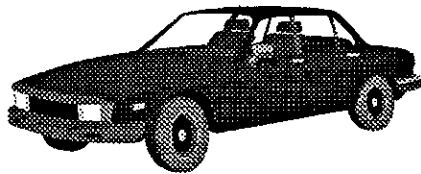
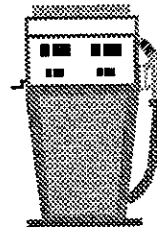


California Environmental Protection Agency

 Air Resources Board

Staff Report

**Proposed Amendments to the California
Regulation Requiring Deposit Control
Additives in Motor Vehicle Gasoline**



Release Date: September 29, 1995

**State of California
California Environmental Protection Agency
AIR RESOURCES BOARD
Stationary Source Division**

STAFF REPORT: INITIAL STATEMENT OF REASONS

**Public Hearing to Consider Amendments to the California Regulation
Requiring Deposit Control Additives in Motor Vehicle Gasoline**

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TABLE OF CONTENTS

I.	SUMMARY AND RECOMMENDATIONS	
1.	Introduction	1
2.	Why Are We Proposing Changes to Gasoline Additive Regulation?	1
3.	What Are We proposing?	1
4.	What Are the Effects of the Proposed Changes?	2
5.	How Were the Proposals Developed?	2
6.	Recommendation	2
II.	BACKGROUND	
1.	Program Review	3
A.	Effect of Deposits on Vehicle Performance	3
B.	Benefits of a Deposit Control Additive Program	4
2.	Certifying Gasoline Containing Deposit Control Additives in California	4
3.	U.S. EPA's Requirements for Gasoline Deposit Control Additives	5
4.	Comparison Between the California Certification Program and the U.S. EPA Certification Programs	6
III.	DISCUSSION OF THE PROPOSED AMENDMENTS	
1.	Certification Test Fuel Requirements	8
2.	Recordkeeping Requirements	9
3.	Test Methods	11
4.	Other Amendments	12
A.	Amendments to Clarify Definitions	12
B.	Amendments to Require Additional Information	13
C.	Allowance for Manual Correction	13
IV.	IMPACTS	
1.	Environmental Impacts	15
2.	Cost Impacts	15
3.	Small Business Impacts	16
4.	Global Warming and Ozone Depletion Impacts	16

REFERENCES

APPENDICES

- A. Comments & Responses from July 20, 1995 Workshop
- B. Proposed Regulation Order
- C. Plain English Summary of Proposed Amendments
- D. Revised ARB Clean Up Vehicle Test Procedure for Port Fuel Injectors

SUMMARY AND RECOMMENDATION

1. *Introduction*

In this report, we are proposing that the Air Resources Board (ARB or Board) consider amendments to the gasoline deposit control additive regulation (title 13, California Code of Regulations, section 2257).

In 1990, the Board adopted the gasoline additive regulation requiring that all commercial gasoline be certified to contain effective deposit control additives. Studies on vehicles experiencing driveability problems indicated that carbonaceous materials from the fuel would adhere to critical areas of the fuel injection system and intake valves to significantly degrade performance. Technical data showed that cleaning these fuel system carbonaceous materials, or "deposits," with gasoline containing additives would result in emission reductions in gasoline-powered motor vehicles.

2. *Why Are We Proposing Changes to the Gasoline Additive Regulation?*

The Board adopted the gasoline additive regulation in 1990 establishing a program to ensure that all commercial gasoline be effectively additized to control deposits in motor vehicle fuel injection systems and intake valves.

Over the past three years, the ARB staff has administered the gasoline deposit control additive program and has approved over 200 applications for certifications. Based on this experience, staff is proposing various amendments to the regulation to fine tune the current California gasoline additive program. The amendments will provide additional clarity, specificity and flexibility to the regulation. In addition, we are proposing amendments to provide consistency with anticipated future federal vehicle testing requirements for deposit control additives.

3. *What Are We Proposing?*

We are proposing to amend the certification test fuel requirements to provide uniformity and clarity for all applicants. Specifically, we propose to modify the criteria for certification test fuels and to clarify the necessary information needed for a complete application. We also propose to fine tune the recordkeeping requirements to provide clarity

and to provide flexibility in meeting the per gallon additive concentration requirement of the regulation. Other general amendments are proposed to clarify definitions used in the regulation and to allow for manual correction of underadditized tanker truck loads. Also, we propose to update the vehicle test methods to the most recent and generally accepted test methods.

4. *What Are the Effects of the Proposed Changes?*

We believe that these proposed amendments do not represent any fundamental change to the overall regulation. The amendments are designed to improve the overall clarity and specificity of the regulation and to provide consistency with future federal requirements. The amendments do not significantly change how we evaluate applications for certification, or how we ensure compliance with the regulation. Certifications previously issued by the ARB will continue to be effective; these amendments will not affect the use of any previously certified gasoline formulation.

5. *How Were the Proposals Developed?*

In developing the proposed amendments to the gasoline additive regulation, we consulted with individual additive and gasoline producers, the Santa Fe Pacific Pipeline Company, and other interested parties. Also, the staff held a public workshop on July 20, 1995.

6. *Recommendation*

We recommend that the Board adopt the proposed amendments to the regulation requiring deposit control additive use in California motor vehicle gasoline.

II

BACKGROUND

1. Program Review

As required by the California Clean Air Act, the ARB adopted section 2257, title 13, California Code of Regulations, on September 28, 1990. This regulation requires the use of deposit control additives in all commercial motor vehicle gasoline by requiring that gasoline be certified to meet specified performance criteria for reducing and preventing deposits in port fuel injectors and intake valves when tested in accordance with specified test procedures. The adoption of this regulation was part of the ARB's strategy to reduce emissions from motor vehicles by reformulating motor vehicle gasoline.

A. Effect of Deposits on Vehicle Performance

Gasoline fuel system deposits are formed by the oxidation of unsaturated hydrocarbons (primarily olefins and diolefins) in the fuel to form gums and resins. Gums and resins act as binders for other contaminants such as exhaust fumes, blow-by gases, and dust that can enter the fuel system and contribute to port fuel injector and intake valve deposits.

Deposits which form on port fuel injectors (PFIs) contribute to increased fuel consumption and can lead to rough idling, stalling, poor acceleration, and increased emissions. In fuel injected systems, deposits can form in the narrow annular region at the tip of the injector, the pintle valve, and the metering orifice surface. Increased PFI deposits deteriorate the injector spray pattern and cause variability in air/fuel ratios from cylinder to cylinder. Too much fuel for the amount of oxygen injected into the cylinders results in increases in emissions of hydrocarbons (HC) and carbon monoxide (CO). Too little fuel for the amount of oxygen injected into the cylinders can cause increases in emissions of nitrogen oxides (NOx).

Deposit formation on intake valves is similar to deposit formation in port fuel injector systems since the metal surface and fuel temperatures are comparable. Intake valve deposits occur mainly on the curved surface of the valve, the valve tulip, and on the valve stem. Unlike the small deposits which form on critical areas of the port fuel injectors, intake valve deposits can range in weight from fractions of a gram to several grams. Deposits on intake valves reduce power, acceleration, fuel economy and increase NOx emissions. For a comprehensive discussion on the formation and the emission effects of deposits, please refer to the August 13, 1990, ARB staff report and technical support document.

B. Benefits of a Deposit Control Additive Program

Studies have been conducted to examine the effects of deposits on emissions and the ability of deposit control additives to clean up fuel system injectors and intake valve deposits. These studies show significant decreases in emissions as a result of removing deposits from fuel injector systems and intake valves. One vehicle study (Society of Automotive Engineers technical paper 861537) was conducted to compare emissions from a vehicle operated with dirty PFIs and with the same PFIs after being cleaned with additives. This test showed a decrease in HC of up to 61 percent and a decrease in CO of up to 86 percent. For intake valves, another study (presented by the Toyota Motor Corp. at the 1989 Coordinating Research Council Intake Valve Deposit Workshop) showed a HC decrease of 33 percent, while CO decreased by 1 percent and NOx decreased by 21 percent when intake valves were cleaned with additives.

In the original rulemaking, the ARB staff estimated the emissions benefit upon the implementation of the gasoline additive regulation. It was estimated that the emissions benefit would result in about a 3 tons per day reduction in HC, 30 tons per day reduction in CO and 2 tons per day reduction in NOx.

2. *Certifying Gasoline Containing Deposit Control Additives in California*

To obtain certification for a gasoline formulation (gasoline and additive), a producer, importer or distributor ("applicant") must submit a written application to the ARB. The application must contain vehicle test data showing that the gasoline formulation passes specific intake valve deposit and port fuel injector (PFI) tests.

The data must demonstrate that the gasoline formulation meets the unlimited mileage standard of a maximum of 100 milligrams of deposit weight as the average of all four intake valves when tested in accordance with the BMW 10,000 Mile Intake Valve Test Procedure, the test method referenced in the regulation. The gasoline formulation must also meet the keep-clean standard of the Stationary Source Division's (SSD's) Test Method for Evaluating Port Fuel Injector Deposits in Vehicle Engines, dated March 1, 1991. Finally, the gasoline formulation must meet the clean-up standard of the SSD's Test Method for Evaluating Port Fuel Injector Deposits in Vehicle Engines, dated March 1, 1991.

As part of the certification process, the applicant must also demonstrate that the certification test fuel, i.e. the gasoline used for vehicle testing, is representative of the gasoline produced, imported or distributed by the applicant, i.e. the gasoline formulation for which certification has been requested. Because it is sometimes difficult to blend a gasoline formulation to meet all the maximum fuel properties requested in the application, applicants have used a series of certification test fuels for which primary and supplemental performance tests are conducted. Through this matrix of certification test fuels and performance tests, the

applicant can make the necessary demonstrations for certification.

In addition to the vehicle test data specified in the regulation, the ARB staff typically must request applicants to provide the reproducibility factor for the analytical test method and density of the additive to complete the review of the application. The reproducibility factor indicates the allowable inter-laboratory variability of test results when testing for additive concentration. The density of the additive is used to convert the additive dosage rate from a weight basis to a volume basis. The analytical test method, reproducibility factor and the additive density are all used as administrative tools to ensure compliance with the regulation.

Once the ARB approves an application for certification, an executive order is issued to the applicant which identifies the conditions of the certification of the gasoline formulation. These conditions specify maximum gasoline properties and the minimum dosage rate of the deposit control additive. The regulation requires facilities to properly additize all volumes of gasoline. Compliance with the executive order is normally ensured by routine auditing of facility records.

3. *U.S. EPA's Requirements for Gasoline Deposit Control Additives*

Currently, the U.S. EPA is implementing a program that requires the addition of effective deposit control additives in commercial gasolines. The first phase of the program consists of interim requirements which focuses on additive registration and recordkeeping. The interim rule was finalized on October 14, 1994, and became effective January 1, 1995. The second phase of the program will consist of a final regulation which, similar to the California program, will require vehicle performance testing. Staff anticipates that the U.S. EPA will publish the final regulation in the summer of 1996.

Under the interim program, the requirements are based primarily on information items already required for the fuel additive registration program under 40 CFR Part 79. Also, the U.S. EPA considers California-certified additized gasoline formulations as equivalent to the interim federal certification requirements. Therefore, the U.S. EPA will grant a certification for a California gasoline based on California certification to eliminate any regulatory duplication or conflicts.

Federal gasoline additive registration under the interim regulations requires applicants to disclose the minimum concentration which the additive manufacturer recommends for control of PFI and intake valve deposits. For enforcement, detergent blenders must perform volumetric additive reconciliation (VAR) procedures to show that on a monthly basis, the actual additive volume used met or exceeded the correct minimum concentration of the approved additive registration. The interim regulations also include other requirements such as additive injection equipment set point control, quarterly calibration of additive injection equipment and product transfer documentation (whenever gasoline, additized or unadditized, is

transferred to a receiving party).

Under the proposed final regulation, an applicant would apply to the U.S. EPA to obtain an additive certification indicating the lowest concentration of the detergent additive package used during the certification vehicle testing.

For the final regulation, the U.S. EPA is proposing to require that all additives be certified to meet vehicle test performance standards. The additives must meet the performance standards when the certification test fuels are used in ASTM D 5500-94, for testing for intake valve deposits, and ASTM D 5598-94, for testing for port fuel injector deposits.

For enforcement, detergent blenders must perform VAR procedures to determine actual additive use, as in the interim program. The U.S. EPA is currently considering whether to impose a per gallon standard in which all gasoline will need to be additized to at least 90 percent of the minimum concentration for the additive. As an alternative, the U.S. EPA has also proposed the requirement for weekly VAR periods instead of the current monthly VAR period of the interim regulation. These requirements are in response to U.S. EPA's concern about potential gross underadditization, which could occur under the currently proposed monthly averaging standard. The final proposed regulations also include other requirements such as additive injection equipment set point control, quarterly calibration of additive injection equipment and product transfer documentation.

The final regulations are expected to be approved by the U.S. EPA by the summer of 1996. Like the interim procedures, they are expected to allow for California certification as an alternative way to meet the federal final regulation certification requirements.

4. *Comparison Between the California Certification Program and the U.S. EPA Certification Program*

The California and U.S. EPA deposit control additive certification programs are similar. Both programs require individual application for certification, performance-based testing for PFI and intake valve deposits, and detailed recordkeeping. However, the California program has additional strengths that ensure compliance.

In the California program, an applicant must include all supporting test data in the application. All data is reviewed by the ARB staff before a certification is approved. The U.S. EPA program is based on self-certification where an applicant submits in the application package an attestation that the certification requirements have been satisfied. All test data is kept by the applicant. The U.S. EPA could then issue a certification to the applicant based solely on this attestation.

The California program also requires PFI clean-up testing in addition to PFI keep-clean

testing to verify an additive's effectiveness to clean up dirty fuel injectors. The U.S. EPA program does not require PFI clean-up testing.

Each program has different requirements for certification test fuels. The U.S. EPA indicated in its notice of proposed rulemaking that the certification test fuels meet a predetermined level of severity. The U.S. EPA has not yet determined the specific criteria for fuel severity. The California program requires that certification test fuels represent the maximum gasoline fuel properties requested for certification.

Both programs require compliance on a "per gallon basis," but each program has different recordkeeping requirements. In the California program, facilities must maintain daily records for each grade of gasoline. Enforcement of the minimum additive dosage rate for each gallon of gasoline is based on daily records that are compiled monthly. The U.S. EPA program proposes to enforce the minimum additive dosage rate on a monthly average based on VAR for automated blenders. However, in the notice of the final interim rule, the U.S. EPA has expressed some concerns about using a monthly averaging period and is considering adding additional requirements to assure a "per gallon" compliance. For hand blending, the dosage rate would be enforced on a per batch basis.

The additional components of the California program are necessary to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources, such as motor vehicle fuels, to achieve the attainment of the state ambient air quality standards by the earliest practicable date as required by the Health and Safety Code, section 43018(a) and (c)(4).

III

DISCUSSION OF THE PROPOSED AMENDMENTS

1. Certification Test Fuel Requirements

This section provides a description of the proposed amendments and a discussion of the reasons for each proposal. A "plain English" summary of the proposed amendments is also provided in Appendix C. This summary is intended to satisfy the requirements of Government Code section 11346.2(a)(1), which requires that a noncontrolling plain English summary of the regulations be made available to the public.

As previously mentioned, applicants are required to demonstrate the effectiveness of their additive to control intake valve and port fuel injector deposits to obtain certification of their gasoline formulations. Effectiveness is shown through vehicle tests using a gasoline known as the "certification test fuel" that represents the maximum properties for which certification is being requested.

Currently, applicants perform vehicle tests using a certification test fuel which represents the typical gasoline production properties. Applicants then augment this vehicle test data by performing "supplemental" tests on additional certification test fuels that represent the maximum properties of the gasoline formulation for which certification is requested. While the use of supplemental tests has been necessary in the past, we believe it may not be necessary when California reformulated gasoline (CaRFG) regulations go into effect.

Starting in March 1996, gasoline in the state will have to meet the CaRFG limits. Effectively, this will limit the variation in gasoline properties within a much smaller range than today's gasoline. Therefore, the properties of typical production gasoline will be very similar to the properties of gasoline meeting the CaRFG "average" limits.

We are proposing that the regulation be amended to require that certification test fuels used for vehicle tests represent the maximum gasoline properties requested in the certification application. However, we recognize that it may be difficult to produce a certification test fuel to exactly meet all maximum gasoline properties due to the inaccuracy of both the blending equipment and the test methods. Therefore, the proposed amendments would allow the properties of the certification test fuel to vary as much as 20 percent below the maximum properties of the gasoline formulation being requested for certification. The proposed amendments also require certification test fuels to be blended from typical refinery blendstocks and to represent commercially available gasoline.

At the July 20, 1995 public workshop, industry fully supported the development of proposal described above. The proposed revision would minimize the need for supplemental tests by allowing a single certification test fuel for use during vehicle tests. This proposed revision would also provide more uniform criteria for blending a certification test fuel and will not affect an applicant's ability to provide supplemental test data if necessary.

2. *Recordkeeping Requirements*

In the original rulemaking, we determined that there was a significant benefit in the use of additives to reduce and prevent fuel system deposits in gasoline motor vehicles. Available test data shows that properly additized gasolines should maintain clean engine fuel system components and thereby prevent excess emissions. To realize these benefits, it is important to ensure that all gasoline is additized to the proper concentrations. The additive regulation states in subsection (a)(1):

"On or after January 1, 1992, no person shall sell, offer for sale, supply, or offer for supply **any** California gasoline unless at the time of the transaction: [i] the producer, importer, or distributor of the gasoline has been issued a currently effective certification pursuant to subsection (c), and [ii] the gasoline contains at least the minimum concentration of the additive or additives identified in final application for certification." [emphasis added]

This provision establishes a California gasoline deposit control additive program based on a per gallon standard.

Under the additive regulation, we have relied on documentation and recordkeeping to ensure compliance with the standards. Subsection (d)(1) of the regulation states:

"Each producer, importer, and distributor who has been issued a certification pursuant to subsection (c) shall maintain records identifying each facility at which he or she adds an additive to California gasoline in order to comply with subsection (a)(1). For each such facility, commencing January 1, 1992, the producer, importer or distributor shall **compile records** showing on a monthly basis for each grade of gasoline: [i] the volume of California gasoline supplied from the facility by the producer, importer or distributor, [ii] the volume of California gasoline to which the producer, importer or distributor added the additive to comply with subsection (a)(1), and [iii] the name and volume of each additive (or additive package) used added to the California gasoline fuel. **Records covering a month shall be compiled** no later than 30 days after the end of the month, and shall be retained for at least two years after the end of the month." [emphasis added]

Since the implementation of the regulation in 1992, the ARB has established compliance procedures for recordkeeping to ensure that each gallon of gasoline is properly additized as required by the regulation. The compliance procedures clarified that facilities must maintain daily records for each grade of gasoline to demonstrate compliance with subsection (a)(1) and compile them monthly, as specified in subsection (d)(1) of the regulation. Enforcement of the minimum additive dosage rate for each gallon of gasoline is based on daily records which are compiled for each business day. Volumes of gasoline and additives dispensed over weekends and holidays are allowed to be compiled the next business day. All facilities have been notified of this interpretation and are conducting daily recordkeeping.

The compliance procedures are based on field evaluations conducted by the ARB's Compliance Division staff of all facilities within the state. In 1992, staff found that most facilities could produce daily records. Staff also found that some facilities misinterpreted the regulatory provisions that require daily recordkeeping and those facilities believed that monthly records were required.

In 1994, a followup field evaluation was conducted by the ARB's Compliance Division staff. The results of this evaluation showed that most facilities throughout the state substantially upgraded their additive injection equipment and computer systems to provide for more accurate control of additization and much improved recordkeeping capability. The improved computer systems allow for closer monitoring of gasoline additization. These facilities have also employed operational procedures to ensure that minimum dosage rates are achieved for all volumes of gasoline. To preclude underadditization, facilities typically overadditize their gasoline, i.e. above the minimum additive dosage. As an additional assurance, facilities maintain automated shut-off systems which are designed to stop any loading procedure in the event of malfunctioning additive equipment. Automated shut-off systems prevent the underadditization of gasoline loads. Based on these findings, the ARB's Compliance Division staff has determined that all facilities within the state have the ability to maintain daily records.

To avoid any continued misinterpretation of the regulations, however, we propose to revise the reference in the regulation pertaining to recordkeeping to clarify that records must be maintained on a daily basis and compiled monthly. We also propose revisions to the recordkeeping requirements to specify that: 1) on a monthly basis, the average additive dosage rate for each month must equal the minimum additive dosage rate for which certification was approved, and 2) on a daily basis (e.g. business day), the average additive dosage rate for each 24 hour period must be at least 95 percent of the minimum additive dosage rate for which certification was approved. These revisions would provide an appropriate level of flexibility in complying with the requirements of the regulation.

Oil refiners had concerns about our proposal stating that a daily recordkeeping requirement would be contrary to the current regulation, would be onerous and may increase costs. Refiner comments state that the current regulation allows additive facilities to "compile records...on a monthly basis..." and does not require daily records. For the reasons stated above, we disagree with each of the conclusions. Pipeline companies had similar concerns

about the daily recordkeeping requirement in the regulation, but indicated that if daily records are required, then a daily tolerance should be allowed.

3. *Test Methods*

During the development of the original gasoline additive regulation in 1990, the ARB staff based the vehicle testing requirements of the regulation on generally accepted test procedures available at the time.

The ARB staff had developed the PFI vehicle test procedures required by the regulation based on the Coordinating Research Council Committee's PFI vehicle test procedure. The ARB's PFI vehicle tests are run to show the additive's effectiveness in reducing (i.e. "clean-up") and preventing (i.e. "keep-clean") PFI deposits. Essentially, this test requires the operation of a four cylinder, 2.2 liter, turbocharged, PFI Chrysler engine over a predetermined cycle while using the additized gasoline formulation. Additive effectiveness is measured by the percent fuel flow plugging of fuel injectors after the test cycle.

The regulations also referenced the Barvarian Motor Works (BMW) 10,000 mile intake valve test procedure to evaluate additive performance on intake valves. This industry test method utilizes a 318i BMW, PFI, 4-cylinder vehicle with new intake valves. The vehicle is driven on a predetermined driving cycle while using the additized gasoline formulation. Additive effectiveness is measured as the weight of the deposits which form on the intake valves during the driving cycle.

Since the 1990 adoption of the regulation, the American Society for Testing and Materials (ASTM) has published updated procedures for PFI keep clean (ASTM D 5598) and intake valve keep-clean (ASTM D 5500) testing. The updated ASTM test methods are based on the test procedures referenced in the regulation but include more detailed procedural instructions and improved quality assurance/quality control procedures. The ASTM test methods are improvements over the current test methods and will serve to reduce overall test variability caused by procedural inconsistencies.

The ARB staff is proposing to amend the current references to the vehicle test procedures contained in the regulation to require the use of the updated ASTM procedures. Also, staff proposes to update the current ARB PFI test method to incorporate ASTM D 5598, with some revisions, into the current clean-up requirements. The revised clean-up test method is contained in Appendix C. These proposed revisions would update the regulation to reflect the latest generally accepted vehicle test procedures.

Oil refiners, the U.S. EPA, additive manufacturers and the Southwest Research Institute all support our amendments to update the vehicle test procedures. The proposed amendments would provide consistency with anticipated federal requirements for deposit

control additives. The U.S. EPA proposes to require the use of ASTM D 5500 and ASTM D 5598 test methods for the final deposit control additive rule expected next year.

The proposed amendments incorporate by reference published ASTM test methods. You can obtain a copy of the test methods by writing to ASTM at 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, or by telephone at (610) 832-9585, or facsimile at (610) 832-9555.

4. *Other Amendments*

The existing regulation contains specific administrative and performance requirements that a producer, importer, or distributor must meet to obtain certification of a gasoline formulation. As part of the administrative requirements, an applicant must provide specific information in support of the applicant's request for certification. The ARB staff uses this information, as well as other requested information as necessary, to evaluate and process applications for certification of gasolines.

Since the initial implementation of the deposit control additive regulation, the ARB staff has approved over 200 individual certification requests for additized gasolines. Having evaluated numerous certification applications, we have identified regulatory text which has frequently been misinterpreted. Therefore, in order to improve the overall clarity of the regulation, we propose to make some minor changes.

A. Amendments to Clarify Definitions

One such change would clarify the definition of the term "gasoline". The current definition of gasoline contained in the regulation defines gasoline as follows:

"Gasoline means any fuel which is commonly or commercially known or sold as gasoline, or which is a mixture of more than 50 percent fuel commonly known or sold as gasoline and alcohol and which is sold or intended for sale as a motor vehicle fuel in California."

The definition can be misinterpreted to mean that gasoline can be a fuel which is a mixture of two components where one component would comprise over 50 percent of the total and be made up of gasoline plus alcohol. To remove the potential ambiguity we propose to amend the definition of gasoline to state more clearly that gasoline can be a gasoline/alcohol blend in which gasoline comprises over 50 percent of the total volume.

Another commonly misinterpreted term is "gasoline formulation". Within the current regulation, the term "gasoline formulation" can refer to two different gasolines. On one hand

it can refer to the gasoline properties requested in the certification application. On the other hand, "gasoline formulation" can also refer to the properties of the certification test fuel. In the past, certification test fuel properties have not been the same as the gasoline properties requested in the certification application. To clarify this definition, we propose to amend this definition to specify that the term "gasoline formulation" refers to one single fuel formulation which represents both the certification gasoline properties and the certification test fuel properties. Industry agrees with this amendment.

B. Amendments to Require Additional Information

The regulation requires that specific information be provided in the certification application. This information includes: a) name of the additive, b) minimum concentration, c) vehicle performance test results, d) copies of all materials pertaining to the U.S. EPA additive registration, e) test method for determining presence and concentration of additive, f) theoretical mechanism of action of additive (if known), and g) data to show that gasoline being certified is representative of gasolines to be marketed by the applicant.

We have found it necessary to routinely request additional information not specified in the regulation to complete the review of applications for certification. The additional information typically requested includes the additive test method reproducibility and additive density. Reproducibility is requested to allow the enforcement of the additive regulation through the use of analytical test methods. The test method reproducibility is a measure of the relative error of the test method.

We have had to request information about additive density to allow the enforcement of the additive regulation through the use of records. The density is used to convert the weight of additive used in gasoline to the volume of additive used for comparison to data maintained in records. However, we agree with recent industry comments recommending that the additive concentration be expressed in terms of gallons of additive used per thousand gallons of gasoline. With this information we would not need to know the density of the additive. This is consistent with the U.S. EPA reporting requirements for gasoline additives.

Therefore, we propose to amend the regulation to require all applicants to submit the test method reproducibility of their additive and that the additive concentration be reported on a volume basis. Inclusion of these amendments in the regulation would clarify the regulation's requirements for all applicants. Industry agrees with these amendments.

C. Allowance for Manual Correction

Under the existing regulation, all gasoline must be additized before leaving the final distribution facility which ships gasoline to the service station. The regulation does not allow for the manual correction of underadditization once a load of gasoline leaves the final distribution facility.

Initially, we considered the appropriateness of providing an upset/breakdown provision to address occurrences of underadditization of gasoline that is beyond the control of a facility operator. Based on our discussions with industry, it appears that facilities have taken steps to ensure that their gasoline is properly additized. However, industry has identified a need to manually additize their gasoline on occasion, due to intermittent upsets or breakdowns of equipment or operations.

At the July 20, 1995 workshop, industry requested that the ARB include an amendment to allow for manual correction of additive concentration prior to use by motor vehicles. We agree that this flexibility would be beneficial and help facilitate compliance with the regulation. Thus, we propose to amend the regulation to allow for manual correction of additive concentration. The proposed amendment would also require that notification to the ARB be made within two business days in the event manual correction was necessary and also requires that the facility maintain records to document such an occurrence. The two day notification period is reasonable and necessary to ensure that the provision for manual correction is properly used.

IV

IMPACTS

1. *Environmental Impacts*

As indicated by the preceding discussion, we propose to amend the regulation to add clarity and flexibility and to conform with U.S. EPA requirements. Specifically, we propose to clarify potential ambiguities with certain definitions, provide additional flexibility when producing certification test fuels and when additizing at an additive facility, update the vehicle test methods and clarify the recordkeeping requirements. These amendments will only affect the certification process rather than the quality of gasoline that is sold and used in California motor vehicles. The current regulation as written already results in an environmental benefit as described in the August 13, 1990 staff report. Therefore, the proposed amendments will serve to make the regulation clearer and simpler to understand and thus improve compliance levels but are not expected to cause any significant environmental impacts.

2. *Cost Impacts*

The proposed amendments require the use of new ASTM test procedures for intake valve and PFI testing. These test methods require additional test validation criteria and an increased level of specificity of the test procedures and equipment. Thus, the cost of conducting individual tests is expected to increase slightly. However, the benefits of improved test procedures will result in a reduction in test variability, which can minimize invalid test runs and reduce the number of tests performed. Therefore, we expect the cost increase, if any, to be minimal.

The proposed amendments to clarify daily recordkeeping requirements will not lead to any significant increase in operating costs. Our understanding is that terminal operators already maintain daily records that could be used to comply with our requirements. Some operators may decide to make some minor changes to their operational procedures to increase the accuracy of their additive records reconciliation. However, the proposed tolerance flexibility and averaging within the recordkeeping requirements will likely reduce recordkeeping costs. Therefore, we expect any cost to be minimal.

We believe that none of the other proposed amendments to the regulation will result in any increase in costs. In fact, several proposed amendments may result in a cost savings due to added flexibility.

3. *Small Business Impacts*

The Government Code requires the ARB to discuss how complying with a proposed regulation could adversely affect small businesses. (Small businesses are defined by Government Code Section 11342 *et seq.*) We do not believe that adoption of the proposal would result in significant, adverse impacts on small businesses.

4. *Global Warming and Ozone Depletion Impacts*

The establishment of specifications for Phase 2 gasoline certification fuel is not expected to increase emissions of greenhouse gases that may contribute to global warming or pollutants that may contribute to stratospheric ozone depletion.

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APPENDIX A
COMMENTS & RESPONSES FROM JULY 20, 1995 WORKSHOP

Appendix A

Summary of Comments and Responses Made at the July 20, 1995 Workshop

- 1) If a large refiner trades with a small refiner when CaRFG is required in March 1996, does the large refiner need to certify a gasoline that meets the more severe deposit forming properties of a small refiner fuel?

Response: Yes. All gasoline that is marketed in California must be certified to contain effective deposit control additives for which certification has been granted. This means that if a large refiner intends to trade gasoline with a small refiner, the refiner must ensure that the gasoline is certified and properly additized. After April 1, 1998, all small refiners will need to conform to all the gasoline specifications for CaRFG, therefore, large and small refiners will certify their gasolines to similar specifications.

- 2) Is it necessary to require disclosure of the additive chemical composition for the gasoline certification?

Response: Chemical disclosure of additives is necessary and is an important aspect in evaluating a gasoline additive certification. The chemical composition allows staff to correlate new additive packages to previous certifications. Also, it allows staff to identify toxic compounds which may be part of the additive package. All proprietary information is used internally by the ARB and is kept confidential.

- 3) The ARB should follow the EPA approach by requiring the disclosure of the minimum additive treatment rate in terms of gallons of additive per thousand gallons of gasoline instead of pounds per thousand gallons.

Response: We agree with this comment. We are proposing to amend the regulation to specify the disclosure of the minimum additive treatment rate on a volume basis.

- 4) Even though it was not the subject of this rulemaking, we encourage the ARB to drop the cleanup testing requirement. Cleanup is redundant and is not necessary.

Response: The cleanup portion of the ARB's vehicle testing requirements are an important part of the demonstration to show an additive's effectiveness in severe gasoline formulations. At this time, we do not have the necessary technical data to conclusively justify the elimination of the cleanup requirement. We will continue to work with industry to evaluate the need for this requirement.

- 5) In the blending of certification test fuels, it may not be possible to exactly meet the properties requested for certification. Therefore, it would be appropriate to provide some blending flexibility. One suggestion is to provide the test method reproducibility as the blending margin or tolerance.

Response: We agree that meeting multiple properties would be difficult when blending certification test fuels. However, we do not agree that the test reproducibility should be the tolerance. The test reproducibility could be very large and can lead to certification test fuels that do not adequately represent gasoline formulations for which certification is being requested. As an alternative, we propose a 20 percent tolerance based on our certification procedures we have used in the past. This means that certification test fuels must be within 20 percent of all maximum gasoline specifications requested for certification.

- 6) The dirty-up fuel specification referenced in the cleanup test should not be proposed as a specification, but rather as a guideline for fuel blenders in order to provide a minimal measure of dirty-up performance.

Response: We agree. The current available literature does not support the specification of exact minimum properties to achieve adequate dirty-up performance. Therefore, we propose to change the current dirty-up fuel properties of the cleanup test method to be a guideline. The dirty-up fuel will still need to achieve 10 percent PFI plugging within 10,000 miles as specified in the cleanup test method.

- 7) Since the regulation specifically states that recordkeeping is to be done on a monthly basis, the ARB's daily recordkeeping requirement is more onerous and could lead to a cost impact.

Response: The regulation requires monthly "compilations" of records. We have interpreted this to mean that daily records must be compiled on a monthly basis to ensure that each gallon of gasoline is properly additized. We understand that all facilities are adequately equipped to provide daily recordkeeping to meet the intent of this requirement and most facilities already maintain daily records. We believe the cost to meet this requirement will be minimal.

8) What is the environmental benefit of daily recordkeeping?

Response: The environmental benefit of daily records comes from the air quality benefit of properly additized gasolines (see ARB Staff Report dated August 13, 1990). The current regulation already requires daily recordkeeping and ARB enforcement efforts impose this requirement. The amendment to the recordkeeping requirements is merely a clarification of the existing requirements and will not have an environmental impact.

9) Santa Fe Pacific Pipeline requested that the regulation provide a daily tolerance of 5 percent in the additive treatment level if daily recordkeeping is required.

Response: Currently, the ARB Compliance Division enforcement policy allows a 5 percent additization tolerance for daily records.

10) Why doesn't the ARB adopt the EPA's recordkeeping approach of the interim regulation instead of proposing the need for daily records?

Response: We believe that at this time, the technical data available clearly supports a per gallon standard. While it may appear from some technical data that occasional underadditization will not have adverse air quality impacts, no comprehensive studies have been done on this subject. Some technical data suggests that just one tankful of unadditized gasoline could result in severe fuel system deposits, which in turn could lead to emission increases.

The EPA's interim regulation recordkeeping requirements are specifically designed to enforce a monthly average additive concentration level. However, gross underadditization is still a concern. In fact, under the latest EPA proposal for the final rule, EPA suggests requiring weekly recordkeeping to better assure that all gasoline is properly additized. We believe that the EPA approach will not provide enough assurance that the per gallon standard could be met. Furthermore, EPA's recordkeeping requirements reflect the national norm of additive monitoring technology, which may not always be adequate to monitor additive use on a daily basis. In California, our evaluations show that all facilities can currently monitor additive use daily.

11) Will previously approved gasoline certifications be valid once the proposed amendments go into effect?

Response: Yes. All currently approved gasoline certifications will be valid.

APPENDIX B
PROPOSED REGULATION ORDER

PROPOSED REGULATION ORDER

Amend title 13, California Code of Regulations, section 2257 to read as follows:

§ 2257. Required Additives in Gasoline.

(a) Regulatory Standard.

(1) On or after January 1, 1992, no person shall sell, offer for sale, supply, or offer for supply any California gasoline unless at the time of the transaction:

[i] the producer, importer, or distributor of the gasoline has been issued a currently effective certification pursuant to subsection (c), and

[ii] the gasoline contains at least the minimum concentration of the additive or additives identified in the final application for certification.

(2) Subsection (a)(1) shall not apply to transactions where the person selling, supplying, or offering the gasoline demonstrates that:

[i] the gasoline has not yet been sold, offered, or supplied from the final distribution facility, and either

[ii] the person has taken reasonably prudent precautions to assure that he or she will bring the gasoline into satisfaction with the requirements of subsection (a)(1) before it is sold, supplied or offered from the final distribution facility, or

[iii] at or before the time of the transaction the person has obtained a written statement from the purchaser, recipient, or offeree of the gasoline stating that he or she is a distributor who has been issued a currently effective certification pursuant to subsection (c), and will cause the gasoline to satisfy the requirements of subsection (a)(1) before it is sold, supplied or offered from the final distribution facility.

(3) *Subsection (a)(1)[ii] shall not apply to the sale, supply, or offer of gasoline from a final distribution facility where the person selling, supplying, or offering the gasoline demonstrates that the gasoline will be corrected to comply with section (a)(1)[ii] prior to or at the time of delivery to the facility at which the gasoline will be dispensed into motor vehicles. If such corrective action is taken, the producer, importer, or distributor of the gasoline must notify the Compliance Division of the Air Resources Board by telephone or in writing within 2 business days of the correction and must maintain records to document each occurrence in accordance with subsection (d).*

(4) For the purposes of subsection (a)(1), each sale of gasoline at retail for use in a motor vehicle, and each supply of gasoline into a motor vehicle fuel tank, shall also be deemed a sale or supply by any person who previously sold or supplied such gasoline in violation of subsection (a)(1).

(b) Definitions.

For the purposes of this section:

(1) "Additive" means any substance or mixture of substances that is intentionally added to gasoline for the purpose of reducing or preventing fuel injection system or intake valve deposits, and that is not intentionally removed prior to the gasoline's sale or use.

(2) "Bulk purchaser-consumer" means a person who purchases or otherwise obtains

gasoline in bulk and then dispenses it into the fuel tanks of motor vehicles owned or operated by the person.

(3) "California gasoline" means gasoline sold or intended for sale ~~asa~~ as a motor vehicle fuel in California.

(4) "Chemical composition" means the name, percentage by weight, and chemical identification of each compound in an additive.

(5) "Distributor" means any person who transports or stores or causes the transportation or storage of gasoline, produced or imported by another person, at any point between any producer's or importer's facility and any retail outlet or wholesale purchaser-consumer's facility.

(6) "Final distribution facility" means the stationary gasoline transfer point from which gasoline is transferred into the cargo tank truck, pipeline, or other delivery vessel from which the gasoline will be delivered to the facility at which the gasoline will be dispensed into motor vehicles.

(7) "Gasoline" means any fuel which is *sold or intended for sale as a California motor vehicle fuel and is either: (a) commonly or commercially known or sold as gasoline, or (b) any fuel blend which is a mixture of gasoline as defined in (a) and alcohol in which the portion of gasoline is more than 50 percent of the total blend fuel commonly known or sold as gasoline and alcohol and which is sold or intended for sale as a motor vehicle fuel in California.*

(8) "Gasoline production facility" means a facility in California at which gasoline is produced; it does not include a facility whose sole operation is to transfer gasoline or to blend additives into gasoline.

(9) "Importer" means any person who first accepts delivery of gasoline in California.

(10) "Import facility" means the facility at which imported gasoline is first received in California, including, in the case of gasoline imported by cargo tank and delivered directly to a facility for dispensing gasoline into motor vehicles, the cargo tank in which the gasoline is imported.

(11) "Motor vehicle" has the same meaning as defined in section 415 of the Vehicle Code.

(12) "Produce" means to convert liquid compounds which are not gasoline into gasoline.

(13) "Producer" means any person who produces California gasoline in California.

(14) "Retail outlet" means any establishment at which gasoline is sold or offered for sale for use in motor vehicles.

(15) "Supply" means to provide or transfer a product to a physically separate facility, vehicle, or transportation system.

(c) Certification Requirements.

(1)(A) No gasoline formulation shall be certified under this subsection (c) unless the applicant for certification demonstrates each of the following to the executive officer's satisfaction:

(i) The gasoline formulation meets the unlimited mileage standard of ~~an average of a maximum of 100 milligrams per averaged over all~~ intake valves when tested in accordance with ~~ASTM D 5500-94 the Stationary Source Division's BMW 10,000 Mile Intake Valve Test~~

~~Procedure, dated March 1, 1991, which is incorporated herein by reference.~~

(ii) The gasoline formulation does not result in a flow loss of more than five percent *for any fuel injector* when tested in accordance with *ASTM D 5598-94 the Stationary Source Division's Test Method for Evaluating Port Fuel Injector Deposits in Vehicle Engines*, dated ~~March 1, 1991~~, which is incorporated herein by reference.

(iii) The gasoline formulation is capable of reducing fuel injector deposits so that no fuel injector suffers a flow loss of more than five percent when tested in accordance with the Stationary Source Division's Test Method for Evaluating Port Fuel Injector Deposits in Vehicle Engines, dated ~~March 1, 1991~~ *[insert date of adoption]*, which is incorporated herein by reference.

(B) The executive officer may approve alternative test procedures for demonstrating satisfaction with any of the performance criteria set forth in subsection (c)(1)(A) if an applicant or potential applicant demonstrates to the executive officer's satisfaction that a gasoline formulation which meets the performance criteria of the alternative test procedure would also meet the performance criteria specified in subsection (c)(1)(A).

(2) Any producer, importer, or distributor may apply to the executive officer for certification of a gasoline formulation in accordance with this subsection (c). The application shall be in writing and shall include, at a minimum, the following:

(A) The name and chemical composition of the additive or additives in the gasoline formulation, except that if the chemical composition is not known to either the applicant or to the manufacturer of the additive (if other than the applicant), the applicant may provide a full disclosure of the chemical process of manufacture of the additive in lieu of its chemical composition.

(B) The minimum concentration of each additive in the gasoline formulation *in terms of gallons of additive per thousand gallons of gasoline*.

(C) The results of tests conducted on the gasoline formulation pursuant to the test procedures set forth in subsection (c)(1), all data generated by the tests, the identity of the entity which conducted each test, and a description of the quality assurance and quality control procedures used during the testing.

(D) ~~Data demonstrating that the gasoline formulation used in the tests is representative of the gasoline produced, imported, or distributed by the applicant~~ *fuel used for certification testing ("certification test fuel") is representative of the gasoline formulation for which certification is requested. Properties of the certification test fuel must be at least 80 percent of the maximum properties of the gasoline formulation to be certified for the following: aromatic hydrocarbon content, olefin content, sulfur content, oxygen content, and T90 distillation temperature.*

(E) *Data demonstrating that the certification test fuel is representative of typical commercial gasoline and will be produced from typical refinery blend stocks.*

(FE) The theoretical mechanism of action (if known) of the additive in meeting any of the performance criteria set forth in subsection (c)(1)(A).

(GF) Copies of all material pertaining to the additive or additives in the gasoline formulation, submitted by the applicant to the U.S. Environmental Protection Agency pursuant to 40 CFR sections 79.6, 79.10 and 79.11. If the applicant has submitted no such material,

copies of all material pertaining to the additive or additives in the gasoline formulation, submitted by the additive manufacturer to the U. S. Environmental Protection Agency pursuant to 40 CFR sections 79.6, 79.20 and 79.21.

(HG) A test method reasonably adequate for determining the presence and concentration of each additive in the gasoline, *including test method reproducibility*. The test method may involve identification of the presence of a surrogate marker substance if the applicant demonstrates that such test method will adequately demonstrate the presence and concentration of the additive.

(3) Within 30 days of receipt of an application, the executive officer shall advise the applicant in writing either that it is complete or that specified additional information is required to make it complete. Within 30 days of submittal of additional information, the executive officer shall advise the applicant in writing either that the application is complete, or that specified additional information or testing is still required before it can be deemed complete.

(4) If the executive officer finds that an application meets the requirements of this section and determines that the applicant has satisfactorily made the demonstrations identified in subsection (c)(1), then he or she shall issue an Executive Order certifying the gasoline fuel formulation. The executive officer shall act on a complete application within 30 days after the application is deemed complete.

(5) If the executive officer determines that the gasoline sold by a producer, importer or distributor contains the minimum concentration of additives identified in an applicable certification, but substantially fails to meet the performance criteria set forth in subsection (c)(1), the executive officer shall revoke or modify the prior certification as is necessary to assure that gasoline sold by the producer, importer or distributor meets the performance criteria set forth in subsection (c)(1). The executive officer shall not revoke or modify a prior certification order without first affording the applicant for the certification an opportunity for a hearing in accordance with title 17, California Code of Regulations, part III, chapter 1, subchapter 1, article 4 (commencing with section 60040). If the executive officer determines that a producer, importer or distributor would be unable to comply with this regulation as a direct result of a certification revocation or modification pursuant to this subsection, the executive officer may delay the effective date of such revocation or modification for such period of time as is necessary to permit the person to come into compliance in the exercise of all reasonable diligence.

(d) Recordkeeping.

(1) Each producer, importer, and distributor who has been issued a certification pursuant to subsection (c) ~~shall~~ *must* maintain records ~~identifying for~~ each facility at which he or she adds an additive to California gasoline in order to comply with subsection (a)(1). For each such facility, ~~commencing January 1, 1992,~~ the producer, importer or distributor ~~shall~~ *must* ~~compile~~ *maintain daily records for each business day and compile those records monthly, showing on a monthly basis* for each grade of gasoline:

[i] the volume of California gasoline supplied from the facility by the producer, importer or distributor,

[ii] the volume of California gasoline to which the producer, importer or distributor added the additive to comply with subsection (a)(1), ~~and~~

[iii] the name and volume of each additive (or additive package) ~~used~~ added to the California gasoline fuel, and

[iv] the actual additive usage rate achieved.

(2) For purposes of demonstrating compliance with the standard in subsection (a)(1) based on the records required under this subsection (d)(1)

[i] Monthly records must demonstrate that for each month the gasoline on average contains at least the minimum concentration of the additive or additives identified in the final application for certification.

[ii] Daily records must demonstrate that for each 24 hour period the gasoline on average contains at least 95 percent of the minimum concentration of the additive or additives identified in the final application for certification.

(3) Daily records and the monthly compilations covering a calendar month must be available for inspection 15 days after the end of the month. The daily records and monthly compilation of ~~Records covering a month shall~~ must be compiled no later than 30 days after the end of the month, and shall be retained for at least two years after the end of the month.

(4) Any person required by subsection (d)(1) to maintain and compile ~~and retain~~ records shall provide to the executive officer any such records within 20 days of a ~~must make~~ those records available for inspection and copying immediately upon request by the executive officer or his/her designee. Upon a written request received from the executive officer or her/her designee, a copy of the daily records must be provided to the executive officer within 20 days of the request ~~before expiration of the period during which the records are required to be retained~~. Whenever such a person fails to provide records regarding a volume of California gasoline in accordance with this subsection (d)(4), the volume of California gasoline shall will be presumed to have been sold by the person in violation of subsection (a)(1).

Note: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101 of the Health and Safety Code, and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code, and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

APPENDIX C
PLAIN ENGLISH SUMMARY OF PROPOSED AMENDMENTS

APPENDIX C

This appendix provides a noncontrolling plain English summary of the proposed amendments to the gasoline deposit control additive regulation, section 2257, title 13, California Code of Regulations, as required by Government Code section 11346.2(a)(1). These amendments will be considered by the Air Resources Board at its November 16-17, 1995 public hearing:

Add new subsection (a)(3). The existing regulation requires that all commercial gasoline be properly additized before it leaves prior to reaching a retail or wholesale facility such as service station. The regulation does not allow for correction of gasoline that does not have the required minimum concentration of additive ("underadditized gasoline") after it leaves the final distribution facility headed for the retail or wholesale facility where it will be dispensed into motor vehicles, for example, a service station. This new provision allows manual correction of underadditized gasoline at the retail or wholesale facility if the following requirements are met: (1) the person who received the certification for the gasoline demonstrates that it was correctly additized before it was dispensed at the retail or wholesale facility, (2) that person notifies the Compliance Division of the ARB that underadditized gasoline was manually corrected within 2 business days, and (3) that person maintains a record of the occurrence.

Amend subsection (b)(7). This amendment clarifies that to qualify as gasoline for purposes of this regulation, a gasoline/alcohol blend must contain more than 50 percent gasoline.

Amend subsection (c)(1)(A)(i). This section as amended incorporates the American Society of Testing and Materials (ASTM) D 5500-94 test method for evaluating the ability of an additive to prevent gasoline deposits on intake valves. ASTM D 5500-94 is a replacement for the ARB test method currently referenced in the regulation. The new test method includes more detailed instructions for conducting the test and better quality assurance/quality control procedures.

This section as amended clarifies that the unlimited mileage standard of 100 milligrams is measured as a average over all of the intake valves.

Amend subsection (c)(1)(A)(ii). This section as amended incorporates the ASTM D 5598-94 test method for evaluating the ability of an additive to prevent gasoline deposits on port fuel injectors. ASTM D 5500-94 is a replacement for the ARB test method currently referenced in the regulation. The new test method includes more detailed instructions for conducting the test and better quality assurance/quality control procedures.

Amend subsection (c)(1)(A)(iii). The amendment to this section incorporates a revision of the ARB test method for evaluating the ability of an additive to clean up port fuel injector deposits.

The test method has been modified to be consistent with ASTM D 5598-94. The revised test method includes more detailed instructions for conducting the test and better quality assurance/quality control procedures.

Amend subsection (c)(2)(B). This amendment specifies that the minimum additive concentration that must be reported in the certification application in terms of gallons of additive per thousand gallons of gasoline.

Amend subsection (c)(2)(D) and add subsection (c)(2)(E). These amendments establish new criteria for the fuel used for certification testing ("certification test fuel"). The amendments provide that the certification test fuel must be produced from typical refinery blend stocks, and must be representative of both typical commercial gasoline and the gasoline formulation for which certification has been requested. The amendments provide that the certification test fuel is representative of the gasoline formulation if its aromatic hydrocarbon, olefin, sulfur and oxygen content and T90 distillation temperature are within 80 percent of the gasoline formula's maximum values for these properties.

Amend subsection (d). Subsection (d) as amended clarifies and modifies the recordkeeping requirements. The amendments clarify that a person who has received certification for a gasoline formulation must maintain daily records for each business day containing specified information, including information about the actual additive usage rate. The existing regulation requires monthly compilation of records, but the amendments shorten the time for completing the compilation from 30 to 15 days after the end of the month.

The amendments provide that when enforcement of the regulations is based on these records, the monthly average additive dose rate must comply with the minimum dosage rate specified in the gasoline certification and that the daily average dose must be at least 95 percent of the minimum dosage rate.

APPENDIX D
REVISED ARB CLEAN UP VEHICLE TEST PROCEDURE
FOR PORT FUEL INJECTORS

Test Method for Evaluating Port Fuel Injector (PFI)

Deposits in Vehicle Engines

NOTE: This document is printed in a style to show both the proposed amendments to the existing Air Resources Board (ARB) test procedure dated March 1, 1991, and ARB's revisions to ASTM D 5598-94, which is incorporated by reference in the ARB test procedure. Proposed amendments to the ARB test procedure appear in *italics* to indicate additions to and ~~strikeout~~ to indicate deletions from the existing test procedure. ARB's revisions to ASTM D 5598-94 are shown in underline to denote additions to and ~~bracketed-strikeout~~ to denote deletions from the ASTM test method.

STATE OF CALIFORNIA
AIR RESOURCES BOARD
STATIONARY SOURCE DIVISION

~~March 1, 1991~~ [insert date of adoption]

TEST METHOD FOR EVALUATING PORT FUEL INJECTOR
(PFI) DEPOSITS IN VEHICLE ENGINES

A. PURPOSE

The purpose of this test procedure is to evaluate the port fuel injector keep-clean characteristics of gasoline formulations and the effectiveness of gasoline formulations in cleaning up injector deposits. This test procedure closely follows ~~the CRC test procedure described in CRC Report No. 565, "A Program to Evaluate a Vehicle Test Method for Port Fuel Injector Deposit-Forming Tendencies of Unleaded Base Gasolines", February 1989 ASTM D 5598, with some modifications to test for clean-up ability.~~

B. TEST PROCEDURE OUTLINE

1. Keep-Clean Procedure

The keep-clean test procedure shall start with a vehicle/engine equipped with new fuel injectors. To avoid variability due to engine break-in effects, testing should begin only after 4,000 miles equivalent have accumulated. At the beginning of the test, the flow capacities of the injectors are measured. The *vehicle/engine* is operated on the applicant's additized gasoline fuel for the prescribed test cycle and the fuel injectors ~~are~~ *may be* flow-tested ~~not more than every 1000 miles equivalent to determine their flow capacities.~~ After the ~~vehicle/engine/vehicle~~ is operated for 10,000 miles equivalent on the prescribed test cycle, the fuel injectors are tested again to determine their flow capacities. *If the fuel injector No. 3 maximum skin temperature does not exceed 90° C (194° F) for more than 95% (685) of the hot soak cycles, then the test will be declared invalid unless a minimum of 685 total hot soak cycles with PFI No. 3 exceeding 90° C are met within an additional 2500 miles.*

2. Clean-Up Procedure

The clean-up test procedure shall start with a vehicle/engine equipped with new fuel injectors. To avoid variability due to engine break-in effects, testing should begin only

after 4,000 miles equivalent have accumulated. At the beginning of the test, the flow capacities of the injectors are measured. The vehicle/engine is operated for the prescribed test cycle on the ~~base dirty-up fuel (as described in section C.4)~~ for 10,000 miles equivalent or for as long as needed so that at least one of the injectors is at the 10% flow restriction level. ~~Fuel injectors are flow tested every 1000 miles equivalent.~~ ~~Then~~ The vehicle/engine shall *must then* be operated on the applicant's additized gasoline formulation for a maximum of an additional 10,000 miles equivalent and fuel injectors shall be tested to determine their flow capacities *the prescribed test cycle up to 10,000 miles equivalent or until the fuel injectors all drop to less than a 5% flow restriction level. The fuel injectors may be flow-tested not more than every 1000 miles. After the test is completed, the fuel injectors are tested again to determine their flow capacities. If the fuel injector No. 3 maximum skin temperature does not exceed 90° C (194° F) for more than 95% of the hot soak cycles, then the test will be declared invalid.*

C. TEST PROGRAM

~~1. Test Vehicle/Engine~~

~~The test vehicle/engine used for this test program shall be a Chrysler vehicle equipped with a 2.2L., I-4, turbocharged engine.~~

~~2. Vehicle/Engine Preparation~~

~~The vehicle/engine shall be tuned to perform according to the manufacturer's specifications.~~

~~3. Test Cycle~~

~~The operating cycle for both keep clean and clean-up test procedures shall consist of 15 minutes of operation at 55 mph road load followed by 45 minutes hot soak with the engine shut off.~~

~~The test cycle is repeated for 10,000 miles equivalent. Vehicle running conditions may be accomplished on a test track, road simulator or chassis dynamometer. It is important that the test vehicle be rapidly brought to 55 mph, as well as back to zero at the end. For open road operations, it is desirable to minimize the travel distance to reach the operating speed of 55 mph.~~

~~For hot soak, no special options are needed, (e.g., blankets, engine shrouds, etc). The intent is to run the vehicle in a realistic way "simulating" customer driving experiences.~~

~~NOTE: ALL TESTS, INCLUDING REPEAT RUNS, ARE TO START WITH NEW,
FLOW-RATED INJECTORS.~~

~~4. Test Fuels~~

~~The base gasoline shall be a full boiling, commercial types unleaded base gasoline with properties approximating those in Attachment A. Another base fuel may be substituted for the fuel prescribed in Attachment A after approval by the Executive Officer. The substitute fuel must be successful in causing enough deposits to plug at least one of the injectors to the 10% flow restriction level before 10,000 miles equivalent of vehicle/engine operation.~~

~~The gasoline formulation tested shall be typical of the product sold or intended to be sold in California.~~

~~Typical properties and analyses (from tests such as listed in Attachment A) for each fuel shall be provided when the fuel batches are made available. As a check on fuel uniformity, the following tests shall be run for each fuel at the beginning and at the end of the test program:~~

- ~~ASTM D381 (gum)~~
- ~~ASTM D525 (stability)~~
- ~~R.V.P.~~
- ~~ASTM distillation~~

~~5. Engine Oil~~

~~The same crankcase engine oil, an SAE 10W-30 viscosity grade of API SE or higher quality, shall be used throughout the test program. Prior to each test run, the engine shall be flushed with fresh oil following an oil filter change. Drain the oil, change filter, and put in a fresh change of the same oil for the test.~~

~~6. Fuel Injectors~~

~~OEM part number pintle style injectors with solid plastic cap ONLY, as manufactured by Bosch, are to be used.~~

~~D. MEASUREMENTS~~

~~1. Fuel Rail Pressure~~

~~The injector fuel rail pressure in the vehicle must be at the manufacturer's specified level during engine operation and remain at about the same level during the 45 minute shutdown period. A malfunctioning pressure regulator will allow the rail pressure to~~

~~decrease during the shutdown period, which can decrease PFI deposit formation rates. Fuel rail pressure shall be checked once per day during the operation period and within 10 minutes after shutdown.~~

~~2. Injector Flow Rate Measurement~~

~~a. The laboratory flow apparatus shall control fuel pressure at about the same level as the fuel rail pressure of the vehicle/engine during operation.~~

~~b. A light hydrocarbon (isooctane, mineral spirit, or stoddard solvent) shall be used for flow rate tests.~~

~~c. The injector shall be flowed statically (wide open) for ten seconds + one second. Longer time intervals may risk overheating the injector solenoid. The timing interval shall be reported to hundredths of a second. Bosch indicates injectors open fully at 8 volts DC without risk of overheating, which allows longer flow times to improve measurement accuracy.~~

~~d. A minimum of three repeat flow rate tests per injector are considered necessary. If necessary, additional tests must be run until repeat results have less than 1% variability (1% variability is reasonable expectation of new injectors). The average (to two decimal places) shall be reported as the flow rate for that injector measurement.~~

~~e. Injector flow rates shall be measured as soon as possible, and in no case greater than 24 hours, after removal from the vehicle to avoid drying out and possible effects on deposit stability.~~

~~f. For clean injectors at the start of each test, run the Injector Leak Rate Test to check for leading, dribbling, etc. (See Attachment B). As injectors become fouled, the probability of pintle leakage increases. Deposit formation may cause an improper seal between pintle and injector opening, thus causing leakage. The upper production limit of leakage with air is 2cc per min. (at approx. 50 psi). Injectors leaking above this rate shall be rejected for the test. To avoid unnecessary rejection of new injectors due to dirt particles, the injectors shall be first flowed with liquid. This will serve to flush the critical internal areas before lead testing with air.~~

~~g. Rate injectors every 1000 miles.~~

~~h. For new injectors, flow rates within a test set for an engine shall fall within + 2% of each other.~~

~~3. Temperature Measurement~~

~~The following temperature measurements shall be recorded:~~

- ~~a. Ambient at test site (maximum and minimum for every 24 hour time period).~~
- ~~b. Inlet air, coolant, oil and fuel tank (typical maximum for each day).~~
- ~~c. Bulk or individual cylinder exhaust gas during operation.~~

~~4. Fuel Consumption~~

~~For each test, the fuel consumed per odometer miles traveled should be recorded with reasonable accuracy. Use of a standard gasoline dispensing pump is satisfactory. One average per test program is a representative measurement.~~

~~E. PRESENTATION OF DATA~~

~~The testing laboratory is required to provide the following in their final report:~~

- ~~1. Total number of soak cycles for the complete test and number of soaks per 1,000 miles equivalent.~~
- ~~2. Tabulation of raw flow rates for each injector by cylinder position as a function of miles or cycles.~~
- ~~3. Graphs of injector flow rates versus vehicle/engine miles equivalent, per fuel.~~
- ~~4. Graph typical exhaust gas temperature during stabilized road load operation for each cycle.~~

1. *Keep-Clean Procedure*

The following procedure must be used: ASTM D 5598-94, Standard Test Method for Evaluating Unleaded Automotive Spark-Ignition Engine Fuel for Electronic Port Fuel Injector Fouling.

2. *Clean-Up Procedure*

The following procedure must be used: ASTM D 5598-94, Standard Test Method for Evaluating Unleaded Automotive Spark-Ignition Engine Fuel for Electronic Port Fuel Injector Fouling, with the following modifications:

a. Section 7. Reagents and Materials, add the following:

7.7 Dirty-Up Fuel -- The dirty-up fuel must be a full boiling, unleaded gasoline that is capable of causing enough deposits to plug at least one of the injectors to the 10% flow restriction level before 10,000 miles of vehicle operation. For example, the dirty-up fuel may have the following properties:

<u>Fuel Property</u>	<u>Level</u>
<u>Octane, (R+M)/2</u>	<u>87 min.</u>
<u>Existent gum, mg/dl</u>	<u>3 min.</u>
<u>Sulfur, ppm</u>	<u>150 min.</u>
<u>Hydrocarbon type, vol%</u>	
<u>Olefins</u>	<u>20 min.</u>
<u>Aromatics</u>	<u>30 min.</u>
<u>Reid vapor pressure, psi</u>	<u>11.5 max.</u>
<u>Distillation, °F</u>	
<u>50% evaporated</u>	<u>170 min.</u>
<u>90% evaporated</u>	<u>374 max.</u>
<u>Induction period, minutes</u>	<u>240 min.</u>

b. Section 7. Reagents and Materials, change the following:

7.5 Test Fuel -- A test fuel shall be either a base fuel or a homogeneous blend of additives and base fuel. A single batch of base fuel shall be blended before the start of the test. The fuel may be stored in drums or tankage and shall be clearly labeled to prevent misfueling. During PFI testing, the test fuel shall be tested for the following properties using standard test methods: aromatics and olefins contents, full distillation range, gum, and sulfur. Quantities of fuel and additive blended and dispensed shall be measured and recorded. [Approximately 2300 L (600 gal) of fuel are required for this test method.]

c. Section 9. Test Procedure, change the following:

9.2 Mileage Accumulation -- The mileage accumulation is divided into two parts: the dirty-up phase and the clean-up phase. Mileage is first accumulated on the dirty-up fuel until at least one of the injectors is at the 10% flow restriction level. After completing the dirty-up phase, the fuel tank is drained and flushed as in 8.2.4. The fuel tank is then filled with the test fuel and mileage accumulation will continue up to a maximum of 10,000 miles on the test fuel or until all injectors measure less than 5% flow restriction. Mileage accumulation will be performed as follows:

The dynamometer, test track, road mileage accumulation cycle, or combination thereof, consists of a series of driving cycles and engine-off hot soak cycles. The test vehicle shall be started and accelerated to 88 kph (55 mph) within 30 s of start-up. The test vehicle shall be accelerated to 88 kph, driven for 15 min, or approximately 22 km (14 miles), and then allowed to coast, or vehicle may be braked, to a stop within 30 s. The engine is then turned off and the vehicle undergoes a 45-min hot soak cycle. The vehicle shall be allowed to soak for 45 min in calm air, with all fans turned off. These test cycles may be run 24 h per day or less. The vehicle shall repeat this cycle for 16,100 km (10,000 miles). The fuel injectors may be removed and flow tested, however, not more than every 1600 km (1000 miles) during the clean-up phase.

d. Section 10. Determination of Test Results, change the following:

10.5.1.1 Test Cycle Validation Criteria -- If the fuel injector No. 3 maximum skin temperature does not exceed 90° C (194° F) for more than 95% of the hot soak cycles [~~of a 16,100 km (10,000-mile) test length (or 685 of 725 hot soak cycles)]~~ then the test will be declared invalid. However, any hot soaks during the test for which PFI No. 3 skin temperature does not exceed 90° C, may be repeated until a minimum of ~~[685]~~ 95% of the total hot soak cycles with PFI No. 3 exceeding 90° C are met [~~within an additional 4000 km (2500 miles). Thus the maximum length for any fuel injector fouling test shall be 21,100 kilometers (12,500 miles) or a maximum of 910 hot soaks]~~]

e. Section 11. Final Test Report, add the following:

11.1.5 Fuel property test results.

ATTACHMENT A

BASE FUEL PROPERTIES

Fuel Properties

Gravity, °API	59.9
Specific Gravity @ 15.6°C	0.74
Distillation, °C	
IBP	33
10%	48
50%	106
90%	188
EP	218
Total Olefins, % vol.	35
Induction Period, minutes	270
RVP (psi)	11.8
Gum, mg/100ml	
Unwashed	7.0
Washed	6.0
Sulfur, % wt.	0.08

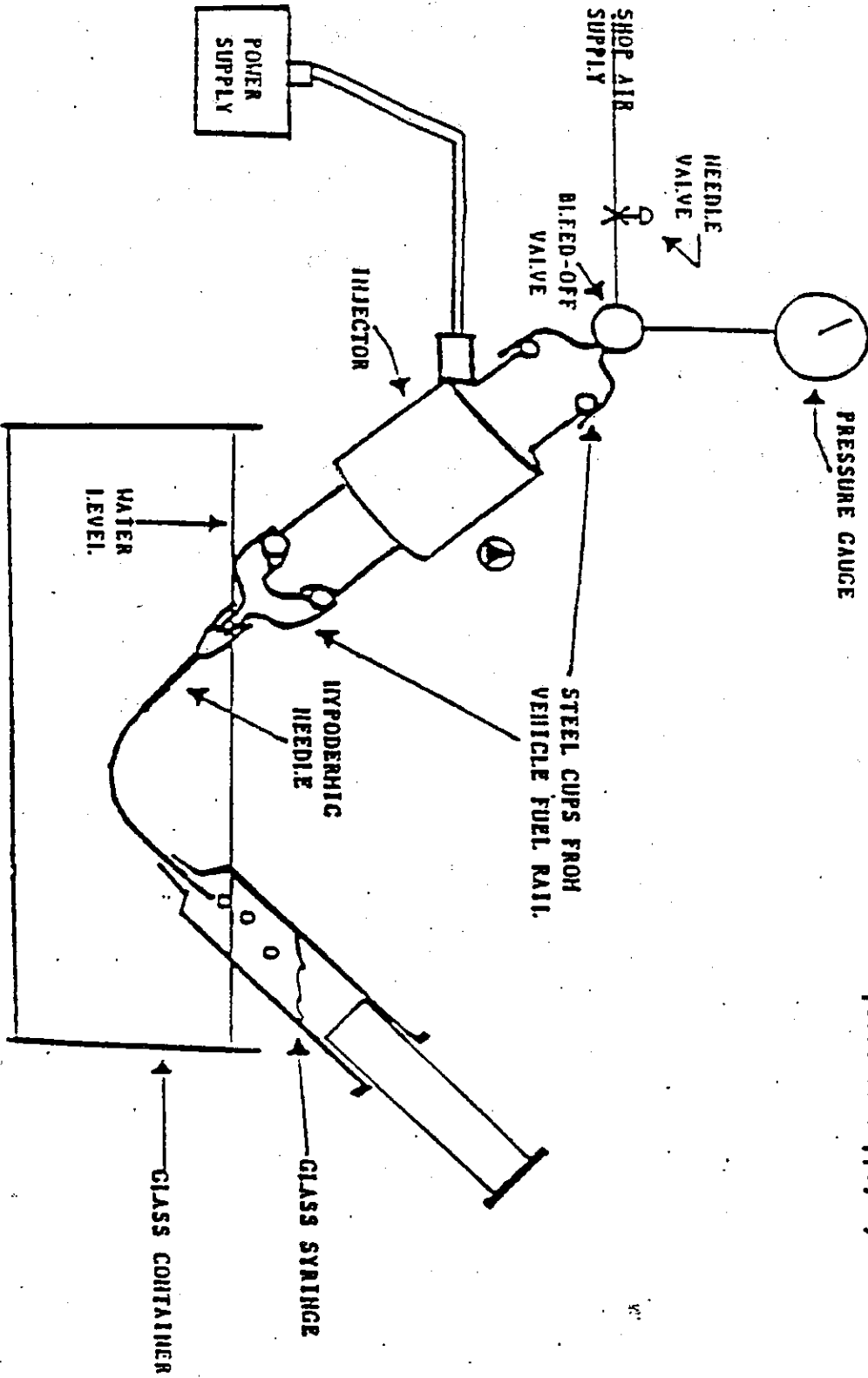
ATTACHMENT B

Injector Leak Rate Test Procedure

1. ~~Blow any residual fluids out of the injector with clean, dry shop air while holding the injector open.~~
2. ~~While the injector is still open, rinse with acetone and blow dry. Repeat.~~
3. ~~Mount injector in rig and attach hypodermic needle assemblies in the diagram.~~
4. ~~Place a 5 ml, water-filled syringe over the hypodermic needle tip for gas collection and volumetric measurements at 0.25, 1.0 and 5.0 ml. Immerse in bath as illustrated.~~
5. ~~Apply 50 PSI air pressure and collect the air bubbles at the hypodermic needle tip using the 5 ml syringe measured over a suitable time period.~~
6. ~~Record results as ml's of air collected per one minute time period.~~
7. ~~Repeat until 3 consecutive results in the same range are obtained.~~

[DELETE]

INJECTOR LEAK TEST APPARATUS



A HOT SHIMM: A clamping device which

holds the injector body into the air pressure supply system.