THE INFLUENCE OF OLEFIN CONTENT IN GASOLINE AGAINST DEPOSIT BUILD UP ON INTAKE VALVE OF MOTOR BIKE ENGINE

By: **Nur Ahadiat**[1)], and **Djainuddin Semar**[1)]
(Researcher[1)] at "LEMIGAS" R & D Centre for Oil and Gas Technology)
Jl. Ciledug Raya Kav. 109, Cipulir, Kebayoran Lama, Jakarta Selatan 12230, Indonesia
Tromol Pos: 6022/KBYB-Jakarta 12120, Telephone: 62-21-7394422, Faxsimile: 62-21-7246150
First Registered on 15 Maret 2010; Received after Corection on 26 Maret 2010;
Publication Approval on : 31 May 2010

ABSTRACT

The specification of gasoline 91, according to Dirjen Migas decree No. 3674 K/24/ DJM/2006 dated March,17 2006 define the limit (maximum) of aromatic content 50% volume, and benzene 5.0% volume, but does not define boundary for olefin content as its is regulated in others countries. Olefin compound happened to be saturated hydrocarbon, its has higher octane number, unstable, produces gum that later on could build up as deposit on intake valve of combustion chamber or nozzle tip of fuel injection system.

The objective of this study was to know how far the influence of olefin content in gasoline 91 to deposit build-up in intake valve of motor bike engine after cruising on road test for certain distance. For this purpose, the motor bike will be fueled with gasoline 91 with olefin content variations and will be compared to motor bike that cruised at the same route and distance accumulation with regular gasoline 91.

Effect of several volume variety of olefin content in gasoline againts deposit development of intake valve engine will be discuss in this paper.

***Key words**: Olefin, deposit and emission*

I. INTRODUCTION

A. *Background*

Generally gasoline's specification focus on limitation of aromatic content, benzene and olefin, reducing sulfur content, use of additive that causes no harm to engine components and environment. TEL (Tetra Ethyl Lead) phase out as octane booster and its replacement by HOMC (High Octane Mogas Component), unfortunately caused higher content of aromatic, benzene and olefin in gasoline. The ascend of hydrocarbon content in gasoline unfortunately not only rose up gasoline's octane number, but also it heightens the threat to environment and gave bad influence to engine components. So to protect the environment and engine parts, in ASEAN countries, such as Malaysia and Thailand they gave restriction of aromatic, benzene and olefin content on their gasoline's specification like in Japan, China, Europe and USA.

B. *Methodology*

The methodology used in this study of "The influence of olefin content in gasoline against deposit build up on intake valve of 4 strokes motor bike engine" is as follow.

Bensin 91 sample is taken from Gas Station in certain amount enough for this test purpose, than labeled as B0-0 and tested according to its specification as decreed by Dirjen Migas No. 3674 K/24/DJM/ 2006 dated March 17, 2006. Some of B0-0 is blended with gasoline component that has higher olefin labeled as B0-1, such that, the olefin content of B0-1>B0-0, then B0-2 that consists of B0-0 mixed with gasoline's component that has higher olefin such that, olefin content of B0-2 > B0-1. The motor bike run used those three gasoline modifications as described in Figure 2 and deposit build up in intake and outtake valve B0-1 and B0-2 are compared with B0-0.

LEMIGAS SCIENTIFIC CONTRIBUTIONS
VOL. 33. NO. 1, MAY 2010 : 52 - 58

II. MATERIALS

Before making gasoline modification as test fuel in motor bike, there are several things that should be taken care of such as; octane number requirement and olefin content in the test fuel.

The purpose of test fuel formulation is it to know how far the changes of olefin content in gasoline affects its research octane number (RON) and other properties of gasoline's such as; volatility (distillations and Reid vapor pressure), stability, corrosiveness that should comply with specification of Bensin 91 decreed by Dirjen Migas No. 3674 K/24/DJM/2006 dated March 17, 2006.

In this study, Bensin 91 (B0-0) mixed with gasoline component that it has different olefin content from Bensin 91 in such a manner to make BO-1 and BO-2 formulation. Accordance with the purpose of properties test and road test on motor bike, there are three kinds of fuels that should be prepared i.e.:

1. B0-0; Bensin 91 from gas station that has minimum RON 91.3 and other properties in accordance with Bensin 91 specification.
2. B0-1; B0-0 blended with gasoline component that has higher olefin, so that the olefin content of B0-1 > B0-1. B0-1 has RON 91.5 and is physical and chemical properties conform with bensin 91 specification.
3. B0-2; B0-1 blended with gasoline component that has higher olefin content, so that the olefin content of B0-2 > B0-1. B0-2 has RON 91.6 and is physical and chemical properties comply with Bensin 91 specification.

III. EXPERIMENTAL APPARATUS AND PROCEDURES

A. *Apparatus*

The motor bike used in this experiment was a single cylinder four stroke engine, details data of motor bike are tabulated in Table 1, and the test Motor Bike are shown in Figure 1.

Before conducting road test, firstly the motor bike was reconditioned, to fit manufacture standard condition program to make it's ready for road test as follows;

- Conducting technical's verification according user guide manual from manufacture. All requirements specified should be comply with the user guide manual, therfore all motor bike equipments were fit and secure to manufacture standard recomendations.
- Recondition and fixation motor bike test execute to the parts of engine that connected to the result of this research, such as fuels and produce of combustion.
- Preceding road test, the fuel tank of motor bike

Figure 1
Test Motor Bike

Table 1
Technical Specifications of Motor Bike

No.	Discriptions	Technical Specifications
1	Fuel Capacity	3,7 liter
2	Engine Type	4 Strokes, OHC, Air Cooling
3	Diameter X Stroke	52,4 X 57,9 mm
4	Stroke Volume	124,9 cc
5	Compression Ratio	9,0 : 1
6	Power Max.	9,3 PS/7500 rpm
7	Torque Max	1,03 kgf/4000 rpm
8	Lube Oil Capacity	0,7 liter at periodical changes
9	Clutch Type	Doble, Automatice, Centrífugal, Wet Type
10	Transmission Gears	4 Speeds
11	Gear Sequence	N – 1 – 2 – 3 – 4 – N system rotary
12	Starter	Kick Starter and Electric.
13	Tare Weight	98,6 kg

LEMIGAS SCIENTIFIC CONTRIBUTIONS
VOL. 33. NO. 1, MAY 2010 : 52 - 58

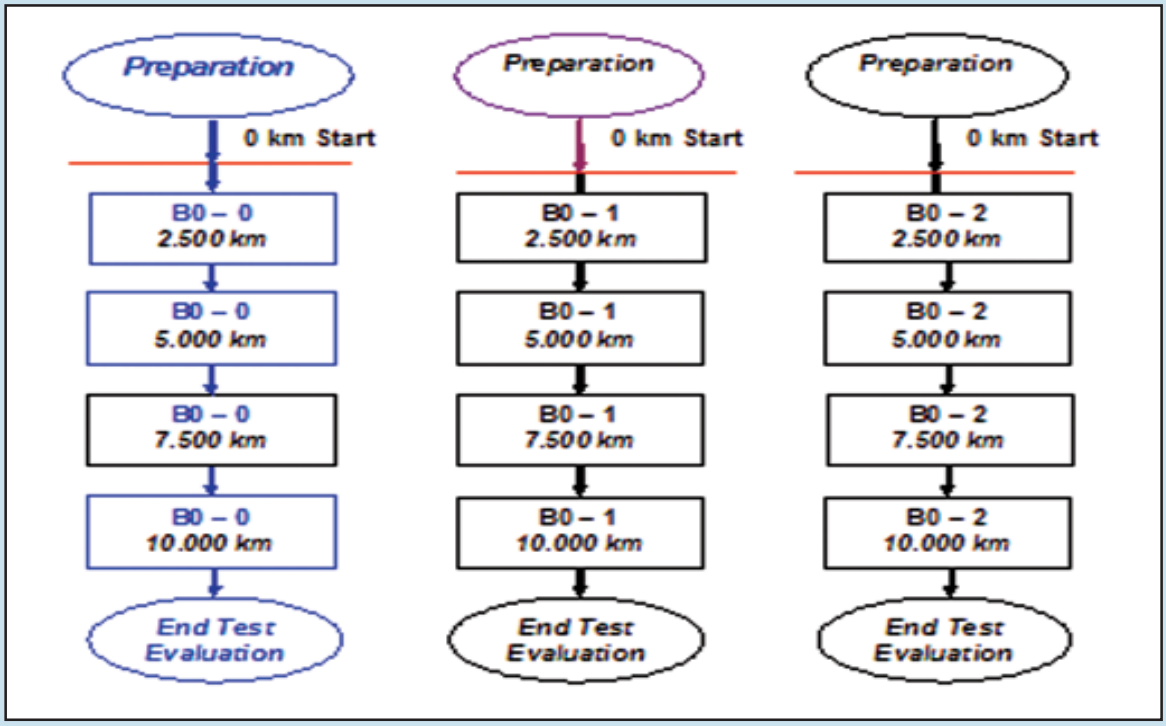


Figure 2
Road test procedure scheme using test fuel B0-0, Bo-1 and B0-2

Table 2
Test result chemical/physical properties of samples PO, B0-1 and B0-2 compare to bensin 91 specifications

Caracteristics	Test result			Bensin 91 specification		*Test method ASTM*
	B0-0	B0-1	B0-2	Min.	Max.	
Research octane number	91,3	91,5	91,6	91,0	-	D 2699
Oxidation stability, minute	> 480	> 480	> 480	480	-	D 525
Olefin content, % vol.	21,60	27,60	33,65	-	-	D 1319
Aromatic content, % vol.	36,04	35,80	35,70	-	50,0	D 1319
Benzene content, % vol.	0,20	0,20	0,20	-	5,0	D 4420
Distillation :						D 86
- 10% vol. Evaporate, ^{o}C	48,0	50,0	55,0	-	70	
- 50% vol. Evaporate, ^{o}C	85,0	90,0	92,5	77	110	
- 90% vol. Evaporate, ^{o}C	162,0	165,0	168,0	130	180	
- End point, ^{o}C	205	206,0	206,5	-	215	
- Residue, % ^{o}C	1,0	1,0	1,0	-	2,0	
- Raid vapor pressure, kPa	60,0	60,5	61,5	45	60	D 323
- Density a15 ^{o}C, kg/m^{3}	735	735	734	715	770	D1298
- CopperStrip Corrosion, merit	1a	1a	1a		negative	D 130

washed out, than refilled with gasoline B0-0, B0-1 and B0-2 according to road test schedule in Figure 1. At the same time, fuel filter, lube oil filter and lube oil were replaced with the fresh filter and fresh lube oil accordingly.

- Recondition and replacement of all engine parts of motor bike test was conducted and confirm strictly to motor bike manufacture guidance and comply with technical specification of the motor bike without any special modification.

B. *Procedures*

1. Fuel Properties

The reference gasoline B0-0 and modified gasoline B0-1, B0-2 were subjected to properties test such as research octane number, stability, oxidation, Reid vapor pressure, distillation (10%, 50% 90% vapor volume, end Point and residue), its hydrocarbon content (aromatic, benzene and olefin), doctor test and corrosion test. Test methods comply with those methods explained in Bensin 91 specification that is shown in Table 2 that included properties test results from B0-1 and B0-2.

2. Road Test

The objective of this study is to know how far the influence of percentage amount of olefin content in gasoline 91 due to deposit built-up and cleanliness of intake valve of motor bike engine, its fuel consumption and exhaust emission of 4 strokes motor bike after cruising on road test for a certain distance.

The road test program was conducted in public road daily with normal operation up to distance accumulation of 10,000 km. using reference fuel B0-0 for the first round, than B0-1 and B0-2 consecutively such as the schedule on Figure 2. Prior to the road test, the motor bike was subjected performance test and all specific data were recorded as commence-

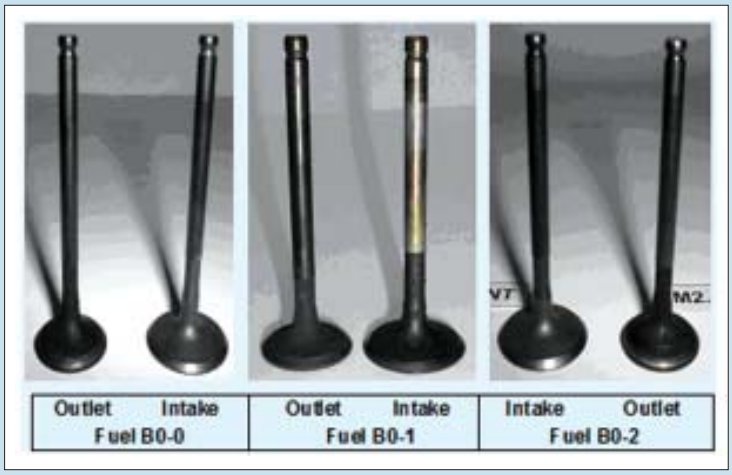


Figure 3
Intake & outlet valves used fuel B0-0

Figure 4
Intake valve and outlet valves used fuel B0-1 and B0-2

Table 3
Exhaust Gas Emission on Motor Bike After accumulative road test 10.000 km

No.	Exhaust gas	Unit	Test result			Threshold, Max. *)
			B0-0	B0-1	B0-2	
1	Hydrocarbon (HC)	ppm	335	325	347	2400
2	Carbon monoxide (CO)	%	2,27	2,24	2,29	5,5
3	Carbon dioxide (CO_2)	%	2,2	2,17	2,22	-
4	Nitrogen oxide (NOx)	ppm	30	28	31	-

Notes:
*) Exhaust emission threshold of used vehicles (Ministry of Environment Regulation No. 05/2006 dated. Agust1, 2006 about Exhaust emission threshold of used vehicles, under year 2010 effective till December 31, 2010).

ment data, than the motor bike performed daily road test operation. The motor bike road tests were carried out at daily normal operation on public road around Jabotabek until distance accumulation of about 100 km./day.

In this road test, engine parts were evaluated, such as intake valve, outlet valve of the road test engine motor bike. The evaluation of intake valve was based on comparing amount of deposit built-up and the cleanliness (rating method) of the intake valve using test fuel B0-1 and B0-2 against deposit built-up and cleanliness of intake valve when using reference fuel B0-0.

At the end of each round of road test, the engine of the motor bike was overhauled to pull out the intake and outlet valve for evaluation. Beside that, at a certain distance of road test, an exhaust emission test was conducted at idle speed for every single type of fuel tested.

Starting with distance through zero km, than 2500 km, 5000 km, 7500 km, and at the end every round road test, 10,000 km, exhaust emission tests were performed at idle speed at laboratory (The schematic diagram of the experimental set up is shown in Figure 2).

Lube oil replacement was conducted at the beginning of road test (0 km), then after accumulation of 2.500 km, 5.500 km, and 7.500km and at the end of road test 10.000 km.

Table 3
Intake valve cleanlines (rating)
due to gasoline fuel B0-1 and B0-2 against B0-0

Observation on	Unit	Gasoline Fuel		
Intake valve :		B0-0	B0-1	B0-2
Tulip/Underside	Merit/10	8,15	7,72	7,55
Average	Merit/10	8,15	7,72	7,55
Average Affect:				
▪ Merit			(-) 0,43	(-) 0,60
▪ % Merit			(-)5,28	(-) 7,37

Notes:
Sign (-) indicate that cleanliness (rating) of B0-1 and B0-2 dertier than B0-0.

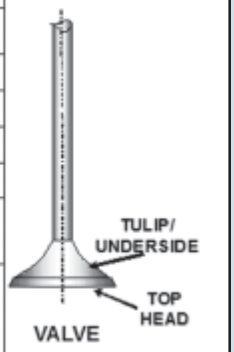
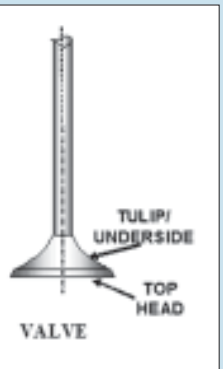


Table 4
Intake valve deposit due to gasoline fuel B0-1
and B0-2 against B0-0

Observation on	Unit	Gasoline Fuel		
Intake valve :		B0-0	B0-1	B0-2
Tulip/Underside	mg	12,80	13,26	13,68
Total		12,80	13,26	13,68
Average Affect of Olefin	%		(+) 3,60	(+) 6,88

Notes:
Sign (+) indicate that deposit B0-1 heavier than B0-0 and deposit B0-2 heavier than B0 - 0.



IV. RESULT AND DISCUSSION

A. *Fuel Properties*

The laboratory analysis of characteristics reference fuel B0-0, B0-1 and B0-2 compared to specification of Bensin 91 were tabulated in Table 2.

All properties of fuel tested B0-0,B0-1 and B0-2 are shown on Table 2: research octane number, oxidation stability, benzene content, aromatic content, distillation, Reid vapor pressure, density, copper strip corrosion comply with the specification of Bensin 91 decreed by Dirjen Migas No. 3674 K/24/DJM/2006 dated March 17, 2006.

B. *Engine Performance*

Motor bike road test with the three kinds fuels was conducted according the procedure as mentioned in Figure 1, using 4 strokes motor bike that operated daily in the same route chosen until the motor bike has accumulated journey of 10.000 km for each kind

LEMIGAS SCIENTIFIC CONTRIBUTIONS
VOL. 33. NO. 1, MAY 2010 : 52 - 58

fuel. At the end of road test for each fuel, the motor bike engine was overhauled to evaluate its intake valves for cleanliness and intake valves deposit beside emission in idle operation.

1. Cleanliness

Rating of intake valve was conducted after motor bike operated with each type of fuel covered a distance 10 000 km. Cleanliness rating of intake valve engine using fuel B0-1 and B0-2 was compared to intake valve engine using fuel B0-0 as reference of Bensin 91 are shown in Figure 3 and Figure 4.

From evaluation of the results of intake valve rating when using fuel B0-1 against intake valve of fuel B0-0, it happened that intake valve from B0-1, its 5.28% dirtier than the intake valve of B0-0

The cleanliness of intake valve engine using fuel B0-2 compared to the intake valve that used fuel B0-0 come up with result that intake valve of B0-2 its 7.36% more dirty than intake valve engine using fuel B0-0. The complete evaluation due to intake valve cleanliness is tabulated in Table 3.

2. Intake Valve Deposit

Deposit evaluation performed to each intake valve of motor bike engine after 10 000 km road test with each type of fuel, i.e.: B0-0, B0-1 and B0-2 are shown in Figure 3 and Figure 4.

The final examination of engine intake valve deposit of fuel B0-1 and fuel B0-2 compared to intake valve deposit when using fuel B0-0 are evaluated and presented in Table 4. The deposit evaluation of intake valve that used fuel B0-1, is 3.60% heavier than deposit of intake valve that used fuel B0-0. From the deposit evaluation of intake valve on fuel B0-2, it is 6.88% heavier than deposit of intake vale used fuel B0-0

3. Emission

Gas exhaust emission in idle condition tested each time the motor bike finished covering the certain distance of 10.000 km following the route fixed as shown in Table 3 and schematically in Figure 2. Exhaust emission examination of motor bike included Hydrocarbon (HC), Carbon Monoxide (CO), Nitrogen Oxide (NOx), and Carbon Dioxide (CO_2) for each kind test fuel after accumulating 10.000 km distance. Evaluation of exhaust emission of HC, CO, NOx and CO_2 using fuel B0-1 compared to fuel B0-0 came up with:

- HC emission decrease 3.00%
- CO emission decrease 1.34%
- NOx emission decrease 6,67%
- CO_2 emission decrease 1,36%

Evaluation of exhaust emission of HC, CO, NOx and CO_2 using fuel B0-2 compared to fuel B0-0 came up with:

- HC emission increase 3,58%
- CO emission increase 0,88%
- NOx emission increase 3,33%
- CO_2 emission increase 0,91%.

All properties of exhaust gas emission tested B0-0,B0-1 and B0-2 are shown in Table 3, Hydrocarbon (HC) and carbon monoxide (CO) comply with the Threshold Value decreed by Ministry of Environment Regulation No. 05/2006 dated. August1, 2006 about exhaust emission threshold limit for used vehicles, under year 2010 effective till December 31, 2010. Whereas the threshold limit of exhaust emission of carbon monoxide (COx) and nitrogen oxides (NOx) were not regulated and included by Ministry of Environment Regulation

4. Fuel Consumption

Fuel consumption measurement of motor bike was performed at certain points according to schematic road test program presented in Figure 1. Fuel

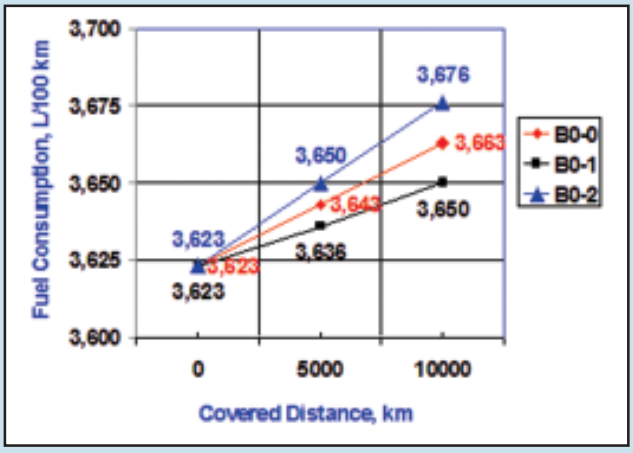


Figure 5
Fuel consumption sample B0-0, B0-1, B0-2

LEMIGAS SCIENTIFIC CONTRIBUTIONS
VOL. 33. NO. 1, MAY 2010 : 52 - 58

consumption evaluation for fuel B0-0, B0-1 and B0-2 each are presented on Figure 5. Overall, fuel consumption of B0-1 and B0-2 compared to fuel B0-0, are as follow;

- Fuel economy of B0-1 increased 0.182% than fuel economy B0-0
- Fuel economy of B0-2 ascended 0.182% than fuel economy B0-0

The reason for those higher fuel consumption was due to deposit build up at combustion chamber and intake valve.

V. CONCLUSION AND RECOMENDATION

A. *Conclusions*

This research has two pricipal tasks, such as reformulation bensin 91 with variable olefin content and to know the effect of using reformulated gasolins as fuels for motor bike road test.

1. Test Fuels

- Gasoline B0-0 happens to be Bensin with research octane number 91.3 and its olefin content is 26.60 % volume, it is used as reference fuel.
- Reformulated gasoline, as test fuel are B0-1 and B0-2, each with olefin content are 27.60% volume and 33.65 % volume.
- Physicals/chemicals properties of those three gasoline (B0-0, B0-1 and B0-2 were tested and conformed with Bensin 91 specification No. 2674 K/24/DJM/2006

2. Road Test

In this road test three kinds gasolines were used as motor bike fuel, running in the same route every day until it went through distance accumulation of 10,000 km for each kind, i.e.: B0-0, B0-1 and B0-2 consecutively.

- From cleanliness analysis (*rating*), the use of gasoline B0-1 compared to B0-0 engine caused intake valve dirtier by 5,28% (merit) and using gasoline B0-2 compared to B0-0 engine caused intake valve dirtier by 7.27% (merit).
- Deposit analysis in accordance with weight, deposit from B0-1 was 5.28% heavier than B0-0 and deposit from B0-2 3.60% heavier than deposit B0-0.
- Exhaust gas evaluation, emission used fuel B0-1 compared with fuel B0-0: in average HC emission decreased 3.7.36%, CO emission declined 0.03%, NOx emission decreased 6,67% and CO_2 emission decreased 0.03% and for fuel B0-2 compared with fuel B0-0, HC emission increased 3.58%, CO emission higher 0.02%, NOx emission climbed 3.33% and CO_2 emission increased 0.02%.

3. Olefin Content

From the performed test result, evaluation of deposit build-up and cleanliness of combustion chamber of the motor bike used in this study, it is concluded olefin content should be included and restricted in the specification of bensin 91.

A. Recommendation

1. This study only used gasoline from refinery UP IV Cilacap and UP VI Balongan, therefore, there should be more study to gasoline produced in others refineries owned by Pertamina to be able to really know the olefin content of every gasoline produce in each Pertamina refinery.
2. This study should be extended to evaluate the influence of olefin content in gasoline to internal combustion engine with fuel injection system.

REFERENCES

1. AMA, ACEA, JAMA, "World Wide Fuel Charter", December 2006.
2. Dirjen Migas, "Spesifikasi Bahan Bakar Minyak Jenis Bensin 91 menurut surat Keputusan Dirjen Migas No. 3674 K/24/DJM/2006 tanggal 17 Maret 2006.
3. Jasjfi, E., Nasution, A.S., The Progress Towards Cleaner Transportation Fuels in ASEAN", LEMIGAS Scientific Contribution 2, 1997/1998.
4. Keith Owen, Trevor Coley, "Automatic Fuels Reference Book", SAE, Inc. Warrentale, 2007.
5. UOP, The Challenge of Reformulated Gasoline. The 1990 Clean Air Act Amendments" Des Plaines Illinois, 1997.
6. US EPA, "Implementers Guide to Phasing Out Lend in Gasoline", Environmental Pollution Prevention Project Haggler Badly Services, Inc. Alexandria, 1999. ˇ