California Environmental Protection Agency

Air Resources Board

Recommendation on Need for a Multimedia Evaluation of Amendments to the California Diesel Fuel Regulations

REPORT TO THE CALIFORNIA ENIVIRONMENTAL POLICY COUNCIL

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Acknowledgments

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I. SUMMARY

In November 1988, the Air Resources Board (Board/ARB) approved regulations limiting the allowable sulfur content of motor vehicle diesel fuel to 500 parts per million by weight (ppmw) statewide and the aromatic hydrocarbon content to 10 percent by volume (vol.%) for large refiners and 20 vol.% for small refiners. These diesel fuel regulations, which became effective in 1993, are a necessary part of the State's strategy to reduce air pollution through the use of clean fuels and lower emitting motor vehicles and off-road equipment.

In July 2003, the Air Resources Board (the Board/ARB) approved proposed amendments to the California diesel fuel regulations that include the following revisions.

- Change the maximum allowable sulfur content of California vehicular diesel fuel from 500 ppmw to 15 ppmw, effective June 1 2006;
- Add a set of fuel specifications that represent the properties of the average in-use fuel as an option to meeting the 10 vol.% aromatic hydrocarbon limit;
- Adopt an airborne toxic control measure (ATCM) to require the use of vehicular diesel fuel in non-vehicular engines except those used in locomotives and marine vessels.
- Establish a diesel fuel lubricity standard of 520 microns wear scar diameter (WSD), based on the High Frequency Reciprocating Rig (HFRR) test method, effective in August 2004.

Health and Safety Code, Section 43830.8, requires that before the ARB can adopt any regulation that establishes a specification for motor vehicle fuel, a multimedia evaluation must be conducted and reviewed by the California Environmental Policy Council (Policy Council). Key components of the evaluation process are the identification and evaluation of significant adverse impacts on public health or the environment and the use of best available scientific data.

A. Sulfur Specification

Reducing the sulfur content of diesel fuel from the statewide average of 140 ppmw to less than 15 ppmw would reduce sulfur oxide (SOx) emissions by about 90 percent. Direct diesel particulate matter (PM) emissions would be reduced by about 4 percent, or about 0.6 tons per day in 2010 for engines not equipped with advanced particulate emissions control technologies. These emissions reductions would be obtained with low sulfur diesel used in mobile on-road and off-road engines, portable engines, and those stationary engines required by district regulations to use CARB diesel.

In addition, oxides of nitrogen (NOx) emissions would be reduced by 7 percent or about 80 tons per year for those engines not currently using CARB diesel, assumed to be about 10 percent of the stationary engine inventory.

The lower sulfur diesel makes much more significant emissions reductions possible by enabling the effective use of advanced emission control technologies on new and retrofitted diesel engines. With these new technologies, emissions of diesel PM and NOx can be reduced by an additional 90 percent.

The refining process to reduce the sulfur content of diesel fuel is not expected to result in a significant change in the chemical composition of the fuel. Therefore, there should be no significant change in the physical or chemical properties that affect the activity of the fuel in soil and water, and any release of low sulfur diesel fuel to the environment should have no additional impact on water and soil quality compared to the current diesel fuel.

The additional hydrotreating to produce low sulfur diesel is expected to increase emissions of greenhouse gases, but the greenhouse effect from diesel production is expected to be substantially offset by the effect of a reduction in CO_2 emissions from the use of low sulfur fuel in diesel engines. This will occur because some of the extra hydrogen from the additional hydrotreating and the energy it represents will be in the fuel, increasing the hydrogen to carbon ratio and reducing CO_2 emitted per million BTU of fuel.

B. Alternative Fuel Specifications

The new equivalent limits are based on the average properties of certified formulations and should therefore preserve the actual emission benefits of California diesel fuel. In addition, this new compliance mechanism would provide additional flexibility for refiners or importers and potentially allow more diesel fuel to be imported into the California market.

C. Air Toxics Control Measure

Particulate emissions from nonvehicular diesel engines represent an increasingly significant portion of the statewide diesel PM emissions. The ATCM would extend the applicability of the California diesel fuel regulations to non-vehicular uses including stationary engines but excluding locomotives and marine vessels. This will facilitate the implementation of the measures in the Diesel Risk Reduction Plan that apply to nonvehicular diesel engines by enabling the use of high-efficiency, PM emission-control devices that would not be effective with higher sulfur levels.

D. Lubricity Specification

It is anticipated that the new lubricity standard of HFRR 520 microns wear scar diameter will not result in any significant change in the current refinery practices or change in the use of lubricity additives. Refiners have already maintained a voluntary minimum lubricity standard consistent with the recommendation of the 1994 Governor's Task Force that was created during the statewide introduction of California's 500 ppmw sulfur reformulated diesel fuel.

Diesel fuel lubricity additives must be federally registered, and must undergo a series of toxic evaluations to determine potential toxic risk to human health. The U.S. EPA has found that current registered lubricity additives do not pose any increase in public health

risk relative to baseline diesel fuel. Therefore, the 2004 lubricity standard will pose no significant adverse impacts on public health or the environment.

E. Reviews of the Specifications

The staff's amendments to the California diesel fuel regulations were subjected to an external peer review and to a review by an interagency multimedia working group.

1. External Peer Review

A scientific peer review was conducted by four peer reviewers selected by the University of California Office of the President.

The reviewers agreed in general with the ARB staff's evaluation of the scientific basis of the amendments and the staff's estimates of emissions benefits. They found that the staff's approach to the alternative fuel specifications option was well founded and the specifications for the fuel properties should provide similar reductions to the 10 percent aromatics standard without the need for costly engine tests. Overall, the reviewers agreed with the ARB's staff that the proposed amendments would have no significant adverse impact on public health and the environment.

2. Environmental Policy Council Workgroup

The ARB staff's initial evaluation of the amended regulations was reviewed by the interagency multimedia fuels workgroup that includes the staffs of the State Water Resources Control Board (SWRCB), the Office of Environmental Health Hazard Assessment (OEHHA), and the Department of Toxic Substances Control (DTSC).

The members of the workgroup found that both the diesel fuel sulfur limit and lubricity standard should have no significant adverse impact on public health and the environment compared to diesel fuel meeting existing requirements and that no further multimedia evaluation is necessary.

II. RECOMMENDATIONS

The ARB staff recommends that:

- the Policy Council concur with the ARB staff's findings that the proposed amendments to the California diesel fuel regulations will not have any significant adverse impact on public health and the environment; and
- the Policy Council determine that no further multimedia evaluation is necessary.

III. BACKGROUND

A. Existing California Diesel Fuel Regulations

The California diesel fuel regulations were approved by the Air Resources Board (ARB) in 1988 and were implemented in 1993. The regulations limit statewide the allowable sulfur content of motor vehicle diesel fuel to 500 ppmw and the aromatic hydrocarbon content to 10 percent with a 20 percent limit for small refiners.

The regulation limiting the aromatic hydrocarbon content also includes a provision that allows producers and importers to comply with the regulation by qualifying a set of alternative specifications of their own choosing. The alternative formulation must be shown, through emissions testing, to provide emission benefits equivalent to that obtained with a 10 percent aromatic standard (or in the case of small refiners, the 20 percent standard). Most refiners have taken advantage of the regulation's flexibility to produce alternative diesel formulations that provide the required air quality benefits at a lower cost.

About 90 percent of the diesel fuel sold or supplied in California meets the requirements for California diesel fuel. Only diesel fuel for stationary engines, locomotives, and marine vessels is currently exempt from the California diesel fuel regulations. However, the great majority of stationary engines use vehicular diesel fuel because of California's single fuel distribution network and because of air districts' best available control technology (BACT) requirements for diesel-fueled stationary engines that specify the use of vehicular diesel fuel.

There is currently no government or industry standard controlling diesel fuel lubricity in the United States. Refiners in California have maintained a voluntary minimum lubricity level consistent with the recommendation of a 1994 Governor's Task Force that was created during the statewide introduction of 500-ppmw sulfur California reformulated diesel. This voluntary level is a Ball-on-Cylinder Lubricity Evaluator (BOCLE) scuffing load (SL) of 3,000 grams or higher.

B. Requirement for Multimedia Evaluation

Health and Safety Code, Section 43830.8, (Stats. 1999, Ch. 813; Senate Bill 529, Bowen) generally prohibits the ARB from adopting a regulation establishing a specification for motor vehicle fuel unless the regulation is subject to a multimedia evaluation by the Policy Council. Key components of the evaluation process are the identification and evaluation of significant adverse impacts on public health or the environment and the use of best available scientific data.

Multimedia evaluation means the identification and evaluation of any significant adverse impact on public health or the environment, including air, water, or soil, that may result from the production, use, or disposal of the motor vehicle fuel that may be used to meet the state board's motor vehicle fuel specifications.

The statute provides that the ARB may adopt a regulation that establishes a specification for motor vehicle fuel without the proposed regulation being subject to a multimedia evaluation if the Policy Council, following an initial evaluation of the proposed regulation, conclusively determines that the regulation will not have any significant adverse impact on public health or the environment. This document represents ARB staff's initial evaluation of impacts of the proposed amendments on public health and the environment.

IV. AMENDMENTS TO THE DIESEL FUEL REGULATIONS

At a July 24, 2003 hearing, the Board approved the changes to the diesel fuel regulations summarized below.

- Reduce the maximum allowable sulfur content of vehicular diesel fuel from 500 ppmw to 15 ppmw. This new sulfur content limit of 15 ppmw would generally align the California requirements with U.S. EPA's standard for on-road diesel fuel, but the ARB requirements would apply to diesel fuel used in off-road motor vehicles as well.
- Provide a new set of fuel specifications as an option to meeting the 10 vol.% aromatic hydrocarbon limit. This new compliance mechanism would provide additional flexibility for refiners or importers and potentially allow more diesel fuel to be imported into the California market. The proposed new equivalent limits are based on the average properties of certified formulations and should therefore preserve the actual emission benefits of California diesel fuel.
- Adopt a new ATCM which would ultimately require that California non-vehicular diesel fuel meet the same ARB standards as California vehicular fuel, once air districts have had the opportunity to adopt their own ATCM on the subject. There would be an exception for diesel fuel used in locomotives and marine vessels.
- Adopt a fuel lubricity standard that would be phased in for all California motor vehicle diesel fuel starting August 1, 2004. The standard is a High Frequency Reciprocating Rig (HFRR) maximum wear scar diameter (WSD) of 520 microns, which will become effective August 1, 2004. The approved amendment also includes a placeholder in the regulation for a more stringent 2006 lubricity standard (corresponding to the 15-ppmw sulfur implementation date) for staff to address future lubricity needs of advanced technology fuel systems.

Other amendments approved by the Board will not affect the overall composition of California diesel fuel. They include improvements to the sulfur test method and other changes to provide flexibility and to help ensure effective enforcement of the regulations.

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V. REVISED SULFUR LIMIT

A. Need for Low Sulfur Diesel Fuel

The California diesel fuel regulations are a necessary part of the State's strategy to reduce air pollution through the use of clean fuels and lower emitting motor vehicles and off-road equipment. The most recent proposed and adopted regulations to reduce diesel exhaust emissions, exposure, and risk will require the use of low sulfur diesel fuel to be effective. The revised sulfur limit is needed to enable the effective performance of sulfur-sensitive exhaust gas treatment technologies. The lower sulfur content can also have a direct effect by decreasing sulfate particulate matter and other sulfur derived vehicle exhaust emissions. The following section is a brief summary of the need for low sulfur diesel fuel. A more detailed discussion is presented in the Staff Report: Initial Statement of Reasons (ISOR) for the regulatory action, which is included in this report as Appendix A and can also be found on the ARB's website at http://www.arb.ca.gov/regact/ulsd2003/ulsd2003.htm.

1. Enabling Diesel Exhaust Aftertreatment Systems

a) Heavy and Medium Duty Diesel Emission Standards

In October 2001, the ARB adopted the new stringent exhaust emissions standards that were adopted in January 2001 by the U.S. EPA for 2007 and subsequent model year heavy-duty highway diesel engines and vehicles. The new emission standards represent a 90% reduction of emissions of NOx, a 72% reduction of emissions of non-methane hydrocarbon (NMHC), and a 90% reduction of emissions of particulate matter (PM) compared to the emission standards that apply starting in the 2004 model year.

The new emissions standards will require the use of diesel particulate filters (DPF), NOx after-treatment and other advanced after-treatment based technologies that could not achieve the required emissions control efficiencies with diesel fuel sulfur levels higher than 15 ppmw. Both the PM and NOx technologies have the potential to make significant amounts of sulfate PM under operating conditions typical of heavy-duty vehicles. The sulfate PM formed in this manner will result in total PM emissions in excess of the total PM standard unless diesel fuel sulfur levels are at or below 15 ppmw.

b) The Diesel Risk Reduction Plan

In August 1998, the ARB identified particulate matter emitted from diesel engines (diesel PM) as a Toxic Air Contaminant (TAC) and in September 2001, approved the Diesel Risk Reduction Plan (RRP) to reduce public exposure to diesel PM. Low sulfur diesel is critical to the effective performance of the high efficiency PM emissions control devices needed to implement the air toxic control measures and regulations recommended in the diesel RRP. The plan requires the use of state-of-the-art DPFs for all new engines and retrofitting of existing vehicles and engines with DPFs whenever technically feasible and cost-effective. The effectiveness of the DPF is so reduced at diesel fuel sulfur

concentrations higher than 15 ppmw that many of the control measures developed to implement the RRP would not be technically feasible.

2. Reduction of Emissions of Sulfur Compounds

Nearly all of the sulfur in diesel fuel reacts with oxygen during combustion to form SO_2 which can react either in the engine exhaust or in the atmosphere with oxidizing agents and water vapor to form hydrated sulfuric acid (H_2SO_4) or sulfate aerosols. Reducing the sulfur content of diesel fuel from the statewide average of 140 ppmw to less than 15 ppmw would reduce sulfur oxide (SOx) emissions by about 90 percent. Direct diesel particulate matter (PM) emissions would be reduced by about 4 percent, or about 0.6 tons per day in 2010 for engines not equipped with advanced particulate emissions control technologies.

B. Actions by Other Regulatory Agencies

The two regulations summarized below will effectively apply to about 75 percent of the diesel fuel used in California. The amendments approved by the ARB will extend the requirement for 15-ppmw sulfur to the remaining 25 percent of the diesel fuel market.

1. SCAQMD Fuel Rule

In September 2000, the South Coast AQMD adopted a 15-ppmw limit for the sulfur content of all diesel fuel sold within the district except for fuel used in locomotives and marine vessels. The 15-ppmw limit is applicable to fuel for stationary engines on or after June 1, 2004 and to all other diesel engine applications on or after January 1, 2005. The rule also allows for extension of the effective date for fuel for motor vehicle use to match a later compliance date adopted by the ARB, but no later than June 1, 2006.

2. U.S. EPA Fuel Regulation

In January 2001, the U.S. EPA adopted new diesel fuel quality standards limiting the sulfur content of on-road diesel fuel to no more than 15-ppmw. Refiners are required to produce this fuel beginning June 1, 2006. Also, all 2007 and later model year diesel-fueled vehicles must use this new low sulfur diesel.

In a May 2003 proposed rulemaking, the U.S. EPA proposed that beginning June 1, 2007, sulfur levels for nonroad, locomotive, and marine diesel fuel be reduced from current uncontrolled levels to 500 ppmw. This does not include diesel fuel for stationary sources. Then, beginning June 1, 2010, the proposed maximum sulfur level would be 15-ppmw for fuel used for nonroad diesel applications (excluding locomotive and marine engines).

C. Technology for Compliance With the Diesel Fuel Sulfur Limit

The primary sources of sulfur in diesel fuel are the sulfur-containing compounds, which occur naturally in crude oil. The sulfur content can vary widely depending on the source of the crude oil. The range for crude oil refined in California is 0.4 percent to 3.3 percent while the average is about 1.3 percent. Most of the sulfur in crude oil is in the heaviest boiling fractions. Since most of the refinery blendstocks used to manufacture diesel fuel

come from the heavier boiling components of crude oil, they contain substantial amounts of sulfur. The sulfur requirements for diesel are achieved through chemical removal of sulfur from distillate by reaction with hydrogen at moderate to high temperature and pressure, in the presence of catalysts. This process is generally known as hydrotreating.

1. U.S. EPA Feasibility Study

The U.S. EPA concluded that all refiners will be technically capable of meeting the 15-ppmw sulfur cap with expansions of the same conventional diesel desulfurization technologies which they are using to meet the current highway diesel fuel standard of 500 ppmw sulfur. Existing commercial hydrotreaters are already producing distillate with average sulfur levels below 10 ppmw. Therefore, the proposed 15-ppmw cap appears to be feasible with today's distillate processing technology. Modifications to the current hydrotreating systems may include any combination of the following: adding a second reactor; installing a second stage hydrotreater, utilizing more effective catalysts, increasing hydrogen purity in the recycle gas, and increasing pressure in the reactor.

2. ARB Evaluation

The ARB staff conducted a statewide survey of refineries to obtain information on current and future diesel fuel production. Among other questions, refiners were asked to indicate what new equipment, modifications to the existing equipment, and changes in refinery operations would be needed to produce low sulfur diesel fuel. The responses to the survey indicated that eight refiners would make minimal process modifications that could include additional reactors in series with existing reactors, three refiners would likely install a new hydrotreater unit, and some would consider using more effective catalysts to increase reactor yield. In addition, they would meet increased demands for hydrogen by modifying existing hydrogen plants, adding new units, or purchasing additional hydrogen from other producers. The ARB's survey results are consistent with the U.S. EPA's findings.

3. SCAQMD Evaluation

The SCAQMD conducted a survey of eight refiners, some of them already producing low sulfur diesel fuel. Most refiners will enhance or expand their current distillate hydrotreating capability to meet the 15-ppmw sulfur cap. The methods that they will use to achieve this goal include all of the options identified in the U.S. EPA's and the ARB's evaluations.

4. Effect of Sulfur Removal Process on Other Fuel Properties

The additional hydrotreating of diesel fuel for further sulfur removal should also result in lower levels of nitrogen, metals and other contaminants in the fuel. Refiners are expected to choose cost effective hydrotreating processes that minimize hydrogen consumption and cracking reactions while achieving the desired sulfur reduction. Hydrotreating for sulfur removal under such conditions should reduce the amount of aromatics by saturating them. While there are few olefins in diesel fuel, these would tend to also be saturated and converted to alkanes. This will tend to reduce the aromatic and olefin content and increase the cetane number of the resulting fuel, both of which tend to decrease diesel

exhaust emissions. The additional hydrotreating should not have a significant effect on the chemical composition of the fuel nor should it have a negative impact on fuel quality except for lubricity as discussed in the next chapter.

VI. LUBRICITY STANDARD

Diesel fuel lubricity is the ability of diesel fuel to lubricate internal fuel system components, thus protecting them from excessive wear. There is no enforceable lubricity standard in place in California. However, refineries have maintained a voluntary minimum lubricity level consistent with the recommendation of a 1994 Governor's Task Force that was created during the statewide introduction of 500-ppmw sulfur California reformulated diesel.

A. Lubricity Additives

Diesel fuel lubricity can be provided by various means. Refineries can adjust their operations to ensure that the natural lubricity of diesel fuel is maintained or can choose to blend diesel fuel with other blendstocks such as biodiesel in small amounts that can improve the lubricity of the resultant blend. When these options are not practical or inadequate, refineries have commonly used lubricity additives to improve the lubricity of diesel fuel.

Diesel fuel lubricity additives have been historically used in diesel fuel as corrosion inhibitors. These additives are mainly high molecular weight (similar to diesel fuel components) fatty acids and esters. Variations of these chemistries are also heavily used in personal care products such as soap. Diesel fuel lubricity additives, when used, are typically found in concentrations below 300 ppmw.

B. Need for Adequate Lubricity

The levels of natural lubricity agents in diesel fuel are expected to be reduced by the more severe hydrotreating needed to meet the 15-ppmw sulfur cap. Because of this reduction in natural lubricity, it is necessary to establish a lubricity standard to ensure consistent adequate diesel fuel lubricity as diesel engine technology that is more sensitive to lubricity enters the market.

Staff anticipates that the HFRR 520 microns wear scar diameter standard that will be implemented in 2004 will not result in any significant change in current refinery practices or change in the use of lubricity additives since the proposed reduction in diesel sulfur to 15 ppmw will not occur until 2006. Refineries will continue their practices to ensure adequate diesel lubricity. In some cases no lubricity additives will be required and in other cases lubricity additives will need to be used. Therefore, staff estimates that the 2004 diesel lubricity standard will have no significant adverse impact on public health or the environment.

C. Actions by Other Regulatory Agencies

The American Society for Testing and Materials (ASTM) recently concluded voting on a ballot that would establish a national lubricity standard for all diesel fuel, identical to the 2004 lubricity standard approved by the Board. While there were some opposing votes from this ballot, the primary objection was that the proposed ASTM standard would be

effective upon publication and the industry would not have sufficient time to prepare for complying with the standard. The ASTM lubricity panel is seeking to add an effective date to the standard in order to provide additional time for compliance preparations. When the ASTM specification becomes effective, the ARB will sunset the 2004 standard, because the national standard will be enforceable by the State Division of Measurement Standards.

In an effort to be protective of advanced technology fuel injection systems, the United States Environmental Protection Agency (U.S. EPA) is considering the pursuit of a lubricity regulation that would align with the ARB standard. Should the U.S. EPA successfully adopt a standard, ARB would rescind their 2004 standard and rely on a national standard.

VII. ENVIRONMENTAL IMPACTS

The amendments to the diesel fuel regulations include new vehicular fuel sulfur specifications and a fuel lubricity standard. Compliance with these amendments is expected to directly affect air quality and could indirectly affect other environmental media as a consequence of the air quality impact.

A. Environmental Impacts of Revised Sulfur Limit

Neither the U.S. EPA nor the SCAQMD has identified any significant adverse impacts on public health or the environment, associated with their sulfur content regulations. Our initial evaluation is consistent with these findings.

1. Emissions Impacts

As discussed above, refineries are expected to modify their operation to varying extents to comply with the amendment to lower the limit on the sulfur content of California diesel fuel. Such modifications in processing could affect refinery emissions, but refineries must comply with the district rules that would limit their emission increases. In addition, the emission benefits of using low sulfur diesel fuel in both on- and off-road engines would far outweigh such increases.

a) Additional Emissions from Refinery

The additional energy needs for the hydrodesulfurization process could mean increases in combustion derived emissions such as NOx, PM, carbon monoxide (CO), and sulfur dioxide (SO_2) from sources such as heaters and boilers that must increase their operation to meet the additional energy demands. The impact of these process changes on air quality will be limited by the requirements of the California Environmental Quality Act (CEQA) and by new source review or Best Available Control Technology (BACT) requirements of the air quality management districts.

b) Emission Benefits from Using Low Sulfur Diesel Fuel

Reducing the sulfur content of diesel fuel from the statewide average of 140 ppmw in 1999 to less than 15 ppmw in 2006 would reduce sulfur oxide (SOx) emissions by about 90 percent or 6.4 tons per day (tpd). Direct diesel PM emissions would be reduced by about 4 percent or 0.6 tons per year (tpy) in 2010 for engines not equipped with advanced particulate emissions control technologies. In addition, NOx emissions would be reduced by up to about 7 percent or 80 tpy for those engines not currently using CARB diesel, assumed to be about 10 percent of the stationary engine inventory.

The most significant effect of the low sulfur fuel will be achieved through the enabling of after-treatment of diesel engine exhaust, which would result in substantial tailpipe emission reductions. Reductions of over 90 percent in diesel PM and NOx emissions, from model-year 2007 and later on-road heavy-duty diesel engines, would be achieved. Significant

reductions of non-methane hydrocarbons (NMHC) and CO can also be achieved with these control devices.

2. Air Quality

Sulfur in diesel fuel contributes to ambient levels of fine particulate matter through the formation of sulfates both in the exhaust stream of the diesel engine and later in the atmosphere. Therefore, reducing the sulfur limit of California diesel to 15 ppmw will have a positive air quality impact by reducing ambient levels of particulate matter.

Significant additional air quality benefits will be achieved from reductions of emissions of ozone precursors (NOx and NMHC) and diesel PM through the use of low sulfur diesel in diesel engines and vehicles equipped with advanced diesel exhaust emissions control technologies. Reductions in diesel PM emissions mean reduced ambient levels of the TACs found in diesel exhaust. In addition, reducing ozone precursor emissions will help to reduce secondary particulate matter formation – whether nitrate or organic compound aerosols.

3. Water and Soil Quality.

Lowering diesel fuel sulfur content would reduce emissions of sulfur oxides and particulate sulfates. As a result, atmospheric deposition of sulfuric acid and sulfates in water bodies would be reduced. The low sulfur diesel will enable the use of emissions control devices to reduce NOx and diesel PM emissions. Consequently, there should be a decrease in atmospheric deposition of nitrogen and airborne diesel particles as well as the associated heavy metals, PAHs, dioxins, and other toxic compounds typically found in diesel exhaust.

The release of diesel fuel to surface water, soil, and groundwater can occur during production, storage, distribution or use, and the potential sources of such releases will be the same as with the current diesel fuel. The refining process to reduce the sulfur content of diesel fuel is not expected to result in a significant change in the chemical composition of the fuel. Therefore, there should be no significant change in the physical or chemical properties that affect the activity of the fuel in soil and water, and any release of low sulfur diesel fuel to the environment should have no additional impact on water and soil quality compared to the current diesel fuel.

As discussed earlier in Chapter V, the additional hydrotreating for sulfur removal could result in saturation of unsaturated compounds such as olefins and conversion of aromatic compounds to aliphatic compounds. This conversion of aromatics to less soluble aliphatic compounds together with the conversion of the more polar sulfur-containing compounds to less polar hydrocarbons could reduce the water solubility of the low sulfur fuel compared to the current diesel fuel. However, a key objective of hydrotreating for sulfur removal is to minimize hydrogen consumption and avoid cracking reactions, collateral hydrogenation of olefins and other molecules, and aromatics saturation. Therefore, the change in chemical composition and solubility is expected to be minimal.

4. Greenhouse Gas Emissions

Greenhouse gases (GHG) are predominantly comprised of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The additional processing to produce low sulfur diesel is expected to increase emissions of greenhouse gases, but the greenhouse effect from diesel production is expected to be substantially offset by the effect of a reduction in CO_2 emissions from the use of low sulfur fuel in diesel engines.

Emissions of CO_2 from refineries will increase due to the increased demand for energy for additional hydrogen production and additional processing to produce low sulfur diesel. Since hydrogen is produced by processing methane, emissions of methane are expected to increase due to increased natural gas production and distribution losses but these methane losses will be small compared to the additional carbon dioxide emissions from refinery processes. Also, a smaller amount of methane and nitrous oxide will be emitted in the refinery processes from increased fuel combustion. As stated above, these GHG gas emissions increases will be substantially offset by CO_2 emissions reductions. This will occur because some of the extra hydrogen from the additional hydrotreating and the energy it represents will be in the fuel, increasing the hydrogen to carbon ratio and reducing CO_2 emitted per million BTU of fuel.

5. Disposal or Use of the Byproducts and Waste Materials

Currently, both California gasoline and diesel fuel regulations result in the removal and processing of about 33,000 tpy of sulfur from California's fuel streams. The proposed amendments to the diesel fuel regulations would result in additional removal and processing of about 1300 tpy of sulfur, which is about a four-percent increase. Historically, this sulfur has been sold in the chemical market, and this should continue. This increase is not expected to cause a significant additional risk to the environment. No other disposal or waste concerns have been identified.

B. Environmental Impacts of the Lubricity Standard

It is anticipated that the HFRR 520 microns WSD will not result in any significant change in the current refinery practices or change in the use of lubricity additives. In some cases no lubricity additives will be required, but in other cases lubricity additives will need to be used. The U.S. EPA considers the practice of blending and use of additives to maintain diesel lubricity as a normal course of diesel production since these practices do not alter the basic chemistry of diesel fuel. Also, diesel fuel lubricity additives must be federally registered, and must undergo a series of toxic evaluations to determine potential toxic risk to human health. The U.S. EPA has found that current registered lubricity additives do not pose any increase in public health risk relative to baseline diesel fuel. Therefore, the 2004 lubricity standard will pose no significant adverse impacts on public health or the environment.

VIII. HEALTH IMPACTS

The reduction in fuel sulfur content would facilitate the implementation of the diesel RRP and the introduction of the new on-road, heavy-duty engine emission standards. These two programs will significantly reduce Californian's exposure to diesel PM and the associated cancer risks. The diesel RRP seeks to reduce Californians' exposure to diesel PM and the associated cancer risks from baseline levels in 2000 by 85 percent by 2020.

Heavy-duty vehicles contribute a substantial fraction of ozone precursors (NOx and VOC) in any metropolitan area. Therefore, reduction of heavy-duty diesel vehicle emissions of NOx and VOCs through the use of low sulfur diesel fuel and exhaust aftertreatment systems will make a considerable contribution to reducing ambient ozone levels, thus reducing the prevalence of the types of respiratory problems associated with ozone exposure.

Control of the emissions of ozone precursors may also provide a small health benefit by reducing condensible PM_{10} emissions from organic ozone precursors and by reducing the ambient concentrations of nitrate formed from oxides of nitrogen.

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IX. MULTIMEDIA WORK GROUP AND EXTERNAL PEER REVIEW

A. External Peer Review

Health and Safety Code, Section 57004, requires the ARB to conduct an external scientific peer review of the scientific basis for any rule being proposed. As required by this statute, the ARB initiated a request to University of California Office of the President (UCOP) in May 2001, under Interagency Agreement #98-004 between the California Environmental Protection Agency (Cal-EPA) and the University of California (UC). As a result, the UCOP selected the following four peer reviewers:

- Wayne Miller, Ph.D., Bourns College of Engineering, UC Riverside;
- Robert Sawyer, Ph.D., Mechanical Engineering Department, UC Berkeley;
- Donald Lucas, Ph.D., Environmental Energy Technologies Department, UC Berkeley and Lawrence Berkeley National Laboratory; and
- Laurence Caretto, Ph.D., College of Engineering and Science, California State University, Northridge.

The peer reviewers evaluated the June 6, 2003 staff report for the diesel fuel rulemaking and all submitted written reports of their findings. Their reports are included as Appendix B.

The reviewers agreed in general with the ARB staff's evaluation of the scientific basis of the amendments and the staff's estimates of emissions benefits. They concluded that adequate technology exists to produce low sulfur reformulated diesel fuel and that the ARB's cost estimates are reasonable and consistent with other analyses of desulfurization. Although the reviewers acknowledged the need to ensure adequate lubricity, they tended to treat the decision to adopt a lubricity standard as a policy rather than a scientific issue. There was some question as to whether the lubricity standard would have a practical impact since it approximates the industry's current voluntary standard.

They found that the staff's approach to the equivalent limits option was well founded and the specifications for the fuel properties should provide similar reductions to the 10 percent aromatics standard without the need for costly engine tests. Overall, the reviewers agreed with the ARB's staff that the proposed amendments would have no significant adverse impact on public health and the environment.

The reviewers also reviewed Appendix D of the June 6, 2003 staff report which was a report of the staff's evaluation of the benefits of the current diesel fuel regulations. The reviewers observed that although the correlation among diesel fuel properties is strong, the published data reviewed by ARB staff generally show that reductions in density and aromatics and increases in cetane number will reduce emissions of NOx and PM in existing engines.

B. Environmental Policy Council Workgroup

An interagency multi-media working group has evaluated the amendments to the diesel fuel regulations. The working group was initially formed to oversee the multi-media assessment of PuriNOx, a water-emulsified diesel fuel, and includes representatives from the CalEPA, the ARB, the State Water Resources Control Board (SWRCB), the Office of Environmental Health Hazard Assessment (OEHHA), and the Department of Toxic Substances Control (DTSC). Members of the interagency multi-media working group are listed in Appendix C. The working group's evaluation addressed the following topics.

- Emissions of air pollutants, including ozone-forming compounds, particulate matter, toxic-air contaminants, and greenhouse gases.
- Contamination of surface water, groundwater, and soil.
- Disposal or use of byproducts and waste materials from the production of the fuel.

The ARB staff was responsible for coordinating the overall multi-media review and for conducting the air quality assessment. The SWRCB staff reviewed the surface and ground water quality assessments, OEHHA staff reviewed potential human health impacts, and DTSC staff reviewed the potential for hazardous waste concerns.

The members of the working group found that the amendments to the diesel fuel regulations should not have a significant adverse impact on public health or the environment. Appendix D contain memoranda from OEHHA, DTSC and SWRCB summarizing their findings.

APPENDIX A

California Environmental Protection Agency, Air Resources Board. Staff Report, Initial Statement of Reasons. Proposed Amendments to the California Diesel Fuel Regulations. June 6, 2003.

The staff report for the diesel fuel rulemaking is available as a separate document. Copies may be obtained in electronic form from the ARB's web page at: http://www.arb.ca.gov/regact/ulsd2003/ulsd2003.htm or printed copies may be requested from Mr. Valentine Montoya, Stationary Source Division, by telephone at (916) 327-1493 or by e-mail at vmontoya@arb.ca.gov.

APPENDIX B

Peer Reviews of the Revisions to the California Diesel Fuel Regulations
Prepared for the California Air Resources Board Under
Interagency Task Force Agreement 98-004, Task Order 42-2

APPENDIX C

Members of the Interagency Multimedia Working Group

MEMBERS OF THE INTERAGENCY MULTIMEDIA WORKING GROUP

ARB

Dean Simeroth, Chief, Criteria Pollutants Branch

Gary M. Yee, Manager, Industrial Section

Robert A. Okamoto Industrial Section

Lesley E. Crowell, Industrial Section

Cherie M. Rainforth, Industrial Section

Steven Brisby, Manager, Fuels Section

Gloria Lindner, Fuels Section

SWRCB

James Giannopoulos, Assistance Division Chief, Ground Water Quality

OEHHA

Page Painter, Ph.D., M.D., Chief, Integrated Exposure Assessment Unit

Karlyn Black, Ph. D, D.A.B.T, Integrated Risk Assessment Section

Charles Salocks, Ph.D. D.A.B.T, Integrated Risk Assessment Section

Hristo Hristov, M.D, Ph.D. Integrated Risk Assessment Section

Bruce Joab, Integrated Risk Assessment Section

David Siegel, Ph.D, D.A.B.T, Chief Integrated Risk Assessment Section

Melanie Marty, Ph.D., Chief Air Toxicology and Epidemiology Section

Robert Blaisdell, Ph.D., Chief, Exposure Modeling Unit

Andy Salmon, D.Phil., Chief, Toxicology and Risk Assessment Unit

Daryn Dodge Ph.D., Exposure Modeling Unit

Bruce Winder, Ph.D., Toxicology and Risk Assessment Unit

DTSC

Edward Nieto, P.E, Chief, Regulatory and Technical Support Section

Li Tang, Ph.D., P.E., Regulatory and Technical Support Section

CAL/EPA

Tam M. Doduc, Deputy Secretary for Environmental Quality, Office of the Secretary

APPENDIX D

Memoranda from the Department of Toxic Substances Control, the Office of Environmental Health Hazard Assessment, and the State Water Resources Control Board