

**Presentation
On**

**CRUDE OIL CHARACTERISTICS
AND
REFINERY PRODUCTS**

By

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Petroleum/Crude oil

- It is Nature's gift to man-kind.
- “**Crude Oil**” means all kinds of hydrocarbons in liquid form in their natural state or obtained by Natural Gas by condensation or extraction. It is a hydrocarbon mixture having simple to most complex structures such as resins, asphaltenes etc.
- Crude oil is formed by bacterial transformation of Organic matter (carbohydrates/proteins/from plant & animal origin) by decay in presence and/or absence of air into HC rich sediments by undergoing biological/physical and chemical alterations

Chemical Composition

- Carbon 83.0 to 87.0%
- Hydrogen 10.0 to 14.0 %
- Sulphur 0.05 to 6.0 %
- Nitrogen 0.1 to 2.0 %
- Oxygen 0.05 to 1.5 %
- Metals 0.00 to 0.14 %

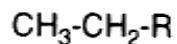
The majority of crude oil is alkanes, cycloalkanes (naphthenes), aromatics, polycyclic aromatics, S-containing compounds, etc.

Gasoline: branched alkanes

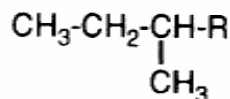
Diesel: linear alkanes

Alkanes

Normal

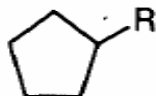


Branched

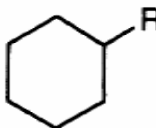


Cycloalkanes (Naphthenes)

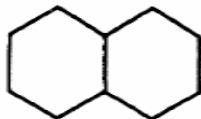
Alkylcyclopentanes



Alkylcyclohexanes

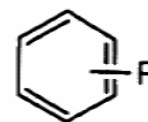


Bicycloalkanes

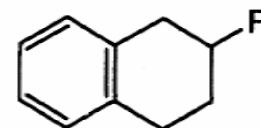


Aromatics

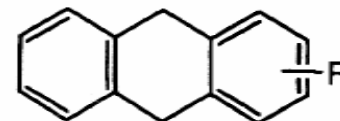
Alkylbenzenes



Aromatic-cycloalkanes



Fluorenes



Binuclear aromatics

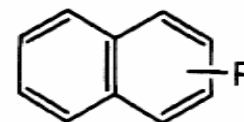


Figure 2.12 Examples of alkanes, cycloalkanes and aromatics present in crude oil.

Sulphur Compounds

Thiols

Sulphides

Cyclic sulphides

Disulphides

Thiophenes

Benzothiophenes

Dibenzothiophenes

Naphthobenzothiophenes

Effect of sulphur compounds

- Great environmental concern, contribute to particulate matter, emission of obnoxious odoured sulphur oxide gases
- Receding sulphur level in all petroleum products
- Refining & Technology Focus shifted to sulphur removal from hydrocarbons

Oxygen compounds

- Alcohols/Ether/Cyclic ether/furan
- Carboxylic acids
- Naphthenic acids

American crude oils : 0.006 to 0.35%wt

Russian crudes oils : 0.2 to 1.05 %wt

North Gujarat crude oil : 0.2%wt

- Increasingly High TAN Crude is being processed

Nitrogen Compounds

Pyrrole

Indole

Carbozole

Benzocarbozole

Pyridine

Quinoline

Indoline

Benzoquinoline

Effect:

Catalysts poison & Nitrogen oxide emission

Metals

- Present as inorganic salts & organic porphyrins (Ni, V, Mg etc.) in ppm
- Salts mostly removed in desalting operation
- Ni & V porphyrins are catalyst poisons

Crude Oil Characterization

- **TRADING** : Density, API Gravity
- **TRANSPORTATION** RVP, Pour Point, KV, Wax content
- **CONTAMINATION** : Salt content, BS&W
- **PROCESSABILITY** : Sulfur, Nitrogen, TAN, Asphaltene, MCR
- **CRACKING POINT** : ASTM Distillation
- **LPG POTENTIAL** : Light hydrocarbons (GC)
- **CLASSIFICATION** : Characterization factor

Classification of Crude Oil

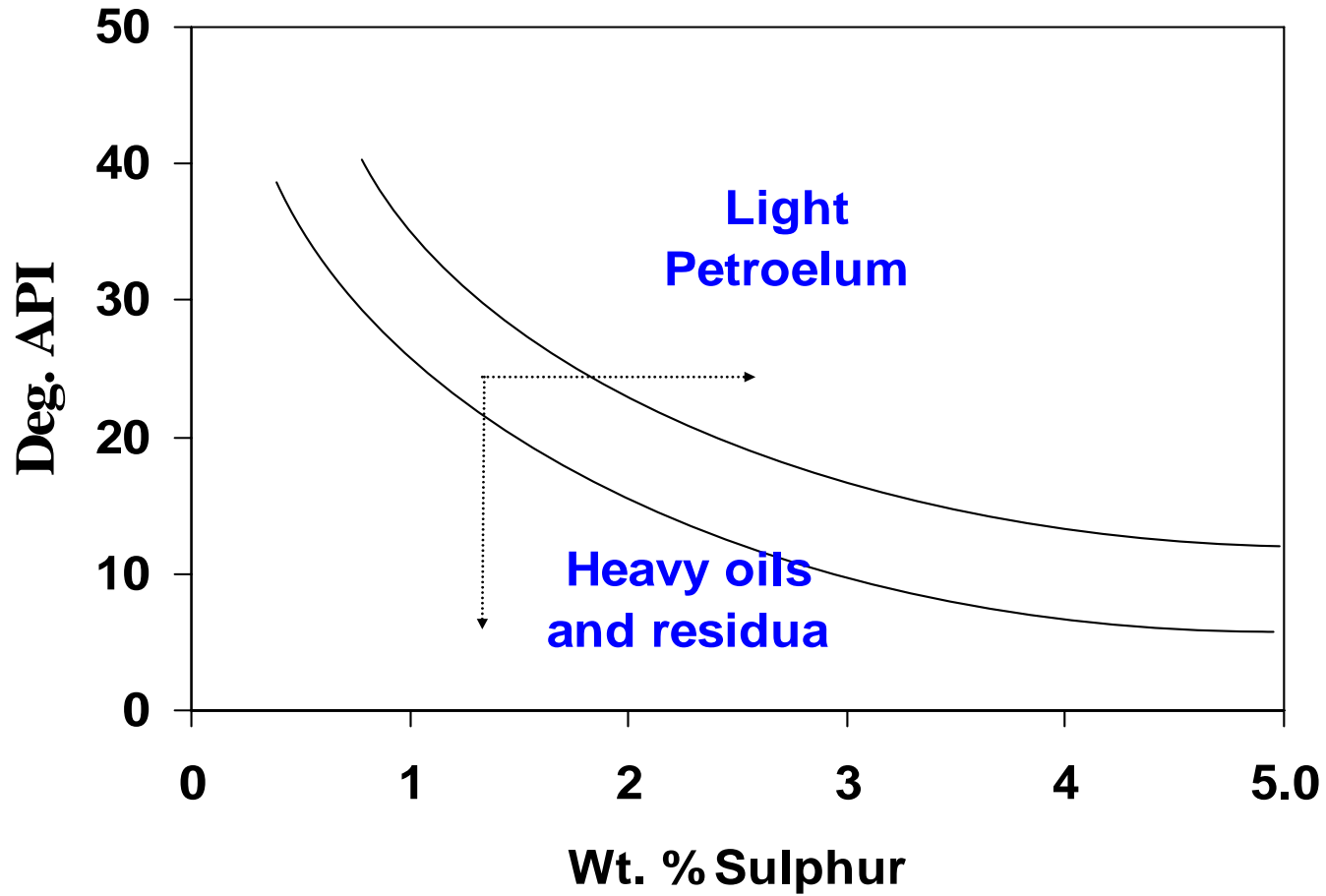
API Gravity

$$\text{API} = (141.5 / \text{sp. gravity}) - 131.5$$

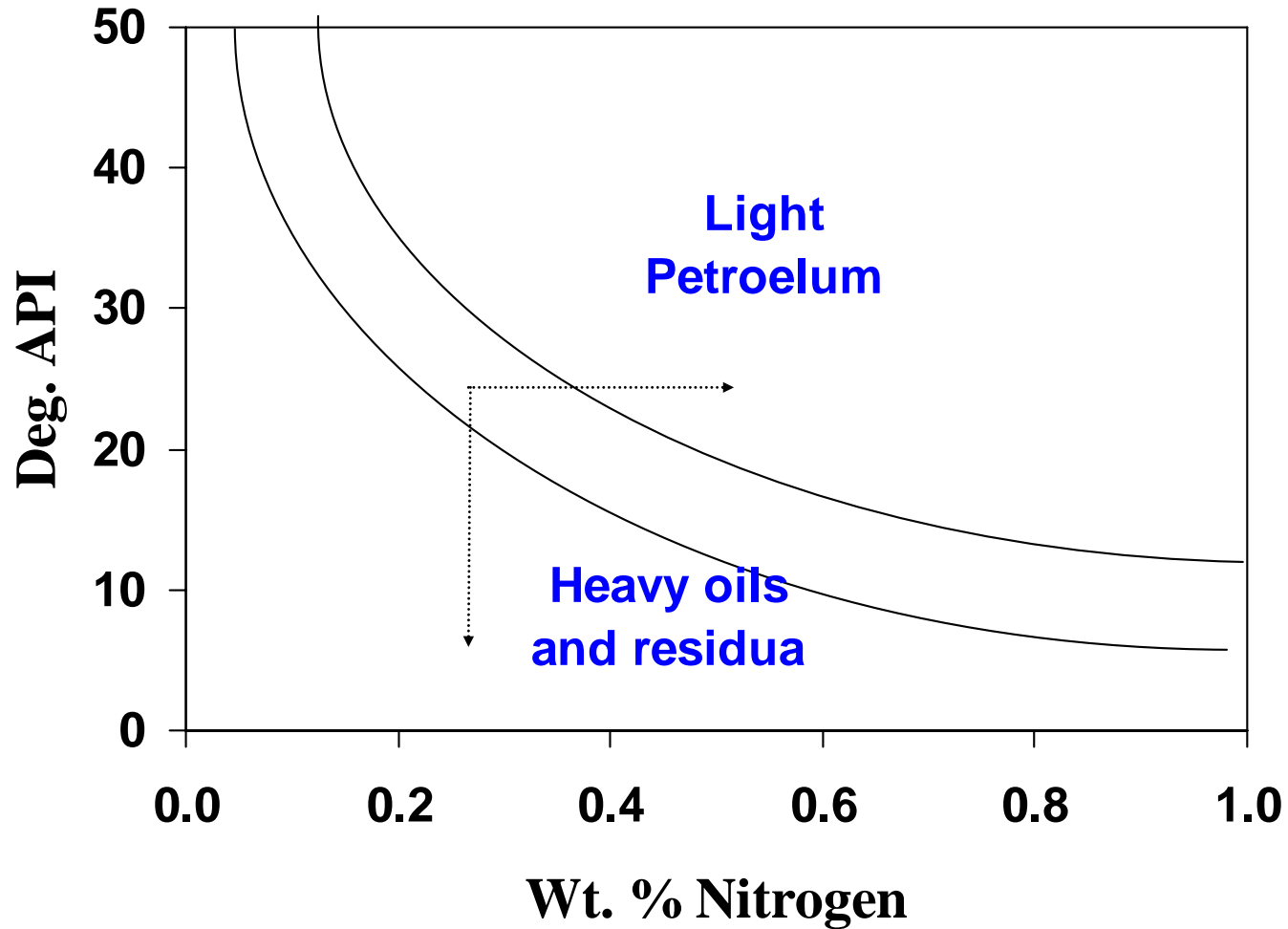
- Light Crude Oil >31
- Mixed Based 22-31
- Heavy crude <22

API is a major factor for Crude pricing

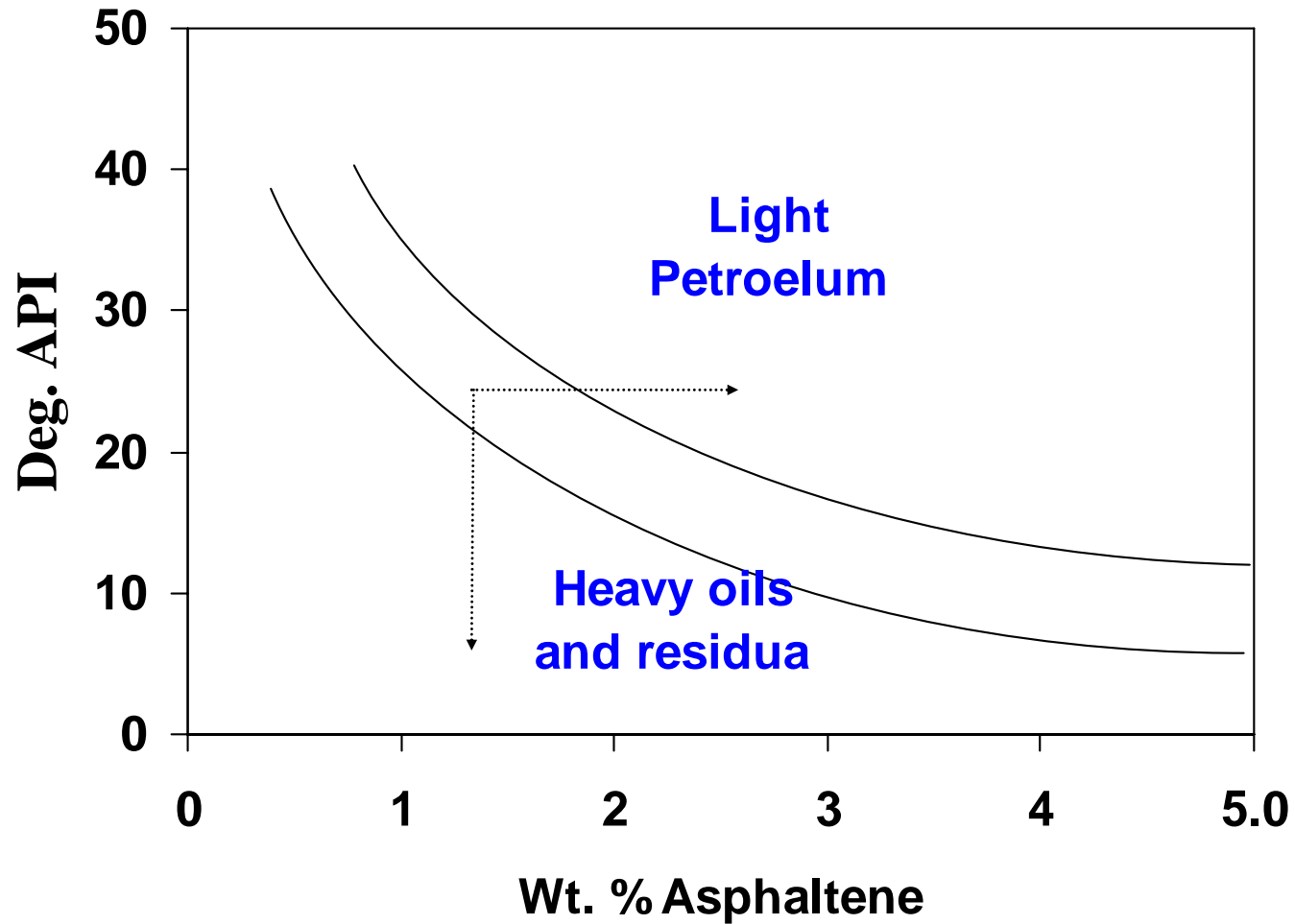
API & Sulphur



API & Nitrogen



API & Asphaltene



Types of Crudes

BITUMINOUS

Lube bearing

Basrah Light

Arab mix

Non-lube bearing

Suez Mix

Dubai

NON-BITUMINOUS

High sulphur

Arab medium

Kuwait

Low sulphur

Qua I boe

Miri light

Hydrocarbon Classification

- PARAFFINIC BASE

WAXY, LESS ASPHALTIC, LOW SULPHUR,
HIGH POUR

- NAPHTHENIC BASE

NAPHTHENIC BASE STOCKS, LESS WAX,
LESS ASPHALTIC, LOW POUR

- ASPHALTIC BASE

HIGH SULPHUR, NITROGEN, SUITABLE FOR
BASE OILS

Hydrocarbon Classification

UOP Characterization factor

K_{UOP} : Cube root of average boiling point(R) divided by specific gravity

- Paraffinic : >12.1
- Mixed based : $12.1 - 11.5$
- Naphthenic : <11.5

Types of Crudes-Imported

- Low Sulphur Crudes
- High sulfur Crudes
 - Lube & Bitumen producing
 - Suitable for Lube producing refineries.
 - Non Lube Producing & Bitumen Producing
 - Suitable during Non Monsoon periods when Bitumen demand takes place
 - Non Lube / Non Bituminous
 - Suitable during Monsoon period when Bitumen production is not required.
- Crude oils for Blending at Mundra-Heavy, High acidic etc (LS or HS)

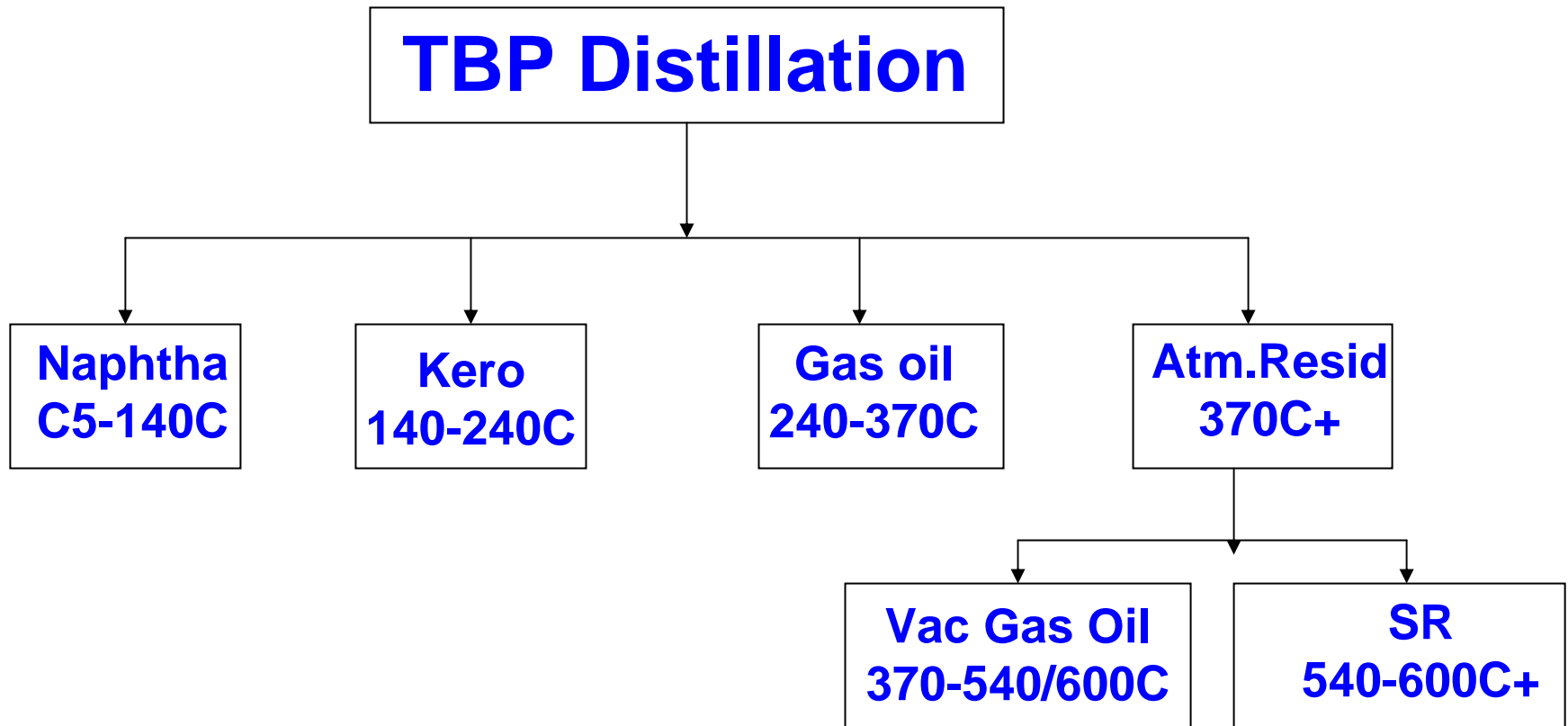
World Crude Oil Quality

Properties of Crude Oil	1985	1990	1995	2001	2010 (Proj)
'S' in crude Oil (wt%)	1.14	1.12	1.31	1.41	1.51
API Gravity of Crude oil	32.7	32.6	32.4	32.2	31.8
Metal in crude oil Residue (ppm wt)	275	286	297	309	320
Residue in crude (vol%)	19	19.4	19.8	20.2	21.3
'S' in crude oil residue (wt%)	3.07	3.26	3.61	3.91	4.0

Crude Oil Assay

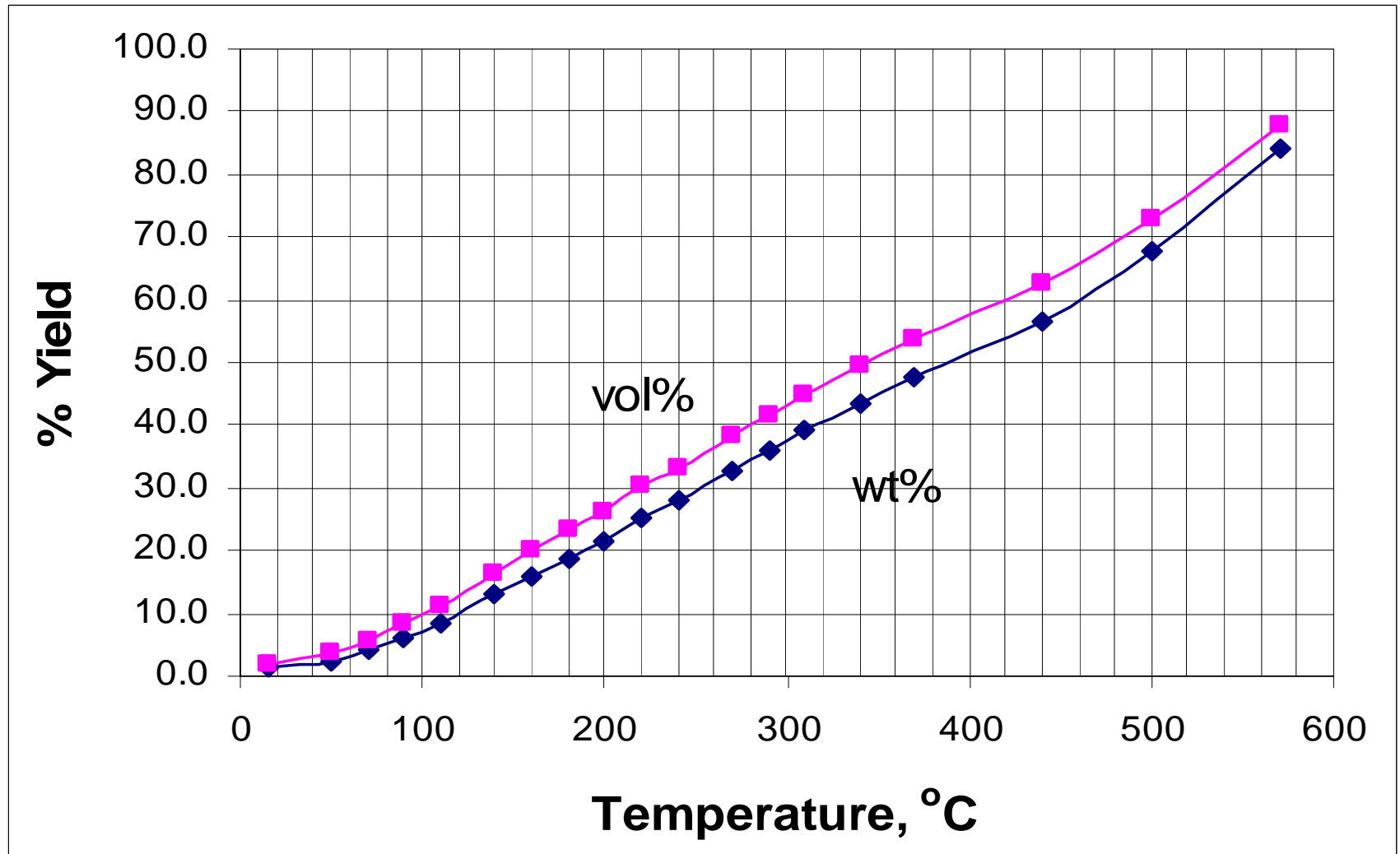
- Crude assay is a detailed report which describes the properties of the whole crude, as well as the major fractions into which a crude is distilled at the refinery - gasoline, naphtha, kerosene, jet fuel, middle distillates, gas oils and resid
- Typically, the data contained in a crude assay includes yields generated from the physical distillation & Distillate/resid properties

Crude Oil Evaluation Scheme



ALL TESTS ARE CONDUCTED AS PER STANDARD TEST METHODS : ASTM/IP/IS

Combined TBP curves of Basrah Light Crude oil



Properties of Crude oil

Characteristics	Basrah Light	Bombay High	Arab mix	Kuwait	North Gujarat
Density, gm/ml	0.8745	0.8200	0.8664	0.8741	0.8932
API gravity	30.3	41.0	31.6	30.3	26.8
Pour point, °C	-30	21	-24	-27	27
Kinematic Viscosity					
@40 °C	-	3.4	10.0	11.1	65.6
@50 °C	-	-	8.9	8.5	31.4
Water content, %wt	nil	nil	nil	nil	4.1
Salt content, ptb	10	-	L20	2.0	200
Sulphur, %wt	3.1	0.09	2.7	2.8	0.08
TAN, mgKOH/gm	-	0.1	0.14	0.14	1.93
CCR, %wt	5.9	1.1	6.4	5.4	2.5
Wax, %wt	1.2	12.7	2.5	6.0	5.9
Asphaltene, %wt	2.6	0.25	2.3	2.5	0.05
ASTMDistillation cracking point, °C	339	372	322	335	367
Metal content, ppm					
Nickel/vanadium	-	-	4/23	4/33	61/L10

Laboratory Distillation

- ASTM D86
- ASTM D1160
- TBP Distillation –ASTM D2892
- High vacuum Distillation, ASTM D5236
- Simulated Distillations based on gas chromatography principle

Test methods- Density

- Density is defined as the mass per unit volume of a substance. (Units:g/mL or g/cm³ or kg/m³). Density is temperature-dependent.
- Density is measured using an Anton Parr DMA 48/Kyoto digital density meter, and following ASTM method D 5002 - Density and Relative Density of Crude Oils by Digital Density Analyzer (ASTM, 1996a).
- Density of crude oils : 0.83 to 0.90 g/ml. Densities can be measured to 0.0001 g/ml with a repeatability of "0.0005 g/ml.

API Gravity

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$$\text{API} = (141.5 / \text{sp. gravity}) - 131.5$$

- Light Crude Oil >31
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API is a major factor for Crude pricing

BS&W

- Base sediments and Water determined by Karl Fischer titration using a Met Rohm 701 KF Automatic Titrator (ASTM D 4377) or by Distillation method, ASTM D4006
- Oils with significant water contents, (>5%), do not represent the properties of the "dry" oil.
- For 0.1%vol change, the cost implication
For 10 MMT purchase at ~\$60/barrel
US\$420/MT x (0.1/100)x10 MMT
~US\$4.20 million

Flash Point

- There are several ASTM methods for measuring flash points. The minimum flash point that can be determined by method D93/IP34 is 10°C. Method D 56 is intended for liquids with a viscosity less than 9.5 cSt at 25°C. The flash points and fire points of lubricating oils can be determined by ASTM method D 92/IP 36
- Many fresh crude oils have flash points below 10°C and/or viscosities above 9.5 cSt at 25°C

Pour Point

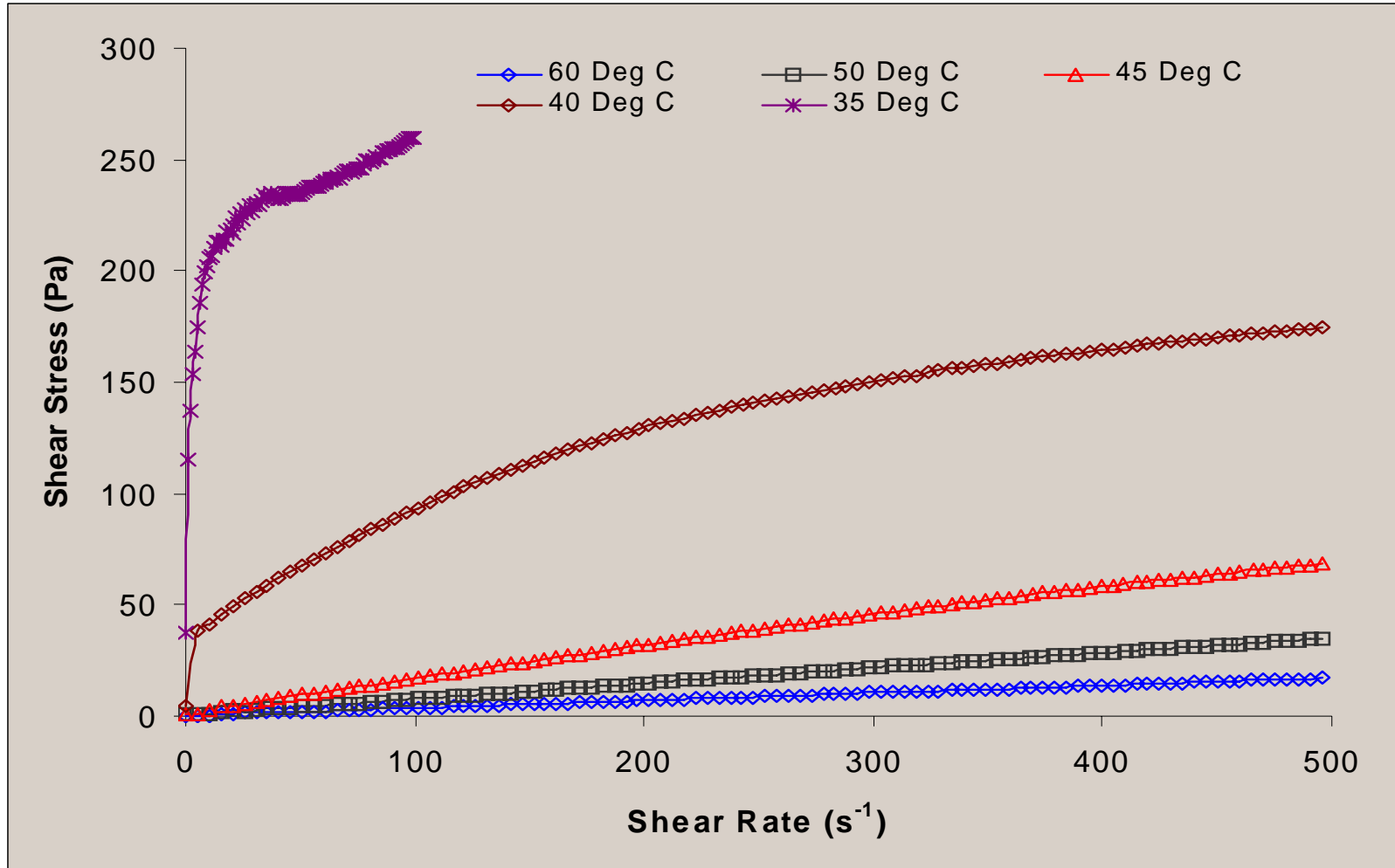
- The pour point of an oil is the lowest temperature at which the oil will just flow, under standard test conditions. The pour point of the oils is therefore an indication, and not an exact measure, of the temperature at which flow ceases.
- ASTM method D 97 - Standard Test Method for Pour Point of Petroleum Oils (ASTM, 1996a) for pour point determinations.
- Heavy & waxy oil transportation is a challenge

Viscosity

There are several ASTM Standard Methods for measuring the viscosity of oils. Of these, only methods D 445 - Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity) and D 4486 - Standard Test Method for Kinematic Viscosity of Volatile and Reactive Liquids, will yield absolute viscosity measurements (ASTM, 1996a).

Both of these methods make use of glass capillary kinematic viscometers and will produce absolute measurements in units of centistokes (cSt) only for oils that exhibit Newtonian flow behavior (viscosity independent of the rate of shear).

Flow curve of waxy crude at different temperatures



Factors Effecting the Selection of Crude oil

Choice of crude oil for a refinery depends on:

- Product mix
 - Product quality
 - Refinery configuration
 - Product treatment facilities
 - Refinery design spec- Metallurgy, desalter etc
 - Environment stipulation for pollution control
 - Pipeline design for inland refineries
-
- Proper crude selection is necessary for optimisation of refinery margin.

Refinery Constraints

- Refinery Configuration
- Refinery metallurgy
- Catalyst
- Down-stream treatment facilities
- Pipeline design constraints

Opportunity

- High S crude oil
- High Acid crude oils
- Beat the market by proper selection of crude
- Overcome refinery design constraints to widen crude basket
- Crude Blending Facility

MAJOR THRUST BY OIL REFINERY

1	Optimise crude mix	: High or Low sulfur
2	Widening crude basket	: Increased No. of crudes
3	Ocean freight reduction	: Higher Cargo size
4	Demurrage control	: Minimise tanker waiting
5	Inventory control	: Min possible inventory
6	Ocean Loss reduction	: Proper controls
7	Reduce F&L	: Proper design,operation

Gross product Worth of crude Oil

API					32.4	32.6	32.7
S, wt%					0.079	0.081	0.13
	Price, /MT	Yield, wt fraction			GPW		
		Miri	Widuri	Cabinda	Miri	Widuri	Cabinda
LPG	220	0.9%	0.1%	1.5%	2.0	0.2	3.3
Naphtha	289	6.4%	1.5%	5.0%	18.5	4.3	14.5
MS	298	8.0%	1.6%	5.4%	23.8	4.8	16.1
Kero	290	21.5%	7.7%	13.0%	62.4	22.3	37.7
Gasoil	264	42.5%	51.2%	45.0%	112.2	135.2	118.8
Fuel oil	166	12.7%	29.9%	22.1%	21.1	49.6	36.7
Fuel & Loss		8.0%	8.0%	8.0%			
Total		100.0%	100.0%	100.0%	239.95	216.46	227.03
BPT					7.28	7.28	7.28
GPW, \$/bbl					32.96	29.73	31.19
Freight					1.2	0.75	1
Crude Price (Calc for Netback-Zero)					31.8	29.0	30.2
Landed Price, \$/bbl					30.51		
Gross Margin,\$/bbl					2.45		

ELEMENTS OF IMPORTED CRUDE COST

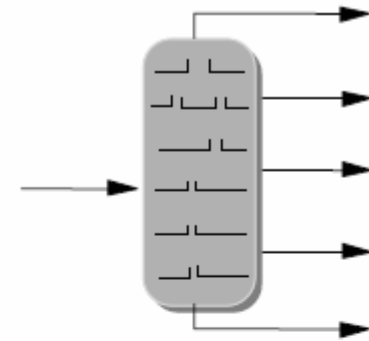
	COST ELEMENT	%
1	FOB	90%
2	OCEAN FREIGHT	3.9%
3	DAUGHTER VESSEL FREIGHT	0.8%
4	INSURANCE	0.05%
5	OCEAN LOSS	0.2%
6	PORT CHARGES	0.08%
7	CUSTOM DUTY	5.0%
8	DEMURRAGE	0.002%
9	ENTRY TAX	0.09%
	TOTAL	100.0%

Gross product Worth of crude Oil

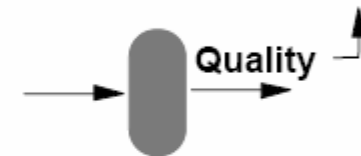
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Gross Margin,\$/bbl					2.45		

Refining

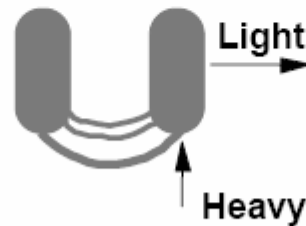
SEPARATION



IMPROVEMENT



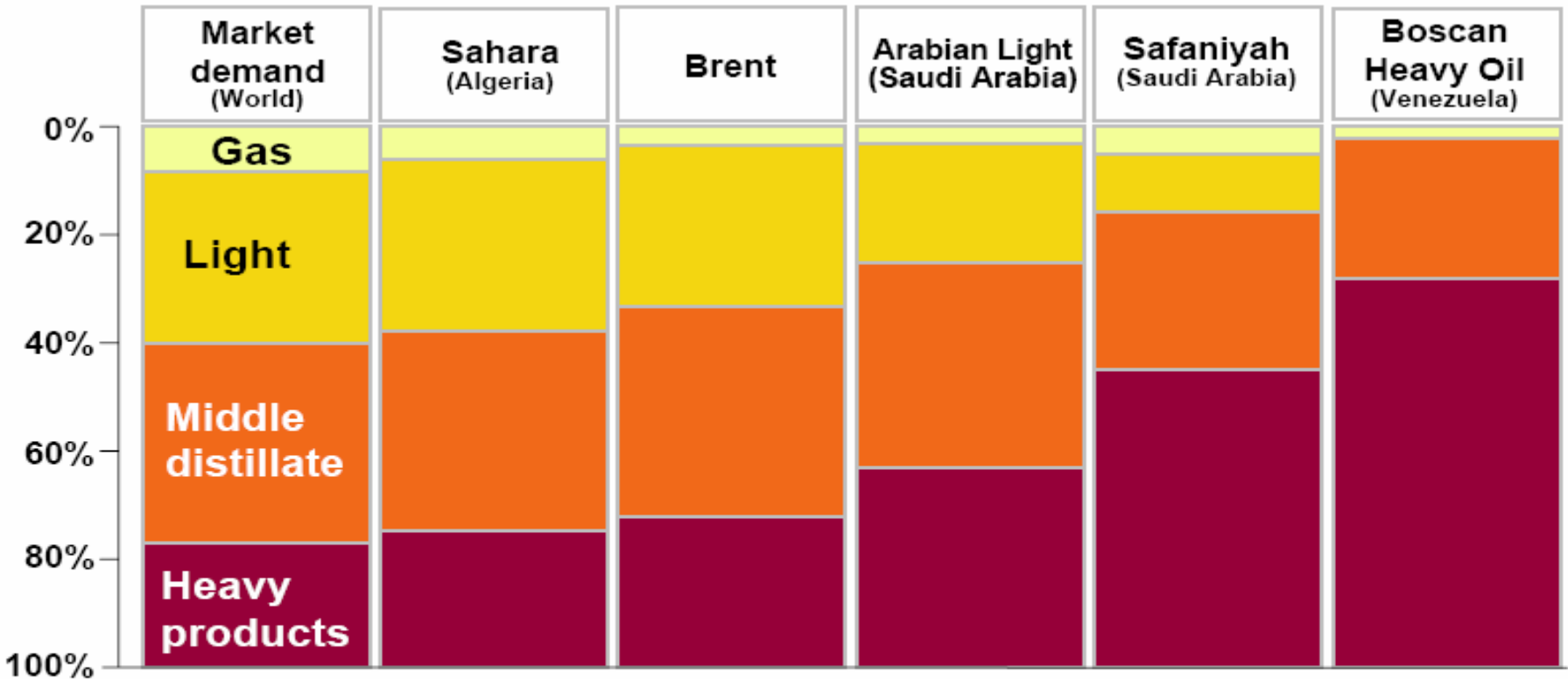
CONVERSION



BLENDING

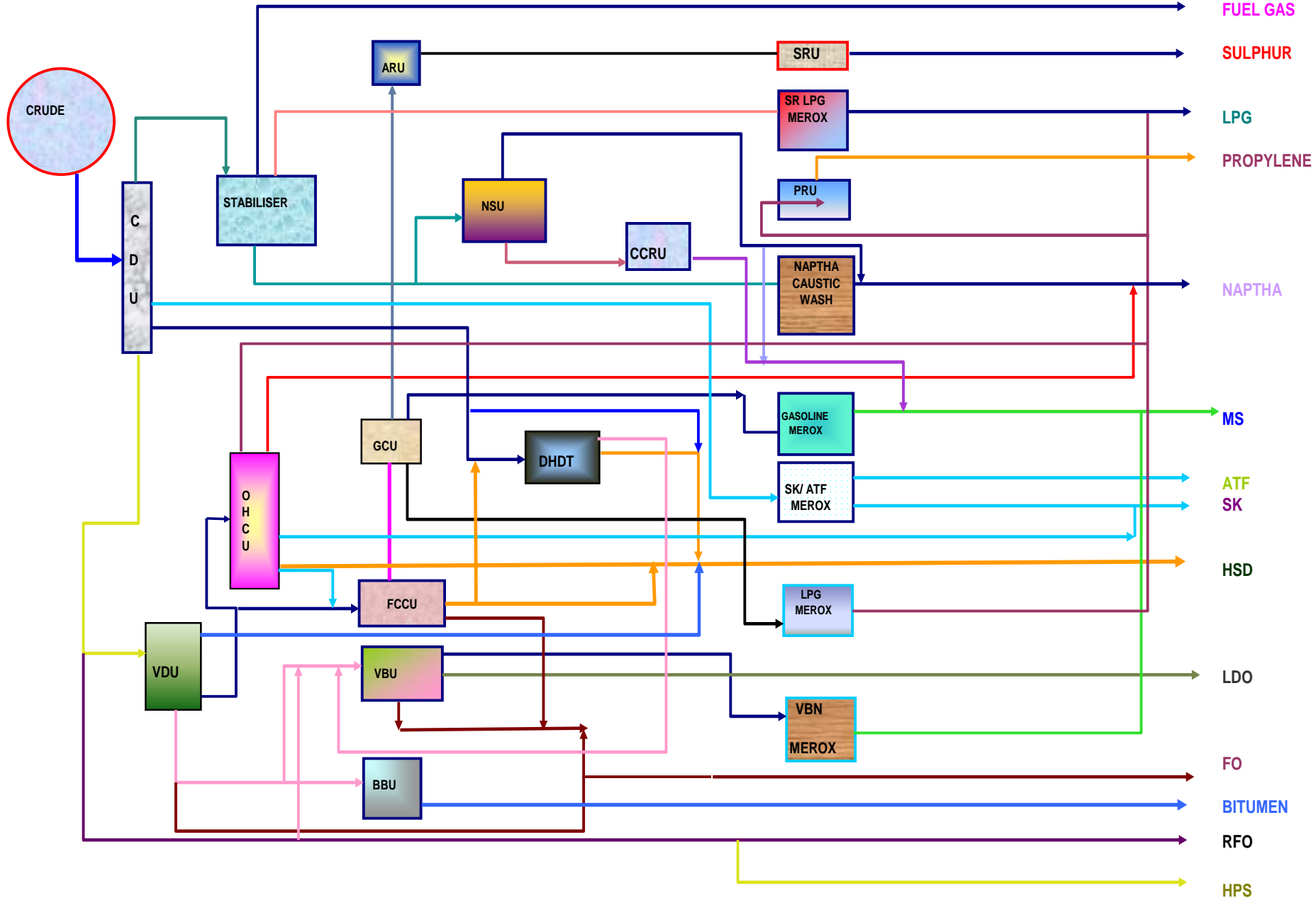


Yield Structure of Various Crudes

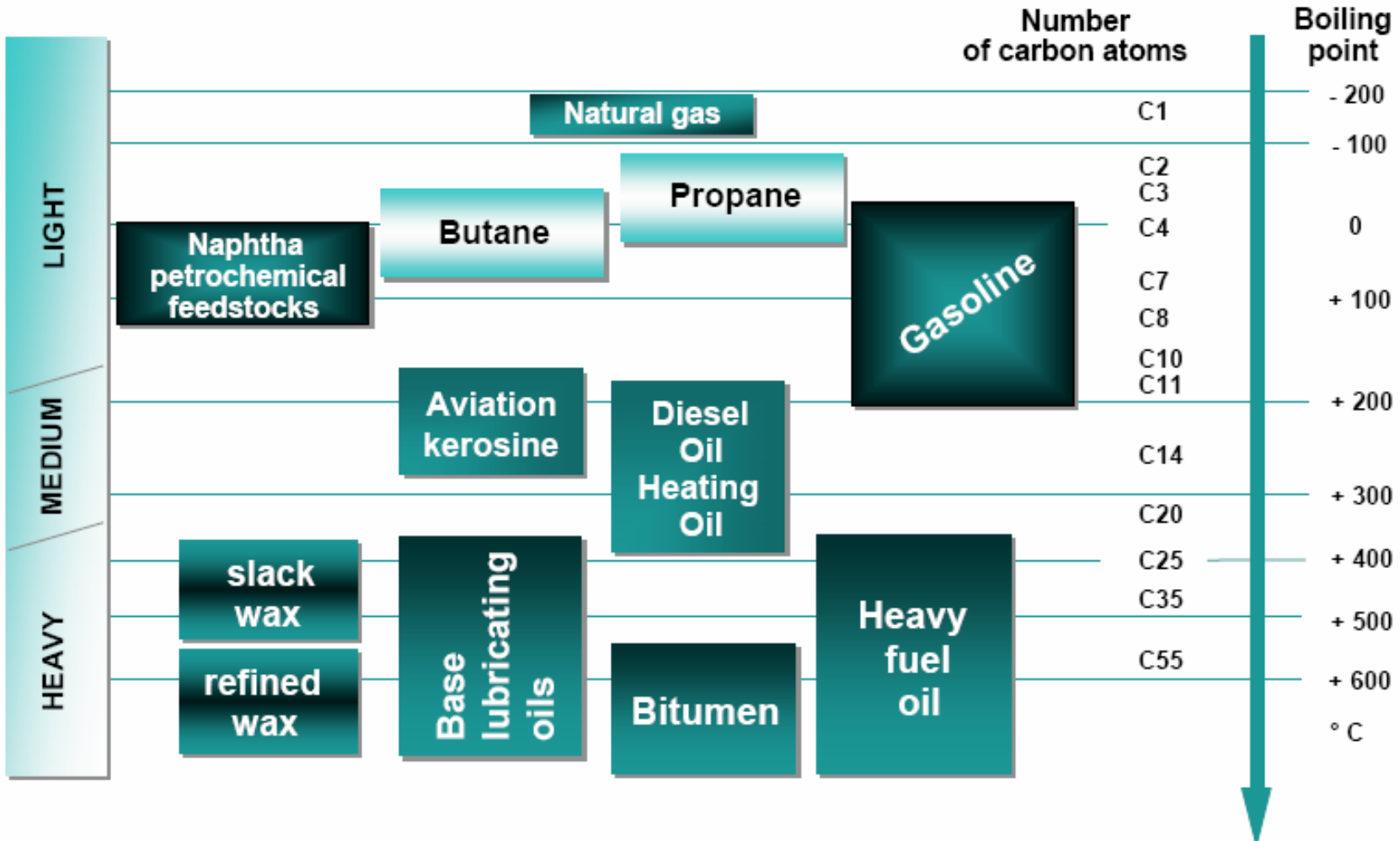


Density	0,806	0,837	0,855	0,893	0,995
° API	44	37,5	34	27	10,7
Sulfur content Wt %	0,2	0,3	1,7	2,8	5,3

TYPICAL REFINERY CONFIGURATION (MATHURA REFINERY)



Oil Products & Cut Points



Products

- LPG
- Naphtha
- Petrol (BS-II/BSIII)
- Kerosene
- ATF
- Diesel (BS-II/BS-III)
- LOBS
- Bitumen
- RPC
- Wax
- Fuel Oil (High S, Low S)
- Fuel Oil (High or low Viscosity)
- LSHS
- HPS
- Petrochemical feed stock
 - LABFS
 - HPL Naphtha
- Petrochemicals
 - pX, PTA
 - LAB etc

Yield Pattern of Crude Oils

Yield, %wt	Basrah Light	Bombay High	Arab mix	Kuwait	North Gujarat	Jodhpur crude
LPG	1.0	1.0	1.0	2.0	1.0	-
Naphtha	12.0	21.0	12.0	15.0	5.0	1.0
Kerosene	15.0	20.0	16.0	18.0	10.0	13.0
Gas oil	20.0	27.0	20.0	17.0	21.0	24.0
VGO	36.0	27.0	29.0	25.0	33.0	21.0
Short resid	16.0	4.0	22.0	23.0	30.0	41.0

Properties of Naphtha

Characteristics	Basrah Light	Bombay High	Arab mix	Kuwait	North Gujarat	MS Spec
Density, gm/ml	0.6912	0.7378	0.6493	0.6958	0.7407	-
Sulphur, ppm	175	LO.01	0.06	LO.02	LO.01	0.005
RSH, ppm	33	nil	117	4.8	1	-
Octane number	-	68.1	53.9	47.4	56.8	95
Aromatics, %wt	9.5	25.8	-	4.3	-	35

Gasoline Specification

	Euro I	Euro II	Euro III	Euro IV
RON	95	95	95	95
Sulphur, Wt%	0.05	0.05	0.015	0.005
Benzene % wt	5	5	1	1
Aromatics % wt	-	-	42	35
Olefins, Wt%	-	-	18	-

Properties of Kero / ATF

Characteristics Of SK/ATF from the Crude:	Basrah Lt.	MH	Arab mix	KEC	NG	ATF Spec
Density, gm/ml	0.783	0.7918	0.7902	0.787	0.7975	-
Smoke, mm	29	21	27	27	28	18
Sulphur, %wt	0.18	0.02	1.3	0.16	0.13	
RSH, ppm	30	nil	8.8	12.9	1	<30
H2S, ppm	nil	nil	nil	3.9	nil	nil
Freezing, °C	<-60	-54	-59	-53	-47	-47
Aromatics, %wt	18.1	27.7	20.6	20	9.2	20

Properties of Gas oil

Characteristics	Basrah Light	Mumbai High	Arab mix	KEC	NG	Diesel Spec
Density, gm/ml	0.8549		0.852	0.85	0.847	-
Pour point, °C	-15	6	-18	-6	3	-6/18
Sulphur, %wt	2.05	0.13	1.7	1.51	0.05	0.005
Cetane No.	48.8	59.5	54.9	56.8	60.6	53
Distillation , T95, C	-					340

Diesel Specification

	Euro I	Euro II	Euro III	EuroIV
Cetane Number	49	49	51	53
Sulphur, Wt%	0.2	0.05	0.035	0.005
Distillation T-95, °C	370	370	360	340

LOBS API classification

CLASS	COMPOSITION	SULPHUR % WT.	VISCOSITY INDEX
Group-I	<90% Saturates	>0.03	95-120
Group-II	>90% Saturates	<0.03	95-120
Group-III	>90% Saturates	<0.03	>120
Group-IV	Poly alpha olefin		
Group-V	Others		



**THANK
YOU !!!**