Lubricant additives and compositions

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Budapest Technical University 2023.11.29

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AGENDA

- ►Lubrication, tribology fundamentals
- ►Tasks of lubricants
- ►Lubricant formulations, additives
- ►Engine oil quality systems
- ►Engine oil development trends

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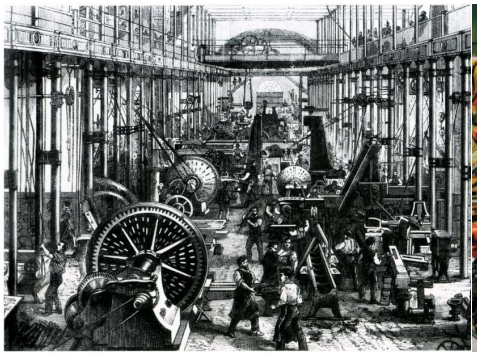
Machines are with us now ca. ~250 years



Friction and wear go hand in hand

Useful machine life is limited

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Machines never reach their designed useful life

?

Loss of machine life
70%
caused by

corrosion
15%

WEAR
55%

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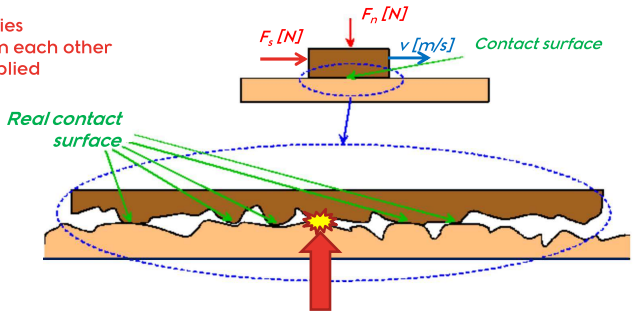
Contact of materials

Solid bodies
Moving on each other
Force applied



- Deformation – reversible or irreversible change
- Friction - heat generation
- Peak broken off - loss of material – wear

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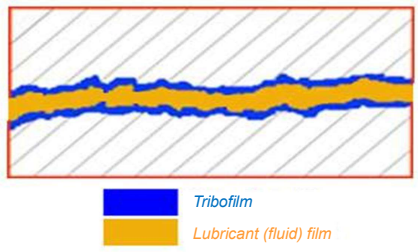
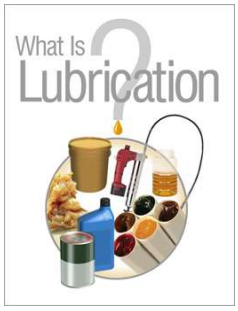
Lubrication





Science of friction reduction
By application of a material (lubricant) to improve the smoothness of movement of one surface over another

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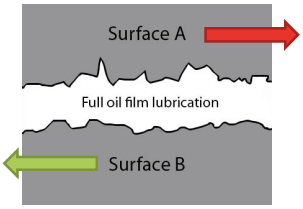
Lubricant

Material applied between interacting surfaces with relative motion that controls (usually reduces) friction and wear

Specially designed and manufactured industrial products, in various physical states – gaseous, liquid, plastic (consistent), or solid



„fluid machine component"

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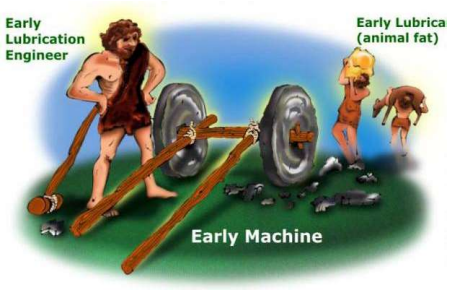
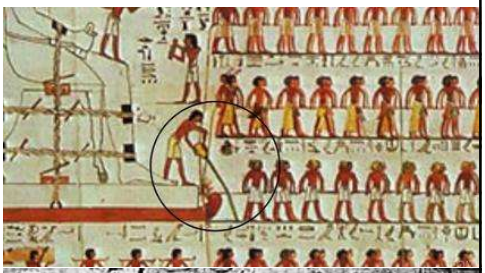
History of lubrication





Lubrication specialist in Egypt →

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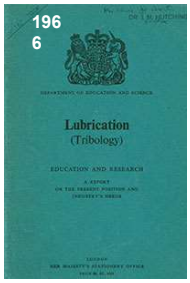
Birth of tribology – Jost report 1966

- Friction, wear and corrosion cost 515 mGBP per year in the UK – 1.5% of GDP
- British government established tribology centers
- Tribology acknowledged as stand-alone science
- Science and technology concerned with interacting surfaces with relative motion, including friction, lubrication, wear and corrosion



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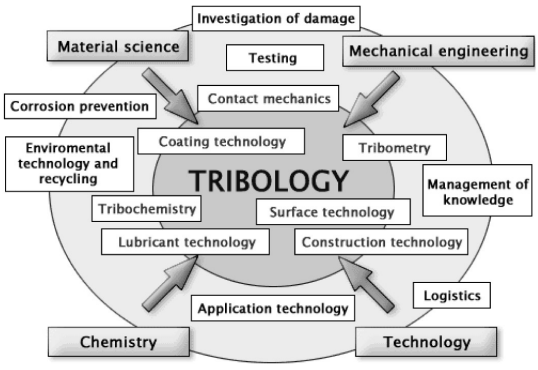
Definition of tribology

Science and technology related to surfaces in contact and in relative motion - including

- friction,
- lubrication
- wear and
- erosion.



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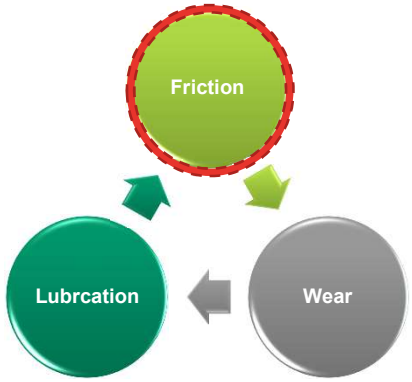
Tribolology



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Friction

Friction is a common natural phenomenon with various forms of appearance:

- Friction between solid bodies
- Friction in liquids and gases
- Friction that occurs when solid bodies and liquids come into contact

Friction between solid bodies usually leads to surface damage - e.g. wear

Friction results in a transformation between types of energy: mechanical energy is transformed into thermal energy. The process is irreversible.

Friction also occurs between machine parts, The effect can be harmful or beneficial.

- Friction is harmful if it causes energy loss.
- Friction is useful when it transfers energy or power, it is essential for the operation of equipment.

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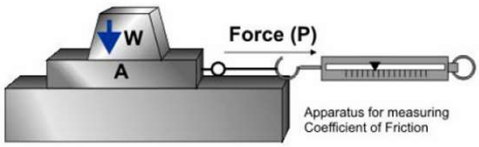
Friction

Coefficient of Friction (μ):

Ratio of the Force (P) required to overcome friction to the Load or Pressure (W) imposed between the surfaces of opposing bodies.

$$\mu = \frac{P}{W} =$$ Number of pounds of "pull" needed to slide 1 pound of "weight"

Assume weight of A = 0



Apparatus for measuring Coefficient of Friction

Coefficient of Friction (μ) for various frictional surfaces

Fluid Friction	0.001 - 0.005
Rolling Friction (Ball)	0.002
Rolling Friction (Roller)	0.004
Sliding Friction (Dry)	0.15 - 0.40
Sliding Friction (Boundary)	0.080 - 0.10
Sliding Friction (Mixed Film)	0.020 - 0.08

Coefficient of Friction (μ) for some materials in sliding contact

Bronze on Bronze	0.20
Cast Iron on Bronze	0.21
Cast Iron on Brass	0.20
Hard Steel on Hard Steel	0.42
Mild Steel on Mild Steel	0.57
Hard Steel on Babbitt	0.34
Mild Steel on Bronze	0.34
Wood on Wood	0.25 to 0.50
Metal on Oak	0.50 to 0.60
Leather on Cast Iron	0.56

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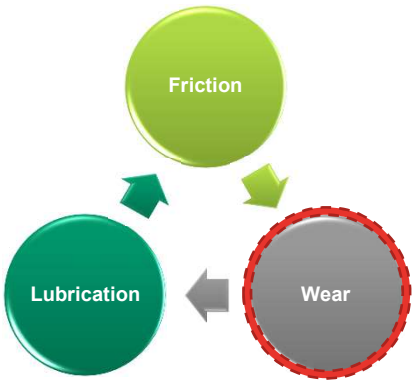
Tribology



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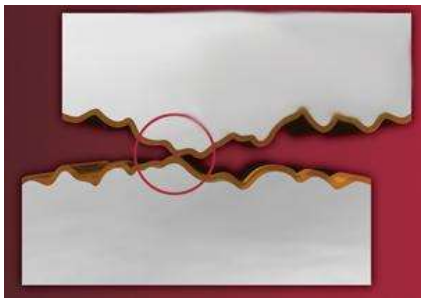
Wear

Wear: irreversible loss of material from contacting surfaces



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Factors determining wear

conditions	properties of friction materials	lubricant	Abrasive particles
Nature of friction	Mechanical	Fluid	size
Load	Physical	Solid	hardness
temperature	Chemical	gaseous	

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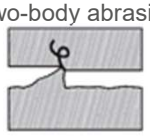
Abrasive wear

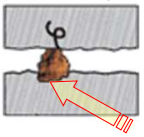
Created as a result of a scratching and chipping effect

two-body abrasion



- In the case of two-body abrasion, the body made of hard material scratches and chips the soft surface.
- In the case of three-body abrasion, a hard abrasive

three-body abrasion



Embedded solid particle

two-body abrasion | three-body abrasion

Ferrography images

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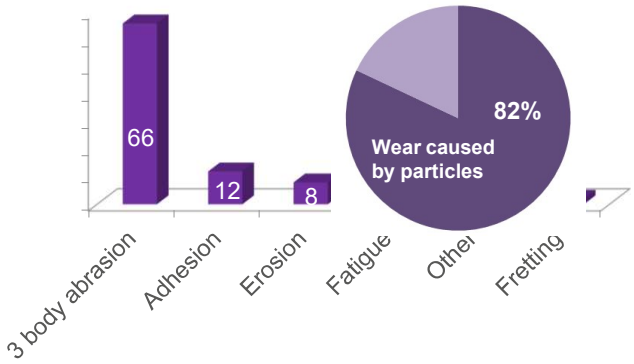
Frequency of types of wear



Forrás: NORIA

Presenting to [name] 19

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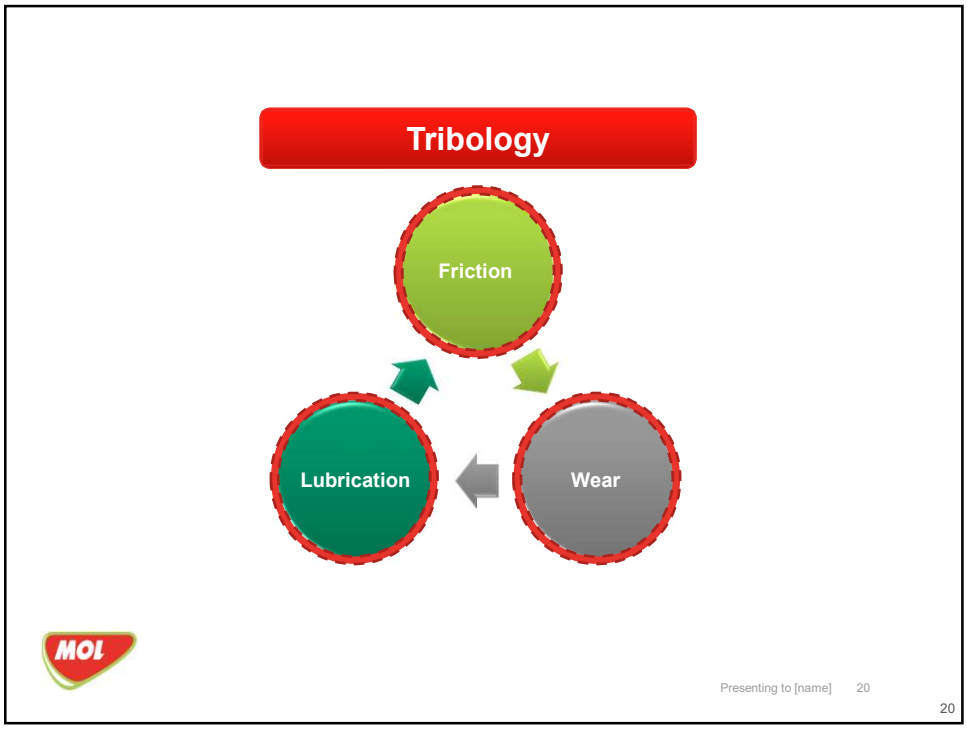

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Types of friction

Sliding Friction	Force that resists relative motion between sliding solid bodies whose opposing surfaces are clean and dry.	Load, Sliding, Welding (Wear), Stationary
Rolling Friction	Force that resists relative motion between two solid bodies when one or both roll over the surface of the other.	Rolling Contact
Fluid Friction	Force that resists the flow of liquids or gases. Such a force opposes the sliding action, one over the other, of the molecular layers of the fluid.	Free Moving Body, Fluid Layers, Maximum Velocity, Zero Velocity, Stationary Body
Boundary Friction	Force that resists relative motion between two solid bodies whose opposing surfaces are wetted by a lubricant, but barely separated by the lubricant film.	Free Moving Body, Lubricant Film, Boundary Contact, Stationary Body
Mixed Film Friction	Force that resists relative motion between two solid bodies whose opposing surfaces are partially separated by a full fluid.	Free Moving Body, Lubricant Film, Mixed Film, Stationary Body

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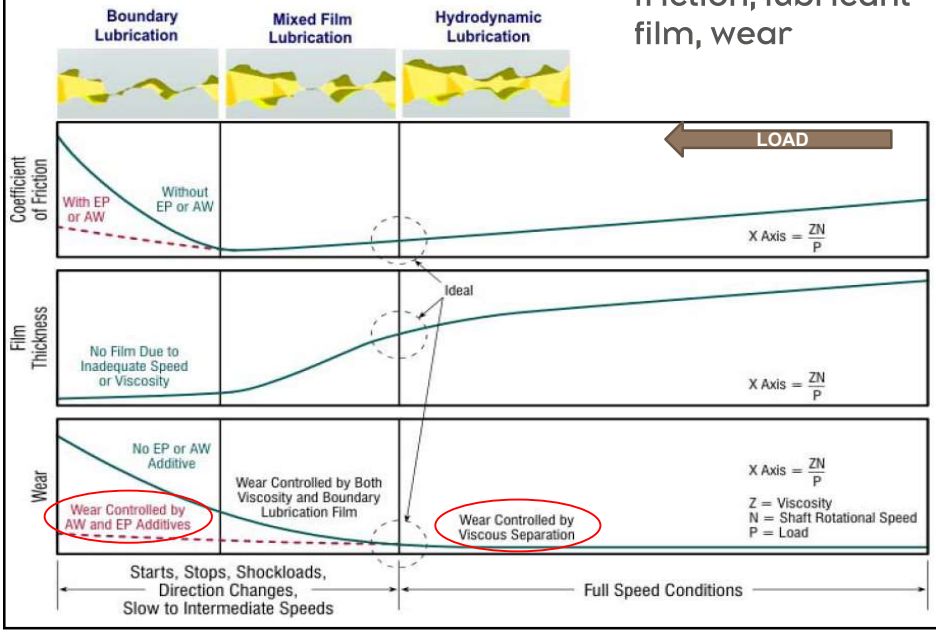
Relationship friction, lubricant film, wear



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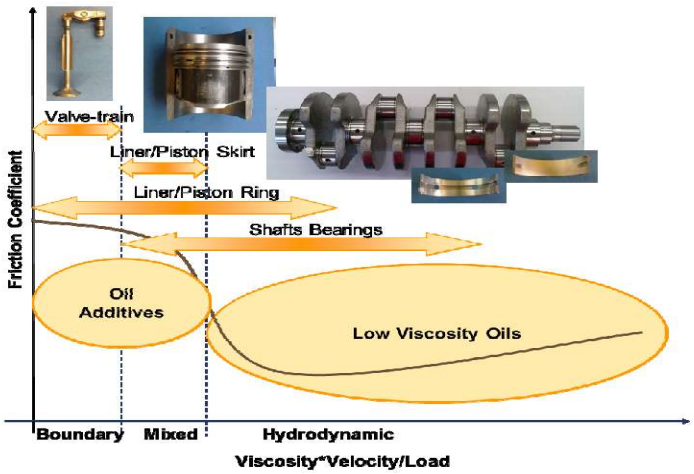
Lubrication in an engine



Internal combustion engine – All types of friction present

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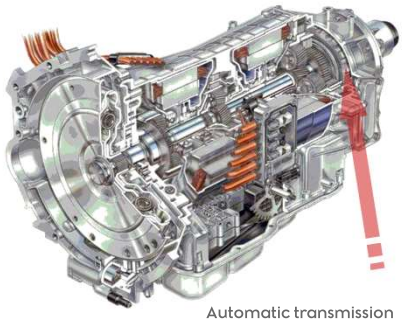
Lubricant application - Friction control

Friction optimization

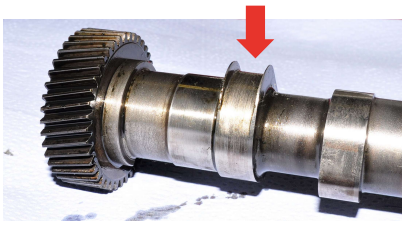


Automatic transmission of a hybrid vehicle
Friction is a must and beneficial
(Forrás: Chrysler)

- When lubricant film is present, friction is dramatically reduced
- Usually we need low friction
- Machine efficiency improved
- If lubricant film cannot be formed, antiwear and friction modifier additives are added
- In some cases friction is required

Lubricant application - Wear protection

Wear



- When lubricant film is present, wear is kept at minimum
- If load is high, fluid is squeezed out and antiwear additives are needed
- Material loss due to wear – main causes:
  - Improper lubricant
  - Bad quality construction materials
  - Poor machine design

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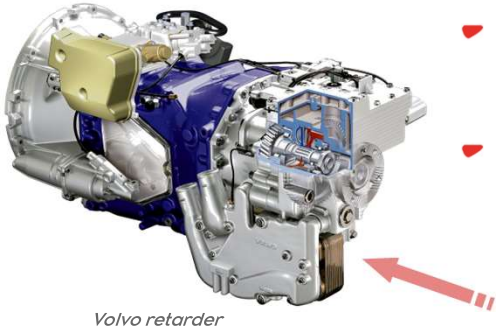
Lubricant application - Heat removal, temperature control



Volvo retarder

Pump (red) and turbine (blue)

- Friction loss and especially combustion in engines generate heat
- Excess heat must be removed – by lubricant

Retarder: hydrodynamic braking unit for trucks, buses
The hydraulic fluid is the same as the lubricant of the transmission
The lubricant removes and dissipates heat to the environment

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Lubricant application - Contamination control

Removal of wear and contaminants (soot, dust, ageing particles etc.) to keep metal surfaces clean

Heavy deposits, oil with bad detergent-dispersant properties

Oil with good detergent-dispersant properties

- Prevent deposits – detergent effect
- Keep contaminants dispersed in the lubricant – dispersant effect
- Contaminants are carried to the filter where they are removed at a filter change

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Lubricant application - Corrosion protection

Prevent rust and corrosion

Consequences to be avoided

- Machine parts are exposed to corrosive environment
- Lubricant provides corrosion protection for both iron and yellow metals

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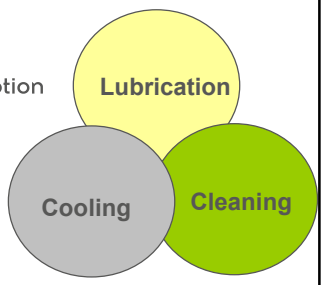
Lubricant functions – complex set of tasks

Friction control	⇨	Separate moving surfaces
Wear protection	⇨	Reduce abrasive wear
Corrosion protection	⇨	Protect surfaces against corrosive materials
Temperature control	⇨	Removes and transmits heat
Contamination control	⇨	Prevent deposits, carry particles and other contaminants to filters, separators
Power transmission	⇨	Transmit power and motion



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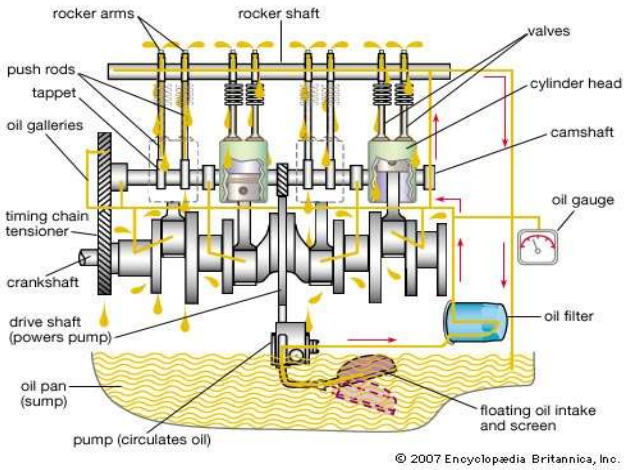
Lubrication system of a four-stroke engine



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AGENDA

- Lubrication, tribology fundamentals
- Tasks of lubricants
- **Lubricant formulations, additives**
- **Engine oil quality systems**
- **Engine oil development trends**

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Two key requirements for lubricating oils

Viscosity (rheology)

- Adequate flow properties
- Cold
- Hot

Performance level

- Oxidation and thermal stability
- Wear protection
- Cleaning capacity (detergent)
- Contaminant handling ability (dispersant)
- Resistance to mechanical shearing
- Foam reduction
- Protection against corrosion
- Eco compliance

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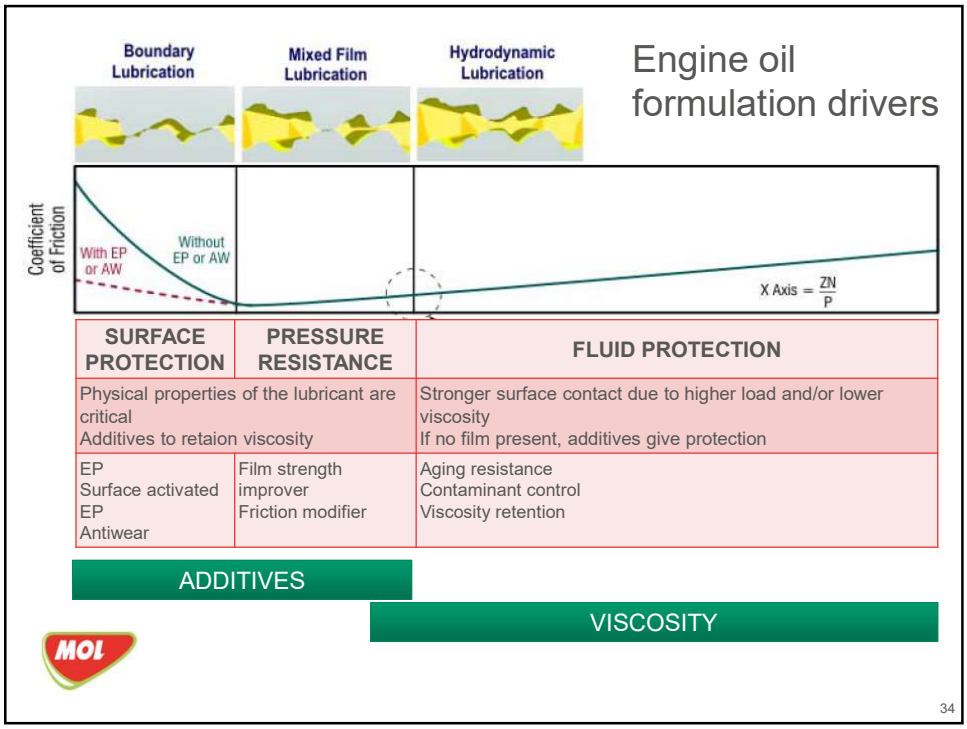
Boundary Lubrication
Mixed Film Lubrication
Hydrodynamic Lubrication
Engine oil formulation drivers
Coefficient of Friction
With EP or AW
Without EP or AW
X Axis = ZN/P
SURFACE PROTECTION
PRESSURE RESISTANCE
FLUID PROTECTION
Physical properties of the lubricant are critical
Additives to retaion viscosity
Stronger surface contact due to higher load and/or lower viscosity
If no film present, additives give protection
EP
Surface activated EP
Antiwear
Film strength improver
Friction modifier
Aging resistance
Contaminant control
Viscosity retention
ADDITIVES
VISCOSITY
MOL
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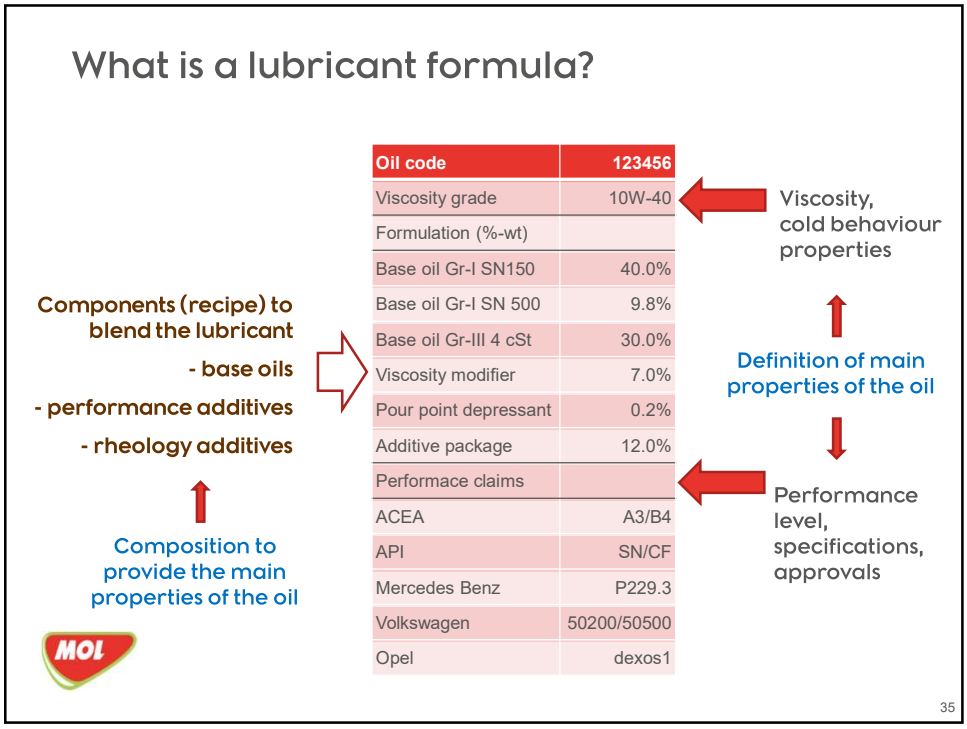
What is a lubricant formula?
Components (recipe) to blend the lubricant
- base oils
- performance additives
- rheology additives
Composition to provide the main properties of the oil
Oil code 123456
Viscosity grade 10W-40
Formulation (%-wt)
Base oil Gr-I SN150 40.0%
Base oil Gr-I SN 500 9.8%
Base oil Gr-III 4 cSt 30.0%
Viscosity modifier 7.0%
Pour point depressant 0.2%
Additive package 12.0%
Performace claims
ACEA A3/B4
API SN/CF
Mercedes Benz P229.3
Volkswagen 50200/50500
Opel dexos1
Viscosity, cold behaviour properties
Definition of main properties of the oil
Performance level, specifications, approvals
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WHAT IS IN THE BOTTLE?

~ 80% base oil

- mineral
  - Gr-I
  - Gr-II
  - Gr.-III
- syntehtic
  - Gr-IV (PAO)
  - Gr-V (ester)

~ 20% additives

Dispersant	Detergent	Anti-wear
EP Agent	Foam Inhibitor	Friction Modifier
Oxidation Inhibitor	Corrosion Inhibitor	Viscosity Modifier/PPD

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Base oils

Mineral

Crude oil derivative. Properties depend on the quality of the crude stock and refining process.

Synthetic

Produced from different chemical man-made fluid compounds.

Vegetable

Derived from vegetable oils. Special refining processes, depending on type of seed.

Performance of a lubricant highly depends on type and quality of base fluids

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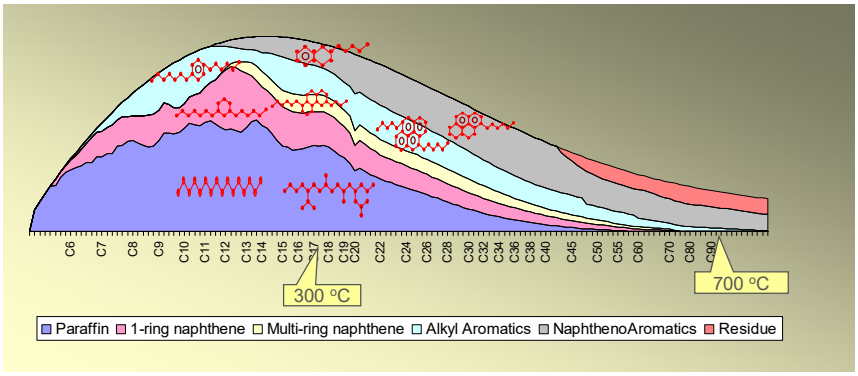
Typical crude oil



Hydrocarbon distribution of a typical crude oil (Arab light)

Linear boiling point temperature scale - proportional to the n-paraffin carbon number

The base oil molecules fall in the distillation range of 300-700 ° C

Refining is required to separate the desired base oil molecules

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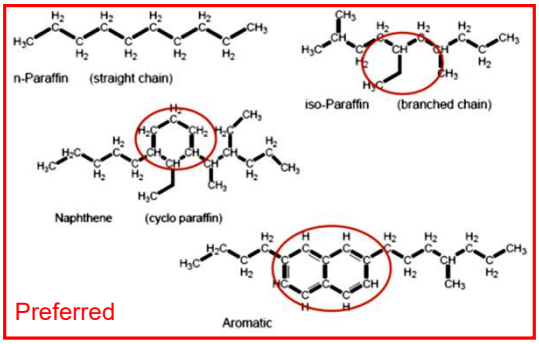
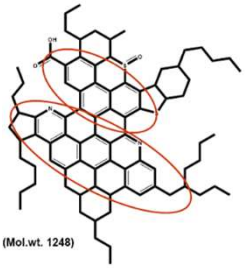
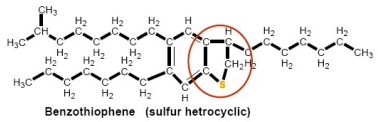
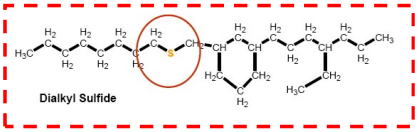
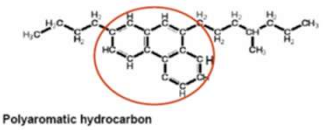
Hydrocarbon molecules in crude oil











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Base oil processing methods

Separation processes
- Distillation
- Solvent extraction
- Dewaxing
- Propane deasphalting

} **Separation methods only**

Hydrogen treatment
- Hydrofinishing
- Hydrotreating
- Hydrocracking
- Hydroisomerisation

} **Methods involving chemical reactions and restructuring the hydrocarbon molecules**

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API - ACEA base oil categories

Conventional solvent

Mild hydrocracking

Hydrocracked, hydroisomerised oils, (VHVI, UHVI,

Category	VI	Sulfur	Saturates	Description
Group I	80-119	>0.03%	<90%	Solvent Neutral (SN) conventional base oils. They contain aromatics, sulfur and nitrogen heteroatpmic hydrocarbons. Typical VI 95-100.
Group II	80-119	<0.03%	>90%	Higher purity, aromatics, sulfur max 50 ppm, typical VI 95-105, Group II+ max VI 119
Group III	>120	<0.03%	>90%	Very high purity, aromatics <<1%, sulfur <10 ppm. V.I. >120. Performance comparable to PAOs.
Group IV				PAO –poly-alfa-olefin from chemical synthesis. Highest purity, high price.
Group V				All other, mainly esters

Group I

Group III / IV

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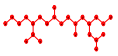
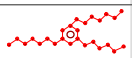
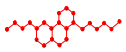
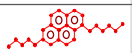
Hydrocarbon constituents in base oils

Molecule	Structure	Viscosity Index	Pour point	Oxidation stability	Solvency	Toxicity
n-paraffin		Excellent	Poor	Excellent	Poor	Low
Polyalphaolefin		Excellent	Excellent	Excellent	Poor	Low
Iso-paraffin		Good/Excellent	Good	Excellent	Medium	Low
Linear naphthenic		Good	Good	Good	Good	Low
substituted monoaromatics		Poor	Good	Good	Good	Low
naphthenic		Poor	Excellent	Good	Excellent	Low
polynuclear aromatics		Poor	Poor	Very Poor	Good	Very High

During refining, sulfur- and nitrogen-containing compounds (heteroaromatics) are removed

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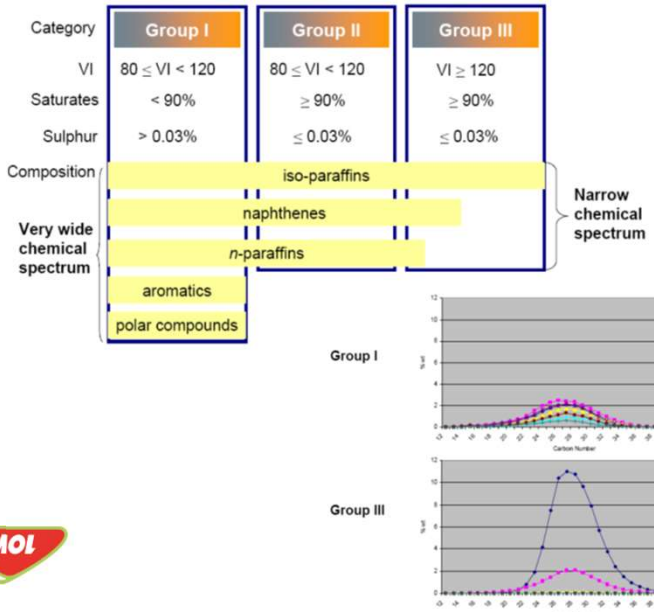
Chemical character of base oil categories



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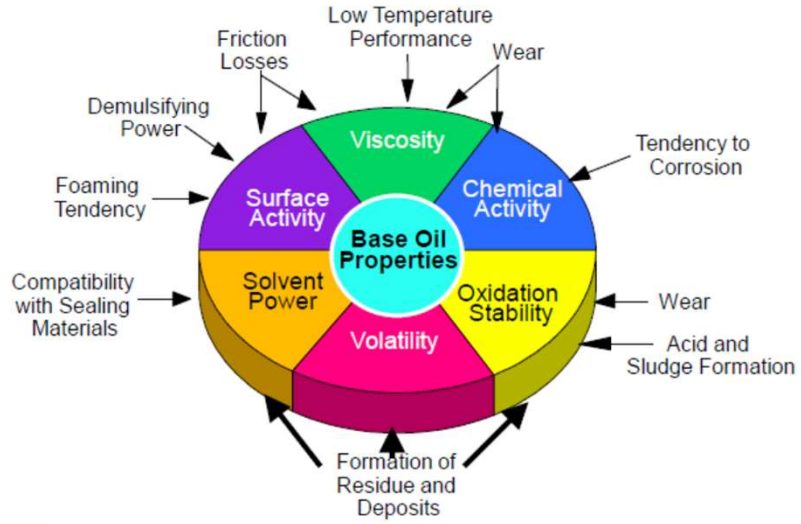
Base oil properties with impact on lubricant quality



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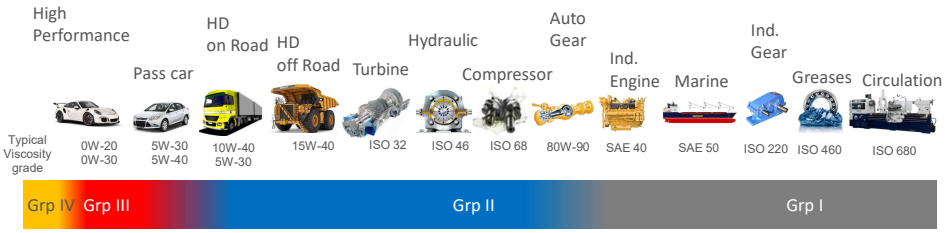
Typical application of base oil categories



Light grades - synthetics

Illustrative examples only

Heavy grades - mineral

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WHAT IS IN THE BOTTLE?

~ 80% base oil
- mineral
  - Gr-I
  - Gr-II
  - Gr.-III
- syntehtic
  - Gr-IV (PAO)
  - Gr-V (ester)

~ 20% additives

Dispersant	Detergent	Anti-wear
EP Agent	Foam Inhibitor	Friction Modifier
Oxidation Inhibitor	Corrosion Inhibitor	Viscosity Modifier/PPD

MOL

MOLGROUP | 47

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Desired lubricant properties

- Viscosity and cold flow characteristics
  - Viscosity measured at high and low temperatures
  - Flow properties at low temperatures, pour point
- High lubricating film strength
- Friction characteristics
- Low corrosion tendency
- Good cleaning and dispersing ability
- Low flammability
- Low toxicity

History of Lubricant Additives

1927	EP-, AW- Additives
1931	Pour Point Depressants
1933	Viscosity Modifiers
1935	Detergents, Dispersants
1936	Anti-Oxidants, Anti-Corrosion
1948	MoS_2
1952	Detergents (over-based)
1953	ZDDP
1957	Dispersants (ashless)

- Additive types
  - Rheological - modifying viscosity-temperature characteristics, cold flow properties
  - Functional (performance) - strengthens the properties of the base oil, providing additional properties (e.g. cleaning effect, wear protection, stability, etc.)

MOL

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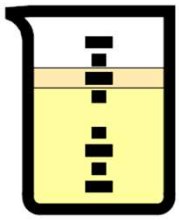
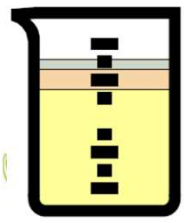
Rheology additives – viscosity modifiers, pour point depressants



0 – 2%wt Viscosity Modifier (VM)

- Viscosity Modifiers are high molecular weight polymers
- Little effect on viscosity at low temperatures
- Polymer solubility increases at higher temperatures – greater thickening effect – higher viscosity than expected for untreated oil



0 – 0.3%wt Pour point depressant

Pour point Depressants

- Lower Molecular weight polymers than VMs
- Used to reduce the temperature at which oil becomes solid
- Tend to be Polymethacrylates or Styrene esters

- Viscosity modifiers
  - Polyisobutylene (PIB)
  - Polymethacrylate (PMA)
  - **Olefin Copolymer (OCP)**
  - OCP-PMA hybrid
  - Maleic Anhydride-Styrene Ester (MSC)
  - Styrene-diene

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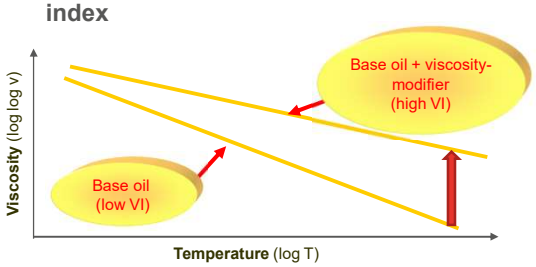
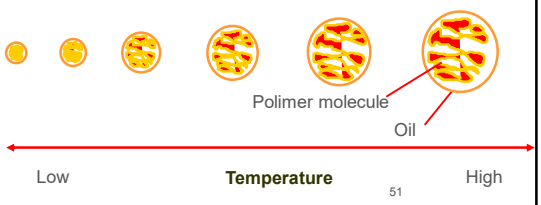
Changing the viscosity = increasing the viscosity index

- The viscosity of base oils used in the production of lubricants usually decreases with increasing temperature to a greater extent than desirable - it is necessary to improve the relationship between temperature and viscosity.
- Viscosity modifiers are polymer additives that improve the viscosity index (VI) of the base oil.





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Engine Oil viscosity classification (SAE J300)

SAE: Society of Automotive Engineers

Multigrade oil

SAE 0W - 30

Low temperature (engine start)

"W" winter "winter" compliance

Smaller number allows operation at a lower temperature - better cold start

2 different viscosity measurements

High temperature (engine in operation)

The thickness of the oil film at high temperatures

Smaller number results in fuel savings

Larger number gives a thicker oil film

2 different viscosity measurements

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Viscosity grades of motor oils

Viscosity classes (SAE J 300)

	CCS max. cP	MRV max. cP	Kinematic viscosity, 100°C min. cSt	Kinematic viscosity, 100°C max. cSt	HTHSV, 150°C min. cP
0W	6,200 at -35	60,000 at -40	3.8	-	-
5W	6,600 at -30	60,000 at -35	3.8	-	-
10W	7,000 at -25	60,000 at -30	4.1	-	-
15W	7,000 at -20	60,000 at -25	5.6	-	-
20W	9,500 at -15	60,000 at -20	5.6	-	-
25W	13,000 at -10	60,000 at -15	9.3	-	-
20	-	-	5.6	< 9.3	2.6
30	-	-	9.3	< 12.5	2.9
40	-	-	12.5	< 16.3	2.9 (0W-40, 5W-40, and 10W-40 grades)
40	-	-	12.5	< 16.3	3.7 (15W-40, 20W-40, 25W-40, 40 grades)
50	-	-	16.3	< 21.9	3.7
60	-	-	21.9	< 26.1	3.7

For example SAE 5W-30
Cold start -30 °C
Cold pumpability -35 °C
Viscosity at 100 °C 9,3-12,5 cSt

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Differences in motor oil formulations

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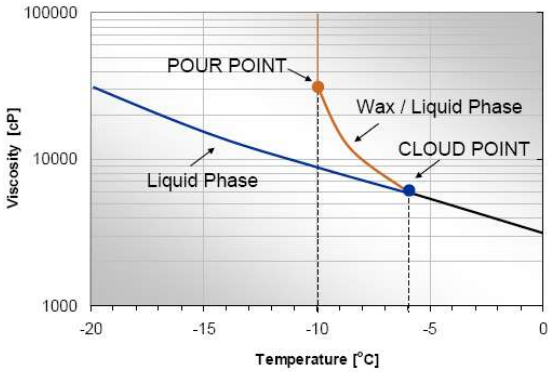
Decreasing pour point of base oils



Effect of wax crystallization on the viscosity of oil near its pour point

Wax Crystals Without PPD

Wax Crystals With PPD

- Pour point depressant additives
  - Modifies the morphology of crystals (co-crystallizes with paraffin)
  - Sterically hinders the formation of large, needle-like, aggregating structures
  - Helps to form a stable dispersion of small paraffin crystals

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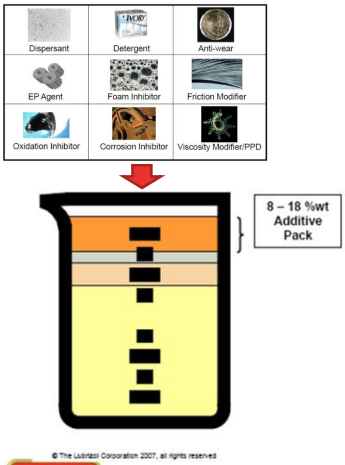
Engine oil performance package



Additive Pack

- Dispersants (40-55)
  - Succinimides
- Detergents (20-35)
  - Sulfonates
  - Phenates
  - Salicylates
- Antioxidants (3-15)
  - Aminic
  - Phenolic
  - Sulfur types
- Antiwear (5-10)
  - Zinc Dialkyl Dithio Phosphate
- Friction Modifiers (<1)
  - Short chain fatty acids / esters
  - Short chain amides
- Others (<1)
  - Foam inhibitor - Polysiloxanes
  - Corrosion inhibitor – PIBSA, detergents

Keep dirt in the oil

Keep machine parts clean

Reduce ageing of the oil

Prevent wear

Reduce friction

Prevent foam
Prevent corrosion

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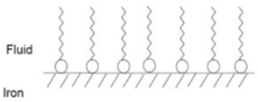
Additives - detergents to keep clean

Washing effect | **Acid neutralization effect**

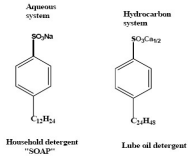
Neutral Detergents - Mode of Action



- Having fatty tail and polar head makes them surfactants
  - Inhibit corrosion, keep surface clean
  - polar particles - remove them from the surface

Detergent - Sulfonate

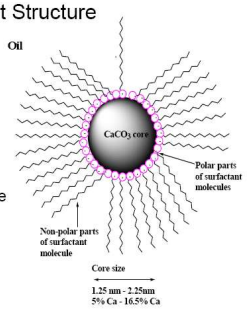
Comparison



Avg. Molecular Weight	347	1024

Overbased Detergent Structure

- Can get up to 50% metal carbonate solutions in oil - completely clear!.
- Usually spherical"core".
- Surfactants form oil soluble "shell"



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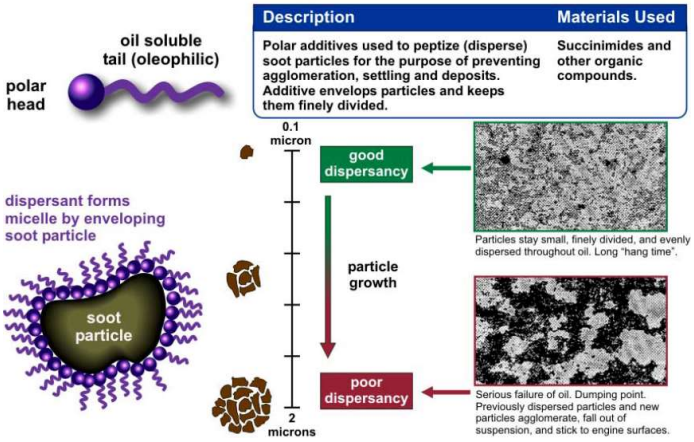
Additives - dispersants to keep dispersed



Their role is to disperse contaminants and prevent their coagulation

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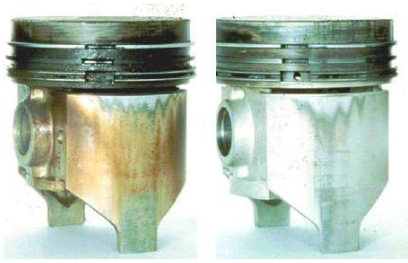
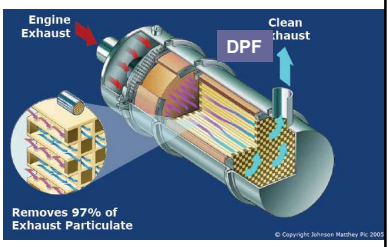
Cleaning effect of detergents

Dispersants & detergents keep pistons clean



Unacceptable **Acceptable**



and limitations…

SAPS
SA – sulfated ash (metallic additives)
P – phosphorus
S – sulfur

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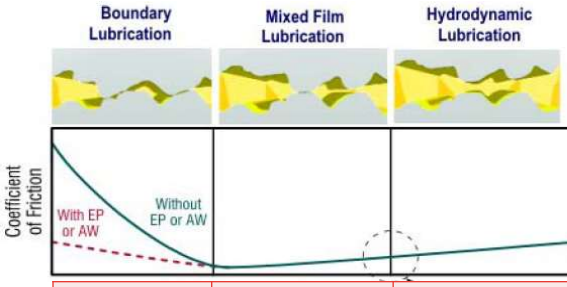
Wear protection



SURFACE PROTECTION	PRESSURE RESISTANCE	FLUID PROTECTION
Physical properties of the lubricant are critical Additives to retaion viscosity		Stronger surface contact due to higher load and/or lower viscosity If no film present, additives give protection
EP Surface activated EP Antiwear	Film strength improver Friction modifier	Aging resistance Contaminant control Viscosity retain

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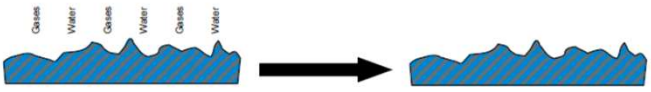
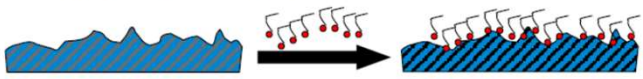
Antiwear (AW) additives

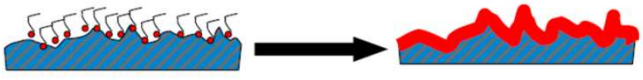
- Break in Period – Remove gas and water and reduce asperities



- Physical or chemical absorption

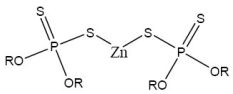


- Surface reaction and protective layer growth

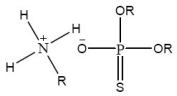


- Mechanism of action
  Tribochemical reaction
- A polyphosphate oxide chemical layer is formed
- The most common compound is zinc dialkyl dithiophosphate

Antiwear Additives (Phosphorus)



Zinc Dialkyl Dithio Phosphate



Amine Thio Phosphate

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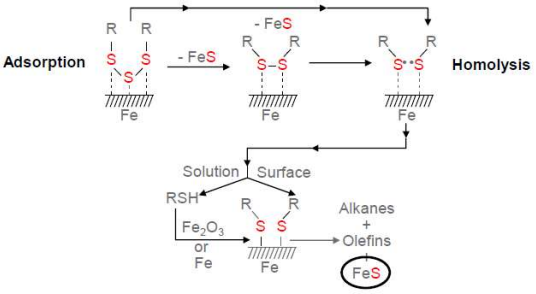
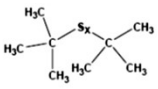
Extreme Pressure, EP additives

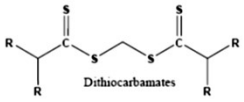
- Mechanism of action
  Tribochemical reaction - at higher pressures and temperatures
- An iron sulfide chemical layer is formed
- Self-sacrificing layers
- The most common compound is sulfurized olefins
- Other types: superbasic Ca-sulfonate, chlorinated paraffins



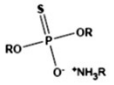
Forms sheets of FeS that protect the surface



Polysulfides



Dithiocarbamates



Amine Thio Phosphate

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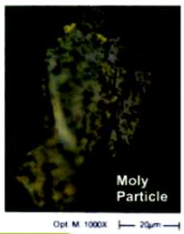
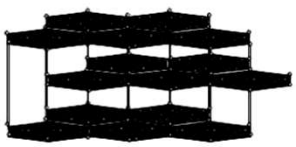
Solid additives for lubricants

Type	Description	Applications	Advantages	Disadvantages
Molybdenum disulfide (Moly)	Molybdenum disulfide (MoS_2) is a powder suspension used to impart special nonsurface sacrificial antiscuff and antifretting performance. Excellent adhesion to surfaces. Moly particles vary in size by design. Small particles (<2 microns) for smooth surfaces and large particles (>5 microns) for rougher surfaces.	High-duty/low speed gear drives. Oil and grease.	Disulfide compound provides good surface adhesive.	Settling and filtration limitations.
Graphite	It is a gray-black crystalline form of carbon arranged hexagonally in regular layers. Graphite gives low friction only when it is contaminated or "intercalated" with water vapor or other condensable vapors.	High-duty/low speed gear drives. Oil and grease.	Low friction, good surface adhesion.	Settling and filtration limitations.
Borate	Esters of boric acid or inorganic borates finely dispersed in oil or grease. Form small spheres of 0.1 micron in diameter. Borate solid particles cling to contact surface, by electrical adhesive forces and work like microscopic ball bearings. Increases surface hardness.	High-duty/low speed gear drives. Oil and grease.	Small particle size. Unlike sulfur phosphorus EP additives, borate additives are noncorrosive.	Settling (white phase). Borates are slightly water soluble and may be dissolved or disassociated from the metal in the presence of water.
PTFE (Teflon)	White solid polymer.	High-duty/low speed gear drives. Oil and grease.	Highly resistant to chemical attack.	Settling and filtration limitations.



Best Control For

Two-body Abrasion	Adhesive Wear
Borates	S-P EP
Moly	ZDDP
Graphite	TCP



Hexagonal lattice structure of graphite

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Types of antioxidant additives

Hydroperoxide Decomposers

Sulfur compounds

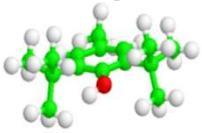
Phosphorus compounds

Phenols

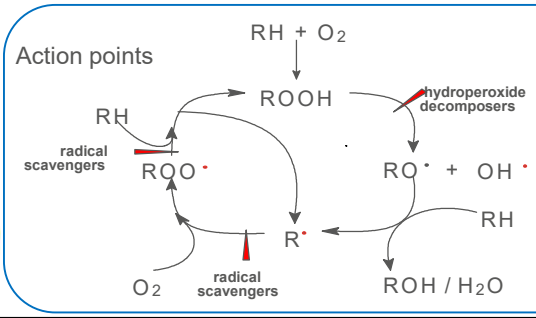
Radical Scavengers

Aromatic Amines

Hindered Phenols



Action points



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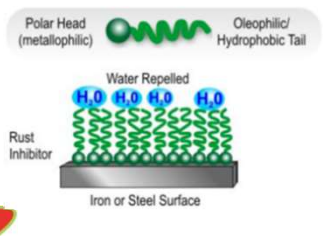
Corrosion inhibitors

Rust Inhibitors form a polar film adherent to steel and cast iron surfaces. The film repels water which inhibits rust formation.

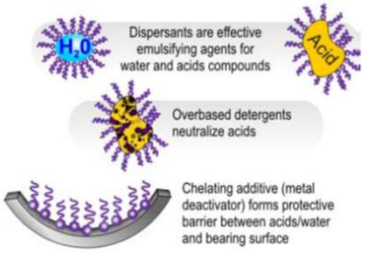
Common Rust Inhibitors:

- **Engines:** Sulfonates (overbased)
- **R&O and Other Industrial Lubricants:** Phosphoric acid derivatives, succinic acid, calcium phenol sulfides, and long-chain fatty acids



Corrosion Inhibitors protect copper, tin and lead-based bearing metals by neutralizing acids and by sealing surfaces from contact with water and corrosive acids.

Common Corrosion Inhibitors:
Overbased detergents, water suspending dispersants and chelating compounds of imidazole, benzotriazole and ZDDP.



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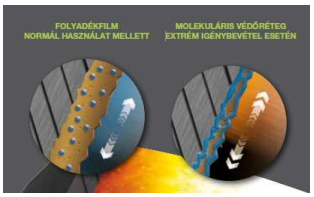
MOL engine oil technologies



Normal conditions
Fluid film

Heavy conditions
Molecular protective film

Dual Film technology

Triple Antioxidant Protection technology

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Components for Engine Lubricants

Additive	Gasoline Engine Oils	Diesel Engine Oils	Natural Gas Engine Oils	Two Cycle Engine Oils
Dispersant	✓	✓	✓	✓
Detergent	✓	✓	✓	✓
Antiwear/EP agent	✓	✓	✓	✓
Oxidation inhibitor	✓	✓	✓	✓
Corrosion inhibitor/ metal deactivator	✓	✓	✓	✓
Friction modifier	✓			
Pour point depressant	✓	✓	✓	
Foam inhibitor	✓	✓	✓	
Viscosity modifier	✓	✓		

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Engine oil additive pack

KOMPONENSEK	EC SZÁM	SZIMBÓLUM / R MONDATOK	MENNYISÉG
Magasan finomított ásványi olaj (C15 - C50)	*	Egyik sem	41 % súlyszázalék
Poliolefin poliamin szukcinimid, poliol	Polimer	R53	23 % súlyszázalék
Cink alkil ditio-foszfát	272-028-3	Xi/R41, N/R51/53	8 % súlyszázalék
Kalcium elágazott láncú alkil-fenolát-szulfid	291-829-9	R53	8 % súlyszázalék
Polialkil aril-amin	270-128-1	N/R51/53	6 % súlyszázalék
Kalcium hosszú láncú alkaril szulfonát	271-877-7 & 290-636-7	Xi/R43, R53	5 % súlyszázalék
Alkenoil sav észter, bórozott	Bizalmas	Xi/R38, R53	4 % súlyszázalék
Kalcium hosszú láncú alkaril szulfonát	Polimer	R53	1 % súlyszázalék
Elágazott láncú alkil-karbolsavat és a elágazott láncú kalcium-alkil-karbolsavat	Polimer	Xi/R38, Xn/Repro. Cat. 3/R62, N/R50/53	1 % súlyszázalék

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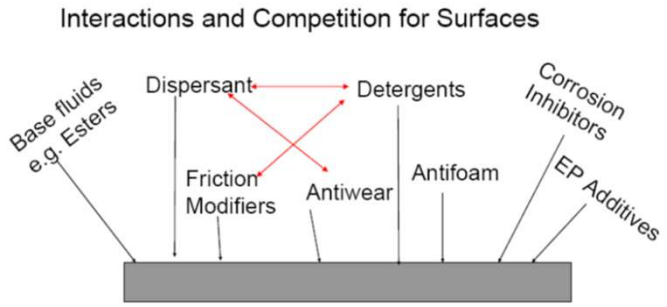
Additives compete on surface



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Greases - what's in the can?

~ 85% base oil
- mineral
  - Gr-I
  - Naphthenic
- synthetic
  - Gr-IV (PAO)

~10% thickener

~ 5% additive

Dispersant	Detergent	Anti-wear
EP Agent	Foam Inhibitor	Friction Modifier
Oxidation Inhibitor	Corrosion Inhibitor	Viscosity Modifier/PPD

Grease is like a lubricating oil kept in a sponge structure

Main thickener types:

- lithium, calcium soap
- lithium, aluminium, calcium complex

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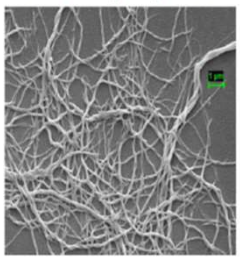
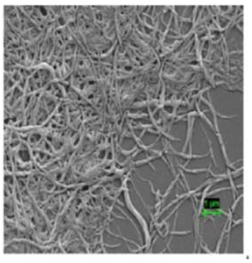
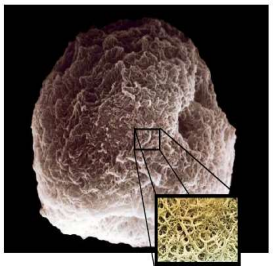
Difference between a simple soap and a complex grease structure

Lithium 12-hydroxystearate



Lithium Complex





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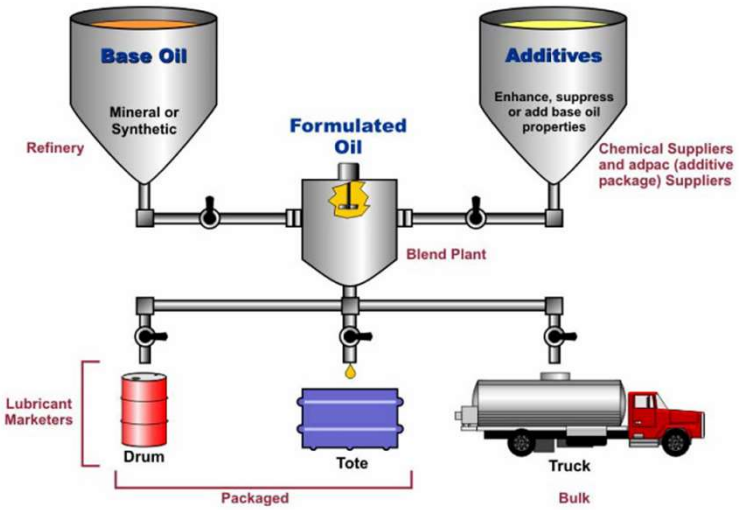
Production process of lubricating oils



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AGENDA

- Lubrication, tribology fundamentals
- Tasks of lubricants
- Lubricant formulations, additives
- **Engine oil quality systems**
- **Engine oil development trends**

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What is a lubricant formula?

Components (recipe) to blend the lubricant
- base oils
- performance additives
- rheology additives

Composition to provide the main properties of the oil

Oil code	123456
Viscosity grade	10W-40
Formulation (%-wt)	
Base oil Gr-I SN150	40.0%
Base oil Gr-I SN 500	9.8%
Base oil Gr-III 4 cSt	30.0%
Viscosity modifier	7.0%
Pour point depressant	0.2%
Additive package	12.0%
Performace claims	
ACEA	A3/B4
API	SN/CF
Mercedes Benz	p229.3
Volkswagen	50200/50500
Opel	dexos1

Viscosity, cold behaviour properties

Definition of main properties of the oil

Performance level, specifications, approvals

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Lubricant specifications

- Contains technical requirements describing the quality of lubricating oil
- Characteristics that ensure that the lubricating oil fits for purpose in the machine / equipment
- Physical and chemical characteristics Compatibility with materials, seals and coatings used in the equipment
- Engine test bench, model machine measurements
- Road / field application test specifications

Test	CNH MAT 3525 [1] (Rev. D Sept 2001) (134-D fluid)	CNH MAT 3526 (Rev. B Sept 2001) (F200-A fluid)
Kinematic Viscosity, mm²/s, ASTM D445		
at 100°C	9.1 - 9.8	8.5 - 9.0
at 40°C, typical	55	35
Shear Stability		
30 passes, min, %, ASTM D3945	-16	
Transmission/Hydraulic oil shear test, mm²/s, min, CNH 86548393		7.9
Brookfield Viscosity, ASTM D2983, mPa·s, max.		
at - 18°C	4000	17000 @ -40°C
Viscosity Index, min.	130	185
Thermal stability, 100 hrs at 150°C, % viscosity change, max.	10, No sludge	10, No sludge
Pour point, °C, ASTM D97, max.	-37	-45
Flash point, °C, ASTM D92, min.	190	160
Foaming, ASTM D892		
Sequence I, ml, max.	20/0	50/0
Sequence II, ml, max.	50/0	50/0
Sequence III, ml, max.	20/0	50/0
Copper corrosion, ASTM D130, 3 hrs at 150°C, max.	2B	2B
Volatility, 48 hrs at 120°C, weight loss, %, max.	1	1
Rust protection, ASTM 665A	No rust	No rust
4-Ball wear, 1 hr, 85°C, 1500 rpm, 40 kg, ASTM D2266, mm, max.	0.4	0.4
Seal test, P70 and P90 reference elastomers, 70 hrs at 125°C		
Volume, %	-3 to +7	-3 to +7
Hardness change, max.	-5 to +5	-5 to +5
Water sensitivity, CNH test		
Sediment volume, ml, max.	0.1	0.1
Water separation, ml	Trace	Trace
Jenkins cycle test, 600 hrs	Pass	Pass
Tandem pump durability test	Pass	Pass
16 x 16 inching/shifting test	Pass	Pass
16 x 16 transmission, 400 cycle stall test	Pass	Pass
16 x 16 transmission, 450 cycle high energy test	Pass	Pass
Field test, 2000 hrs	Pass	Pass
Brake test	Pass	Pass
PTO clutch test	Pass	Pass
Dynamic co-efficient of friction	0.095 - 0.135	0.095 - 0.135
Static co-efficient of friction	0.085 - 0.110	0.085 - 0.110

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Who issue specifications?

- International, national, industry organizations: ISO, DIN, SAE, etc.

- OEMs (machine manufacturers): VW, BMW, Flender, Siemens, stb.

- Government bodies: EU, military

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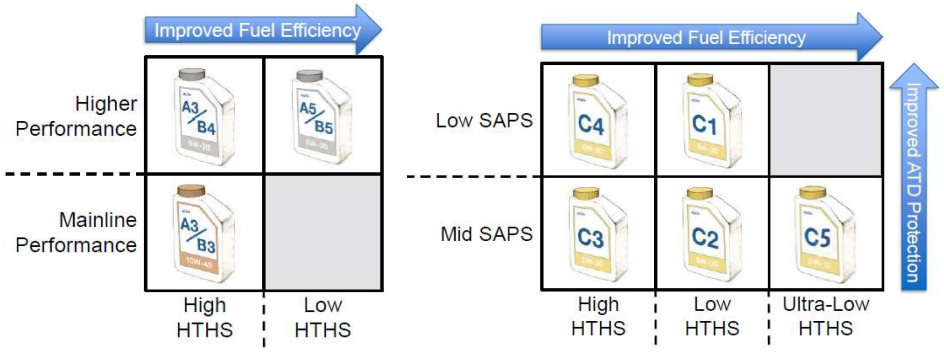
European passanger car engine oil specifications (ACEA)



- Defines the minimum requirements for service-fill oils
- Used by car manufactureres as a basic standard
- A: conventional gasoline engines;
- B: conventional diesel engines;
- C: modern gasoline and diesel engines (SAPS - sulphate ash, phosphorus, sulfur content)

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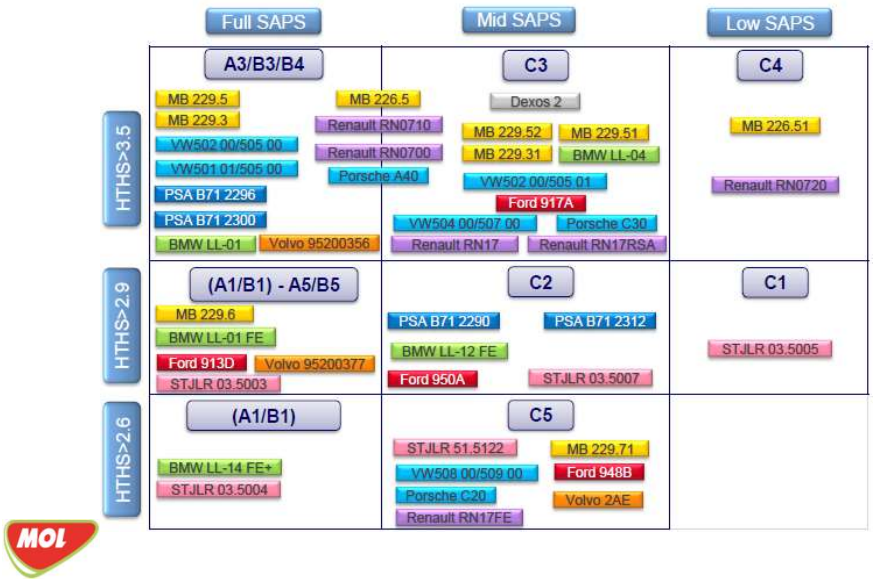
ACEA and OEM passanger car motor oil specs



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Where are they on the bottle?

SAE 5W-30 viscosity

dexos2

Back label: API SN, ACEA C3

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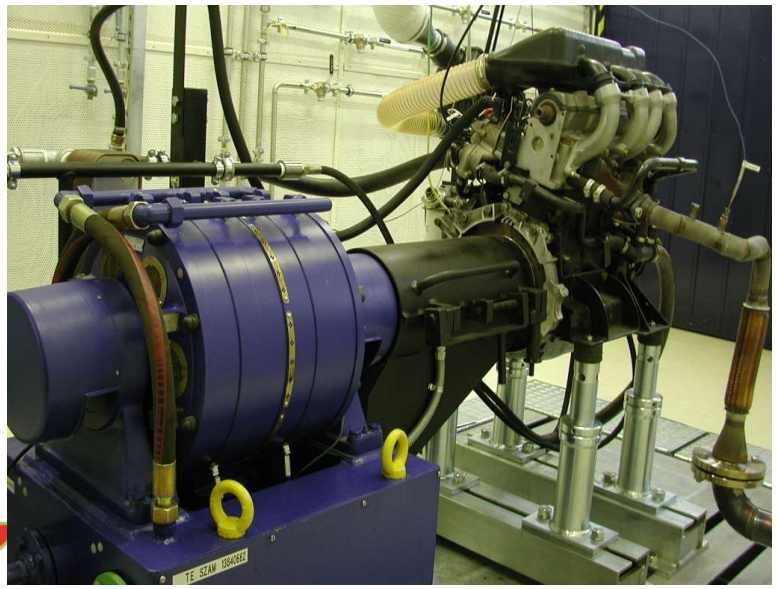
Engine test bench



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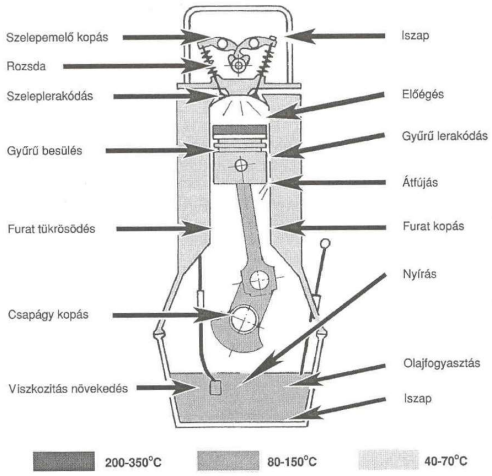
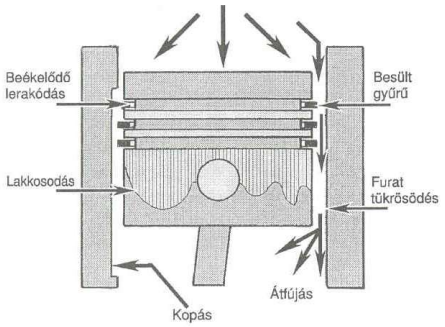
Engine tests – evaluated parameters





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Engine oil development

I. **original**
   I. Very expensive, difficult return

II. **reblend**
   I. Full formula (base oils, additives) takeover
   II. Optional adaption of local base oils
   III. Own blending

III. **rebrand**
   I. Purchase of finished lubricant and sales under own brand name
   II. Usually purchased in bulk or IBC

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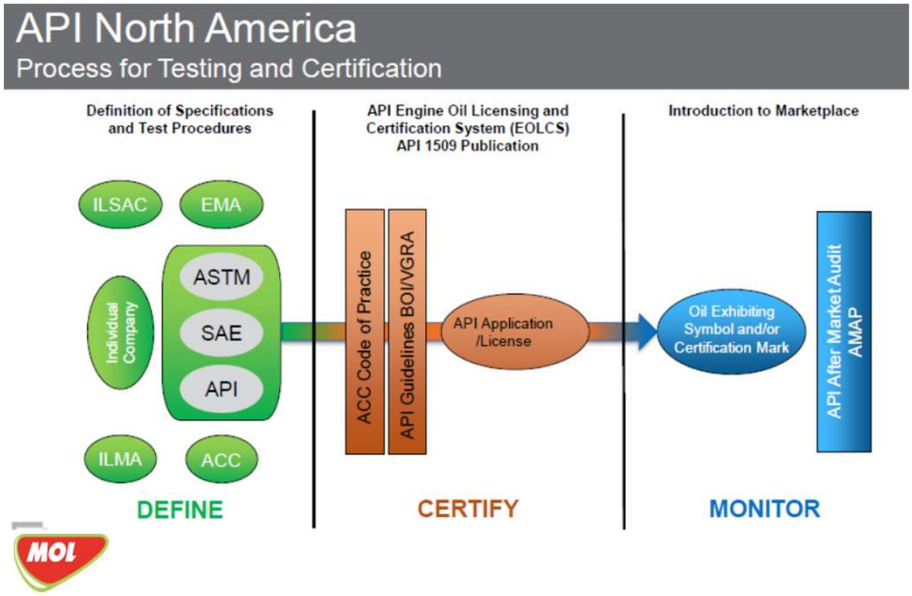
Quality assurance framework for engine oil testing



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AGENDA

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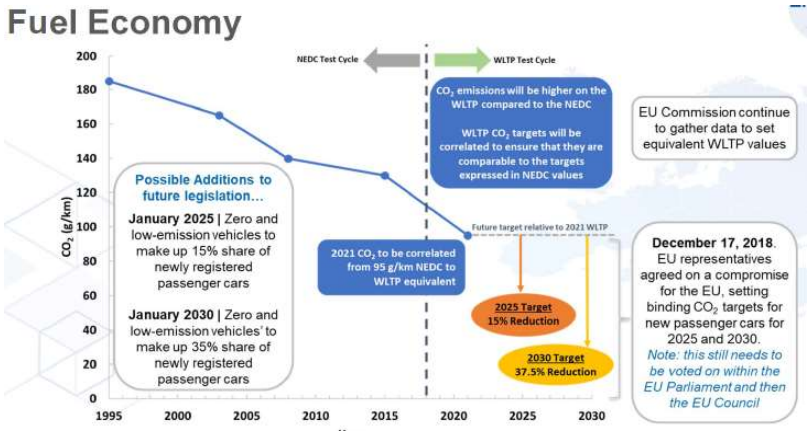
CO_2 kibocsátás csökkentésre vonatkozó EU előírások



- Motorolajban rejlő lehetőségek
  - direkt hozzájárulás az üzemanyag fogyasztás csökkenéshez
  - a formula robosztusság és stabilitás növelésével lehetővé teszi a motortechnológia változások adaptálását

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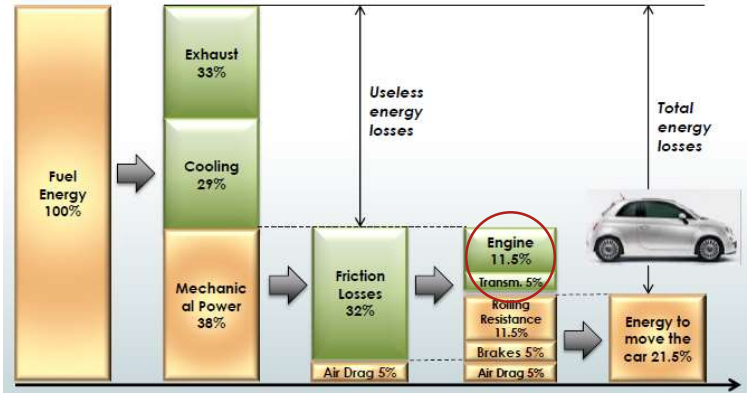
Energy balance in a car



- Ca. 16% friction loss
- a) viscosity reduction (Gr-III base oils)
- b) friction modifier additives

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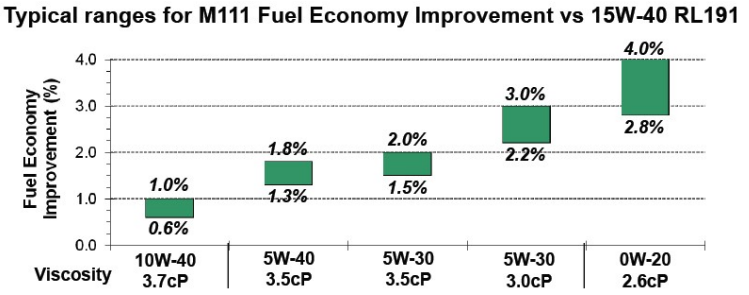
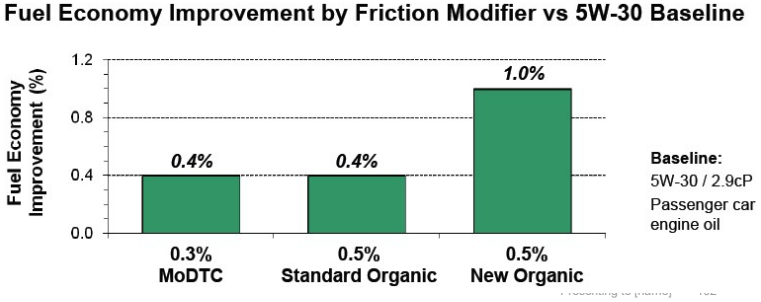
Achievable fuel (CO_2) savings

- a)



- b)



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Viszkozitási osztályok változása

Fuel Economy | Meeting Future CO_2 Targets

		2010	by 2021
Volkswagen	*Gasoline and Diesel*	SAE 5W-30 3.5cP	SAE 0W-20 2.6cP
Renault	*Gasoline*	SAE 5W-30 2.9cP	SAE 0W-20 2.6cP
	Diesel	SAE 5W-30 3.2cP	SAE 0W-20 2.6cP
PSA	*Gasoline*	SAE 5W-30 2.9cP	SAE 0W-20 2.6cP
	Diesel	SAE 5W-30 2.9cP	SAE 0W-20 2.6cP
BMW	*Gasoline and Diesel*	SAE 5W-30 3.5cP	SAE 0W-20 2.6cP
Daimler	*Gasoline and Diesel*	SAE 5W-30 3.5cP	SAE 0W-20 2.6cP

- A viszkozitás csökkenési tendencia általános
- Szintetikus formulák, kifinomultabb adalék technológia

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Lubricant and other fluids demand

Powertrain Applications	ICE	Hybrid	Battery
			
Engine oil	✓	✓	–
Transmission oil	✓	✓	✓ / –
Greases	✓	✓	✓
Specialty greases	✓	+	+
Lubricants for Auxiliary systems	✓	+	+
Cooling & functional liquids	✓	+	+

– Omitted ✓ Required + Increased

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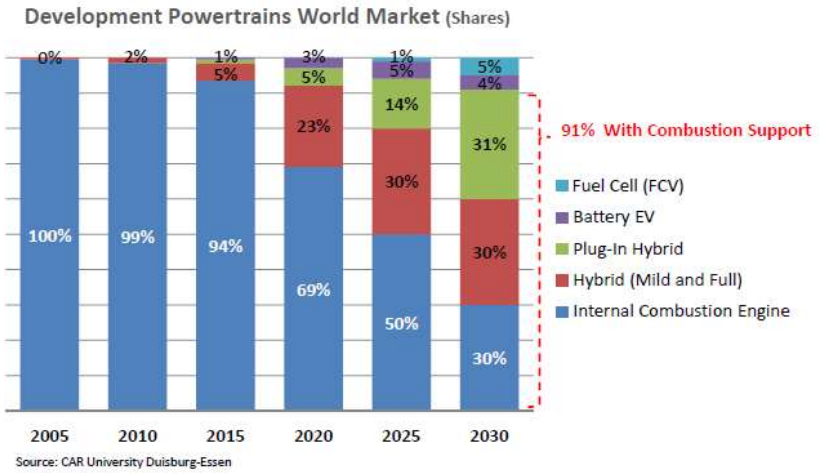
Powertrain changes



Source: CAR University Duisburg-Essen

- 2030-ban még 90% a legalább részben belsőégésű motorral hajtott autók részaránya

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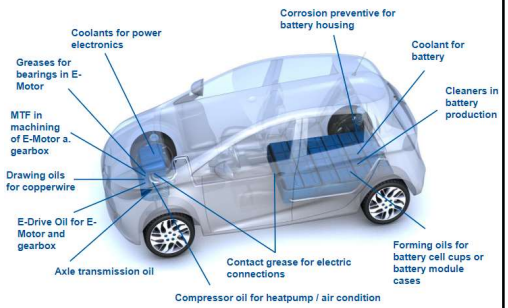
Electrification - opportunities

Impacts of growing EV manufacturing on lubes/AC portfolio

- New lubricant applications
- Higher requirements of existing applications, like ICE, precise machining
- New requirements – conductivity, materials compatibility, etc.

- (-) no motor oil
- (-) decline in conventional metal processing fluids (e-motor 1/10th of parts compared to ICE)
- (+) antifreeze coolants for battery, electronics
- (+) transmission e-fluids
- (~) compressor oil (AC/heat pump)
- (+) MWF
  - Cu wire drawing oil
  - machining fluid for gearbox, e-motor
  - forming oils, cleaners, corrosion preventives in battery production
- (+) grease
  - bearings in e-motor
  - contact grease



Plus lubes independent of the powertrain

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