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MONITORING OF LEAD-FREE GASOLINE AND SURVEY OF GASOLINE PUMP NOZZLE SIZE IN BRITISH COLUMBIA

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By

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SUMMARY

The Pacific and Yukon Regional Office of the Environmental Protection Service (EPS) is responsible for monitoring the lead level in lead-free gasoline sold in British Columbia to ensure compliance with the federal Lead-free Gasoline Regulations under the Clean Air Act. During the compliance monitoring activities conducted in 1980, 1981, 1983 and 1984, EPS also conducted a study to determine the extent of the problem of nozzle switching at gasoline retail outlets.

During the 1980 compliance monitoring program, 251 gasoline samples were collected. Two percent of the samples contained lead in excess of the regulated level of 0.013 grams per litre. In 1981, 2.8% of the 311 samples collected contained more than the regulated level; in 1983, 1.8% of the 331 samples collected were over the regulated level; and in 1984, 2.5% of the 398 samples contained lead over the regulated level.

In 1980, 522 nozzles were checked at retail outlet dispensing pumps and all were found to conform to the proper size for dispensing leaded gasoline. Of the 434 leaded gasoline nozzles checked in 1981, 10% of the nozzles were switched to the smaller diameter nozzle which are used only for lead-free gasoline. In 1983, 626 nozzles were checked and 73% had been switched. In 1984, 887 nozzles were checked and 14% had been switched to the smaller nozzle. The substantial reduction in nozzle size switching from 1983 to 1984 is attributed to an increased public and industry awareness of the importance of preventing mis-fueling motor vehicles designed to operate on lead-free gasoline.

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1.0 INTRODUCTION

The tail pipe of an automobile is one of the major emission sources of air pollutants. The Canadian National Emission Inventory indicates that the emission of carbon monoxide (CO) from automobiles in British Columbia amounted to 774 thousand tonnes in 1978, contributing to 51% of all CO emissions in the province. Hydrocarbons (HC) is another type of pollutant that emanates from cars and contributes significantly (30% in 1978) to pollution of the atmosphere.

	CO Emissions from Automobiles in B.C. in thousand tonnes (percent of total emissions)	HC Emission from Automobiles in B.C. in thousand tonnes (percent of total emissions)
1970	1318 (64%)	202 (60%)
1972	1177 (66%)	160 (58%)
1974	1140 (63%)	145 (56%)
1976	936 (57%)	112 (46%)
1978	774 (51%)	87 (30%)

In order to reduce exhaust emissions, car manufacturers have used a device called a "catalytic converter" in many post 1975 automobiles. This device cleans the exhaust gas before emitting it to the atmosphere and is capable of reducing carbon monoxide and hydrocarbon emissions by 80% to 90%. The cleaning action of the catalytic converter is enhanced by the action of metal pellets inside the converter. These pellets are coated with platinum and are capable of converting the harmful carbon monoxide and hydrocarbons into relatively harmless water vapour and carbon dioxide gas.

Catalytic converters cannot tolerate contaminants such as lead in gasoline. When burned in the combustion chamber of a car, the lead in gasoline becomes fine particles of metallic lead. These fine lead particles form a coating over the platinum on the pellets (called catalyst) and reduce the cleaning actions by "poisoning" the catalysts. The use of

several tanks of leaded gasoline can poison the catalyst extensively and render the converter useless. Federal Regulations were promulgated to limit permissible lead concentration to 0.013 grams per litre in lead-free gasoline to ensure that the platinum catalyst is protected from damage. The provincial governments including Ontario, Nova Scotia and Quebec have passed legislation to prohibit nozzle switching at gasoline retail outlets. At the same time, the petroleum refining industry designed and carried out strict procedures for gasoline handling to ensure that the lead-free gasoline products are not contaminated by lead.

At gasoline retail outlets, the effort to avoid contaminating lead-free gasoline is made by using a different nozzle size on the dispensing pump to eliminate the possibility of pumping leaded gasoline into a car designed for using lead-free gasoline. A car requiring lead-free gasoline has a gasoline filling pipe that can only receive gasoline from a nozzle size of 13/16 inch (20.6 mm) outside diameter. All pump nozzles for dispensing leaded gasoline have an outside diameter of 15/16inch (23.8 mm) which prevents its use in any lead-free gas tank receptor. If a small size nozzle (13/16" O.D.) is equipped on a leaded gasoline pump, a retailer is providing an opportunity for dispensing leaded gasoline to a lead-free requiring car, either intentionally or unintentionally.

The regional office of Environmental Protection Service has been conducting survey programs to spot check the lead level of lead-free gasoline in British Columbia and to determine the nozzle size on the dispensing pumps. This report presents the survey results of 1980, 1981, 1983 and 1984. No sampling was carried out in 1982.

2.0 THE SURVEY PROGRAM

The survey program is carried out to make lead measurements and nozzle size checks in a spot-checking manner. Gasoline retail outlets in urban centres were visited without predetermination of time, location or brand. Following the selection of a subject area for a survey on a certain day, checks were made at gasoline stations. A surveyed area would not be revisited in the same year unless a serious contamination problem had been identified.

Samples of lead-free gasoline were collected at retail outlets and a field analysis for lead was conducted soon after the sampling by using a colorimetric analyzer. When a high lead concentration was detected by the field test the sample would be analyzed again by using the Atomic Absorption method at a chemistry laboratory to confirm the test results.

The nozzle surveys were conducted in conjuction with the gasoline sampling program. The size of nozzles for leaded gasoline was checked at retail outlets by using a template specially prepared for the survey (Figure 1).

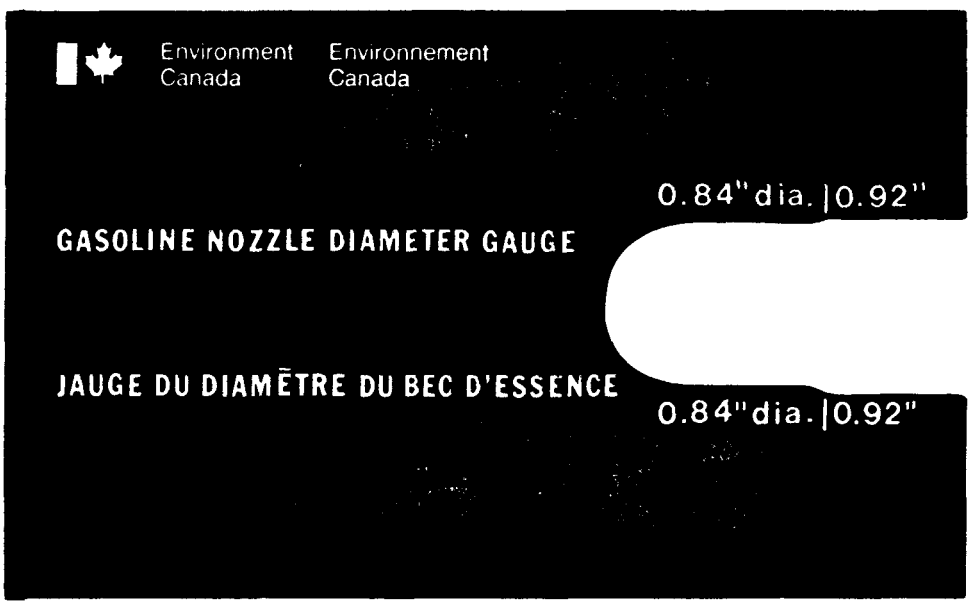

Figure 1 Plastic Template for Nozzle Size Measurement

The template is designed to make quick checks to identify undersized nozzles. By inserting the nozzle into the opening of the template, the nozzle size is easily determined.

Nozzle Size	Outside Diameter Inch (mm)	Indication on Template	Implication
Large	15/16 (23.8)	Does not fit into opening	Correct size to dispense leaded gasoline
Small	13/16 (20.6)	Fits into inner opening	One can dispense leaded gasoline easily to cars requiring unleaded gasoline
Medium	14/16 (22.2)	Fits into outer opening	One can dispense leaded gasoline to cars requiring lead-free gasoline by forcing the nozzle into the receptor neck

3.0 SURVEY RESULTS

3.1 Lead in Gasoline, 1980

A total of 251 samples of lead-free gasoline were collected. Five of these contained lead in excess of the regulated level of 0.013 grams per litre (g/L). A non-compliance rate of 2.0% was found as a result. Only one contaminated sample was found in the Greater Vancouver and Greater Victoria areas; while 5 contaminated samples were found in the Okanagan area.

3.2 Lead in Gasoline, 1981

A total of 311 samples of lead-free gasoline were collected. Nine of these contained lead in excess of the regulated level of 0.013 grams per litre. A non-compliance rate of 2.8% was found as a result. Contaminations were found at retail outlets of Chevron, Esso, Gulf, Husky, Merit, and Texaco brands.

3.3 Lead in Gasoline, 1983

A total of 331 samples of lead-free gasoline were collected. Six of these contained excess lead. A non-compliance rate of 1.8% was found as a result. No contamination was found in the Okanagan area. Contaminations were found at retail outlets of Chevron, Esso, Petro Can and Shell brands.

3.4 Lead in Gasoline, 1984

A total of 398 samples of lead-free gasoline were collected. Ten of these contained excess lead. A non-compliance rate of 2.5% was found as a result. No contamination was found on Vancouver Island. Contaminations were found at retail outlets of Shell, Gulf, Husky, Mohawk, Seven-Eleven, Super Save and Texaco brands.

3.5 Nozzle Survey, 1980

A total of 522 nozzles for leaded gasoline were checked at service stations of the Chevron, Esso, Gulf, Mohawk, Pacific 66, Shell and Texaco brands. Surveyed areas were Vancouver, Victoria, Hope, Princeton, Keremeos, Osoyoos, Oliver, Penticton, Summerland, Kelowna, Vernon, Salmon Arm, Kamloops, Cache Creek, Lytton, Boston Bar and Yale. All 522 nozzles conformed to the 23.8 mm size (15/16 inches).

3.6 Nozzle Survey, 1981

A total of 434 nozzles for leaded gasoline were checked and 43 were found to be undersized. As a result, 10% of the checked nozzles were undersized. Service stations of the Chevron, Esso, Gulf, Husky, Mohawk, Pay'N'Save, Payless, Petro Can, Shell and Texaco brands were found to be using undersized nozzles. Comparatively more undersized nozzles were found in the Okanagan area and on Vancouver Island.

3.7 Nozzle Survey, 1983

A total of 626 nozzles for leaded gasoline were checked. Four hundred and fifty-seven (457) of these were found to be undersized. As a result, 73% of the checked nozzles were undersized. A total of 176 service stations were surveyed and 157 were found to be using at least one undersized nozzle for dispensing leaded gasoline.

3.8 Nozzle Survey, 1984

A total of 887 nozzles for leaded gasoline were checked. One hundred and twenty-three (123) of these were undersized. As a result, 14% of the checked nozzles were undersized. In Vancouver, a total of 348 nozzles were checked and 7% of these did not conform to the proper size.

TABLE 1 LEAD-FREE GASOLINE SURVEY RESULTS (By Location)

LOCATION	1980		1981		1983		1984	
	Samples	Non-Compliance	Samples	Non-Compliance	Samples	Non-Compliance	Samples	Non-Compliance
West Vancouver	24		35				9	0
North Vancouver	28	1	61		31		36	2
Vancouver	35		69	4	93	2	59	2
Burnaby	23						41	0
Port Moody	2						9	0
Richmond	7				27		24	0
New Westminster	6							
Surrey	6						46	0
Langley	-						46	0
Victoria	51		31	1	51	3	9	1
Nanaimo							42	0
Hope	9		4				24	0
Princeton	7		6		26		5	0
Keremeos	3						1	1
Osoyoos	4		6	1	6			
Oliver	4		6		7			
Penticton	6	1	8	2			14	0
Summerland	1		3	1	2		4	1
Kelowna	6		16		21			
Vernon	8	1	16		22		8	0
Kamloops	6				21		14	0
Cache Creek	4		15		15			
Lytton	1							
Boston Bar	4	1						
Yale	2	1						
Salmon Arm	4							
Westbank			3		8			
Gold River			5					
Campbell River			25					
Saanich			2					
Tavlor					1	1		
Others							7	3
Total	251	5	311	9	331	6	398	10

TABLE 2 LEAD-FREE GASOLINE MONITORING RESULTS (By Brand)

COMPANY	1980		1981		1983		1984	
	Surveyed Stations	Non-Compliance	Samples	Non-Compliance	Samples	Non-Compliance	Samples	Non-Compliance
Beaver	-	-	-	-	-	-	2	0
Chevron	26	1	78	1	72	3	74	0
Econo	-	-	4	0	2	0	3	0
Esso	34	0	57	1	71	1	68	0
Exxon	-	-	-	-	-	-	-	-
Gulf	22	0	44	1	42	0	54	2
Husky	-	-	5	1	7	0	11	1
Merit	-	-	4	1	-	-	1	0
Mohawk	3	0	7	0	12	0	20	1
Pay N Save	-	-	8	0	2	0	4	0
Payless	-	-	7	0	3	0	9	0
Petro Can	4*	0	12	0	22	1	37	0
Seven-Eleven	-	-	-	-	6	0	4	1
Shell	27	3	56	3	57	1	64	3
Texaco	24	1	29	1	35	0	33	1
Others							14	1
Total	140	5	311	9	331	6	398	10

TABLE 3 NOZZLE SIZE SURVEY RESULTS (by brand)

BRAND	1980			1981			1983			1984		
	Nozzles Surveyed	Undersized Nozzles	% Undersized	Nozzles Surveyed	Undersized Nozzles	% Undersized	Nozzles Surveyed	Undersized Nozzles	% Undersized	Nozzles Surveyed	Undersized Nozzles	% Undersized
Beaver	-	-	-	-	-	-	14	14	100%	9	0	0%
Chevron	111	0	0%	108	12	11%	145	88	61%	126	8	6%
Dome	-	-	-	-	-	-	-	-	-	4	0	0%
Econo	-	-	-	10	0	0%	4	-	-	12	2	-
Esso	112	0	0%	72	8	11%	126	97	77%	143	17	12%
Exxon	-	-	-	3	0	0%	-	-	-	-	-	-
Gulf	88	0	0%	45	1	2%	74	67	91%	117	13	11%
Husky	-	-	-	8	2	25%	14	7	50%	31	13	42%
Merit	-	-	-	12	0	0%	-	-	-	4	1	25%
Mohawk	14	0	0%	16	3	19%	30	23	77%	57	7	12%
Pay'N'Save	-	-	-	6	2	33%	4	0	0%	11	0	0%
Payless	-	-	-	14	6	43%	8	8	100%	60	25	42%
Petro Can	12*	0	0%	20	3	15%	39	24	62%	81	3	4%
Rebel	-	-	-	-	-	-	-	-	-	4	0	0%
Sears Gas	-	-	-	-	-	-	-	-	-	4	0	0%
Seven Eleven	-	-	-	-	-	-	12	8	67%	12	3	25%
Shell	99	0	0%	85	1	1%	97	71	73%	108	9	8%
Super Save	-	-	-	-	-	-	-	-	-	29	10	34%
Texaco	86	0	0%	35	5	14%	59	50	85%	68	9	13%
Turbo	-	-	-	-	-	-	-	-	-	7	3	43%
Total	522	0	0%	434	43	10%	626	457	73%	887	123	14%

* Brand name as Pacific 66

**No survey conducted during 1982

TABLE 4 1983/1984 NOZZLE SURVEY RESULTS (by location)

LOCATION	NOZZLES SURVEYED		UNDERSIZE NOZZLES		PERCENT OF UNDERSIZE	
	1983	1984	1983	1984	1983	1984
Cache Creek	37	-	18	-	49%	-
Hope	-	39	-	4	-	10%
Kamloops	38	56	30	18	79%	32%
Keremeos	-	14	-	6	-	43%
Kelowna	42	-	23	-	55%	-
Monte Creek	-	9	-	4	-	44%
Nanaimo	-	142	-	22	-	15%
Oliver	8	-	6	-	75%	-
Osoyoos	7	-	4	-	57%	-
Penticton	49	47	48	5	98%	11%
Princeton	-	15	-	2	-	13%
Summerland	4	6	2	2	50%	33%
Trout Creek	-	10	-	1	-	10%
Vancouver	301	348	206	24	68%	7%
Vernon	39	26	28	10	72%	38%
Victoria	91	175	82	25	90%	14%
Westbank	10	-	10	-	100%	-
Total	626	887	457	123	73%	14%

4.0 DISCUSSION

4.1 Quality Control of Lead Level in Lead-Free Gasoline

Based on the survey results of 1980, 1981, 1983 and 1984, we found that 2.0%, 2.8%, 1.8% and 2.5% respectively, of the samples contained excess lead. These rates of non-compliance are slightly below the national average of 4.2% for 1974-1980*.

Quite a few contaminations were identified in the Okanagan area during 1980 and 1981. After the oil companies were advised of the results, no contamination was identified in this area during 1983 when 128 samples were analyzed. Contamination also occurred more often at retail outlets of some particular brands than other brands. A lack of attention to quality control procedures appears to be the main reason for the contaminations.

4.2 Compliance of Lead-Free Gasoline Regulations

It is the responsibility of EPS to monitor leaded and lead-free gasoline to ensure compliance with the federal regulations under the Clean Air Act. The compliance monitoring program is carried out to encourage the industry to maintain proper quality control procedures for its products during the production, transportation and handling operations. Enforcement actions have been taken in those instances where non-compliance has been identified.

4.3 Possibility of Fuel Switching

Fuel switching is the use of leaded gasoline in a vehicle designed for lead-free fuel. This requires the deliberate action either by the vehicle owner such as removing the special fitting in the fuel tank filler pipe or using a nozzle adaptor; or by the station or retail outlet in replacing the larger, leaded gasoline nozzle with the smaller size

*Report EPS 3-AP-82-3

nozzle designated for use with unleaded gasoline. A comparison of the survey results of 1980 to those of 1983 shows that the nozzles of leaded gas pumps changed from 0% undersized to 73% undersized. This may be interpretted that, in 1983, the gas stations made it possible for consumers to mis-fuel their vehicles at 73% of the leaded pumps while in 1980, no opportunity was provided by the gas stations. However, 1984 survey results indicate that the average nozzle switching rate in B.C. has dropped to 14%.

4.4 Impact on Air Pollution

The use of catalytic converters and lead-free gasoline is designed for the purpose of controlling air pollution. If fuel switching is practiced consistently, the catalytic converter is damaged and tailpipe emissions will increase significantly.

4.4.1 Emissions of Carbon Monoxide (CO) and Hydrocarbons (HC).

Emissions of carbon monoxide (CO) and hydrocarbons (HC) from automobiles are reduced by 80% to 90% if catalytic converters are used in conjunction with lead-free fuel. The increasing use of lead-free gasoline in Canada and British Columbia indicates that car exhaust emissions in B.C. have been cut by an estimated 190,000 tonnes of CO and 22,000 tonnes of HC in 1981, as compared to zero reduction in 1974 when the catalytic converter was not used to control tail-pipe emissions. This advancement of pollution control will be jeopardized if fuel switching occurs.

A catalytic converver will be permanently damaged after a few tanks of leaded fuel have been used. Once permanently damaged, the catalytic converter will remain ineffective and fails to control tail-pipe emissions even if use of lead-free fuel is resumed.

With 73% of undersized nozzles on leaded gasoline pumps in B.C. in 1983, which provided opportunities for fuel switching, concerns are that many cars are in operation with damaged catalytic converters. Consequently tail-pipe emissions from these cars will be much higher.

* YEAR	LF Gas Prod. 10^6 IG	Total Gas Prod. 10^6 IG	% of LF in Total	Calculated Emission Reductions of CO & HC
1975	440	7785	5.7%	4.6%
1976	1001	7974	12.6%	10.1%
1977	1462	8040	18.1%	14.5%
1978	1865	7914	22.5%	18.0%
1979	2639	8206	32.2%	25.8%
1980	3076	8400	36.6%	29.3%
1981	3138	8150	38.5%	30.8%

*EPS Report EPS 3-AP-83-1

LF - Lead-Free

IG - Imperial Gallon

4.4.2 Lead Emissions. With the use of lead-free gasoline, it can be expected that particulate lead emissions will be proportionately reduced. In 1981, approximately 300 million gallons of lead-free gasoline was used in B.C., which reduced lead emissions by about 600 tonnes. Fuel switching will cause part of these 600 tonnes to be lead emissions to the atmosphere of B.C.

As a result of lead-free fuel use and tail-pipe emission control, the ambient lead level in Vancouver indicates a reduction in recent years. The Greater Vancouver Regional District operates 38 ambient monitoring stations in Vancvouer, 18 of which include measurements of ambient lead. Results of these measurements indicate reduction of lead concentration since 1976. For example, the station at Burrard Street, downtown Vancouver recorded lead levels of 2.3 micrograms per cubic metre (ug/m^3) in 1976, and 0.7 ug/m^3 in 1981. The ambient lead concentration at this location has been cut down to 1/3 in 6 years.

4.4.3 Other Emissions. In addition to what happens to emissions of lead, CO and HC, deposits caused by lead and other additives in leaded fuel could plug up exhaust gas recirculation (EGR) valves and lead to a substantial increase in emissions of nitrogen oxides (NO_x). Fuel switching will also increase the emission of ethylene dibromide (EDB) and ehtylene dichloride (EDC) if these chemicals are used in leaded gasoline to reduce the deposits inside the engine caused by the combustion of the lead additive. These will be emitted from a vehicle using leaded fuel both from the exhaust and from the vapours that are emitted from the fuel system.

4.5 Control of Nozzle Size

The nozzle size on the gas pump is easy to control. Service station operators and oil companies should take the initiative and measure or check the size of nozzles and replace any nozzle that is being misused. Gas stations or the oil companies should be able to maintain the size control in their quality assurance procedures. It is not too difficult to see from the survey results in 1980 and in 1983 that very little, if any, action was taken in 1983 to control the misuse of nozzles.

Gas stations and oil companies should be responsible for maintaining good quality control and for making proper corrections if any undersized nozzles are identified. The substantial reduction in nozzle size switching in 1984 is attributed to an increased industry and public awareness of the practice and the importance of preventing mis-fueling vehicles designed to operate on lead-free gasoline.

4.6 Legislation on Nozzle Size Control and Fuel Switching

There is no federal legislation that controls or prohibits nozzle switching as this is provincial jurisdiction. There is no provincial law and Municipal Bylaw to control these problems in B.C.; but in some parts of Canada and in the U.S., these controls are mandatory, as follows:-

4.6.1 Ontario. Ontario has recently amended the Gasoline Handling Code. Effective September 2, 1983, it is an offence in Ontario to dispense leaded gasoline from a smaller diameter nozzle intended for unleaded gasoline. Also it is illegal to install an adaptor on a nozzle to reduce the diameter of a leaded nozzle to that of an unleaded nozzle. Offenders are liable on conviction to a fine of up to $10,000 or to a prison term of up to one year, or both.

4.6.2 Nova Scotia. Nova Scotia has instituted Section 8.04 and 8.05 in its Gasoline and Fuel Oil Regulations to control nozzle size in dispensing gasoline. Effective July 29, 1980, leaded gasoline must be dispensed at an outlet by using a nozzle of not less than 15/16 inches or 2.83 centimeters. Lead-free gasoline must be dispensed at an outlet by using a nozzle of not more than 13/16 inches or 2.1 centimeters.

4.6.3 Quebec. Effective July 8, 1984, provincial legislation prohibits nozzle switching at gasoline retail outlets in Quebec.

4.6.4 United States. The U.S. Environmental Protection Agency (EPA) promulgated regulations in 1974 to prohibit gas station employees to dispense or allow dispensing leaded gasoline to automobiles that require unleaded fuel. The U.S. EPA also specified nozzle sizes to be used for dispensing leaded gasoline and unleaded gasoline in its Regulation of Fuels and Fuel Additives. The Agency considered a survey result of 15% fuel switching unacceptable and decided to include nozzle size specifications in the regulation.