Automotive Base Oil Presentation

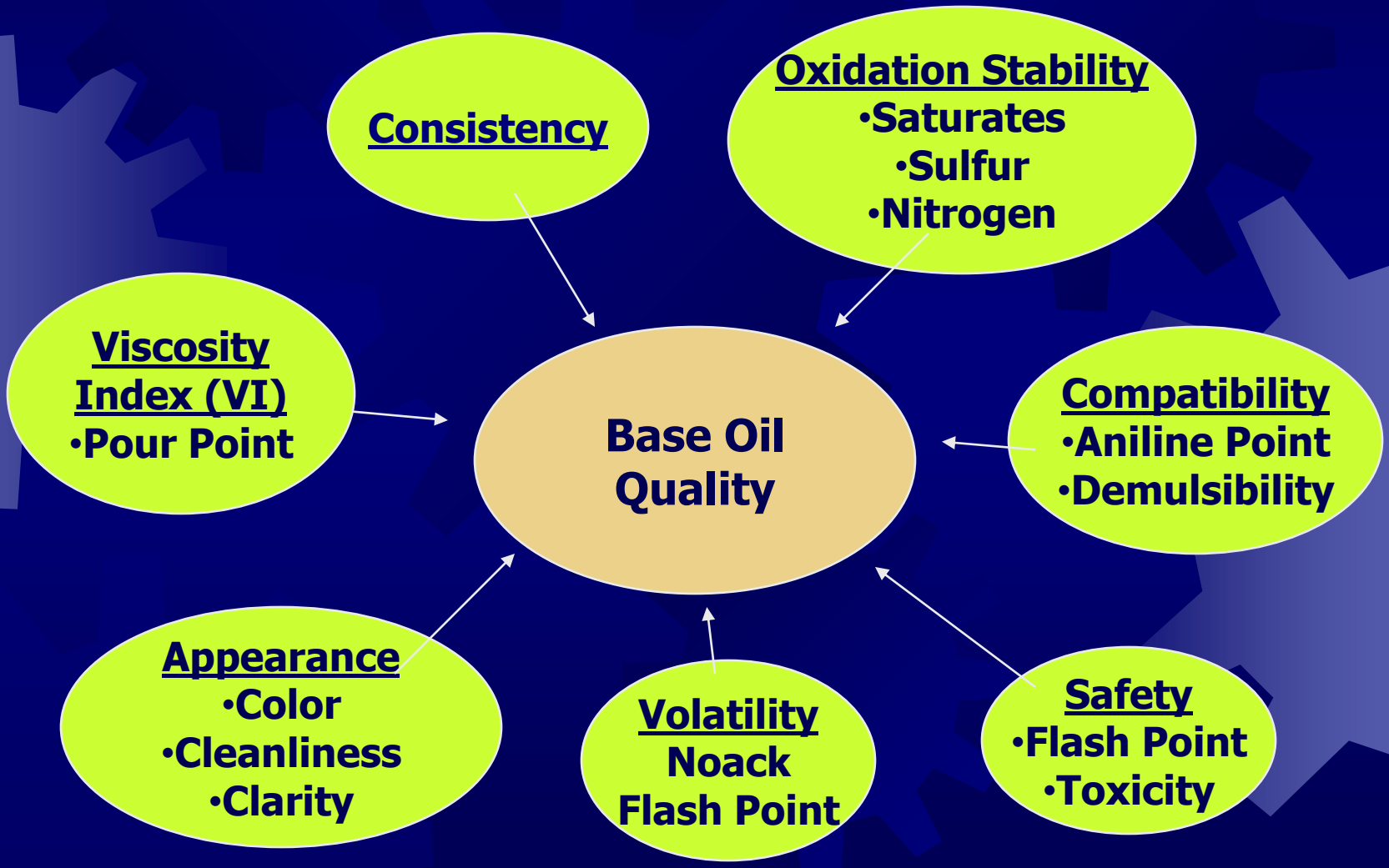
What is a Base Oil?

- The refined petroleum mineral or synthetic material that is produced by a refinery to a required set of specifications.

- A lubricant's quality can depend upon:
  - Type of base oil used or
  - Refining and/ or production method used to produce the base oil .

- Base oils normally make up 70% to 99% of a lubricant's formulation.

Base Oil Quality is a Function of Many Factors:



Types of Base Stocks Used:

- **Mineral Base:**
  Derived from petroleum base stocks.
  - Paraffinic.
  - Naphthenic.
  - Aromatic.

- **Synthetic Base:**
  Produced from different chemical bases & components (I.E. PAO, Esters, PAG).

- **Synthetic Blend:**
  Combination of Mineral & Synthetic Base Fluids.

Mineral Oils

- **Mineral oil basestocks are derived from crude oil, which also produces gasoline, diesel fuel, kerosene, asphalt, gases and petrochemical feedstocks.**
- **Approximately 95% of all lubricating base stocks come from petroleum.**
- **The three different types of crude are:**
  - **Paraffinic.**
  - **Naphthenic.**
  - **Aromatic.**
- **Crude oil is sold in 42 gallon barrel quantities.**

Synthetic Base Oils

- **Synthetic base oils are base stocks** in which a chemical conversion of one complex mixture of molecules into another complex mixture has taken place.

- **The most common synthetic base oils used are:**
  - Polyalphaoefin (PAO)
  - Diesters,
  - Polyol esters
  - Polyalkylene glycols (PAGs).

Base Oil Categories

Lubricant base oils are categorized by their physical characteristics and/or refining process.

API Base Oil Categories

Group	Sulfur % Wt.		% Saturates	Viscosity Index
I	> 0.03	And/or	≤ 90	80 to 120
II	≤ 0.03	And	≥ 90	80 to 120
III	≤ 0.03	And	≥ 90	≥ 120
IV	100% Polyalphaoefin (PAO)			
V	All base oils not included in Groups I – IV (naphthenics, esters and polyglycols)			

In recent years, these categories have been informally subdivided into Group I+, Group II+ and Group III+

What Are Saturates?

- Type of molecule commonly found in base oil.
- The most common types are:
  - Paraffins (WAX)
  - Naphthenes.
- High saturate levels are more resistant to oxidation.
- Present naturally in base oil, but high levels achieved in the refining process.

Sulfur Levels in Base Oils

- Naturally occurring in crude oil.
- Has positive and negative impacts.
- Some sulfur compounds are natural antioxidants.
  - Improves oxidative stability.
- Can contribute to exhaust pollution.
- Damaging impact on exhaust after treatment devices (catalytic converters).
  - Poison and deactivate catalysts.

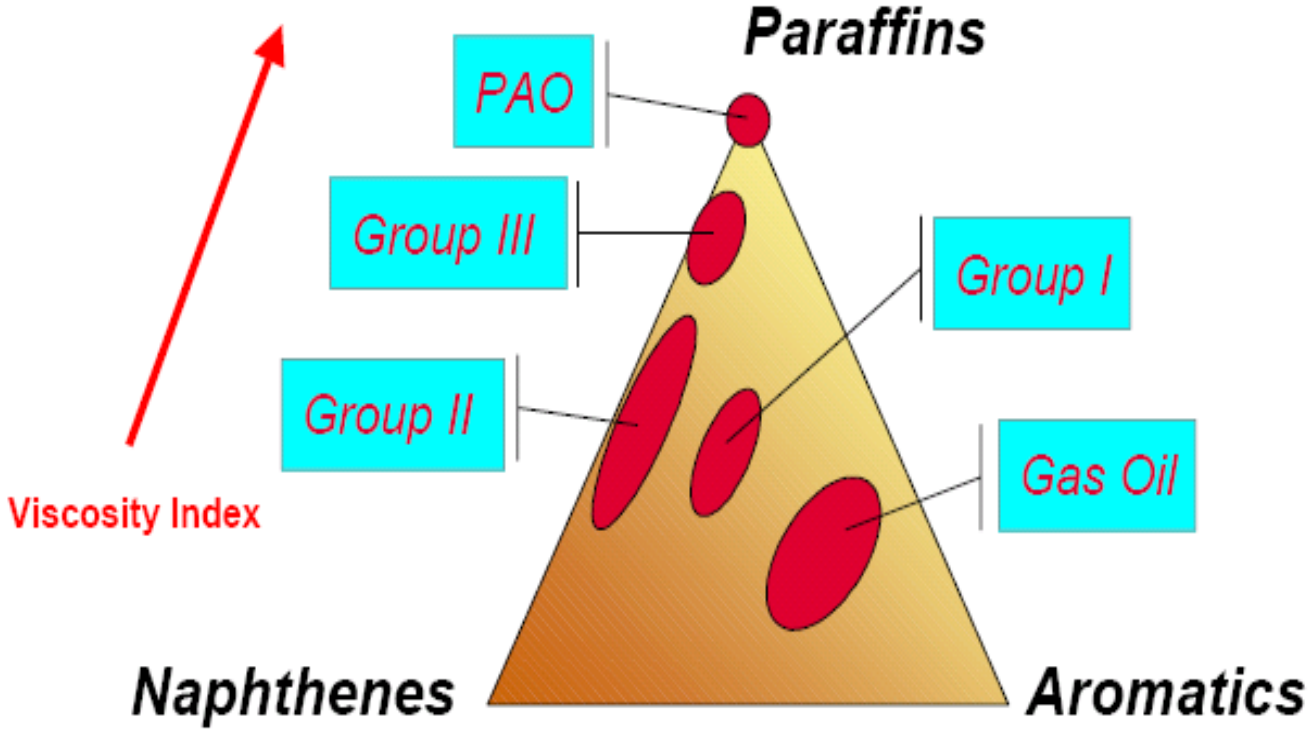
Viscosity Index

- **Viscosity changes due to temperature are measured as viscosity index.**

- **Higher the viscosity index, less it changes with respect to temperature.**

- **<u>All Oils:</u>**
- **Increase in viscosity with decreasing temperature.**
- **Decrease in viscosity with increasing temperature.**

- **Change in viscosity with respect to temperature does not respond in a consistent manner.**



- **Higher Paraffin content results in higher Viscosity Index (VI)**
  - VI is a good surrogate for many performance characteristics

Automotive Oil Basics –Viscosity

Viscosity – This is the single most important property of a lubricating oil. It is the measure of the flow or an oil at a given temperature,

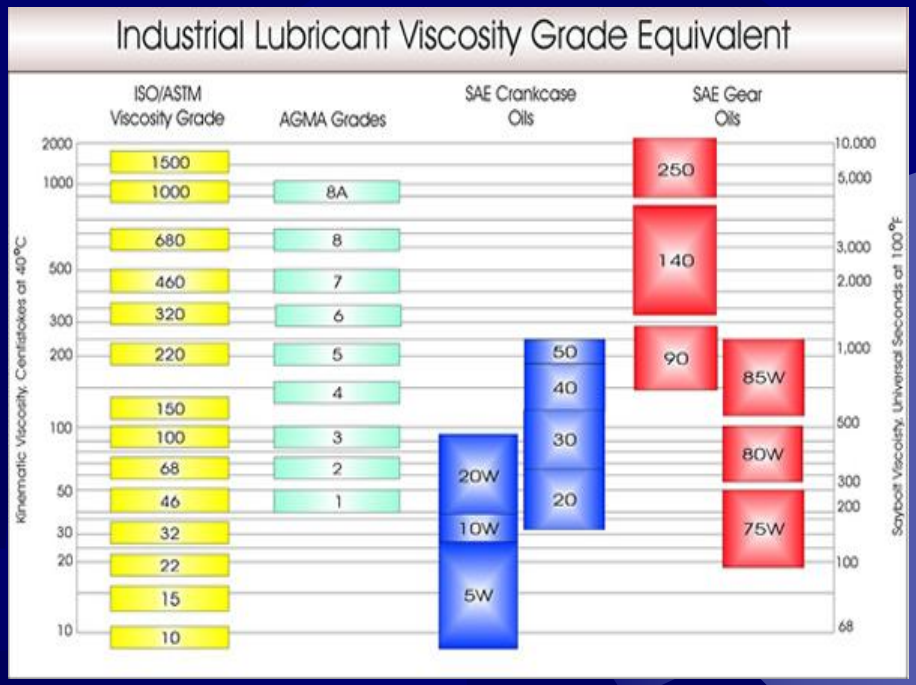
ISO Viscosity Test is @40C

SAE Viscosity Test (s) are taken at 100C or about 210F.

VISCOSITY @ 100c

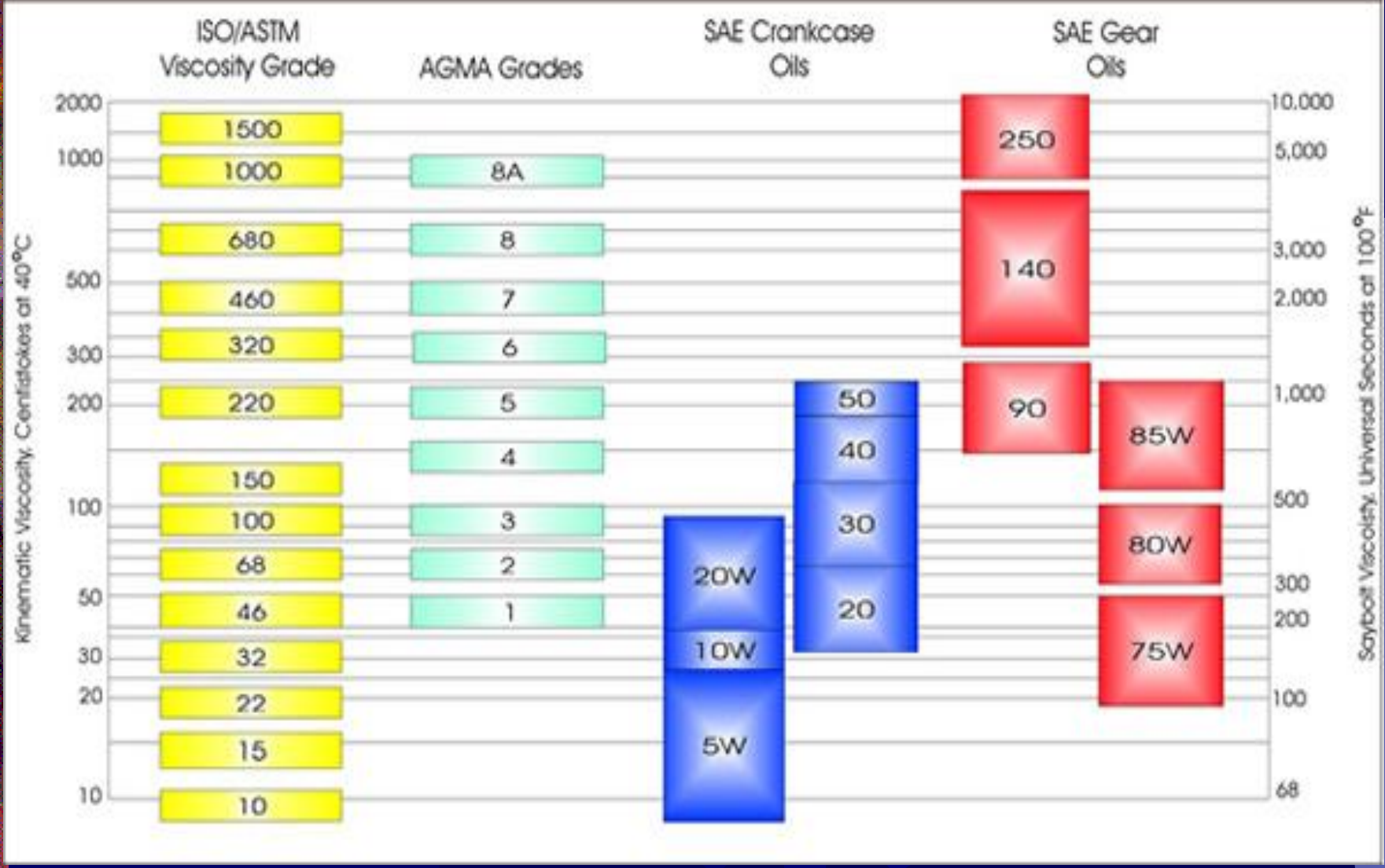
Engine oils.

SAE Grade	Range (CST)
5	3.80
10	4.10
20	5.60-9.29
30	9.30-12.49
40	12.50-16.29
50	21.90 – 26.09



Note: Synthetic oils over non-synthetic products has the ability to flow easier, maintain viscosity index longer, come temperature and disperse heat quicker. But Synthetics base oils do not replace the quality of other required additives for high standards of performance.

Industrial Lubricant Viscosity Grade Equivalent



Typical Viscosity Index Range for Different Types of Base Stocks:

BASE STOCK TYPE	VISCOSITY INDEX RANGE
Some phosphate esters	-20 to 0
Naphthenic petroleum base oils and some types of diesters	0 to 75
Paraffinic petroleum and synthetic blend base oils	80 to 135
VI Improved oils and synthetics	100 to >200

What Is a Naphthenic Oil?

- Refined from crude oil rich in naphthenes.
- Contain high levels of aromatics and low levels of wax.

- Low Viscosity Index (0-75).
- Low Saturate Level (35-50%).

- Poor to fair oxidation stability.
- Poor to fair thermal stability.
- Good solvency.
- Low pour point.

What is a Paraffinic Oil?

- Most widely used base oils.
- High Viscosity Index (90-140).
- High Saturate Levels (>70%).
- Good to very good oxidation stability.
- Increased thermal stability.
- Generally produced by solvent refining and/or some type of hydroprocessing.
- Group I, II and III base oils.

Base Stock Property Comparison

Property	Group I	Group II	Group III	Group IV
Oxidation/ Thermal Stability	Good	Improved	Better	Best
Volatility	Good	Good to Very Good	Better	Best
Solvency	Very Good	Good to Poor	Poor	Good (Co-Stocks)
Low temp.	Good	Good	Good to Very Good	Best
Efficiency – Traction	Good	Good	Improved	Best
Viscosity Range	10-1500	22-100	22-68	5-1000+

Oxidation Stability

- **Oxidation is thermal breakdown – which causes a chemical reaction between oils and oxygen which forms organic acids, varnish, sludge.**
- **The process of oxidation can be catalyzed or increased by heat, water and wear metals.**
- **The rate of oxidation becomes significant above 160 F (71 C). For every 18 F (10 c) rise over this temperature the rate of oxidation doubles.**
- **The proper selection of the type of base stocks and the use of anti-oxidants in the formulation help controls oxidation.**

Synthetic > synthetic blend > paraffinic >naphthenic.

Thermal Stability

- The ability of a lubricant to resist thermal degradation.
- Often measured by the tendency to form deposits at high temperatures.
- Physical process instead of chemical process.
  - Good thermal stability = good oxidative stability.
  - Depends on chemical structure of base oil.

Volatility

- Refers to how readily it evaporates.
- Low volatility under operating conditions is important.
- Function of molecular size.
  - Light hydrocarbon molecules evaporate quickly.
- Cannot be improved by use of additives.
- Base oils with higher Viscosity Index have lower volatility.

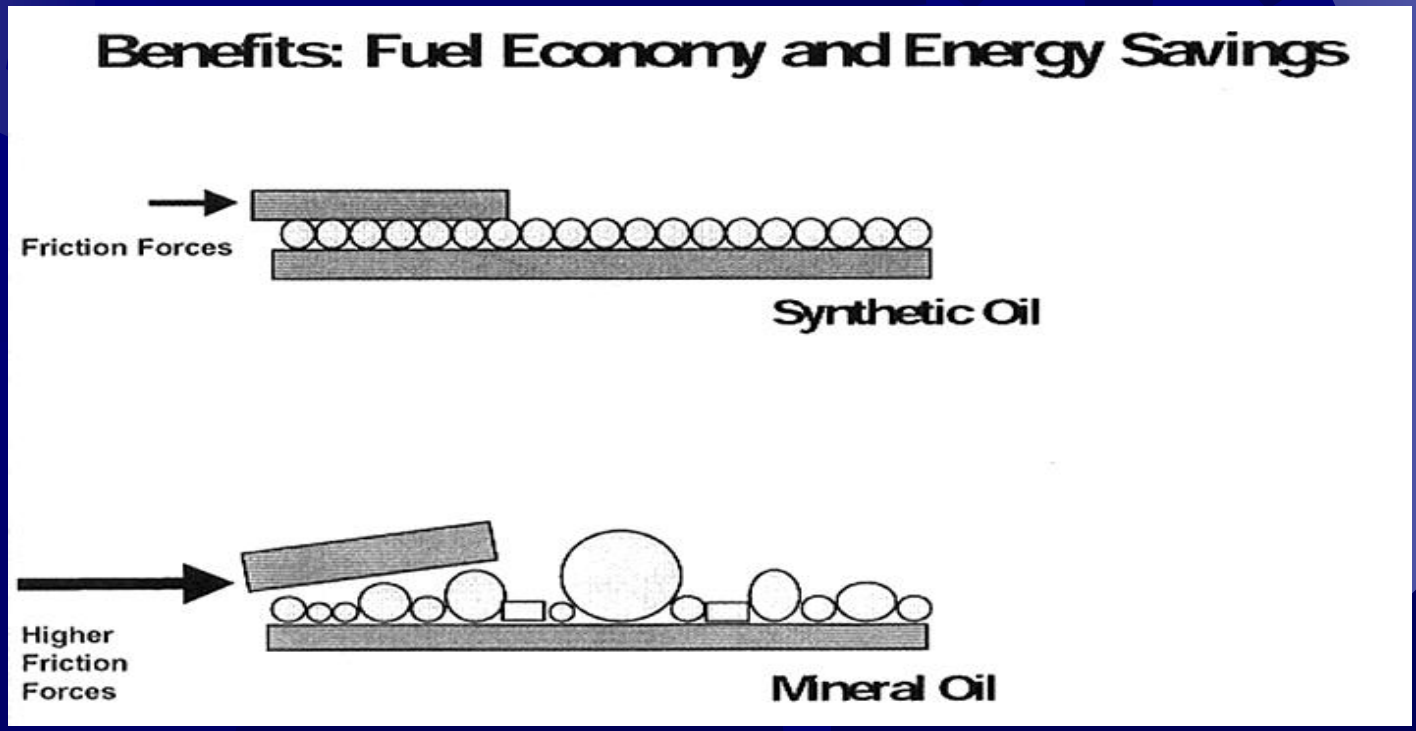
Solvency

- Ability of base oil to dissolve additives and contaminants.
  - Affects the ability to hold sludge and other residue in suspension.
  - Determines the amounts and type of additives used.
- Best with Group I oils and progressively decreases.
- Better base oil stability off sets solvency.
  - More naphthenic and aromatic content.
  - Oils with higher solvency have lower oxidative and thermal stability.

Efficiency - Traction

- Traction is the lubricant's molecular resistance to motion of one layer of fluid sliding over or along another layer of fluid.

- Low traction translates directly into greater energy efficiency up to 8%.

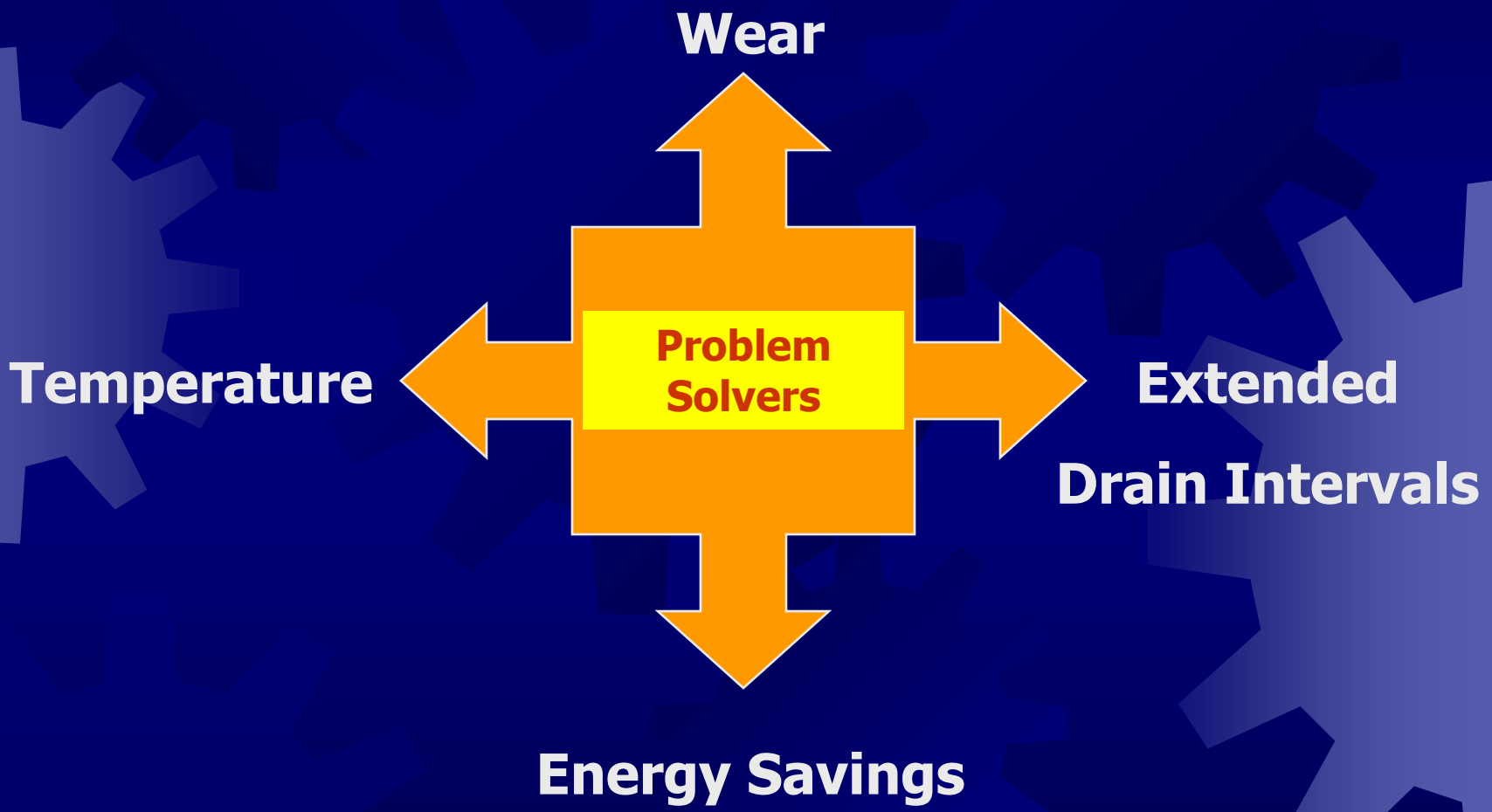


Synthetic Base Oils

Synthetic Basestocks

- **Types of basestocks:**
  - Polyalphaolefin (PAO)s
  - Alkylated aromatics
  - Diesters
  - Polyol esters
  - Phosphate esters
  - Polyalkylene glycols
  - Silicones

Synthetic Basestocks



Synthetic Lubricant Properties Possible Advantages

PROPERTY	WHAT IT MEANS
Higher flash point	Improved fire resistance and thermal stability
Lower pour point	Improved low temperature pumpability/lubrication
Oxidation stability	Extended oil drains, resists severe conditions

Synthetic Lubricant Properties
Possible Advantages

PROPERTY	WHAT IT MEANS
Thermal Stability	Oil doesn't degrade or thicken at high temperatures
High Viscosity Index	Functions like a multi-grade oil
Lower Friction	Reduced energy consumption costs
Natural detergency (esters)	Helps keep surfaces clean of deposits
Higher Shear Strength	No viscosity thinning, unlike petroleum base petroleum oils.
Fire resistance (phosphate and polyol esters, some types of PAGs)	Good for high risk hydraulic applications

Synthetic Lubricant Properties Possible Disadvantages

PROPERTY	WHAT IT MEANS
Higher cost	Can cost 2-4Xs more than petroleum base stocks
Toxicity	Phosphate esters may be a toxicity risk. Other types have low order of toxicity and are used in food grade lubricants
Hazardous disposal	Phosphate esters are more expensive to dispose of

Synthetic Lubricant Properties Possible Disadvantages

PROPERTY	WHAT IT MEANS
Polarity	Some synthetics are polar in nature and can compete with additives for the metal surface
Seal compatibility	Without additives - Some types of seals may shrink or swell with synthetics
Hydrolytic stability	Ester base synthetics may degrade in the presence of water. Some PAGs are water soluble
Mix-ability	Some synthetics are not compatible in other fluids.

Polyalphaolefin (PAO)

- **Most versatile of all synthetics.**
- **Similar to branched paraffins.**
- **Does not contain any sulfur, phosphorus, wax or metals.**

- **High oxidative and thermal stability.**
- **Excellent low temperature fluidity.**

- **Produced from raw materials derived from crude oil & polymerized to obtain viscosity grades.**
- **Available in viscosity grades 2 cSt to 3200 cSt at 100 C.**
- **Viscosity Index ranging from 135 to 300.**

Polyalphaolefin (PAO)

- Low pour points (<-85 F).
- Excellent shear resistance.
- Excellent hydrolytic stability.
- Very good oxidation and thermal stability.
- Very good to excellent low volatility characteristics.
- Very low coefficients of traction.
- Compatible with mineral oils and ester based synthetics.
- Good to very good corrosion resistance.
- Excellent lubricity and viscoelastic behavior.

Polyalphaolefin (PAO)

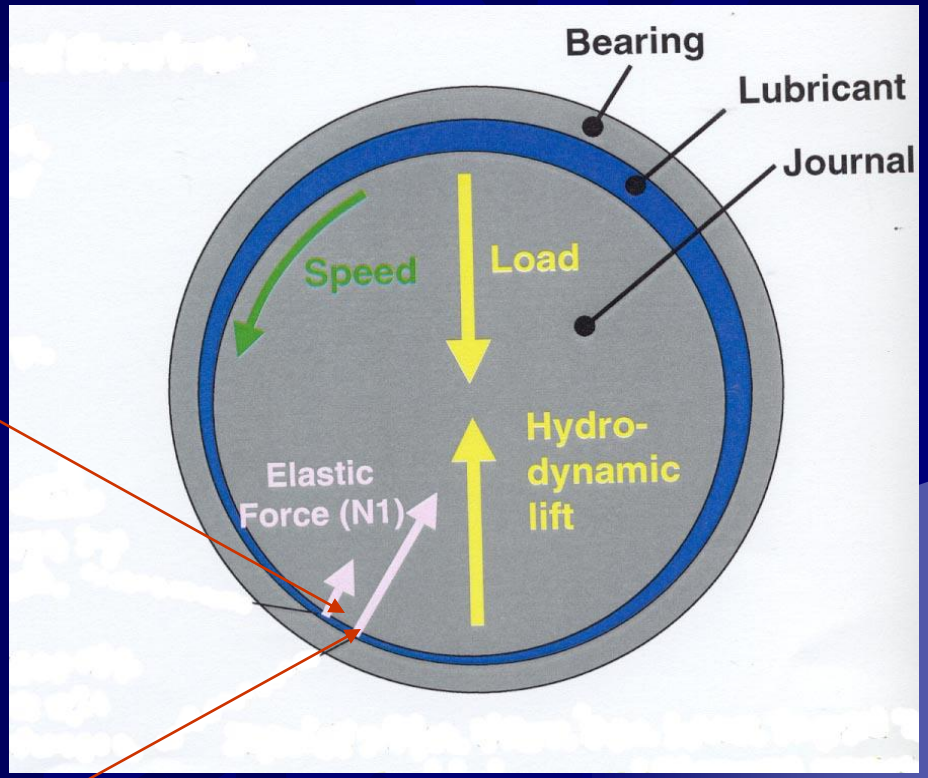
- Compatible with mineral oil resistant paints and elastromeric materials.
- Non-toxic – used in the formulation of food grade lubricants.
- Higher viscosity grades (100cst and greater) can be used as viscosity index improvers.
- Moderate solubility with some types of additive systems.
- Biodegradability moderate for low viscosity grades and poor for high viscosity grades.

Viscoelastic Effects

Load Support In Bearings

When the hydrodynamic film thickness is large, the normal force is small

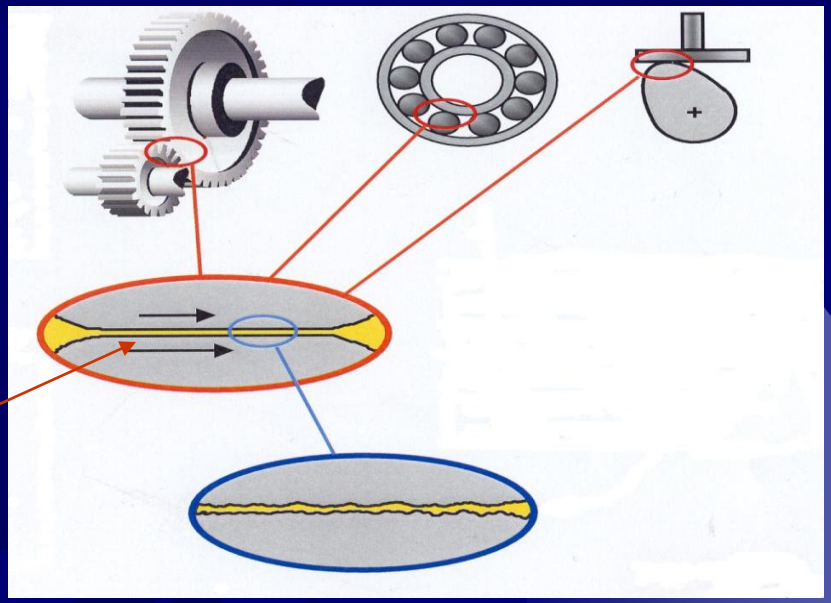
If the film gets thinner due to high loads, shear rate and shear stress increase, and the elastic force can become large enough to support some of the load.



Polyalphaoefin (PAO) used by Premium Lubricnats generate high normal forces, which provides additional load support.

Elastic Hydrodynamic Lubrication (EHL) Regime

Due to its unique PAO molecular structure used in premium lubricants mechanical shear resistance in EHL contacts area's generates thicker film protection.



Under very thin EHL conditions quality PAOs provide premium film thickness boost that protects against wear and reduces metal-to-metal contact .

National Advertising Division of the Council of Better Business Bureaus Definition of Synthetics

- Synthetic base oils are base stocks in which a chemical conversion of one complex mixture of molecules into another complex mixture has taken place.
- This chemical conversion is made with stocks in which the molecular structure of a substance such as wax from solvent dewaxing or base oils with waxy side chains are broken apart and transformed through a chemical reaction to create a new molecule that is different from naturally occurring substances.
- The NAD definition results in a commodity definition that allows lubricants that contain group III severely hydrocracked base oils being called synthetic.

Group III Vs. Group IV PAO

- Group III base oils come close in performance:
  - Viscosity Index.
  - Volatility.
  - Oxidative and thermal stability.
    - Antioxidants still needed.
  - Low temperature properties.
    - Need pour point depressants.
- Cost less than PAOs.
- Group III base oils can have uninformed molecular shapes and sizes.
- Can still contain some impurities.

Group III Vs Group IV PAO

- PAOs have better operating temperature ranges.
- PAOs are available in wider viscosity ranges.
- PAOs are available in food grade quality.
- The manufacturer of PAOs is more controlled than Group III base oils.
  - Complete saturation.
  - Not subject to crude variances.
  - Uniform molecule size and shape.

Base Oil Presentation - END.