



Sulphur in Nigerian Diesel

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Reduction in Vehicle Fuels, Lome, Togo,**

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Outline



- **Introduction**
- **Classification of Crude oil**
- **Characteristics of Nigerian Crude oil**
- **Crude Oil Distillation**
- **Complexity of Nigerian Refineries**
- **Products and Specifications from Nigerian Refineries**
- **Refinery Modifications to Achieve 50 ppm S**
- **Nigerian Diesel Specifications**
- **Recommended Future Nigerian Diesel Specifications**



Introduction



- **Sulphur is chemically bonded to crude oil components. During refining, it concentrates in bottom fractions, diesel and fuel oil.**
- **SO₂ is emitted from vehicle exhaust, in direct proportion to the amount of Sulphur in Fuel.**
- **SO₂ Effects:**
 - Exacerbates respiratory symptoms (asthma, etc).
 - Forms Acid rain.
 - Forms secondary particulate matter, which can cause serious respiratory adverse health effects
 - Cause some loss of catalytic activity in catalytic convertors.
- **Fuel specifications therefore limits the amount of Sulphur.**



Classification of Crude Oil



- **BASE** – Paraffinic, Naphthenic, Waxy, Non-Waxy
- **GENERAL** - API Gravity, Sulphur, Viscosity, Pour Point
- **IMPURITIES** - Salt, Water



Crude Type

	North Africa	N. Sea	Middle East	North America	Latin America
Specific Gravity	0.8	0.84	0.87	0.89	1
Sulphur %wt	0.2	0.3	2.5	1	5.5
Viscosity @ 38c	1.4	4.5	9.6	13.4	19.4
Pour Point	-51	0	-24	0	15
Wax % wt	3	9	6	7	2

Each crude oil is unique, consisting of a wide variety of hydrocarbons



Characteristics of Nigeria's Bonny Light Crude Oil

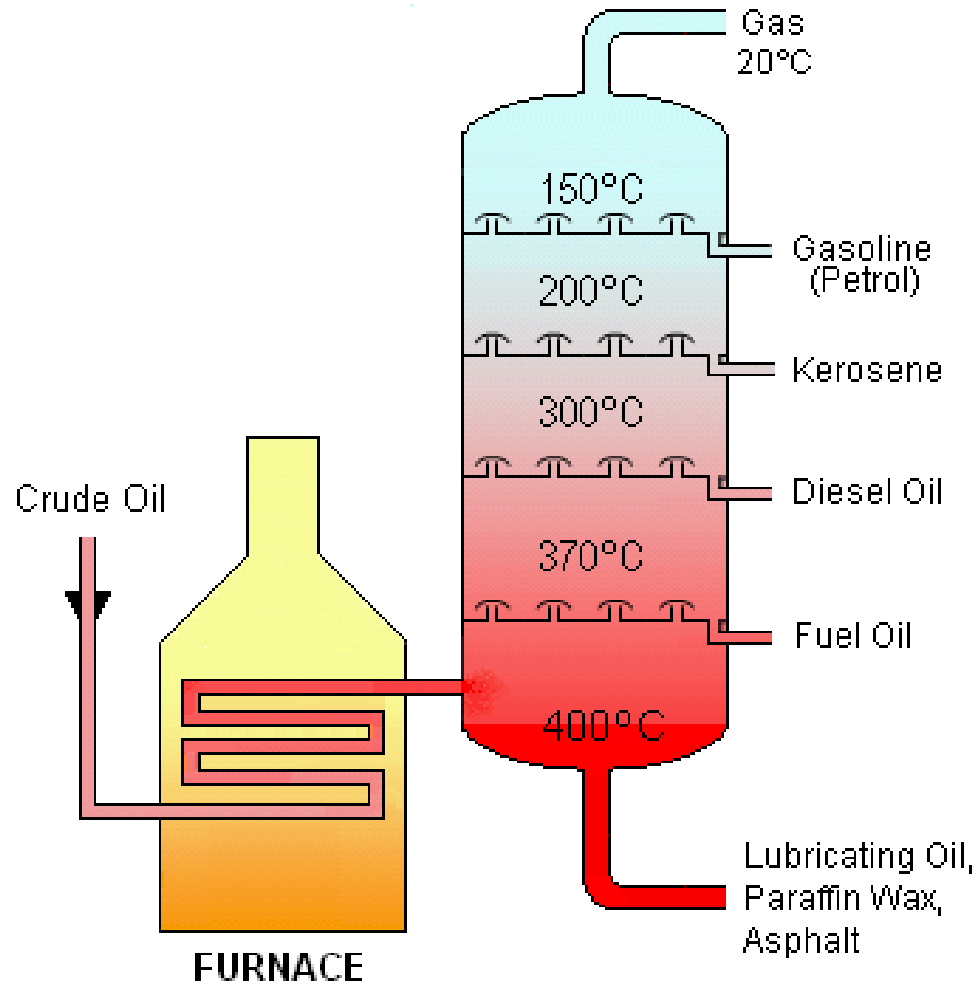


Property	Measured	Blended Back
Gravity, API°	35.4	35.8
Gravity SG	0.8478	0.8459
Sulfur, wt%	0.14	0.14
Total Nitrogen, ppm		1030
Hydrogen, wt%		13.2
Acid Number, mg KOH/g	0.27	0.25
Pour Point, °F / °C	0 / -18	0 / -18
Charact. Factor (K-FACTOR)		11.9
Viscosity, cSt at 40°C (104°F)	3.41	
Viscosity, cSt at 50°C (122°F)	2.90	2.90
Vanadium, ppm		0.4
Nickel, ppm		3.6
MCR, wt%		0.99
Ramsbottom Carbon, wt%		0.93
Asphaltenes, (H.C7) wt%		0.007

Quality of crude influences refinery configuration to achieve stipulated products' specifications



Simple Crude Oil Distillation

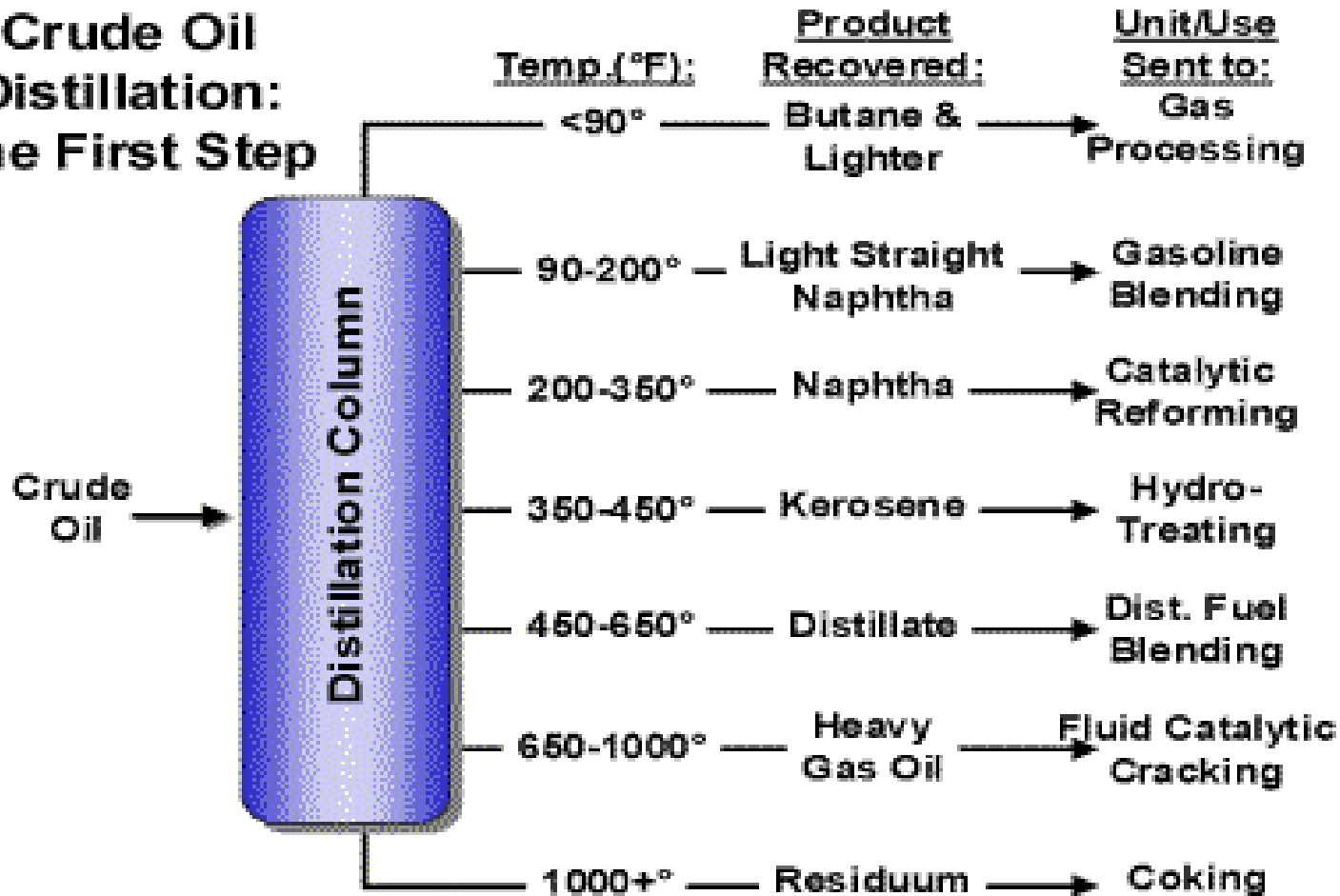




Complex Crude Oil Distillation



Crude Oil Distillation: The First Step





Sulphur Reduction in Refineries



Refinery technology options for meeting low sulfur challenge

choice depends on the local situation including:

- Configuration of the existing refinery
- Gasoline specs for sulfur and olefins -- current, new, future
- Availability of existing hardware
- Refinery octane balance
- Value of octane, LPG, and C5+

Configuration of refinery with

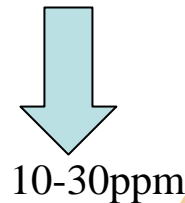
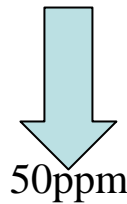
- reformer feed pre-fractionation
 - Alkylation unit
 - Oxygenate
 - Isomerization Unit
- is ready for future gasoline restrictions*

Gasoline Sulfur Management

Sulphur mainly from FCC Gasoline
2 options for sulphur reduction

- FCC feed hydrotreating
- FCC gasoline desulfurization (FCC Catalyst Selection)

Additional FCC feed pre-treater



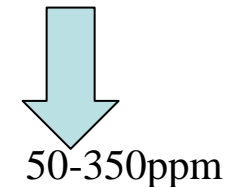
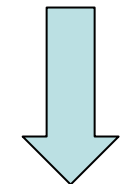
High Octane Penalty

Diesel Sulfur Management

Sulphur mainly from AGO distillate
2 options for sulphur reduction

- Deep HDS (FCC Catalyst Selection)

Hydrotreaters operated at higher operating severity



Cetane Number Penalty



Complexity of Nigerian Refineries



PHRC

Old Port Harcourt Refinery –60,000bpd, commissioned in 1965
Crude Distillation Unit 60,000BPSD UOP 1965

Platforming Unit 6,000BPSD UOP 1965

LPG Plant 60 MT/Day UOP 1965

The utilities section of the refinery includes a Packaged Boiler, Crude Waste Heat Boiler, Cooling Water system, Plant Air, Raw water System, Demineralization Unit and a Flare Unit.

New Port Harcourt Refinery –150,000bpd, commissioned in 1989- more complex refinery with 8 processing units:

Crude Distillation Unit(CDU) – 150,00bpsd

-Vacuum Distillation Unit(VDU) – 53,560bpsd

-Naphtha Hydro treating Unit(NHU) – 33,000bpsd

-Catalytic Reforming Unit(CRU) – 33,000bpsd

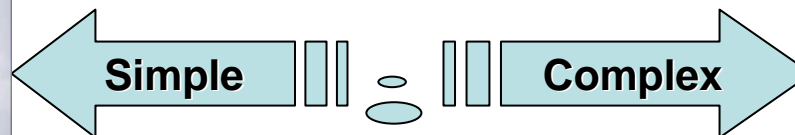
-Kerosene Hydro treating Unit(KHU) –14,500bpsd

-Fluid Catalytic Cracking Unit(FCCU) – 40,000bpsd

-Dimersol Unit (DIMU) – 4,459bpsd

-HF Alkylation Unit – 7,200bpsd

-Gas Concentration Units





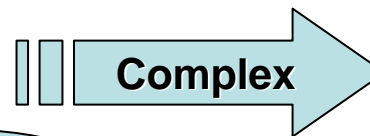
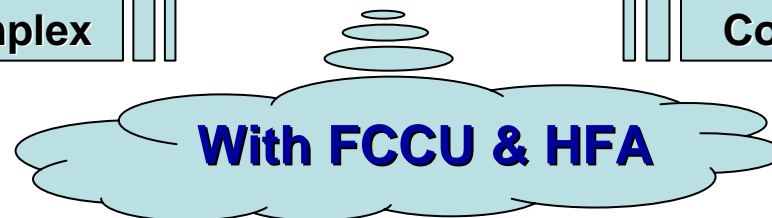
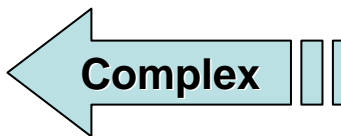
WRPC

Warri Refinery and Petrochemical Refinery commissioned in 1978
Fuels Plant – installed capacity – 125,000bpsd
Petrochemical Plant commissioned in 1988
Polypropylene Plant – installed capacity –35,000 tons of polymer per year
Carbon Black Plant – installed capacity –18,000 metric tons of various grade of carbon black per annum
Utilities and Offsite Facilities: Power Plant, Tank Farms, Jetty etc

KRPC



Kaduna Refinery and Petrochemical Company Limited Commissioned sequentially between 1980 and 1988, with installed capacity for refining 110,000 bpsd
Fuels Plant – capable of processing 60,000 bpsd
Lubes Plant - designed to process 50,000bpd of heavy crude oil imported from Kuwait or Venezuela, or Saudi Arabia
Light Crude into lubes base oils, waxes and asphalts.
Petrochemicals Plant (Linear Alkyl Benzene Plant)
Utilities Production Plants
Manufacturing Plants
Offsite Plants comprising tankage and oil movement





Products and Specifications from Nigerian Refineries



- **Total Refinery Capacity: 445,000 bpsd**
- **Daily Refinery Design Production, MT:**
 - PMS: 17,170
 - AGO: 14,317
 - DPK: 8,429
 - LPFO/HPFO: 9,898
 - LPG: 2,007
- **Typical Specification from the refineries:**

PMS

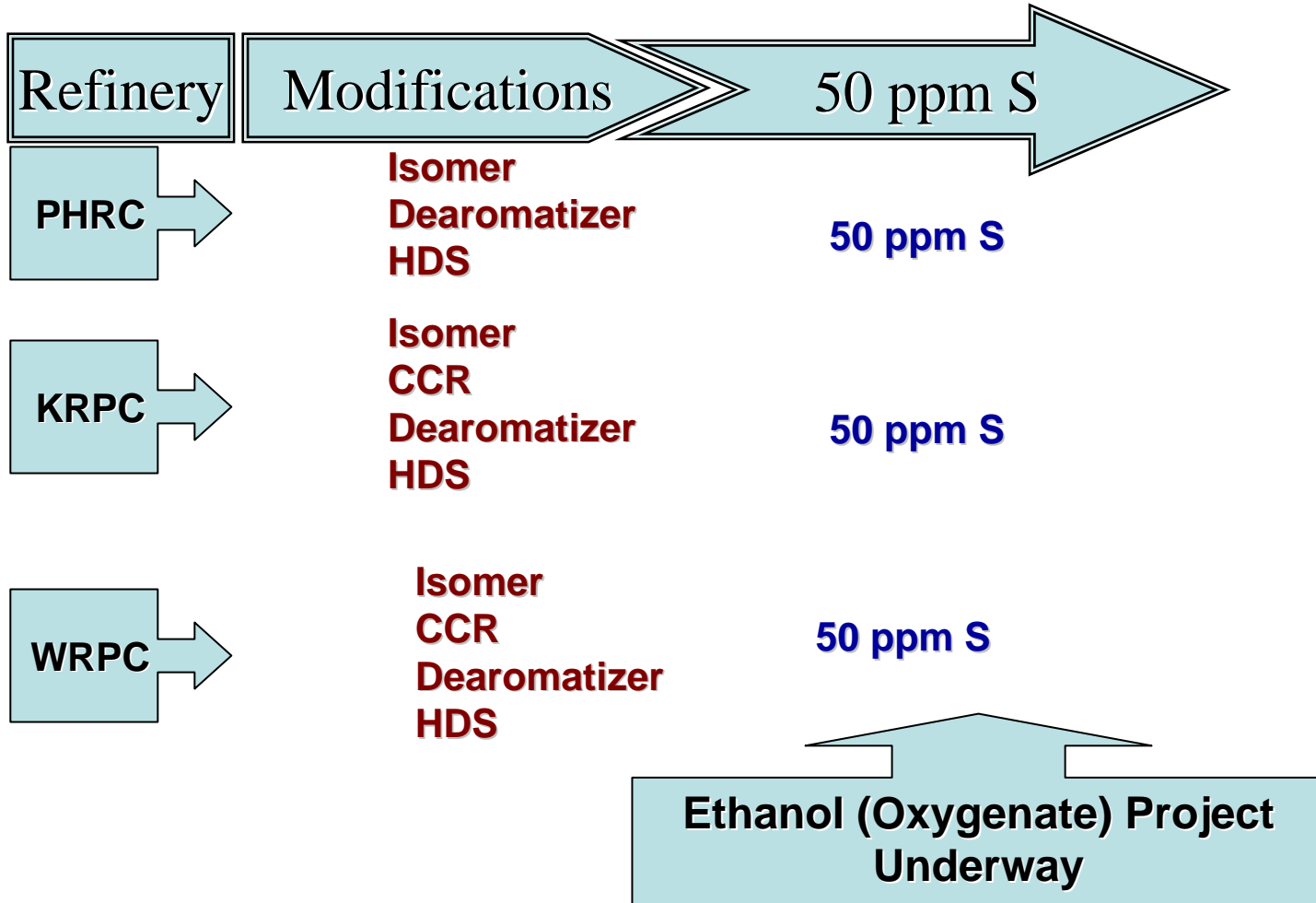
RON	Lead	Sulphur, ppm Max	GUMS	FBP	Benzene, % Vol	Olefins, % Vol
90	NIL	Not reported	4	205	Not reported	Not reported

DIESEL

Density	Sulphur, ppm Max	Flash Point	Diesel Index	Temp at 95% Distillation
871	1330	100	50	357



Refinery Modifications to Achieve <50 ppm S



High octane gasoline pool low in sulphur, aromatics, olefins & ultra low sulfur Diesel



Nigerian Diesel Oil Specifications



Qualities	Unit	Requirement	Actual from Nigerian Refineries
Sulphur	ppm max	3000	1330
Density	Kg/m ³ max	820-870	871
Cetane number	min	47	50
Total Acid Number	Mg KOH/g max	0.5	
Final Boiling Point	°C max	385	358



Recommended Future Nigerian Diesel Specifications



Qualities	Unit	Year X (Euro II)	Year X+5 (Euro III)	Year X+10 (Euro IV)
Sulphur	ppm max	<500	<300	<10
Density	Kg/m ³ max	835-845	833-837	833-837
Cetane number	min	49-53	52-53	52-53
Polycycl. Aromatics Hyd.	wt % max		3-6	3-6
Temp. 95% dist.	°C max	320-340	345-350	345-350



- Thank you very much for your attention!