BASE OIL REFINING & SPECIFICATION

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Outline

- Base Oil
- Refining
- Types
- Properties
- Specification
- Synthetic

Base oils....?

- Base oils are produced either by refining crude petroleum oils, or, by the manufacture of synthetic base stock having a controlled chemical structure.
- Crude oils are complex mixtures of chemical compounds, their composition varies considerably depending on origins.
- Mixing base oils in various proportions produces a large number of blends with a wide range of viscosities and physical properties.

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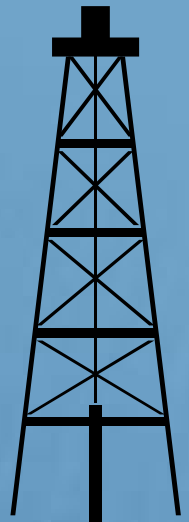
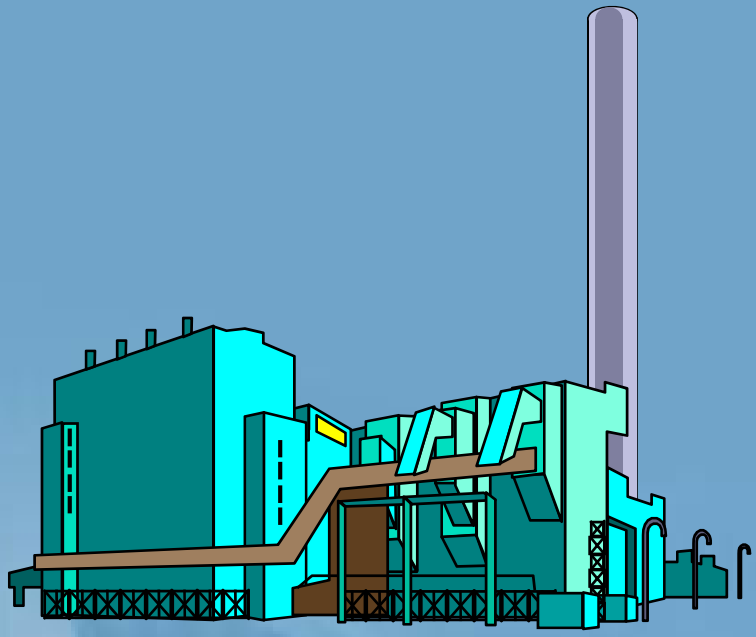
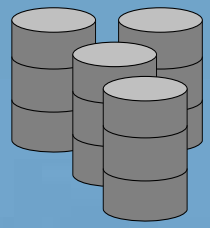
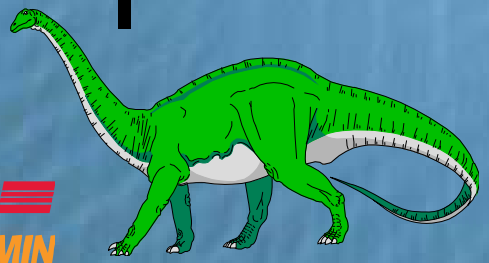
Refinery Overview







Crude oil → Refinery processes → Petroleum products



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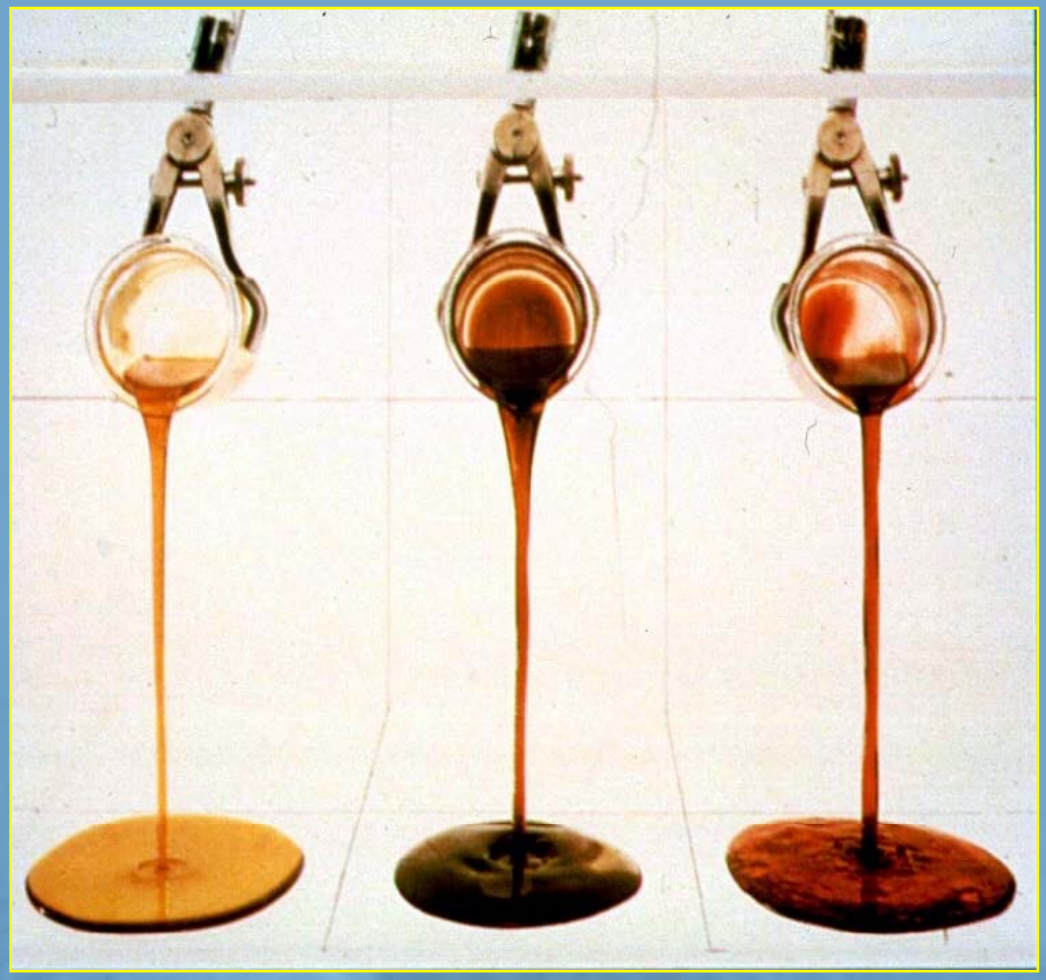

Surakhany Arabian Light Barrow Island, Australia

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Arabian Heavy

Pennsylvania

Santa Barbara

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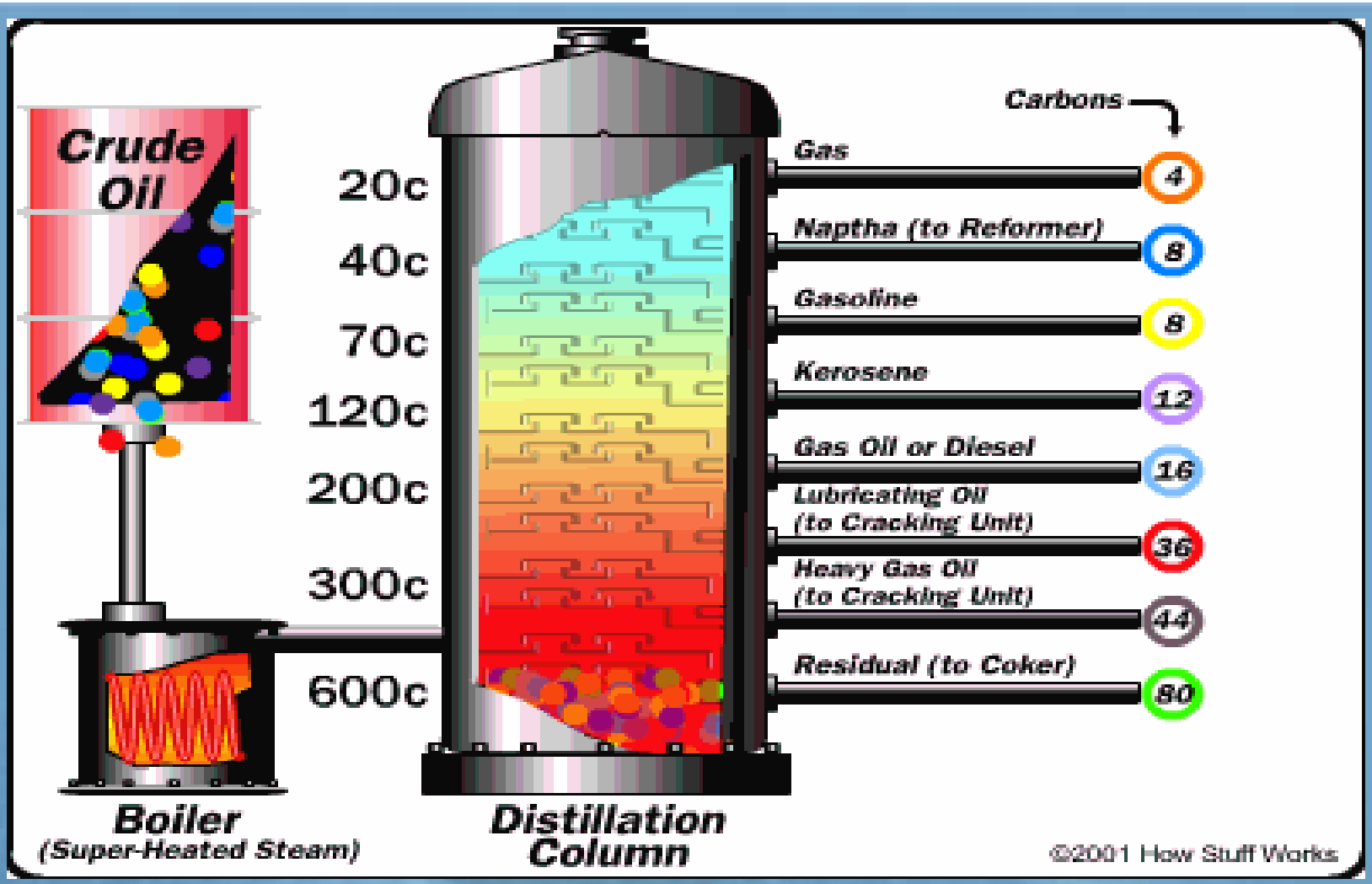
Refining



- *Atmospheric Distillation: at pressures slightly above atmospheric and at temperature range of 600ºC.*
- *Vacuum Distillation :produce gas oils, lubricating-oil base stocks, and heavy residual for propane de-asphalting*

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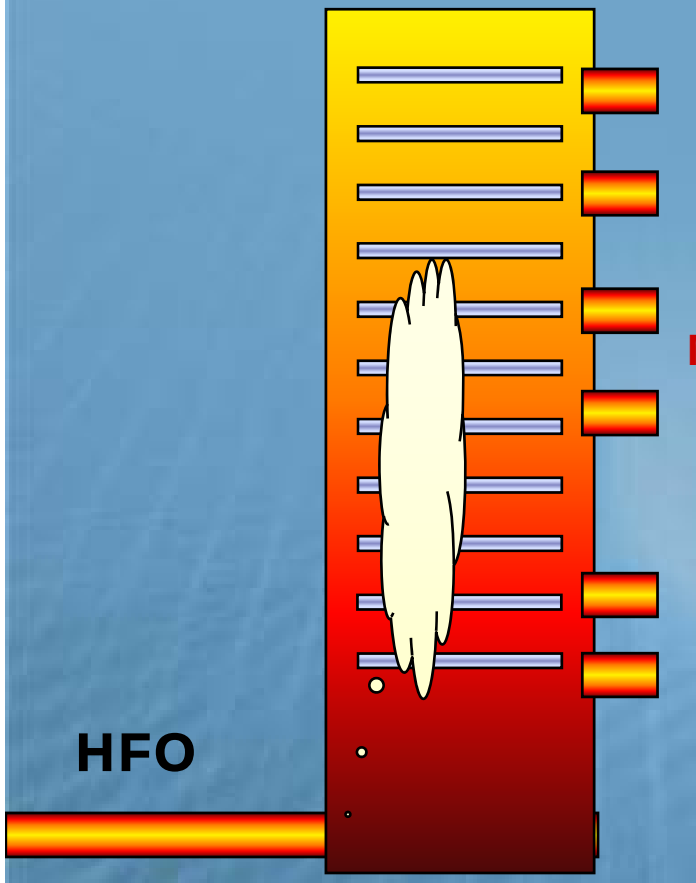
Base Oil Production



	Typ Vis @40 C cSt
100 Neutral	20.4
200 Neutral	40.8
300 Neutral	56.5
500 Neutral	91.8
700Neutral	130.9
Bright stock	473.0

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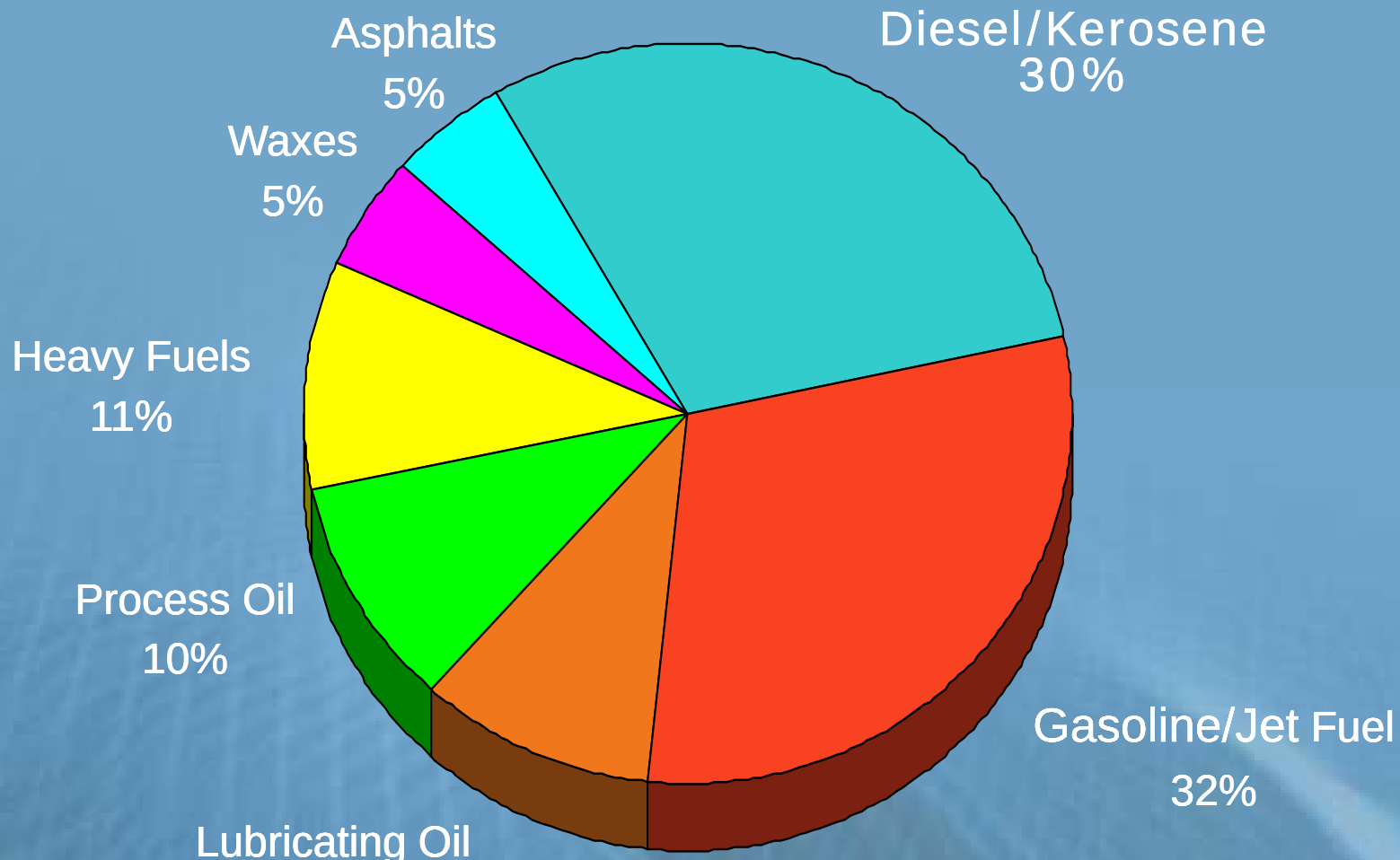
Refinery Products From Crude Oil



7% Lubricating Oil, 73% Fuels

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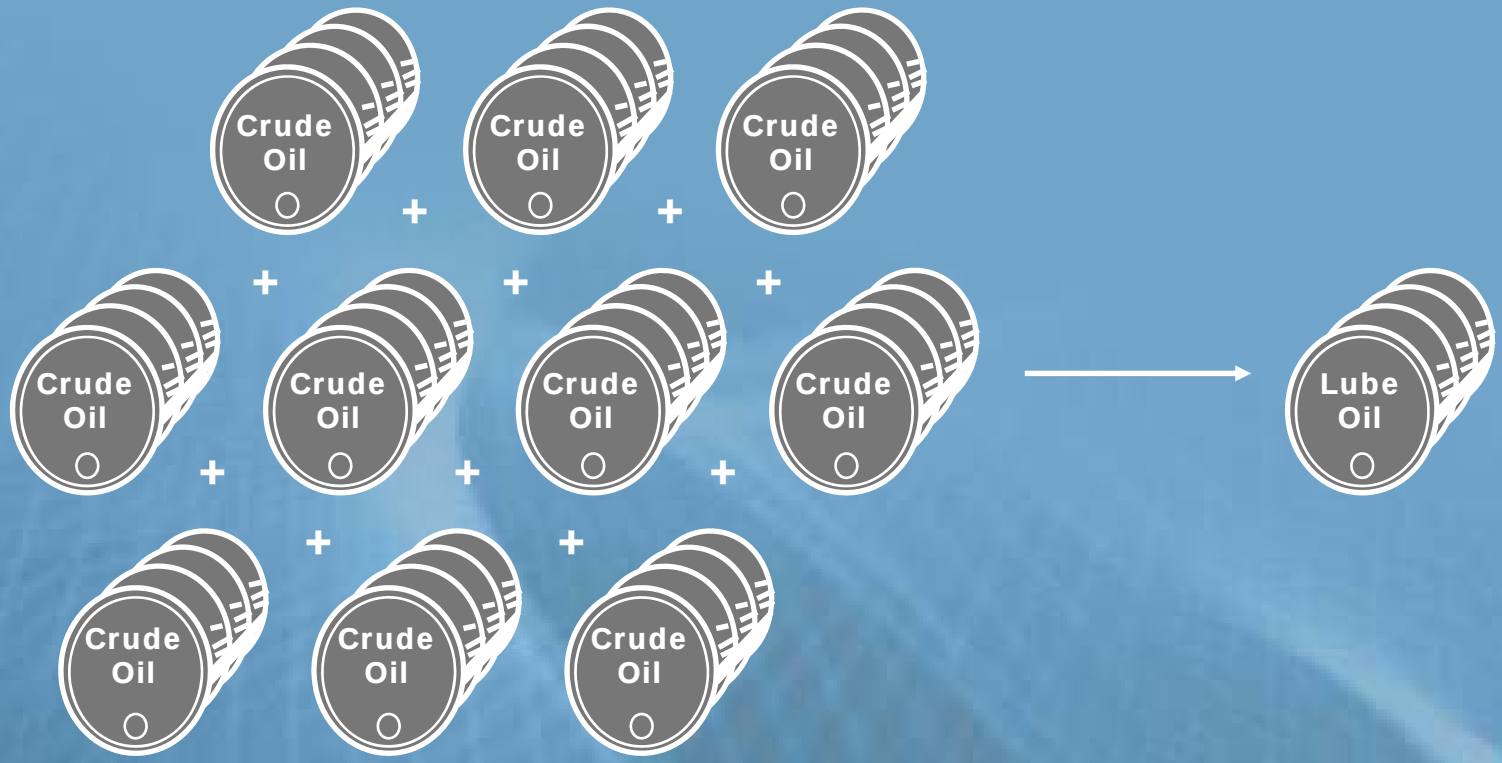
How Much Crude to Get Base Oil?



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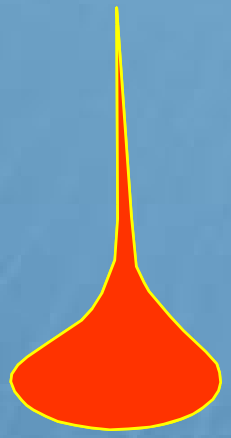
Components of Lubricants

Lubricants are combination of..

1. Base oils

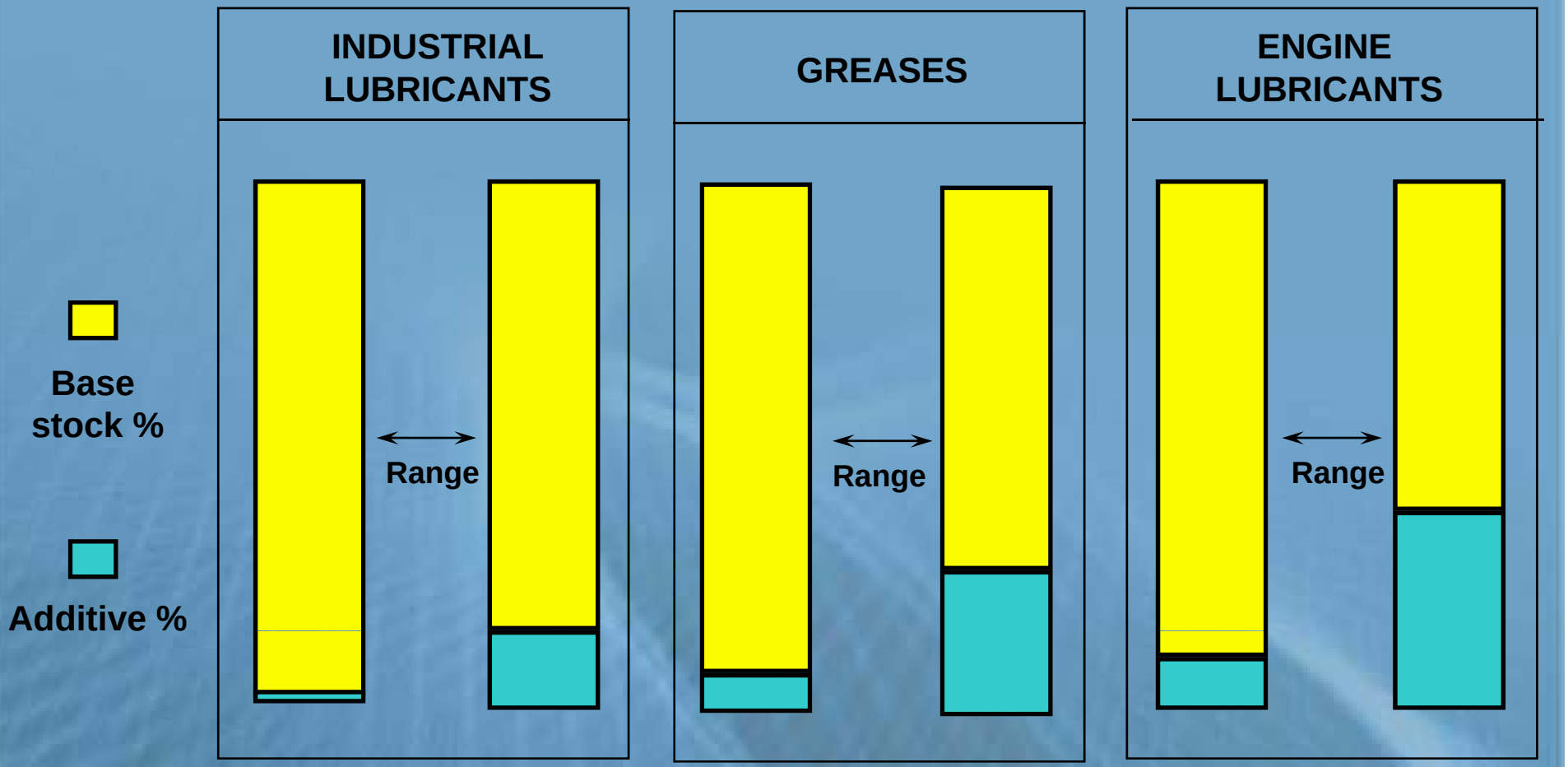


- Crude oil contains a wealth of interesting chemicals, but they are not in useful chemical balance.
- Refining takes out most of these chemicals.
- Differ in color, viscosity, viscosity index , flash point, pour point , color , and other physical properties.

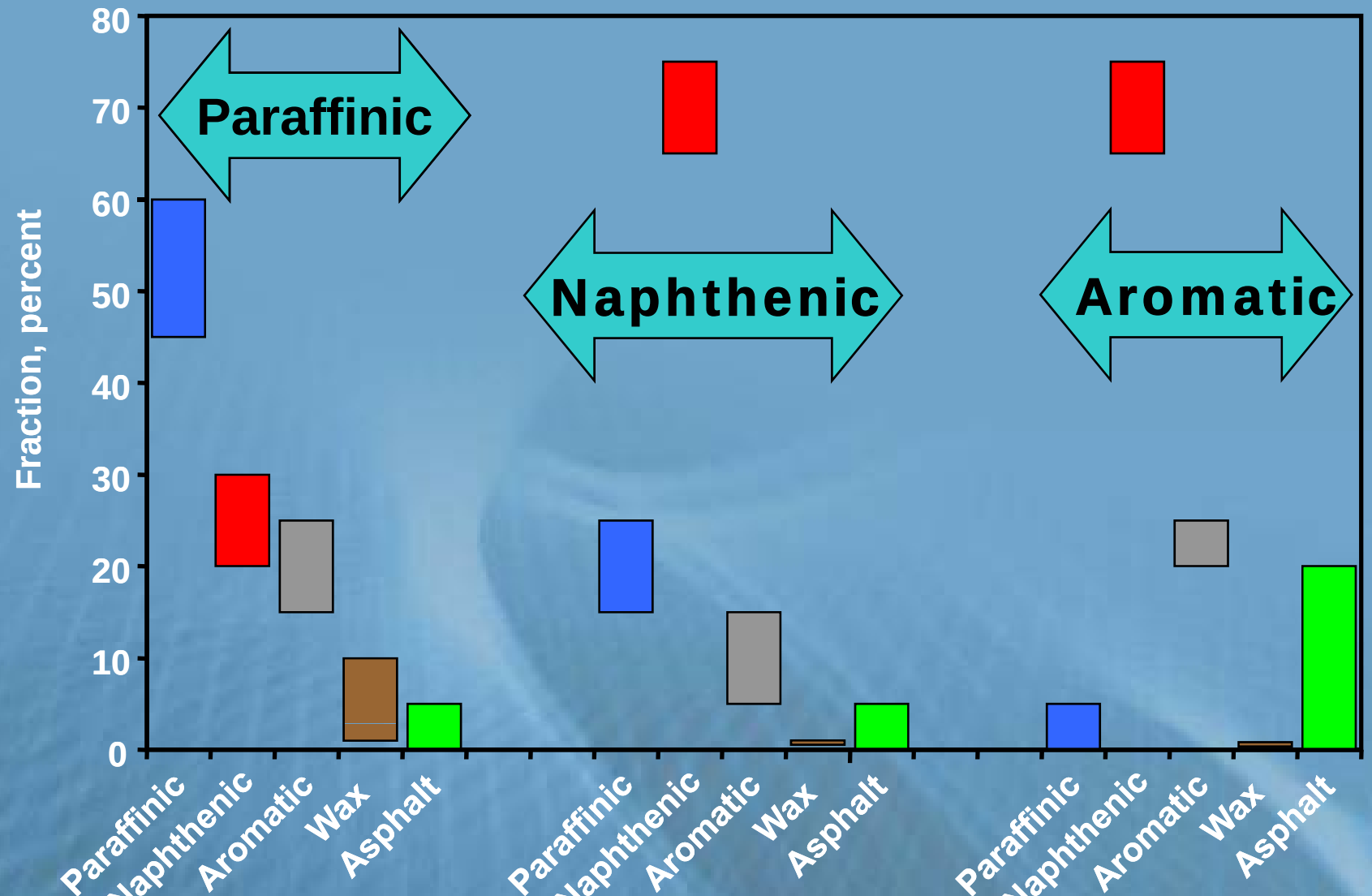
2. Additives

- Balanced amount of additives are added to enhance their performance in specific applications.
  - **Modify performance of lubricant**
  - **Protect lubricant**
  - **Protect lubricated surface**

Base Oil –A Major Component of All Lubricants



Crude Types



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Why Refine

To Stabilize

To Obtain Desired

- Viscosity
- Flash Point
- Pour Point

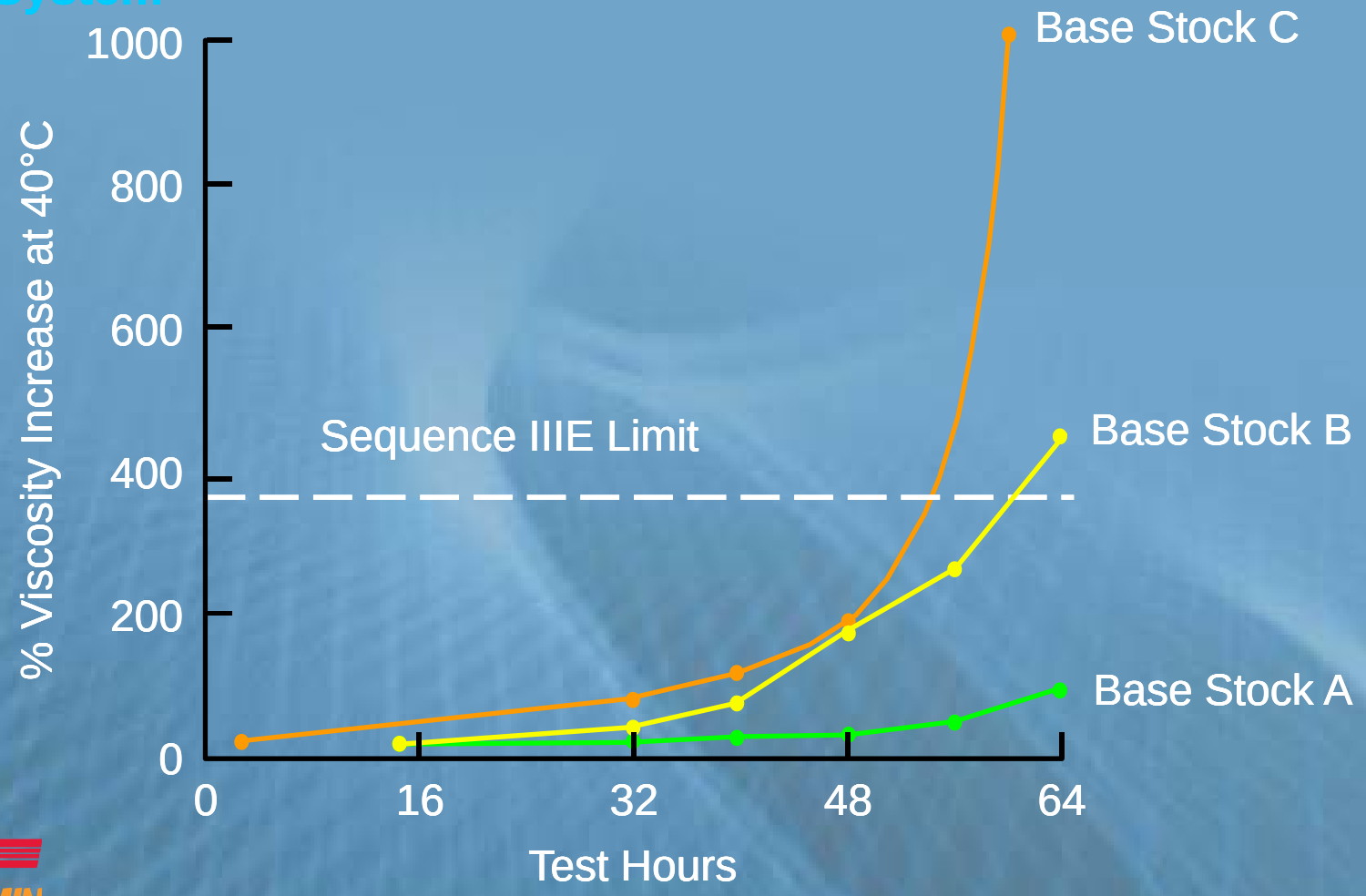
To Remove Undesirables

- Aromatics
- Polars
- Asphaltenes
- Wax

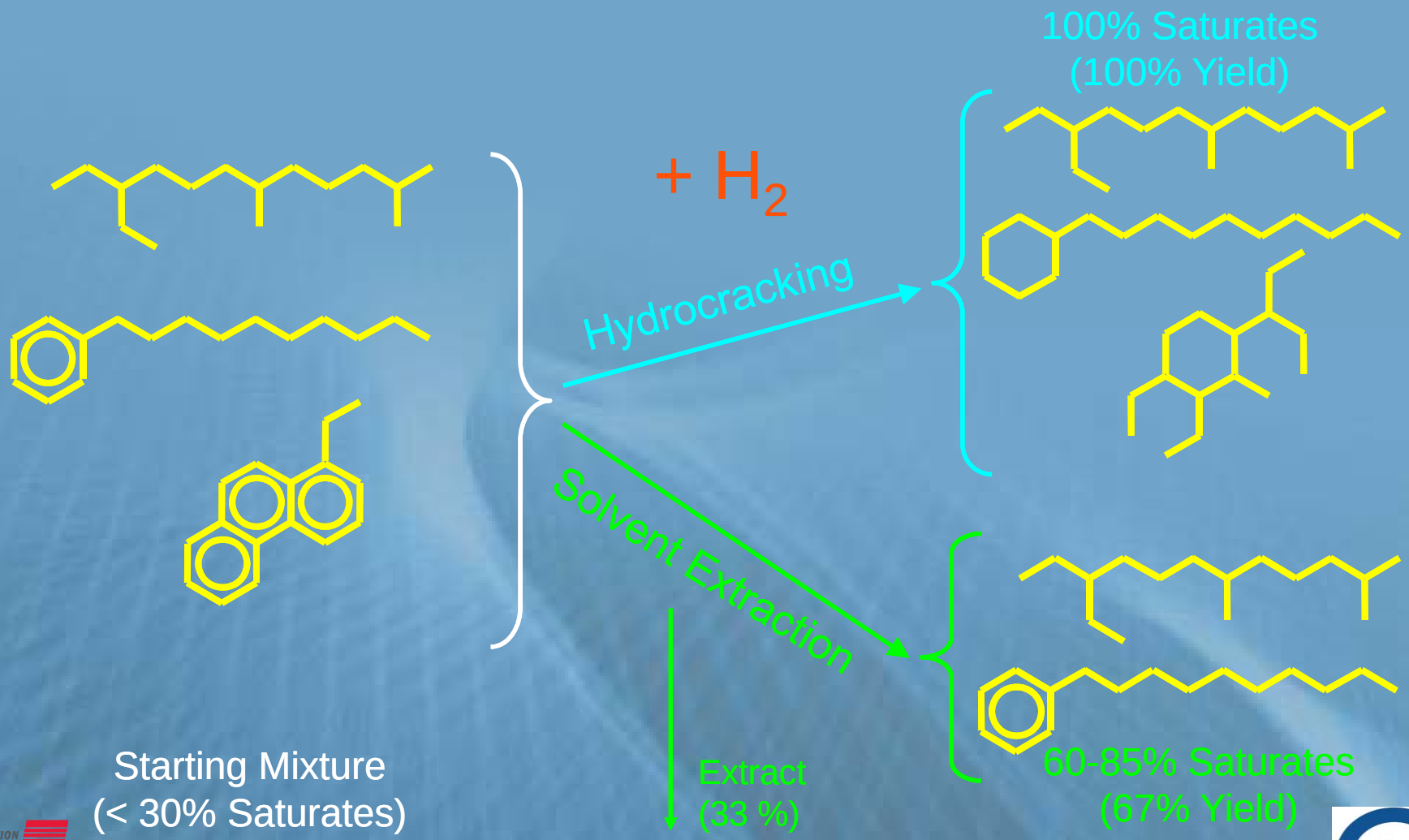
To Improve Color

Base Stock Quality - Impact by Oxidation (thickening)

Same Additive System



Extraction Vs. Hydrocracking



Key Base Oil Specs

- Viscosity
  - Affects viscometrics of finished blend
  - Defines base stock grade
  - Controlled by distillation
- Viscosity Index (VI)
  - Base stocks become thinner (less viscous) with increasing temperature. The higher the VI, the less the basestock thins
  - Related to oxidation stability for single crude source/processing
  - Increases with solvent extraction (SE) or hydrocracking (HC)
- Pour Point
  - Affects borderline pumping temperature in MRV
  - Controlled by crude source and dewaxing severity

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Key Base Oil Specs

- Volatility
  - Affected by the presence of light (small) molecules
  - Measured as % off at 371°C (D2887, D5481) or by NOACK
  - Affects oil consumption and piston deposits
  - Controlled by distillation (minor effect of SE and/or HC)
- Flash Point
  - Temperature at which vapors can ignite
  - Used to indicate safety and handling precautions
  - Related to volatility

Key Base Oil Specs

- Saturates
  - Measures paraffins/naphthenes vs. aromatics
  - Affects oxidation, solvency and additive compatibility
  - Depends on crude source
  - Increases with SE and/or HC
- Sulfur content
  - Relates to “natural antioxidant” content
  - Depends strongly on crude source
  - Decreases with SE and/or HC
- Nitrogen and Basic Nitrogen
  - Relates to pro-oxidant species
  - Decreases with SE and/or HC

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Base Stock Grade Equivalents

Grade	Saybolt Universal Seconds at 100°F	mm2/s at 100°C	mm2/s at 40°C
75SN	75	3.1	13.2
100SN	100	4.1	20.2
150SN	150	5.1	30.3
300SN	300	8.4	64.5
500SN	500	10.9	91.2
600SN	600	12.1	113
150 Bright Stock	2680	31.5	480

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Mineral Base Stocks

Composed of thousands of different molecules:

- Saturates
  - Paraffins
    - Straight Chain
      - Wax
    - Branched Chain
  - Naphthenes (Rings)
    - Don't confuse with "Naphthalene"
- Aromatics (Unsaturated)
- Polars
  - Sulphur
  - Nitrogen
  - Oxygen

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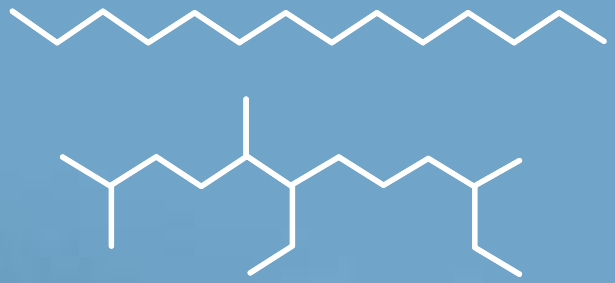
Hydrocarbons

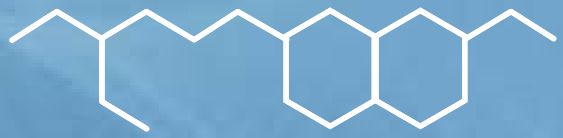
Type	Structure

- Saturates
  - Paraffins (wax)
    - Straight chain
    - Branched
  - Naphthenes
    - Alkylcyclohexane
    - Alkylcyclopentane
- Aromatics

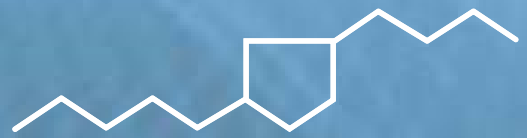


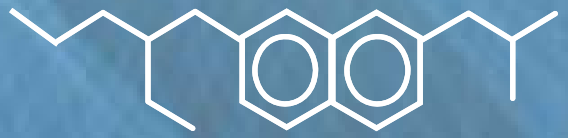
Waxy, high pour very high VI

Medium pour high VI



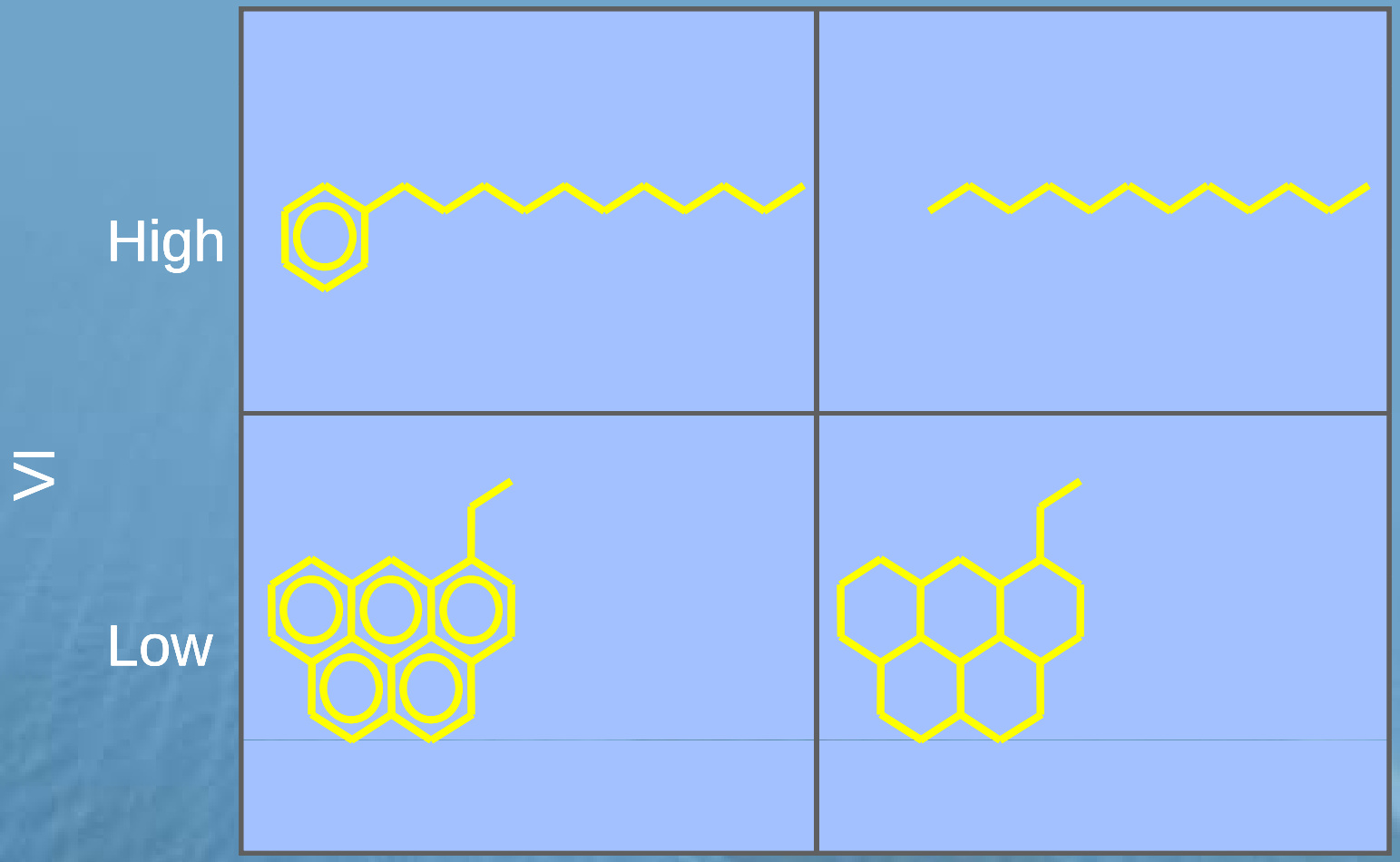
Low pour medium VI





Pour and VI depend on chain lengths

VI and Oxidation



Typical Lube Base Stock Properties (Solvent Neutrals)

	Light (S100N)	Medium (S150N)	Heavy (S500N)
Viscosity @ 100°C, cSt	4.1	5.3	10.8
Viscosity @ 40°C, cSt	20.2	30.6	92.0
Viscosity Index	98	98	97
Volatility, % off @ 371°C	20	15	7
Flash point, °C	204	216	248
Pour point, °C	-12	-12	-9

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Base Stock Trends

- Crude source changes and flexibility
  - Driven by economics and politics
- Increased use of hydrocracking
  - To use lower quality crudes and/or
  - To produce higher quality base stocks
    - Viscosity vs. volatility for passenger car
    - Diesel soot control for heavy duty
    - Viscometrics for ATF
- Increasing use of Group II+, Group III and Group IV
  - To meet increasingly severe performance requirements
  - For low viscosity grades

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Refining Processes

Refining has two main types of processes:

- Separation processes
  - Select desirable components from the crude
    - Leave undesirables behind
      - Distillation
      - Solvent extraction
      - Solvent dewaxing
- Conversion processes
  - Change undesirable components into desirable
    - Hydrotreating
    - Hydrofinishing
    - Hydrocracking
    - Catalytic dewaxing
    - Catalytic isodewaxing (Catalytically isomerizes the molecule of wax to Iso-paraffin)

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Base Stocks From Hydrogen Conversion Process (Synthetic)

Typical Properties of 4 cSt Base Stocks

Process Grade	Solvent 100SN	Hydrogen Conversion		Synthetic PAO 4
		100N	VHVI 4	
KV @ 40°C, cSt	20.3	21.2	19.5	16.8
KV @ 100°C, cSt	4.0	4.2	4.3	3.85
VI	95	115	130	123
Pour point, °C	-15	-18	-21	-72
Volatility				
- GCD, D2887, %	18	4.8	2	<1
- NOACK, %	23	14.5	12	11.5

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Re-refining

- Processing used oil for re-cycling as base stocks
- Similar processes as refining
  - Adds an initial step
  - Water/Glycol Removal
    - To remove catalyst contaminants
      - Thin-film evaporation
      - Propane extraction
- Quality
  - Can be comparable to virgin base stocks
    - Reactive species may present depend upon Re-Refining Process

SYNTHETIC BASE STOCK

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Synthetic Base Stock?

- Tailored/molecular structure is planned and controlled
- Chemically reacts low molecular weight materials into higher molecular weight components
- Predictable properties

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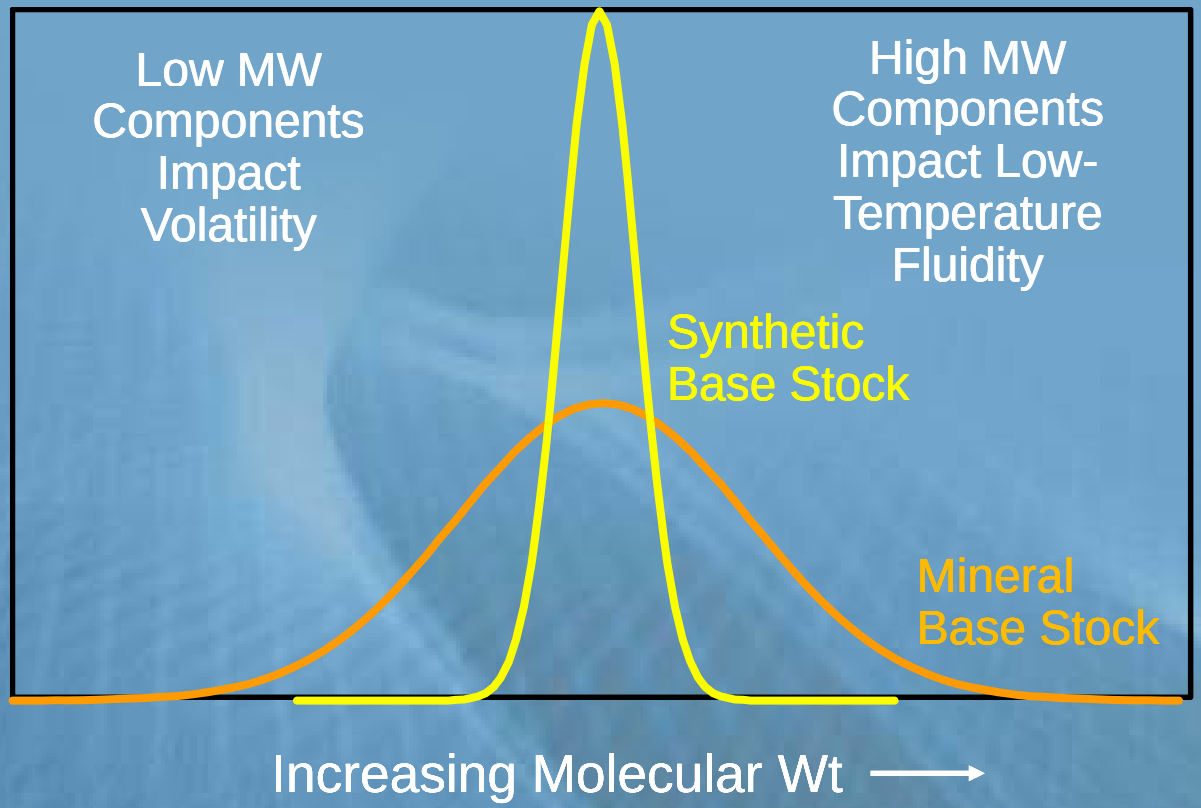
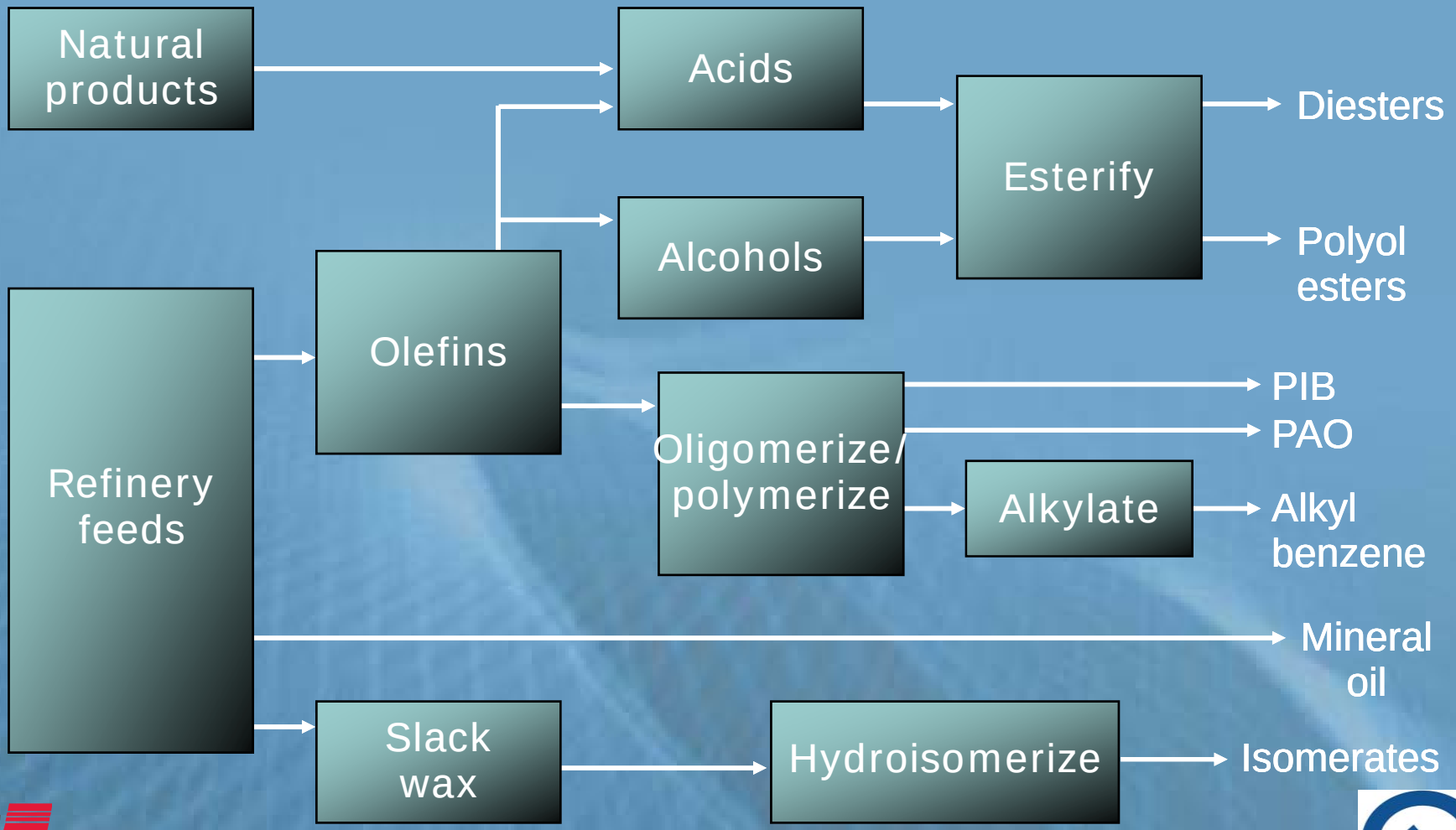
Control Of M. Wt. Distribution Yields Performance Advantages



Routes To Major Synthetic Base Stocks



PolyAlphaOlefin (PAO)
Is The Most Common Synthetic Base Stock

- Low-temperature fluidity
- Very High VI
- Extreme Low volatility
- Hydrolytic stability
- Compatibility
  - OK with mineral oils/esters
  - Highly polar additives are insoluble
  - Non-polar additives OK

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Synthetic Base Oil
Viscosity Of 5-6 cSt @ 100°C

Base Stock	VI	K VIS @ -20°C, cSt	Pour Pt. °C	Flash Pt. °C
PAO	137	1100	-60	238
Diester	135	1300	<-62	218
Polyol esters				
- Linear	136	800	<-62	260
- Branched	93	2900	<-60	231
Isomerates	142	1400	-21*	238
Mineral oil 150N	103	3900	-15	220

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*** Pour Depresses to -30°C in Engine Oils**

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Base Stock Quality Is A Function Of Many Factors

THANK YOU