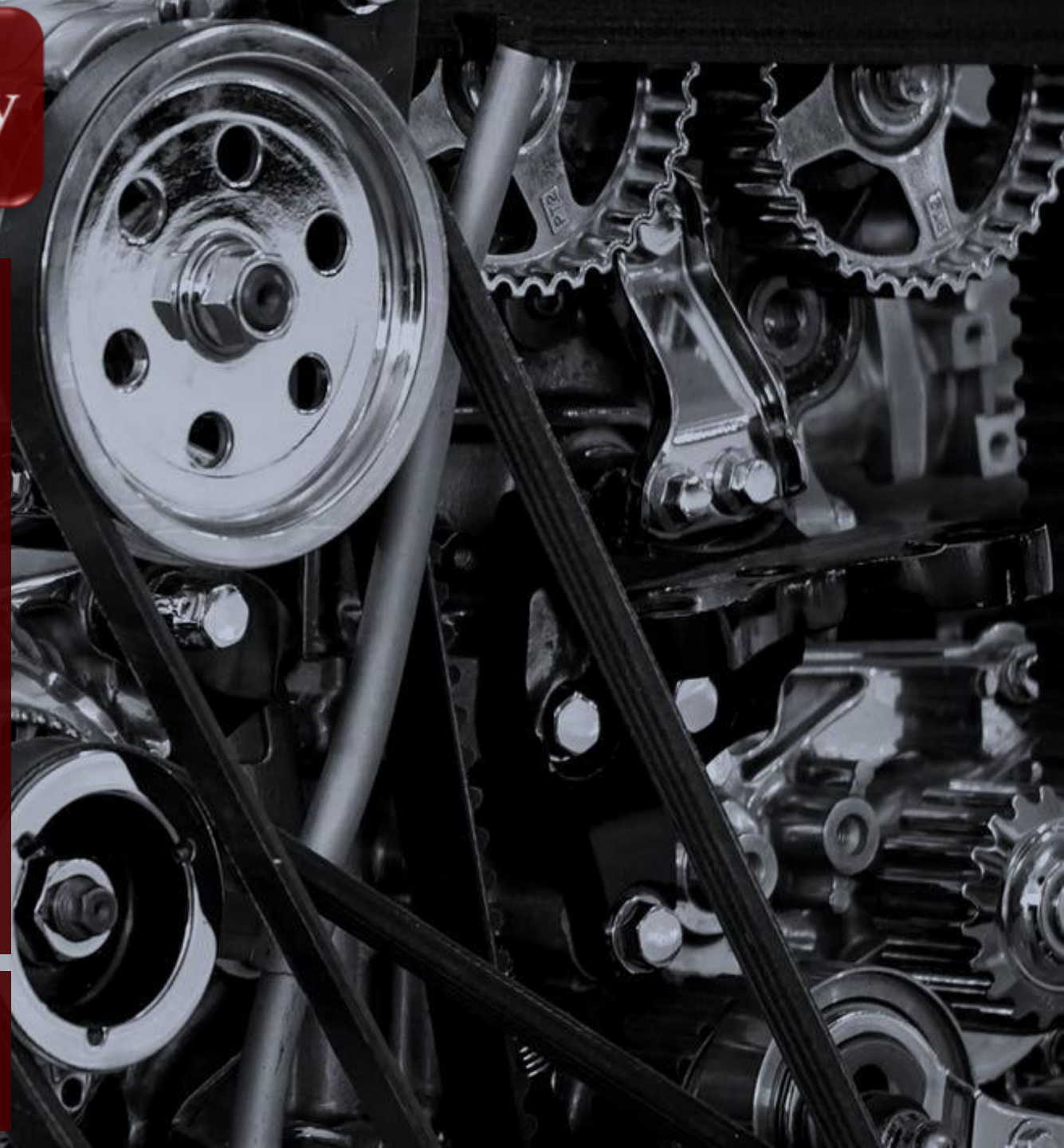


GSA Training

Module 1

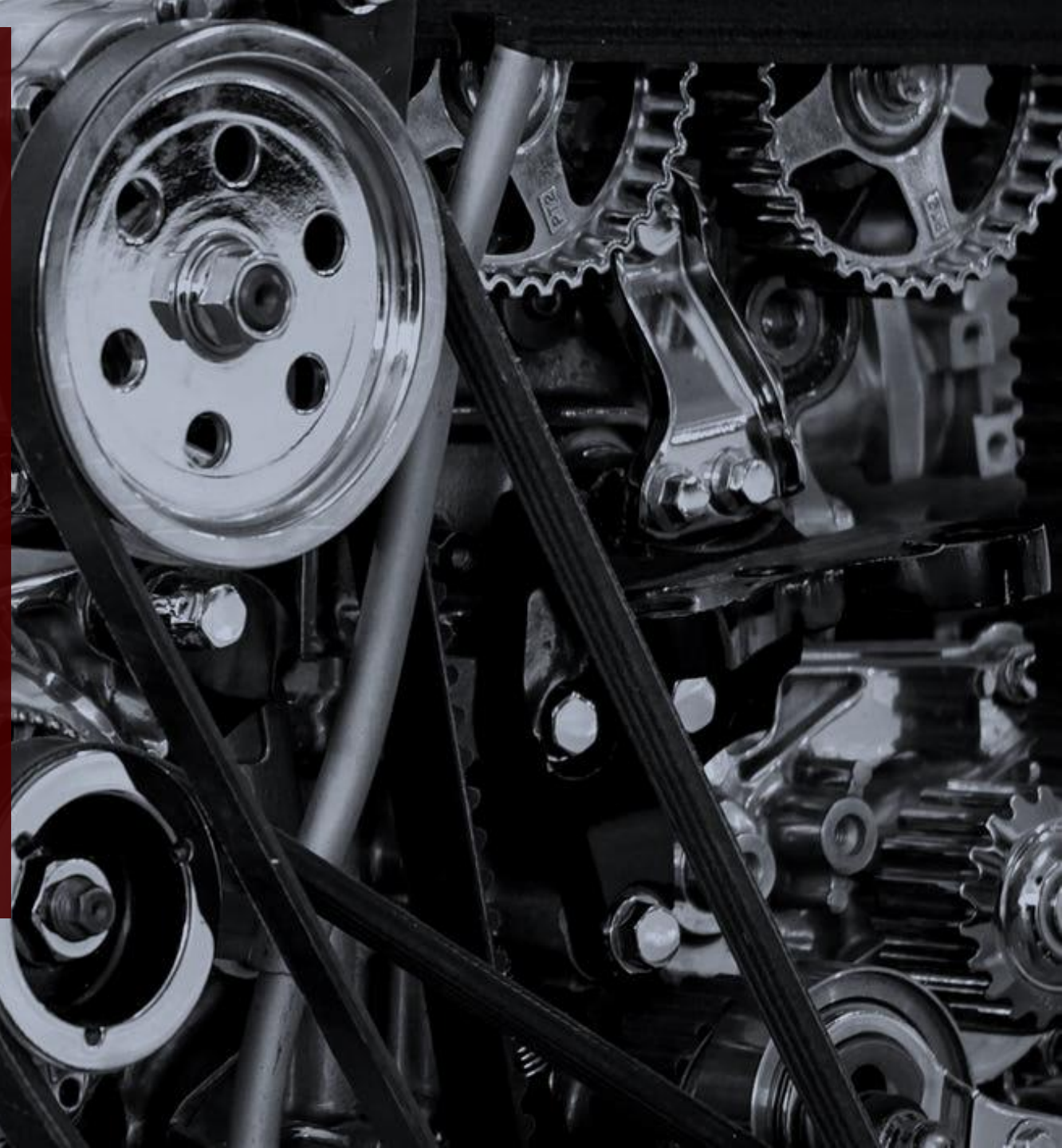
Gasoline and Diesel Engine Fundamentals, Fluids, and Lubricants

Instructor: Andrew Tillman
Email: andrew.j.Tillman@siu.edu



Agenda:

1. Engine components and operation
2. The basics of the 4 stroke cycle & compression ignition engines
3. Fuels (Gas and Diesel)
4. The lubrication system
5. The cooling system
6. Wrap-up & questions



Before we begin:

Any questions?



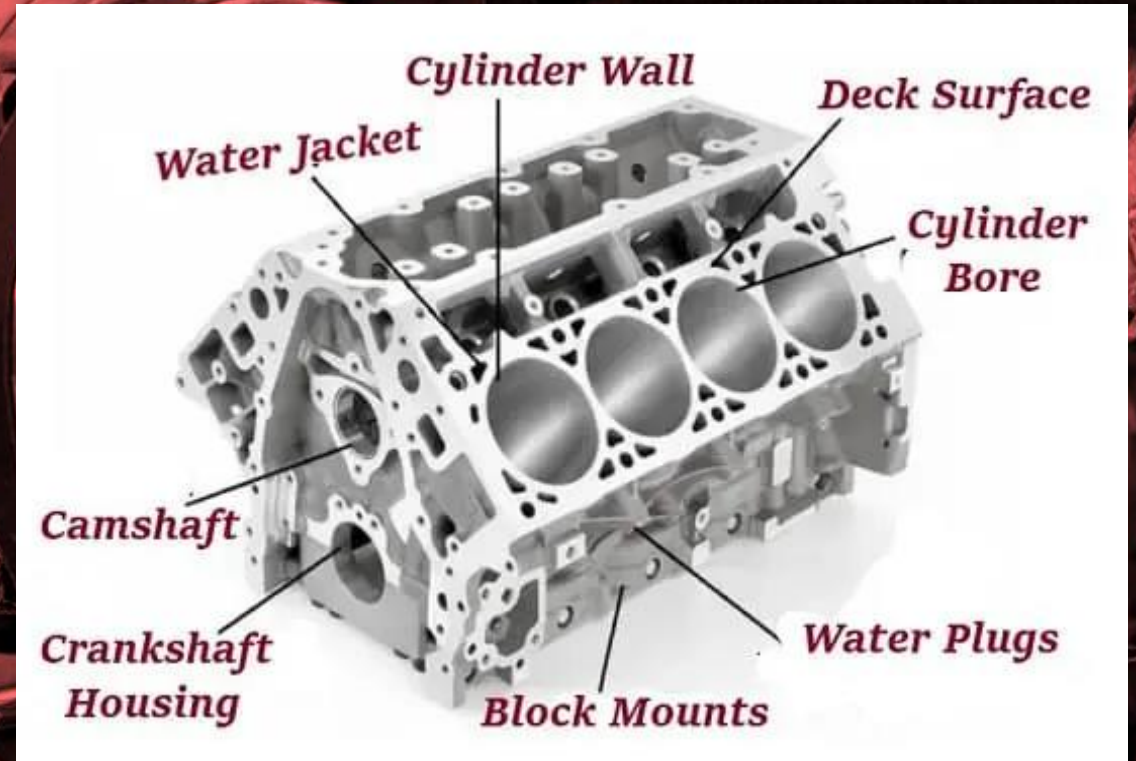
Engine components and operation

The Block

of cylinders
(1, 2, 4, 6, 8, etc.)

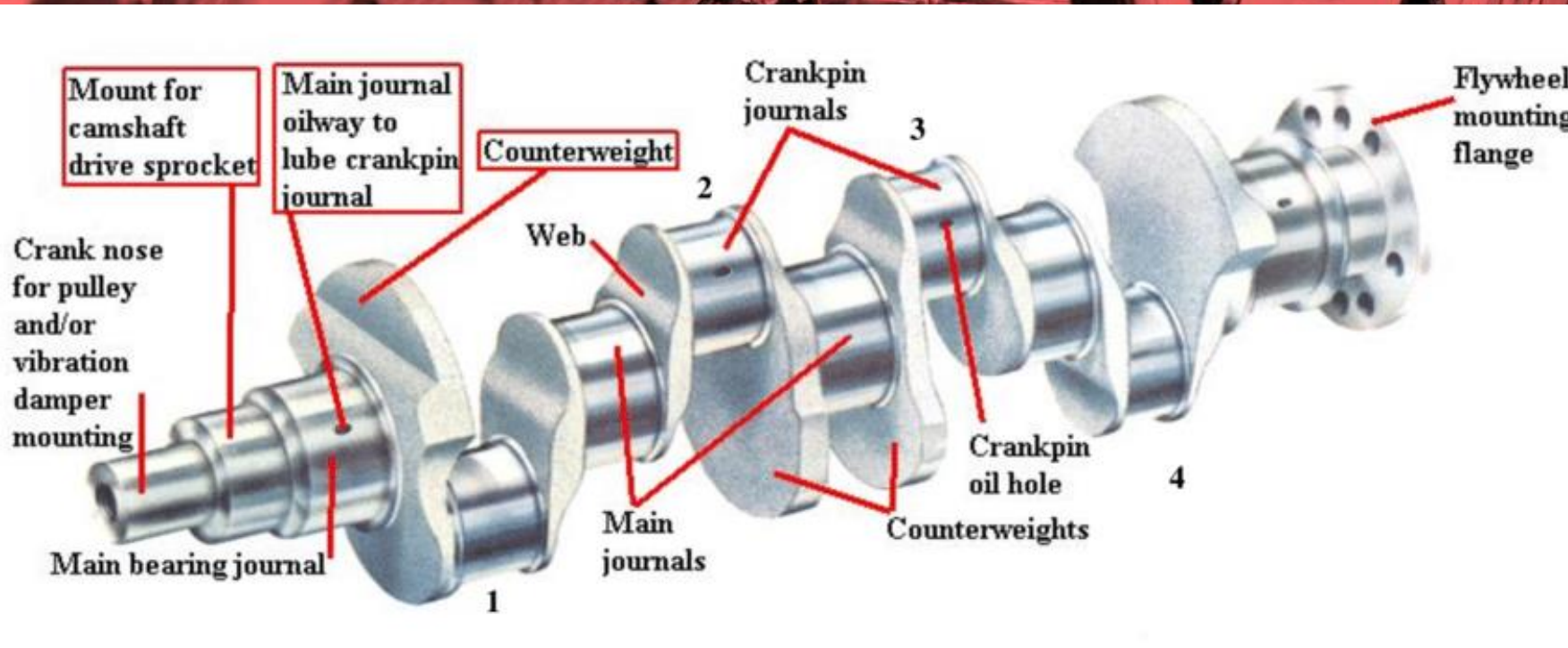
Arrangement of cylinders
(Inline, V, Opposed, etc.)

Displacement
(2L, 5.7L, 350 CI)



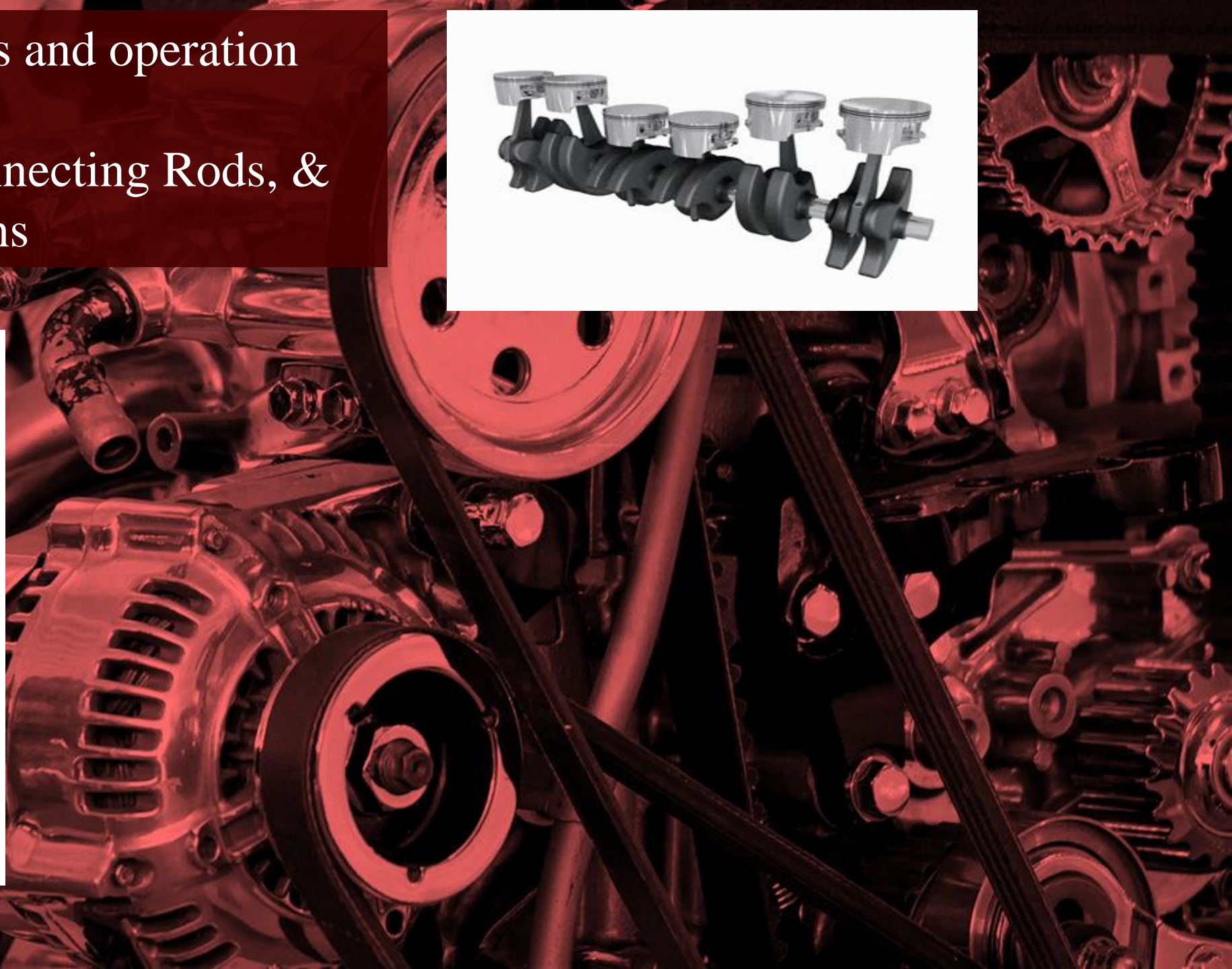
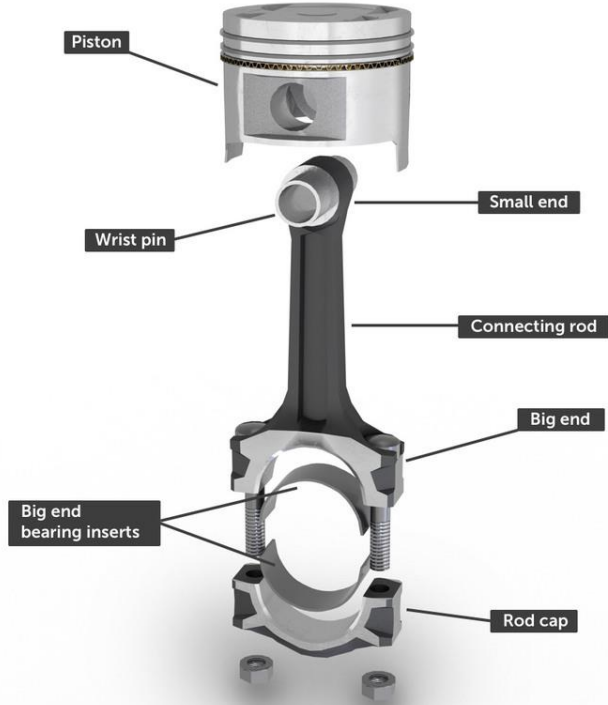
Engine components and operation

The Crankshaft



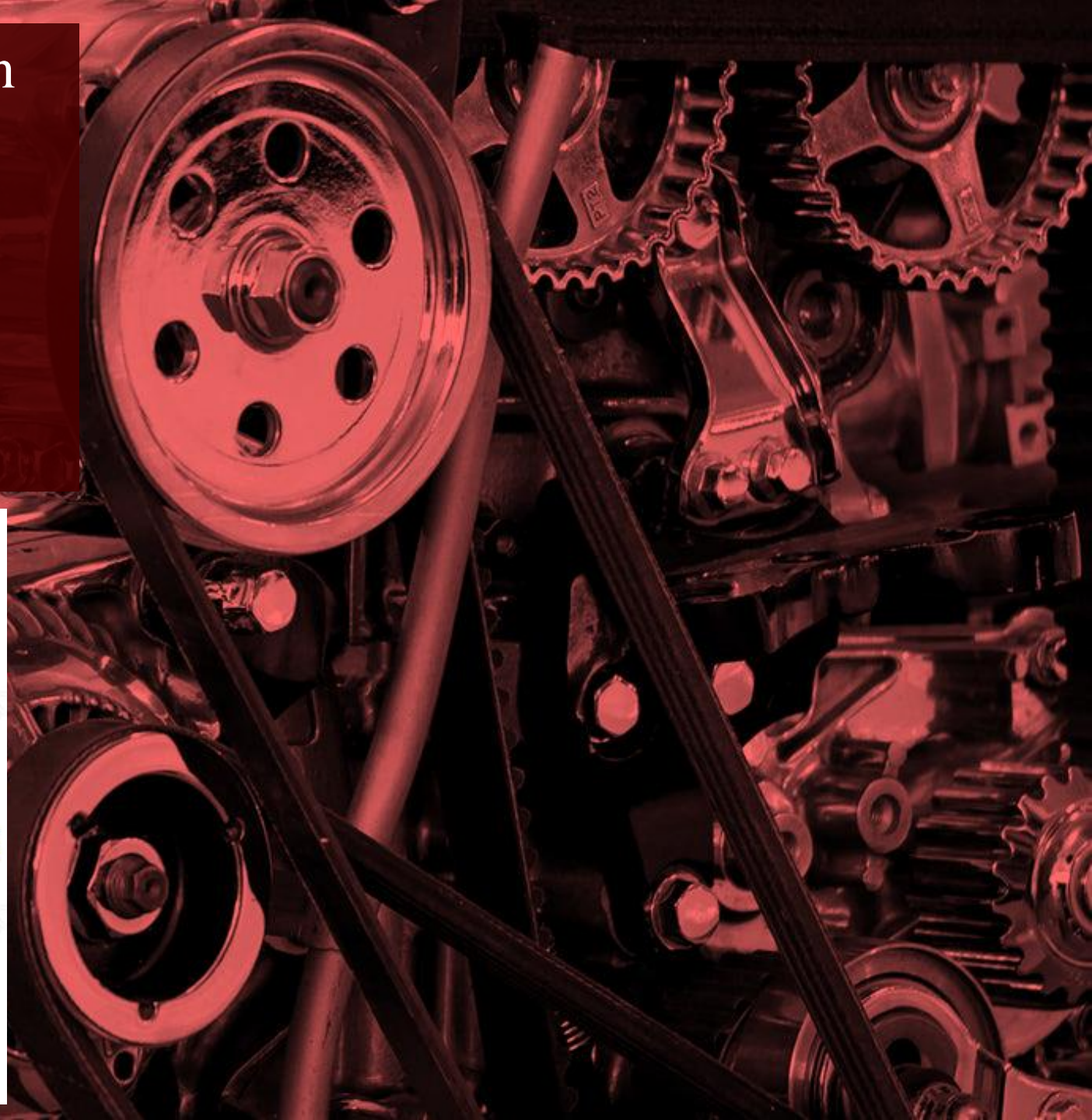
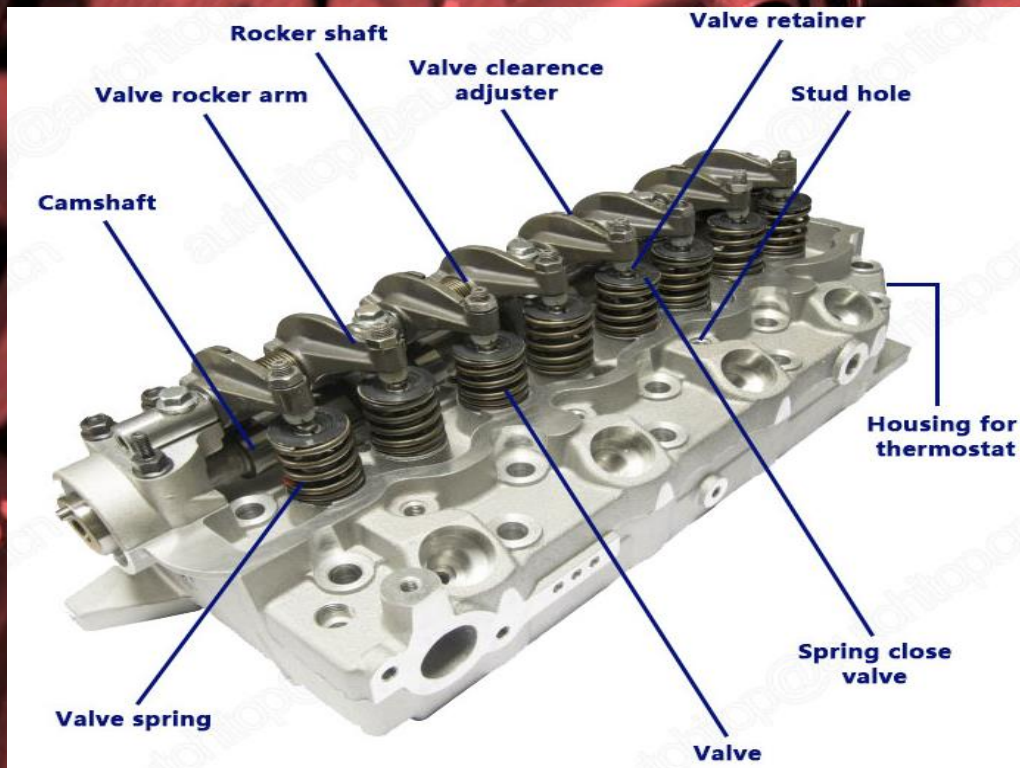
Engine components and operation

The Crankshaft, Connecting Rods, & Pistons



Engine components and operation

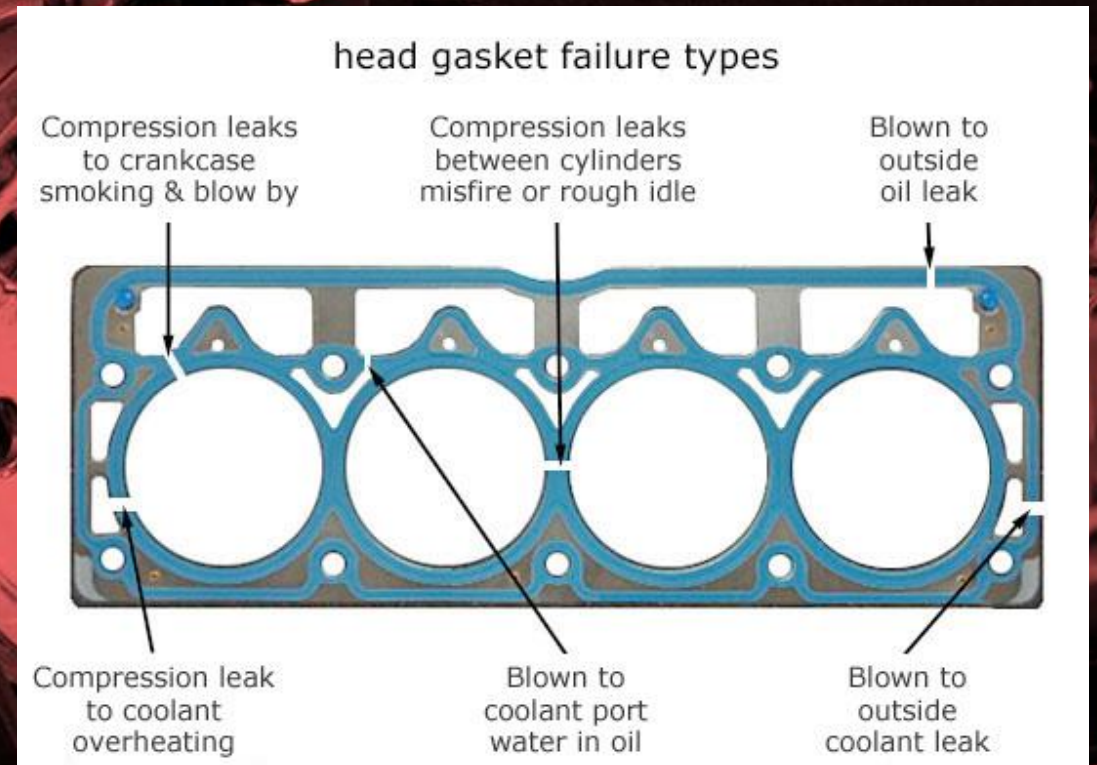
The Head
Sits on top of the Block
(OHV, OHC, DOHC)



Engine components and operation

The Head Gasket

Seals:
Compression
Coolant
Oil

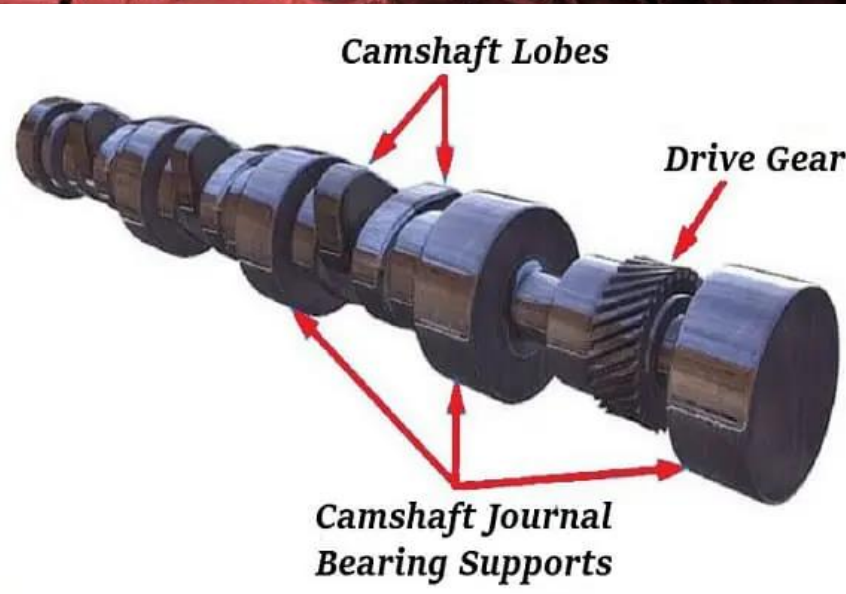
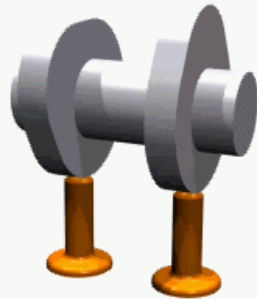
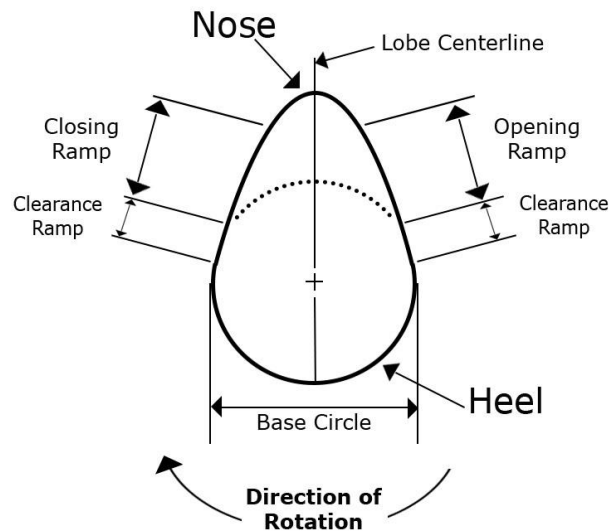


Engine components and operation

Camshaft(s)

Cam in block or Overhead Cam(s)

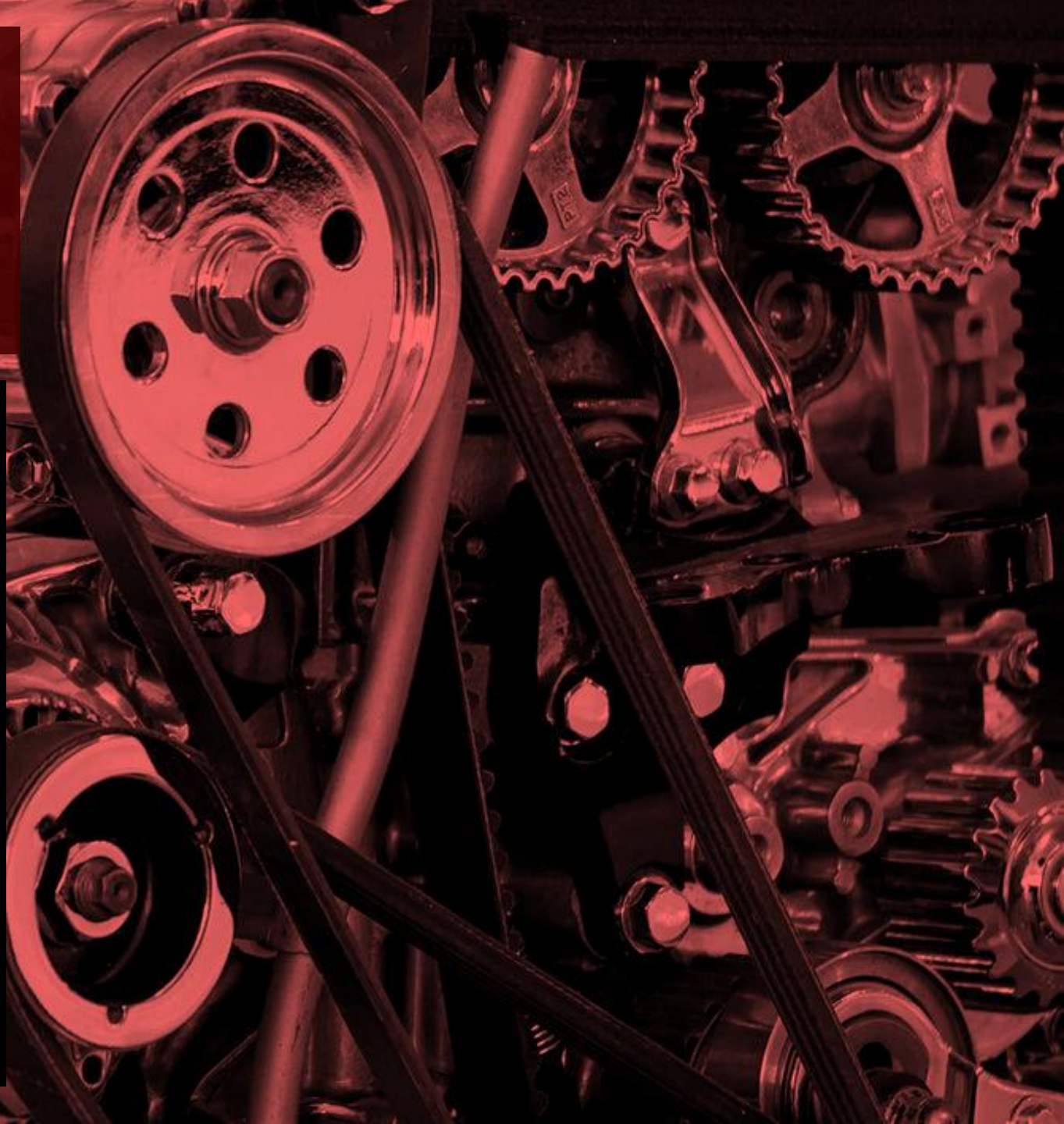
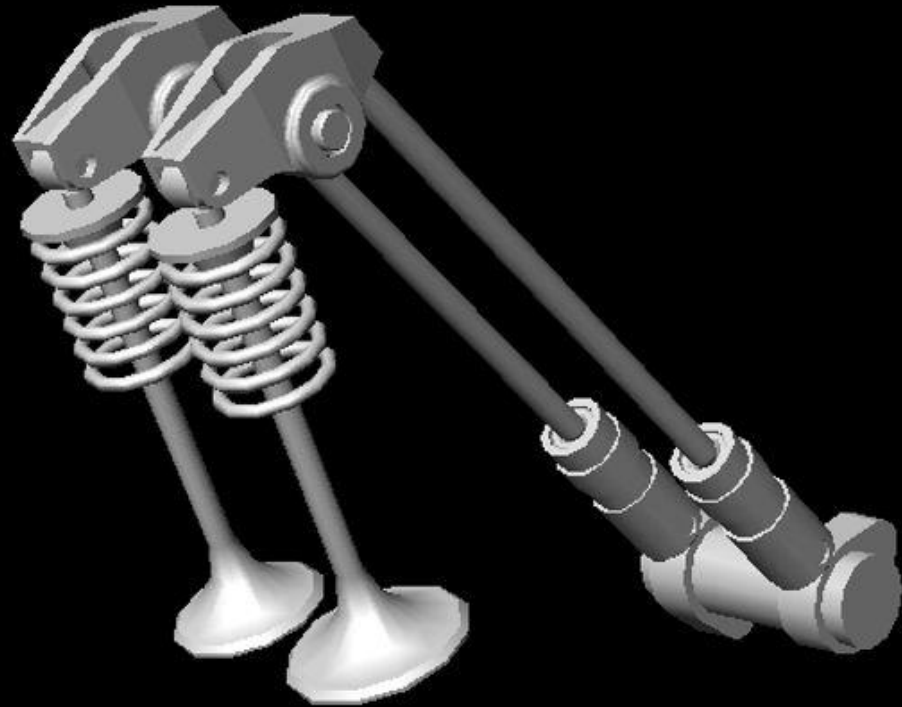
Cam Profile Terms



Engine components and operation

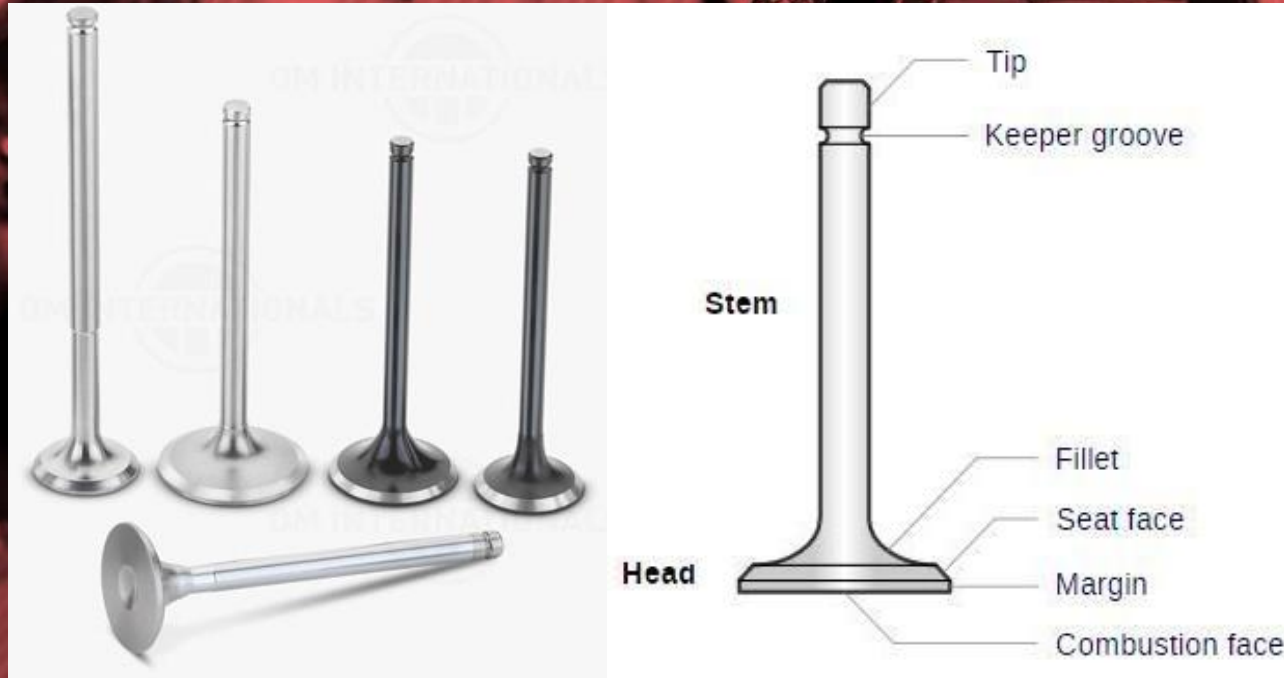
(OHV) engine

Lifters, Pushrods, Rocker arms



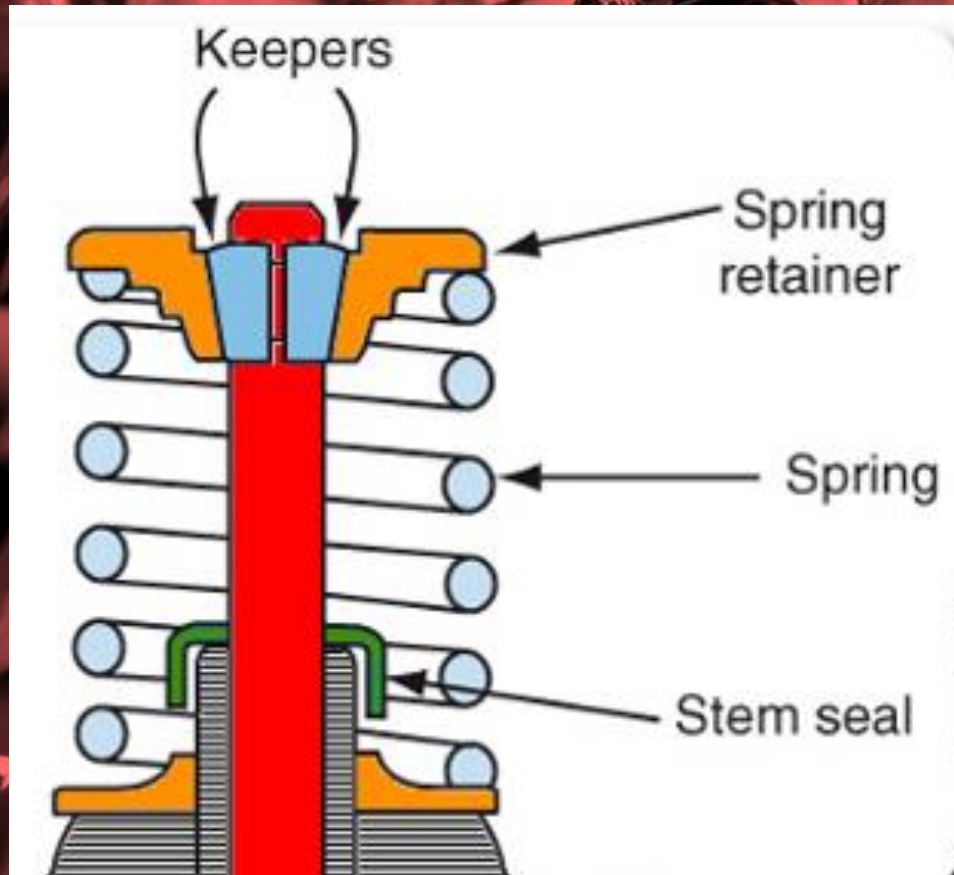
Engine components and operation

Valves



Engine components and operation

Valve springs



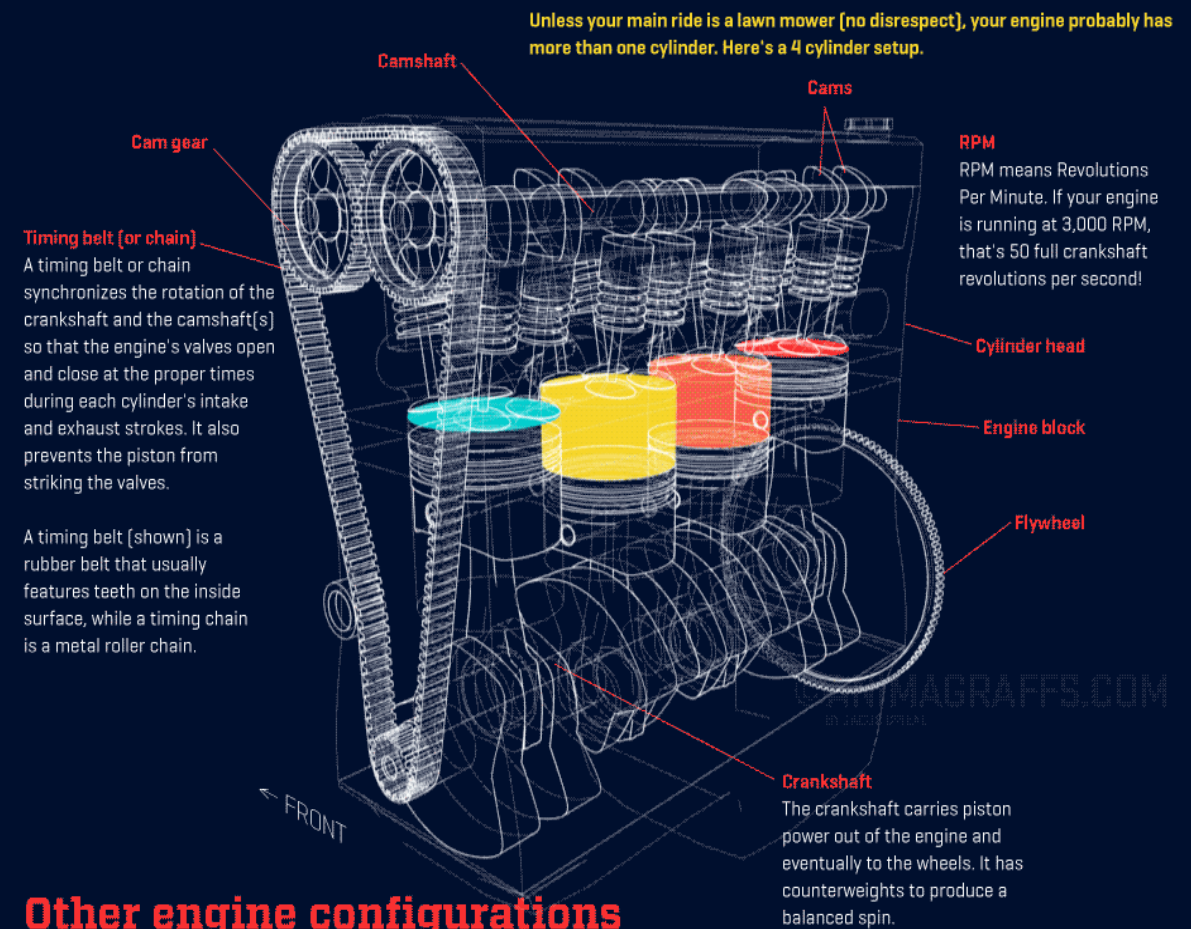
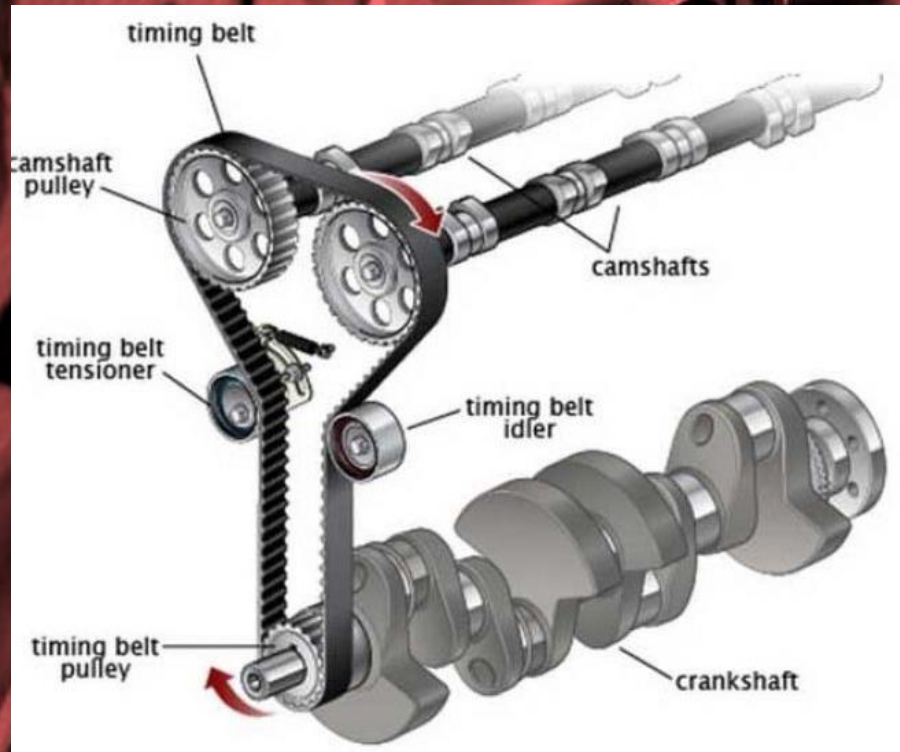
Engine components and operation

Timing

Belts

Chains

Gears (heavy duty applications)



Other engine configurations

You told all your buddies when dad bought that V8 sedan. Now you can find out what it actually means: opposing cylinders arranged in a "V" shape.

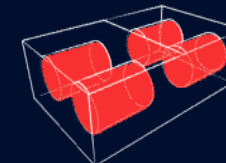
V TWIN

A two cylinder arrangement. Many Harley-Davidson motorcycles use this configuration, for instance.



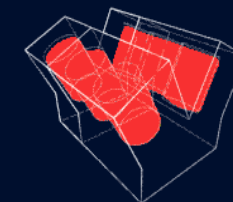
FLAT FOUR

Four cylinders arranged in a flat, opposing configuration. Found in classic VW Beetles and various current Subaru model cars.



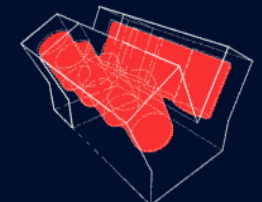
V 6

Six opposing cylinders. Well suited for sports cars or mid-size SUVs.



V 8

Eight opposing cylinders. Generally suited for muscle-car applications or heavy duty engines.



Engine components and operation

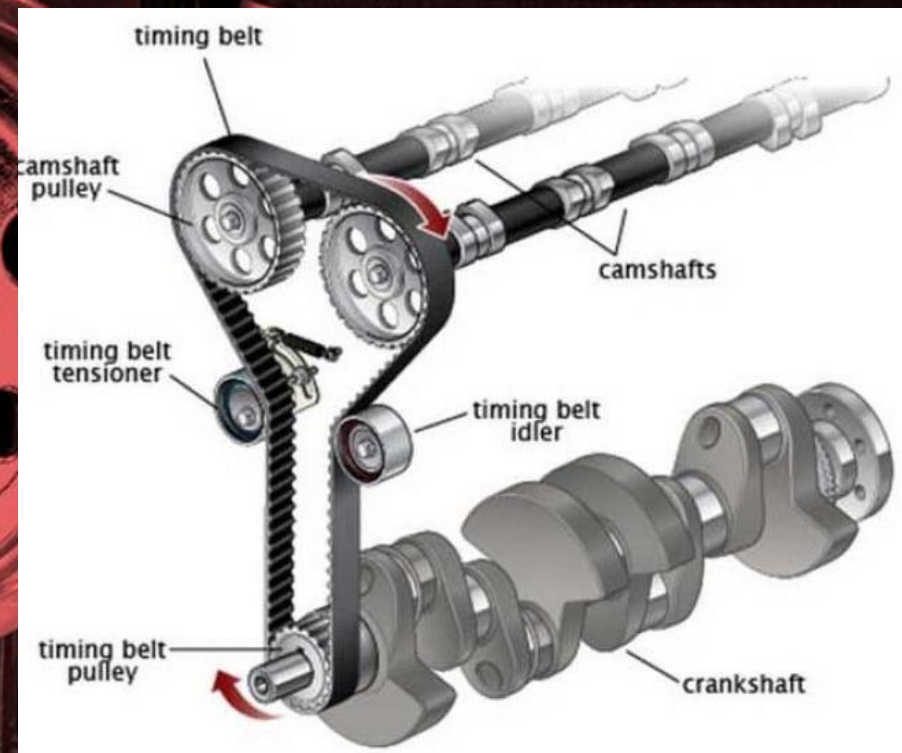
Timing

Belts

Require the most service
(60k – 100k miles)

Very Quiet

Prone to contamination



Engine components and operation

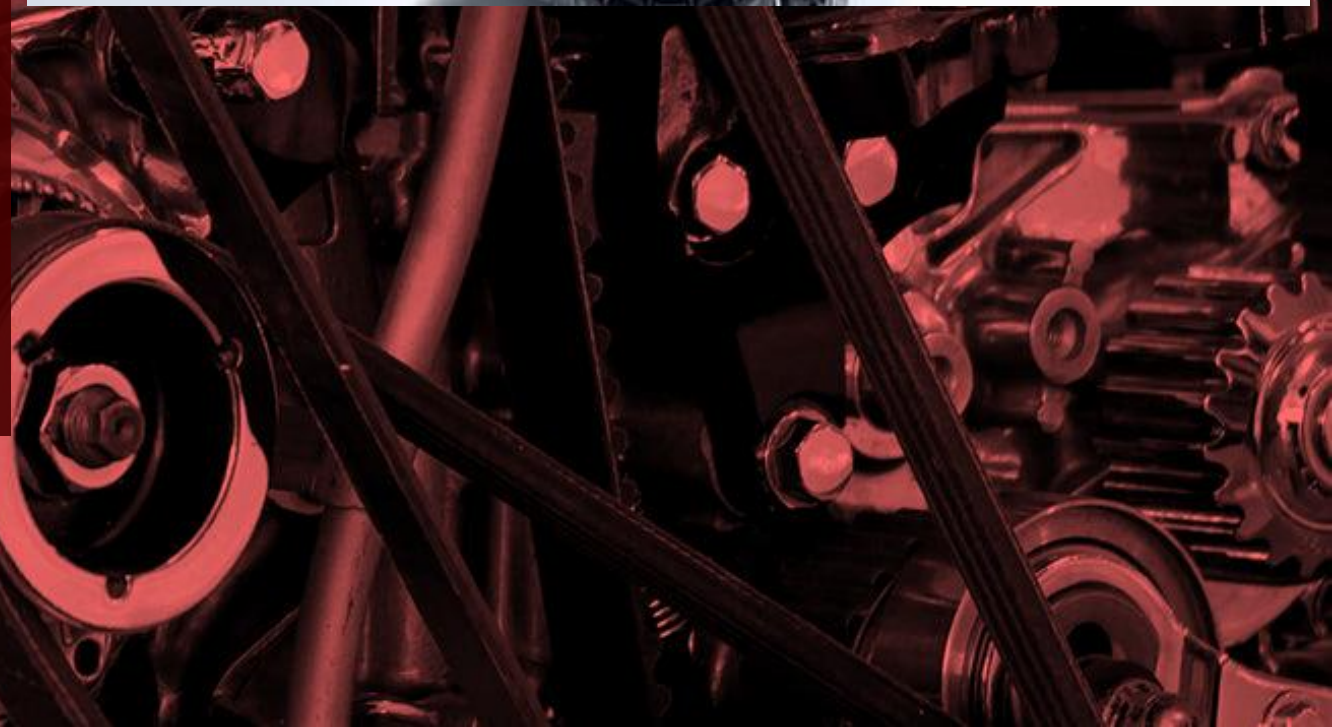
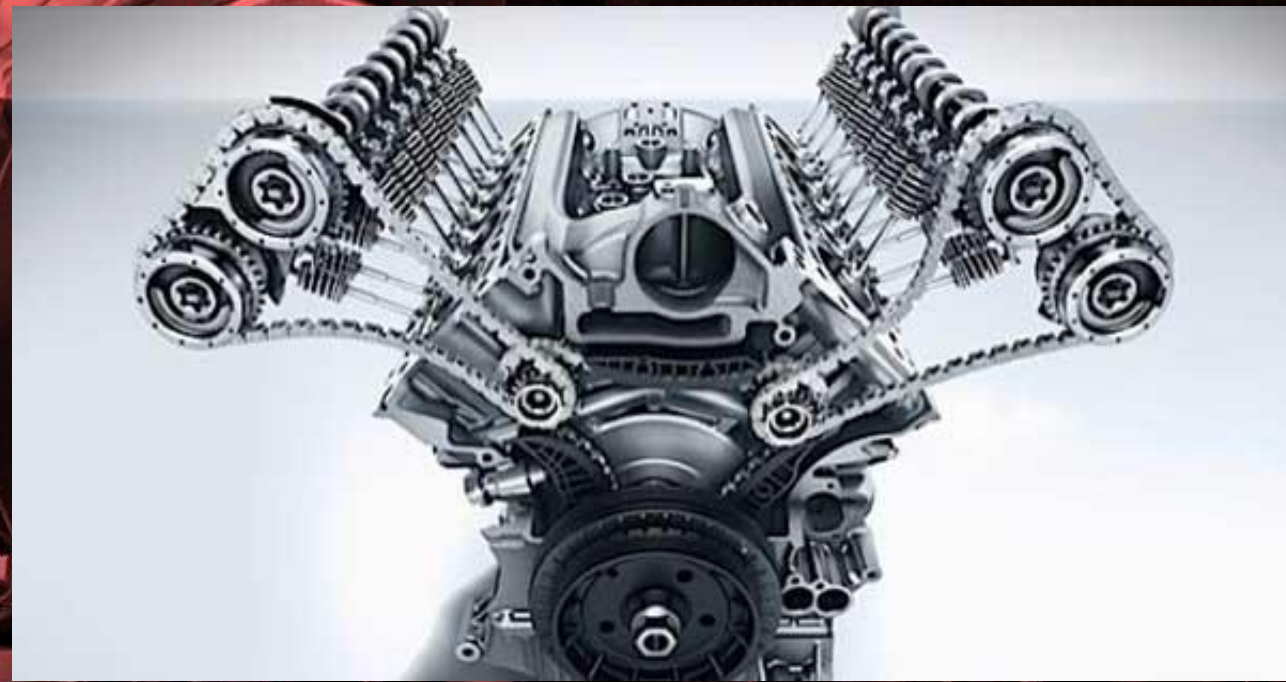
Timing

Chain

Require the less service
(80k – 150k+ miles)

Durable but do stretch/wear over time

Lubricated by engine oil



Engine components and operation

Timing

Gears

Require the least service

Most durable

LOUD!

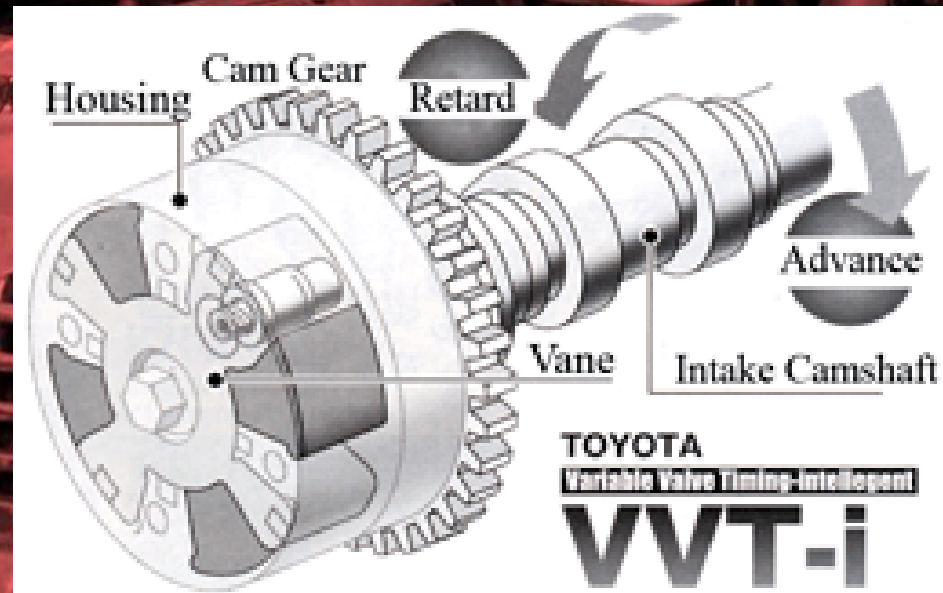
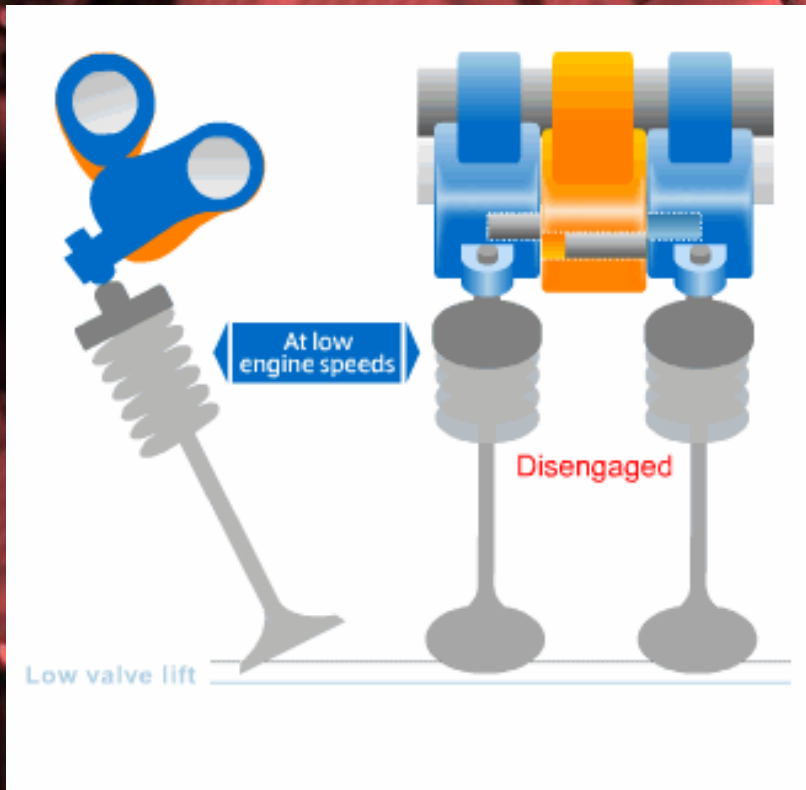
Lubricated by engine oil



Engine components and operation

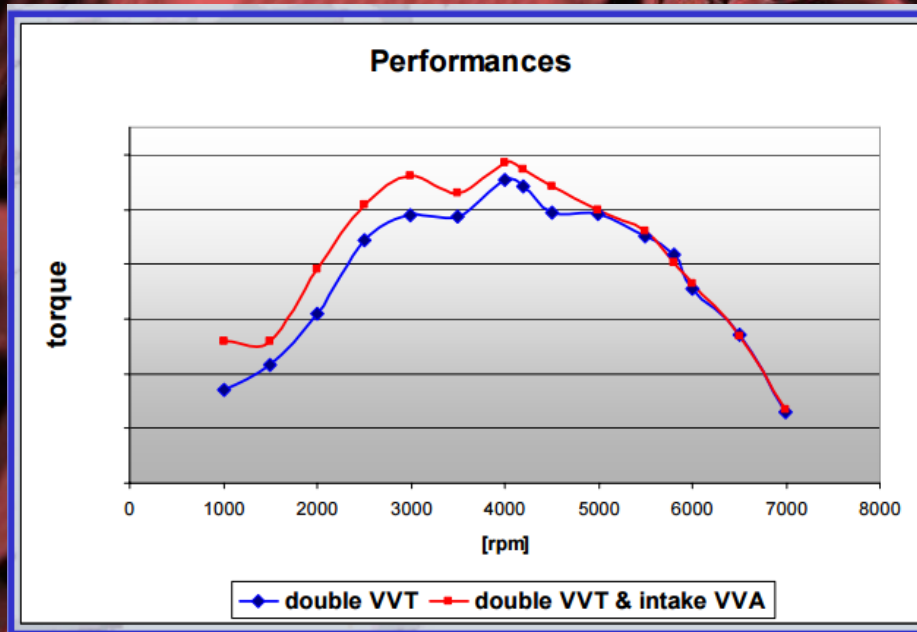
Variable (Valve) Timing

Improve combustion by altering valve duration and/or lift



Engine components and operation

Improve combustion by altering valve duration and/or lift



Gasoline / Diesel Direct & indirect Injection

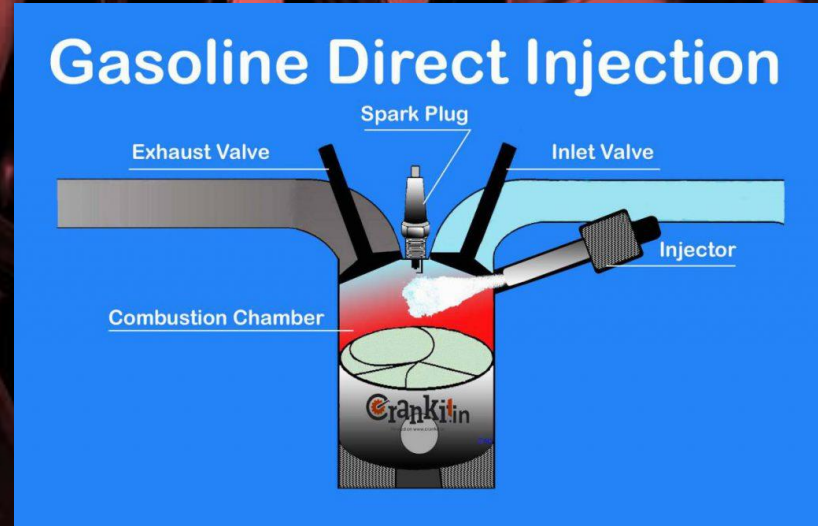
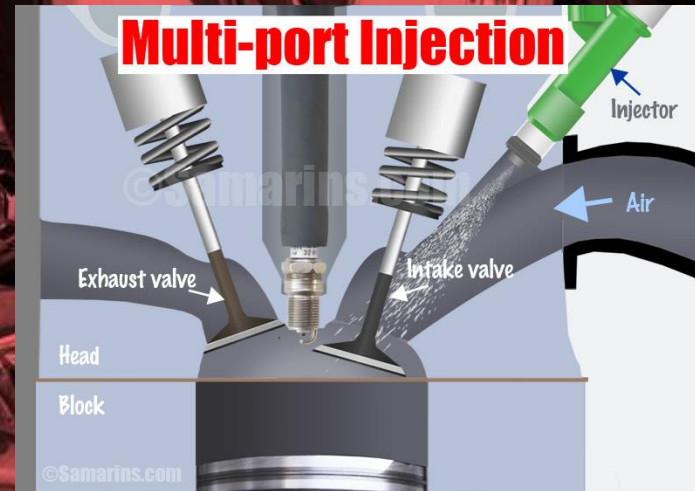
Gasoline delivery –

Carbureted

Throttle Body Injection

Multi-Port Injection

Direct Injection



Gasoline Ignition Systems

Distributor

Distributor-less

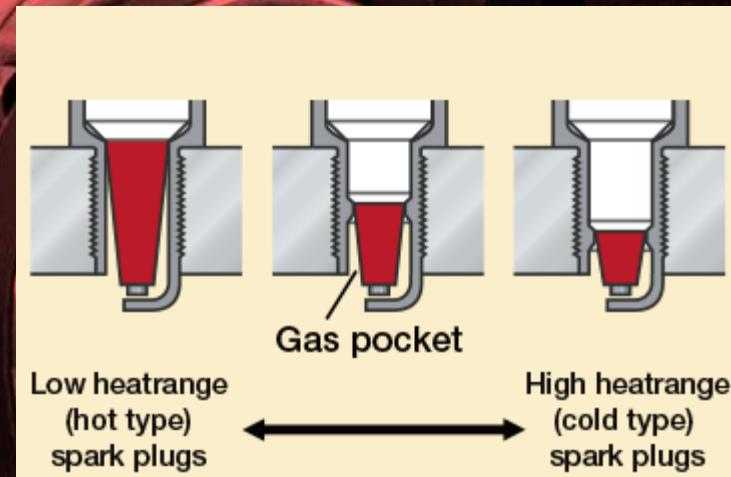
Coil-On-Plug



Ignition sources

Gasoline – Spark Plugs

Can help diagnose cylinders



Copper



Silver



Platinum



Iridium

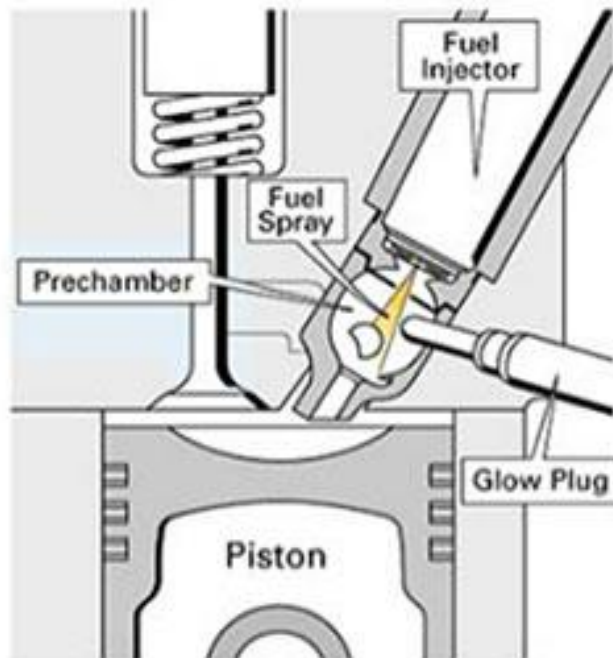
Gasoline / Diesel Direct & indirect Ignition

Diesel delivery –

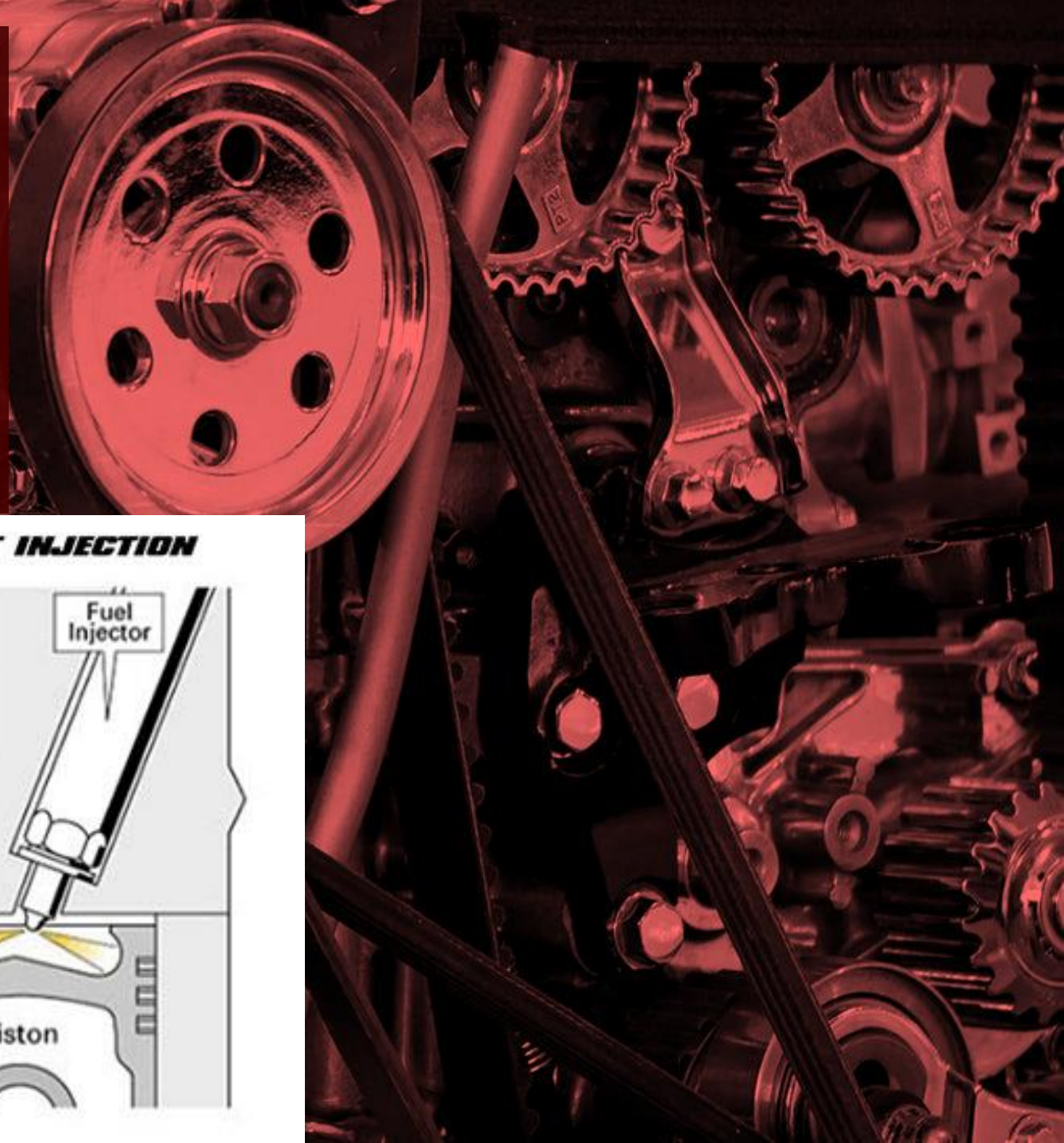
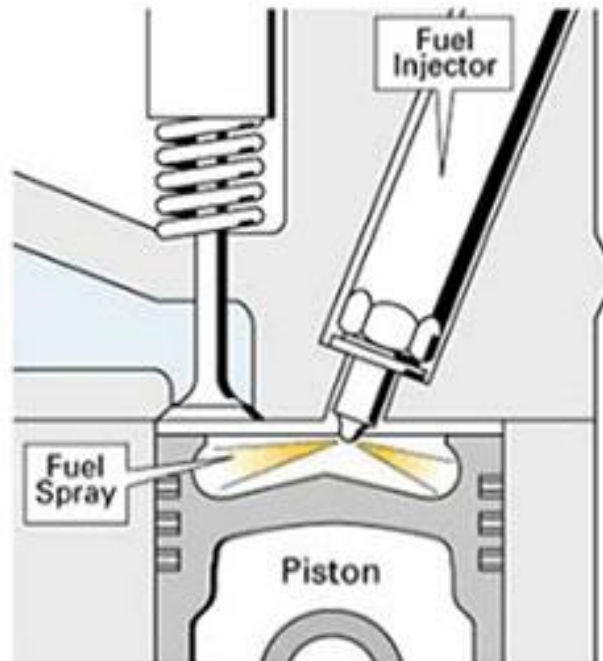
Indirect Injection

Direct Injection

IDI - INDIRECT INJECTION



DI - DIRECT INJECTION



Ignition sources

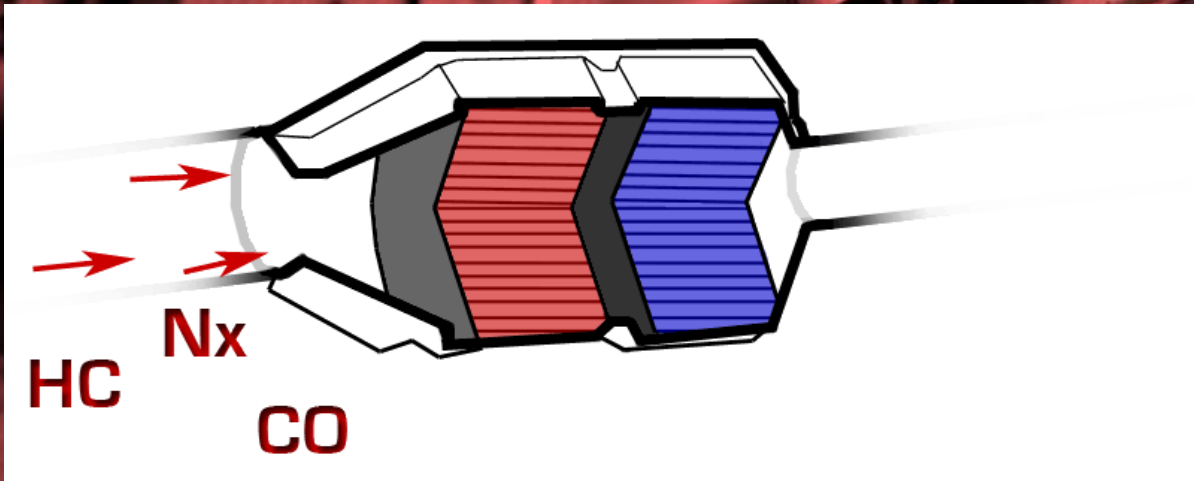
Diesel – Heating element /or
compression



Catalytic Converters

Convert harmful emissions to clean ones! (99-95% effective)

HC, NO_x, CO, CO₂, O₂, H₂O, N₂



Stolen for the precious metals

Diesel Exhaust Fluid (DEF)

32.5% urea in 67.5% de-ionized water

NEVER ADD TO DIESEL FUEL!

For emission control –
DEF is sprayed into the exhaust,
breaking down NO_x gases into
nitrogen and water, also good for
Particulate Matter emissions



Engine components

Common issues:

Gasket Failures

Overheating

Valve Train Noise

Timing Issues

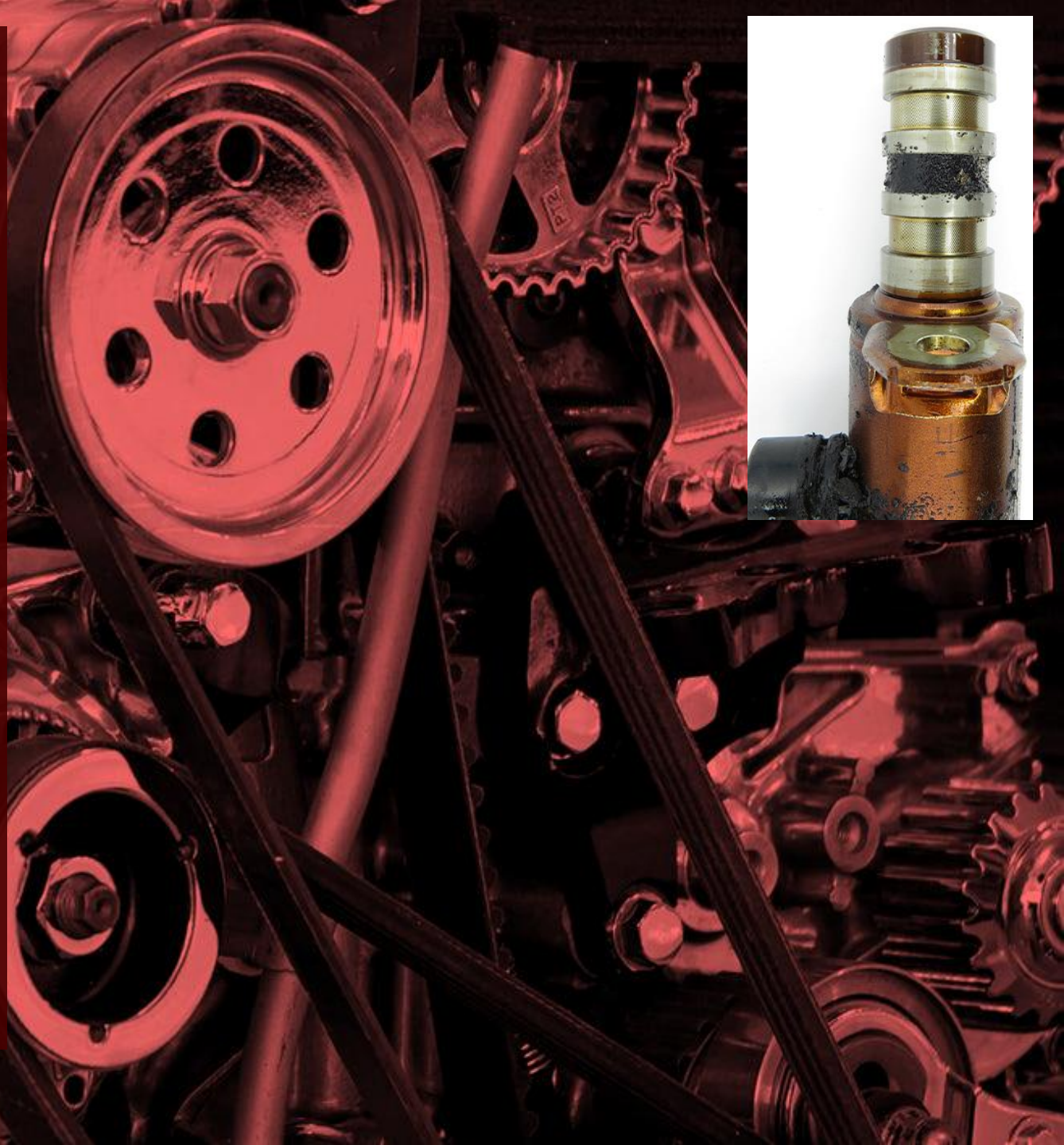
Engine Knocking

Rod Knock

Detonation

Spun Bearings

Oil starvation

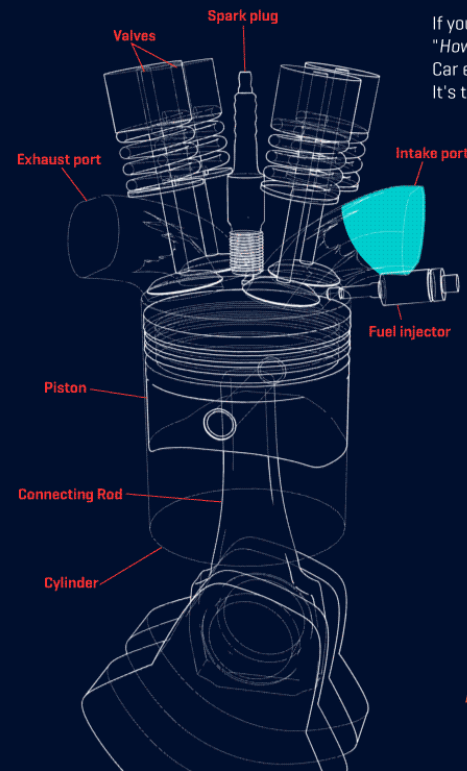


The basics of the 4 stroke cycle & compression ignition engines

HOW A CAR ENGINE WORKS

[And a note about hybrid gas-electric cars too]

If your only experience with a car engine's inner workings is "How much is that going to cost to fix?" this graphic is for you! Car engines are astoundingly awesome mechanical wonders. It's time you learned more about the magic under the hood!



The 4 Stroke Cycle

Let's take a look inside just one cylinder.

1 INTAKE STROKE

The piston descends, sucking air into the cylinder through open intake valves as fuel is injected.

2 COMPRESSION STROKE

With all valves closed, the piston comes back up, compressing the fuel-air mixture. Compressing the mixture delivers better power and efficiency.

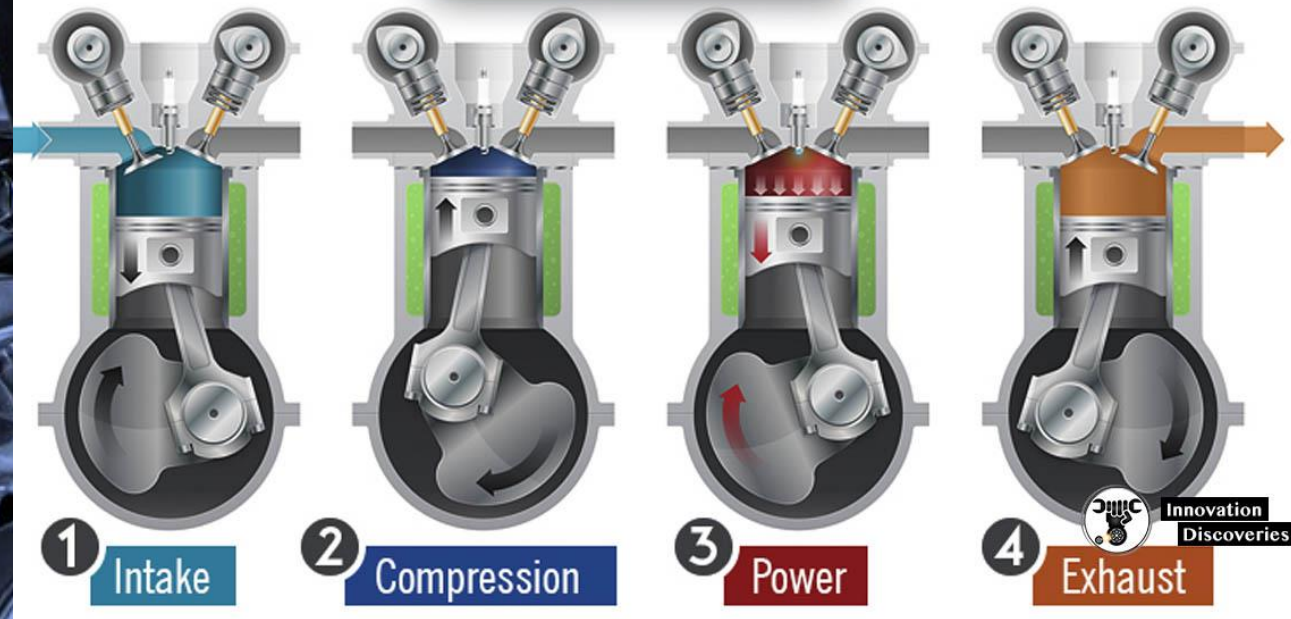
3 POWER STROKE

A spark ignites the compressed fuel-air mixture, and the resulting combustion forces the piston to the bottom of the cylinder again.

4 EXHAUST STROKE

The piston comes back up, pushing the spent mixture out through open exhaust valves.

4-Stroke Engine

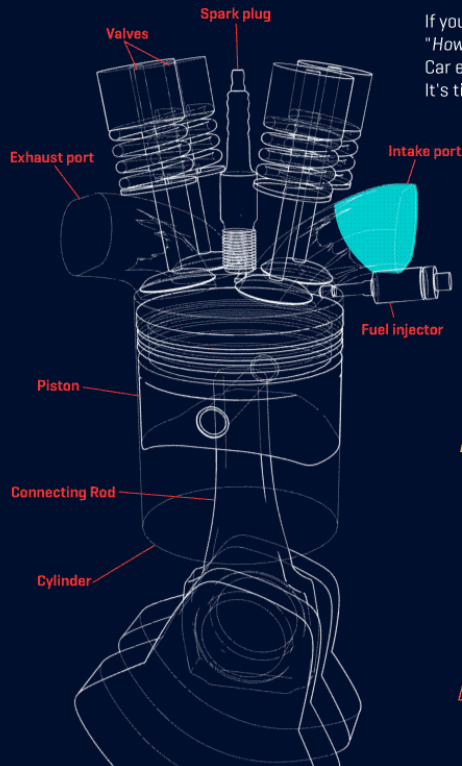


The basics of the 4 stroke cycle & compression ignition engines

HOW A CAR ENGINE WORKS

[And a note about hybrid gas-electric cars too]

If your only experience with a car engine's inner workings is "How much is that going to cost to fix?" this graphic is for you! Car engines are astoundingly awesome mechanical wonders. It's time you learned more about the magic under the hood!



The 4 Stroke Cycle

Let's take a look inside just one cylinder.

1 INTAKE STROKE

The piston descends, sucking air into the cylinder through open intake valves as fuel is injected.

2 COMPRESSION STROKE

With all valves closed, the piston comes back up, compressing the fuel-air mixture. Compressing the mixture delivers better power and efficiency.

3 POWER STROKE

A spark ignites the compressed fuel-air mixture, and the resulting combustion forces the piston to the bottom of the cylinder again.

4 EXHAUST STROKE

The piston comes back up, pushing the spent mixture out through open exhaust valves.

1) The intake stroke

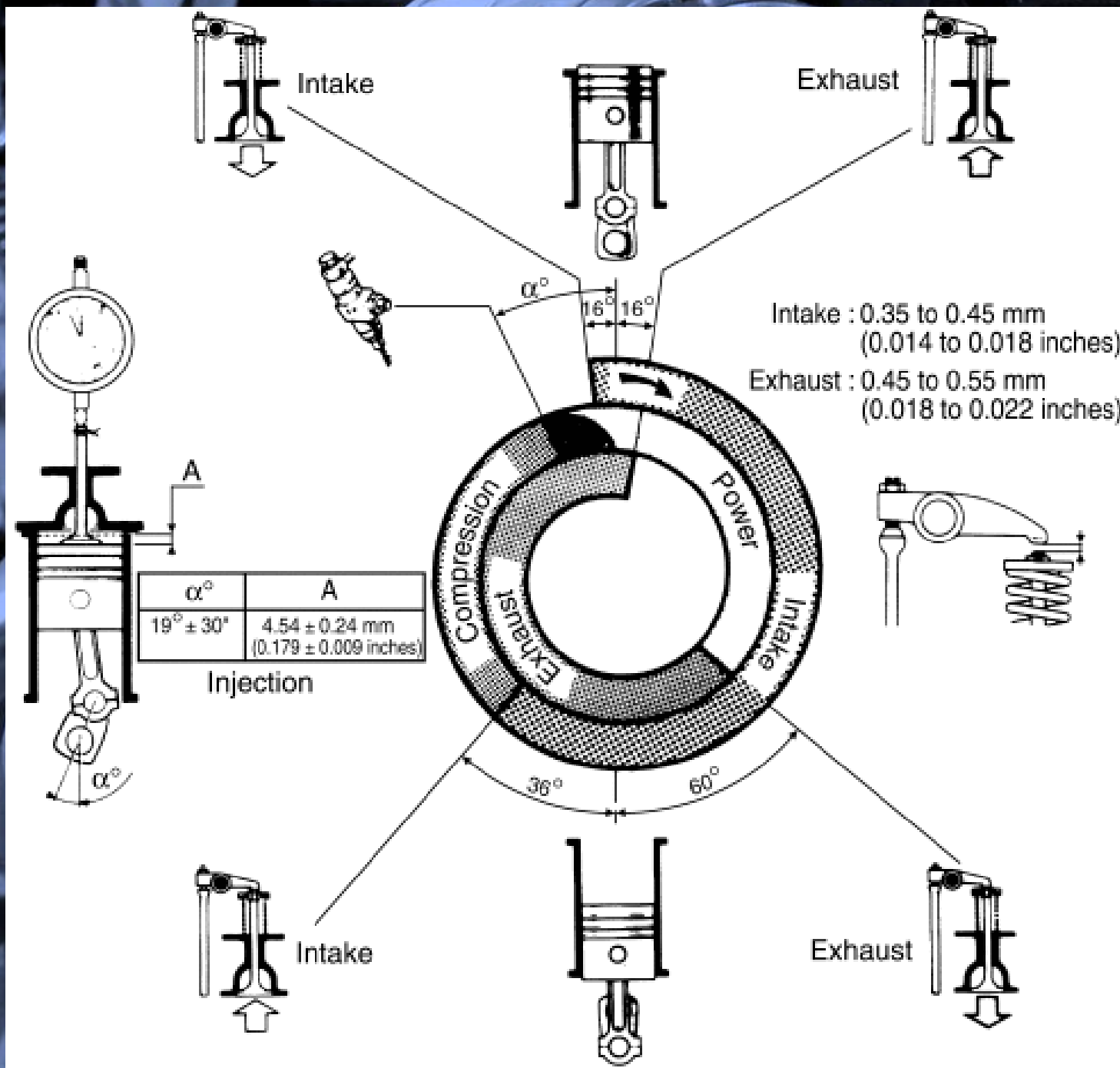
Gasoline can be injected before or during intake stroke

Starts when intake stroke opens (10-20 degrees BTDC) – Exhaust stroke still happening!

Ends when the intake stroke closes (60 degrees ABDC)

Approx. 250 degrees of rotation – the longest stroke





2) The compression stroke

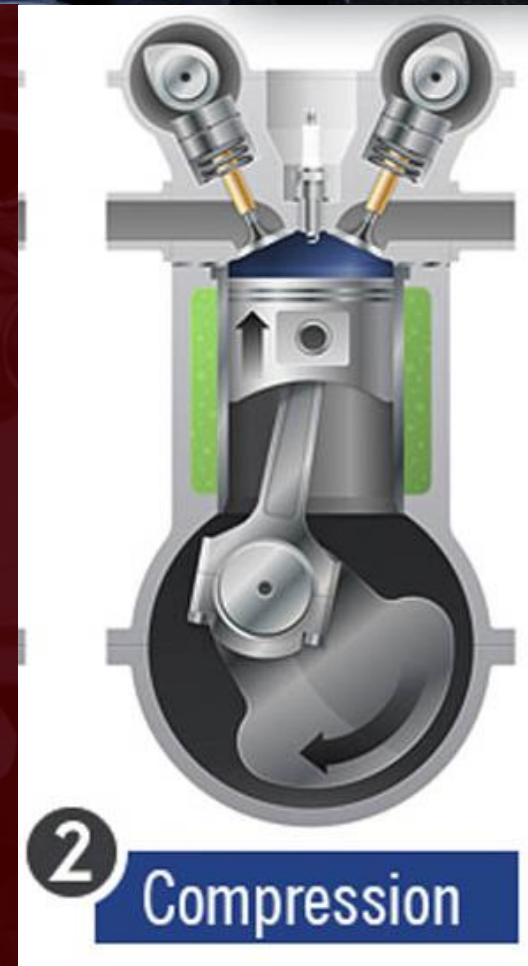
Air & Fuel is compressed (adding heat)

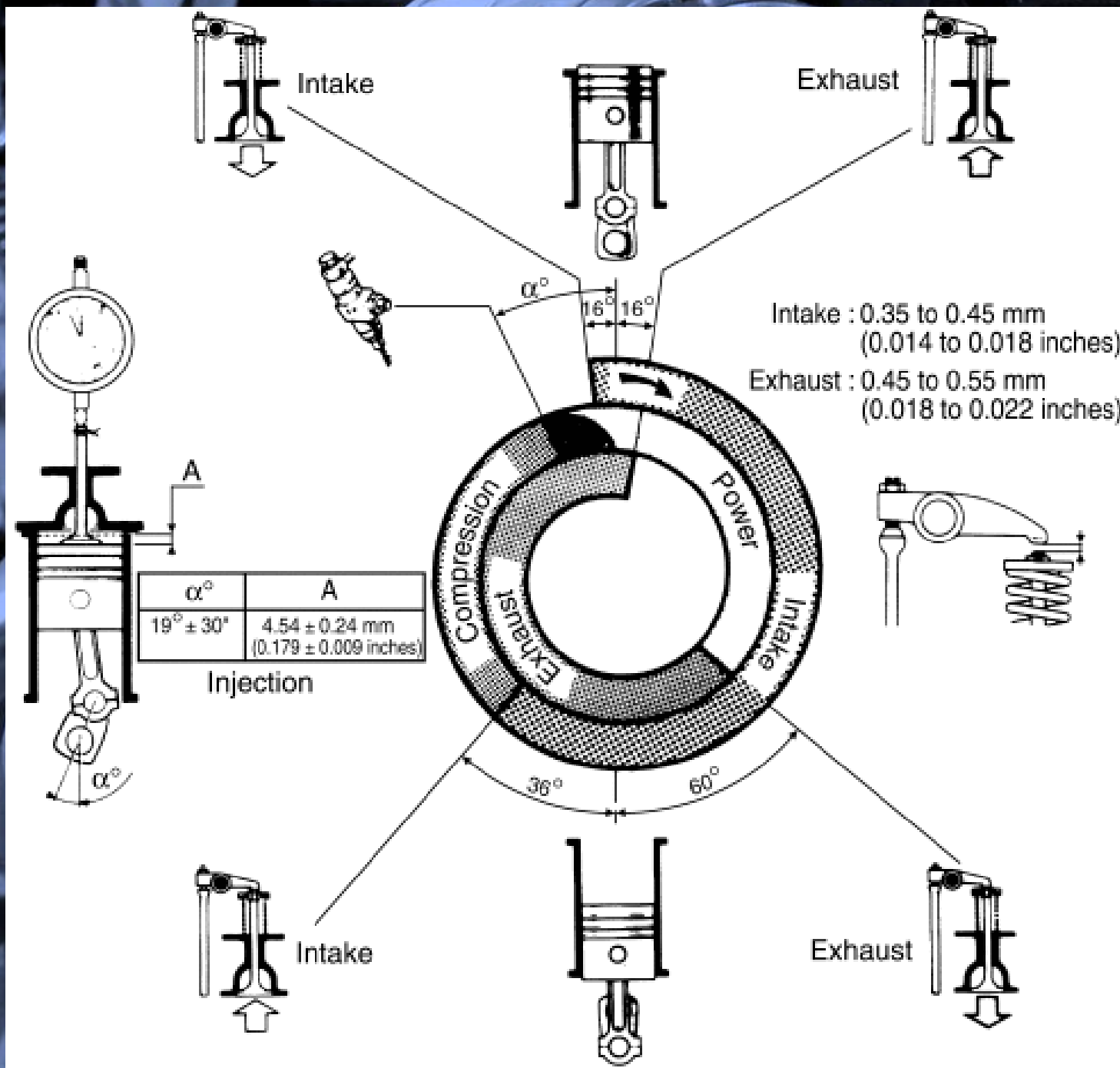
Gasoline Compression ratio: average 8:1 – 9.5:1

Diesel Compression ratio: average 16:1 – 20:1

Shortest stroke in terms of degrees

Piston already heading up from BDC





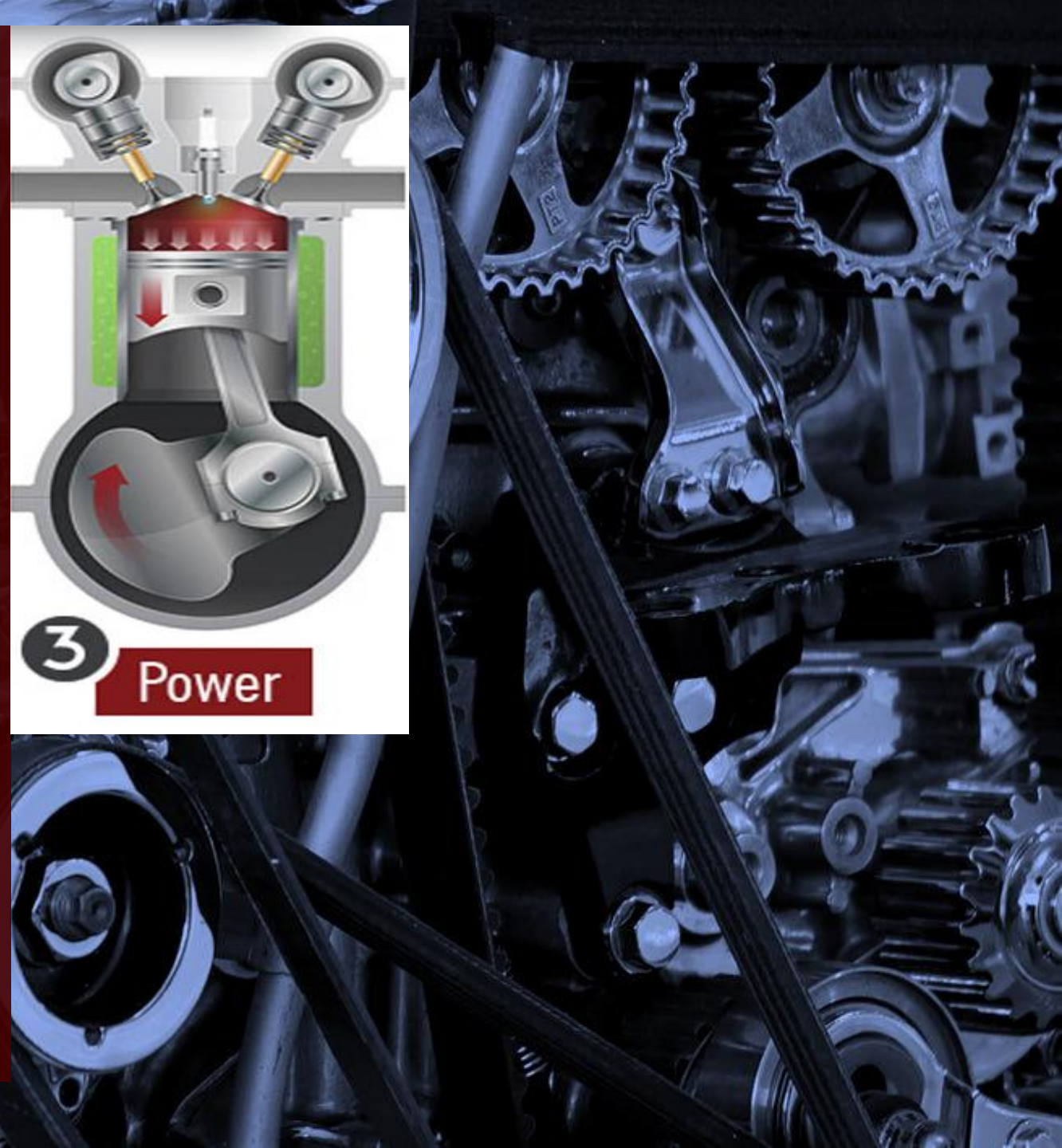
3) The power stroke

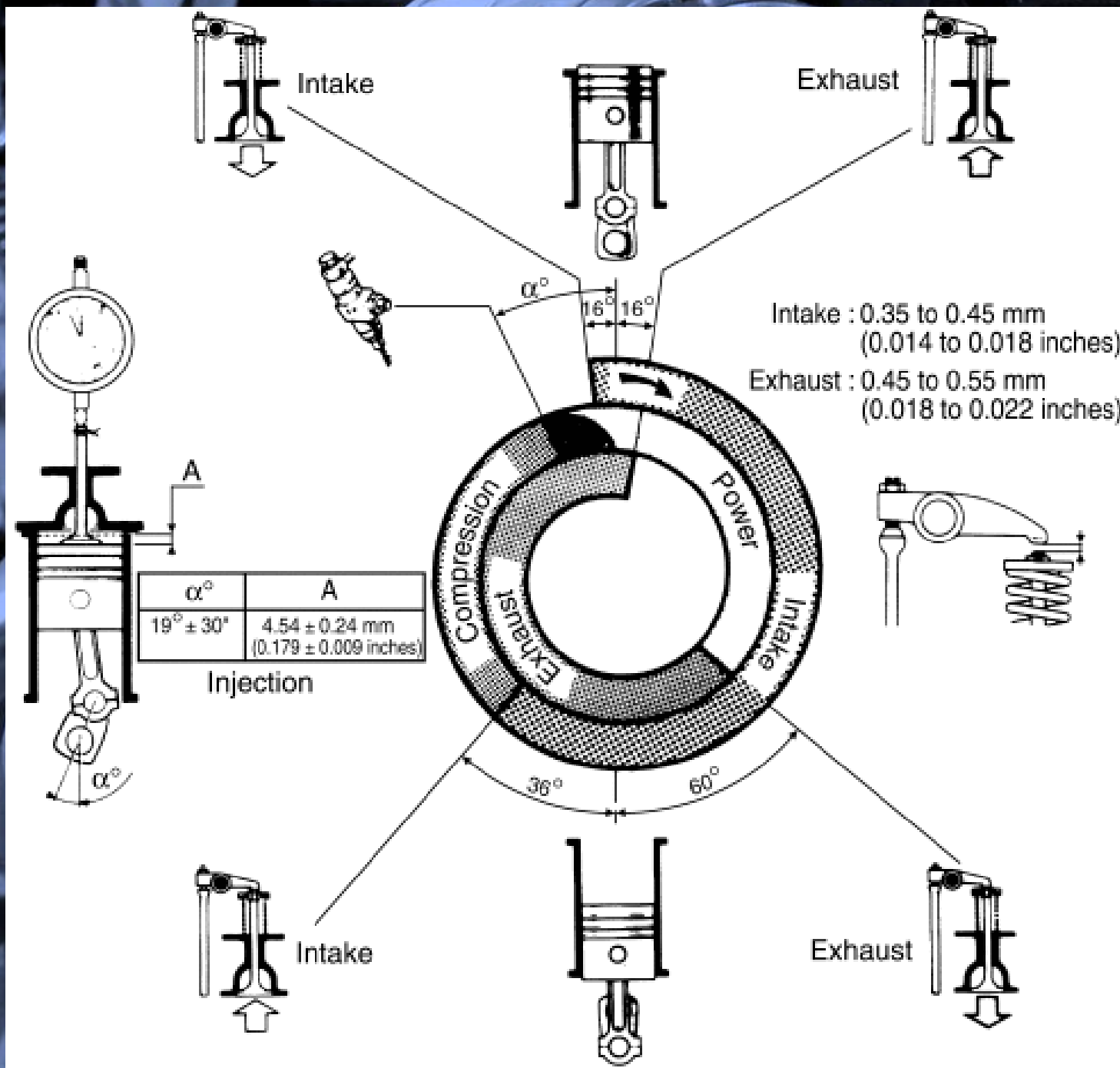
Begins when spark plug ignites
(or diesel combusts)

Typically about 10 degrees btdc

Build cylinder peak pressure about
22.5 degrees atdc (when piston moves
fastest)

Ignition timing (when spark or fuel
injection occurs) can vary –
mechanically or by computer control)





Combustion Problems

Pre-ignition – Wrong fuel

Detonation – Overheating

Misfire – Spark issue

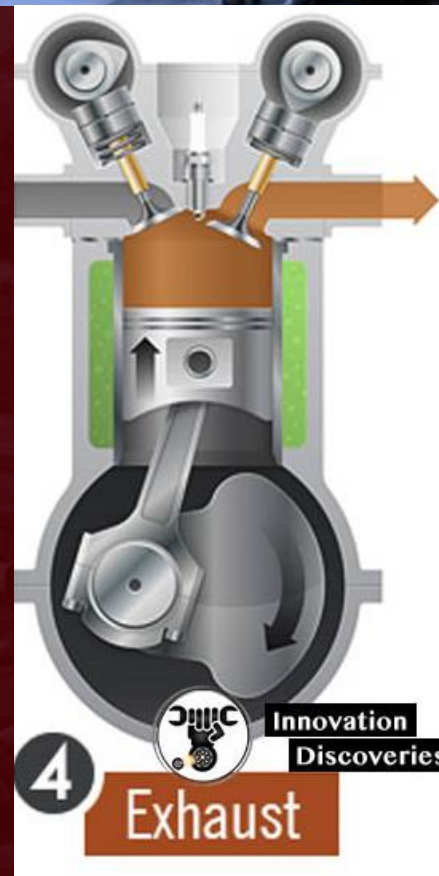
Knock sensors - detectors

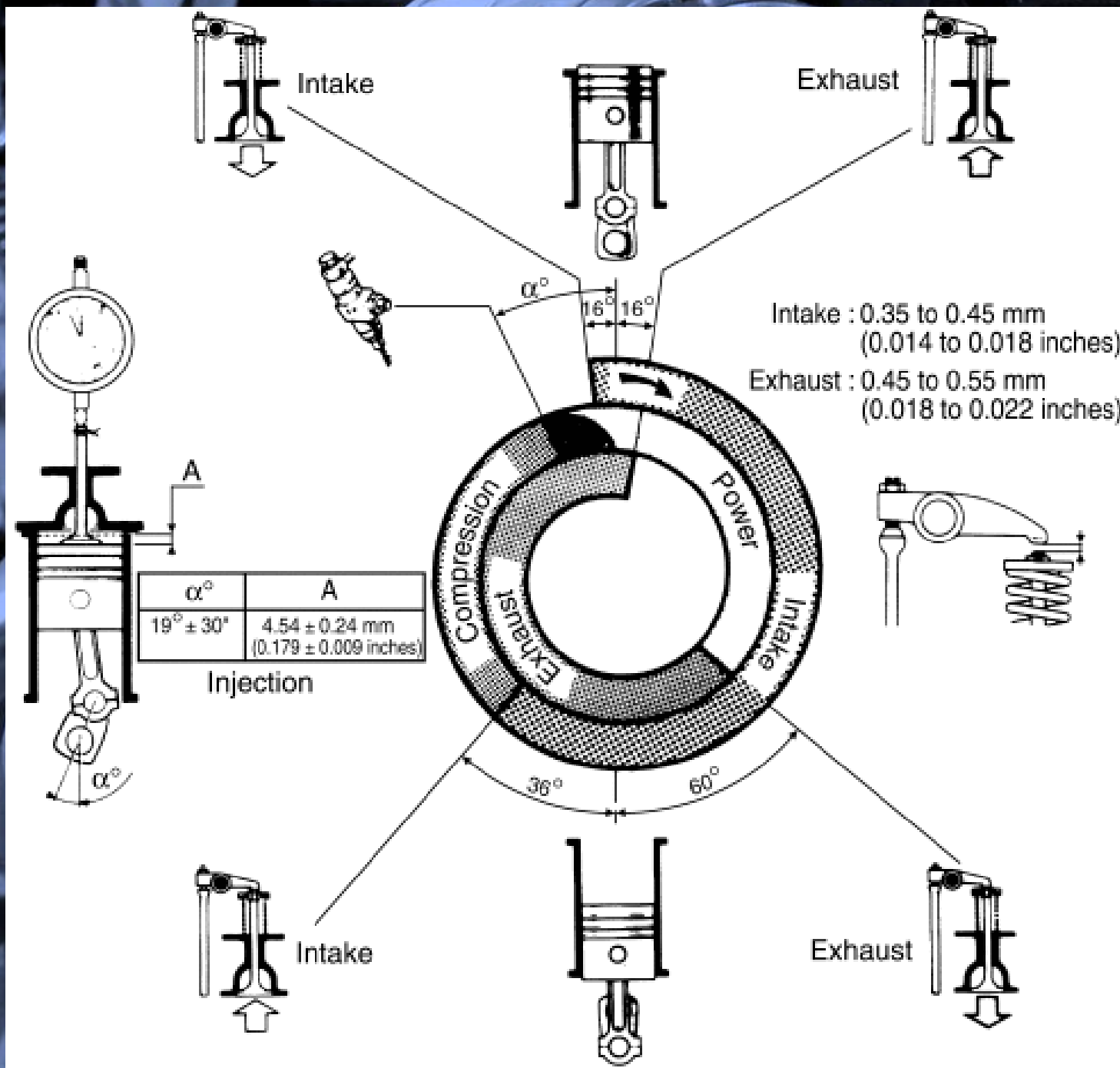


4) The exhaust stroke

Exhaust valve opens 60 degrees before BDC and stays open 10 degrees after TDC

Same 250 degrees as intake – but is a shorter because of valve overlap



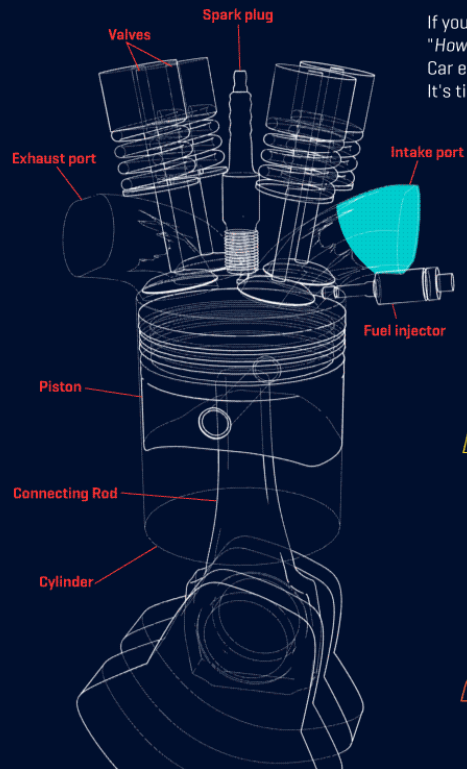


4 stroke wrap-up

HOW A CAR ENGINE WORKS

[And a note about hybrid gas-electric cars too]

If your only experience with a car engine's inner workings is "How much is that going to cost to fix?" this graphic is for you! Car engines are astoundingly awesome mechanical wonders. It's time you learned more about the magic under the hood!



The 4 Stroke Cycle

Let's take a look inside just one cylinder.

1 INTAKE STROKE

The piston descends, sucking air into the cylinder through open intake valves as fuel is injected.

2 COMPRESSION STROKE

With all valves closed, the piston comes back up, compressing the fuel-air mixture. Compressing the mixture delivers better power and efficiency.

3 POWER STROKE

A spark ignites the compressed fuel-air mixture, and the resulting combustion forces the piston to the bottom of the cylinder again.

4 EXHAUST STROKE

The piston comes back up, pushing the spent mixture out through open exhaust valves.

Understanding Fuels

Octane Ratings (Gasoline)

Cetane Rating (Diesel)

Alternative Fuels (E85, Biodiesel)

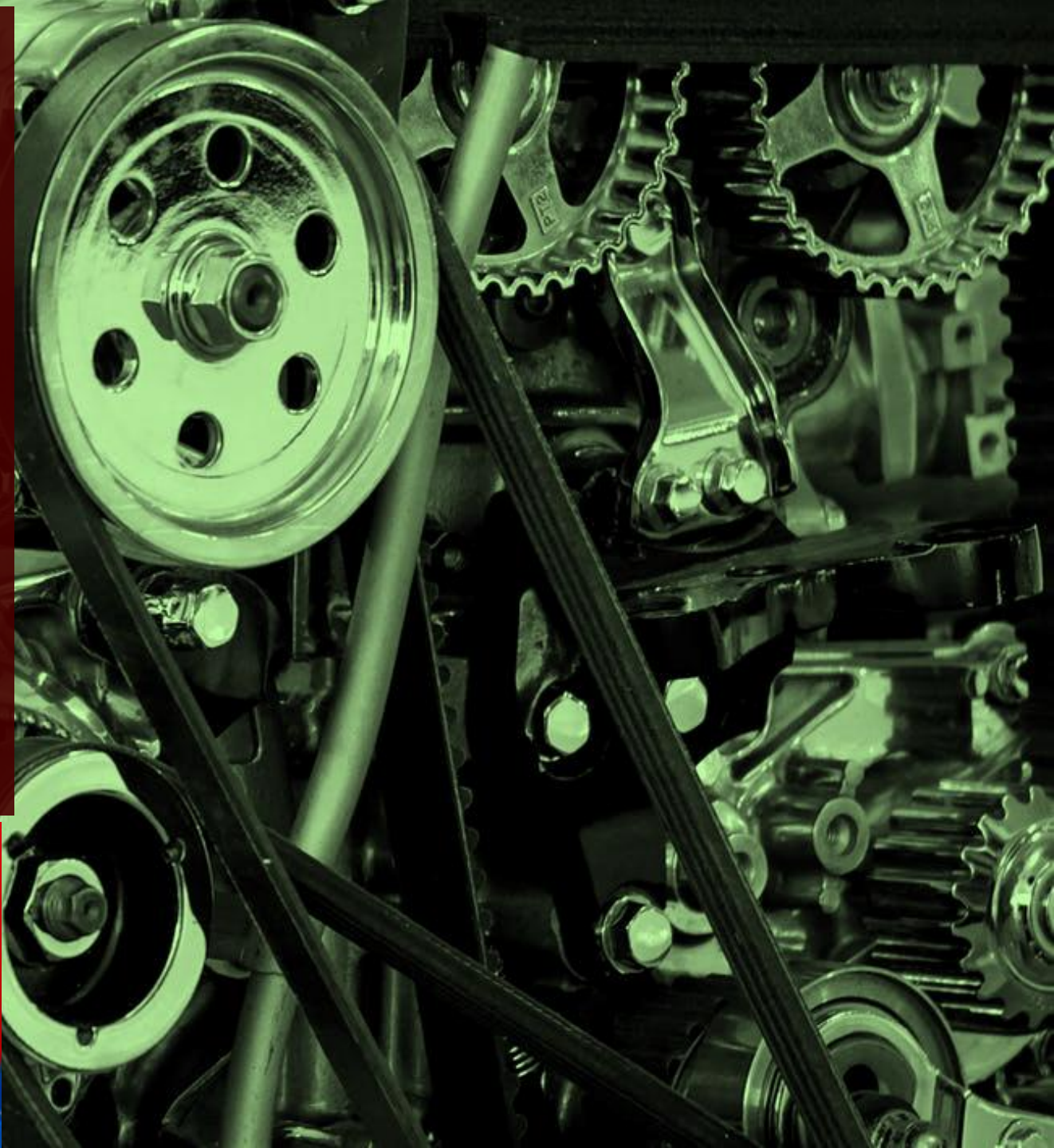


Octane Ratings (Gasoline)

Octane rating is a measure of a fuel's ability to resist knocking (autoigniting).

The higher the compression the higher the octane needed.

No benefit from high octane in a low compression vehicle



Cetane Ratings

Equivalent to Octane for diesel

The higher a fuel's cetane number, the quicker it ignites — and that carries a variety of benefits for diesel

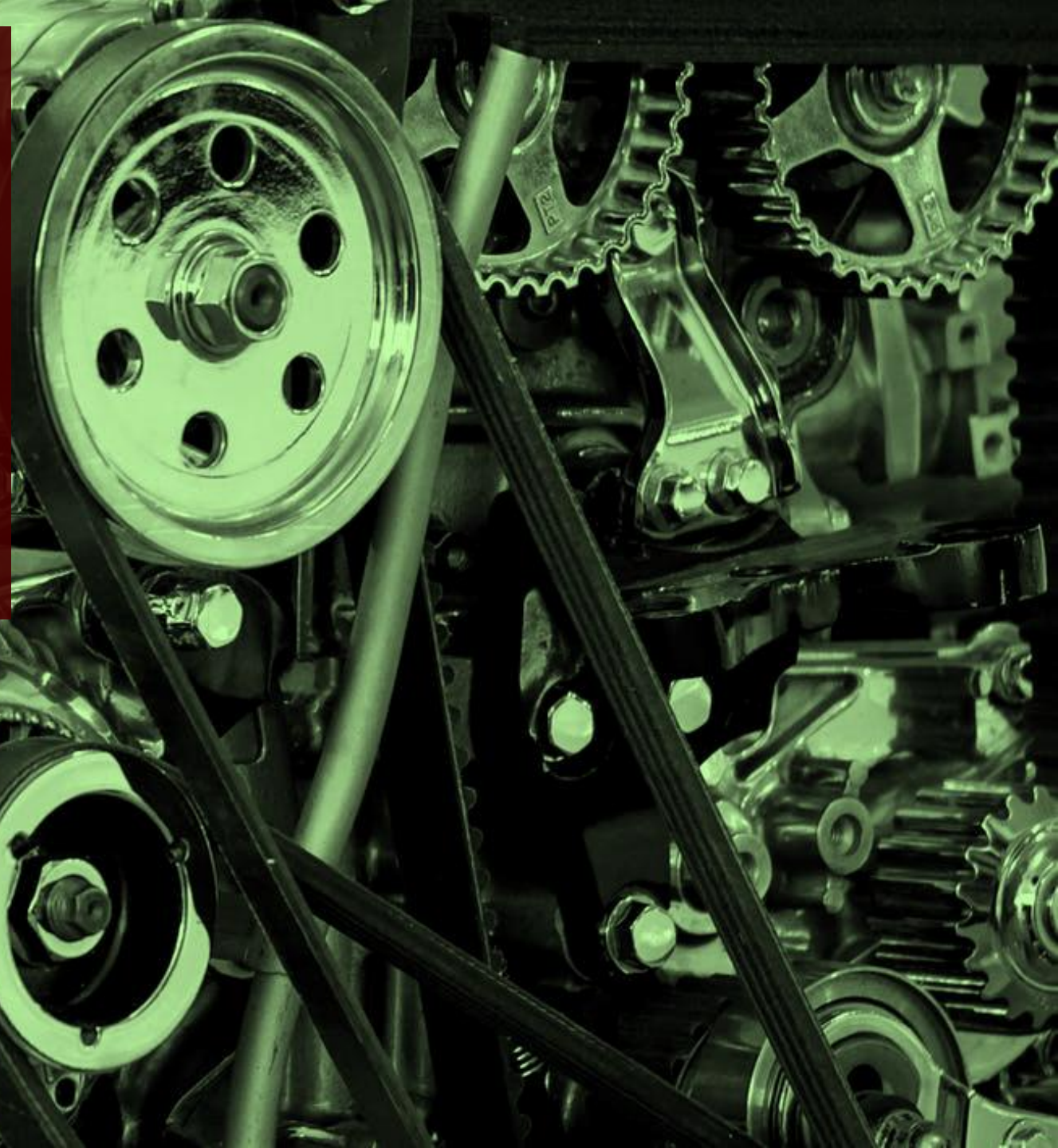


Diesel #1 & #2

#1 = Premium - added lubricants, detergents, cold weather benefits, etc.

#2 – Pump fuel – costs less, common

Ultra low sulfur



Diesel Fuel Filters

For most Diesel trucks it is recommended that you replace your fuel filter every 10,000-25,000 miles.

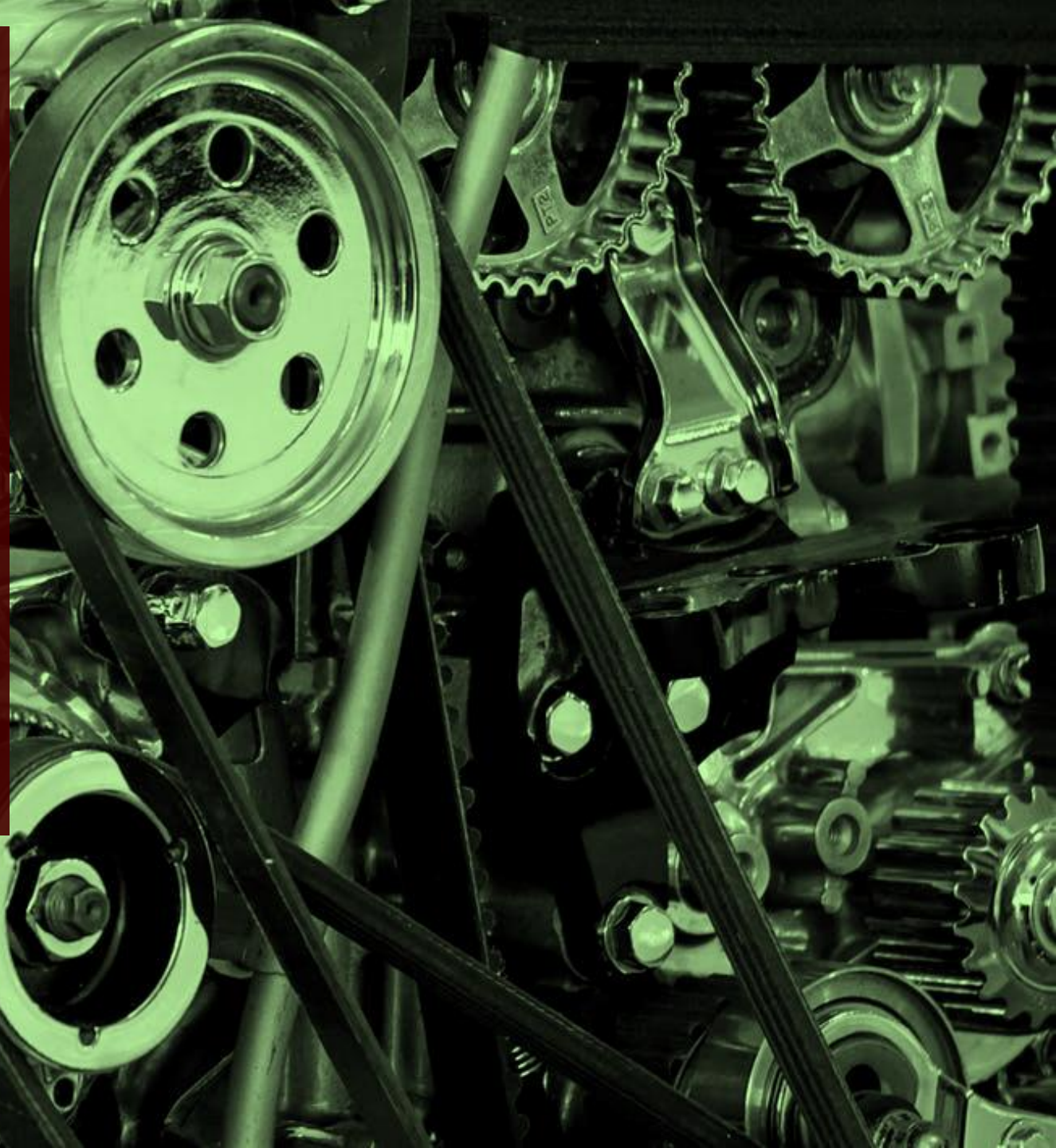


E85

Common flex fuel – typically made from corn.

Will typically have a higher octane rating.

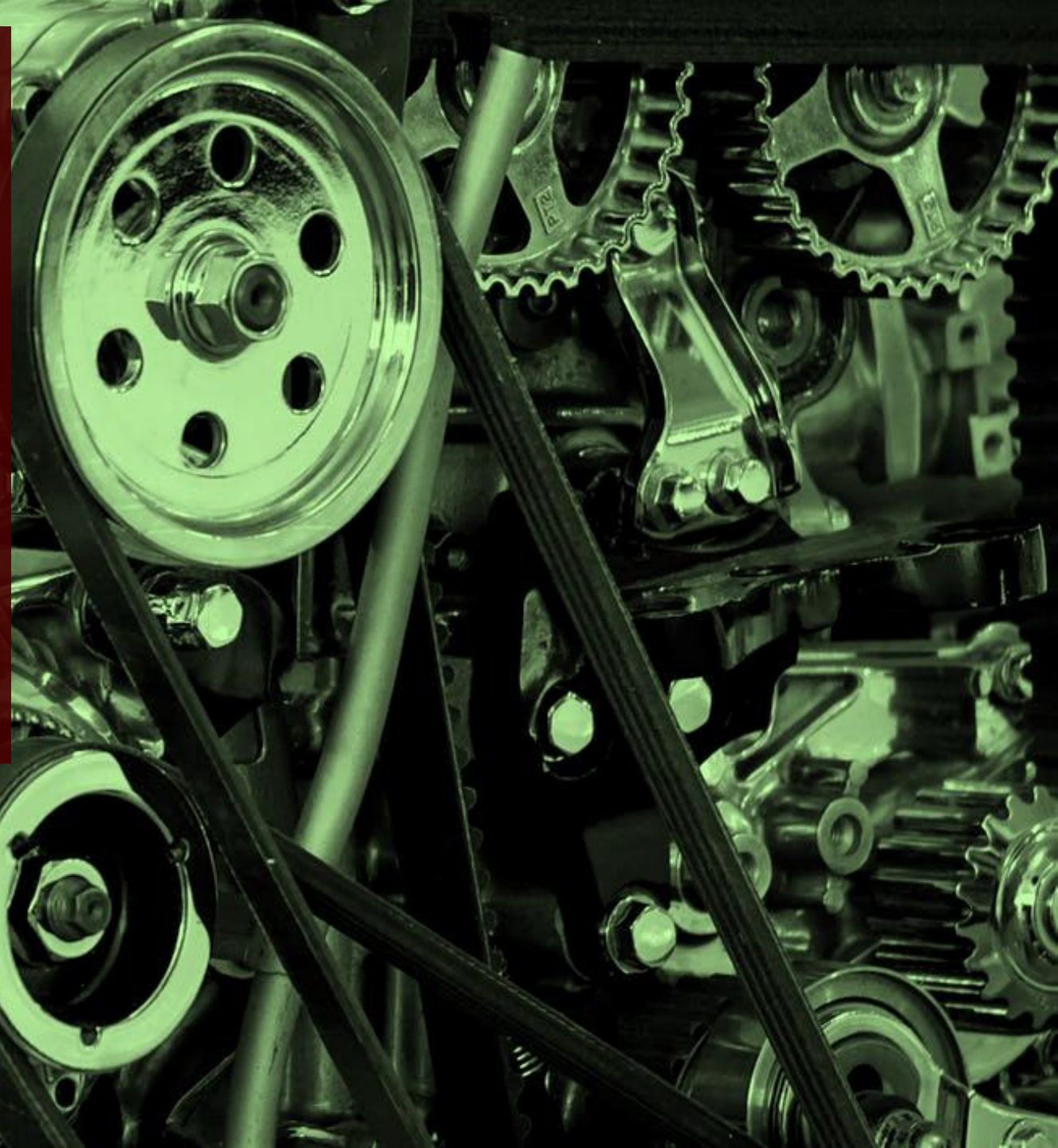
Ethanol can be corrosive to vehicles not rated to handle it.



Biodiesel

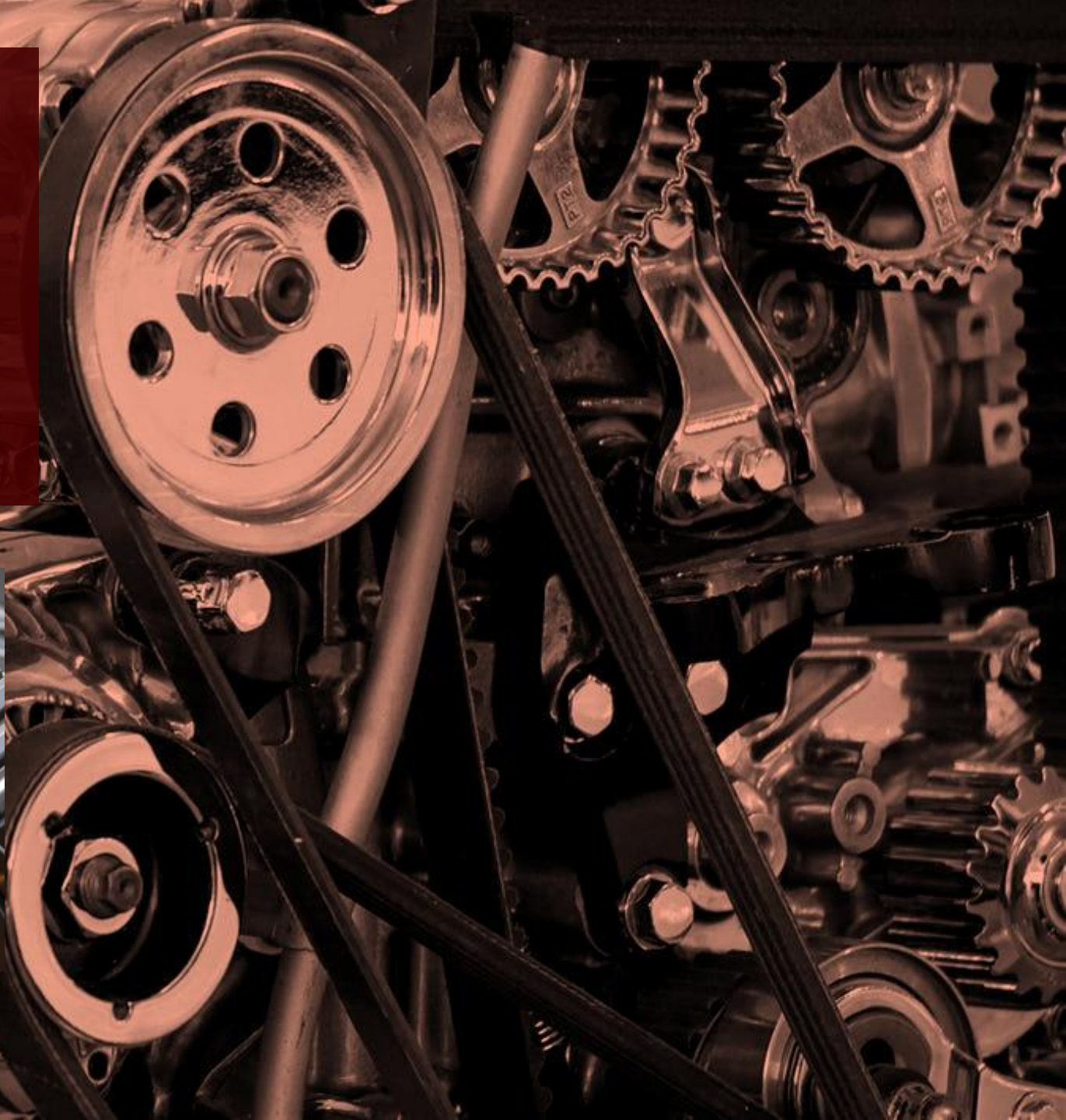
Less commonly found, renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease.

Engine may need modifications to run
(Ex. fuel filters, injectors)



Lubrication

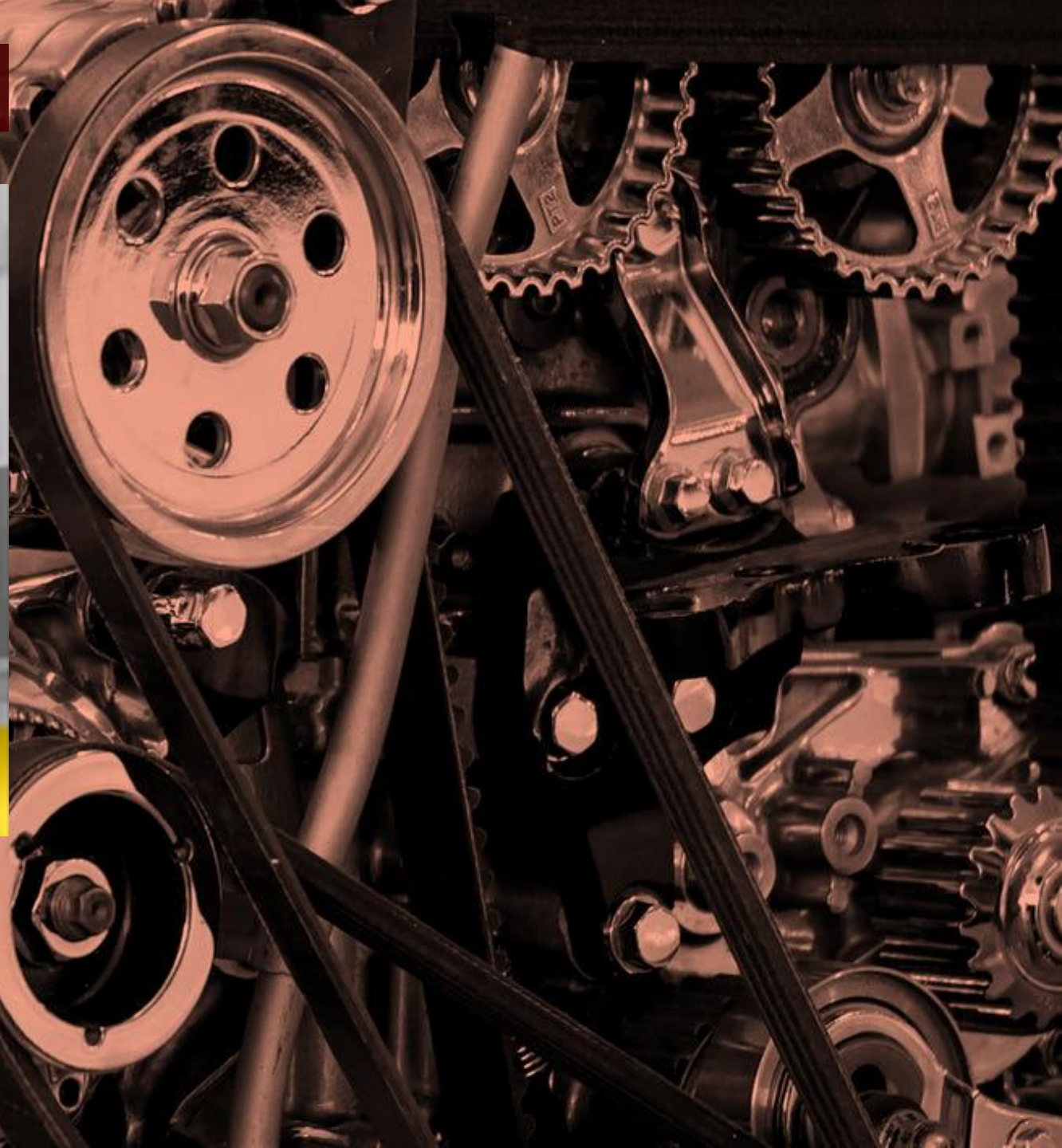
1. Understanding Oil Weights
2. Understanding Oil Grades
3. Oil Ratings
4. Types of Oils
5. Lubrication problems



Oil weight is a term used to describe the **viscosity** of an oil, which means how well it flows at a specific temperature.



Lubrication - Weights



Lubrication – Multi-Weight Oils

Weight that oil
emulates in cold
temperatures

Stands for
“winter”

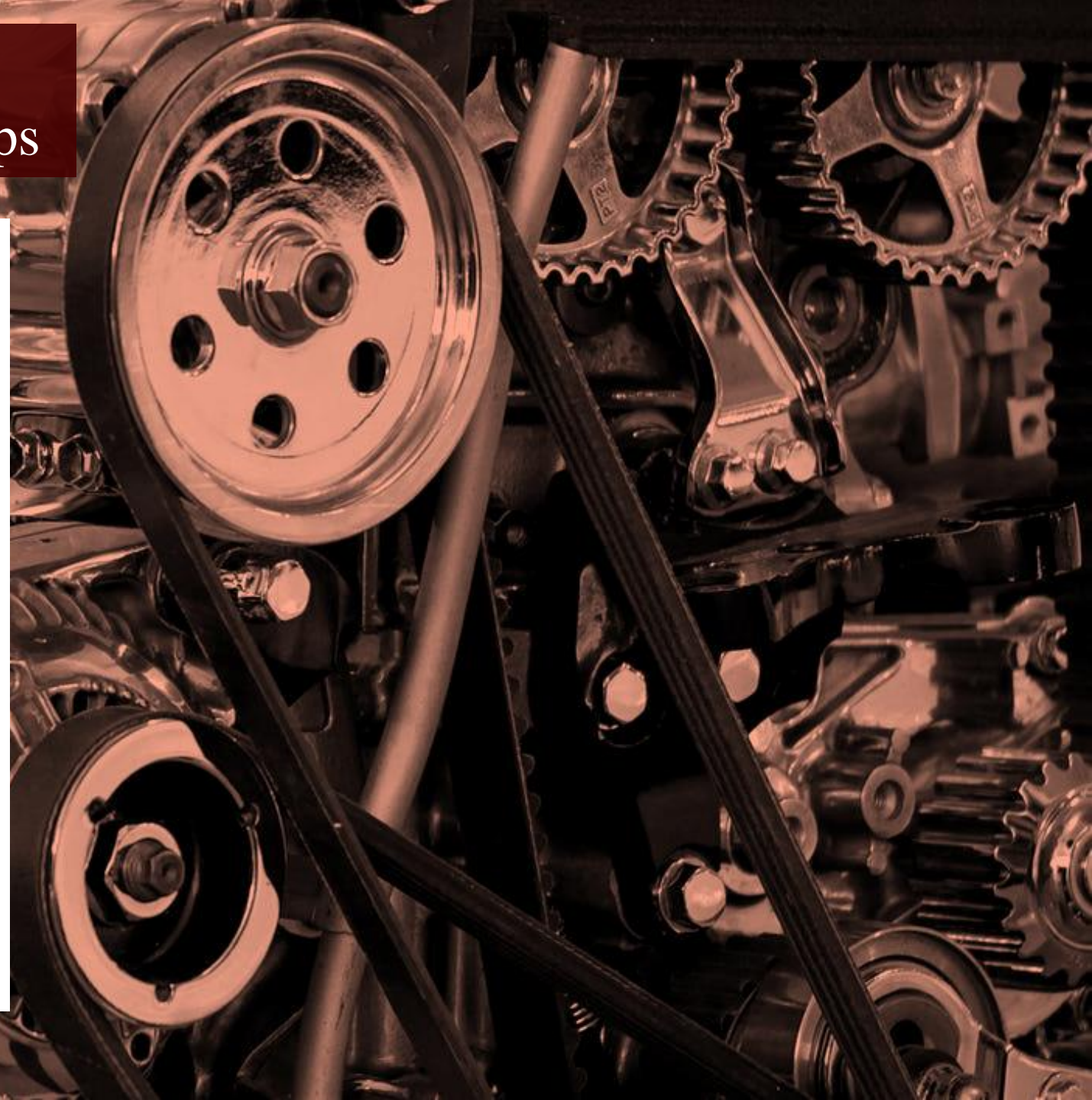
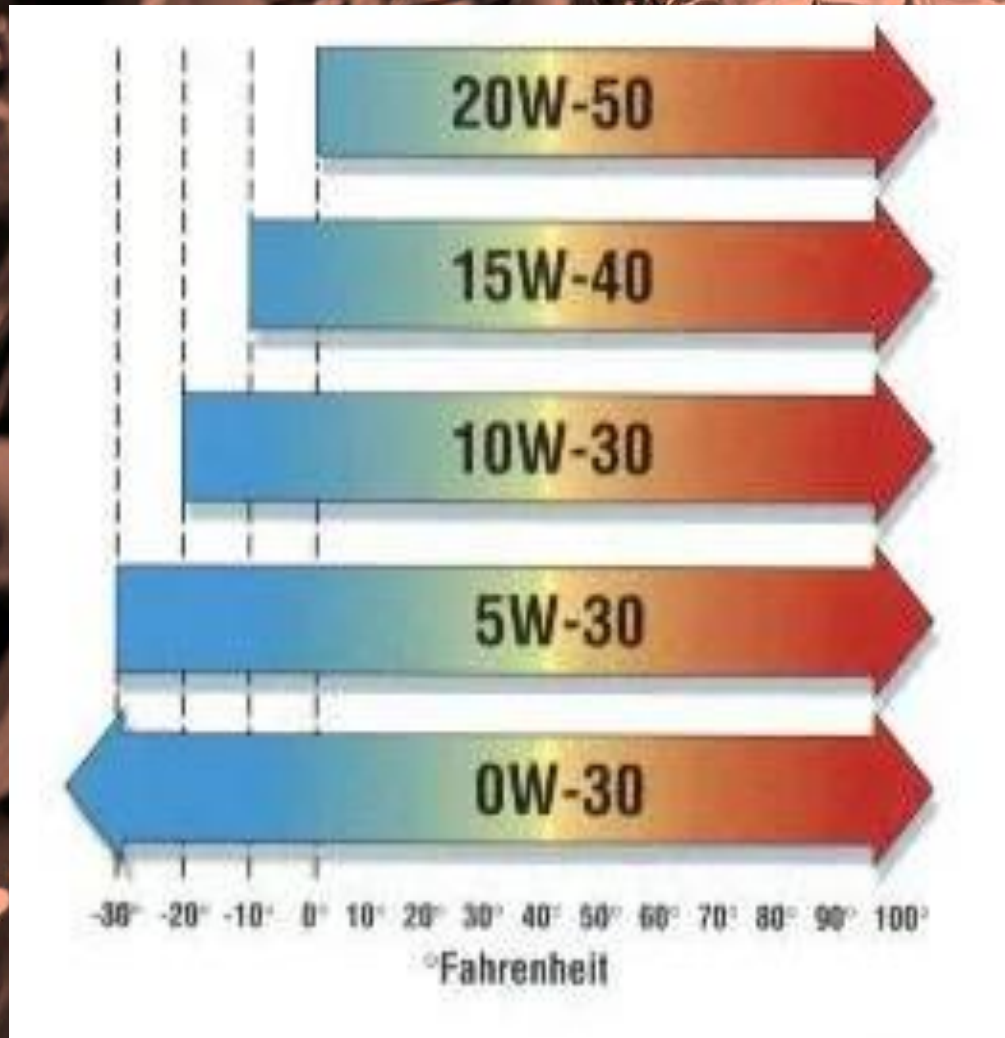
Oil weight under
normal operating
conditions (warm)

10 w 30

A 10 w 30 is an SAE 30 weight oil that *acts* like a 10 weight oil in the winter.

Lubrication – Weights

More viscous = better @ high temps



Lubrication – Ratings

API
(American Petroleum Institute)
"Starburst"

The presence of this symbol indicates that the motor oil is formulated to meet the most current International Lubricant Specification Advisory Committee (ILSAC)

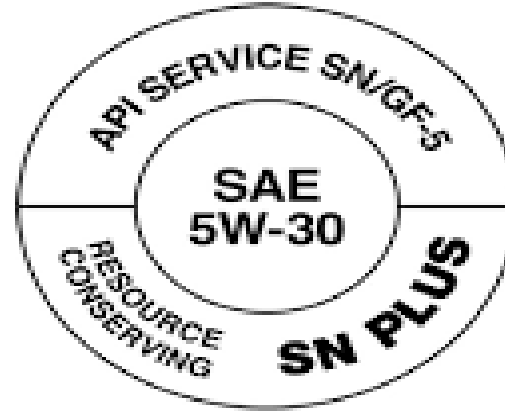


Lubrication – Ratings

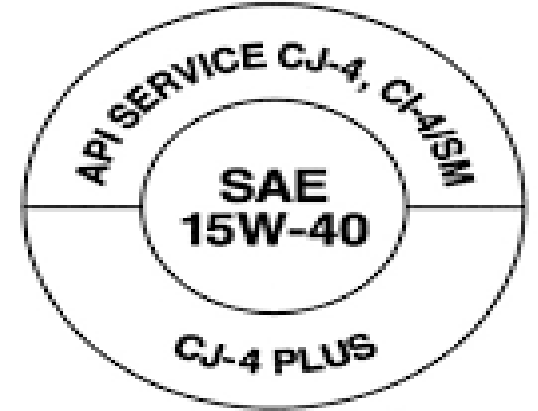
API

(American Petroleum Institute)

The API "Donut" identifies oils that meet current API engine oil standards. It includes the SAE viscosity grade of the oil, API standards met by the oil, ILSAC rating, SAE Viscosity



Gasoline Engine Oil



Diesel Engine Oil

Meets or exceeds all requirements of API SP, API SN with SN PLUS, API SN, Resource Conserving, ILSAC GF-6A and all preceding API and ILSAC gasoline categories. Additional Specifications: Chrysler* MS-6395, Ford* WSS-M2C961-A1, GM* dexos1™ Gen 2 (license #D10198GL103). Recomendado para el servicio de motores a gasolina de vehículos último modelo y años anteriores.

CAUTION: Avoid prolonged or repeated skin contact with used engine oil. Used engine oil has been shown to cause cancer in laboratory animals. Thoroughly wash exposed area with soap and water.

DON'T POLLUTE. CONSERVE RESOURCES. RETURN USED OIL TO COLLECTION CENTERS.

NO CONTAMINE. NO TIRE EL ACEITE. CONSERVE LOS RECURSOS, DEVUELVA EL ACEITE USADO A LOS CENTROS DE RECOLECCIÓN.



API service CK-4, CJ-4, CI-4 PLUS, CI-4, CH-4, SP, SN and all prior API gasoline categories/y todas las anteriores especificaciones API para gasolina

CAUTION: Avoid prolonged or repeated skin contact with used engine oil. Used engine oil has been shown to cause cancer in laboratory animals. Thoroughly wash exposed area with soap and water.

DON'T POLLUTE. CONSERVE RESOURCES. RETURN USED OIL TO COLLECTION CENTERS.

NO CONTAMINE. NO TIRE EL ACEITE. CONSERVE LOS RECURSOS, DEVUELVA EL ACEITE USADO A LOS CENTROS DE RECOLECCIÓN.





Automobile Model Year

1930

1951

1967

1971

1979

1993

1988

1996

2001

2010

2011

2015

2018²

2020³

API Service Categories



OBSOLETE/CAN CAUSE EQUIPMENT HARM					OBSOLETE		ACTIVE						
SA	SB	SC	SD	SE	SF	SG SH	SJ	SL	SM	SN	SN PLUS	SP	



ILSAC*

There was no ILSAC Specification Prior to 1993

Whereas ILSAC GF-6A (SAE 0W-20, SAE 5W-20, SAE 0W-30, SAE 5W-30, and SAE 10W-30) is backward-compatible to previous categories, GF-6B (SAE 0W-16) is not backward-compatible

GF-1

GF-2

GF-3

GF-4

GF-5

GF-6A

GF-6B

0W-20, 5W-20, 0W-30, 5W-30, 10W-30

0W-16



General Motors

There was no dexos[®] Specification Prior to 2010

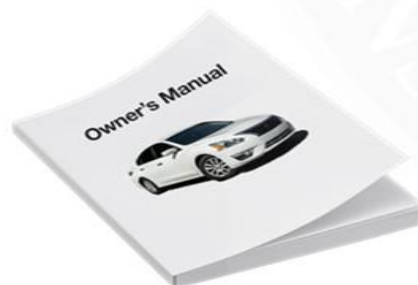
Prior to 2010, General Motors did employ their own specifications, GM6094 and GM4718M. When issued, GM dexos1[™] was back serviceable to 1996 superseding GM6094 and GM4718M.

dexos1[™]

dexos1[™] Gen2

API SN PLUS
ILSAC GF-5
dexos1[™] Gen2
Back Serviceable

Always refer to your vehicle owner's manual for proper motor oils recommended for use in your vehicle.



Two letter code on the API "Donut"

SAE viscosity grade

ILSAC "Starburst"

API "Shield" for 0W-16



API SP



ILSAC GF-6A



ILSAC GF-6B

Images of above
Marks courtesy of API

For GMs, look for the dexos mark



Other OEM specifications

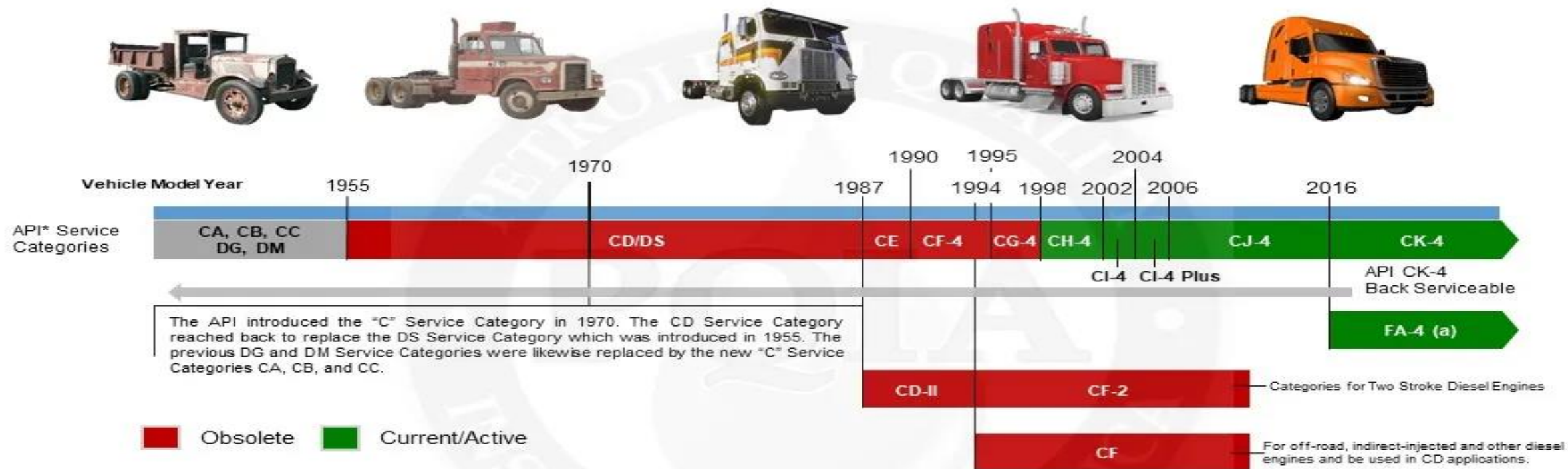
In addition to General Motor's dexos specification for motor oils, there are other original equipment manufacturers that also have their own recommended specifications other than those of the API and ILSAC. Examples are seen with Mercedes, BMW, Volkswagen, and Audi.

Note: Until May 1, 2021, motor oils displaying the ILSAC Starburst can represent either API SN/SP Plus or API SP along with Resource Conserving. On May 1, 2021, all products displaying the Starburst must meet API SP/Resource conserving

Motor oils are not all the same, and using the wrong motor oil in a vehicle can void its warranty and potentially cause harm



Heavy Duty Engine Oil (HDEO)



Look for the "API Donut" and Service Category on the back of the bottle. If the label says API Service "CA," it's an engine oil made for use in cars built prior to 1961. API CA through CG-4 motor oils are classified by the API as "OBSOLETE." Always consult your owner's manual for the correct viscosity grade and performance specification(s) required for your vehicle.

Look for the Service Category on the "API* Donut"



Note: This chart is provided for illustrative purposes only. The categories have differing relevance depending on your region. While API CH-4 is essentially irrelevant in North America today, it is a dominant (and in some cases a high tier) category in other markets. CI-4/CJ-4 may also have much longer life in certain developing regions of the world. **Always refer to your vehicle manufacturer's recommendations for the appropriate API Service Category required for use in your engine.**

(a) API FA-4 are formulated for use in certain engines designed to meet 2017 on-highway emission standards, and are not backward compatible or interchangeable with other diesel engine oils meeting current service categories.

* American Petroleum Institute

Rev DS4-2018

Lubrication – Types of oil

Conventional
Synthetic
Blends
High Mileage
Recycled



Lubrication – Types of oil

Conventional
Vs.
Synthetic

Follow the manufacturers guidelines!

Oil changes -
Old wisdom every 3k
Now every 5k
Up to 10K+



Conventional vs. Synthetic Oil



Lubrication – Types of oil

Diesel

"Low Ash"

Ash can clog Particulate filters in diesels

Some manufacturers specify a maximum Sulfated Ash/Sulfur/Phosphorus (SAPS) level in the engine oil. Such engine oils are referred to as 'low SAPS'.

Follow the manufacturers guidelines!

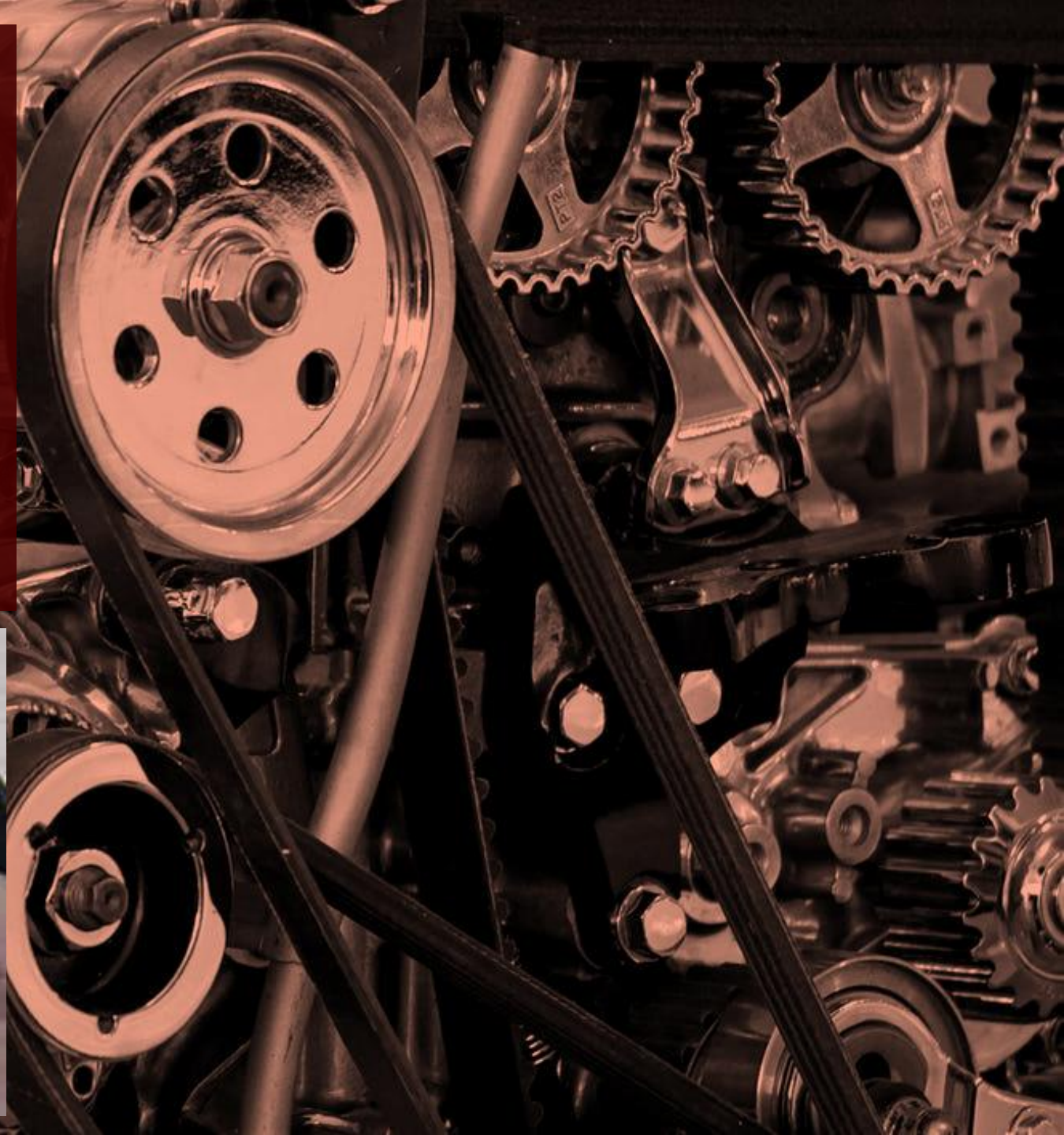


Lubrication – Oil filters

You often get what you pay for

Quality of material

Quantity of material



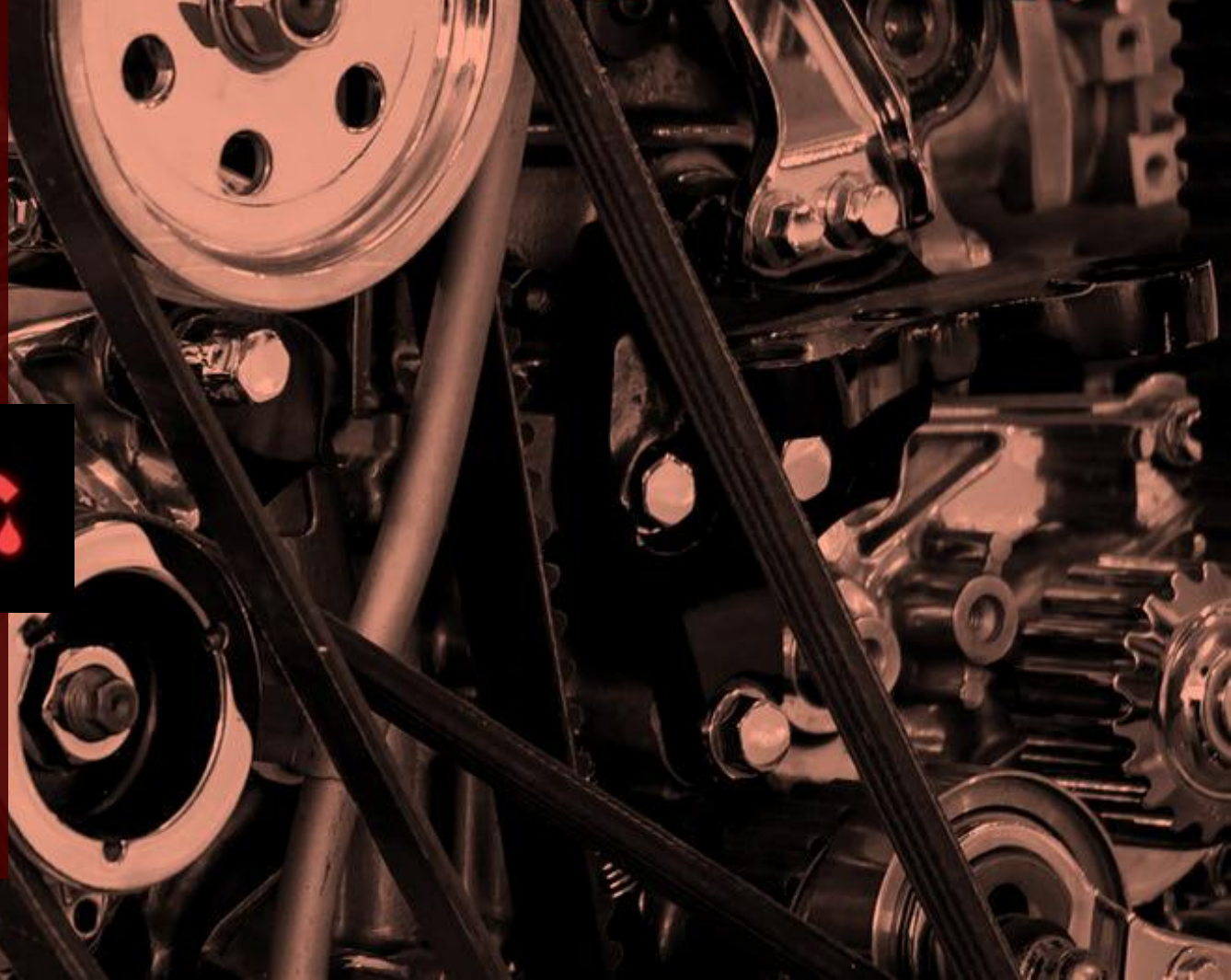
Lubrication – Problems

Leaks – internal or external

Oil starvation (low oil)

Signs:

- Oil pressure warning light
- Burning oil smell
- Strange noises
- Weaker performance
- Overheating Engine



Lubrication – Problems

Oil sludge or contamination

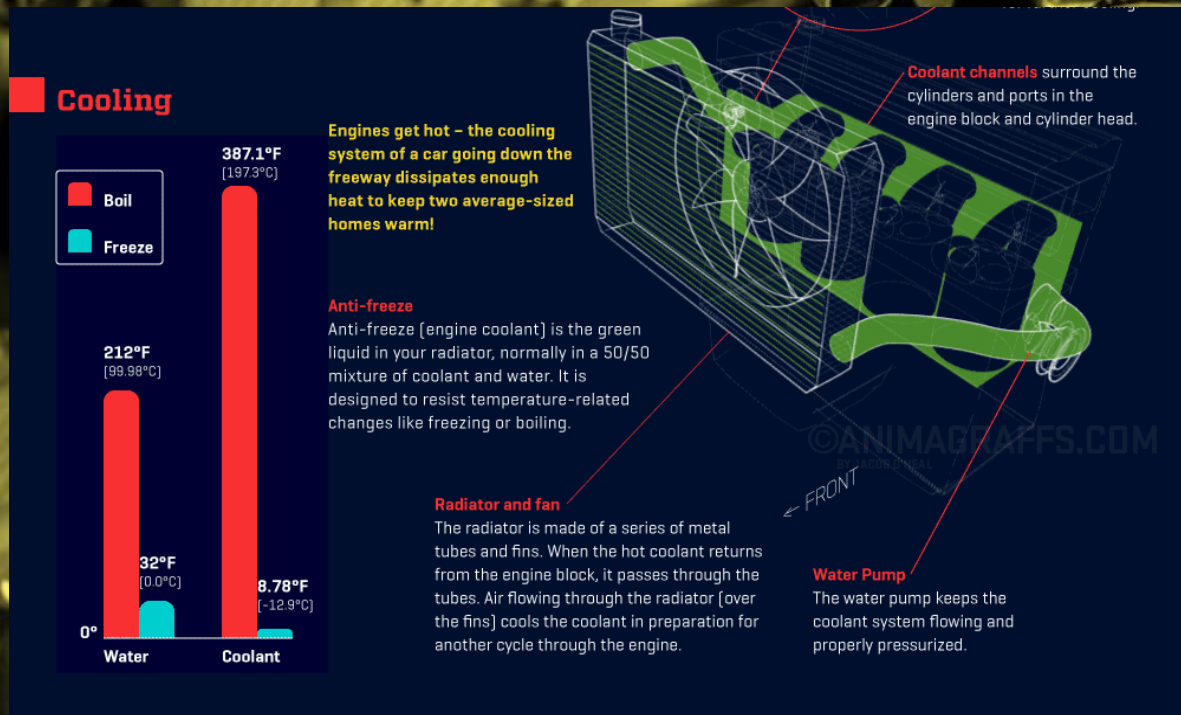


Cooling Systems

Types of coolant

How the system operates

Common Problems



ANTIFREEZE COOLANT APPLICATION CHART

[illegible]

Types of coolant

Propylene glycol and Ethylene glycol

Inorganic Additive Technology (IAT)

2 year/24k service life

Organic Acid Technology (OAT)

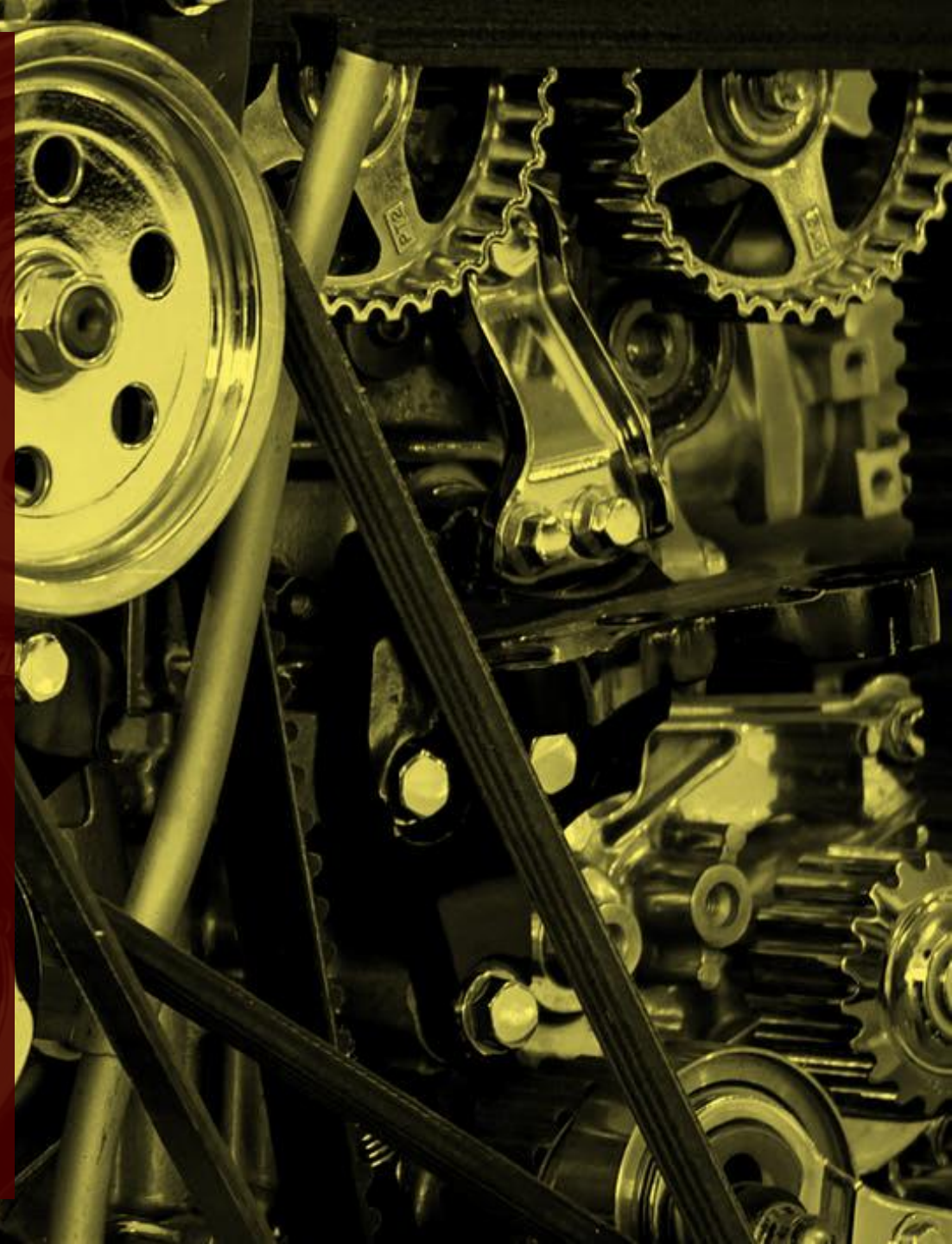
5 year “Dex cool”

Hybrid Organic Acid Technology (HOAT).

5 year

Generic “All makes”

More frequent service life



Types of coolant

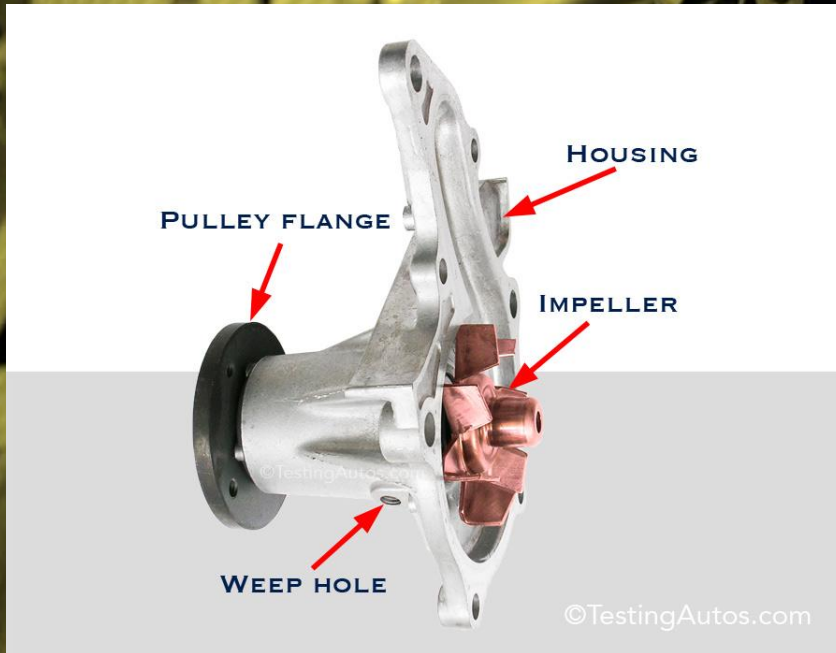
PEAK® ANTIFREEZE & COOLANT MEANS MAXIMUM SEVERE CONDITIONS PROTECTION

Cooling System Capacity in Quarts	Quarts of Antifreeze Required for Protection to Temperatures (°F) Shown									
	3	4	5	6	7	8	9	10	11	
8	-7	-34	-69							
9	0	-21	-50	-70						
10	4	-12	-34	-62						
11	8	-6	-23	-47	-65					
12	10	0	-15	-34	-57					
13		3	-9	-25	-45	-64				
14		6	-5	-18	-34	-54	-68			
15		8	0	-12	-26	-43	-62			
16		10	2	-8	-19	-34	-52	-64		
17			5	-4	-14	-27	-42	-58	-69	
18			7	0	-10	-21	-34	-50	-62	
19			9	2	-7	-16	-28	-42	-56	
20			10	4	-3	-12	-22	-34	-48	
FREEZE/BOIL PROTECTION CHART	% of Cooling System Capacity		PROTECTS FROM							
			Freezing Down to				Boiling Up to*			
	50		-34°F				265°F			
	60		-62°F				270°F			
*Using a 15 PSI Pressure Cap		70	-84°F				276°F			

For best overall protection, solution strengths within the yellow color band are recommended.

Cooling system operation

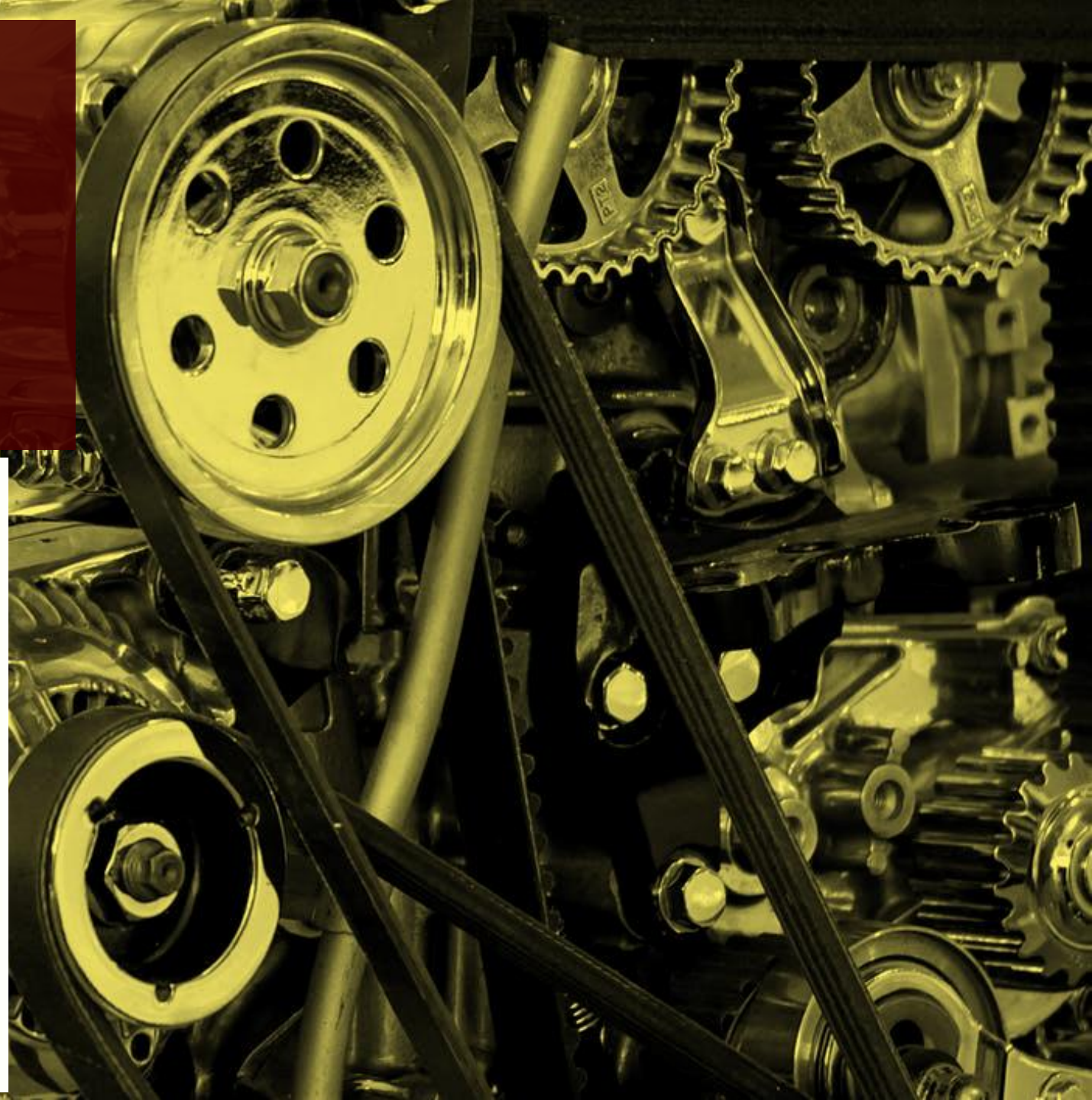
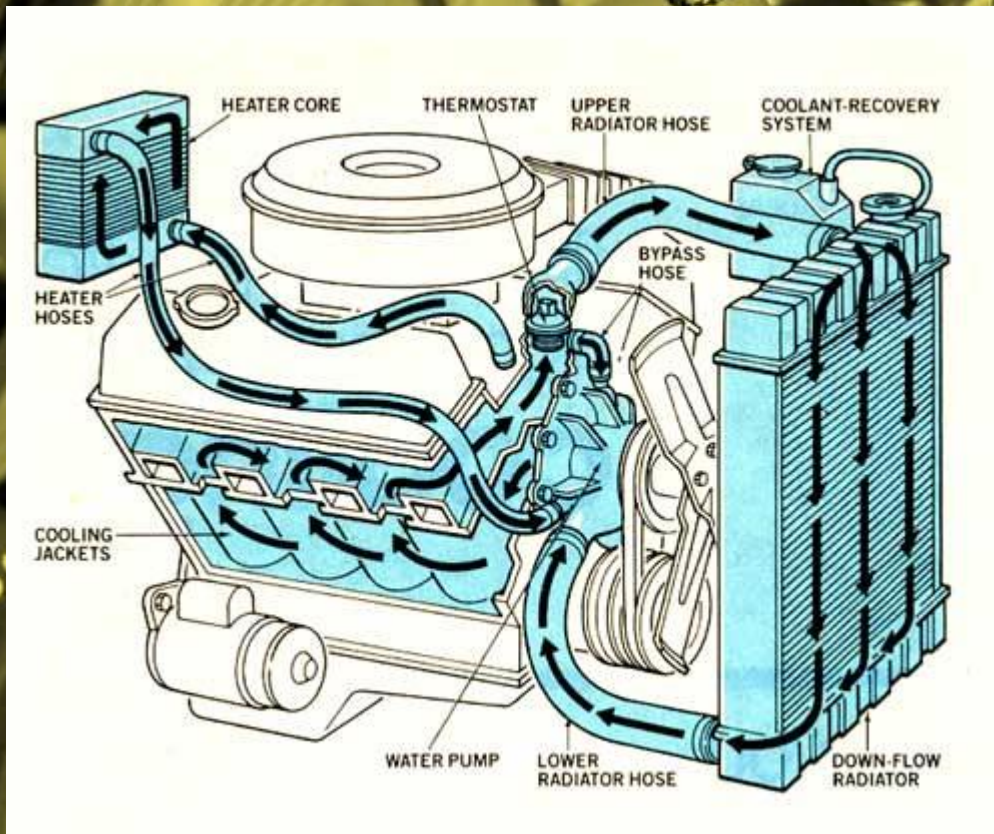
Starts at the water pump – Circulates coolant when engine is on – can be drive belt, timing, or electric pump driven



Cooling system operation

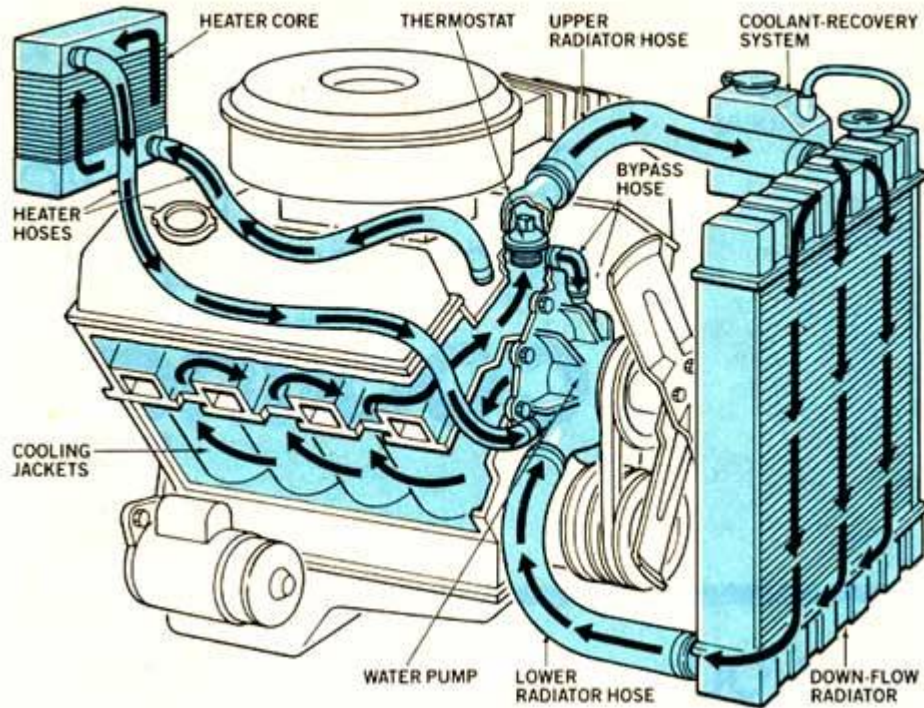
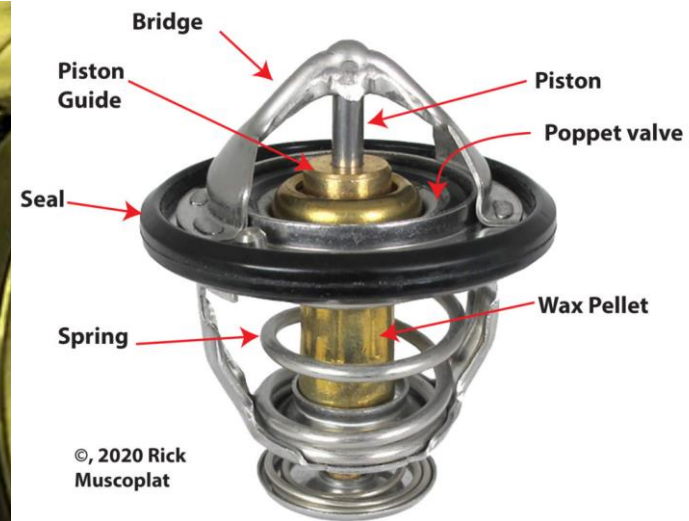
Water jackets – pathways to move through the block

Heater core – passenger heat



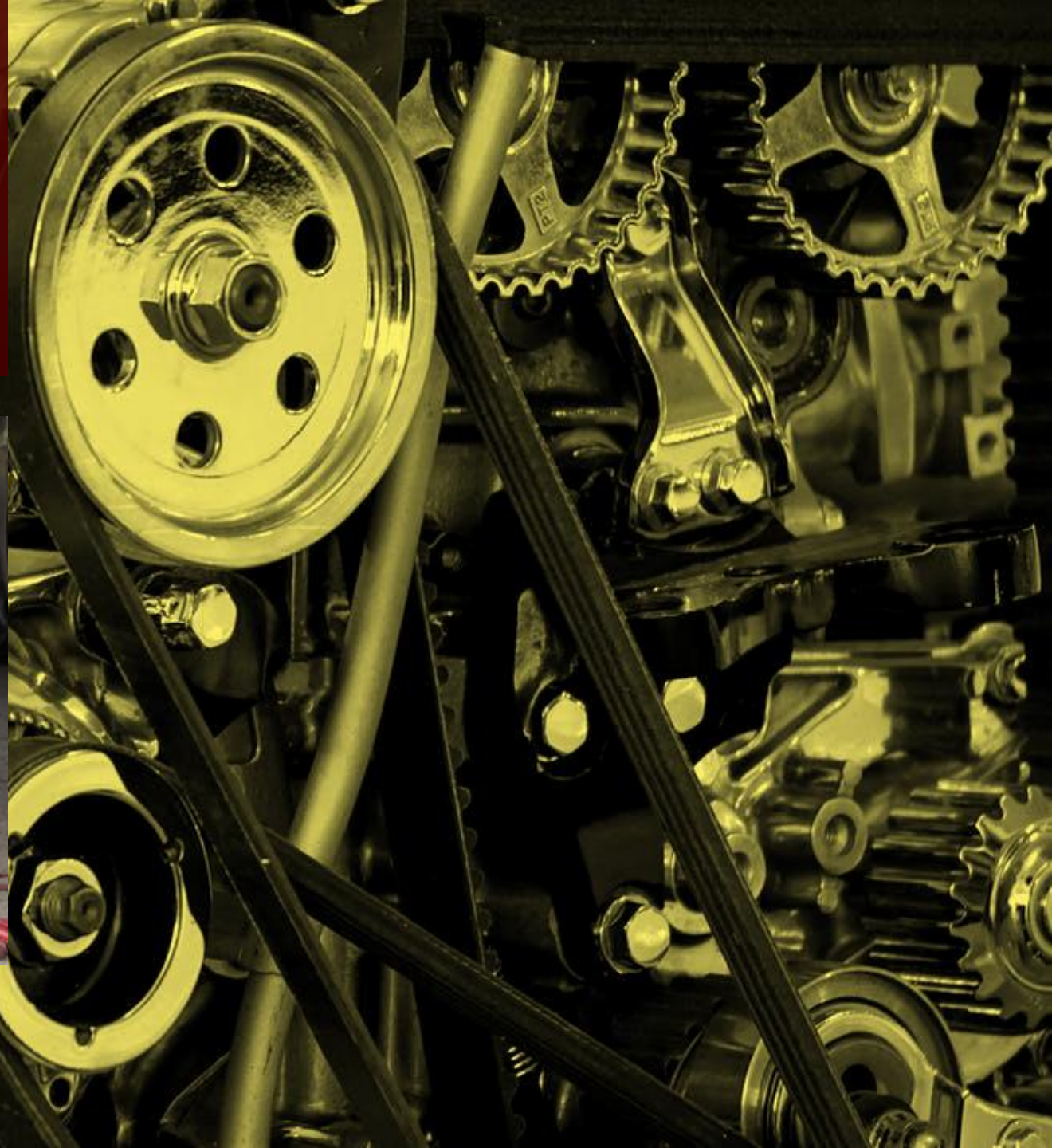
Cooling system operation

Thermostat – helps engine heat up quickly



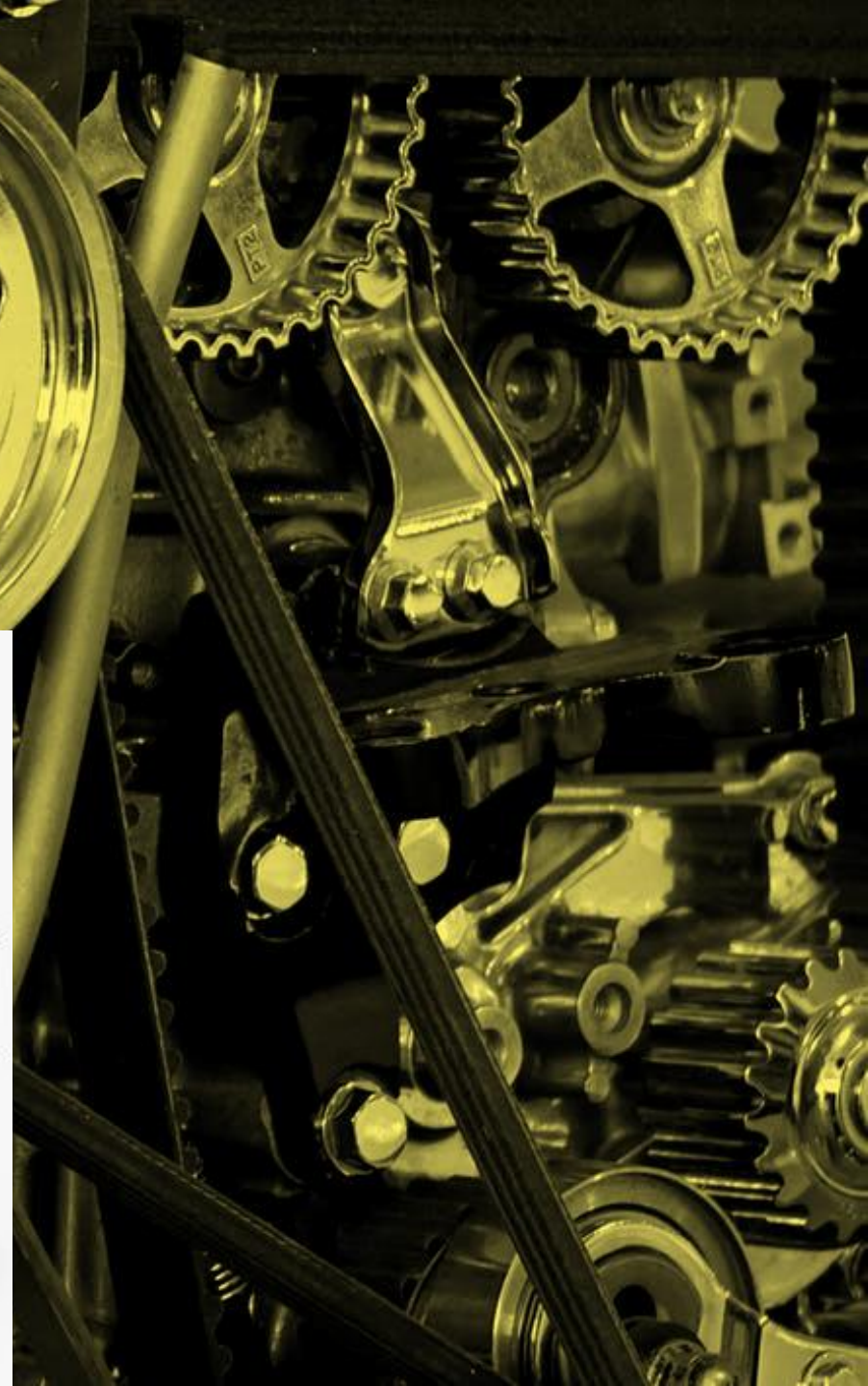
Cooling system operation

Radiator – Heat exchanger – in front of vehicle



Cooling system operation

Cooling fan(s) – Mechanical or electric

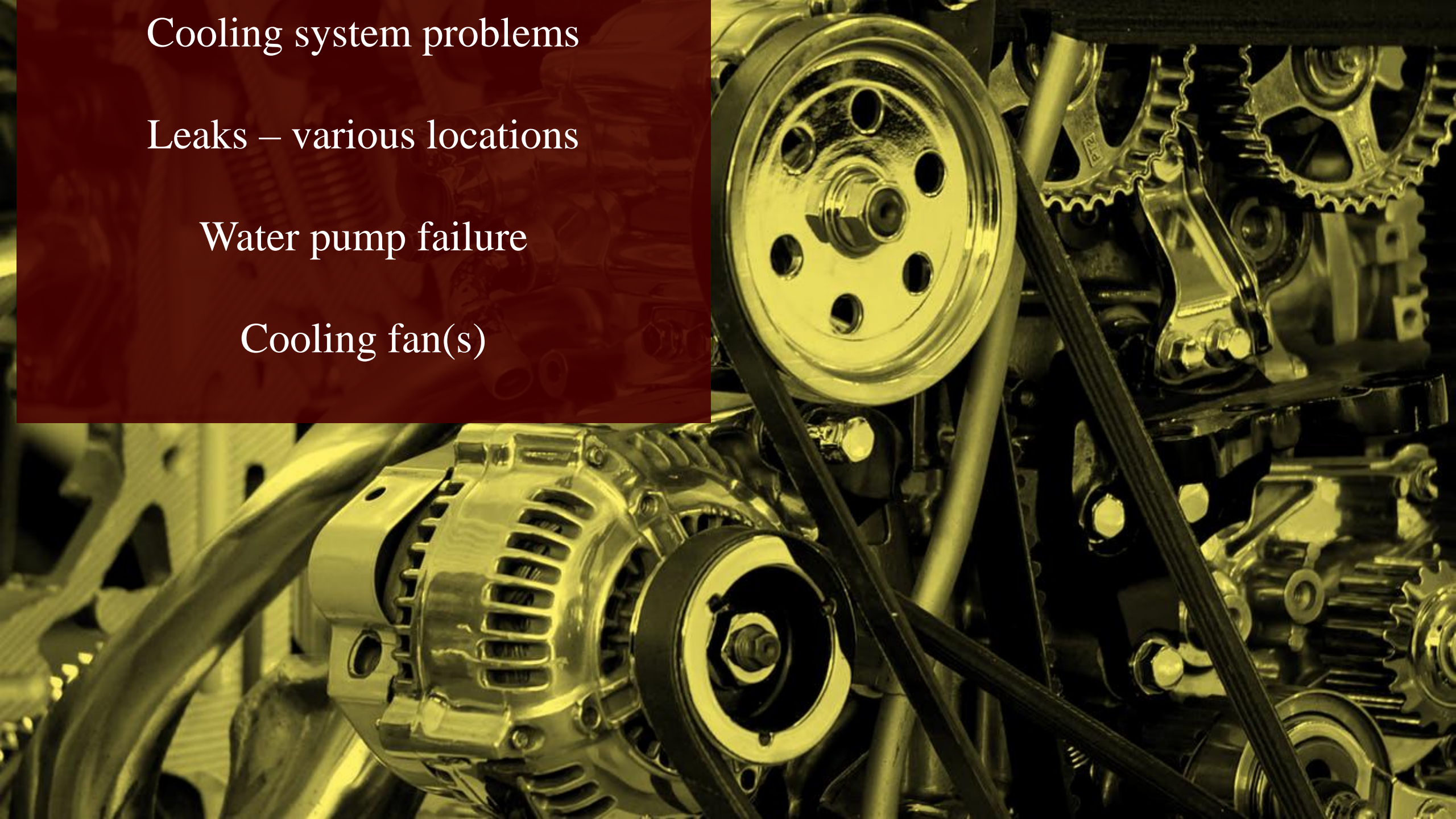


Cooling system problems

Leaks – various locations

Water pump failure

Cooling fan(s)



Wrap-up & questions

