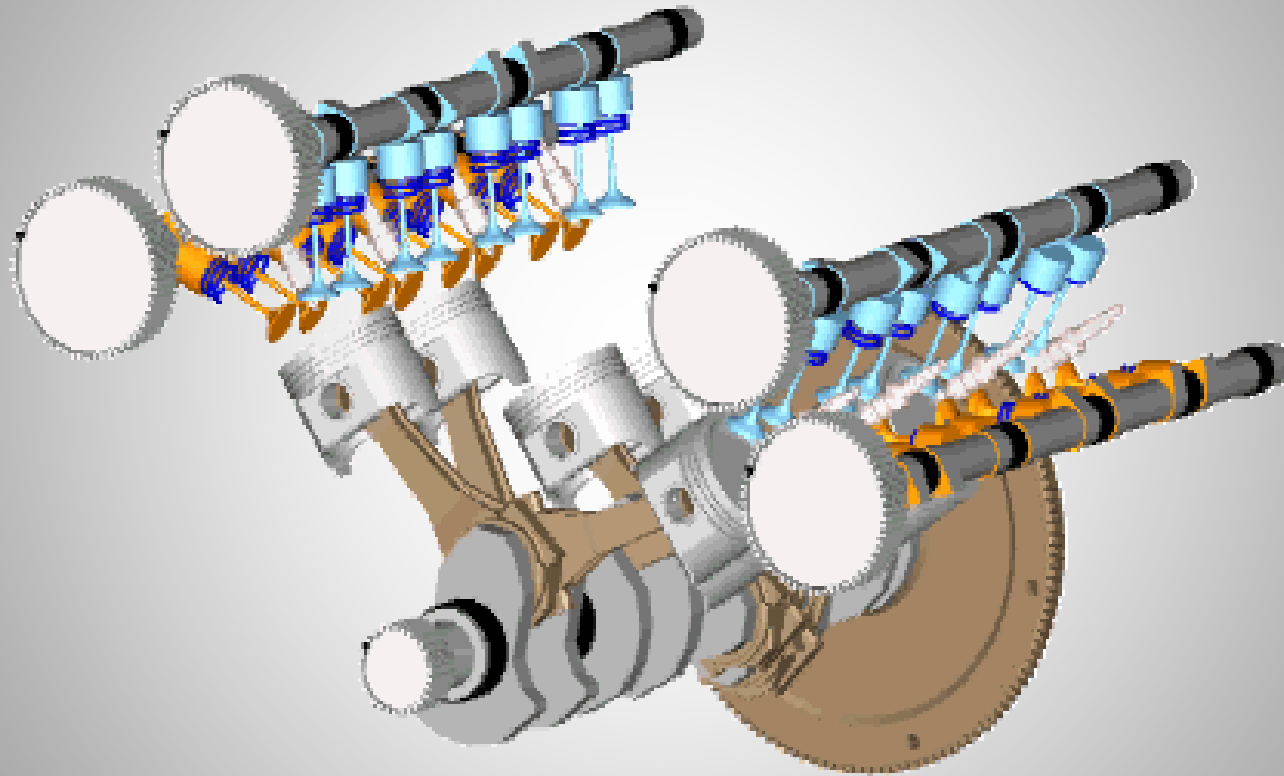
4 stroke cycle engine

The Combustion Process – 4 Stroke Cycle



2 stroke cycle engine





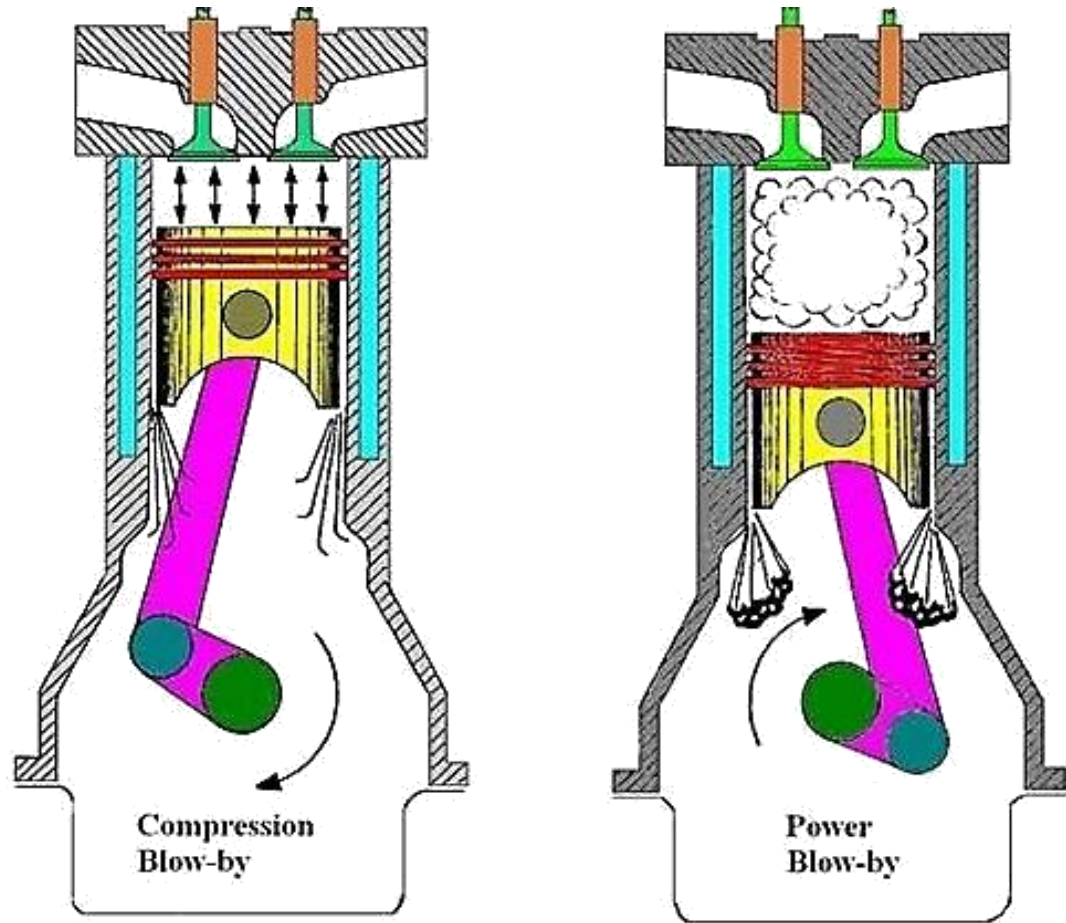
Engine Wear and Tear

Engine Wear and Tear

- Description of Wear
 - Contact
 - Pressure
 - Relative Motion
- Normal & Abnormal wear
- Major wear items
 - Cylinder liners
 - Seals & gaskets
 - Piston rings
 - Turbo bearings and seals
 - Valves, guides, and seats
 - Main and rod bearings

Oil Consumption and Blow-by

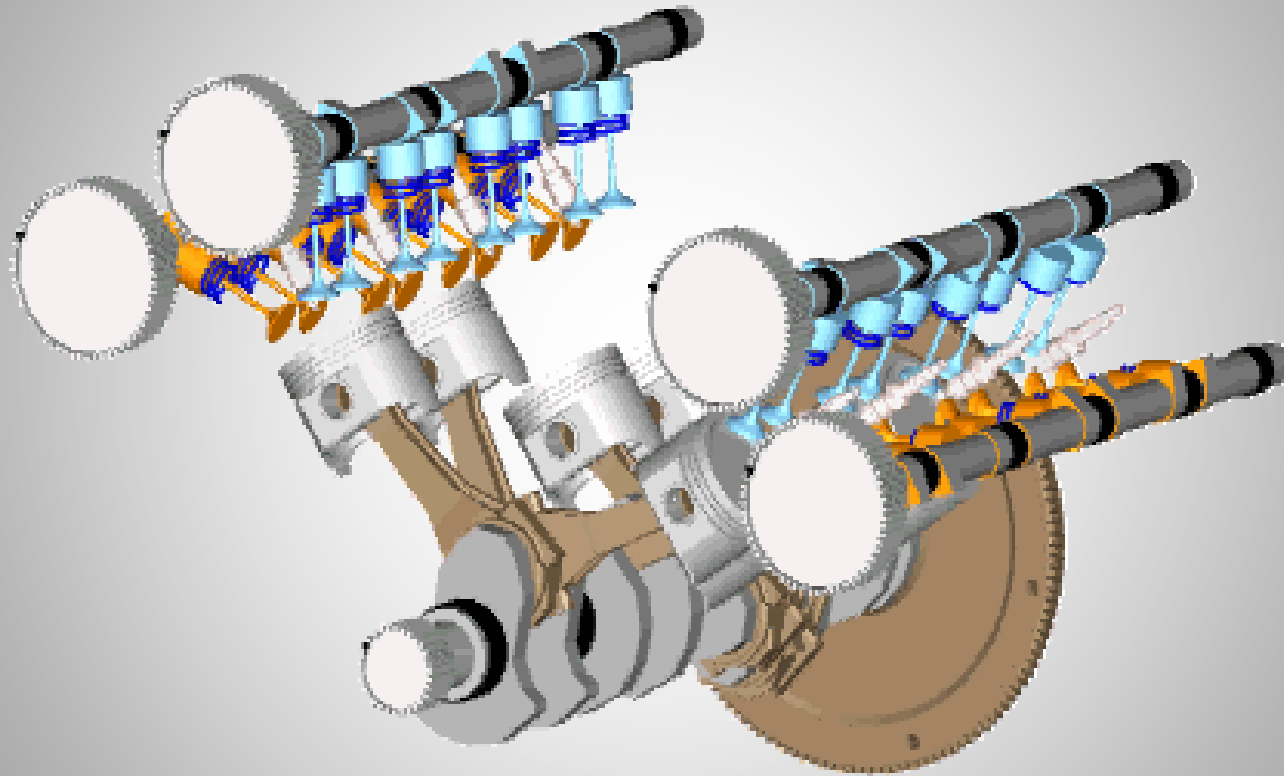
- Low power
- High Oil consumption
- High amount of soot in the oil.



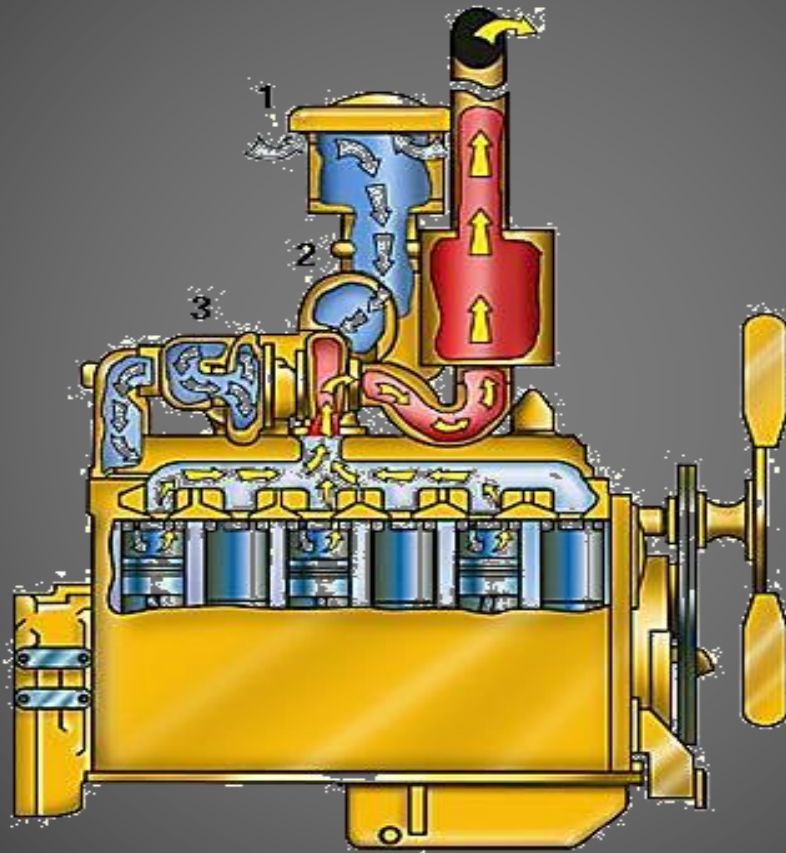
Emission Regulations Standards

- PM
- CO
- NO_x
- Sulfur





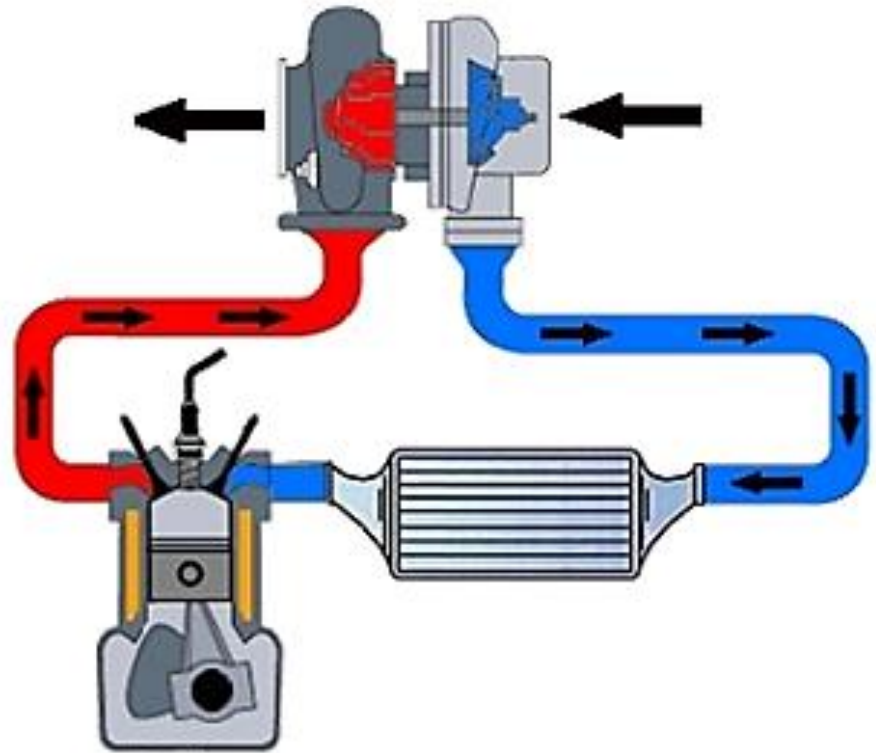
MAJOR ENGINE SYSTEM



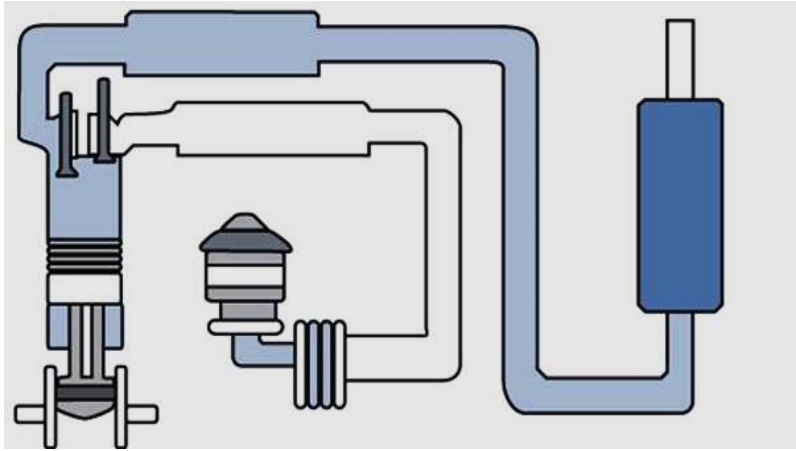
Air Intake & Exhaust System

Air Intake & Exhaust System Functions

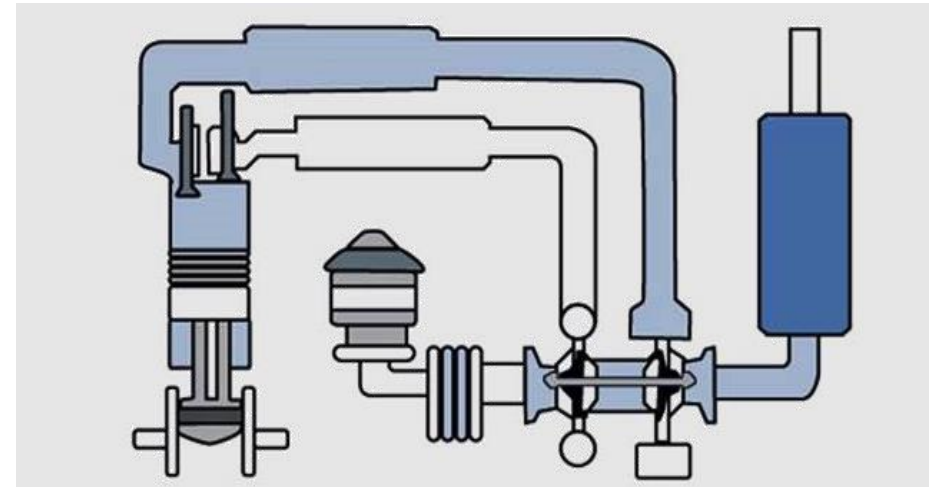
- Provide adequate quantities of clean filtered intake air
- Compresses and Boost the intake air into the cylinders in order to produce more power
- Removes exhaust gases and reduces exhaust noise



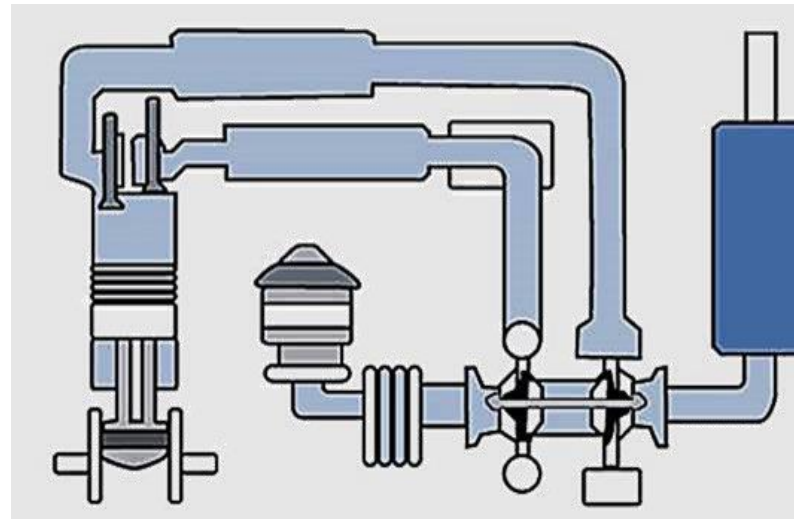
Air Intake & Exhaust System Types



**Naturally Aspirated/ Old
System**



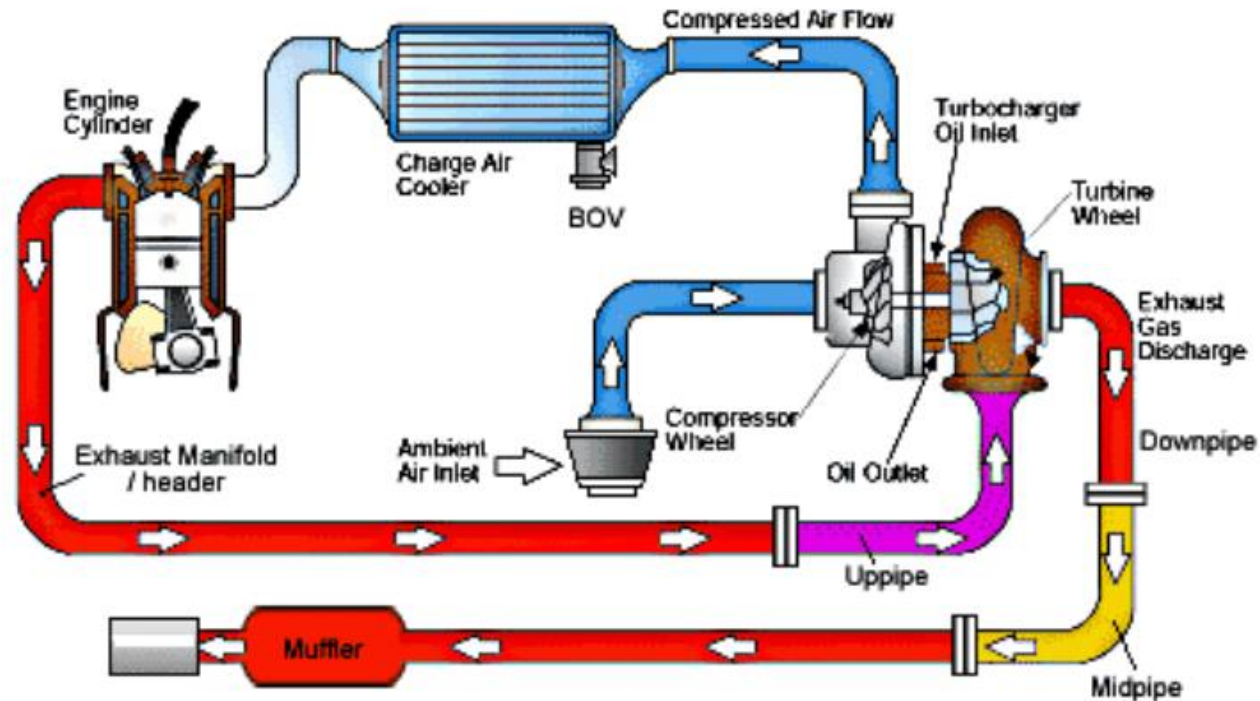
**Turbo Charged Air
System**



Turbocharged Intercooled

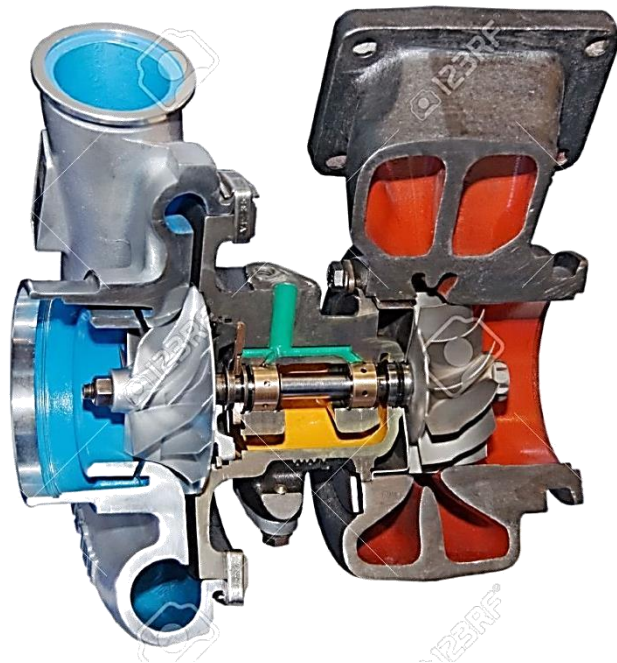
Air Intake & Exhaust System Operations

1. Pre Cleaner
2. Air Filter /Cleaner
3. Turbocharger
4. After cooler
5. Intake Manifold
6. Combustion Chamber
7. Exhaust Manifold
8. Muffler
9. Exhaust Stack

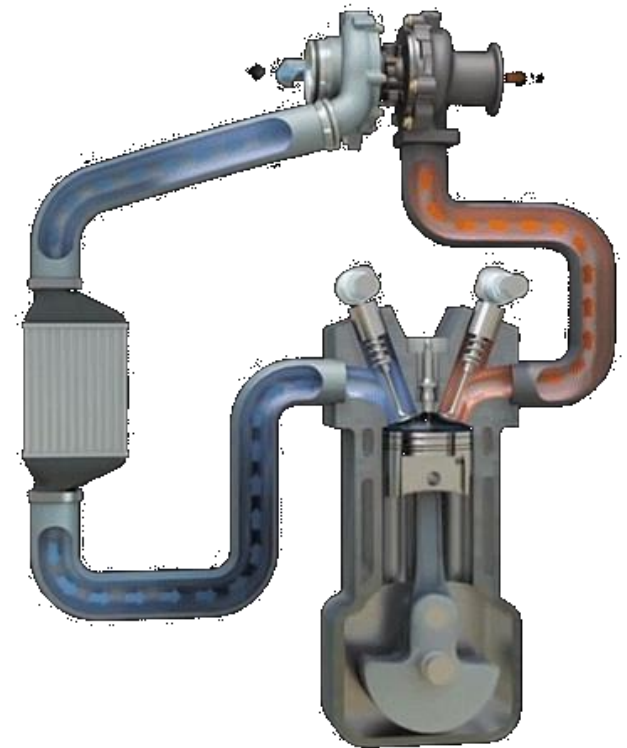


Air Intake & Exhaust System Component

Turbocharged Intercooler



- Boost/ increase Amount of Air
- Maintain amount of air at High Altitude



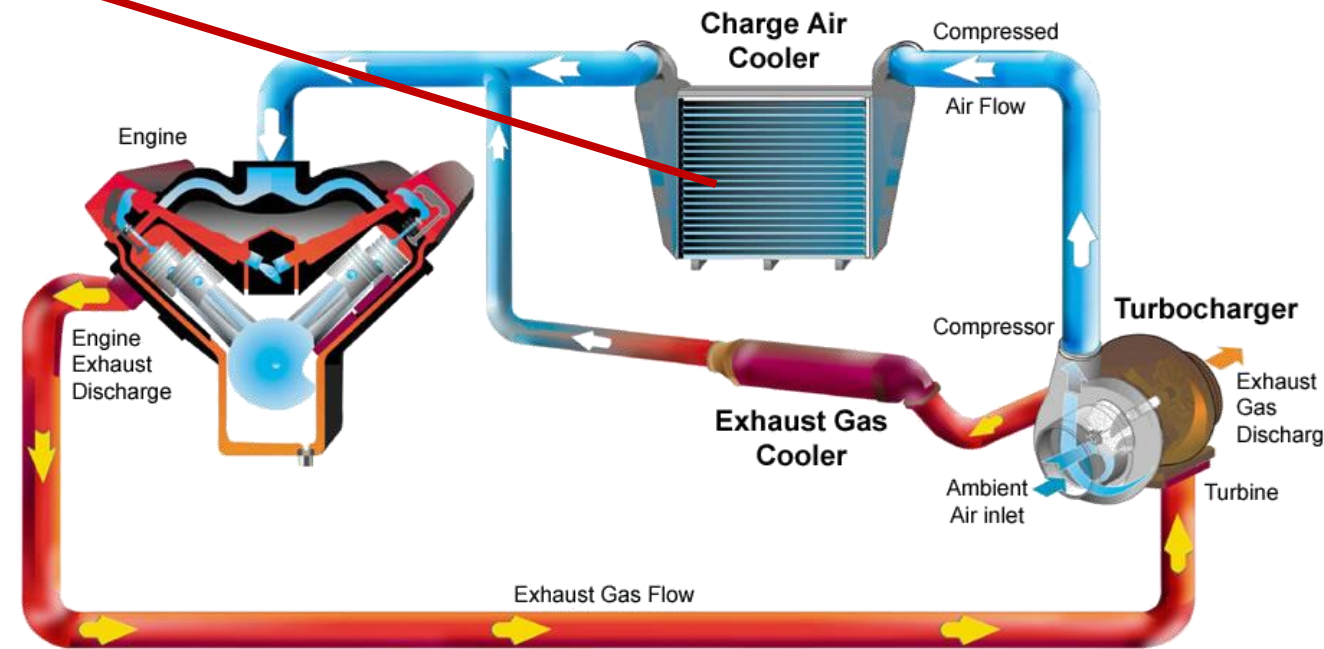
- Cools the compressed air by turbocharger

Air Intake & Exhaust System Component



AFTER COOLER

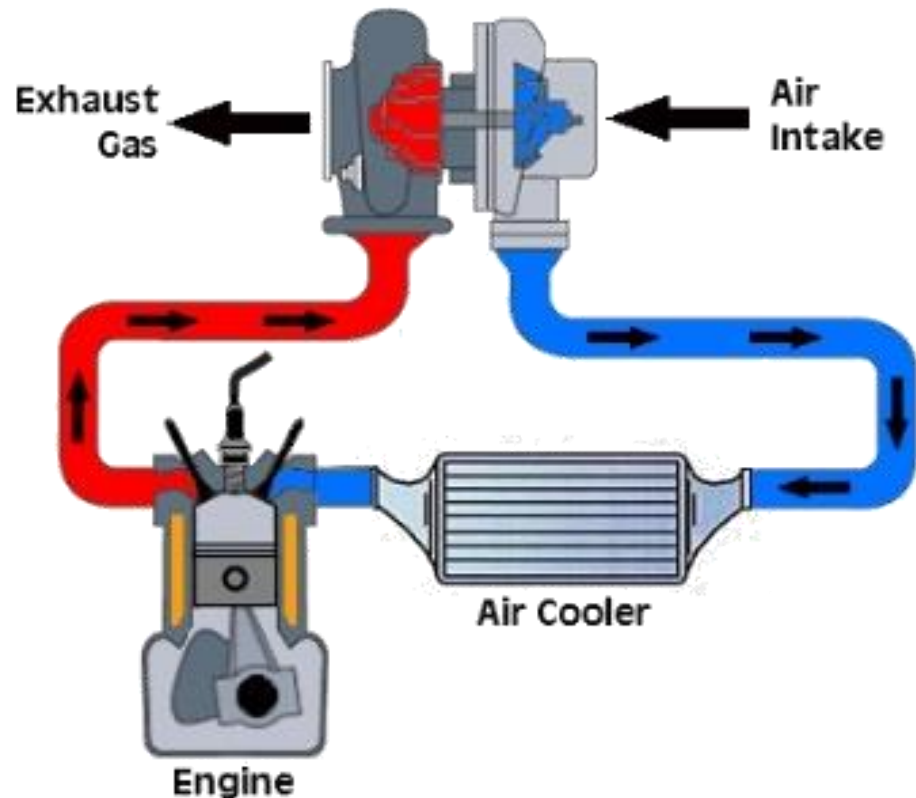
-Cools the compressed air.



Air Intake & Exhaust System Condition

Effects of restriction in intake and exhaust System

- Low power
- Overheating



Common problem

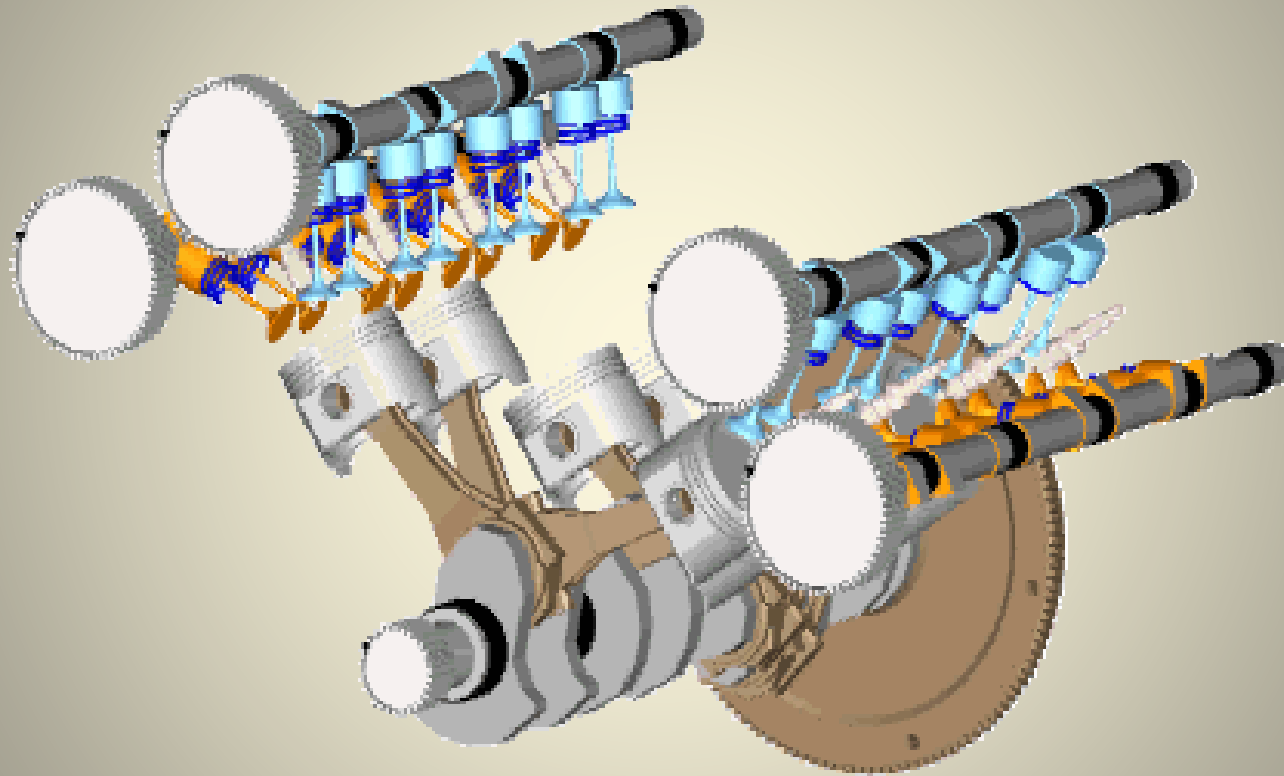
- **Dust Ingestion**

- Causes accelerated abrasive wear of Piston Rings and Cylinder Liners
- Most often caused by inlet leaks around flexible joints in air inlet piping
- May also be caused by defective /damaged Air Filters, or poor maintenance practices

Air Inlet & Exhaust System Maintenance

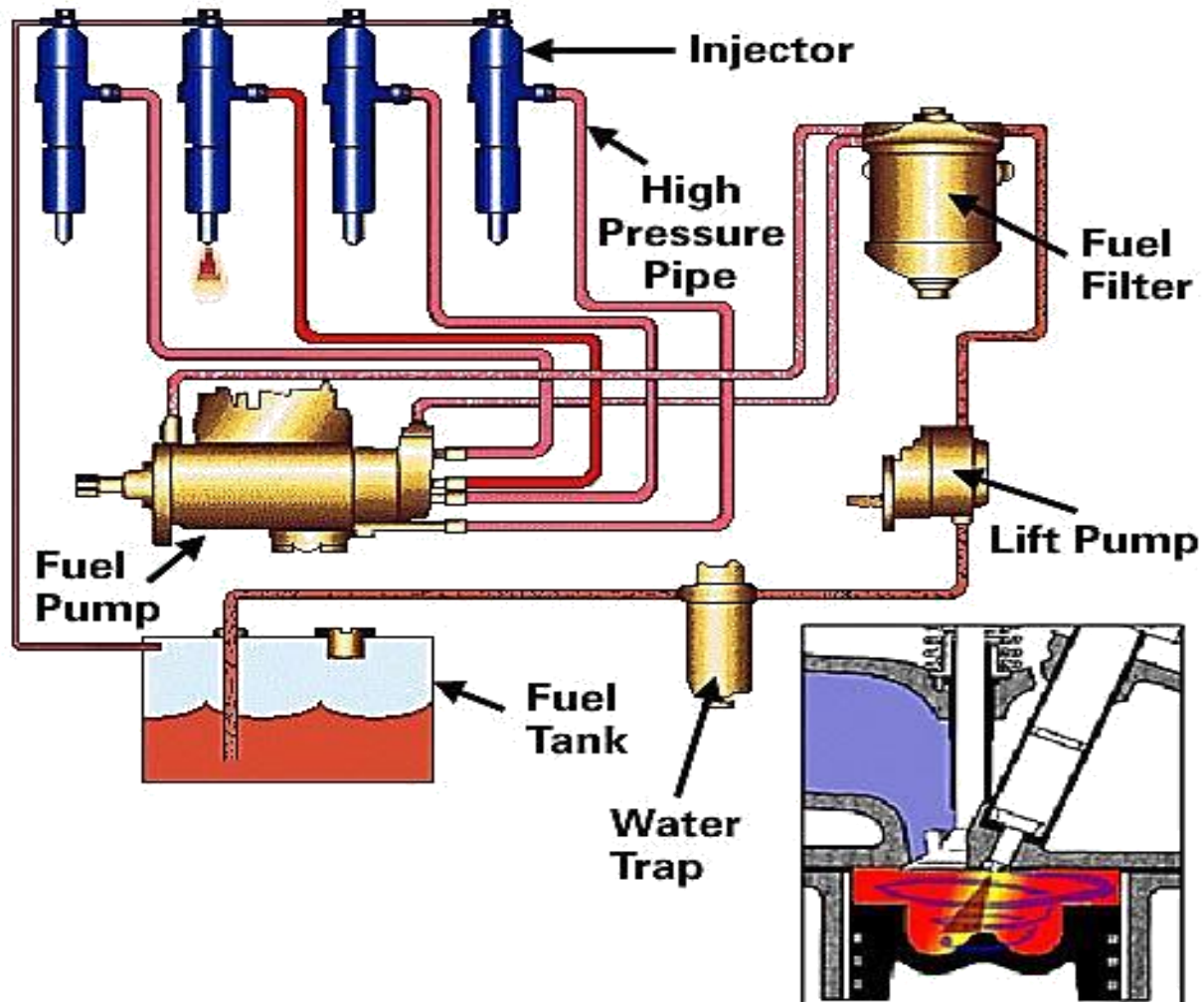
Air System Maintenance:

- Check Pre cleaner
- Check Piping, Hoses and Clamps
- Check /Clean air filter with low pressure air (30 psi)
- Inspect for damages/holes
- Replace yearly or after 6 times of cleaning (necessary)
- Drain exhaust muffler (drain pipe with valve)
- Check tail pipe flapper



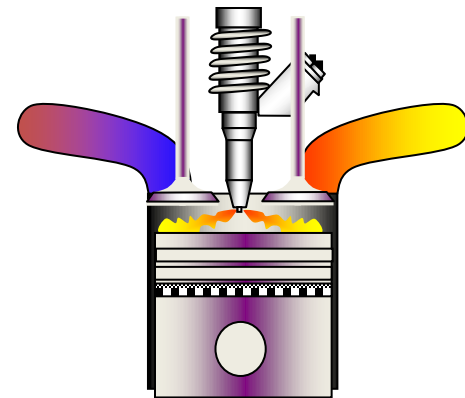
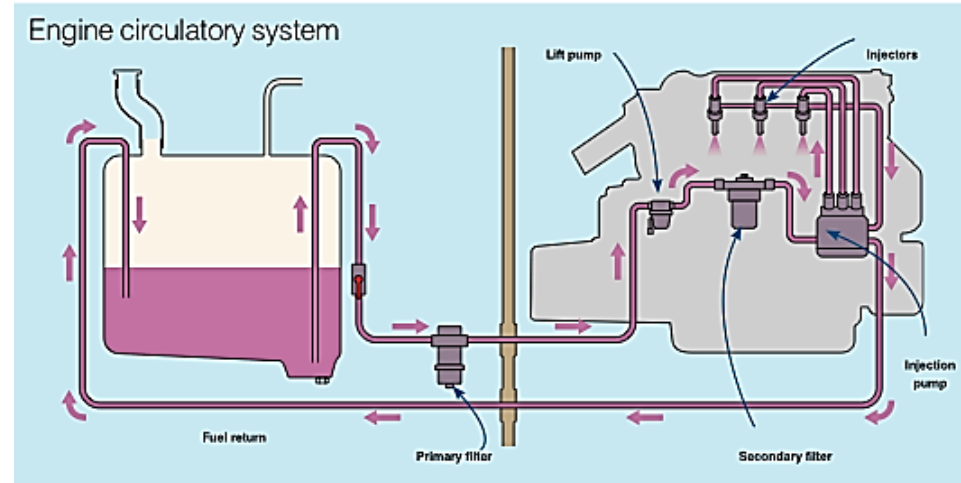
Engine Fuel System

Fuel Delivery



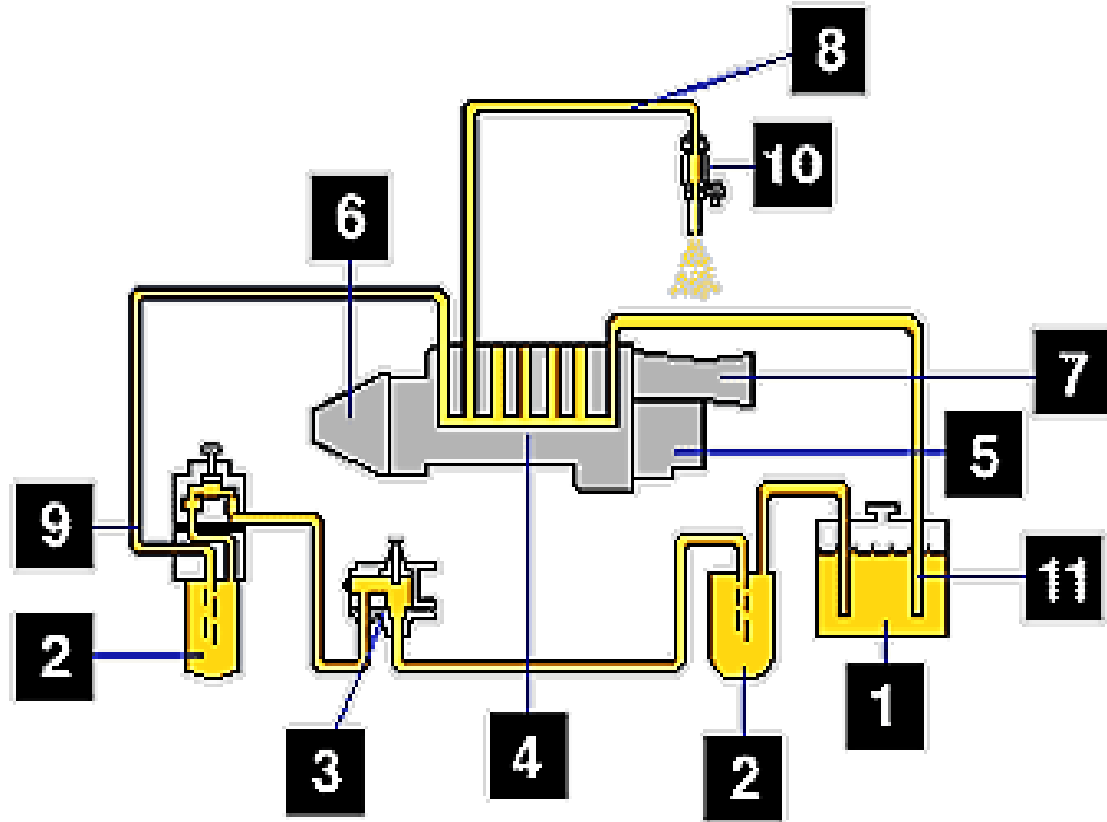
Function of Fuel System

- Meters the amount of fuel to achieve desired power
- Regulates Engine speed and timing sequence
- Helps controls emissions



Mechanical Fuel System

1. Fuel Tank
2. Fuel Filters
3. Transfer Pump
4. Injection Pump
5. Governor
6. Timing Advance Mechanism
7. Fuel Ratio Control
8. High Pressure Fuel Lines
9. Low Pressure Fuel Lines
10. Nozzles
11. Return line

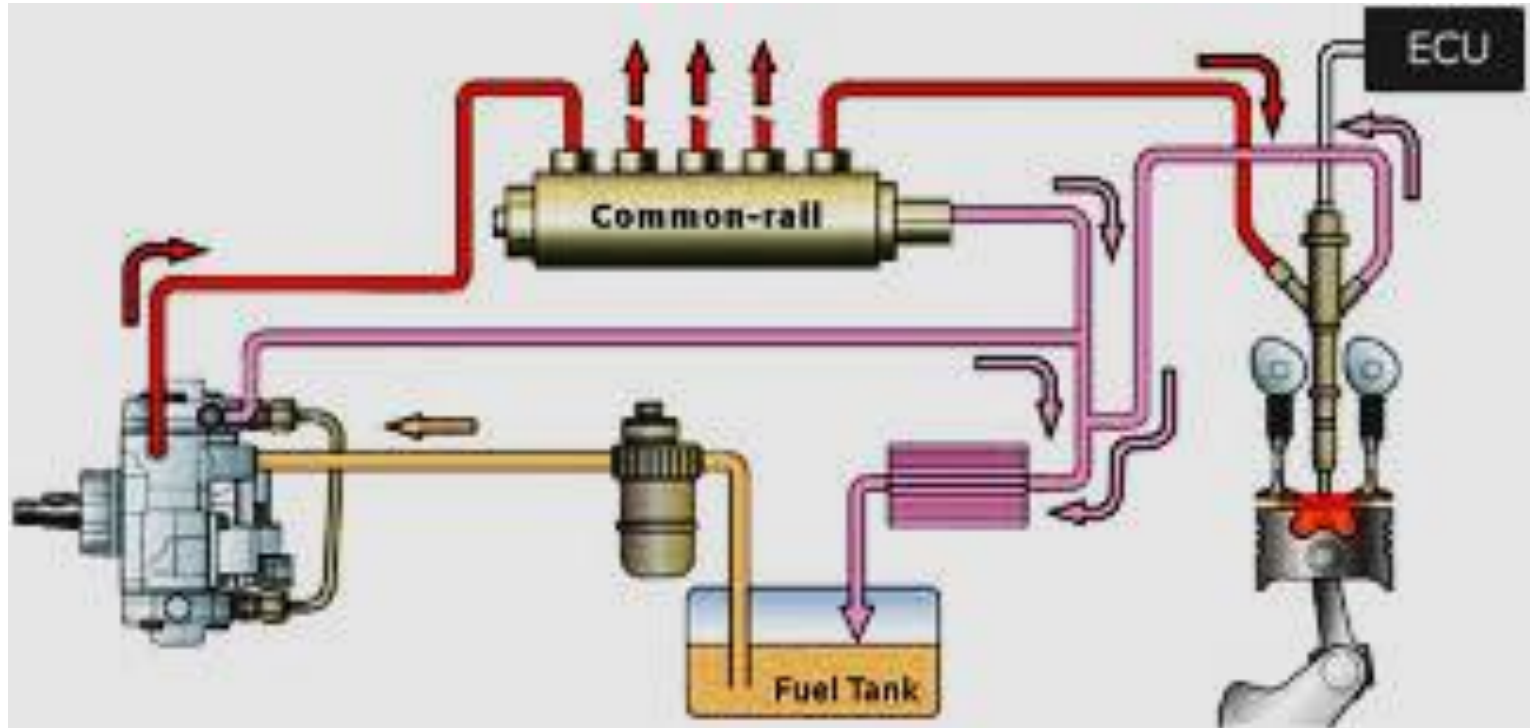


Source: Caterpillar Fuel System



Source: Caterpillar

Common Rail Fuel System

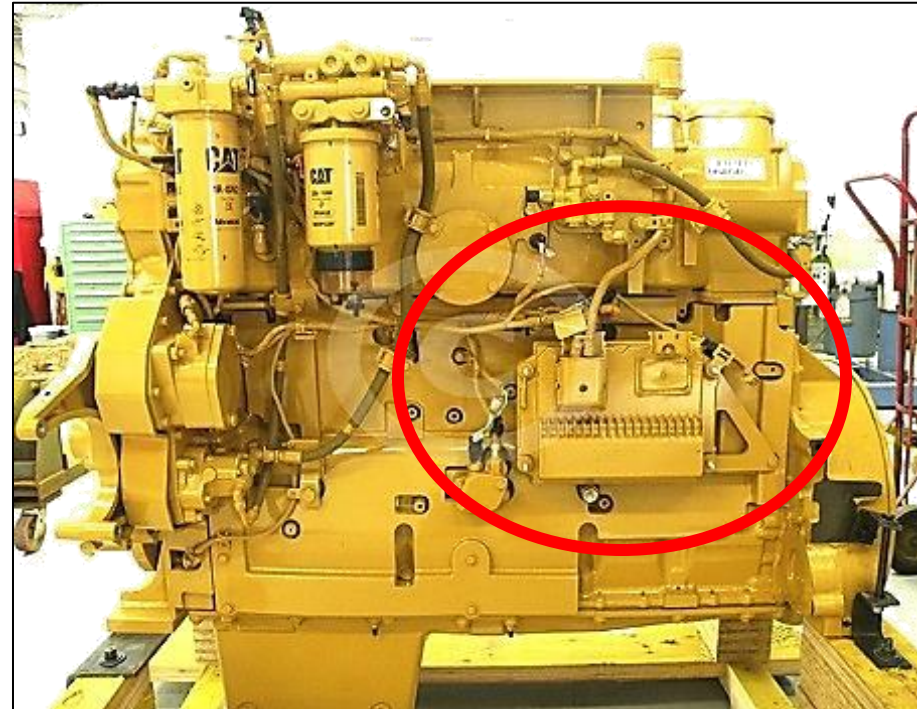


Mechanical VS. Electronic

Mechanical Governor



Electronic Governor



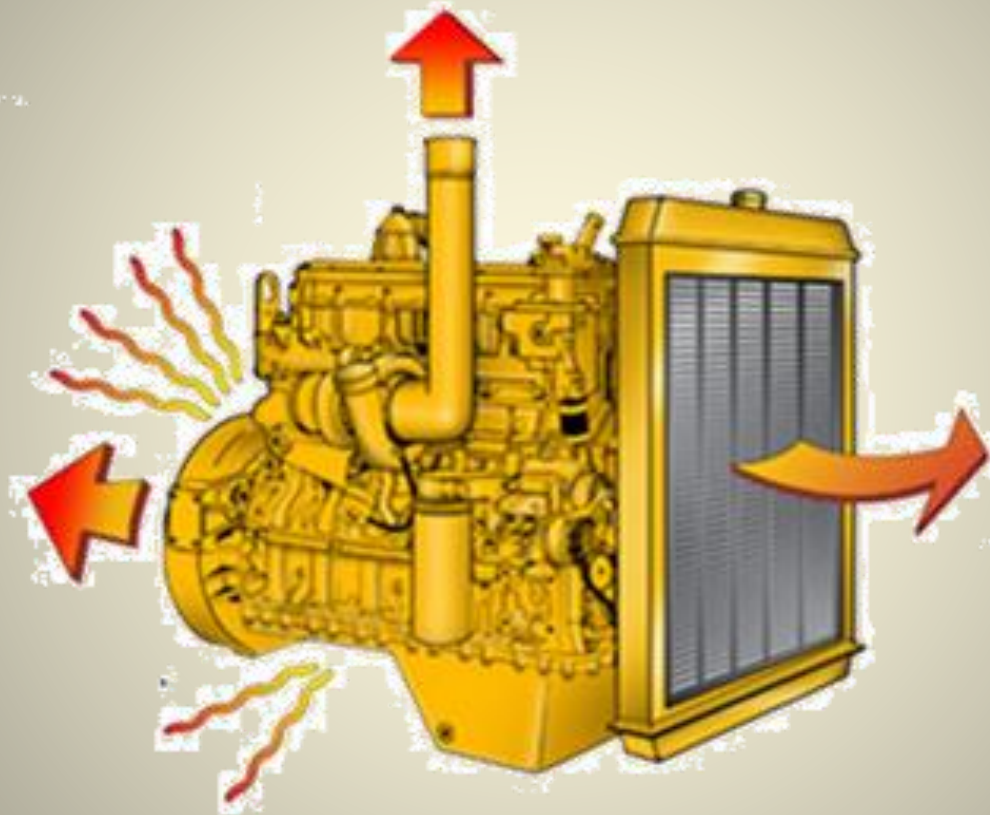
Fuel System Regular Maintenance

- **If necessary**
 - Prime Fuel System
- **Weekly**
 - Drain Water from water Separator
- **Based on Operation Manual**
 - Inspect fuel nozzle or injector
- **Yearly**
 - Replace Primary Fuel and Secondary Fuel Filter.
 - Drain fuel storage tank and Fuel day Tank.

Fuel System Maintenance

Other Maintenance Tips:

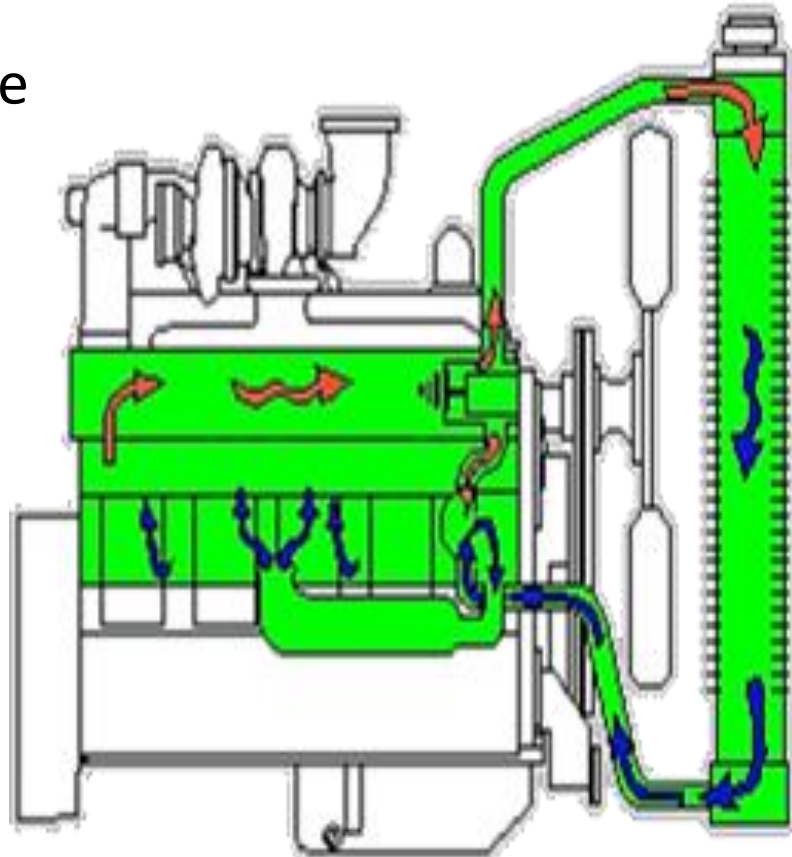
- Buy clean fuel
- Keep it clean
- Drain water and sediments from fuel tanks
- Fill the tank at the end of the day



ENGINE COOLING SYSTEM

Function of Cooling System

- Helps to easily heat ups engine
- Maintain proper engine temperature for optimum performance
- Removes excess heat from other engine system.
- Cools compressed inlet air to improve combustion



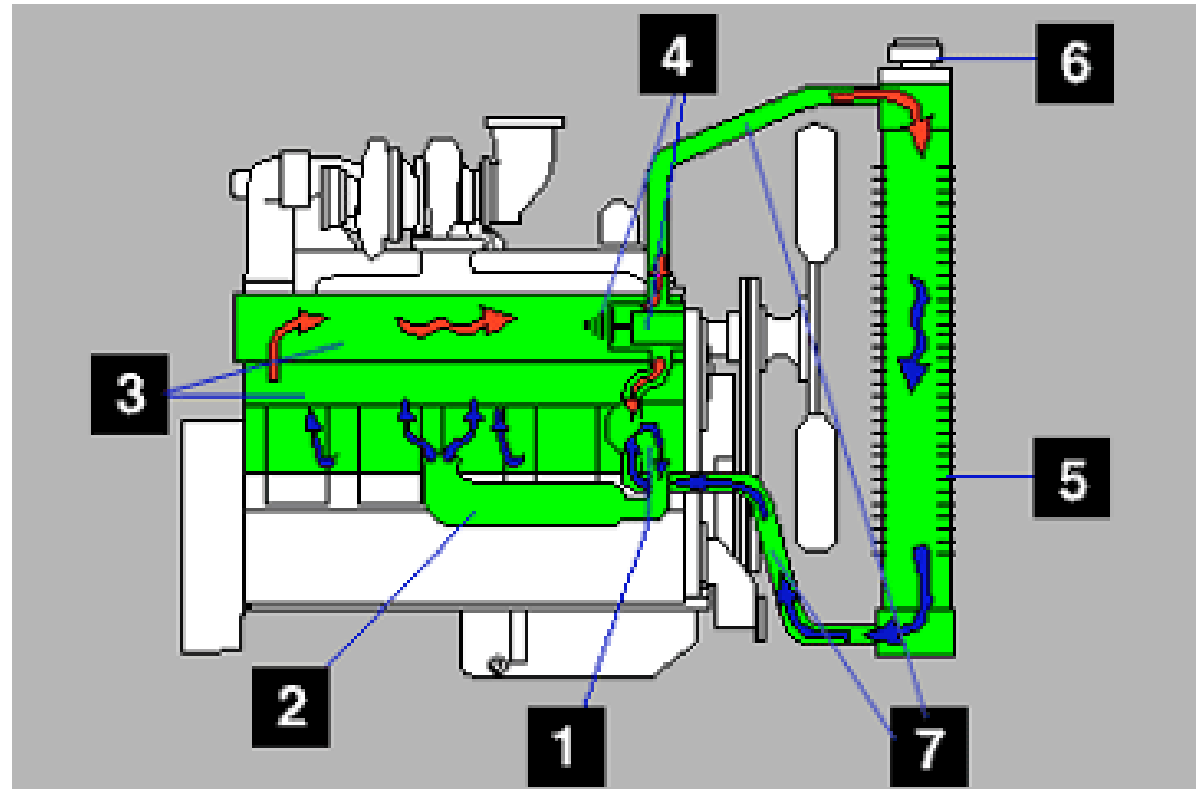
Engine Cooling System

All Engines has a pressurized Cooling System, which offers three advantages:

- ✓ Cooling System can operate safely at a temperature that is higher than the normal boiling point of water.
- ✓ The Cooling System prevents cavitation in the water pump.
- ✓ Reduced air or steam pockets.

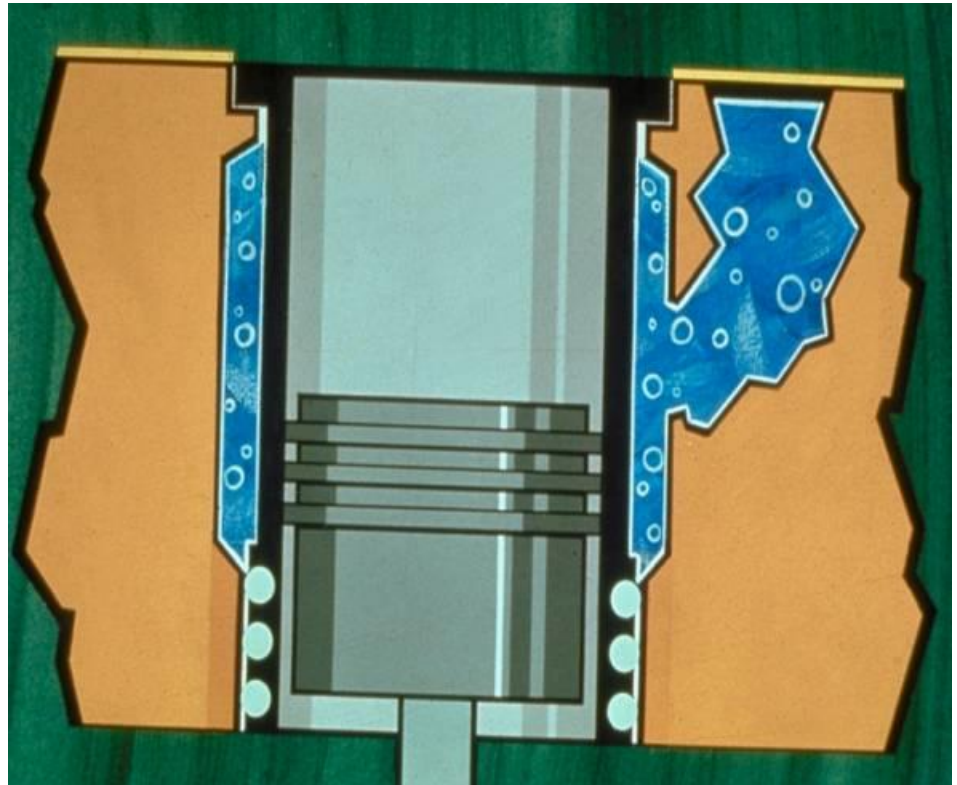
Cooling System Components

- 1 Water Pump
- 2 Oil Cooler
- 3 Passages through block and head
- 4 Temp. Regulator & Regulator Housing
- 5 Radiator
- 6 Pressure Cap
- 7 Hoses & Pipes



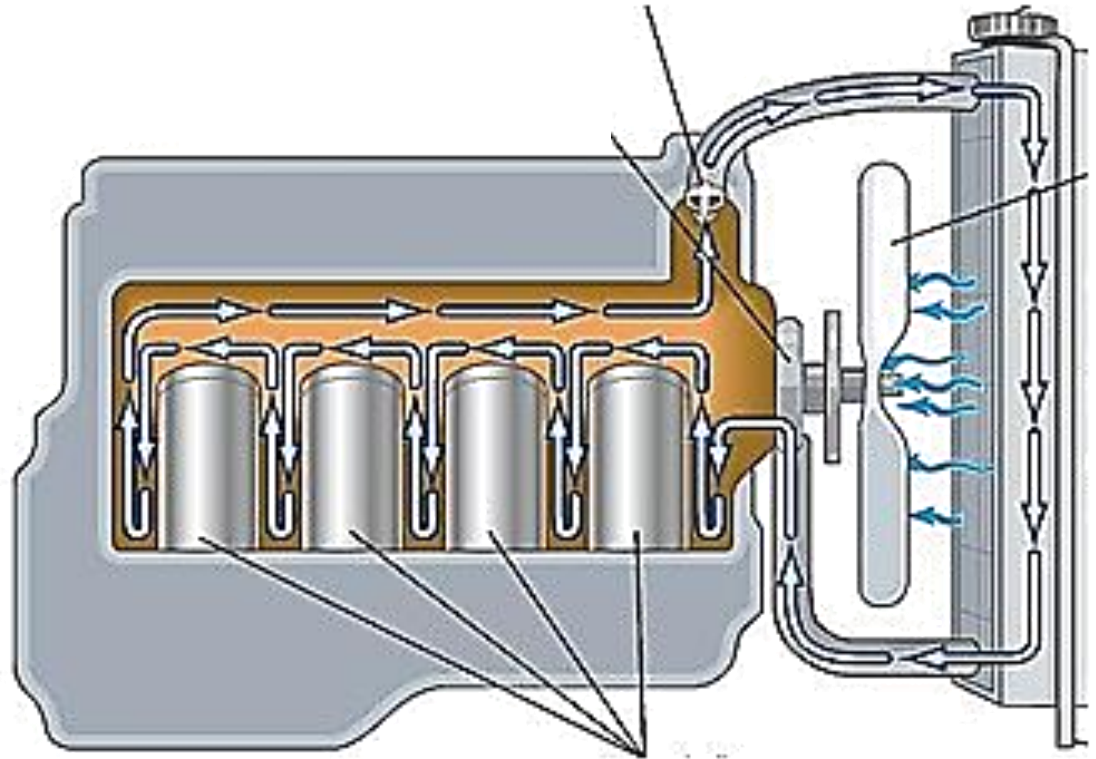
Cooling Systems

- Coolant flows around cylinder liners
- Absorbs heat from the combustion chamber
- Prevents breakdown of oil film between pistons and liners



Cooling Systems

- Coolant flows through passages in the cylinder block into the cylinder head
- Water seals prevent coolant leaks.

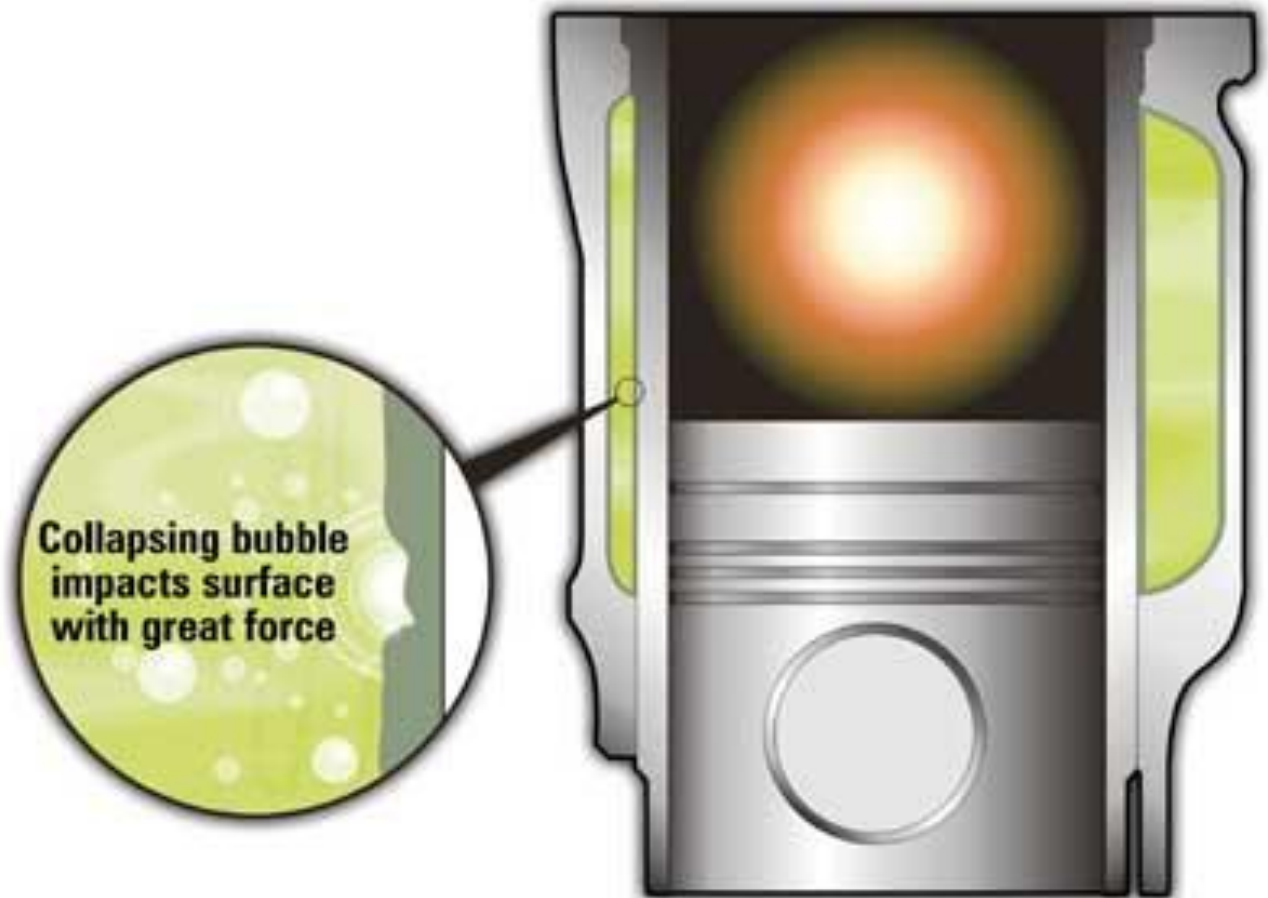


Effects of Cavitation Erosion

- Failure – causing corrosion on a water pump.
- Cylinder wall cavitation erosion

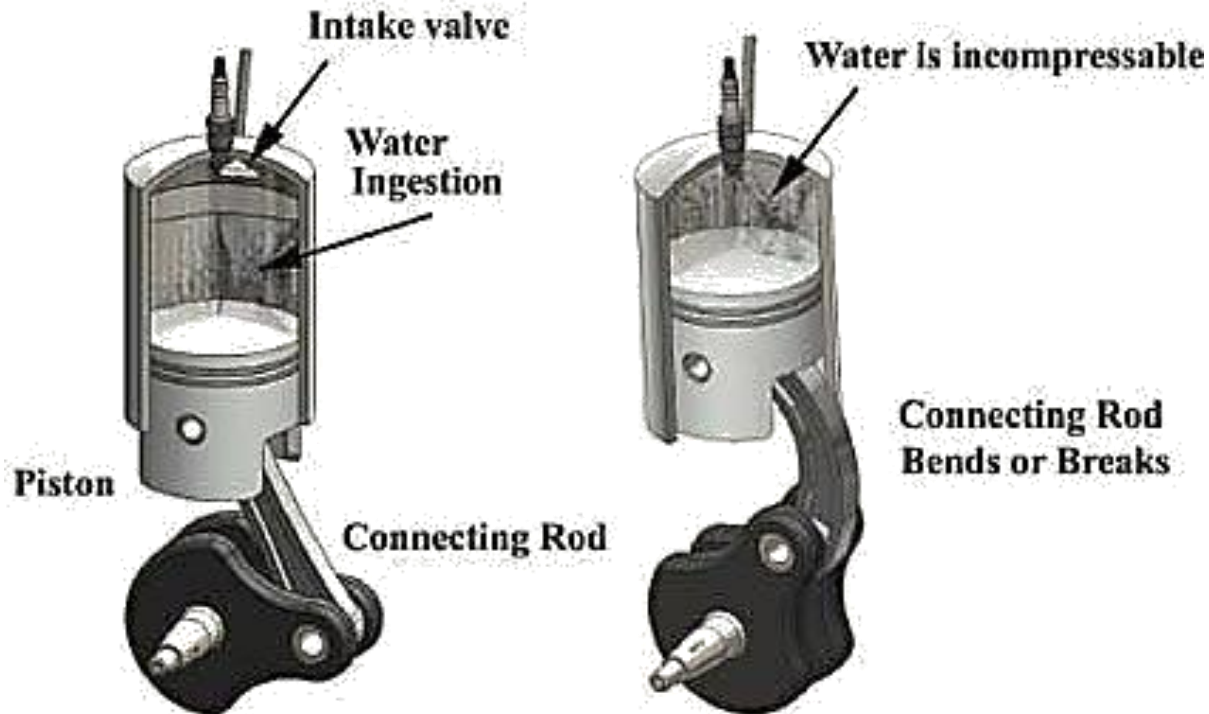


Cavitation Erosion & Pitting



Worst Case Scenario

Cavitation of the cylinder wall will eventually allow coolant to leak into the cylinder



Cooling System Component

Pressure cap and Thermostat



180 Degree Fahrenheit
Ideal Opening temp

Engine Cooling System

What to Fill in?

Coolant is mixture of:

- Good quality water
- Anti-Freeze
- Additives/Inhibitor

Water Quality

DISTILLED WATER

Engine Cooling System

Water Quality

NOT ACCEPTABLE:

- Mineral water
- Sea water
- River water
- Well water

POSSIBLY ACCEPTABLE:

- Distilled water
- Tap water

Engine Cooling System

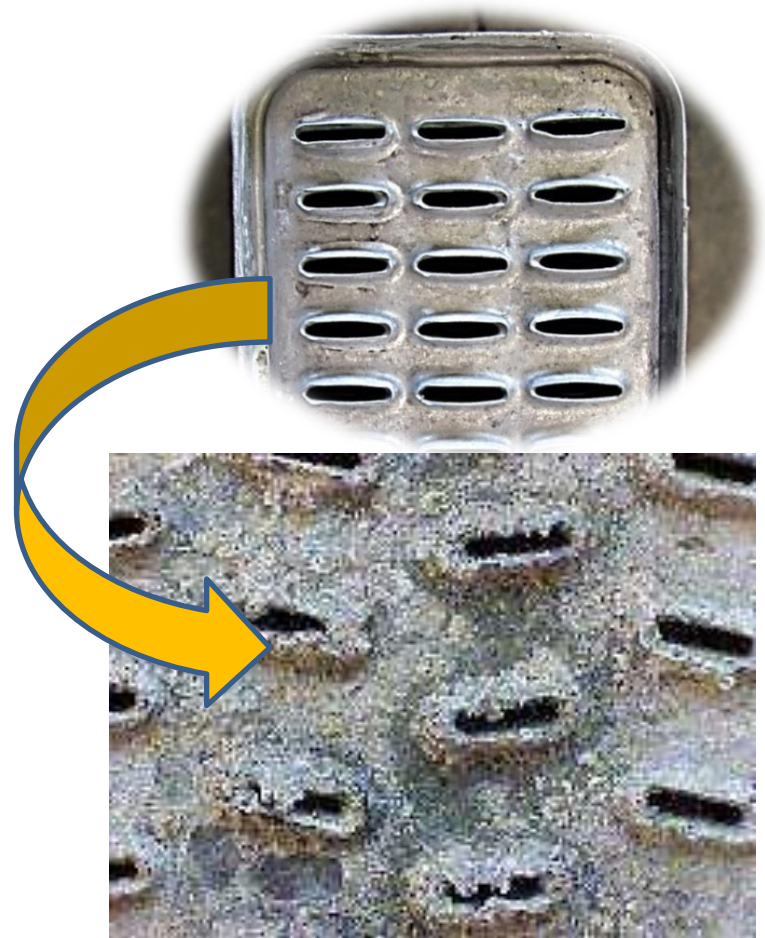
COOLANT ADDITIVES THEY ARE VERY NECESSARY!



Engine Cooling System

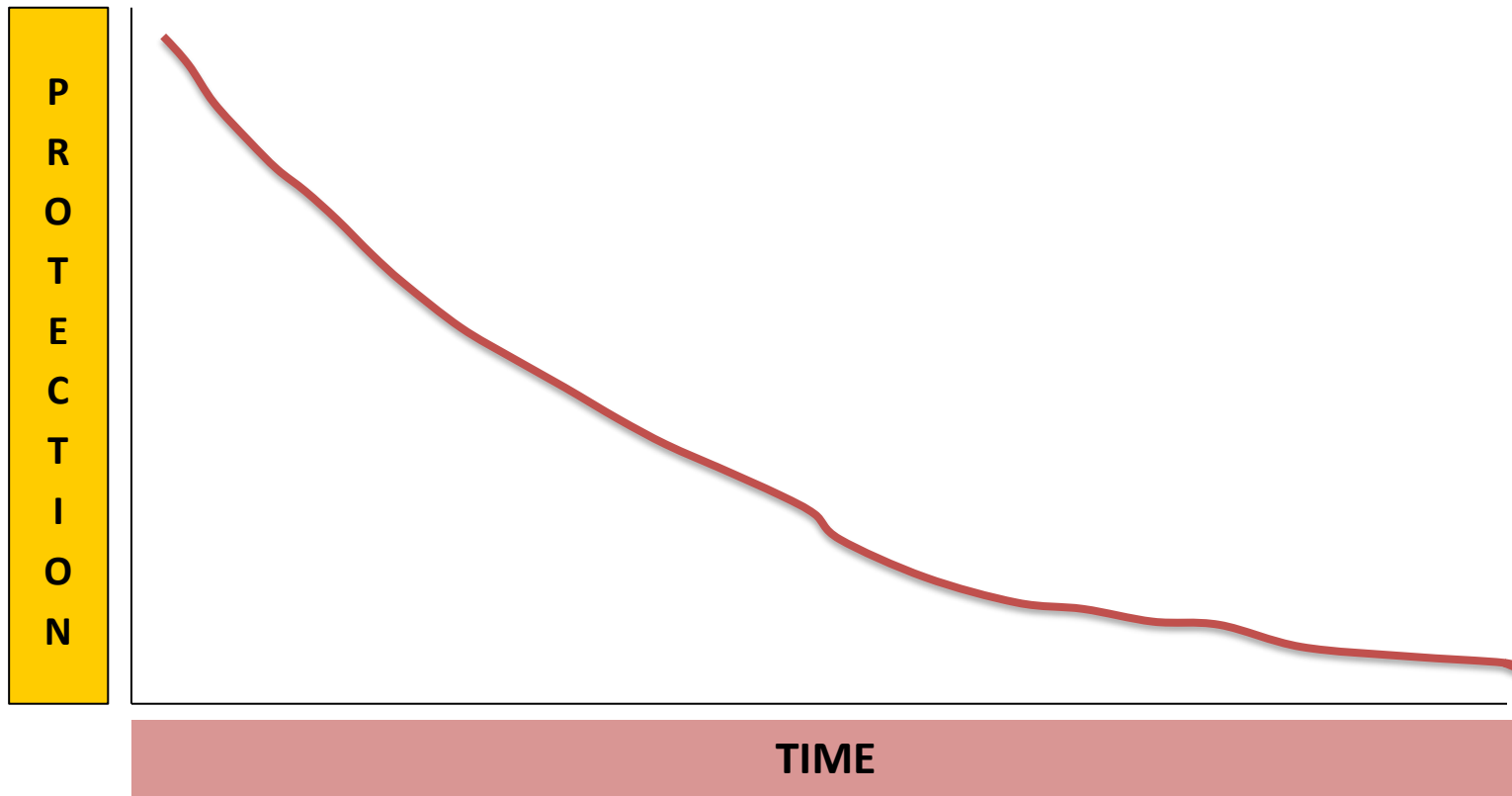
Functions of Coolant Additives

- Protection of metal composition of the radiator.



Engine Cooling System

Depletion of Additives



Engine Cooling System

What is Antifreeze?

- Lowers freezing point
- Raises boiling temperature
- Helps dilute low quality water
- Helps protect against cooling system corrosion and cavitation erosion

Engine Cooling System

basic cooling problems:

Overheating

Overcooling

Cooling System

Overheating Causes

- Coolant Flow and Level
- Excessive Engine load
- Ambient temperature
- Defective water pump
- Defective Thermostat
- Clogged radiator (internal and External)
- System pressure (no radiator cap)
- Loose/slipping belts
- Over concentration of additives
- Low heat transfer through scale build-up

Engine Cooling System

Overheating Effects

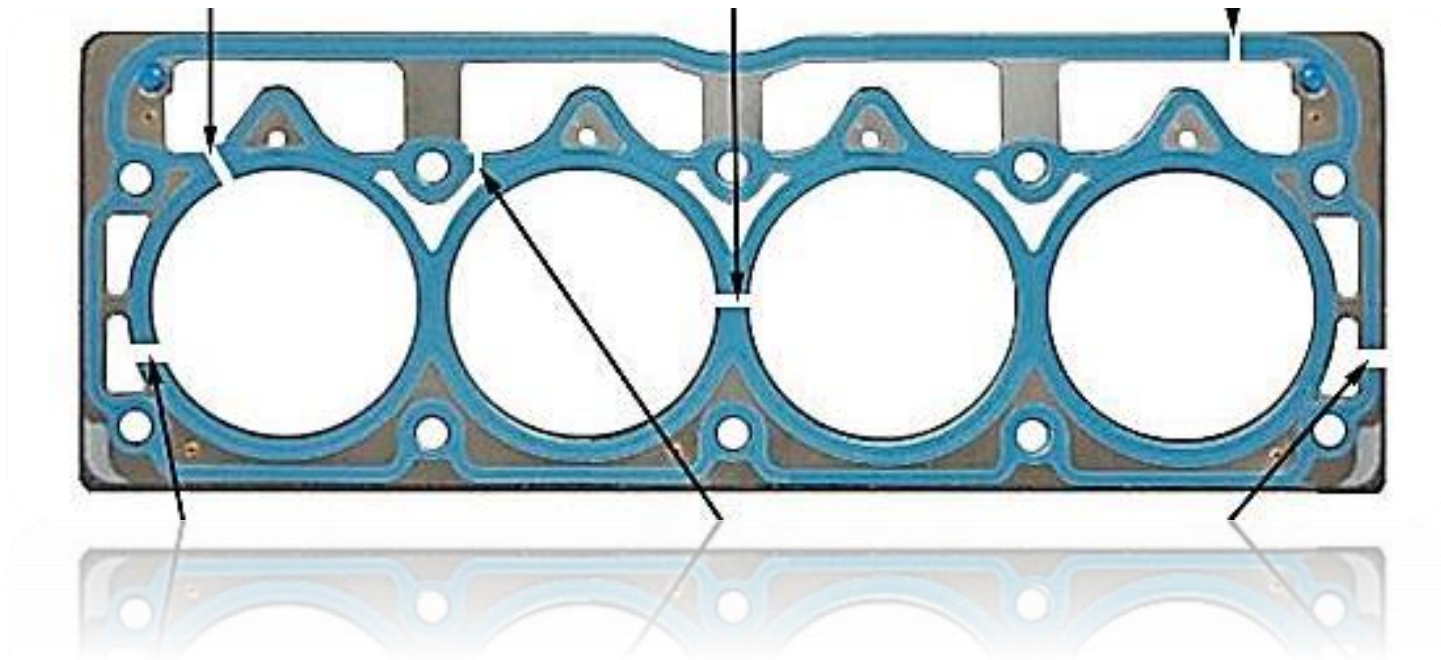
Cracked Or Warped
Cylinder Heads



Engine Cooling System

Overheating Effects

Cylinder head gasket failure



Engine Cooling System

Causes of Over **COOLING**

- Very low ambient air temperatures
- Light Engine loads/no load
- Removed thermostat or stuck

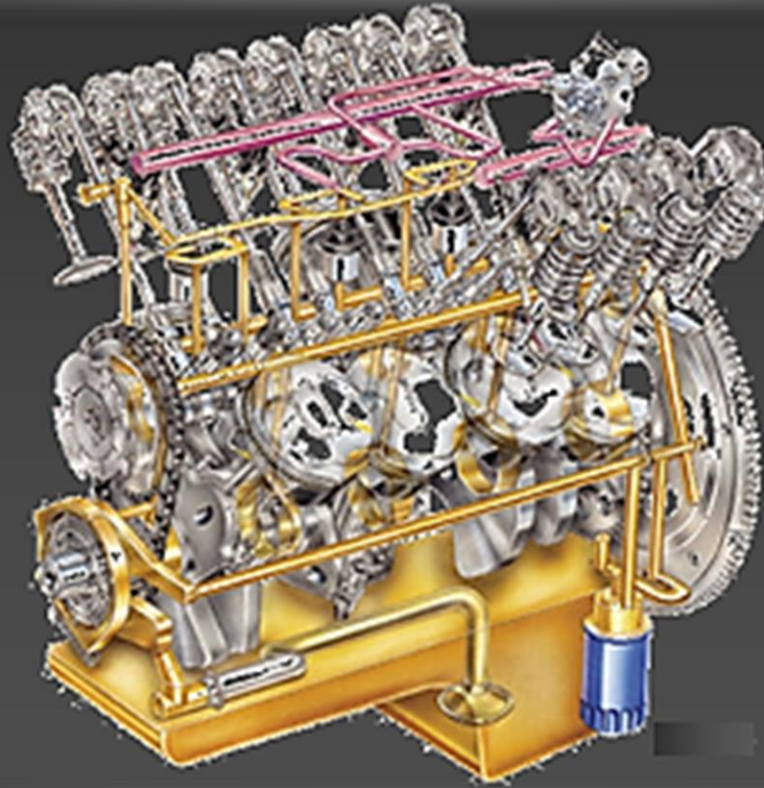
EFFECTS:

- Inefficiency and wear cause of vibration)
- High oil consumption
- Carbon build-up

Engine Cooling System

Maintenance

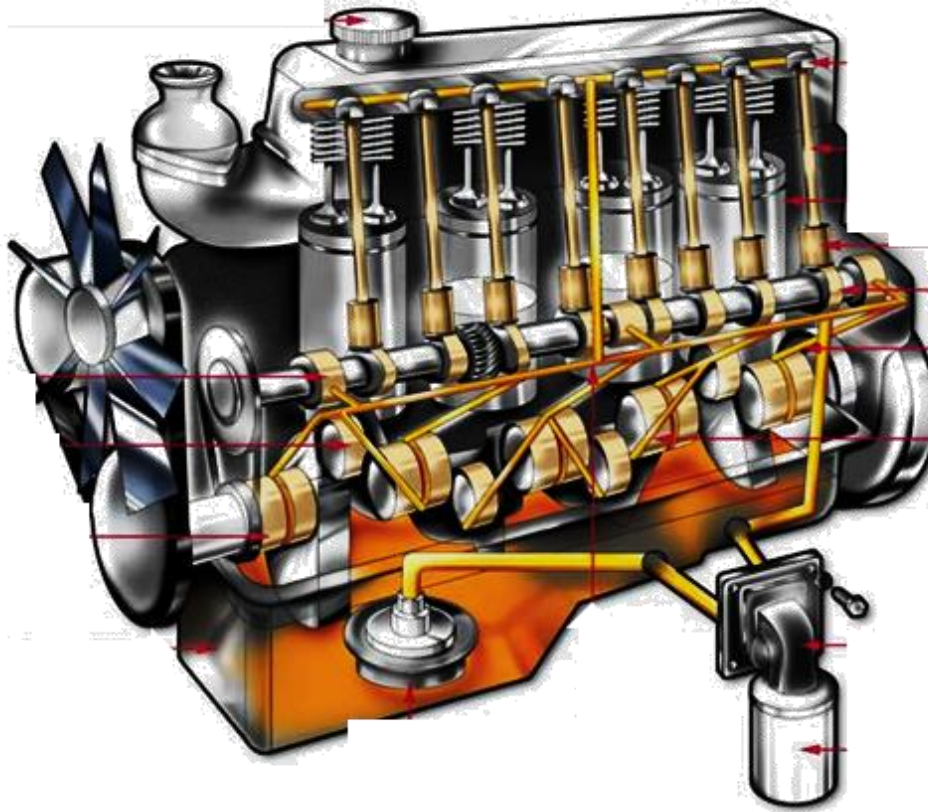
- **Daily**
 - ✓ Check coolant level
 - ✓ Check for coolant leak
 - ✓ Check radiator external
- **Every 6 months**
 - ✓ Check coolant concentration
- **Every Year**
 - ✓ Check hoses (replace if necessary)
 - ✓ Check Water pump
 - ✓ Check Radiator cap
 - ✓ Check coolant concentration (add/ replace if necessary)



ENGINE LUBRICATION SYSTEM

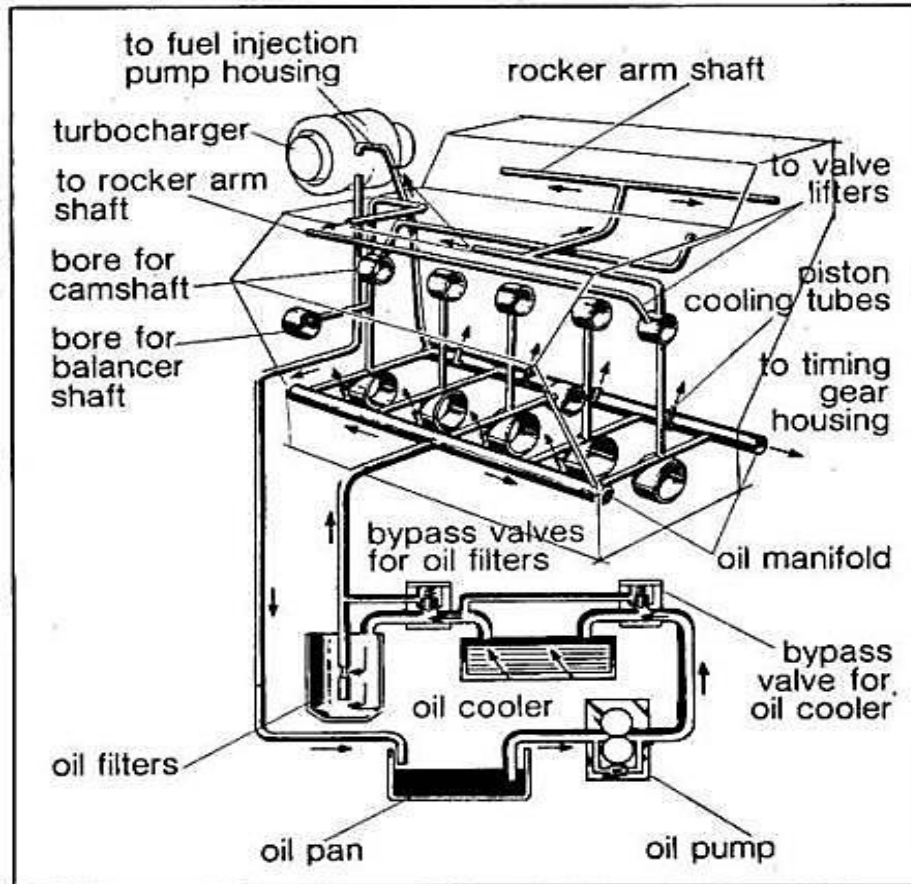
Importance Lubrication System

80% crankshaft bearing failures are due to oil Contamination



Lubrication System

Schematic of Typical Engine Lube System

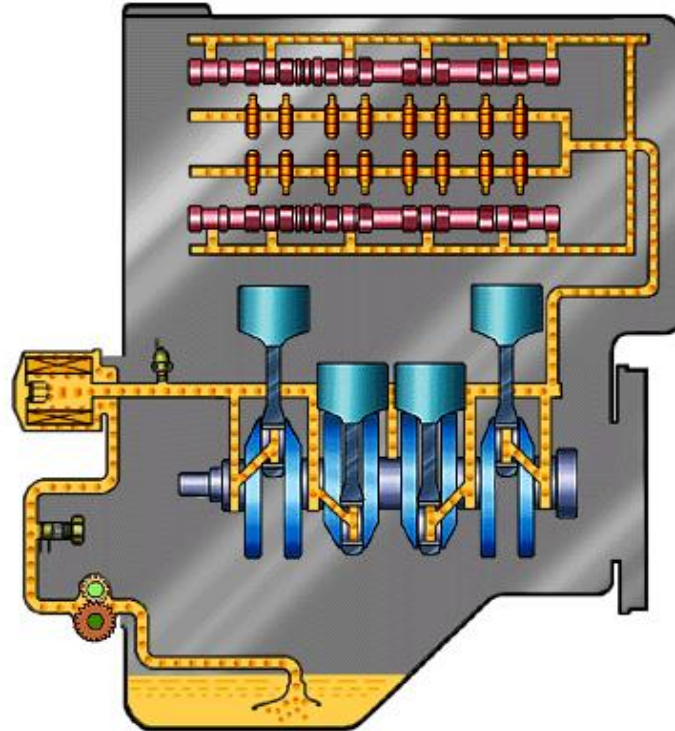


Lubrication System

Lubrication Oil

Functions

- Lubricate
- Remove Heat
- Clean
- Prevent Corrosion
- Remove Contaminants



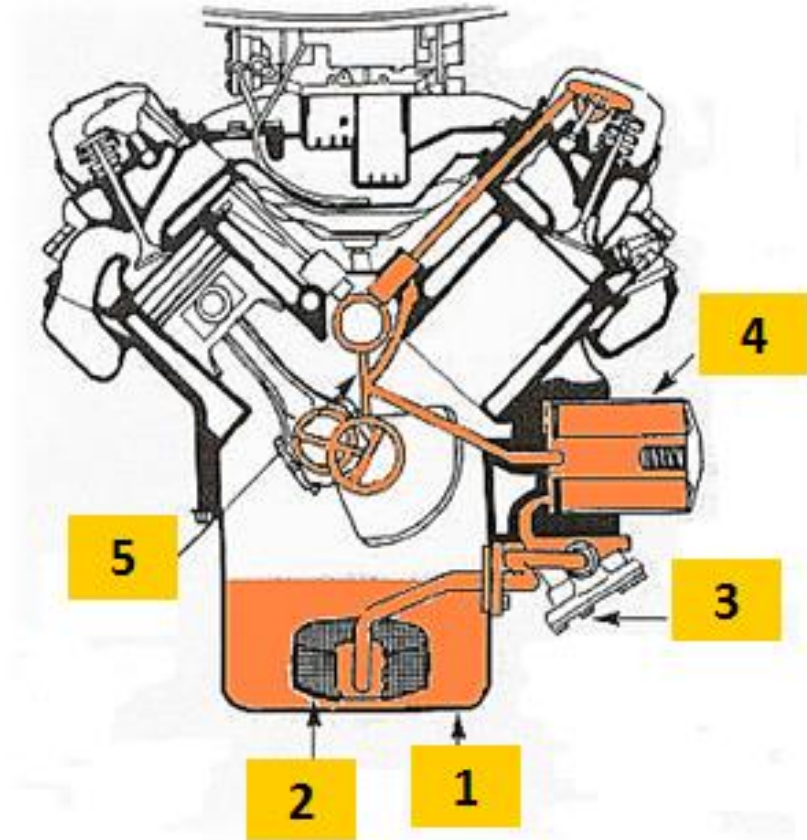
Lube oil additives make an oil perform

Lubrication System Components

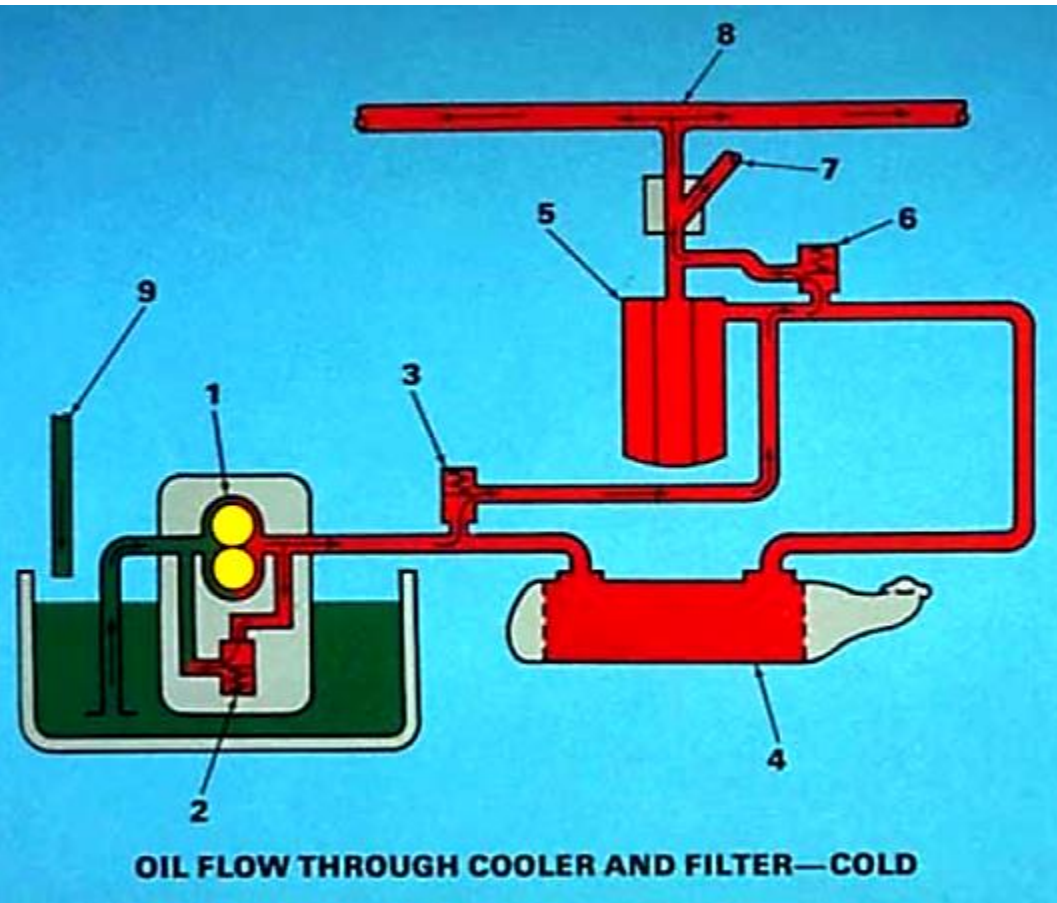
- 1 Oil Pan
- 2 Oil Screen
- 3 Oil Pump/relief valve
- 4 Oil Filter
- 5 Oil Galleries

- Additional accessories on modern engines

1. Oil cooler
2. By pass valve



Lubrication System Operation (Cold)

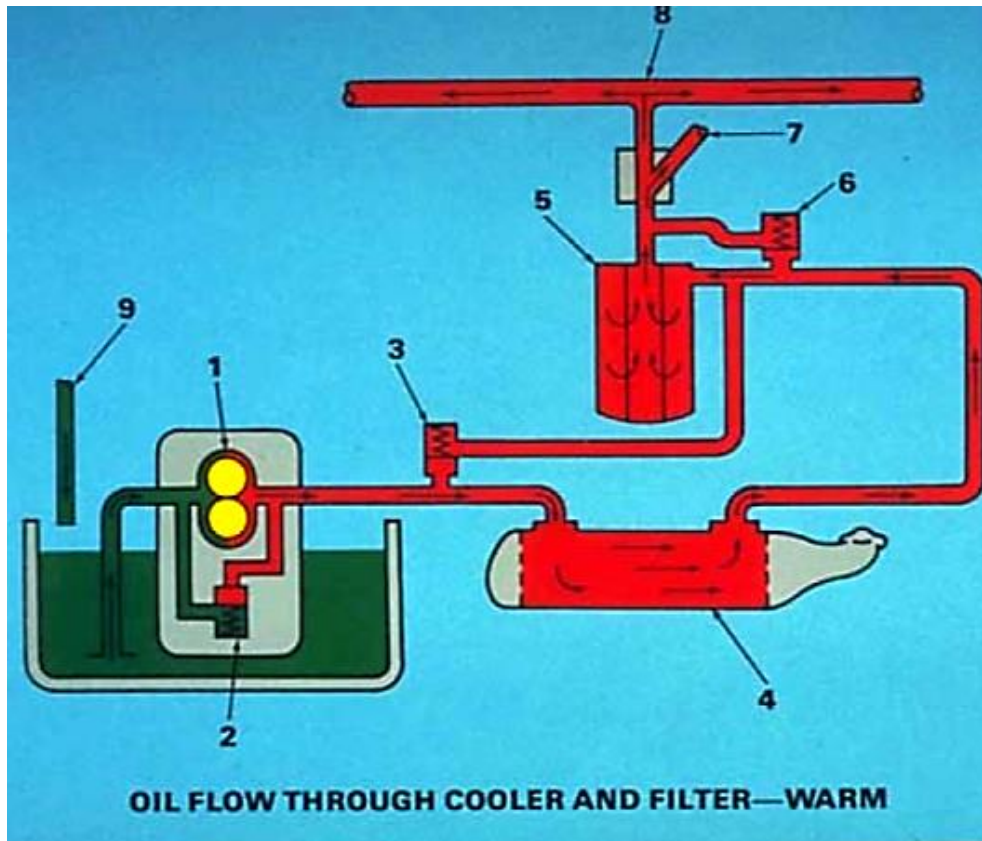


Flow Of Oil (Engine Cold)

- (1) Oil Pump
- (2) Pressure Control Valve
- (3) Oil Cooler Bypass Valve
- (4) Oil Cooler
- (5) Oil Filter
- (6) Oil Filter Bypass Valve
- (7) Turbocharger Supply Line
- (8) Oil Galleries
- (9) Oil Return Line form Turbocharger

The Oil Cooler and Oil Filter bypass valves are open.

Lubrication System Operation (Warm)



FLOW OF OIL (ENGINE WARM)

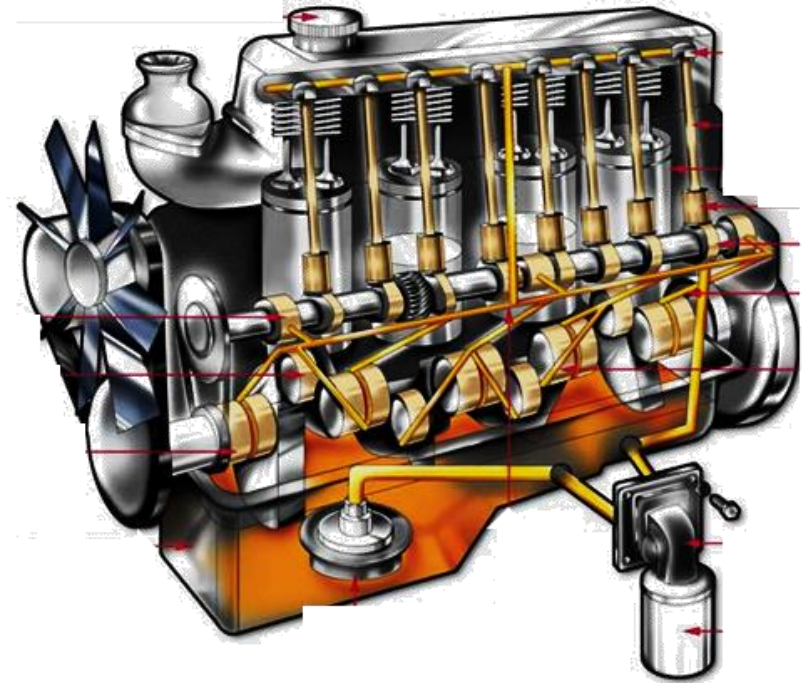
- (1) Oil Pump
- (2) Pressure Control Valve
- (3) Oil Cooler Bypass Valve
- (4) Oil Cooler
- (5) Oil Filter
- (6) Oil Filter Bypass Valve
- (7) Turbocharger Supply Line
- (8) Oil Galleries
- (9) Oil Return Line form Turbocharger

Lubrication System Operation

- Oil pressure ranges from 35-90 psi
- Oil temperature ranges (175°F) to (240°F)

Causes of Lube System Wear & Failure

- Extended oil change intervals
- Excessive soot in the oil
- Poor quality engine oil
- Poor maintenance practices
- Dilution (Fuel/Coolant)



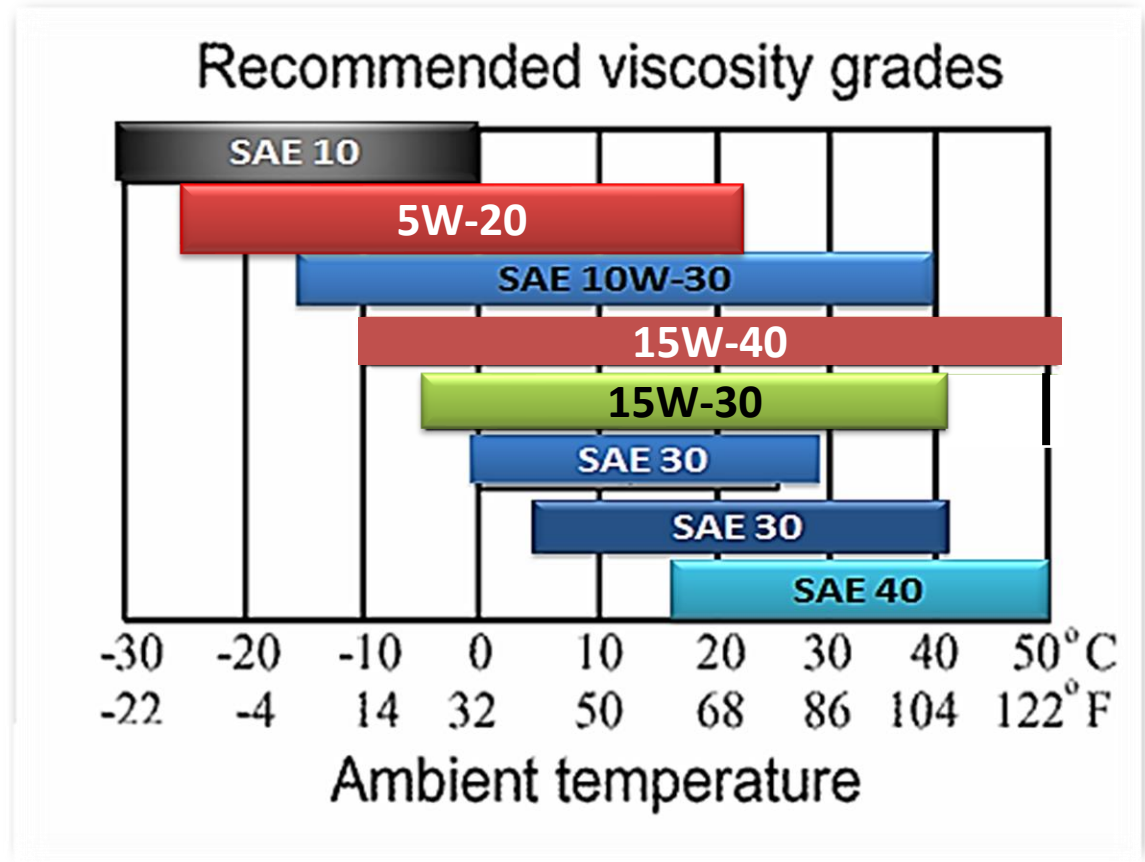
Lubrication System Maintenance Intervals

- **Daily/Prior for Start up**
 - Check oil Level
- **Every Year or 250/500 Service Hours**
 - Clean Engine Breather
 - Replace Engine Oil & Filter
 - Check blow by
- **Engine Oil Recommendations for Diesel Engine**
 - CH-4
 - CI-4
 - 15W-40 Viscosity

Lubrication System Maintenance Intervals

Engine Oil Recommendations:

- API CI-4
- SAE 15W-40





Day 2

Generator Set

Operation and Maintenance

Training

Agenda

- **Battery Maintenance**
- **Alternator/Generator System**
 - System Operation
 - Generator Sets Maintenance
 - Generator Sets Troubleshooting /Diagnostics



BATTERY MAINTENANCE

Learning Outcome

- Safety
- Battery types
- Battery construction
- Battery operation
- Maintenance

Safety

Lead - Acid Batteries

- Contains *Sulphuric Acid Electrolyte*
- Highly corrosive
- Contact with the skin will cause burns and contact with the eyes may cause blindness

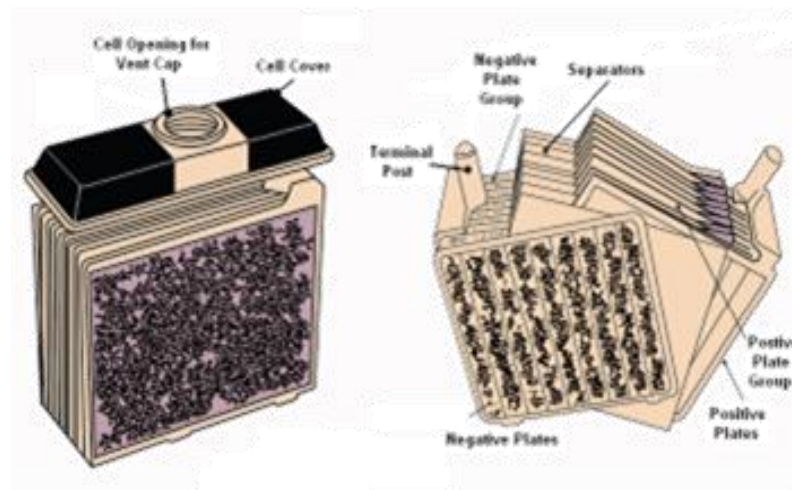
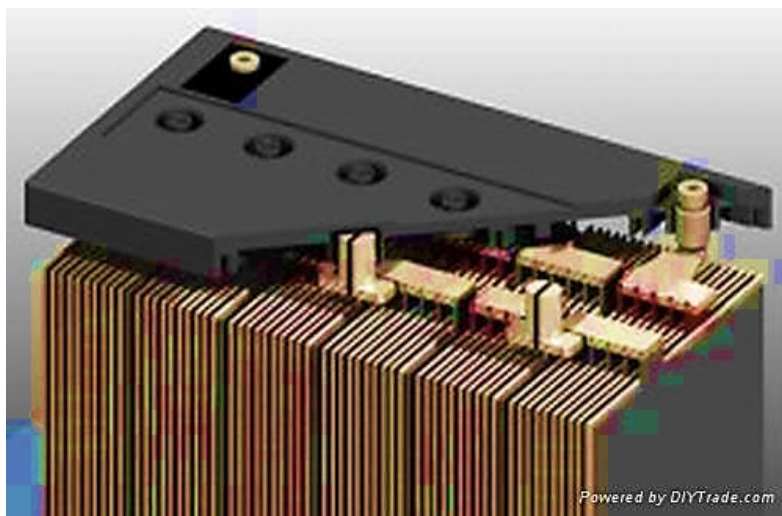
SAFETY

- Always wear (PPE)
- Keep all sparks
- Flames
- Tobacco products
- Never try to open a battery with non removable vent caps.
- Ventilation

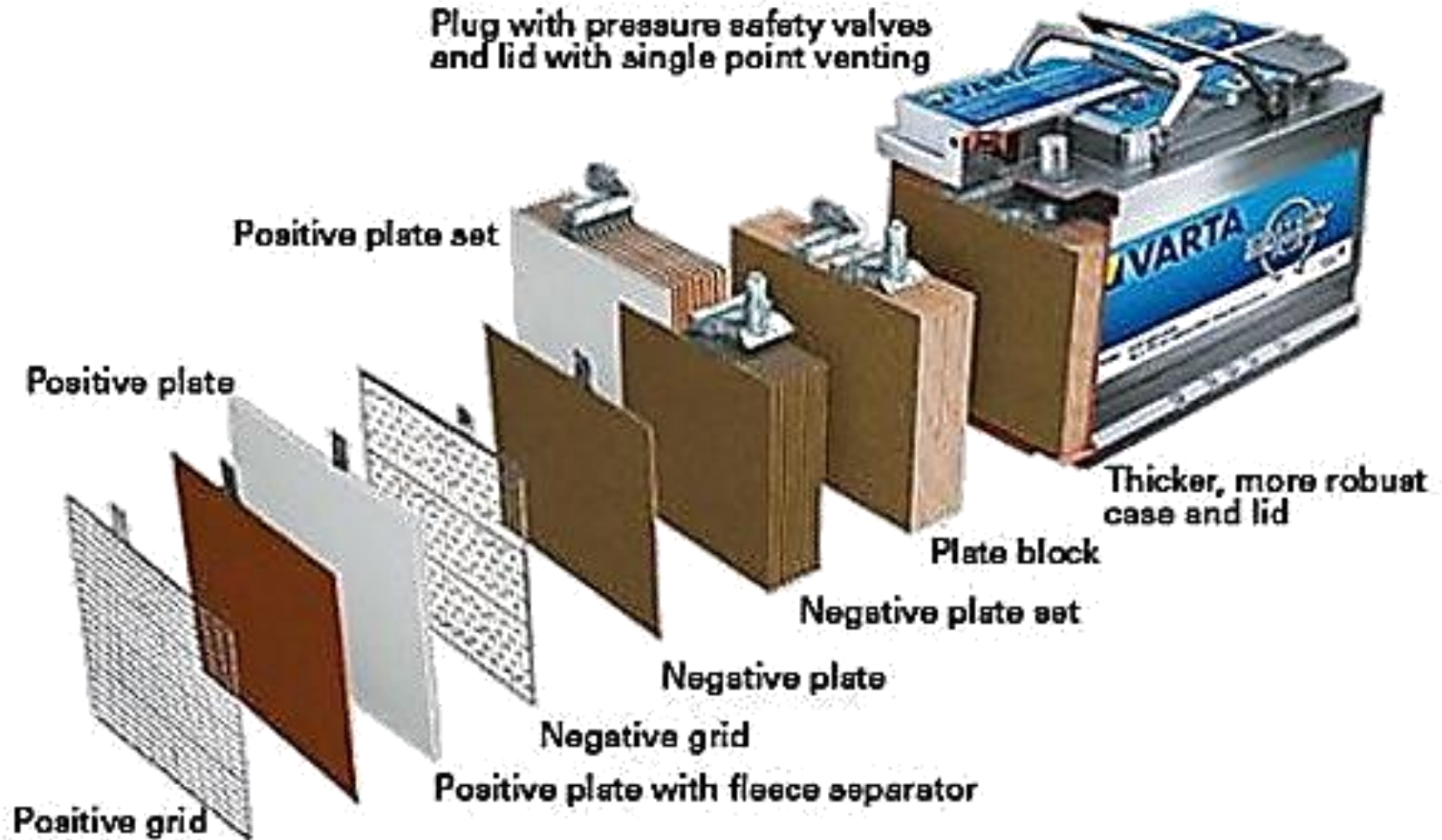
Batteries Options

- **Dry charge battery**
- **Wet charge battery**
- **Maintenance free battery**

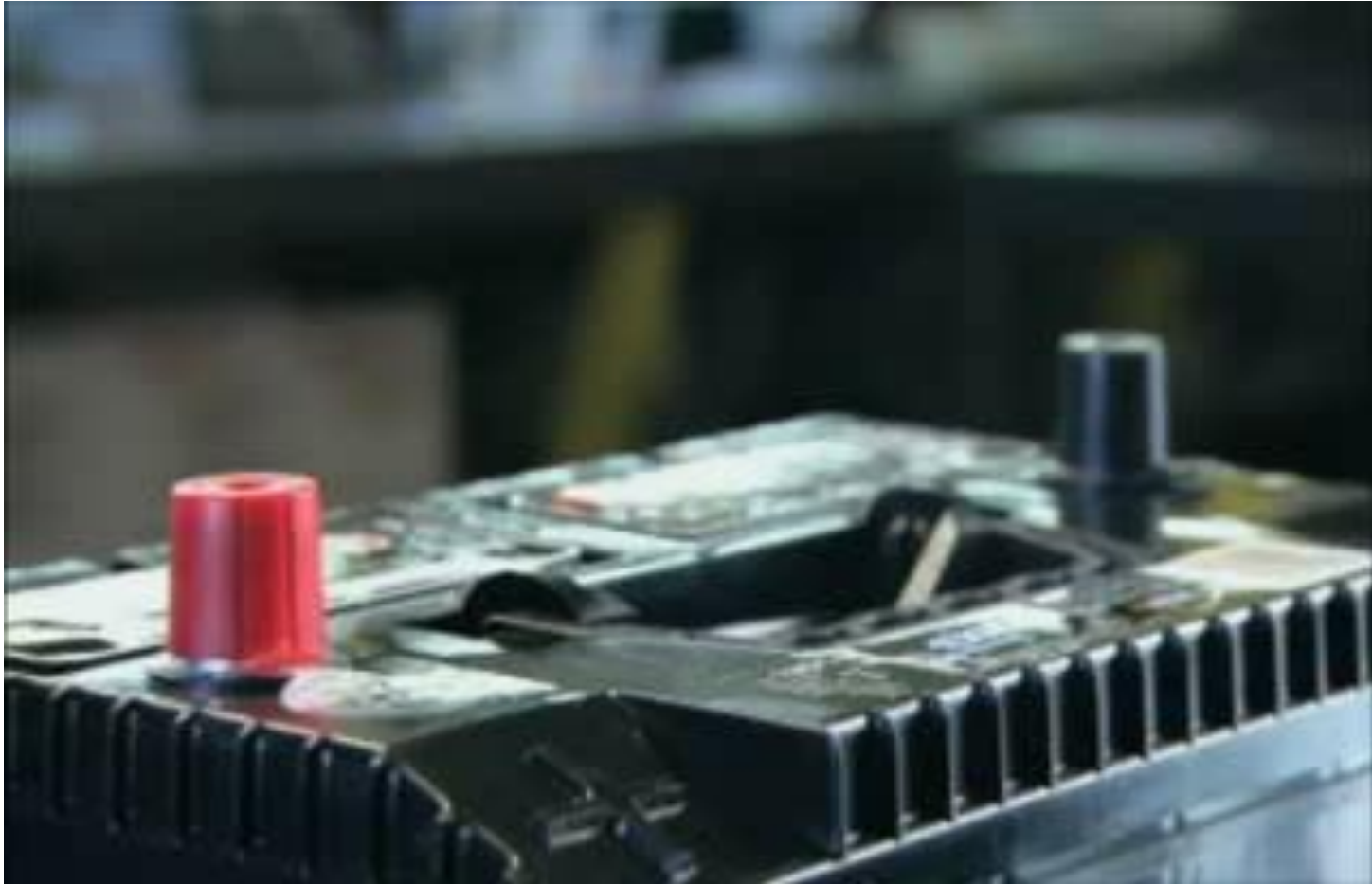
Battery Construction



Battery Construction



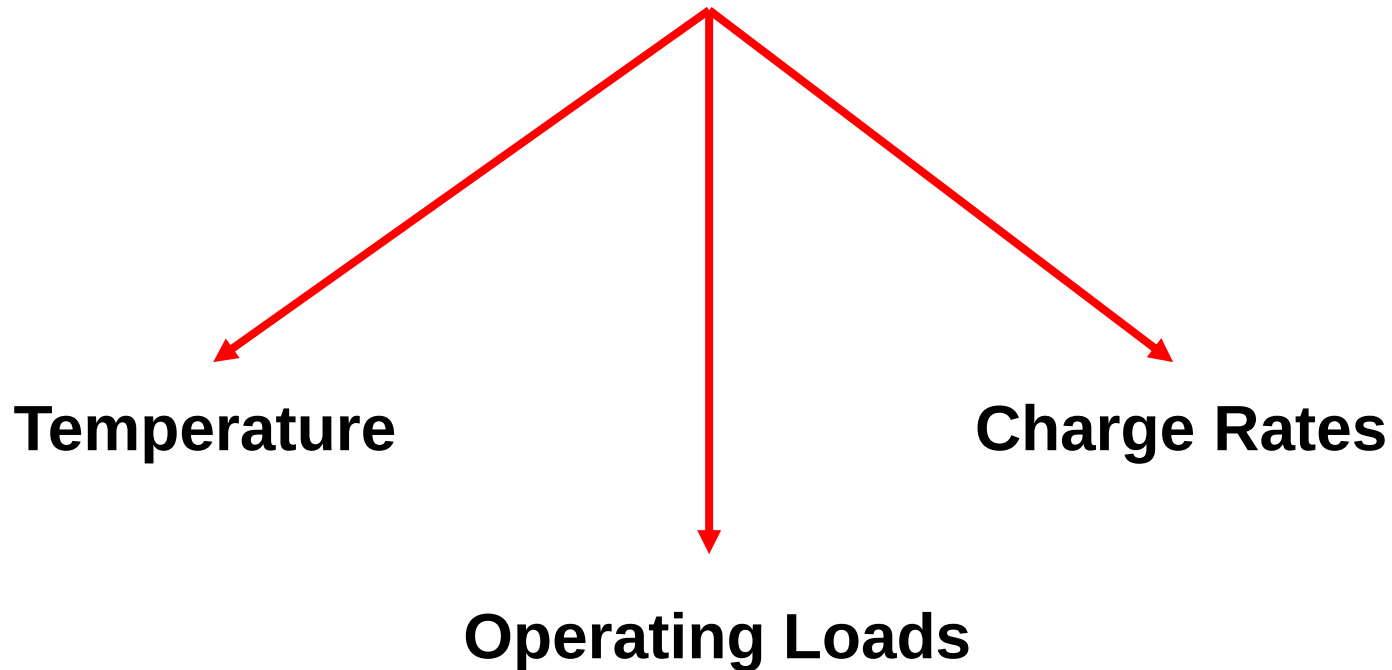
Battery Operation



Battery Cycles

Terminal Voltage

Factors affecting Terminal Voltage



Battery Cycles

Temperature

- At lower temperatures:
 - Chemicals do not react as fast
 - Battery has lower voltage
 - Temperature affects terminal voltage
- At 27°C (80°F) – battery is 100% efficient
- At -30°C (-22°F) – battery is 30% efficient

Battery Cycles

Deep Cycling*

- Occurs when battery is close to complete discharge – then recharged
- Tends to be hard on battery due to heat created by internal resistance
- Causes plate buckling
- Deep cycling batteries have thicker plates

MAINTENANCE

INSPECTION

- Visually inspect the battery for:
 - ✓ Corrosion
 - ✓ Leaking case
 - ✓ Damaged or leaking terminals
 - ✓ Loose cable connections
 - ✓ Cracked or broken case/cover
 - ✓ Sulphation
 - ✓ Check electrolyte level every year.
 - ✓ Coat the clamp Silicone Lubricant or petroleum jelly



Battery Storage

- Store in cool, dry area in an vertical position.
- Wet batteries have a max. shelf life of 2 years
- Never stack batteries directly on top of each other unless protected by corrugated packaging.
- Test non-maintenance free wet batteries every 4-6 months, Maintenance Free every 9 months, and recharge if below 12.40V.

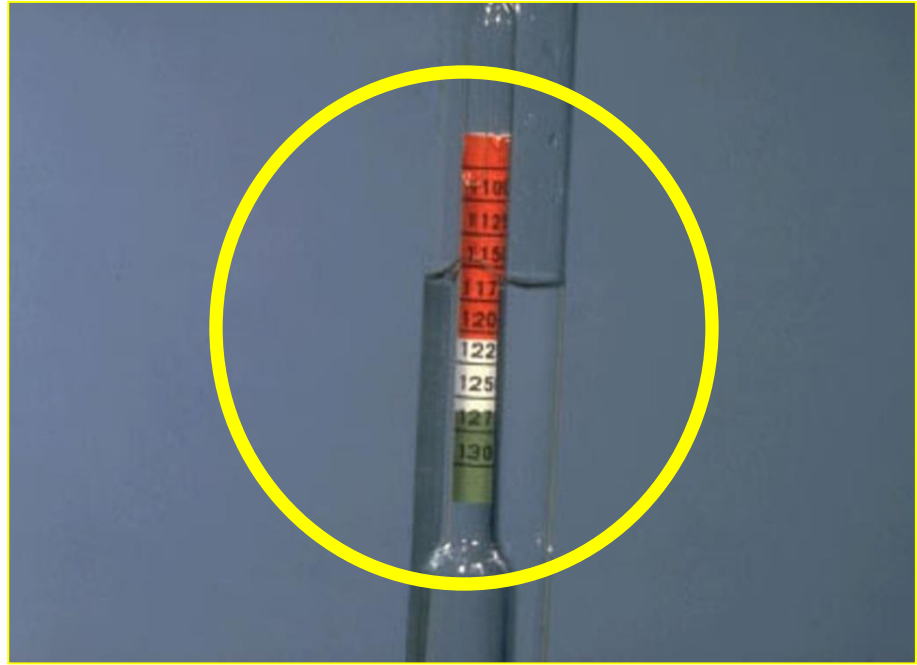
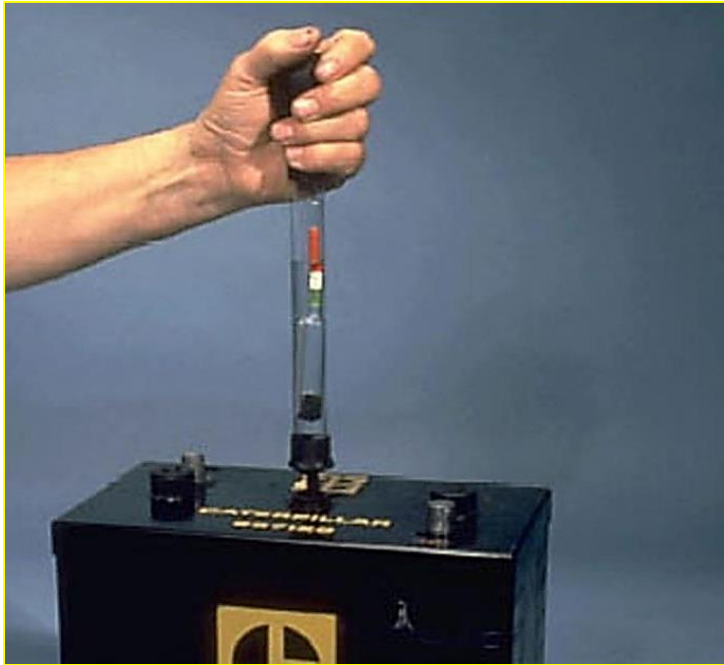
Battery Rating

- **COLD CRANKING AMPS (CCA)**
 - **Cranking amps** are the numbers of **amperes** a lead-acid **battery** at 32 degrees F (0 degrees C) can deliver for 30 seconds and maintain at least 1.2 volts per cell (7.2 volts for a 12 volt **battery**). ... In other words, CCA/**cold cranking amps** determine how much power you have to start your car on **cold** winter mornings.

Testing Batteries

Specific Gravity Testing

Hydrometer Testing



Testing Batteries

STATE OF CHARGE	VS	SPECIFIC GRAVITY	VS	VOLTAGE
100%		1.265		12.62(6.3)
90%		1.251		12.54
80%		1.236		12.45
75%		1.225		12.40(6.2)
60%		1.206		12.27
50%		1.190		12.18
25%		1.155		11.97(6.0)
DISCHARGED		1.120		11.76

New Battery

- Rating the same or greater than the battery being replaced (CCA rating)
- Dimensions
- Type of posts
- Height
- Mounting
- Check OEM Specifications

Installing a Battery

- Check the earth system (+ or -)
- Identify positive (+) and negative (-) cables
- Identify + and – posts and install battery into carrier
- Fit battery clamp
- Fit terminals, positive (+) **FIRST**
- Fit negative (-) cable
- Ensure cables terminals are firm onto the posts – use correct tooling
- Function Test



GENERATOR SYSTEM

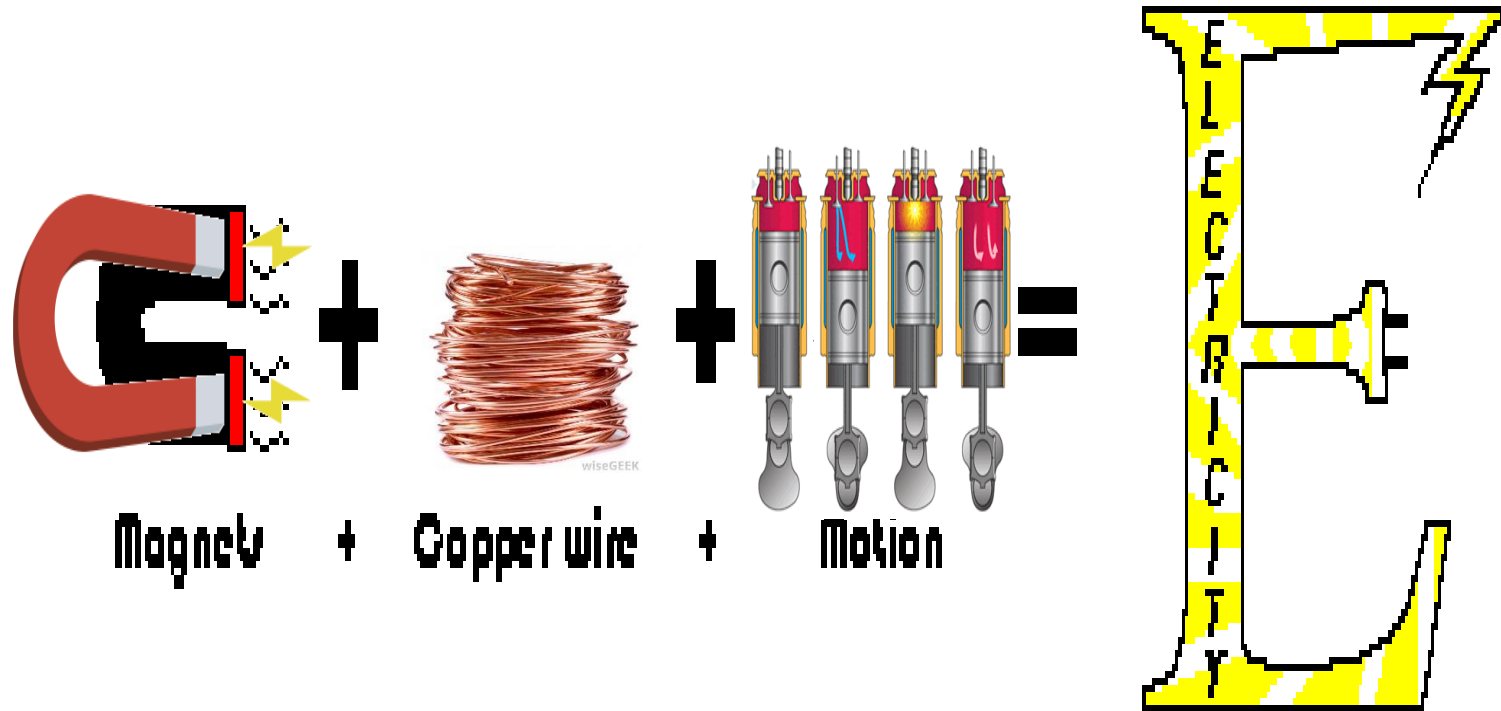
Generator Basics

GENERATOR

is a device that converts mechanical energy
into electrical energy.

Question

WHAT ARE THE BASIC REQUIREMENTS TO PRODUCE ELECTRICITY?



INTERACTION BETWEEN A MAGNETIC FIELD AND
ELECTRICAL CONDUCTORS

Generator Basics

Generator Sets Applications

1. **Prime Power** – Output is available with varying loads
2. **Continuous Power** – Output is available without varying loads for an unlimited time.
3. **Standby Power** – Output is available with varying loads for the duration of an interruption of normal source power

Generator Basics

Generator Components

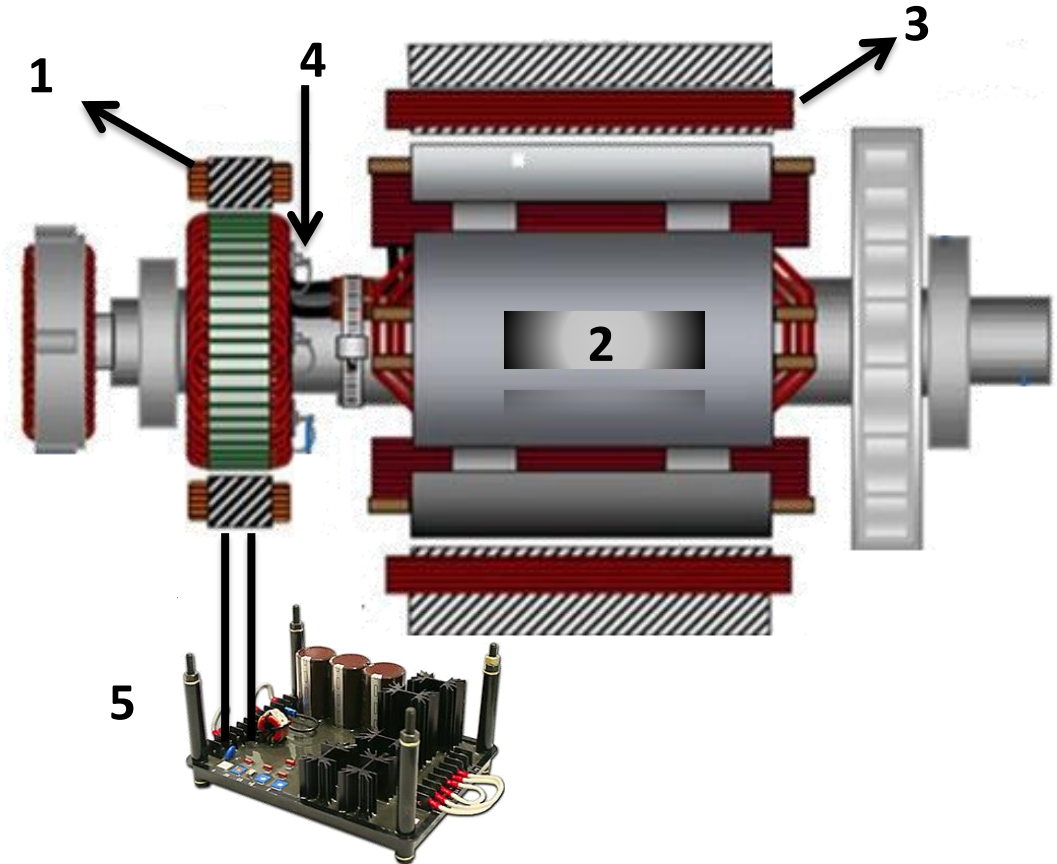
1. Exciter

2. Rotor

3. Stator Winding

4. Rectifier

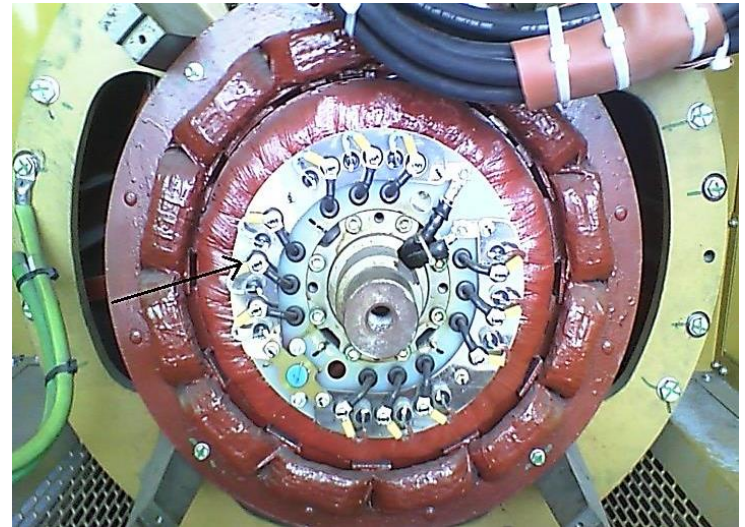
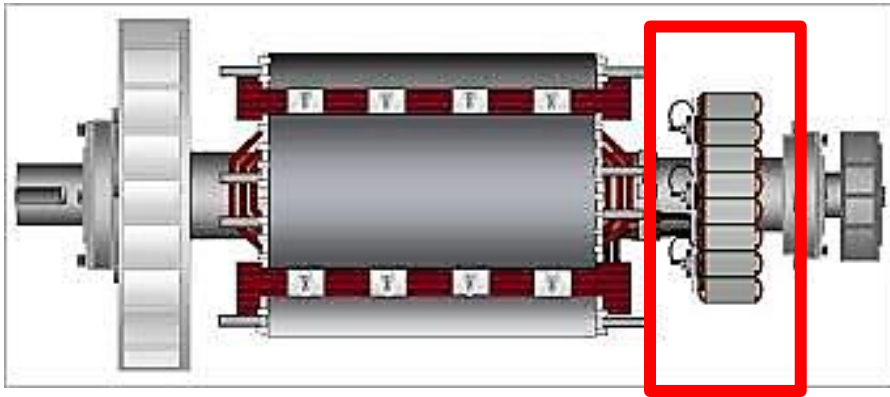
5. Voltage Regulator



Main Generator Components

Exciter

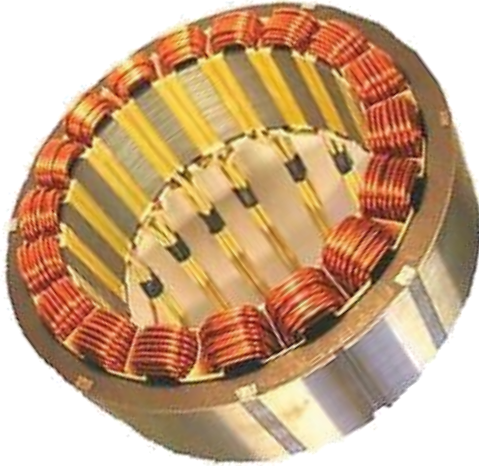
- Function is to supply the excitation DC voltage to the main rotor.



Main Generator Components

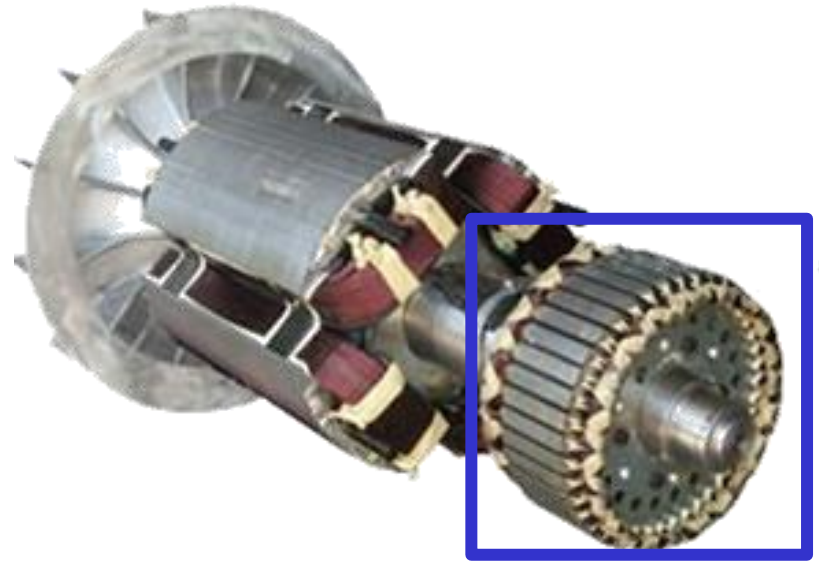
Exciter Components

Exciter Stator/Field



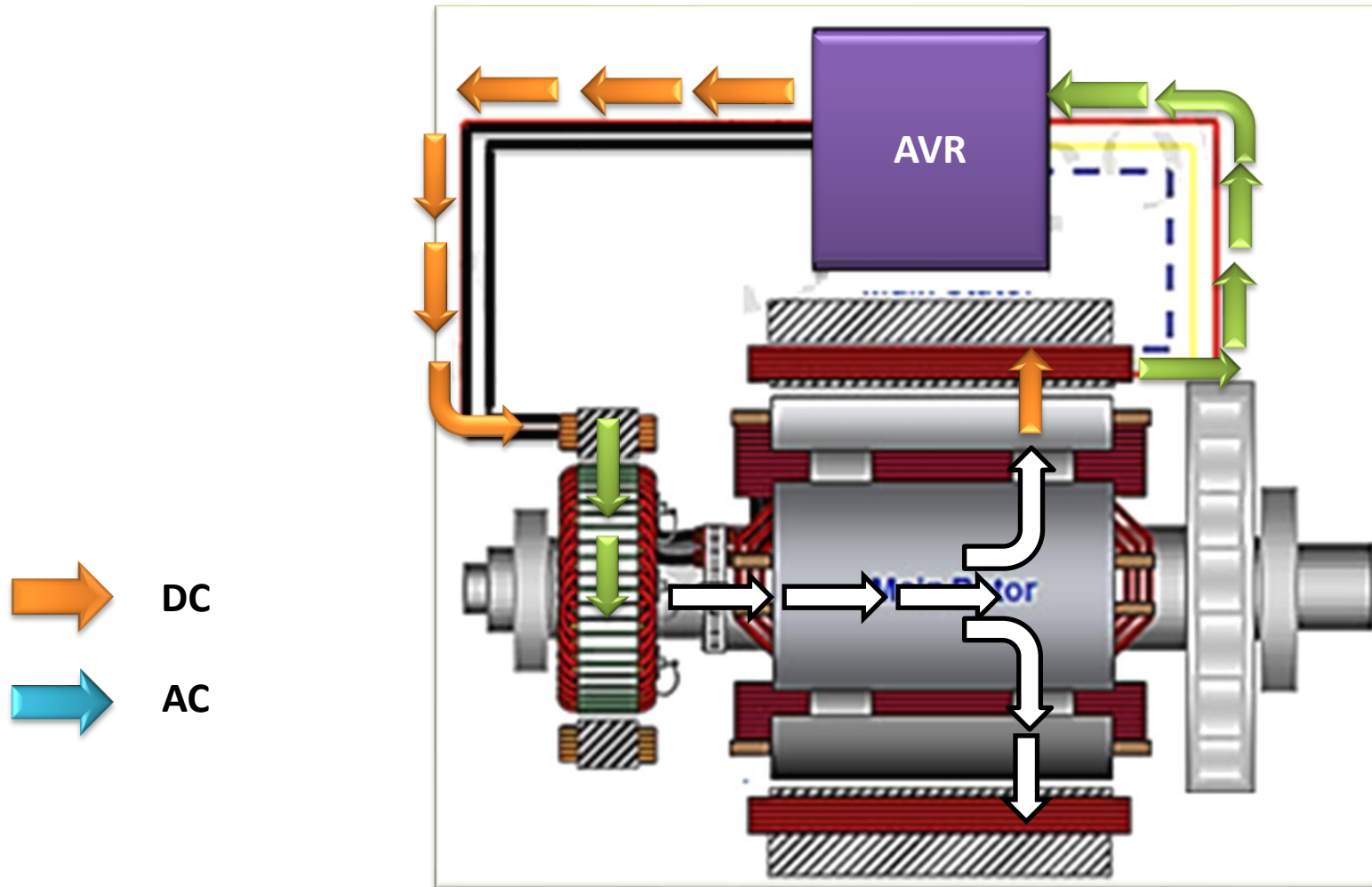
- Produce a MAGNETIC FIELD

Exciter Rotor/Armature



- ROTATING PART of the generator direct induced AC voltage to the rectifier assembly

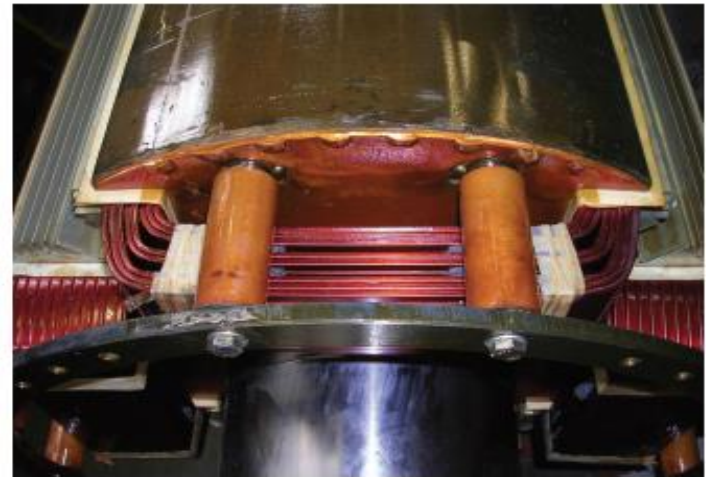
Generator Operation



Main Generator Components

Revolving Field End Turns

- Driven by an Engine or some Prime mover
- Interaction of the resulting MAGNETIC FIELD with the STATOR WINDING produces a voltage.

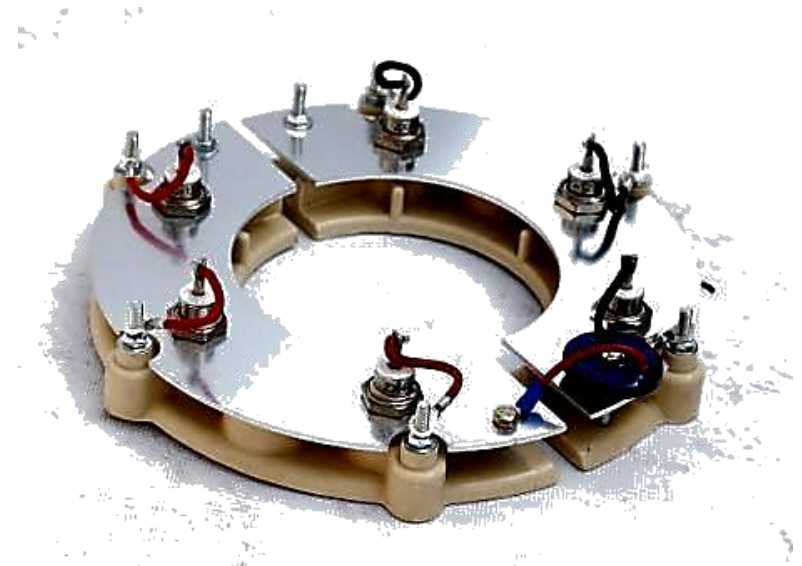
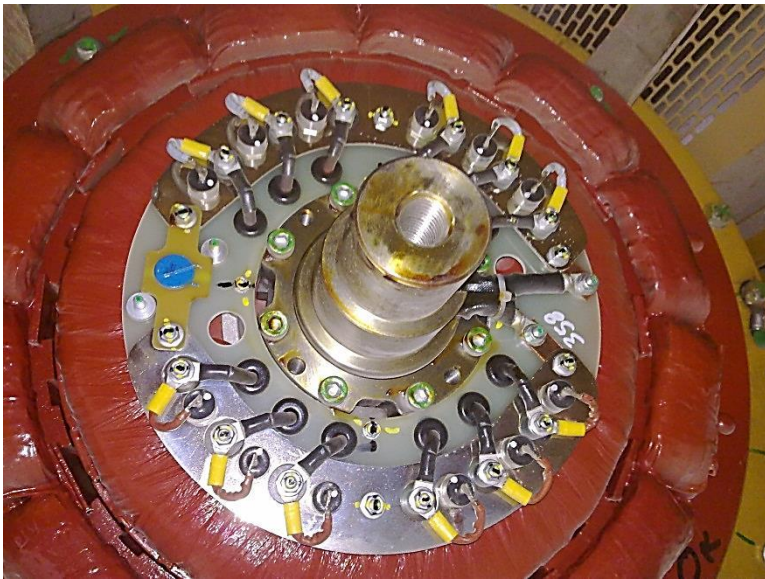


Main Generator Components

Rectifier Diode Assembly

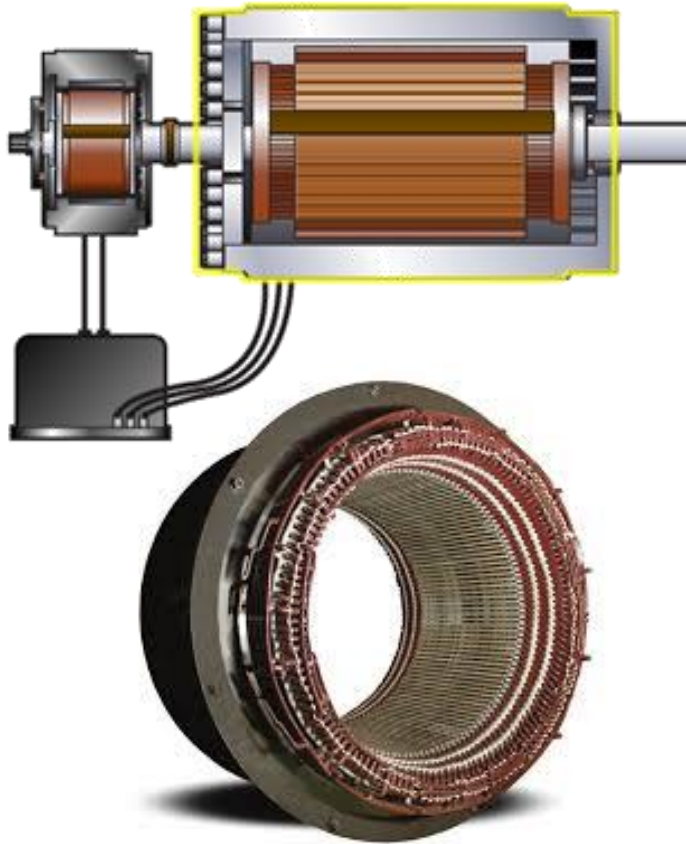
Rotating Diode

- DIODE – allows current to pass in one direction only.
- Converts AC to DC



Main Generator Components

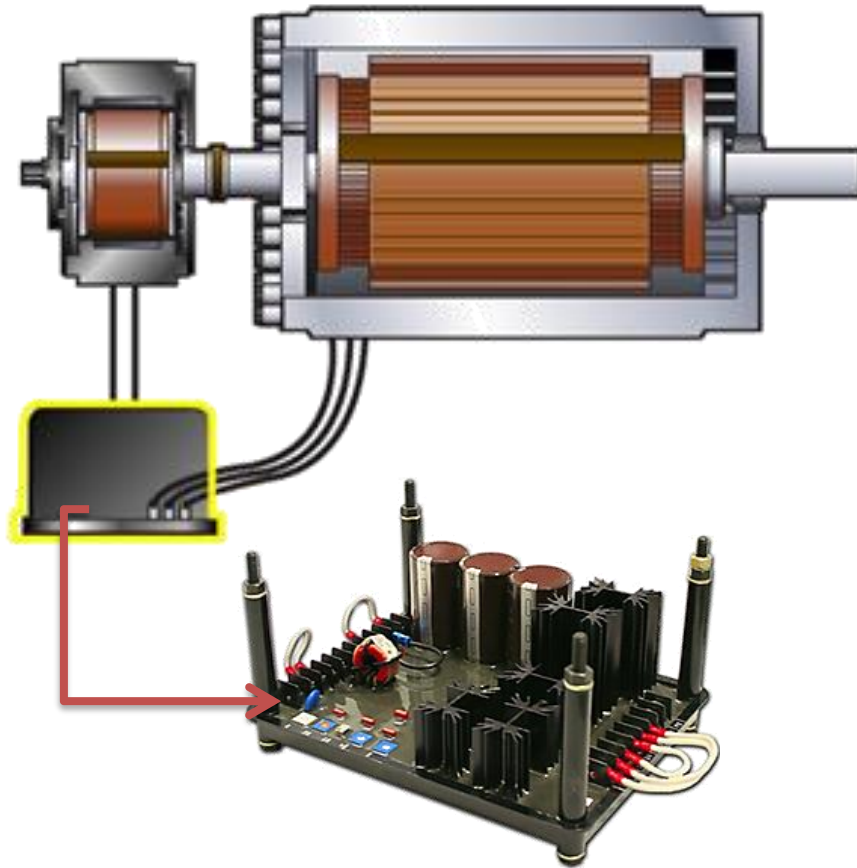
Stator Windings



- Are stationary coils of copper wire spatially placed in the slots to produce three – phase AC voltage
- The Generator output leads are connected directly to the Stator Windings

Main Generator Components

Voltage Regulator



- Controls the output voltage produce by the Generator by controlling the excitation.
- The Voltage Regulator is connected to the Generator AC output. The AC is rectified to DC, then applied to the Exciter Field in the precise amount required to maintain a regulated AC voltage from the Generator under various load conditions.



Generator Set Operation Procedure

Before Running Engine

Walk around

- ✓ Check All engine system prior for starting the engine.
- ✓ **AIR SYSTEM SYSTEM** – Indicator for clogged and air filter, air leak, loose hoses clamps or bolts.
- ✓ **LUBE SYSTEM** – Check oil level, oil leaks and Filters
- ✓ **COOLING SYSTEM** – Coolant level, leaks, crack hoses and loose clamps, radiator cap, clogged radiator pins and loose belts.
- ✓ **FUEL SYSTEM**- Fuel supply., Drain water from the water separator
- ✓ **BATTERY** Check cables, connections and corrosions
- ✓ **WIRING** for loose connections and for worn wires or frayed wires.
- ✓ **LOAD** remove load or minimize load
- ✓ **GUARDS** must be put in place and tighten

During Engine Running

- Conduct again a Walk around inspection.
- Observed/listen for Unusual noise
- Monitor all parameters in Gauges or Panel
- Apply Load gradually.
- Continue to check all parameters.

Stopping The Engine

- Make sure all load must be remove or off GCB;
- Wait 3-5 minutes before turning the key to off position (For manual genset);
- Press “Stop” button and make sure cool down time (3-5 minutes) is programmed to the Control Panel. (Electronic Control Unit);
- Again Walk around inspect the Genset;
- Check any possible/ potential problem

Generator Exercise

- Every week/ without load
 - 5 minutes (lubrication and Battery)
- Monthly
 - load the genset at least 30% and above (Cooling system circulation)

NOTE:

Avoid Prolong running of genset below 30% load or without load to avoid high oil consumption.



Generator Set Maintenance Procedure (Standby)

Maintenance Intervals

- The Higher the Load (= Fuel consumption), the Shorter the Maintenance Intervals!
- Engine Running Hours do not consider Engine Loads
- TOTAL Fuel Consumption is accurate representation of Engine Operations

Maintenance Intervals

Good:



Running hours

Better:



Total fuel consumed

Avoid Unscheduled Down time!

HOW TO ACCOMPLISH?

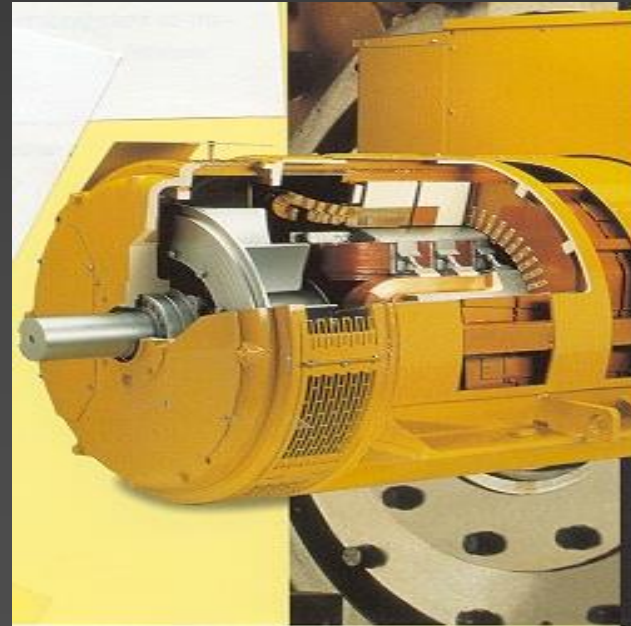
- Rigid PM Schedule
- Regular Component Inspections
- Pay Attention to Repair Indicators

Repair Indicators

- Total fuel consumed
- Oil consumption (increased)
- Increased blow by
- Service hours
- Hard starting
- Smoke (color)
- Loss of power
- Noise
- Debris in oil
- Decreased oil pressure



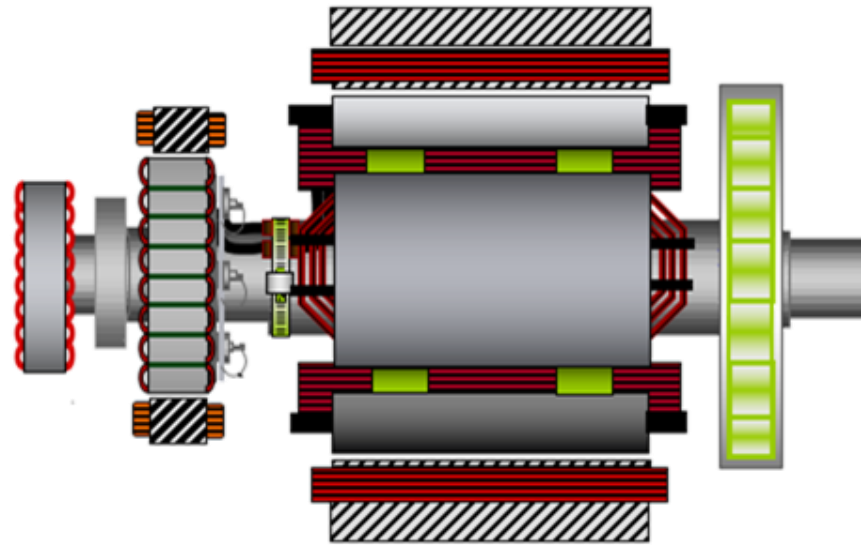
Alternator Maintenance



Generator Maintenance

Winding Insulation Resistance:

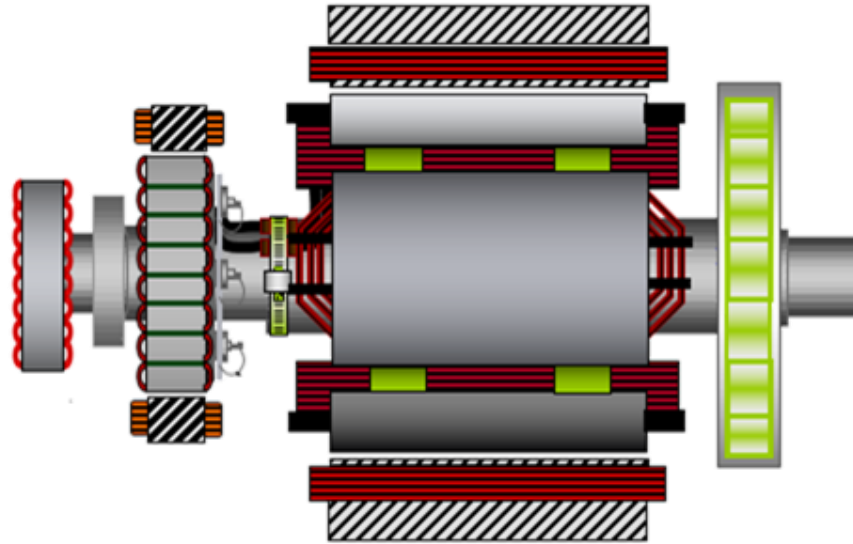
- Before start-up
- After long storage period
- Every 3 - 6 months during normal operation
- Should not drop below 1.5 Mega Ohm



Generator Maintenance

Bearing Greasing:

- Observe greasing information plate for details
- Use recommended grease
- Do not mix greases
- Do not over grease
- Follow recommended greasing procedures



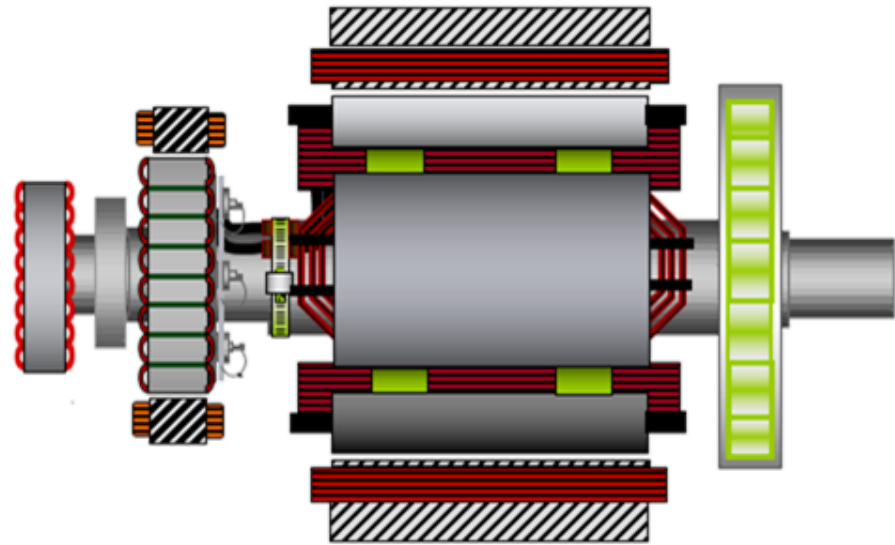
Generator Maintenance

Bearing Maintenance:

- Monitor bearing temperature
- Observe vibration levels

Bearing Replacement:

- Major overhaul



Generator Maintenance

Internal Cleaning:

- Bearing
 - Greasing
 - Maintenance
 - Replacement
- Internal cleaning by any of these methods:
 - vacuuming
 - steam cleaning (must be followed by re-varnish)

**CAUTION: Use of compressed air is
NOT recommended**



Generator Set Troubleshooting

Genset Protection

- Speed
- Pressure
- Temperature
- Starting
- Level
- Voltage
- Current
- Frequency
- Reverse Power

Troubleshooting

Signs

Causes

1. No voltage output

- Defective Exciter – no excitation/residual voltage
- Defective Diode block – no output coming from AVR (X1/X2)

2. Unbalance voltage

- Moisture on stator winding
- Defective diode

3. Low voltage

- Defective AVR
- Defective Exciter
- Low engine rpm

4. Voltage fluctuation

- Defective AVR

Engine Warning Signs

Signs

Causes

1. black smoke



- Dirty primary/secondary air cleaner
- Overloading
- Over fueling
- Faulty Turbocharger

2. Increased oil consumption/
excess blow-by



- Hours on engine • Worn rings/liners
- Worn turbocharger seals
- Prolong running without load
- Worn valve guides

3. Unusual noise



- Worn piston pin bushings
- Worn rod/main bearings
- Too much valve lash

4. Lack of power



- Dirty air cleaner
- Dirty fuel filter
- Incorrect adjustment of governor

Troubleshooting

Signs

Causes

7. Increased fuel consumption



- Fuel leak
- Malfunctioning fuel nozzles/injectors
- Dirty air cleaner

8. Overheating



- Plugged radiator core(external & internal)
- loose or worn belts/pulleys
- Low coolant level
- Malfunctioning temperature regulators
- Dirty air cleaner

9. Hard Starting
Engine Misfiring



- Battery Voltage low/voltage drop low
- Worn fuel injector pump
- Malfunctioning fuel nozzles/injectors
- Low cranking speed.

10. Oil Level Over Full



- Coolant/Fuel leak into oil pan • Improper oil fill



Generator Set Operation and Maintenance Training