

Specifications for Unleaded and Low Sulphur Fuels: Global and Africa Trends

Presented at Workshop
on Leaded Gasoline
Phase-Out in North Africa

Tunis, Tunisia
14-16 Aug, 2008

1. EU and US Specifications: Current State and Planned Changes

- Oil product specifications shaped by a number of factors, e.g.:
 - Continued growth in demand for transport fuels and vehicles,
 - Continued pressure to reduce air pollution, CO₂ and greenhouse gases emissions,
 - Reduction of sulphur levels in transport fuels,
 - Reduction of sulphur content in off-road fuels and bunkers,
 - Increased content of biofuels.

Comparison between EU and US

Sulphur Limits: GASOLINE

USA				EUROPE			
Year	Designation (control technology)	Emission Limitations g/mile	Fuel Sulphur (ppm)	Year	Designation (control technology)	Emission Limitations g/mile	Fuel Sulphur (ppm)
1975	First catalysts (Oxidation)	--	1,000	Pre-1993	Country specs (leaded)	--	1,000 - 2,000
1980	Tier 0 (TWC)	CO - 3.4 NOx - 1.0 PM - 0.2	1,000	1993	Euro-1 (TWC)	CO - 2.72 NOx - 0.49 PM - no std	
1994	Tier 1 (TWC)	CO - 3.4 NOx - 0.4 PM - 0.08	1,000	1996	Euro-2 (TWC)	CO - 2.2 NOx - 0.25 PM - no std	
1999	NLEV (advanced TWC)	CO - 3.4 NOx - 0.3 PM - 0.08	1,000	2000	Euro-3 (TWC)	CO - 2.3 NOx - 0.15 PM - no std	
2004	Tier 2 (advanced TWC)	CO - 3.4 NOx - 0.07 PM - 0.08	80 (max) 30 (average)	2005	Euro-4 (advanced TWC)	CO - 1.0 NOx - 0.08 PM - no std	

Comparison between EU and US

Sulphur Limits: DIESEL

USA				EUROPE			
Year	Designation (control technology)	Emission Limitations g/mile	Fuel Sulphur (ppm)	Year	Designation (control technology)	Emission Limitations g/mile	Fuel Sulphur (ppm)
				1980	EEC/75/716	--	5,000
1988	Engine Mod	--	5,000	1989	EEC/87/219	--	3,000
1991	Engine Mod	CO - 15.5 NOx - 10.7 PM - 0.6	500	1993	Euro 1	CO - 4.5 NOx - 8.0 PM - 0.36	2,000
1998	Engine Mod	CO - 15.5 NOx - 5.0 PM - 0.25	500	1996	Euro 2	CO - 4.0 NOx - 7.0 PM - 0.15	500
2004	EGR	CO - 15.5 NOx - 4.0 PM - 0.1	500	2000	Euro 3	CO - 2.1 NOx - 5.0 PM - 0.10	350
2007	Particulate Filters	CO - 15.5 NOx - 0.2 PM - 0.01	15	2005	Euro 4 (Introduction of particulate filters)	CO - 1.5 NOx - 3.5 PM - 0.02	50 (10 ltd avail.)

Overview of EU Fuel Quality Programmes

Fuel Programme	Programme Type	Implementation Dte and Coverage	Target pollutants
Lead Prohibition	Current - Banned the use of lead in gasoline	2000 (Greece, Italy, Spain, French overseas territories derogation to 1/1/2002; UK, Denmark, Sweden, Finland started phasing out lead in the 80's)	Lead (elimination to enable vehicle emission controls as well as protect public health from lead toxin exposure)
Reformulated Gasoline Programme	Current - Performance standards for Nitrogen Oxides, Volatile Organic Compounds, Air Toxics and maximum standards for oxygen content	Phase I - 2000 focused on lead phase-out, sulphur, aromatics, and benzene decrease; Phase II - 2005/2009 focuses on low and ultralow sulphur	Ozone, <i>Nitrogen Oxides</i> , <i>Hydrocarbons</i> , Air Toxic Controls
Reformulated Diesel Programme	Current - Performance standards for Nitrogen Oxides, and particulates.	Oct, 1998; Phase I - focused on 350ppm sulphur max; Phase II - 2005/2009 focuses on low and ultralow sulphur; alignment of non-road diesel by 2009	Ozone, <i>Nitrogen Oxides</i> , Particulate Emissions, CO2
Sulphur Liquid Fuels	Current - Performance standards for Nitrogen Oxides, SO2 and particulates, ozone.	Mar, 1997; Off-road diesel sulphur content - maximum permissible sulphur content 1,000 mg/kg by 1st Jan, 2008	Ozone, <i>Nitrogen Oxides</i> , Particulate Emissions, CO2

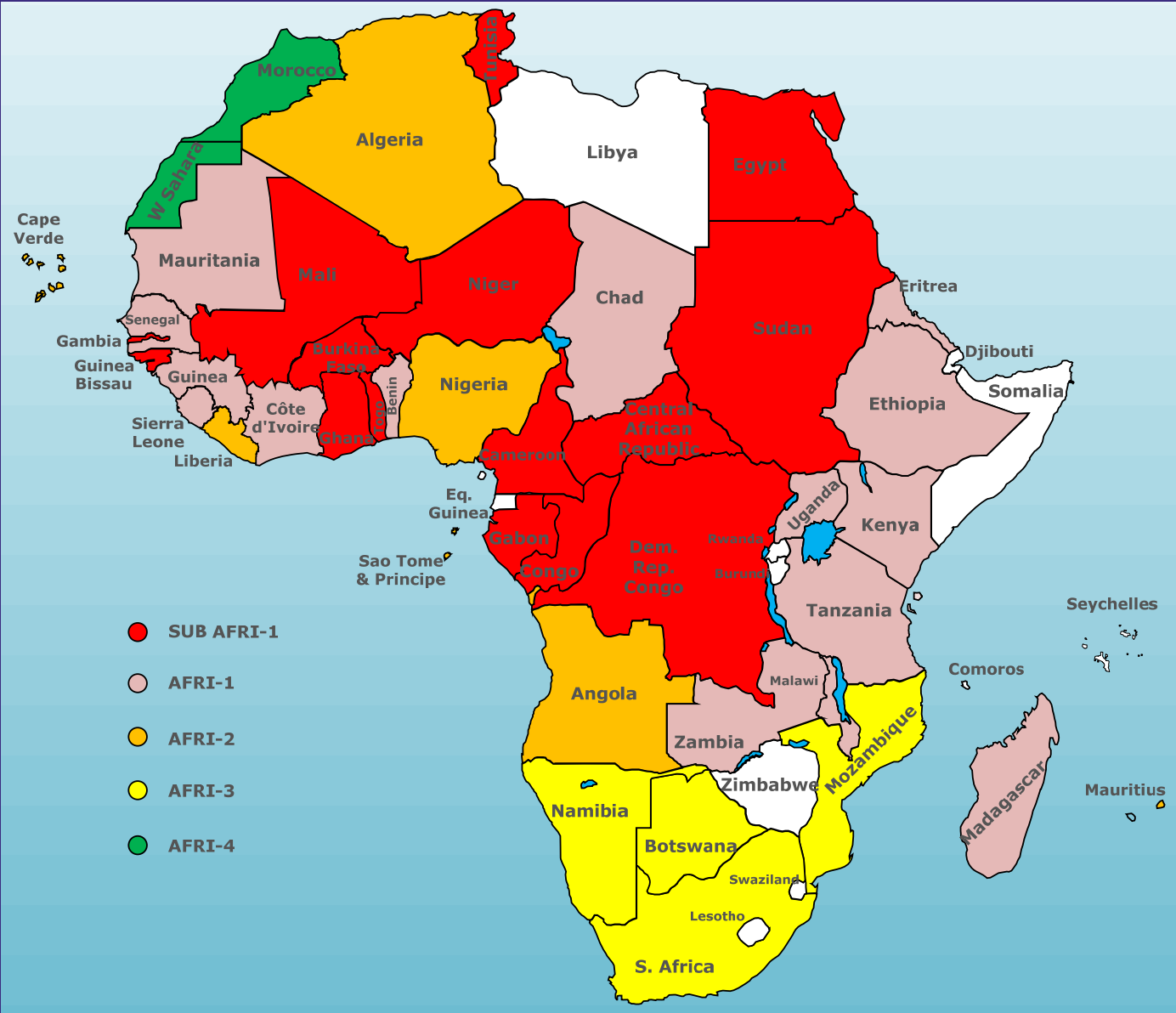
EURO Specifications

GASOLINE	EN 228:	Dir 98/70	Dir 98/70	Dir 98/70	Dir 98/70
	1993	1996	2000	2005	2009
	<i>Euro I</i>	<i>Euro II</i>	<i>Euro III</i>	<i>Euro IV</i>	<i>Euro V</i>
Aromatics, vol%, max	No limit	No limit	42	35	35
Olefins, vol%, max	No limit	No limit	18	18	18
Benzene, vol%, max	5	5	1	1	1
Oxygen, wt%, max	2.5	2.5	2.7	2.7	3.7
Sulphur, ppm, max	1000	500	150	50 (10)*	10
RON, min	91	91	91	91	91
RVP, kPa	35 - 100	35 - 100	60 - 70	60 - 70	60 - 70
Lead, g/lt, max	0.013	0.013	None	None	None
DIESEL	EN 590:	Dir 98/70	Dir 98/70	Dir 98/70	Dir 98/70
	1993	1996	2000	2005	2009
	<i>Euro I</i>	<i>Euro II</i>	<i>Euro III</i>	<i>Euro IV</i>	<i>Euro V</i>
Poly Aromatics, vol%, max	N/A	N/A	11	11	11
Sulphur, ppm, max	2,000	500	350	50 (10)*	10
Cetane number, min	49	49	51	51	51
Density @ 15°C, kg/m ³	820 - 860	820 - 860	845	845	845
Distillation, T95°C, max	370	370	360	360	360

* 2005 introduction of 10ppm sulphur gasoline: fuel must be geographically available in an appropriately balanced manner

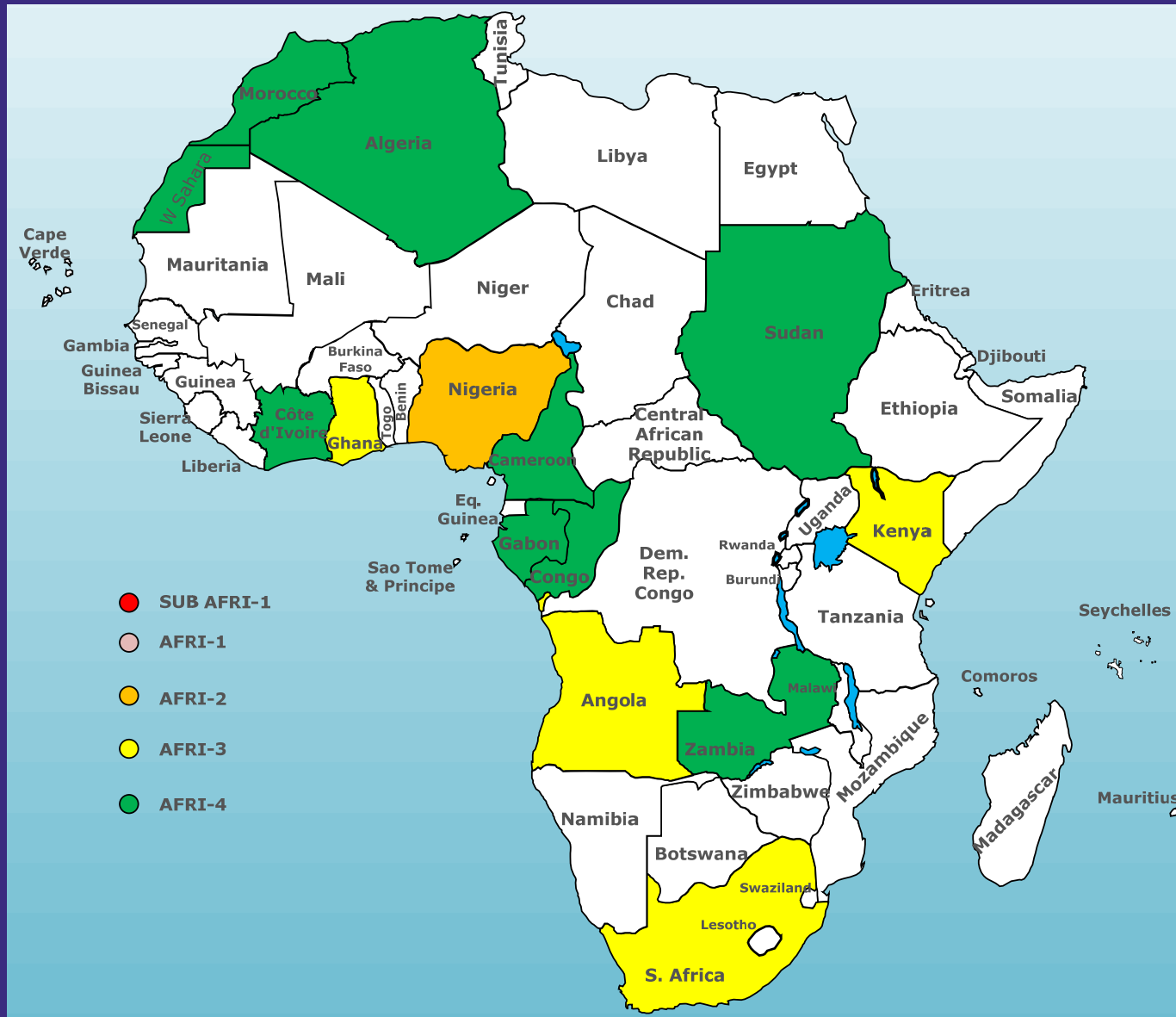
2. Current Situation in Africa: Existing Specifications

Official Sulphur Specs: GASOIL



- How does the **typical** output of African refineries compare with official specifications?

Refinery Output Sulphur Levels: GASOLINE



3. Conclusions

- Tighten official specifications to reflect typical refinery output:
 - Regional harmonisation
 - Prevention of lower-specification imports
 - First step towards improving air quality

THANK YOU FOR YOUR ATTENTION

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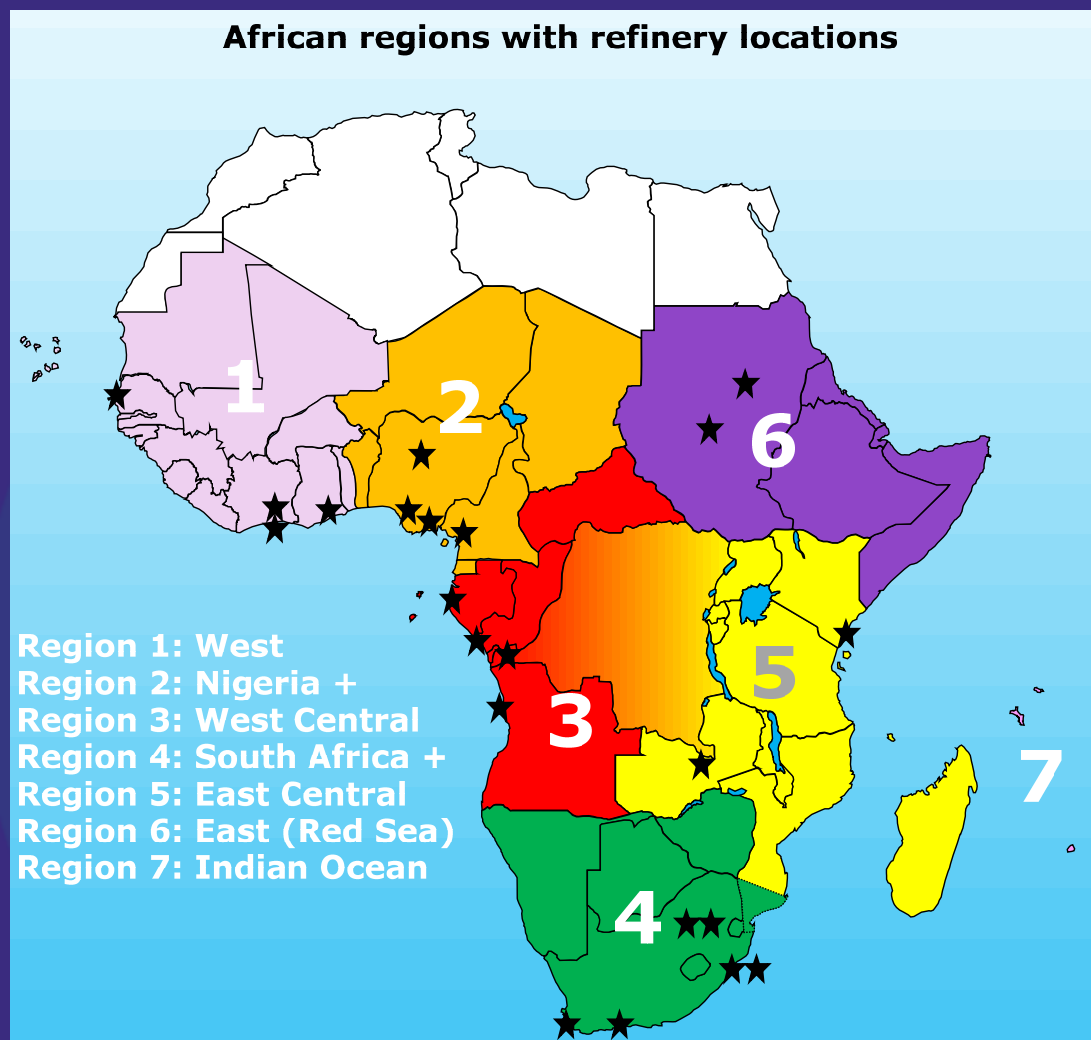
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ANNEX

Study Regions



Mogas Summary (Region 1)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
RON, min	91	91	91	91
MON, min	81	81	81	81
Lead content, g/l max	0.013	0.013	0.013	0.013
Sulphur content, mass %, max	0.1	0.05	0.03	0.015
Benzene content, vol % max	REPORTED	REPORTED	5	1

	SIR – Côte d'Ivoire	SAR - Senegal	TOR - Ghana
RON	91.2		91
MON			
Lead content, g/l	0.001		
Sulphur content, mass %,	nil	0.22	0.022
Benzene content, vol %	3.5		

Mogas Summary (Region 2)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
RON, min	91	91	91	91
MON, min	81	81	81	81
Lead content, g/l max	0.013	0.013	0.013	0.013
Sulphur content, mass %, max	0.1	0.05	0.03	0.015
Benzene content, vol % max	REPORTED	REPORTED	5	1

	NNPC - Nigeria	SoNaRa – Cameroon
RON	88	91.3
MON		
Lead content, g/l	nil	0.00
Sulphur content, mass %,	0.007	
Benzene content, vol %		

Mogas Summary (Region 3)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
RON, min	91	91	91	91
MON, min	81	81	81	81
Lead content, g/l max	0.013	0.013	0.013	0.013
Sulphur content, mass %, max	0.1	0.05	0.03	0.015
Benzene content, vol % max	REPORTED	REPORTED	5	1

	CORAF - Congo	SOGARA - Gabon	SONANGOL - Angola
RON	91.1	91.3	93
MON			
Lead content, g/l	<0.013	0.012	nil
Sulphur content, mass %,	0.01	0.00012	0.023
Benzene content, vol %		“/”	

Mogas Summary (Region 4)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
RON, min	91	91	91	91
MON, min	81	81	81	81
Lead content, g/l max	0.013	0.013	0.013	0.013
Sulphur content, mass %, max	0.1	0.05	0.03	0.015
Benzene content, vol % max	REPORTED	REPORTED	5	1

	Engen - South Africa	Calref – South Africa
RON	96	95.9
MON	85	85
Lead content, g/l	0.002	0.003
Sulphur content, mass %,	0.02	0.0158
Benzene content, vol %	4.48	2.82

Mogas Summary (Region 5)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
RON, min	91	91	91	91
MON, min	81	81	81	81
Lead content, g/l max	0.013	0.013	0.013	0.013
Sulphur content, mass %, max	0.1	0.05	0.03	0.015
Benzene content, vol % max	REPORTED	REPORTED	5	1

	KPRL - Kenya	KPRL - Kenya (imports)	Indeni - Zambia
RON	91.2	93.5	91
MON			
Lead content, g/l	< 0.015	< 0.003	“nil”
Sulphur content, mass %,	<0.02	0.0233	“nil”
Benzene content, vol %			2.73

Mogas Summary (Region 6)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
RON, min	91	91	91	91
MON, min	81	81	81	81
Lead content, g/l max	0.013	0.013	0.013	0.013
Sulphur content, mass %, max	0.1	0.05	0.03	0.015
Benzene content, vol % max	REPORTED	REPORTED	5	1

	KPC - Sudan
RON	92
MON	
Lead content, g/l	0.002
Sulphur content, mass %,	0.003
Benzene content, vol %	



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Gasoil Typicalals

Gasoil Summary (Region 1)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
Sulphur content, mass % max	0.8	0.35	0.05	0.005
Density at 20°C, kg/litre (min/max)	.80/.89	.80/.89	.80/.89	.82/.88
Cetane index (calculated), min	42	45	45	45
Lubricity (HFRR @60°C), micron, min	REPORTED	REPORTED	460	460

	SIR – Côte d'Ivoire	SAR – Senegal	TOR – Ghana
Sulphur content, mass %	0.2	0.1609	0.27
Density, kg/litre	0.8779	0.8704	0.857
Cetane index (calculated)	45.2		52
Lubricity (HFRR @60°C), micron			460

Gasoil Summary (Region 2)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
Sulphur content, mass % max	0.8	0.35	0.05	0.005
Density at 20°C, kg/litre (min/max)	.80/.89	.80/.89	.80/.89	.82/.88
Cetane index (calculated), min	42	45	45	45
Lubricity (HFRR @60°C), micron, min	REPORTED	REPORTED	460	460

	NNPC – Nigeria	SoNaRa - Cameroon
Sulphur content, mass %	0.116	0.11
Density, kg/litre	0.8696	0.862
Cetane index (calculated)	48	50.4
Lubricity (HFRR @60°C), micron		

Gasoil Summary (Region 3)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
Sulphur content, mass % max	0.8	0.35	0.05	0.005
Density at 20°C, kg/litre (min/max)	.80/.89	.80/.89	.80/.89	.82/.88
Cetane index (calculated), min	42	45	45	45
Lubricity (HFRR @60°C), micron, min	REPORTED	REPORTED	460	460

	CORAF – Congo	SOGARA - Gabon	SONANGOL – Angola
Sulphur content, mass %	0.16	0.76	0.148
Density, kg/litre	0.8582	0.8485	0.8508
Cetane index (calculated)	51.7	51.05	
Lubricity (HFRR @60°C), micron			

Gasoil Summary (Region 4)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
Sulphur content, mass % max	0.8	0.35	0.05	0.005
Density at 20°C, kg/litre (min/max)	.80/.89	.80/.89	.80/.89	.82/.88
Cetane index (calculated), min	42	45	45	45
Lubricity (HFRR @60°C), micron, min	REPORTED	REPORTED	460	460

	Engen – South Africa	CALREF – South Africa
Sulphur content, mass %	0.044	0.0198
Density, kg/litre	0.8389	0.8571
Cetane index (calculated)	54	50.1
Lubricity (HFRR @60°C), micron		356

Gasoil Summary (Region 5)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
Sulphur content, mass % max	0.8	0.35	0.05	0.005
Density at 20°C, kg/litre (min/max)	.80/.89	.80/.89	.80/.89	.82/.88
Cetane index (calculated), min	42	45	45	45
Lubricity (HFRR @60°C), micron, min	REPORTED	REPORTED	460	460
	KPRL - Kenya	KPRL - Kenya (Imports)	Indeni - Zambia	
Sulphur content, mass %	0.77	0.168	0.473	
Density, kg/litre	0.8455	0.8476	0.8473	
Cetane index (calculated)	60		55.04	
Lubricity (HFRR @60°C), micron				

Gasoil Summary (Region 6)

	AFRI-1	AFRI-2	AFRI-3	AFRI-4
Sulphur content, mass % max	0.8	0.35	0.05	0.005
Density at 20°C, kg/litre (min/max)	.80/.89	.80/.89	.80/.89	.82/.88
Cetane index (calculated), min	42	45	45	45
Lubricity (HFRR @60°C), micron, min	REPORTED	REPORTED	460	460

	KPC – Sudan
Sulphur content, mass %	0.007
Density, kg/litre	0.8373
Cetane index (calculated)	55
Lubricity (HFRR @60°C), micron	