III.

PROPOSAL FOR DEPOSIT CONTROL ADDITIVES

A. INTRODUCTION

1. California Clean Air Act (CCAA) Requirements

The California Clean Air Act mandates for maximum emissions reductions possible from vehicular and other mobile sources, set forth in Section 43018 of the Health and Safety Code, and discussed previously. Section 43018(d)(2) requires that workshops on the adoption of regulations governing detergent content be conducted by January 31, 1991, and that hearings to consider these regulations be conducted by the Board no later than November 15, 1991.

2. Status of Today's Gasoline

The ARB staff is proposing a regulation which requires that motor vehicle gasoline sold in California contain detergents and deposit control additives. Studies conducted by additive manufacturers, fuel producers, vehicle manufacturers, and engine manufacturers have indicated that the use of deposit control additives can result in both performance and emissions reduction benefits. At the present time, there are no requirements that motor vehicle gasoline contain detergents and deposit control additives; however, a significant portion of the gasoline sold today already contains some type of additive. It is estimated that of the total gasoline pool, about 50 percent of the gasoline pool contains an intake system deposit control additive and 40 percent of the gasoline pool contains a carburetor/injector system deposit control additive. About 10 percent of the gasoline pool does not contain any type of additive.

3. Vehicle Certification Testing

As new vehicle control technology becomes increasingly sophisticated and maintenance of tolerances more critical, it is increasingly important that motor vehicle fuels be more uniform and cause minimal problems to a vehicle's control system. In partial recognition of this, vehicle manufacturers use certification fuels with deposit control additives for vehicle emission certification testing. To ensure that vehicles perform as they did during certification testing, the in-use fuels should have additives that are as effective as those used in the certification fuel. If vehicles are operated on fuel with deposit control additives, the staff believes that prevention of deposit formation will help maintain the durability of the vehicle emission control system, therefore minimizing potential increases in emissions that could occur due to deposits.

B. TYPES OF ADDITIVES AND DETERGENTS

1. Carburetor Detergents

Carburetor deposit control additives are detergents made from low-molecular weight amines and amine carboxylates. The molecules of carburetor detergents contain polar and non-polar ends. The polar ends are attracted to the metal surfaces, deposits, and deposit precursors while the non-polar ends are attracted to the fuel. Detergents are typically added to fuels in the range of 40 to 600 parts per million (ppm) depending upon the fuel supplier.

2. Port Fuel Injector (PFI) Deposit Control Additives

Some port fuel injector (PFI) deposit control additives, referred to as injector detergents, can be carburetor detergents which are added in higher concentrations. Although these additives can clean injectors, some can also decompose or oxidize and cause deposits on the intake valves and ports. Deposits on valves and ports can cause power loss, poor driveability, and leakage of exhaust emissions into the fuel system.

Another type of PFI additives are detergent dispersants. Detergent dispersants are composed of alkenyl succinimides or hydrocarbyl amines. Besides their detergent action, these additives also have the ability to disperse deposits into fine particles which allow the deposits to pass through the fuel system into the combustion chamber and burn with the fuel. These additives can clean up the intake manifold and intake ports, but are not effective in cleaning carburetors or in controlling intake valve deposits. The treatment rate for detergent dispersants is typically 3 to 5 times the dosage level for carburetor detergents.

3. Intake Valve Deposit (IVD) Control Additives

Intake valve deposit (IVD) control additives are polymeric structures of high molecular weight hydrocarbons. These additives are more thermally stable and less attracted to metal surfaces than detergents or detergent dispersants, and therefore are less likely to form deposits on intake valves and ports. Because IVD control additives are longer chain hydrocarbons, they are more soluble in the fuel and better at dispersing deposits and deposit precursors than detergent dispersants. Depending upon the concentration, intake valve deposit control additives can either clean up or prevent deposits in carburetors, injectors, intake manifold, and intake ports and valves.

In the early 1970's, IVD control additives were based on polyolefin structures, usually polybutene. These additives had to be combined with synthetic or petroleum-based carrier oil. When polyolefinic additives are added to unleaded gasoline, they cause increased combustion chamber deposits which can lead to increased vehicle octane requirements. These additives also increase the extent of oil thickening due to penetration of the viscous polybutene and carrier oil into the engine crankcase.

To address these problems, improved IVD control additives were developed in the early 1980's based on polyether structures. The polyether additives have the same cleaning ability as polybutene additives, but they produce less combustion chamber deposits. These additives do not require a carrier oil, so the increase in viscosity of the engine oil is minimal. Intake valve deposit control additives are typically added in concentrations ranging from 20 to 600 ppm.

C. EFFECTS OF DEPOSITS ON ENGINE PERFORMANCE

1. Carburetor

a. Formation of Carburetor Deposits

Deposit formation in the carburetor systems depends upon fuel composition, traffic density, and atmospheric conditions. It is believed that unsaturated hydrocarbons (primarily olefins and diolefins) in the fuel partially oxidize to form gums and resins, which act as binders for other contaminants such as exhaust fumes, blow-by gases, and dust that can enter the carburetor and contribute to carburetor deposits. Fuel oxidation can also take place directly in the throttle body area during hot soaking following engine shutdown.

b. Effects of Carburetor Deposit on Emissions

Deposits have a tendency to form on the carburetor's throttle body just below the throttle blade and in the idle air circuit and metering orifice/jets. These deposits tend to restrict air flow and cause fuel enrichment in the air to fuel ratio. This can cause rough idling, stalling, poor acceleration, and reduced fuel economy and result in higher hydrocarbon (HC), carbon monoxide (CO), and in certain cases oxides of nitrogen (NOx) emissions.

Test data indicate that the use of intake valve or PFI deposit control additives can result in emissions benefits from carbureted vehicles. However, the use of these additives will also reduce or prevent deposit formation in other parts of the engine. Therefore, the emission effects discussed below cannot solely be attributed to the removal of carburetor deposits.

Chevron Research Company conducted vehicle tests to evaluate the effects of a polyether IVD control additive and a polybutene PFI deposit control additives on exhaust emissions from carbureted vehicles using fuels with and without these additives. The test results with the polyether IVD control additive showed emission reductions of 16 percent, 12 percent, and 14 percent for HC, CO, and NOx, respectively. Vehicles operated on fuels with the polybutene PFI deposit control additive had emission reductions of 16 percent, 5 percent, and 12 percent for HC, CO, and NOx, respectively. In another study conducted by the same company using 1978 and 1979 model year vehicles, the use of gasoline with deposit control additives resulted in decreases in HC, CO, and NOx emissions by 12 percent, 15 percent, and 18 percent, respectively.

Results from engine tests conducted by Polar Molecular Corporation showed that NOx emissions were reduced over a wide range of air/fuel ratios when the engine was operated on fuels treated with a deposit control additive. HC and CO emissions also decreased near the theoretical air/fuel ratio, however these emissions increased at the extremes of the range of air/fuel ratios.

In summary, the use of fuels containing an intake valve or a PFI deposit control additive would result in reductions of HC, CO, and NOx emissions from carbureted vehicles.

2. Port Fuel Injector Systems

a. Formation of Port Fuel Injector (PFI) Deposits

Deposits in PFIs are formed during the hot soak period after the engine is turned off. Small amounts of fuel in the fuel injector pintle tip can form gums and resins as the lighter components in gasoline evaporate. The gums and resins act as binders for minute particles that originate from intake air, exhaust and blowby gases. Deposits formed in critical pintle tip areas of the injector can restrict the flow of fuel to the cylinder, which causes lean air/fuel ratio and can result in misfiring due to the excess air. The deposits result in reduced engine power, reduced fuel economy, emission increases, and increased driveability problems.

b. Effects of PFI Deposits on Engine Performance

Performance testing, as measured by fuel economy, has indicated the detrimental effects of PFI deposits. In one study, two vehicles were used in fuel economy tests to compare the effect of fouled injectors versus clean injectors. One of the vehicles with fouled injectors had a decrease of 2 percent in fuel economy when compared to the same vehicle with clean injectors. The same test with the other vehicle showed a decrease of 11 percent in fuel economy.

In another study, a fuel economy test was conducted on a 2.2L vehicle with dirty PFIs to determine the effectiveness of a PFI deposit control additive in removing deposits. Results of this test showed that after using a fuel with a PFI deposit additive at a concentration of 4000 ppm, the vehicle attained a 7 percent improvement in fuel economy.

c. Effects of PFI Deposits on Exhaust Emissions

Increased PFI injector deposits not only impact fuel economy, but also increase emissions. Injector deposits can cause variability in air/fuel ratios from cylinder to cylinder. Because the vehicle's electronic equipment adjusts the amount of fuel injected in each cylinder according to the average oxygen level measured in the exhaust, the resultant fuel flow may be in error for all cylinder when deposits are present. This can lead to overfueling which increases HC and CO emissions or underfueling, which causes increases in NOx emissions.

Table 2 shows a summary of test data relating PFI deposits to exhaust emissions. In the first test, the results showed a 26 percent increase in hydrocarbons (HC) and a 16 percent increase in carbon monoxide (CO) emissions due to injector deposits. In the second test, the results showed a 44 percent increase in HC emissions and a 270 percent increase in CO emissions, while NOx emissions decreased by 28 percent. In the third test, an engine was tested first with clean injectors and then with four different sets of fouled injectors. The test data indicate increases in HC emissions ranging from 63 percent to 170 percent and increases in CO emissions ranging from 130 percent to 670 percent. NOx emissions in this test ranged from a decrease of 62 percent to an increase of 110 percent.

The last test presented in Table 2 shows the effects of different deposited injectors on exhaust emissions. The results indicate that the engine with fouled injectors increased HC, CO, and NOx emissions by 230 percent, 48 percent, and 170 percent, respectively. The control of these deposits would allow the injectors to perform more effectively, and therefore would reduce emissions.

The test results presented in Table 3 summarize the emissions benefits of additives when used for a clean-up function. In these tests, the cleaning of PFI deposits resulted in reduction of HC and CO exhaust emissions that ranged from 10 percent to 61 percent and 20 percent to 86 percent, respectively. The effects of deposits on NOx emissions showed inconsistent results with some injector sets indicating emissions increases and other sets indicating emissions decreases. This variation is not unexpected since the information from Table 2 indicates that the clean-up emissions benefits are dependent on fuel injector design, deposit type, additive concentration, and duration of additive use.

3. Intake Valves

a. Formation of Intake Valve Deposits

Intake valve deposits are formed as a result of thermally and oxidatively unstable fuel components such as mono and diolefins, alcohols, and lubricating oils that pass between the intake valve guide and stem during high vacuum operation (idle). Lubricating oils can contain oxidized

TABLE 2

Estimated Emissions Increases as a Result of PFI Deposits

Engine Tested	Test Type	Reported Percent Emission Increases [a/] HC	CO	NOx
'83, 1.6L, I-4	Cold Transient FTP	26 [b/]	16 [b/]	-5 [b/]
'83, 2.4L, I-6	Cold Transient FTP	44 [c/]	270 [c/]	-28 [c/]
'85, 2.2L, T.C., I-4 Fouled Injectors	Bag 2-Hot 72 CVS			
Set No. 4		84	130	110
Set No. 24811		170	540	-42
Set No. 592688		150	600	-12
Set B		63	670	-62
2.6L, T.C., Fouled Injectors		230	48	170

a/ Emissions increases compared with fouled injectors *vs.* clean injectors; Level of fouling is not reported. Negative numbers denote decreases in emissions.

b/ Engine out emissions.

c/ Tailpipe emissions.

Source: SAE Paper No. 861537

TABLE 3

Estimated Exhaust Emission Reductions Resulting from Cleaning-Up PFI Deposits

Engine Tested	Test Type	Reported Percent Emission Reductions a/ HC	CO	NOx
85, 2.2L, T.C., I-4	FTP CVS-72			
Inj. set #4				
(40 miles, 500 ppm)		52	50	58
(10 gal, 500 ppm)		42	52	65
Inj. set #24811				
(40 miles, 500 ppm)		61	72	-2
Inj. set #592688				
(250 miles, 80 ppm)		56	86	-110
Inj. set B				
(250 miles, 80 ppm)		10	47	-40
2.3L, T.C.				
(250 miles, 80 ppm)		59	20	-16

a/ Emissions comparisons between fouled injectors and cleaned-up injectors. Negative numbers denote increases in emissions.

Source: SAE Paper No. 861537

materials and contaminants which accumulate from blowby gases. Upon further exposure to air at elevated temperatures, these high molecular weight materials can deposit or coke on the intake valve tulip. Different engine designs can develop different levels and types of intake valve deposits. It is the "thin" type of deposits observed with high technology, lean-burn engines with port fuel injector systems that cause driveability problems.

b. Effects of Intake Valve Deposits (IVD) on Engine Performance

The detrimental effects of intake valve deposits (IVD) on engine performance may be measured by power output, vehicle acceleration, and driveability. Intake valve deposits can lean the air/fuel mixture during the transient conditions of the cold start/warm-up phase which results in hesitation and/or poor throttle response during the 15-30 seconds after cold start. Intake valves deposits also restrict the flow of air and fuel into the engine and reduce vehicle power and acceleration.

One additive/fuel company has conducted tests to determine the effects of deposits on engine power output. Data from these tests indicate a direct relationship between the flow restriction and the net power output. Although the test data from this test program is limited, the information indicates that fast burn engines lose more power with heavy deposits than conventional engines. This company also looked at the average times for three vehicles with and without deposits on the intake valves to accelerate from a steady speed of 25 and 35 miles per hour (mph) to 55 mph. The results of these acceleration tests showed that vehicles with deposits on the intake valves required more time (about 1 to 3 seconds) to reach 55 mph than vehicles with clean valves.

Two vehicle manufacturers investigated the effects of intake valves deposits on vehicle driveability. One vehicle manufacturer determined that there is a direct relationship between intake valve deposits and driveability. The other vehicle manufacturer determined that intake valves with a rating of 6 on the Coordinating Research Council (CRC) deposit rating scale will have driveability problems, while valves with a CRC rating of 8 may have problems. The CRC deposit rating scale ranges from 1 (heavily deposited) to 10 (no deposits).

c. Effects of Intake Valve Deposits on Emissions

Intake valve deposits have impact of leaning the air/fuel mixture during the transient conditions of the cold start phase and thereby, increase NOx emissions. One researcher hypothesized two possible mechanisms to explain this effect. In the first mechanism, intake valve deposits could increase the intake flow velocities, which in turn could increase the in-cylinder turbulence level and ultimately increase combustion rate. The higher combustion rate would increase the overall cycle pressure and temperature, therefore the NOx emissions would increase. In the second mechanism, intake valve deposits could effect NOx emissions by restricting the flow of residual gases during the valve overlap period. This would reduce the amount of internal EGR in the cylinder and result in more NOx emissions than an engine with clean valves.

Figure 2 shows typical NOx emissions reductions due to intake system cleaning. In this test, NOx emissions were measured for six vehicles before and after clean-up. The average NOx emissions were reduced from 0.62 g/mile to 0.41 g/mile, an emissions reduction of about 33 percent.

A number of tests have been conducted to evaluate the effect of intake valve deposits on exhaust emissions. Results from these tests are shown in Table 4.

Test A was a deposit clean-up test that involved 297 vehicles which are 1970 and older model year vehicles. The study showed that the use of a gasoline with deposit control additives resulted in reductions of about 14 percent in HC emissions, about 12 percent reduction in CO emissions, and about 6 percent reduction in NOx emissions.

Test B was a keep-clean test which involved 30 model year 1978 and 1979 vehicles. Results from this test showed that HC emissions, CO emissions, and NOx emissions were reduced by 12 percent, 15 percent, and 18 percent, respectively, when the vehicles operated on fuels with deposit control additives.

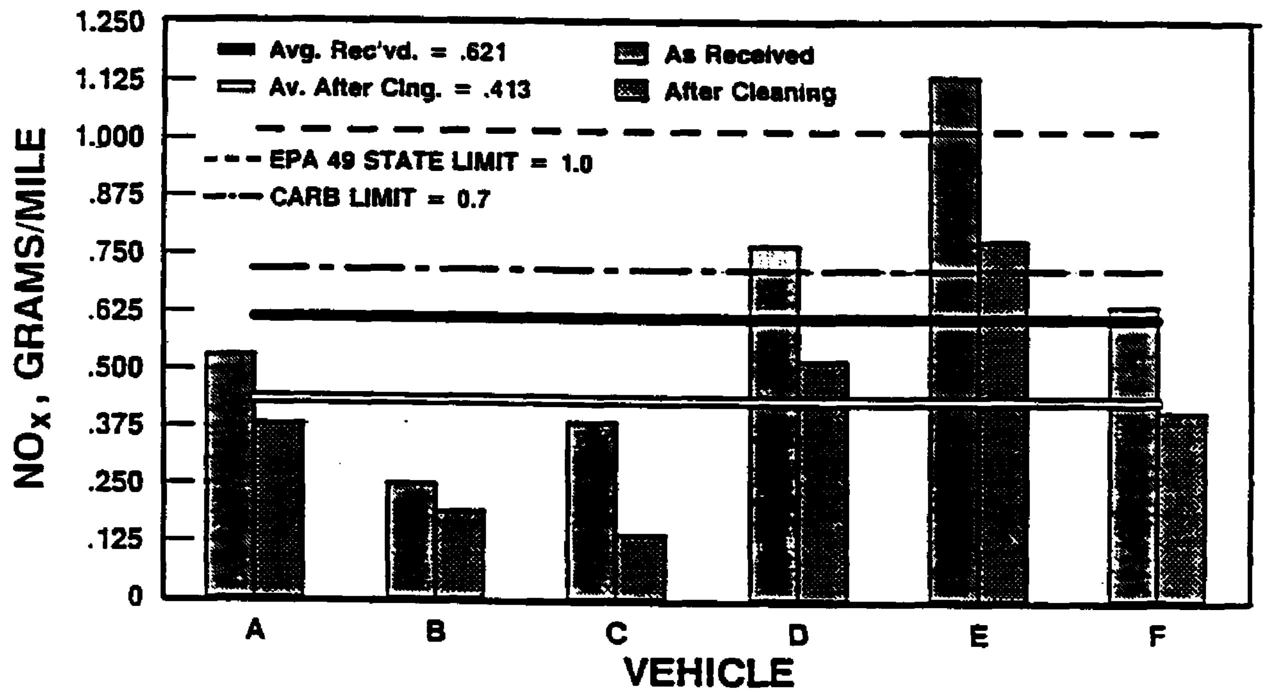
Test C was to allow evaluation of exhaust emissions before and after the removal of intake valve deposits. The removal of intake valve deposits resulted in improvements in CRC deposit ratings from 6 to 9. Emission reductions were determined to be: a 33 percent reduction in HC emissions, a 1 percent reduction in CO emissions, and a 21 percent reduction in NOx emissions.

Test D, Test E, and Test F were parts of a study conducted to evaluate the effects of deposits from different parts of the engine on exhaust emissions from forty seven 1989 model year vehicles, which are representative of about 17 percent of the types of vehicles sold in the United States. In Test D, the exhaust emissions were compared from the test fleets after removal of the combustion chamber deposits to the base case emissions. The results indicate that HC, NOx, and CO emissions were reduce by about 6 percent, 3 percent, and 3 percent, respectively.

In Test E, exhaust emissions were measured after the removal of the intake system deposits to the base emissions. In this case, HC and CO emissions increased by 7 to 8 percent, while NOx emissions decreased by 5 percent. In Test F, exhaust emissions were measured after total clean-up of engine deposits and compared to the base emissions. As with Test E, HC and CO emissions increased and NOx emissions decreased.

FIGURE 2

TYPICAL NO_x EMISSION REDUCTION DUE TO INTAKE SYSTEM CLEANING



Source: BMW/Unocal Presentation to ARB, July 28, 1989.

TABLE 4

Emission Reductions Associated With Removal of Intake Valve Deposits

Test #	Company	No. of Vehicles	Model Year of Vehicles	Emissions Reductions,% HC	CO	NOx
A	Chevron	297	1970 and older	14	12	6
B	Chevron	30	1978 and 1979	12	15	18
C	Toyota	N.R.	N.R.	33	1	21
D	Texaco	12	1989	3	4	< 1
		35	1989	7	2	4
		47**	1989	6	3	3
E	Texaco	12	1989	8	-2*	8
		35	1989	-15	-9	4
		47**	1989	-9	-7	5
F	Texaco	12	1989	11	2	9
		35	1989	-7	-7	8
		47**	1989	-2	-5	8

N.R. = Not reported.

* Negative numbers indicate an increase in emissions.

** Combined average of the data from 12 and 35 car fleets.

D. DISCUSSION OF THE REGULATORY PROPOSAL FOR DEPOSIT CONTROL ADDITIVES

1. Certification Requirement Criteria

The proposed regulation requires that gasoline sold starting January 1, 1992 meet certification requirements pertaining to detergent and deposit control additives. The certification approach was developed because the staff believes it would be inappropriate to mandate the use of a specific, named additive in all instances. Several kinds of additives have been proven to have some beneficial effects, and it is appropriate for gasoline suppliers to be allowed to chose the additive(s) they wish to use in their fuel as long as the additive is effective. The certification process enables gasoline formulations containing additives to be evaluated on a case-by-case basis. The process would not certify additives per se, because the additive needs to be evaluated in terms of how it works in a specific gasoline formulation.

Gasoline producers, importers, and distributors could apply for certification of a gasoline formulation containing an additive or additives they believe cause the formulation to effectively control carburetor, port fuel injector (PFI) system, and intake valve deposits. The application would have to contain test data demonstrating that the gasoline formulation achieves specified performance criteria for controlling carburetor, PFI, and intake valve deposits when tested in accordance with the test procedures adopted by the Air Resources Board.

2. Performance Criteria

The required tests and standards for each test are as follows:

- The gasoline formulation meets the standard of an average of a maximum of 100 milligrams per intake valve when tested in accordance with the BMW 10,000 Mile Intake Valve Test Procedure.
- The gasoline formulation has a carburetor rating of 9 or higher when tested in accordance with the Carburetor Cleanliness Test Procedure.
- The gasoline formulation does not result in a flow loss of more than 5 percent when tested in accordance with the Test Method for Evaluating Port Fuel Injector Deposits in Vehicle Engines.
- The gasoline formulation is capable of reducing carburetor deposits to a rating of 9 or higher when tested in accordance with the Carburetor Cleanliness Test Procedure.
- The gasoline formulation is capable of reducing fuel injector deposits so that no fuel injector suffers a flow loss of more than 5 percent when tested in accordance with the Test Method for Evaluating Port Fuel Injector Deposits in Vehicle engines.

The standards for carburetors and PFIs are the same for reducing deposits as they are for preventing deposits. The respective test procedures have different test modes for clean-up (reduction) and prevention of deposits. The test procedures for intake valves, port fuel injectors, and carburetors are found in Exhibits 1, 2, and 3.

Upon approval from the Executive Officer of the ARB, alternative test procedures can also be used to demonstrate that gasoline with the candidate additive will effectively reduce and prevent deposits in carburetors, port fuel injectors, and intake valves. To be acceptable, the alternative test procedures have to be demonstrated to give equivalent results compared to the BMW Intake Valve Deposit Test, the Carburetor Cleanliness Test, and the Port Fuel Injector Test.

The performance test methods and standards referenced above are based on criteria that industry is currently using to evaluate the effects of additives on deposits on intake valves, port fuel injectors, and carburetors. The test methods were recommended to staff by industry and are widely acceptable. The 100 milligrams per intake valve standard for the BMW test method is the criteria that was developed by BMW and is used to determine if an additive is acceptable for preventing deposit formation in intake valves. The standards for the carburetor test methods (carburetor rating of 9 or higher) and the port fuel injector evaluation test methods (fuel injector flow loss of not more than 5 percent) were selected by staff based on the standards specified by the Coordinating Research Council and on information from studies conducted by industry to evaluate the effectiveness of additives on port fuel injectors and carburetors. Staff feel that these test methods and standards are necessary to ensure that additives approved for added to gasoline will be effective in reducing or preventing deposits.

3. Other Performance Standards

In earlier drafts, the staff proposed that the applicant be required to demonstrate that the additives not increase emissions of any noxious or toxic substance not otherwise emitted, and not cause harm to engine or emission control components. Because of the difficulty in identifying and implementing adequate methods for making such demonstrations, we are no longer proposing such requirements. We believe that application of federal restrictions on fuels should provide substantial protection in this area. Federal Clean Air Act section 211(f) prohibits the introduction into commerce of gasoline or gasoline additives that are not "substantially similar" to any fuel or additive used in the certification of any fuel or additive used in any 1975 or subsequent model-year vehicle, unless EPA issues a waiver. EPA has issued an interpretive rule describing what fuels or additives fall within the term "substantially similar." (46 Fed.Reg. 38582 (July 28, 1981).) This ruling has the effect of prohibiting substances such as metals and chlorinates in unleaded gasoline. To further enable the staff to be aware of any potential adverse effects from the additives in applicants' gasoline formulations, the proposed regulation would require the applicant to submit copies of all material pertaining to the additive(s) that the applicant has submitted to EPA under EPA's registration program.

4. Certification Application

The regulation would establish minimum requirements for the certification application. The application would have to include specified information necessary to enable the Executive Officer to adequately evaluate the application. Among other things, the applicant would have to provide the name and chemical composition of the additive(s) or, if not known, the chemical process of manufacture. These provisions are very closely patterned after the EPA regulations which require submittal of the same data by the manufacturer of any additive before it is introduced into commerce, and submittal of such data by refiners. (see 40 CFR secs. 79.2(i), 79.4, 79.31.) Under the Board's existing regulations governing data claimed to be confidential (17 CCR Sections 91011, 91022), applicants may claim that the composition and\or concentration of the additives are trade secret or exempt from disclosure under some other recognized exemption in the California Public Records Act. The Board's legal counsel has determined that where this information is demonstrated to be trade secret, the ARB can protect it from disclosure.

5. Revocation of Certification

The regulation would authorize the Executive Officer to revoke or modify a certification where it is shown that the gasoline formulation substantially fails to meet the specified performance criteria for certification. This is necessary to assure that the additized formulations continue to work as intended, even if the nature of the gasoline changes. To assure fairness, the applicant would be entitled to a hearing prior to revocation or modification. There could be instances where an immediate revocation or modification would temporarily force a supplier out of the gasoline market. In light of this consideration, the regulation would permit the Executive Officer to delay the effective date of the revocation or modification for such period of time as is necessary to allow the supplier to come into compliance in the exercise of all reasonable diligence.

6. Regulated Activities

The regulation would prohibit the sale, offer for sale, supply, or offer of supply of any vehicular gasoline unless the producer, importer, or distributor has received a certification, and the fuel contains the additive or additives and in the range of concentration identified in the application in the certification. These requirements are necessary to assure that in-use fuel will perform similarly to the fuel evaluated during certification. Producers, importers and distributors have been the entities that historically have additized motor vehicle fuel, and the staff therefore recommends they be ultimately responsible under the regulation.

The sale and supply prohibitions would apply throughout the distribution system, as is the case with most of the Board's other fuels regulations. This enhances the potential enforceability of the regulation and encourages entities involved in fuel distribution to help assure compliance. However, refiners have indicated that motor fuel is often not additized until it reaches the final distribution facility (from which the fuel is directly supplied to retail outlets and other final destinations), and there could in some cases be adverse consequences for the supply system if fuel was always required to be additized at the refinery. Therefore, the regulation provides that the sales and supply prohibitions will not apply to transactions occurring before the gasoline is sold or supplied from the final distribution facility, if the person selling or supplying the gasoline demonstrates that he or she has taken specified precautions to assure it will be brought into compliance before it is sold or supplied from the final distribution facility. Since there is less control where the gasoline will be additized by another person, in that case the person selling or supplying the fuel must obtain a written statement from the recipient that he or she will bring the gasoline into compliance. These provisions will provide needed flexibility for suppliers while helping to assure that the fuel will in fact be additized.

The proposed regulation contains language identical to that in the proposed RVP regulation on deeming sales by retailers to also be sales by any person who previously sold the gasoline in violation of the regulatory requirements.

7. Recordkeeping Requirements

Producers, importers and distributors with certifications would be required to compile and maintain specified records regarding compliance with the regulation at each facility at which vehicular gasoline is additized. The recordkeeping requirements are necessary to enable enforcement staff to audit compliance with the regulation. The records would include monthly compilations of the volume of fuel sold or supplied, the volume additized, and the volume of additives used. The records would have to be maintained for a minimum of two years, and must be provided to the Executive Officer within 20 days of a request.

E. COST OF DEPOSIT CONTROL ADDITIVES

The cost of additives used will depend on the type of additives and the recommended dosage. Although no detailed information on the additive costs is available, it has been reported that the cost of additive treatment could range from 0.1 cent to 1 cent per gallon of fuel treated. The most typical reported cost is in the range of 0.3 to 0.5 cent per gallon. Because a significant portion of gasoline sold today already contains some kind of additive or additives, the cost of the proposed regulatory action to the consumer would be different for different gasoline brands.

An oil company has projected that in 1989, 50 percent of the total gasoline pool contained intake system deposit control additives, 40 percent contained fuel metering system deposit control additives, and 10 percent of the gasoline pool contained no additives. The staff expects that for gasoline brands already marketed with intake system deposit control additives, no additional costs would be required. For fuels marketed with fuel metering system deposit control additives, there can be a cost to upgrade the additives used. It has been reported that the incremental cost to upgrade a carburetor or a PFI deposit control additive to an IVD deposit control additive would range from 0.05 cent to 0.5 cent per gallon of fuel treated. Fuels that do not contain additives would experience the maximum cost increase of 0.3 to 1.0 cents per gallon of fuel treated.

F. IMPACTS OF PROPOSED REGULATION

1. Emission Impacts

The testing of additives added to gasoline has historically only been to allow the evaluation of a specific property or desired effect of the additive. Also, very few of the test programs included an evaluation of the impact of the use of additives in gasoline on emissions to the atmosphere. This situation in combination with variability that exists in the makeup of the California vehicle fleet and in the variability in the fuel used in these vehicles makes an estimate of the impact of staff's proposal difficult, at best. With these limitations, staff have attempted to estimated emission benefits. The staff estimates that the proposed regulation in 1992 will result in emission reductions of about 3 tons per day (T/D) of HC, about 30 T/D of CO and about 2 T/D of NOx. The staff calculated these emissions benefits conservatively. The staff used these estimates to present the worst case scenario for cost-effectiveness. The emissions benefits are based on the following assumptions, which are described in greater detail in the Technical Support Document:

a) For the pre-1981 vehicle population, the use of additized gasoline will result in reductions in HC, CO, and NOx emissions of 15 percent, 10 percent and 15 percent, respectively. It is also assumed that 5 percent of the pre-1981 vehicle fleet would have emission reduction resulting from the use of deposit additives.
b) The use of additives would not result in any emissions benefits from the 1981-1992 throttle body injection (TBI) vehicle fleet.
c) Data has shown that for PFI vehicles, HC and CO emissions can be reduced by 10 to 230 percent and 20 to 670 percent, respectively, as a result of removing PFI deposits. The staff assumed a 75 percent reduction for both HC and CO emissions. The staff also assumed that only 1.5 percent of the PFI vehicles in the fleet would have sufficient deposits to benefit from the proposed regulation. These assumptions are based on information presented to the ARB staff by WSPA.
d) Available data are inconclusive concerning emission benefits for reducing IVD deposits. Therefore for the emissions estimates, the staff assumed that IVD reductions would not result in emissions benefits.
e) The staff assumed that 50 percent of the 1981-1992 fleet vehicle miles travelled is from PFI vehicles.
f) The staff did not calculate any emissions benefits from gasoline-powered trucks and motorcycles, though such benefits would occur.

2. Benefits of Deposit Control Additives

Additives can both clean existing engines and prevent future problems. The build up of deposits in carburetors, port fuel injectors and intake valves can result in the degradation of the vehicle's driveability and fuel economy, as well as increasing vehicular emissions. The use of deposit control additives in motor vehicle gasoline can remove and control engine deposits and therefore, reduce the vehicle owner's operation and maintenance costs while reducing emissions increases that occur as vehicles age.

Vehicle manufacturers use certification fuels with deposit control additives for vehicle emission certification testing. To ensure that vehicles perform as they did during certification testing, the in-use fuels should have additives that are as effective as the certification fuel. As new vehicle control technology is becoming increasingly sophisticated and maintenance of tolerances more critical, the best approach is to require in-use fuels to be more uniform and cause minimal problems to a vehicle's control system. If vehicles are operated on fuel with deposit control additives, the staff believes that prevention of deposit formation will help maintain the durability of the vehicle emission control system, therefore, minimizes potential increases in emissions that could occur due to deposits.

3. Adverse Impacts of Deposit Control Additives on Engine Performance

The use of some PFI deposit control additives can have harmful effects on engine performance. Although these additives can clean the injectors, some can also decompose or oxidize and cause deposits on the intake valves and ports. Deposits on valves and ports can cause power loss, poor driveability, and leakage of exhaust emissions into the fuel system. This situation may result in an increased engine octane requirement and increase in engine oil viscosity. However, the harmful effects can be minimized by lowering the concentration of these additives or by using other deposit control additives that do not cause increases in deposit chamber deposits and engine oil viscosity. Requiring that additives meet EPA's unleaded gasoline additive requirements for "substantially similar" should prevent these harmful effects from occurring.

4. Economic Impacts

The staff estimates that for a projected 1992 gasoline fuel consumption rate of about 34 million gallons of gasoline per day, the cost is about $29,000 a day. This is based on the assumption that 10 percent of the gasoline pool has an average cost of 0.4 cent per gallon, 40 percent of the gasoline pool has a cost of 0.1 cent per gallon and for the remaining 50 percent of the pool, the cost of compliance is zero. It is important to note that no additional costs would occur for the regulations requiring the cleaning-up of carburetors and PFIs because the additive dosage required for this function would be the same as the additive dosage required for keeping clean carburetors, PFIs, and IVD. The staff estimates that the cost-effectiveness is about $1.60, $0.20, and $2.30 per pound of HC, CO, and NOx reduced if the cost is divided equally among the three pollutants respectively. The overall cost effectiveness for all pollutants controlled is about $0.50 per pound of pollutant. This falls within the range of cost-effectiveness of other regulations adopted by the Board.

The costs of additive use could be balanced out by engine performance benefits such as savings in repair costs because of improved engine cleanliness, and savings from potential fuel economy benefits. These cost savings which could be significant have not been considered in this cost-effectiveness analysis.

5. Other Environmental Impacts

The staff has not identified any adverse impacts that would result from this proposal.