EGYPTIAN AND INTERNATIONAL AUTOMOTIVE DIESEL FUELS: SPECIFICATIONS MEETING CHALLENGES TO REFINING INDUSTRY

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ABSTRACT:

This paper presents a brief summary and comparison of Egyptian automotive diesel fuel to the international one. Recent legislation all over the world, requiring further reduction in sulfur, aromatics, T_{90} and T_{95} and increasing cetane value of the transportation diesel fuels, presents numerous technical and economic challenges to the refiners. While refiners grapple with these challenges, they will also face pressure from the increased demand of transportation diesel fuel and tighter capital restrictions. Overcome of these challenges makes a fair competition. A comparison of the Egyptian automotive diesel fuel and the international one will be a guide to locally and globally facing these challenges.

Introduction:

This paper compares between Egyptian and international automotive diesel fuels in order to meet new diesel fuel specifications to resolve the engine emissions problems. Such comparison will clear the way towards how to provide Egyptian market by clean and healthy diesel fuels and provide refiners by some valuable information about the projects, they need, to make their diesel fuel friendly to the environment. Also, the paper displays the worldwide and Egyptian demand for diesel fuels during the period 1995–2004 by demonstrating the amount of production and consumption. Such display will give an information about the gap between the two extremes of demand, production and consumption, and the required projects to reduce this gap. Such projects must show its friendliness to the environment. For an instant Gas To Liquid technologies can be used to reduce the mentioned gap.

Environmental drivers:

Until recently, diesel engines and diesel fuels were not scrutinized as severely as gasoline engines and gasoline. However, because of increasing pressure to further reduction the same emissions targeted by the RFG programs, legislators have now turned their attention to the next most-significant transportation fuel source. Another growing worldwide concern is greenhouse gas emission. Governmental commitments for reducing these emissions may influence the demand for diesel-powered vehicles, the composition of diesel fuel, and the design of diesel engine. Because diesel engines generally use less fuel per distance traveled than gasoline-powered engines , they emit lower levels of CO_2, a significant greenhouse gas.

Emissions and Diesel Fuel Properties:

Extensive engine testing of diesel fuels identified several properties ,such as sulfur and aromatics content, that influence emissions. The sulfur in diesel fuel is one of the major contaminants that contribute to the formation of particulates and SO_x in diesel exhaust. Aromatics and polyaromatic hydrocarbons (PAHs) have also been linked to particulate formation. These PAHs as well as fuel density affect ignition temperature, which influences NOx formation. Another important property is cetane value, which is a measure of the ignition properties of diesel and hence the combustion quality of the fuel. Higher cetane value results in better combustion and lower emissions. However, the amount of improvement depends on diesel engine design and the load applied to the engine. Emissions from modern engines have a lower sensitivity to changes in cetane value. Distillation temperature also influence emissions. A high 90 or 95 % point can increase the quantity of unburned hydrocarbons and the level of particulates emitted.

Legislation:

The first major change in diesel fuels was the reduction in sulfur levels. In 1993 the United States reduced sulfur level to 500 wppm, and Europe followed in 1996. Since then ,this sulfur limit in diesel fuel has been adopted by many other regions of the world. California, Finland, and Sweden have specifications for other diesel properties that are more stringent than those in the rest of the world. Even more changes in diesel composition and engine design will occur as countries lower the allowable emission from diesel transportation vehicles.

Unlike in Europe and the United States ,diesel specifications in other areas of the world will be influenced, at least for the short term, by a strong growth in product demand. This situation is particularly true in Egypt, India, China, other countries of the Asia-Pacific region , Russia and the Central Asian & Baltic republics. In the long term, environmental pressure and a global perspective will lead to improved quality specification in these areas as well.

Comparison specifications:

Diesel specification in Egypt, USA, Europe, Japan, India and China are compared in Table (1). United states has provided a process for qualifying an alternative fuel, and these alternatives have higher cetane number (55 to 59) and lower sulfur (33 to 20 wppm) but higher aromatics (15 to 25 % vol.). Many of these alternative formulations are made from hydro-cracked diesel. The EMA proposal for premium diesel focuses on higher cetane (50 cetane number and 45 cetane index). Also included in the proposal are recommendations for detergency, lubricity, and low-temperature flow properties. A comparison of Egyptian diesel fuel to others show that Egyptian diesel fuels approaches the specifications of the international diesel fuels except in one item; sulfur content (1 wt%). Actually this percent ranges from 0.18 to 0.97 according to the type of crude as demonstrated in Table (2).

Solutions for meeting diesel specifications and demand:

Various solutions affect the quality and availability of diesel fuel: they range from simple solutions such as re-fractionating products or adding cetane improvers to more complex solutions such as hydro-processing. The critical hydro-processing technologies for making high quality blend stocks, such as LCO, include conventional hydro-treating, hydro-cracking, and aromatics saturation. The options available for meeting sulfur, cetane, aromatics, and distillation specifications. Sulfur specifications are being reduced around the world (Table 1). Meeting these low targets requires the full use and possible modification of existing de-sulfurization units. Some refiners may find that new high pressure de-sulfurization hydro-treaters are required as well. Operating or process modifications will be required to meet the changing objectives for product quality resulting from legislation already discussed. Choosing the best solution for complying with the legislation is complicated by another constraint: increasing demand. Although, the specifics of supply and demand for various global regions are different, the demand for distillate fuels, especially jet and transportation diesel, is increasing in a faster rate than for any other fuel.

Diesel Demand:

Diesel fuel is used primarily for the transportation of goods. Allover Egypt diesel fuel is marketed according to Fig.1. However, in Europe, Japan, and elsewhere, diesel is a significant source of energy for automotive transportation. The demand for diesel is forecasted to grow faster than the demand of energy in general. In Europe, the demand is expected to increase the same time that gas oil use in higher-sulfur heating oil and in fuel oil decreases. The change in relative demands results in additional blend stock being available for diesel production; however, its quality is no sufficient to meet standards. Much of this increased diesel demand can be traced to the greater efficiency of diesel high-compression engines compared with gasoline engines and to a favorable tax structure. Worldwide demand growth for diesel fuel is shown in Fig.(2). Projected rates vary from a low of 1% per year for Japan to higher of 6% per year for china . both of these countries are included in the Asia-Pacific data. The growth rate in the remaining regions is in the range of 1 to 3% per year.

It is shown in Fig.3 that the gap between consumption and production of demand growth for the Egyptian diesel fuel increases from year to year, where it equals about 2.838 MMTPY by the year 2004 and it is expected to be 3.177 MMTPY by the year 2005. Fig.4 shows that the international price of diesel fuel increase directly from the year 2002 up till now and it is clear from Figs.3,4 that the gap (which is evaluated as US dollars in Fig.5) between consumption and production increases due to the decrease of the quantity of crude oil as shown in Fig.6. In view of this situation, it is clear that new technologies such as Gas To Liquid technology (GTL) must be introduced to reduce the gap between consumption and production, knowing that the expenditures for importing diesel fuel during the year 2004 exceeds the capital investment of a GTL plant of capacity 34000 BBLS/D, from which 72% is a diesel fuel.

Meeting Diesel Demand:

Refiners have several means available for increasing diesel production to meet growing worldwide demand (Fig.2). Purchasing a crude slate that is higher in diesel–boiling–Range material is one option. However, this option may result in higher feedstock costs and a less- flexible operation. No matter what the crude slate, crude and product distillation towers should be optimized to recover distillate. If blend stocks are derived from other blending pools. They will probably need upgrading to meet the required quality> Another option is to exchange or purchase outside blend stocks within a region or a company. This option may prove advantageous because refiners can optimize their unit operations or product blending. New capacity for heavy gas oil conversion is required if incremental processing and optimization do not reach the required goals. The best method for maximizing high-quality diesel production is adding new or incremental hydro-cracking capacity, which can come from a dedicated fuels hydro-cracking unit or a partial–conversion unit that feeds an FCC unit, ethylene plant, or lube-oil complex. Another option is modifying the FCC operation toward a maximum distillate mode. The additional LCO from the GCC unit can be upgraded in a combined de-sulfurization and aromatics saturation unit or in a hydro-cracking unit.

Refining Industry Situation:

Because of more-stringent specifications and increased demands, refiners will have difficulty meeting diesel quality and quantity requirements. Consequently, they will need to use combinations of de-sulfurization, aromatics saturation, catalytic de-waxing, selective ring opening, and hydro-cracking to convert existing refinery streams into high-quality diesel. Determining which processing approach to adopt is case specific; that is, the approach depends on the refinery's crude slate, equipment, and overall processing strategy. Another difficulty is recovering the capital expenditures required to meet future fuels specifications. Strong competition in the industry has resulted in low operating margins. Refinery economics will vary from region to region. The public may or may not be willing to accept price increase to achieve environmental goals. The degree of incremental processing required determines the level of capital required.

Alternative Fuels:

Two nontraditional materials can be used as blend stocks for diesel fuel or used directly as fuel in the diesel engine. The first is synthetic distillates produced from natural gas (or potentially from other carbon sources) through Fischer- Tropsch (FT) chemistry, and the second is bio-diesel. The economics of FT technologies depend on the availability of natural gas, its price, and the ease of getting it to market. The syncrude produced from FT is essentially free of sulfur, aromatics, and contaminants. The diesel portion has a cetane number greater than 75. Bio-diesel is produced by a simple process known as trans-esterification, which involves reacting natural vegetable or animal oils with a short-chain alcohol. Because it is biodegradable and nontoxic, biodiesel is particularly attractive for environmentally sensitive areas, such as inland waterways and national parks, and for use in city buses, At current vegetable oil prices, a 20% blend of biodiesel and petroleum diesel would cost 60 to 80 cents per gallon more than petroleum diesel alone.

Conclusion:

In view of the our paper, it is clear that there is a remarkable decrease in crude oil quantity and increase in consumption of diesel fuel, where the produced diesel fuel is totally consumed in the local market. The main consumer to diesel fuel is the transportation sector. Also, it is clear that there is gap between production and consumption which is covered by importation. So, there is release in the sulfur content of the Egyptian standard specification to maximize production and to lower the price. Maximizing the utility of existing assets is a high priority because the refiner can reduce investment costs. In addition, refiners will be seeking low-cost, innovative solutions to produce these new high-quality diesel fuels economically. Each potential solution needs to be locally optimized to determine the most-economical route. Because of timing uncertainty, flexible options and staged investments will have value in managing the financial burden and risks.

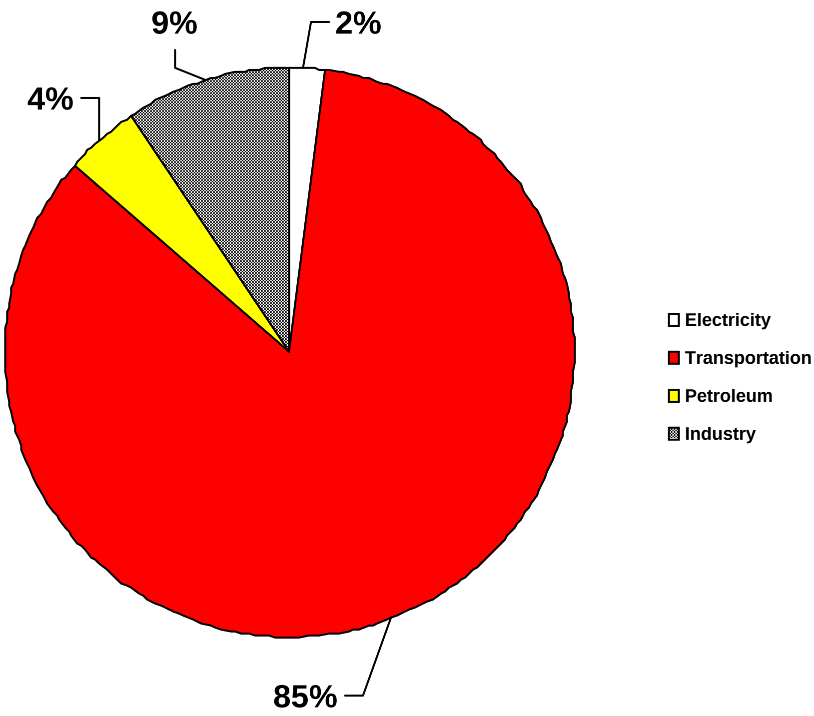

Fig.1 Different sectors cnsuming diesel fuel

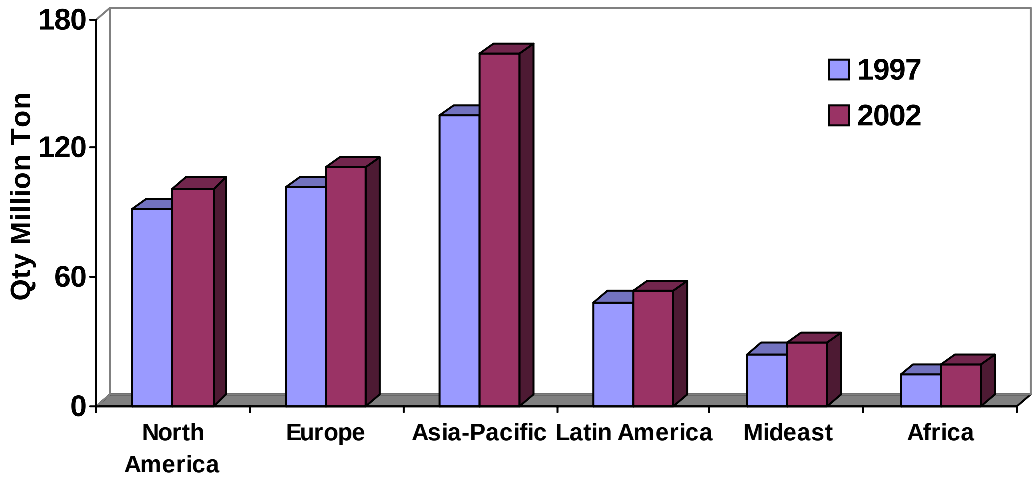

Fig.2 Worldwide demand for diesel fuel.

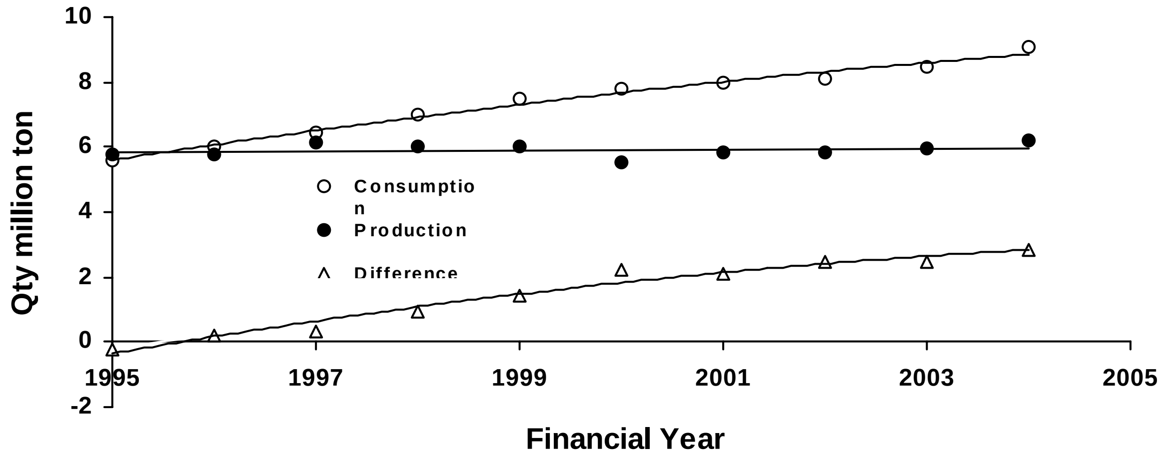

Fig.3. Demand growth for Egyptian diesel fuel.

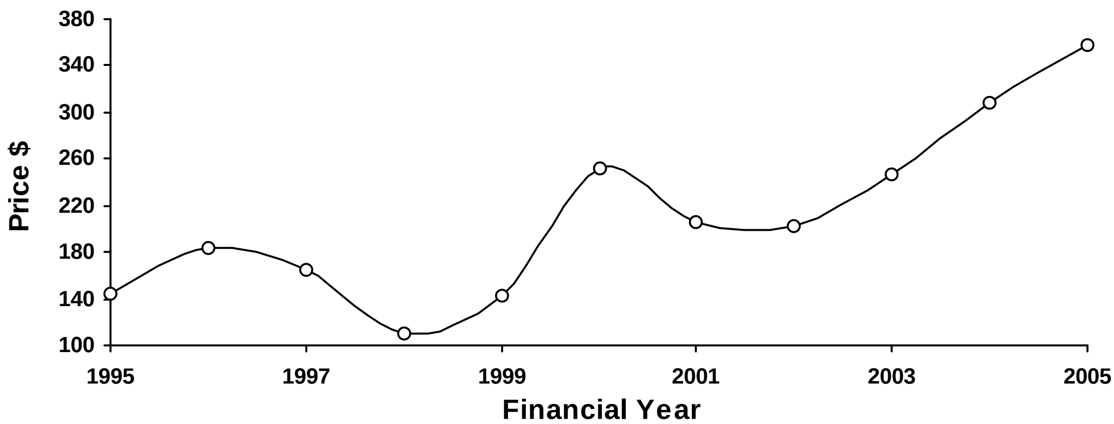

Fig.4. Average price of diesel fuel.

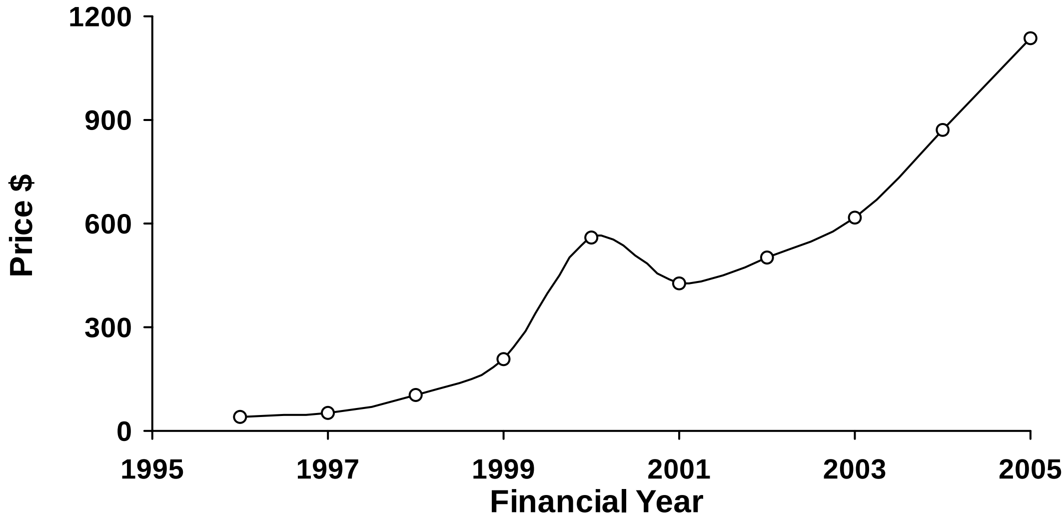

Fig.5. Total expenditures of importing diesel fuel.

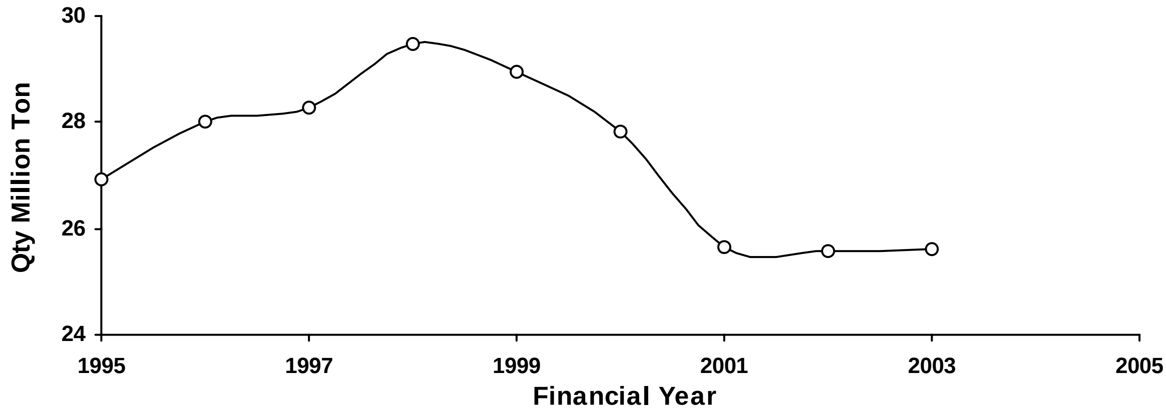

Fig.6. Crude oil production.

Table (1)

Property	Unit	ASTM D 975	EN 590	JIS K 2204	Indian 1460	Chinese GB252	ESS 16
Color (ASTM)		--------	--------	-------	-------	3.5	4 max
Cetane number		40 min	51 min	-------	48 min	45 min	-------
Cetane index		--------	46 min	50 min	-------	-------	46 min
Density at 15^oC	kg/m^3	--------	820 – 845	-------	820 – 870	Report	820 – 870
Polycyclic aromatic hydrocarbons	% (m/m)	--------	11 max	-------	-------	-------	-------
Sulfur content	% (m/m)	0.05 max	0.035 max	0.05 max	0.25 max	Supper 0.2; Premium 0.5; Regular 1	1 max
Flash point (P.M.C)	^oC	52 min	above 55	50 min	35 min (Abel)	65	55 min
Carbon residue (on 10% distillation residue)	% (m/m)	0.35 max	0.3 max	0.1 max	0.3 max	0.3	0.1 max
Ash content	% (m/m)	0.01 max	0.01 max	-------	0.01 max	0.01 max	0.01 max
Water content	mg/kg	0.05 max	200 max	-------	0.05 max	Trace	1000 max
Total contamination	mg/kg		24 max	-------	-------	-------	
Copper strip corrosion (3h at 50^oC)	rating	< class 3	class 1	-------	class 1	class 1	class 1
Oxidation stability	g/m^3	--------	25 max	-------	-------	2 mg/100 ml for Premium	-------
Lubricity, corrected wear scar diameter (wsd 1,4) at 60^oC	µm	--------	460 max	-------	-------	-------	-------
Kinematic viscosity at 40^oC	mm^2/s	1.9 – 4.1	2 – 4.5	2.7 min	2 – 5	3 – 8	1.6 – 7
Pour point	^oC	--------	-------	+5 max	-------	-------	***
Cold filter plugging point	^oC	--------	**	-------	6 max in winter 18 max in summer	****	-------
Gross calorific value	Mj/ kg	--------	--------	--------	--------		44.3 min
Distillation							
% (V/V) recovered at 250^oC	% (V/V)	--------	< 65	-------	--------		--------
% (V/V) recovered at 350^oC	% (V/V)	--------	85 min	-------	85 min		85 min
90 % (V/V) recovered at	^oC	282 – 338	-------	360 max	--------		-------
95 % (V/V) recovered at	^oC	--------	360 min	-------	370 min		-------

* ESS; means Egyptian Standard Specification

** For climate dependent requirements options are given to allow for seasonal grades to be set nationally. The options are for temperate climates six CFPP as follow :

Grade A	Grade B	Grade C	Grade D	Grade E	Grade F
+5	0	-5	-10	-15	-20
**** Brand 10	Brand 0	Brand -10	Brand -20	Brand -35	Brand -50
12	4	-5	-14	-29	-44

*** 3 For Dec. to Mar.; 9 for April, May, Oct., and Nov.; 15 for June to Sept.

Table (2): AVERAGE ANALYSIS FOR GAS OIL DURING JULY 2003 - JUNE 2004

COMPANY / TEST		CAIRO OIL	TANTA PET.	SUEZ PET.	NASR PET.	ASSUIT PET.	ALEX. PET.	AMERIYA PET.
DENSITY @ 15 ^{O}C	KG/L	0.8284	0.8338	0.8465	0.8336	0.8403	0.8424	0.8414
COLOR		1.0	1.4	2.2	2.2	2.5	1.7	1.6
FLASH POINT	^{O}C	69.7	66.0	68.9	65.7	64.0	62.9	62.2
KINEMATIC VISCOSITY @ 40 ^{O}C	CST	2.44	--	--	--	--	--	3.24
REDWOOD VISCOSITY @ 40 ^{O}C	SEC	32.37	36.80	33.86	31.91	36.25	33.90	--
* POUR POINT :	^{O}C							
FOR: OCTOBER , NOV. , JAN. , FEB., MAR.		1.20	4	-2	-4.08	0.00	3.75	4
FOR: APRIL , SEPT.		4	7.5	0	-4.55	0	4.5	12
FOR: MAY , JUNE , JULY , AUG.		1	10.5	0	-5.2	0	6	9
WATER CONTENT	% VOL.	NIL	--	0.006	0.05	--	--	--
SEDIMENTS	% WT.	NIL	--	--	0.004	--	--	--
WATER AND SEDIMENTS	% VOL.	NIL	NIL	--	--	NIL	NIL	0.05
ASH CONTENT	% WT.	NIL	NIL	NIL	0.007	NIL	NIL	NIL
CONR. CARBON RES. (@ 10 % RES.)	% WT.	0.020	0.014	0.031	0.024	0.064	0.013	0.200
TOTAL SULPHUR	% WT.	0.325	0.180	0.804	0.969	0.855	0.463	0.409
COPPER STRIP CORROSION @ 100 ^{O}C		NO CHANGE	DIV.1	DIV.1	DIV.1	DIV.1	DIV.1	DIV.1
INORGANIC ACIDITY & ALK.		NIL	NIL	NIL	NIL	--	NIL	NIL
DISTILLATE @ 350 @ ^{O}C	% VOL.	95.9	92.1	89.1	93.6	91.8	91.1	91.1
CETANE INDEX		53.3	54.7	--	--	53.7	--	52.0
GROSS CALORIFIC VALUE	MJ/KG	46.03	45.80	45.60	--	--	--	45.50
GROSS CALORIFIC VALUE	K CAL/KG	--	--	10893	10941	--	--	--

PERCENTAGE OF SHARING IN PRODUCTION	13.069	9.053	13.956	18.292	9.547	19.327	16.756

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