Impact of lead phasedown on Saudi refineries

Saudi Arabia's refineries add the maximum allowable lead to their gasoline production. Reversal of this, though time-consuming, will benefit the entire Kingdom

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MANY COUNTRIES have been forced to reduce the lead content in their gasoline due to its negative environmental impact. In the United States, the environmental protection agency (EPA) ordered reductions in gasoline lead content to 0.45 gm/liter in 1973. In 1980, the average lead content was reduced further to 0.13 gm/liter. Unleaded gasoline officially was required to be available to the U.S. market from mid-1974. Then, in early 1985, the EPA announced the following schedule for further reductions of lead content:

- July 1985, 0.13 grams per liter
- January 1985, 0.03 grams per liter
- January 1988, 0.01 grams per liter.

By 1990, lead will be eliminated from all U.S. gasoline.[1]

In Japan, since 1975, the lead content regulations of gasoline have been as follows:

- Premium gasoline—maximum lead content of 0.31 gm/liter
- Regular gasoline—maximum of 0.02 gm/liter.

In Western Europe, the lead content of gasoline was reduced to 0.4 gm/liter by Jan. 1, 1986, and will be reduced to 0.15 by 1990. Unleaded gasoline currently is available throughout Europe and especially in Germany, the leader in antipollution control.

Most industrialized countries have taken actions to reduce the lead content of gasoline or to switch completely to unleaded gasoline. Gasoline-powered automobiles are considered the major source of lead in the atmosphere. Therefore, by reducing gasoline lead content, airborne lead emissions can be reduced.

To control the other automobile emissions such as unburned hydrocarbons, carbon monoxide and nitrogen oxides, lead must be completely eliminated from gasoline. To date, all catalysts used for this purpose are intolerant to lead.

MEETING THE LEAD PHASEDOWN

The reduction of lead content in gasoline will increase octane requirements to maintain the current production rate and quality of gasoline. The following options can be used to deal with the octane shortage resulting from the reduction in lead content of gasoline[2]:

- Increase reforming severity
- Increase aromatic blending
- Increase oxygenate blending such as MTBE.

The selection among these does not involve any extra capital investment. These process options are suitable at the lead elimination stage.

Examples. In Saudi Arabia's Riyadh refinery, the current gasoline pool consists of light straight run naphtha, light isomaxate from hydrocracking and platformate. The average lead content is 0.30 gm/liter. By increasing the severity to maximum, the average lead level is reduced to 0.20 gm/liter. A further lead level can be obtained by replacement of the existing reformer catalyst, R15, with catalyst of a greater capacity, R62. The average lead level then would be 0.09 gm/liter.

The gasoline pool at Ras Tanura refinery consists of pentanes, light and medium straight run naphtha and reformate from a Rheniformer. Currently, the refinery produces premium gasoline at 0.84 gm/liter lead content with the Rheniformer operating at minimum severity 92.5 RON. By increasing the Rheniformer severity to the maximum to produce 98 RON, lead content can be reduced to 0.60 gm/liter. The addition of 4,300 bpd of MTBE reduces the lead level to 0.42 gm/liter. Further reduction in lead content requires new process investments such as recycle isomerization of light naphtha.

The Yanbu refinery manufactures premium gasoline with 0.49 gm/liter lead level using light straight run naphtha and platformate derived from medium and heavy straight run naphtha feed. The reformer operates at the minimum severity of 92 RON. By increasing the reformer severity to the maximum 96 RON, lead level is reduced to 0.21 gm/liter. Replacement of the current reformer catalyst will allow further reduction of the gasoline lead content to 0.15 gm/liter.

In the Jeddah refinery, only regular gasoline of 0.84 gm/liter lead content is produced. The existing gasoline pool consists of light naphtha, platformate from the reforming of heavy naphtha and FCC gasoline. Increasing the reformer severity to the maximum can reduce the lead level to 0.74 gm/liter. A further reduction to 0.54 can be achieved by the catalyst replacement. The use of 1,700 bpd of MTBE will allow a reduction of lead level to 0.28 gm/liter. A reduction

TABLE 1—Capacity of Saudi refineries to reduce lead content

	Lead content, gm/liter		
	Current	Operational changes	With MTBE blending
Ras Tanura	0.84	0.60	0.42
Jeddah	0.84	0.74	0.28
Riyadh	0.30	0.10	–
Yanbu	0.49	0.15	0.12
Total	0.61	0.37	0.25

TABLE 2—Maximum permitted lead content of gasoline in different countries, Feb. 1983

	Lead content (grams/liter)
Austria	0.40 premium
	0.15 regular
Canada	0.77
Finland	0.40
New Zealand	0.84
	0.45 from 1984
Norway	0.40 premium
	0.15 regular
Portugal	0.64
South Africa	0.84
Spain	0.65 98 RON
	0.60 96 RON
	0.48 90 RON
Sweden	0.15
Switzerland	0.15
Yugoslavia	0.60

Source: Worldwide Survey of Motor Gasoline Quality, The Associated Octel Co. Ltd., 1984

to 0.15 gm/liter can be met by investment in a new continuous reformate and a new associated naphtha hydrotreater.

The capabilities of these refineries for the reduction of lead content in gasoline are shown in Table 1. Lead content of Saudi Arabian refineries can be reduced to 0.37 gm/liter without any investment or purchase of outside feedstock. A further reduction in lead content to 0.25 gm/liter can be achieved by blending MTBE.

UP CLOSE: SAUDI PERSPECTIVE

Most of the gasoline produced in Saudi Arabia is used as automobile fuel. It is produced in two grades, regular and premium, with no low-lead or non-leaded gasoline currently under production. The principal difference between the regular and premium gasoline is the antiknock performance. As high as 0.84 gm/liter of the octane enhancer, tetra ethyl lead (TEL) is added to the gasoline. This is considered high as compared with the rate used by other countries (Table 2).

TABLE 3—Growth in vehicles operating in Saudi Arabia from 1973 to 1983

	1973	1983
Private cars	112,115	1,167,406
Commercial vehicles	92,078	958,452
Taxis	18,328	14,380
Buses	5,959	14,667
Total	228,481	2,154,905
Estimated gasoline burning vehicles	190,756	1,769,324

Source: Statistical Year Book 1985, Kingdom of Saudi Arabia

As a result of the fast growth of vehicle use in Saudi Arabia (Table 3), ambient airborne lead level at traffic locations has exceeded both the EPA and the EEC air quality standards and directions for lead pollution. It is expected that a rapid phasedown of lead will take place in the Kingdom.

Lead toxicity. Many elements are beneficial or even essential to human health in trace amounts, e.g., calcium, sodium, potasium, iodine and magnesium. Lead, however, is toxic. About 47% of atmospheric lead is caused by gasoline additives, and gasoline combustion accounts for 94.8% of lead emission (Tables 4 and 5)[3].

As mentioned before, lead alkyls are used in the refinery in the manufacturing of gasoline as an octane number enhancer. They provide the least expensive way to increase

TABLE 4—Sources of environmental lead in U.S., 1970

Source	% Pb introduced annually
Pigments	16
Gasoline additives	47
Ammunition	12
Metal	5
Solder	10
Batteries	10

Source: Environmental Studies Program, Progress Report, University of Illinois at Urbama, U.S.A., 1971

TABLE 5—Sources of emission of lead to the atmosphere

Source	Percentage
Lead smelters	0.50
Industry	2.00
Lead alkyl manufacturing	0.43
Fuel combustion	0.50
Crankcase oil	1.60
Municipal refuse	0.15
Gasoline handling	0.02
Gasoline combustion	94.80
Total	100.00

Source: Ref.[3]

the octane rating of the gasoline. Since some Saudi-produced gasoline has a lead content of 0.84 gm/liter, about 10,000 tons of lead are combusted annually. Based on this figure of 0.84 gm/liter, an automobile traveling at 100 km/h and consuming one gallon of fuel every 24 kilometers may exhaust in excess of 2,000 micrograms of lead every second.

Abdominal cramps, headaches, constipation, loss of appetite, fatigue, anemia and motor-nerve paralysis are results of lead compounds inhalation.[4]

Children are more susceptible to lead intoxication than adults. For them, lead poisoning is a major source of brain damage, mental deficiency and serious behavior problems.[5]

TABLE 6—Lead content in Saudi Arabia refineries

Refinery	Production (thousand barrels/day)	Current lead content (grams/liter)
Ras Tanura	64.9	0.84
Jeddah	13.6	0.84
Riyadh	43.4	0.30
Yanbu	37.6	0.49
Total	159.5	0.60

TABLE 7—Average composition of gasoline of Saudi refineries, vol %

	Jeddah	Ras Tanura	Riyadh		Yanbu
	(Regular)	(Premium)	(Premium)	(Regular)	(Premium)
Pentanes	–	10	–	–	–
Light naphtha	50	9	2	48	21
Medium naphtha	12	8	–	–	–
Light hydrocrackate	–	–	20	–	–
Reformate	13	70	76	52	77
GCC gasoline	22	–	–	–	–
Butanes	3	3	2	–	2
Total	100	100	100	100	100

Refineries' present status. The four domestic refineries in Saudi Arabia currently produce gasoline that has an average lead level of 0.6 grams per liter (Table 6). Table 7 gives the average composition of gasoline produced in Saudi Arabia's refineries. It can be seen that the light naphtha and reformate exist in significant volumes. These can be upgraded in

order to improve the octane level.

About 70% of isobutylene feedstock derives from the catalytic cracking of ethylene, and 27% from the ethylene plant byproduct. Isobutylene is used in the manufacturing of methyl tertiary butyl ether (MTBE). The future increase of MTBE production depends upon the following:

- Octane requirements in automobiles
- Level of lead in the environment
- The demand for gasoline
- Refineries' capabilities.

MTBE is used primarily as an octane booster. It is an excellent gasoline component for several reasons:

- It has a high octane number
- It improves the engine efficiency of automobiles in the low speed acceleration phase
- It is unaffected by the level of lead alkyls.

As 10 to 15% by volume of MTBE can be blended with gasoline without a loss in engine efficiency, the addition of MTBE is a more flexible alternative than modification of the refinery processes.[6]

CONCLUSION

The reduction of the average lead level from 0.60 to 0.37 gm/liter has a considerable environmental gain.

Currently, 93.4 RON gasoline has satisfied 92% of the present vehicle fleet, and 99.5% are satisfied with 95.5 RON.[7] It is desirable to have automobiles that operate at lower octane ratings. When 99% of the vehicle fleet are satisfied by 91 RON gasoline, a shift to a new process alternative in the reduction of lead content in the gasoline can be considered.

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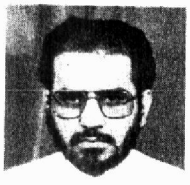

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