
# PUBLIC MEETING AGENDA

**March 23, 2006**

**9:00 a. m**

Agenda Items to be heard;

06-3-1: 06-3-2: 06-3-3:

06-3-4

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## ELECTRONIC BOARD BOOK

California Environmental Protection Agency

# Air Resources Board

**LOCATION:**
Air Resources Board
Byron Sher Auditorium, Second Floor
1001 I Street
Sacramento, California 95814

## PUBLIC MEETING AGENDA

This facility is accessible by public transit. For transit information, call (916) 321-BUSS, website: http://www.sacrt.com
(This facility is accessible to persons with disabilities.)

**March 23, 2006**
**9:00 a.m.**

Item #

**06-3-1: Report to the Board on a Health Update: Spatial Analysis of Air Pollution & Mortality in Los Angeles**

*Staff will present the results of a study that examined the association between air pollution and mortality using within-city exposure measures in Los Angeles, California. The investigators examined a subgroup of the American Cancer Society Study and found associations between deaths and exposure to $PM_{2.5}$ for the period 1982-2000. The investigators observed nearly 3 times greater effects from their within-communities models than in previous models relying on comparisons between communities. They also found that $PM_{2.5}$ was more strongly associated with ischemic heart disease than with cardiopulmonary or all-cause mortality.*

**06-3-2: Public Hearing to Consider the Proposed Amendments to the Verification Procedure, Warranty & In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines**

*Staff will make recommendations on limiting the $NO_2/NO_x$ ratio of diesel retrofit devices in order to minimize adverse impacts of increased $NO_2$ emissions while reducing PM. Retrofit devices, such as diesel particulate filters, achieve a very high level of PM emission control; however, some also increase $NO_2$ emissions. Staff will propose limiting $NO_2$ emissions by establishing a maximum incremental $NO_2$ ratio of 30% in 2007 and 20% in 2009 to minimize the air quality impact of $NO_2$ emissions while preserving the health benefits of the diesel PM emission program as a whole.*

**06-3-3: Public Meeting to Update the Board on the Governor's Greenhouse Gas Reduction Targets and Related Activities**

*Staff will update the Board regarding the greenhouse gas reduction targets established by the Governor in July 2005, and will provide background information on the ARB activities underway to help meet the proposed targets.*

**06-3-4: Public Meeting to Update the Board on ARB's Tools for Public Access to Air Quality Information**

*Staff will provide an overview of the tools ARB has developed to provide the public with information on air quality and emissions data throughout the State. The presentation will highlight several innovative systems for displaying community-specific information on local emission sources, real-time and historical air quality data, and community health and public exposure.*

**OPEN SESSION TO PROVIDE AN OPPORTUNITY FOR MEMBERS OF THE PUBLIC TO ADDRESS THE BOARD ON SUBJECT MATTERS WITHIN THE JURISDICTION OF THE BOARD.**

*Although no formal Board action may be taken, the Board is allowing an opportunity to interested members of the public to address the Board on items of interest that are within the Board's jurisdiction, but that do not specifically appear on the agenda. Each person will be allowed a maximum of five minutes to ensure that everyone has a chance to speak.*

**TO SUBMIT WRITTEN COMMENTS ON AN AGENDA ITEM IN ADVANCE OF THE MEETING:**

**CONTACT THE CLERK OF THE BOARD, 1001 I Street, 23rd Floor, Sacramento, CA 95814 (916) 322-5594**
**FAX: (916) 322-3928**
**ARB Homepage:** www.arb.ca.gov

***To request special accommodation or language needs, please contact the following:***

- TTY/TDD/Speech-to-Speech users may dial 7-1-1 for the California Relay Service.
- Assistance for Disability-related accommodations, please go to http://www.arb.ca.gov/html/ada/ada.htm or contact the Air Resources Board ADA Coordinator, at (916) 323-4916.
- Assistance in a language other than English, please go to http://www.arb.ca.gov/as/eeo/languageaccess.htm or contact the Air Resources Board Bilingual Coordinator, at (916) 324-5049.

**THE AGENDA ITEMS LISTED ABOVE MAY BE CONSIDERED IN A DIFFERENT ORDER AT THE BOARD MEETING.**

**SMOKING IS NOT PERMITTED AT MEETINGS OF THE CALIFORNIA AIR RESOURCES BOARD**

California Environmental Protection Agency

# Air Resources Board

LOCATION:
Air Resources Board
Byron Sher Auditorium, Second Floor
1001 I Street
Sacramento, California 95814

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## INDEX

**March 23, 2006**
**9:00 a.m.**

# TITLE 13. CALIFORNIA AIR RESOURCES BOARD

## NOTICE OF PUBLIC HEARING TO CONSIDER REGULATORY AMENDMENTS TO THE VERIFICATION PROCEDURE, WARRANTY AND IN-USE COMPLIANCE REQUIREMENTS FOR IN-USE STRATEGIES TO CONTROL EMISSIONS FROM DIESEL ENGINES

The Air Resources Board (ARB or the Board) will conduct a public hearing at the time and place noted below to consider regulatory amendments to the Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines.

DATE: March 23, 2006

TIME: 9:00 a.m.

PLACE: California Environmental Protection Agency
Air Resources Board
Central Valley Auditorium
1001 "I" Street
Sacramento, California 95814

This item will be considered at a two-day meeting of the Board, which will commence at 9:00 a.m., March 23, 2006, and may continue at 8:30 a.m., March 24, 2006. This item may not be considered until March 24, 2006. Please consult the agenda for the meeting, which will be available at least ten days before March 23, 2006, to determine the day on which this item will be considered.

If you have a disability-related accommodation need, please go to http://www.arb.ca.gov/html/ada/ada.htm for assistance or contact the Americans with Disabilities Act Coordinator at (916) 323-4916. If you are a person who needs assistance in a language other than English, please contact the Bilingual Coordinator at (916) 324-5049. Teletypewriter/Telecommunications Device for Deaf/Speech-to-Speech users may dial 7-1-1 for the California Relay Service.

## INFORMATIVE DIGEST OF PROPOSED ACTION AND POLICY STATEMENT OVERVIEW

**Sections Affected:** Proposed amendments to title 13, California Code of Regulations (CCR), sections 2702, 2703, 2704, 2706, 2707, and 2709.

**Background:** In 1998, the ARB identified diesel particulate matter (PM) emissions as a toxic air contaminant (Title 17, CCR, section 93000). In 2000, the ARB adopted the Diesel Risk Reduction Plan (DRRP or Plan), which established a goal of reducing emissions and the resultant health risk from virtually all diesel-fueled engines and vehicles within the State of California by the year 2020. The Plan envisioned that diesel

particulate matter emissions would be reduced by 75 percent in 2010 and 85 percent in 2020. To achieve those goals, the Plan identified various methods including more stringent standards for all new diesel-fueled engines and vehicles, the use of diesel emission control strategies on in-use engines, and the use of low-sulfur diesel fuel.

Staff developed a verification procedure (Procedure) to ensure that effective emission control systems are available to reduce Californians' exposure to diesel PM. The Board adopted the Procedure at the May 16, 2002 Public Hearing. In accordance with the DRRP, the ARB has adopted and may in the future adopt regulations to require reduction of PM from in-use diesel vehicles through the application of verified, retrofitted diesel emission control strategies. These retrofit regulations specify levels of particulate matter reductions and the Procedure is used to designate strategies that ARB finds achieve specific levels of emission reductions and meet all other verification criteria.

The Procedure includes emissions test procedures, warranty requirements, and in-use compliance requirements. It also sets limits for secondary emissions from verified emission control systems. One common secondary emission is nitrogen dioxide ($NO_2$). Some diesel emission control systems, while highly effective at reducing emissions of diesel PM, also increase emissions of $NO_2$. $NO_2$ is classified as a criteria pollutant and has both federal and state ambient air quality standards. $NO_2$ emissions also contribute to formation of ozone and particulate nitrates. A limit for $NO_2$ emissions of 20 percent of the baseline oxides of nitrogen (NOx) emission level was adopted as part of the Procedure, effective in 2004.

In February 2004, the Board amended the Procedure. One of the key amendments was a three-year delay in the effective date of the $NO_2$ limit, to January 1, 2007. This was necessary because manufacturers were not able to meet the original 20 percent limit without sacrificing the robustness and breadth of applicability of their products. The purpose of the delay was to enable the continued implementation of efficient PM emission controls while staff reevaluated what level of $NO_2$ control was most appropriate and the potential impacts on air quality. This evaluation has been completed.

Staff concludes that most verified PM control devices remain unable to meet the $NO_2$ limit that begins next year. Therefore, if no change is made to the existing $NO_2$ limit, nearly all of the approved diesel particulate filters will lose their verifications on January 1, 2007. With few PM emission control devices available for installation on in-use diesel engines, ARB's Diesel Risk Reduction Plan would be stymied, and the health benefits of the plan would not be achieved.

**Proposed Amendments:** To assure implementation of the Diesel Risk Reduction Plan continues, staff is proposing amendments to the Procedure. The most significant change is to revise the $NO_2$ emission limit for verified emission control systems. The proposed amendments to the Procedure are summarized below. The actual regulatory language and explanations can be found in the Staff Report: Initial Statement of Reasons (ISOR) and the attachments thereto.

1. $NO_2$ Emission Limit

Staff proposes that the Board change the form of the $NO_2$ emission limit, and revise its stringency.

Staff's proposal would change the form of the $NO_2$ limit. Currently, the Procedure limits total tailpipe-out $NO_2$ emissions regardless of how much $NO_2$ is contributed by the engine. Staff's proposed change would limit the allowable increase in $NO_2$ emissions, not the total emissions level.

Beginning January 1, 2007, staff also proposes a revision to the $NO_2$ limit to allow a maximum increase of $NO_2$ emissions equivalent to 30 percent of the total baseline NOx emission level. Most of the currently verified filters would be able to meet this limit, and therefore would continue to be available for use in reducing diesel PM emissions. Beginning January 1, 2009, staff proposes that the maximum increase be reduced to 20 percent. Staff also proposes that the Board create verification classifications designated by "Plus" (e.g., Level 3 Plus) which signify early compliance with the 2009 limit and thus encourage the use of low-$NO_2$ controls where possible.

Staff's proposal will result in higher $NO_2$ emissions from retrofitted diesel engines relative to the current $NO_2$ limit. Modeling and analyses for Southern California 2010 indicate higher $NO_2$ emissions will increase peak ozone levels by about one percent. Microscale analyses for high exposure scenarios show that local ambient $NO_2$ concentrations will increase, but will not exceed the current ambient $NO_2$ standard.

Staff believes the benefits of avoiding hundreds of premature deaths due to continuing use of PM control devices that reduce PM emissions by up to 85 percent clearly outweigh the adverse health impact of a relatively small increase in ozone.

2. Additional Pre-Conditioning Requirements

Staff proposes additional pre-conditioning requirements for emission control systems whose $NO_2$ emissions may be influenced by the presence of soot and ash at the time of testing. The proposal covers pre-conditioning for the new and aged units in the original verification as well as units involved in the first-phase of in-use compliance testing. It includes requirements regarding filter condition, test cycles, duration of testing, test conditions, and backpressure. It also includes requirements regarding the test engine's condition and $NO_2$ emission level.

3. Other Proposed Amendments

Staff proposes a clarification to sections 2702(g) and (h) that not all listed conditions are required. The "and" in the list of sources would be changed to an "or". Staff proposes extending the reporting deadline specified in section 2707(c) by an additional two months. Staff also proposes adding a provision stating expressly that issuance of a verification does not release the applicant from complying with other applicable legal requirements.

## COMPARABLE FEDERAL REGULATIONS

There are no comparable federal regulations. The United States Environmental Protection Agency (U.S. EPA) has published a draft document, "General Verification Protocol for Diesel Exhaust Catalysts, Particulate Filters, and Engine Modification Control Technologies for Highway and Nonroad Use Diesel Engines," but has not promulgated formal regulations for this verification protocol. This federal verification protocol is intended to support the voluntary retrofit programs initiated by the U.S. EPA, while the staff's proposal is to support the ARB's Diesel Risk Reduction Plan. Also, the protocol does not regulate changes in emissions of $NO_2$ caused by emission control systems.

## AVAILABILITY OF DOCUMENTS AND AGENCY CONTACT PERSONS

The ARB staff has prepared a Staff Report: Initial Statement of Reasons (ISOR) for the proposed regulatory action, which includes a summary of the environmental and economic impacts of the proposal. The report is entitled: Proposed Amendments to the Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines.

Copies of the ISOR and the full text of the proposed regulatory language in underline and strikeout format to allow for comparison with the existing regulations may be accessed on ARB's website listed below, or may be obtained from ARB's Public Information Office, Visitors and Environmental Services Center, 1001 "I" Street, First Floor, Sacramento, California 95814, (916) 322-2990, at least 45 days prior to the scheduled hearing on March 23, 2006.

Upon its completion, the Final Statement of Reasons (FSOR) will also be available and copies may be requested from the agency contact persons in this notice, or may be accessed on the website listed below.

Inquiries concerning the substance of the proposed amendments may be directed to the designated agency contact persons, Mr. Paul Henderick, Air Resources Engineer, Retrofit Assessment Section, at (626) 350-6440, or by email to phenderi@arb.ca.gov, or Ms. Shawn Daley, Manager, Retrofit Assessment Section, at (626) 575-6972, or by email to sdaley@arb.ca.gov.

Further, the agency representative and designated back-up contact persons to whom non-substantive inquiries concerning the proposed administrative action may be directed are Ms. Artavia Edwards, Manager, Board Administration & Regulatory Coordination Unit, at (916) 322-6070, or by email to aedwards@arb.ca.gov, or Ms. Alexa Malik, Regulations Coordinator, at (916) 322-4011, or by email to amalik@arb.ca.gov. The Board has compiled a record for this rulemaking action, which includes all the information upon which the proposal is based. This material is available for inspection upon request to the contact persons.

This notice, the ISOR, and all subsequent regulatory documents, including the FSOR, when completed, are available on the ARB Internet site for this rulemaking at www.arb.ca.gov/regact/verpro06/verpro06.htm.

## COSTS TO PUBLIC AGENCIES AND TO BUSINESSES AND PERSONS AFFECTED

The determinations of the Board's Executive Officer concerning the costs or savings necessarily incurred by public agencies, private persons and businesses in reasonable compliance with the proposed regulations are presented below.

Pursuant to Government Code sections 11346.5(a)(5) and 11346.5(a)(6), the Executive Officer has determined that the proposed regulatory action will not create costs or savings to any state agency or in federal funding to the State, costs or mandate to any local agency or school district whether or not reimbursable by the State pursuant to Part 7 (commencing with section 17500), Division 4, Title 2 of the Government Code, or other non-discretionary savings to State or local agencies.

In developing this regulatory proposal, ARB staff evaluated the potential economic impacts on representative private persons or businesses. The ARB is not aware of any cost impacts that a representative private person or business would necessarily incur in reasonable compliance with the proposed action. Participation in the Procedure is purely voluntary both in its current form and as amended under the proposed action. While it is true that participation in the verification process is voluntary and there is no prohibition on selling diesel emission control strategies in California that have not been verified by the ARB, the ARB has adopted and may in the future adopt regulations to requiring reductions of PM from in-use diesel vehicles through the application of verified, retrofitted diesel emission control strategies in specific situations. Entities subject to these retrofit requirements must use verified diesel emission control strategies to comply with these requirements. Consequently, these entities will only purchase systems from manufacturers that have obtained ARB's verification. In any event, the proposed regulatory action would make the requirements for verification less stringent than they are now, allowing for more systems to become verified and avoiding the loss of verifications by most currently-verified systems on January 1, 2007. Thus staff does not expect the proposal will result in adverse economic impacts.

The Executive Officer has made an initial determination that the proposed regulatory action will not have a significant statewide adverse economic impact directly affecting businesses, including the ability of California businesses to compete with businesses in other states, or businesses directly affected or on representative private persons.

In accordance with Government Code section 11346.3, the Executive Officer has determined that the proposed regulatory action will not affect the creation or elimination of jobs within the State of California, the creation of new businesses or elimination of existing businesses within California, or the expansion of businesses currently doing business within California. An assessment of the economic impacts of the proposed regulatory action can be found in the ISOR.

The Executive Officer has also determined, pursuant to title 1, CCR, section 4, that the proposed regulatory action will not affect small businesses because participation in the Procedure is purely voluntary. There are no cost impacts that a representative private person or business would necessarily incur in reasonable compliance with the proposed action.

The Executive Officer has also determined, pursuant to Government Code section 11346.5(a)(8), that the proposed regulation will not have a significant, statewide adverse economic impact directly affecting businesses, including the ability of California businesses to compete with businesses in other states because the proposed regulation will have no regulatory effect on business.

In accordance with Government Code sections 11346.3(c) and 11346.5(a)(11), the ARB's Executive Officer has found that the reporting requirements of the regulation which apply to businesses are necessary for the health, safety, and welfare of the people of the State of California.

Before taking final action on the proposed regulatory action, the Board must determine that no alternative considered by the agency or that has otherwise been identified and brought to the attention of the board would be more effective in carrying out the purpose for which the action is proposed or would be as effective and less burdensome to affected private persons than the proposed action.

## SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing at the hearing, and in writing or by e-mail before the hearing. To be considered by the Board, written submissions must be received by **no later than 12:00 noon, March 22, 2006** and addressed to the following:

Postal Mail is to be sent to:

Clerk of the Board
Air Resources Board
1001 "I" Street, 23rd Floor
Sacramento, California 95814

Electronic mail is to be sent to: http://listserv.arb.ca.gov/major/comm/email.php and received at the ARB **no later than 12:00 noon, March 22, 2006.**

Facsimile submissions are to be transmitted to the Clerk of the Board at (916) 322-3928 and received at the ARB **no later than 12:00 noon, March 22, 2006.**

The Board requests, but does not require, that 30 copies of any written statement be submitted at least ten days prior to the hearing so that ARB staff and Board Members have time to fully consider each comment. The ARB encourages members of the public to bring to the attention of the staff in advance of the hearing any suggestions for modification of the proposed regulatory action.

## STATUTORY AUTHORITY AND REFERENCES

This regulatory action is proposed under that authority granted in sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018, 43105, 43600, 43700, and 43830.8 of the Health and Safety Code. This action is proposed to implement, interpret and make specific sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, 43204-43205.5, and 43830.8 of the Health and Safety Code and Title 17 California Code of Regulations section 93000.

## HEARING PROCEDURES

The public hearing will be conducted in accordance with the California Administrative Procedure Act, Title 2, Division 3, Part 1, Chapter 3.5 (commencing with section 11340) of the Government Code.

Following the public hearing, the Board may adopt the regulatory language as originally proposed, or with non-substantial or grammatical modifications. The Board may also adopt the proposed regulatory language with other modifications if the text as modified is sufficiently related to the originally proposed text that the public was adequately placed on notice that the regulatory language as modified could result from the proposed regulatory action; in such event the full regulatory text, with the modifications clearly indicated, will be made available to the public, for written comment, at least 15 days before it is adopted.

The public may request a copy of the modified regulatory text from the Board's Public Information Office, 1001 I Street, Sacramento, California 95814, (916) 322-2990.

CALIFORNIA AIR RESOURCES BOARD

Catherine Witherspoon
Executive Officer

Date: January 24, 2006

# CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
## AIR RESOURCES BOARD

## STAFF REPORT: INITIAL STATEMENT OF REASONS

## PROPOSED AMENDMENTS TO THE VERIFICATION PROCEDURE, WARRANTY AND IN-USE COMPLIANCE REQUIREMENTS FOR IN-USE STRATEGIES TO CONTROL EMISSIONS FROM DIESEL ENGINES

Date of Release: February 3, 2006
Scheduled for Consideration: March 23-24, 2006

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## TABLES

## EXECUTIVE SUMMARY

In 1998, the Air Resources Board (ARB or Board) identified diesel particulate matter (PM) as a toxic air contaminant. Diesel PM is the largest contributor to health risk posed by toxic air pollutants, constituting approximately 70 percent of the total statewide risk. Significant annual health effects attributed to diesel PM include 2,900 premature deaths, 2,600 cases of chronic bronchitis, and 5,300 hospital admissions including asthma-related emergency room visits (Lloyd and Cackette, 2001). To address this large-scale health concern, the ARB adopted a comprehensive Diesel Risk Reduction Plan in 2000. A significant component of the plan is the use of emission control systems to reduce PM emissions from in-use diesel vehicles and equipment. To ensure that any technology used toward that end would achieve real and durable emissions reductions, staff developed the Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines (the Procedure), which was adopted by the Board in May 2002.

The purpose of the Procedure is to ensure effective control systems are available to reduce Californians' exposure to diesel PM. The Procedure also limits secondary emissions from these controls. One common secondary emission is nitrogen dioxide ($NO_2$). $NO_2$ is classified as a criteria pollutant and has both federal and state ambient air quality standards. $NO_2$ emissions also contribute to formation of ozone and particulate nitrates. The Board adopted a limit for $NO_2$ emissions of 20 percent of the baseline oxides of nitrogen (NOx) emission level as part of the Procedure, effective in 2004. The Procedure includes a limit on $NO_2$ because some diesel emission control systems, while highly effective at reducing emissions of diesel PM, also increase emissions of $NO_2$.

In February 2004, the Board amended the Procedure. One of the key amendments was a three-year delay in the effective date of the $NO_2$ limit to January 1, 2007. This was necessary because manufacturers were not able to meet the original 20 percent limit without sacrificing the robustness and breadth of applicability of their products. The purpose of the delay was to enable the continued implementation of efficient PM controls while staff reevaluated what level of $NO_2$ control was most appropriate and the potential impacts on air quality. This evaluation has been completed.

The staff has concluded that most verified PM control devices remain unable to meet the $NO_2$ limit that begins next year. Catalyzed PM filters, the most common high efficiency retrofit device, need sufficient $NO_2$ to assure collected PM can be burned off in a wide variety of engine applications and duty cycles. Low $NO_2$ works against both of these desired features of catalyzed filters. Thus to avoid de-verifying many retrofit devices that play an important role in implementing the Board's Diesel Risk Reduction Plan and adopted PM reduction regulations, the $NO_2$ limit set to go into effect January 1 needs to be relaxed.

Staff proposes both a new structure and magnitude for the revised $NO_2$ limit. Instead of defining the limit as a cap on total $NO_2$ emissions equivalent to 20 percent of the

baseline NOx emissions, staff proposes a maximum incremental increase over the model-specific engine-out level. In other words, the new limit does not include the $NO_2$ emitted by the engine itself and limits only the $NO_2$ contributed by the device. Effective January 1, 2007, staff proposes a maximum increase of $NO_2$ equivalent to 30 percent of the total baseline NOx. Most of the currently verified filters would be able to meet that limit and therefore continue to serve California's diesel PM reduction needs in the near-term. Effective January 1, 2009, staff proposes that the maximum increase be reduced to 20 percent. That level would require device manufacturers to redesign their devices to reduce emissions of $NO_2$.

By assuring PM control devices remain available for use, staff's proposal will reduce emissions of diesel PM. However, the higher limit on $NO_2$ will result in a slight increase in summer ozone and an increase in localized $NO_2$. The magnitude of these effects is discussed next.

Modeling of the South Coast Air Basin for the year 2010 indicates that lower PM emissions resulting from continued use of verified devices, such as catalyzed filters that comply with the staff-proposed revision to the $NO_2$ limit, will prevent about 235 premature deaths annually. These health benefits will not likely be realized if the $NO_2$ limit is not changed.

The higher amount of $NO_2$ allowed might increase peak ozone in the South Coast Air Basin by one to two parts per billion (ppb), or about 1 percent, on the worst days. The higher ozone is equivalent to a 10-30 ton per day increase in hydrocarbon emissions. Recently, ozone has been associated with premature deaths. The increase in ozone due to the revised $NO_2$ limit reduces the avoided premature deaths from lower PM emissions by less than 1 percent.

Higher $NO_2$ emissions from catalyzed filters will also increase ambient $NO_2$ levels. Exposure to $NO_2$ has been associated with adverse health effects including respiratory symptoms, cardio-respiratory hospital admissions, and reduced lung function. Currently, all of California is in compliance with the State 1-hour ambient $NO_2$ air quality standard, often by a wide margin. Staff analyzed the impact on micro-scale exposures such as at schools where school buses idle and on freeways with heavy diesel traffic. The analysis showed no violations of the 1-hour standard.

The benefits of lower diesel PM emissions, the significant reduction in premature deaths in particular, clearly outweigh the adverse impacts of slightly higher ozone exposure and higher ambient $NO_2$. Thus staff has proposed the higher $NO_2$ limit for verified devices, as discussed above.

Currently verified retrofits have a wide range of $NO_2$ increases even within a given PM reduction level. To encourage the development and use of lower-$NO_2$ products where possible, staff proposes creating new classifications for the years 2007 and 2008: Level 3 Plus, Level 2 Plus, and Level 1 Plus. A control system would meet one of the Plus levels if it achieves the diesel PM reduction of the corresponding level (e.g., at least 85

percent for Level 3) and also meets the proposed 2009 $NO_2$ limit of 20 percent ahead of schedule. Control systems that meet a Plus level would set the standard for the Best Available Control Technology (BACT).

Staff proposes two additional amendments that would enable more accurate and representative $NO_2$ measurements. These would create more specific pre-conditioning requirements for emission control systems and restrict test engines to those with representative engine-out $NO_2$ levels.

Although staff's proposal does not have direct emissions benefits, it will enable other ARB rules to achieve greater reductions in diesel PM. When staff proposes rules to implement in-use controls for the various categories of diesel engines, it will provide more detailed estimates, taking into account the specific issues associated with each category. Staff's proposed amendments do not change the voluntary nature of the Procedure. Therefore, economic impacts will be incurred by only those entities that choose to participate in the Procedure. Staff expects that its proposal will benefit business relative to the current Procedure because more of the products that businesses have already verified will be able to comply with the proposed $NO_2$ limit and continue to participate in the California market.

ARB staff recommends that the Board adopt the proposed amendments to Sections 2702, 2703, 2704, 2706, 2707, and 2709, Title 13, California Code of Regulations, as set forth in the proposed Regulation Order in Appendix A.

# 1 INTRODUCTION

This report, written by the staff of the Air Resources Board (ARB or Board), describes proposed amendments to the Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines (Procedure), which is in the California Code of Regulations, Title 13, Sections 2700-2710. The primary purpose of the Procedure is to support California's Diesel Risk Reduction Plan, which aims to dramatically reduce Californians' exposure to diesel particulate matter (PM). Verification of an emissions control system under the Procedure is the key to participating in the diesel emission control market in California. Staff determined that changes could be made to improve the Procedure and better enable ARB to meet the goals of the Diesel Risk Reduction Plan. This report describes those changes and the rationale behind them.

# 2 BACKGROUND

## 2.1 The Diesel Risk Reduction Plan and the Verification Procedure

In 1998, following a ten-year review process, the ARB identified diesel PM as a toxic air contaminant. A toxic air contaminant is an air pollutant that contributes to mortality or serious illness, or poses other potential hazards to human health. Diesel PM is of particular concern because it is distributed over large regions, thus creating widespread public exposure.

Diesel PM is the largest contributor to health risk posed by toxic air pollutants, constituting approximately 70 percent of the total statewide risk. To address this large-scale health concern, the ARB adopted the Diesel Risk Reduction Plan in 2000 (ARB, 2000). One of the primary goals of the Diesel Risk Reduction Plan is to reduce emissions of diesel PM from the long-lived in-use fleet. The Plan outlines measures that include the use of diesel emission control systems with existing diesel vehicles and equipment in on-road, off-road, and stationary applications. To be able to implement those measures, ARB must first verify that candidate emission control technologies are effective in reducing emissions.

In response to that requirement, ARB staff developed a procedure to verify systems that provide real and durable reductions in diesel PM emissions. For systems able to achieve a verifiable PM reduction, the Procedure can also assess and recognize NOx reductions of at least 15 percent. The Board adopted the Procedure at the public hearing held on May 16, 2002. The Procedure encompasses on-road, off-road, and stationary applications and is designed to evaluate a broad range of technologies, including aftertreatment systems, alternative diesel fuels, and fuel additives. It establishes emission testing requirements that manufacturers of emission control technologies must meet in order for their products to receive verification, as well as warranty and in-use compliance testing requirements.

## 2.2 Development of the Current $NO_2$ Limit

The focus of staff's proposal is the limit on emissions of $NO_2$ in the Procedure. The limit is a performance requirement that diesel emission control systems must comply with to be verified. Exposure to $NO_2$ has been associated with adverse health effects including respiratory symptoms, cardio-respiratory hospital admissions, and reduced lung function. As a result, $NO_2$ is classified as a criteria pollutant and has both federal and state ambient air quality standards. The Procedure includes a limit on $NO_2$ because many diesel emission control systems, while highly effective at reducing emissions of diesel PM, were also found to increase emissions of $NO_2$ (though not total NOx emissions). These systems use a platinum catalyst to oxidize nitric oxide (NO) in the exhaust to $NO_2$, which is useful for burning off collected PM (as in the case of a catalyzed diesel particulate filter). Excess $NO_2$ enters the exhaust stream and can lead to a significantly higher fraction of $NO_2$ than was originally present in the engine's exhaust.

As described in the Procedure's Initial Statement of Reasons released on March 29, 2002, ARB conducted atmospheric modeling for the year 2010 to investigate the effects of large-scale implementation of high-$NO_2$ strategies (ARB, 2002). The model assumed an aggressive retrofit scenario: 90 percent of all diesels were equipped with diesel particulate filters that increase emissions of $NO_2$. After reviewing the results of the modeling and presenting them before the International Diesel Retrofit Advisory Committee (IDRAC) at its February 6, 2002 meeting, staff determined that an $NO_2$ emission limit of 20 percent of the total baseline NOx emissions (by mass) would both minimize potential negative side effects (such as increases in ozone exposure) and potentially leave the door open for effective strategies that rely on $NO_2$ formation to work properly. To give manufacturers time to redesign their control strategies to meet the limit, the Board approved an effective date of January 1, 2004.

In December 2003, the Board heard proposed amendments to the Procedure that it was later able to formally adopt in February 2004. One of the adopted amendments was a delay in the effective date of the $NO_2$ limit to January 1, 2007. The primary reason for the delay was that none of the manufacturers were able to develop and verify a compliant particulate filter. There were also questions concerning direct exposure to $NO_2$ in the near-field (or at the "micro-scale"), variability of engine-out $NO_2$, and whether the assumptions that lead to the 20 percent limit were realistic. The Board adopted a three-year delay to enable the continued implementation of PM controls while staff reevaluated what level of $NO_2$ control was warranted.

## 2.3 Post-Hearing Activity

Following the February 2004 public hearing, staff convened an $NO_2$ working group comprised of representatives from the emissions control system industry, the diesel engine industry, end-user groups, and government entities. The working group focused on the concern of micro-scale exposure to $NO_2$, alternatives to the current form of the $NO_2$ limit, and gathered data on engine-out $NO_2$ emissions. In October 2004, the working group presented its findings and recommendations at another IDRAC meeting.

Subsequent to the adjournment of the working group, staff conducted another round of regional-scale atmospheric modeling to investigate the impacts of a more realistic implementation scenario using an updated emissions inventory. Rather than assuming that 90 percent of all diesel engines would be retrofit with catalyzed diesel particulate filters in 2010, staff assumed a mix of control options that acknowledged the limitations of filter technology and used revised market penetration estimates. Both the working group's recommendations and the results of the new regional-scale modeling are discussed in more detail in Section 4 of this report.

Taking all post-hearing activity into consideration, staff has developed a proposal that redefines the $NO_2$ limit. Staff's proposal is briefly summarized in the next section and discussed in more detail in Section 4.

## 3 SUMMARY OF PROPOSED AMENDMENTS

### 3.1 $NO_2$ Limit

Staff proposes to change the limit on emissions of $NO_2$ from retrofitted diesel engines to facilitate the verification of high-efficiency diesel PM control technologies. Currently, the Procedure limits total tailpipe-out $NO_2$ emissions regardless of how much $NO_2$ is contributed by the engine. Staff proposes to limit the increase in $NO_2$ emissions, not the total emissions level. Staff also proposes to relax the level of control of $NO_2$ emissions to enable the verification of the most effective PM control systems. The proposal could result in higher $NO_2$ emissions on average, but achieves a balance between the adverse impacts of increased $NO_2$ and the benefits of PM reductions from retrofitting diesel engines.

Under staff's proposal, the maximum total $NO_2$ emission level would depend on the baseline or engine-out $NO_2$ level. On average, about 7 percent of the NOx emitted by diesel engines are in the form of $NO_2$ (see Appendix B). Staff proposes that retrofitted engines have a maximum incremental increase in $NO_2$ of no more than 30 percent of the baseline NOx emission level effective January 1, 2007, and 20 percent effective January 1, 2009. For in-use compliance testing, staff proposes a maximum $NO_2$ increase of 33 percent for the 2007 limit and 22 percent for the 2009 limit. These levels are consistent with the ten percent allowance included in the PM reduction requirement for passing in-use compliance testing.

Staff's proposal differs in structure from the present $NO_2$ limit. The Procedure currently limits the total post-control $NO_2$ emissions to 20 percent, which includes the engine's contribution to $NO_2$. In contrast, staff's proposal focuses on $NO_2$ contributed by the device, not the engine. Two advantages of staff's proposal are that manufacturers are given a fixed design target and that the Procedure would directly regulate the effect of the emission control system itself. As a result, staff expects that the proposal will enable broader verifications than the current $NO_2$ limit.

Although staff's proposal would result in higher $NO_2$ emissions from diesel engines relative to the current $NO_2$ limit, modeling and analyses indicate it would still be

protective of public health. Besides enabling significantly greater reductions in exposure to diesel PM, the proposal would also keep general exposure to $NO_2$ below the 1-hour ambient air quality standard and limit increases in exposure to ozone to a few percent.

### 3.2 New Verification Levels

To create an incentive for manufacturers to verify lower $NO_2$ systems ahead of schedule, staff proposes creating new classifications called "Level 3 Plus" and "Level 2 Plus" and "Level 1 Plus" for the years 2007 and 2008. A system would meet one of the Plus levels if it achieves a diesel PM reduction of at least 85 percent (Level 3), 50 percent (Level 2), or 25 percent (Level 1) and also meets the proposed January 1, 2009 $NO_2$ limit of 20 percent ahead of schedule. Systems that meet a Plus level would set the standard for the Best Available Control Technology (BACT) beginning January 1, 2007. Note that a Level 3 system would be considered a higher level than a Level 2 Plus or Level 1 Plus system, and a Level 2 system would similarly be higher than a Level 1 Plus system.

### 3.3 Additional Pre-Conditioning Requirements

Staff is proposing additional pre-conditioning requirements for emission control systems whose $NO_2$ emissions may be influenced by the presence of soot and ash. The proposal covers pre-conditioning for the new and aged units for the original verification as well as the units involved in first-phase in-use compliance testing.

To control the amount of soot and ash in the new unit, staff proposes a more specific pre-conditioning procedure that entails repeating an appropriate certification test cycle for 25 to 30 hours. For the purposes of stabilizing catalyst performance, an applicant may, as part of the 25 to 30 hour period, choose to run the engine for up to ten hours under conditions that include significant high load operation. Following the pre-conditioning period, the unit must be run on the emissions test engine using the emissions test cycle, and the backpressure must be recorded. The unit would then be ready for testing.

Verification requires that a unit be aged via field use or prolonged operation in a laboratory, and that the aged unit undergo emissions testing to demonstrate durability. Staff proposes that at the time of emissions testing, the average backpressure of the aged unit must be within 30 percent of the average backpressure recorded for the new device. Further, in-use compliance testing is performed on units operated by customers. For these, the backpressure must also be within 30 percent of the value recorded for the "new" reference unit. If the backpressure is too high, the applicant may burn off excess soot and clean out excess ash as necessary until the backpressure requirement is met. Units selected for in-use compliance testing that do not initially meet the requirement may not be replaced by other units that do comply.

More information on the proposed pre-conditioning requirements can be found in Appendix E.

### 3.4 Test Engine Requirements

Staff proposes that the test engine's $NO_2$ emission level serve as one of the criteria by which a given test engine is approved for verification testing. In particular, staff proposes that the test engine must not have engine-out $NO_2$ emissions that exceed 15 percent of the total NOx emissions by mass as measured over the emissions test cycle. If there is a special category of engines with $NO_2$ emission levels that normally exceed 15 percent, this requirement may be adjusted for those engines at the discretion of the Executive Officer.

### 3.5 Other Proposed Amendments

3.5.1 Support for Verification Extensions and Design Modifications

As written, Sections 2702(g) and (h) suggest that all listed forms of support for verification are required. Staff proposes a clarification that not all are required, but that those listed are the types of support that staff will consider. The "and" in the list of sources would be changed to an "or".

3.5.2 Warranty Report Requirements

Section 2707(c) of the Procedure requires that applicants submit a warranty report to ARB by February 1 of each calendar year. A number of applicants have indicated that they need additional time to prepare the report. Staff proposes to change the annual deadline to April 1. This gives applicants two additional months to comply with the requirements.

3.5.3 Verification and Other Legal Requirements

To clarify how verification interacts with regulations of other agencies and other legal requirements in general, staff proposes adding Section 2706(l). This section would simply state that when a diesel emission control system is verified by ARB, the applicant is not released from complying with all other applicable legal requirements.

## 4 DISCUSSION OF IMPACTS

This section of the report includes discussion on the potential impacts of staff's proposal.

### 4.1 Impacts of Staff's Proposal

Staff's proposal would prevent California from losing large reductions in emissions of diesel PM. As shown in Table 1, only two of the currently verified Level 3 diesel emission control systems comply with the existing $NO_2$ limit. By contrast, staff estimates that the proposed 2007 limit would enable three-quarters of the Level 3 systems to remain verified as well as at least two of the Level 2 systems. Compliance is also somewhat better for the proposed 2009 limit.

**Table 1. Estimates for Compliance of Verified Systems with Proposal**

| PM Level | Verified System | Complies with existing limit | Complies with proposed 30% increase (2007) | Complies with proposed 20% increase (2009) |
|---|---|---|---|---|
| Level 3 | 1 | | | |
| | 2 | | | |
| | 3 | -- | | |
| | 4 | -- | | -- |
| | 5 | -- | | -- |
| | 6 | -- | | -- |
| | 7 | -- | | -- |
| | 8 | -- | | -- |
| | 9 | -- | | -- |
| | 10 | - | -- | -- |
| | 11 | -- | -- | -- |
| | 12 | -- | -- | -- |
| Level 2 | 1 | -- | | |
| | 2 | -- | | -- |
| | 3 | unknown | unknown | unknown |
| | 4 | unknown | unknown | unknown |
| Level 1 | 1 | | | |
| | 2 | | | |
| | 3 | | | |
| | 4 | | | |
| | 5 | | | |
| | 6 | | | |
| | 7 | | | |
| | 8 | | | |
| | 9 | | | |

If the current 20 percent $NO_2$ limit remained in place, and Level 3 devices such as PM filters complied with the limit, as staff envisioned in 2002 and 2004, in-use emission reduction regulations and programs, both adopted and planned, would result in about 345 fewer premature deaths due to PM exposure (South Coast Air Basin in 2010). As discussed above, staff now expects that most Level 3 catalyzed PM filters will be de-verified if the current $NO_2$ limit remains in place. Should this occur, most in-use diesel clean-up will rely on Level 1 devices which reduce PM emissions by about 25 percent, compared to 85 percent for Level 3 devices such as PM filters. This will reduce the number of avoided deaths from the diesel clean-up program to about 116 deaths.

Staff's proposal to revise the $NO_2$ limit will allow the continued use of Level 3 catalyzed PM filters. As shown in last line of Table 2, this will result in about 235 avoided deaths.

The lower number of avoided deaths, compared to staff's assessment in 2002 and 2004, is due to increased $NO_2$ emissions that form additional nitrate PM, and a revised estimate of the mix of PM control devices that will be used to comply with the Board's regulations (more less effective Level 1 and 2 devices that earlier estimates).

In addition to positive impacts of the proposal, staff also analyzed potential adverse impacts. With a higher $NO_2$ limit, emissions of $NO_2$ from diesel vehicles and engines will increase on average. As a result, exposure to $NO_2$ and ozone could increase. To estimate these possible effects, staff assessed both near-source and regional air quality impacts of its proposal.

Results indicate that peak ozone may increase by one or two ppb (about one percent) during severe ozone episodes. For the South Coast Air Basin, the increase in ozone is roughly equivalent to a 10 to 30 ton per day (tpd) increase in hydrocarbon emissions, a precursor to ozone formation.

As discussed in Section 4.2.2, staff also analyzed impacts on localized exposure to ambient $NO_2$. The analysis showed that increased $NO_2$ emissions will not cause an exceedance of the 1-hour ambient air quality standard for $NO_2$.

Table 2 summarizes overall impacts for the South Coast Air Basin. The benefits of staff's proposal far outweigh adverse impacts.

**Table 2. Estimated Impacts of Staff's Proposal (South Coast Air Basin)**

| Pollutant | $PM_{2.5}$* | Ozone* | $NO_2$** |
|---|---|---|---|
| Exposure | Decreases | Increases | Increases |
| Result | 230-240 premature deaths avoided | 1-2 ppb ozone - 1-2 more premature deaths | None; Exposure remains below 1-hr State standard |

*Based on a regional air quality model simulation of a multi-day episode for 2010 in the South Coast Air Basin (see Section 4.2.1). Premature deaths avoided are for the year 2010 only.
**Based on micro-scale analyses (see Section 4.2.2).

## 4.2 Modeling and Analysis of Potential Impacts

In this section, staff provides additional detail on the potential regional and micro-scale air quality impacts of the proposal.

### 4.2.1 Simulated Impacts at the Regional-scale

The original $NO_2$ limit was based on modeling simulations of air quality for the summer, fall, and winter in Southern California for multi-day periods in 2010 (Table 3). It assumed that 90 percent of all diesel vehicles and equipment were retrofitted with filters

and considered a range of 15 to 50 percent for the $NO_2$ fractions. Based on the results of the modeling, staff selected a conservative $NO_2$ limit of 20 percent at the tailpipe. This limit ensured that no violation of the State ambient air quality standard for $NO_2$ would occur and that there would be no effect on regional ozone formation. Staff now believes that the original analysis was overly conservative because catalyzed PM filters will be applied to less than 90 percent of all diesel engines due to application limitations and the availability of other control options (e.g., actively regenerating filters and engine replacement). Some of these options do not significantly increase $NO_2$ emissions.

**Table 3. Summary of Simulated Impacts of Diesel Particulate Filters* in Southern California, 2010 (Original Rulemaking)**

| Diesel $NO_2/NOx$ (90% of all diesel engines) | | Baseline 10%** | 15% | 20% | 25% | 30% | 50% |
|---|---|---|---|---|---|---|---|
| | | (Percent change from baseline) | | | | | |
| Summer | Peak 1-Hour $O_3$ | 0 | -1 | 0 | 0 | 0 | 1 |
| | Cumulative Daily 1-Hr $O_3$ Exposure > 90 ppb | 0 | -3 | -2 | 0 | +2 | +5 |
| | Peak 24-Hour $PM_{2.5}$ | 0 | -3 | n/a | n/a | -2 | -1 |
| Fall | Peak 24-Hour $PM_{2.5}$ | 0 | -6 | n/a | n/a | -5 | -3 |
| Winter | Peak 1-Hour $NO_2$ | 0 | +1 | +6 | +12 | +18 | +41 |

*90 percent of all diesel engines assumed to be retrofitted with catalyzed diesel particulate filters.
**Consists of 5 percent engine-out $NO_2$ plus 5 percent $NO_2$ from in-plume conversion of NO to $NO_2$.

To estimate regional air quality impacts that would result from a more realistic mix of various emission control technologies, staff developed a new scenario. Instead of 90 percent of all diesel engines being equipped with $NO_2$-generating filters in 2010, staff applied a mix of technologies to 90 percent of the fleet (Table 4). This new scenario is as aggressive as the original scenario in terms of implementation, but it recognizes that fewer passive ($NO_2$-generating) filters will be used and that other options are available.

The mix of emission control options that staff assumed includes $NO_2$-generating filters, non-catalyzed filters, flow-through filters, diesel oxidation catalysts (DOCs), and engine repowers or vehicle/equipment replacements (see Appendix C for details). Staff applied a 30 percent increase in the $NO_2$ fraction for $NO_2$-generating filters, consistent with the proposed $NO_2$ limit. The penetration of $NO_2$-generating filters into the off-road market is assumed to be lower than that for on-road engines because of the less predictable and more diverse duty cycles of off-road applications. No off-road repowers or replacements were assumed because in the 2010 timeframe, regulations also require retrofit. For stationary engines, staff assumed all prime engines would use $NO_2$-generating filters.

**Table 4. Revised "Most Likely" 2010 Penetration Scenario**

| Control Option | On-road Diesels | Off-road Diesels |
|---|---|---|
| $NO_2$-generating filters | 50% | 30% |
| Non-catalyzed filters | 10% | 15% |
| Flow-through filters | 25% | 25% |
| Diesel oxidation catalysts | 10% | 30% |
| Repower/Replacement | 5% | 0% |
| Percent of fleet using the control option mix | 90% | 90% |

Staff updated the estimates of impacts of widespread diesel retrofits to include the revised "most likely" scenario. The results also reflect the more recent 2003 State Implementation Plan (SIP) emissions inventory for 2010 and not the interim inventory used to generate the results in Table 3. Also, the updated estimates for ozone are based on a different photochemical model (CAMx). Additional information can be found in Appendix C.

Presented in Table 5 is staff's updated assessment of the impact of the $NO_2$ limit on avoided premature deaths. The last row reflects the staff's proposal to revise the $NO_2$ limit, and the more realistic estimate of the mix of technologies that will be used to reduce PM emissions from in-use engines. As shown, the number of avoided deaths is about 235 in the South Coast Air Basin in 2010. Had catalyzed filter manufacturers been able to reduce $NO_2$ emissions to the currently required 20 percent limit (represented in the table as a 10 percent increment), premature deaths avoided would be about 345. As discussed previously, $NO_2$ emissions of catalyzed filters have not been reduced and exceed the current limit. Thus if the limit is not revised, these devices will not be available for use in reducing PM emissions. The alternative under the Board's regulations is to use less effective devices. Most of these would be Level 1 devices that reduce PM emissions by about 25 percent, as compared to the 85 percent reduction of catalyzed filters. Staff estimates that if the current $NO_2$ limit is not revised, the avoided deaths will be reduced to about 116, due to the lower PM emission reductions. Clearly, the staff proposal achieves the greatest reduction in premature deaths, given the general unavailability of low $NO_2$ catalyzed filters that meet the existing $NO_2$ limit.

**Table 5. Estimates for Premature Deaths Avoided (South Coast Air Basin, 2010)**

| $NO_2$ Increment | | $PM_{2.5}$ Deaths Avoided (Modeled)* | $O_3$ Deaths Avoided (Modeled)* | Net Deaths Avoided |
|---|---|---|---|---|
| 90% of diesels with filters | 5% | 370 | <1 to 4 | 370 |
| | 10% | 340 to 350** | 1 to 2 | 340 to 350 |
| | 15% | 320 to 340** | <1 | 320 to 340 |
| | 20% | 290 to 320 | -2 to -1 | 290 to 320 |
| | 30% | 240 to 280** | -5 to -2** | 240 to 280 |
| | 40% | 190 to 240 | -9 to -3 | 180 to 230 |
| Most Likely Scenario | | 230 to 240*** | -2 to -1 | 230 to 240 |

* Range reflects two modeled PM episode days (Dabdub and Knipping, 2002) and 3-5 modeled ozone episode days, which are not necessarily representative of the annual averages of these pollutants. There is +/- 50 percent uncertainty behind each estimate due to uncertainty in concentration-response relationships between exposures to the pollutants and premature death.

** Derived via linear interpolation.

*** The most likely scenario reflects a mix of retrofit technologies (not just 90 percent filters as in the other scenarios) that results in a 16 percent increase in the $NO_2$ fraction. The estimate for deaths avoided uses the result for the 15 percent increment scenario adjusted for the difference in diesel PM reductions (55 percent for the likely scenario vs. 77 percent for the other scenarios).

Staff's proposal to revise the $NO_2$ limit will result in greater $NO_2$ emissions. Staff updated its assessment of the impact of these higher emissions on ozone. Table 6 contains the results. For the most likely scenario (right hand column), peak ozone is expected to increase by about 1 percent in southern California in 2010. This is equivalent to 1 to 2 ppb ozone. Also shown for reference are the original scenarios used to establish the existing 20 percent limit. The 10 percent $NO_2$ column represents the current limit, and as shown there is no increase in ozone, which was the criterion for selecting the $NO_2$ limit in 2002. Unfortunately, a tradeoff now exists. To achieve the lower PM emissions and substantially reduced premature deaths, higher $NO_2$ emissions must be allowed, and a small increase in ozone is the result. This increase is further reduced once the allowable $NO_2$ increase is reduced to 20 percent in 2009.

**Table 6. Updated Simulated Impacts of Diesel Retrofits on Ozone in Southern California, 2010 (2003 SIP emissions inventory)**

| Air Quality Parameter | | Baseline 10% $NO_2/NO_x$ | 90% of diesels with filters: $NO_2$ increment | | | | | Most Likely Scenario |
|---|---|---|---|---|---|---|---|---|
| | | | 5% | 10% | 15% | 20% | 40% | |
| | | (Percent Change from baseline) | | | | | | |
| Summer | Peak 1-Hour $O_3$ | 0 | -1 | -1 | 0 | 0 | 2 | 1 |
| | Cumulative Daily 1-Hr $O_3$ Exposure > 90 ppb | 0 | -6 | -3 | 1 | 4 | 19 | 8 |
| | Peak 8-Hour $O_3$ | 0 | -1 | -1 | 0 | 0 | 2 | 1 |
| | Maximum Daily 8-Hr $O_3$ Exposure > 70 ppb | 0 | -2 | -1 | 0 | 1 | 4 | 1 |

*Consists of 5 percent engine-out $NO_2$ plus 5 percent $NO_2$ from in-plume conversion of NO to $NO_2$.

In addition to health impacts, staff also estimated the reduction in ozone precursor emissions that would be required to offset the modeled increase in ozone for the South Coast Air Basin. To do this, staff used year 2010 air quality simulations[1] to examine the sensitivity of the maximum daily 8-hour ozone concentration to changes in precursor emissions. At emissions rates that are expected to achieve attainment of the 8-hour ozone standard for the modeled episode, simulated ozone concentrations showed almost no response to changes in NOx emissions. For hydrocarbons, however, reductions of 8-14 tons per day caused a one ppb reduction of the 8-hour ozone concentration[2]. If it is assumed that increases in peak 1-hour and 8-hour ozone concentrations are equivalent, a reduction in hydrocarbon emissions of roughly 10 to 30 tons per day would be required to offset the increase in peak 1-hour ozone expected from staff's proposal (one to two ppb).

4.2.2 Estimated Micro-scale Impacts

In addition to investigating potential air quality impacts at the regional-scale, staff also considered micro-scale impacts. The concern at the micro-scale is the potentially high acute exposure to $NO_2$ at short distances from the source, such as might occur when closely following a vehicle equipped with an $NO_2$-generating filter. Staff evaluated conservative, worst-case scenarios based on both actual field measurements, described first, and dispersion modeling, described second. The results show that

[1] Based on the August 3-7, 1997, episode conditions used for the 2003 South Coast 1-hour Ozone SIP update.

[2] This ozone concentration response estimate is based on reductions of all volatile organic compound species by the same percentage. Therefore, it does not necessarily represent an actual emissions control strategy.

staff's proposal to allow higher $NO_2$ emissions will not result in local exceedances of the 1-hour ambient air quality standard for $NO_2$.

A. Evaluations of Measurement-based Exposure Scenarios

ARB staff in the $NO_2$ Working Group conducted an assessment of several worst-case micro-scale exposure scenarios (Fruin et al, 2004). In brief, these scenarios were:

(1) Driving on a diesel-dominated Freeway – This scenario focused on the segment of the 710 Freeway from Long Beach to the 5 Freeway (16 miles long), which is the busiest diesel truck corridor in California. For the analysis, staff assumed that 50 percent of all the diesel trucks on this freeway segment were equipped with filters that generate excess $NO_2$. Also, on-road concentrations of NO and $NO_2$ were assumed to be those obtained by staff from recent on-road measurements taken on the 710 Freeway.

(2) Riding in a self-polluting, filter-equipped diesel school bus – This scenario considered the re-entrainment of a fraction of the bus' own exhaust ("self-pollution") into the passenger cabin and made use of tracer gas measurements from the ARB Children's School Bus Exposure Study[3].

(3) Following a filter-equipped diesel vehicle – To estimate potential $NO_2$ exposure immediately behind a vehicle exhaust plume, staff used dilution measurements from an ongoing ARB School Bus follow-up study. In these experiments, two school buses followed each other closely while driving in real-world traffic conditions. A conservative approach was taken, and the lowest-observed, short-term dilution rates were assumed for the analysis.

The $NO_2$ concentrations staff used as threshold to assess the potential exposure in each scenario were the State 1-hour ambient air quality standard of 250 ppb and a 15-minute level of 370 ppb derived from the 1-hour standard. This derivation used an exponential relationship derived from animal studies of $NO_2$ exposures (ten Berge et al., 1986 as cited in Fruin et al., 2004). Scenarios (1) and (3) are suited to the shorter 15-minute timescale since the 710 Freeway segment is only 16 miles long, and vehicles usually do not follow each other for long periods of time. In addition, the 15-minute interval is also appropriate for the simultaneous occurrence of all three scenarios, which amounts to being in a filter-equipped vehicle that is following behind another filter-equipped vehicle on the 710 Freeway.

The analysis found that the proposed 30 percent incremental $NO_2$ limit over the engine-out level is still protective at the micro-scale for the 1-hour and 15-minute timescales, in spite of a doubling of the total exposure calculated for the original 20 percent absolute limit. Staff found this result for the scenarios individually as well as when they occurred simultaneously (see Table 7). It is also important to recognize that although the filters in

[3] For information on the Children's School Bus Exposure Study, please see: http://www.arb.ca.gov/research/schoolbus/schoolbus.htm

these scenarios caused increased $NO_2$ exposures, they also caused large reductions in diesel PM exposures. Table 3 shows that when the scenarios are combined, the filters reduce diesel PM exposure from 58 µg/m³ to 20 µg/m³7.

**Table 7. Micro-scale $NO_2$ Exposure and PM Reduction Estimates**

| High Exposure Scenarios | Estimated $NO_2$ Exposure (ppb) | | Estimated Diesel PM Exposure | |
|---|---|---|---|---|
| | 30% $NO_2$ increment | 20% $NO_2$ absolute limit | No filters (µg/m³) | Reduction with filters |
| (1) 710 Freeway | 94 | 47 | 28 | 43%* |
| (2) Self-Pollution | 57 | 28 | 14 | 85% |
| (3) Following | 37 | 19 | 16 | 85% |
| Total | 188 | 94 | 58 | 65% |

*50 percent of trucks equipped with filters

B. Evaluations of Dispersion Modeling-based Exposure Scenarios

Staff simulated two worst-case, acute $NO_2$ exposure scenarios using dispersion modeling of exhaust:

(1) Idling School Buses – Twenty filter-equipped school buses, in groups of five, were assumed to idle five minutes each (the State limit) at the loading zone for 20 minutes total. The NOx emission rate at idle for the school buses was 81 g/hr based on the EMFAC 2002 V2.2 emissions model. Idling was assumed to take place at 8 A.M. and 2 P.M. each weekday. Staff used the U.S. EPA ISCST3 air dispersion model and assumed the impacted receptor of interest to be 20 meters away.

(2) High Volume Freeway – A segment of the 710 Freeway with high diesel truck traffic was simulated. The freeway scenario included a nominal traffic volume of 26,312 trucks per day, the 99th percentile of truck traffic on freeways in California. Staff used the CAL3QHCR roadway model, available from U.S. EPA and derived from the CALINE Model. The impacted receptor was assumed to be 20 meters from the edge of the freeway.

Table 8 shows a summary of the highest 1-hour $NO_2$ concentrations for the two scenarios discussed above, all of which are below the State 1-hour ambient air quality standard of 250 ppb. Because a hot, heavily-catalyzed filter may be able to produce as much as 70 percent $NO_2$ at idle, staff chose to model that scenario as well. Even in that case, exposure does not exceed the 250 ppb level, though it comes close.

**Table 8. Summary of 1-Hour $NO_2$ Impacts* Anticipated from Retrofitting Diesel Engines with Filters**

| Scenario | Baseline (no filters) (10% $NO_2$/NO) | With Filters (40% $NO_2$/NO) | With Filters (70% $NO_2$/NO) |
|---|---|---|---|
| Idling School Buses | 120 ppb | 170 ppb | 240 ppb |
| Freeway | 150 ppb | 180 ppb | --- |

*These results include ambient hourly $NO_2$ as background.

## 5 INTERACTION WITH OTHER ARB DIESEL PROGRAMS

ARB in-use diesel programs rely on emission control systems verified under the Procedure to achieve their diesel PM reduction goals. If the $NO_2$ limit is not changed, nearly all of the currently verified filters would be de-verified in January 2007, removing one of the most effective PM control technologies from the market. End-users would resort to lower-efficiency systems that achieve 25 to 50 percent PM reductions, resulting in lower overall PM control than what is envisioned in the Diesel Risk Reduction Plan. While it is true that participation in the verification process is voluntary and there is no prohibition against selling diesel emission control strategies in California that have not been verified by the ARB, the ARB has adopted and may in the future adopt regulations requiring reductions of PM from in-use diesel vehicles. (See, e.g. title 13 CCR section 2020, et seq., Solid Waste Collection Vehicles; 13 CCR section 1956.2, Fleet Rule for Transit Agencies; 13 CCR section 2477, Transportable Refrigeration Units; 17 CCR section 93115, Airborne Toxic Control Measure for Stationary Compression Ignition Engines; 17 CCR section 93116, Airborne Toxic Control Measure for Diesel Particulate Matter from Portable Engines Rated at 50 Horsepower and Greater). One of the compliance options available to entities that must comply with these regulations is the application of verified, retrofitted diesel emission control strategies in specific situations. Entities subject to these retrofit requirements may then, under certain circumstances, be obliged to use verified diesel emission control strategies to comply with these requirements, perhaps because it is the compliance option most attractive to them. Consequently, these entities will only purchase systems from manufacturers that have obtained ARB's verification. The proposed regulatory action would make the requirements for verification less stringent than they are now, allowing for more systems to become verified and avoiding the loss of verifications by most currently verified systems on January 1, 2007.

## 6 ISSUES

### 6.1 Health Effects and the Balance Between $NO_2$ Emissions and Diesel PM

The current $NO_2$ limit for verified devices will effectively preclude the continued use of most catalyzed PM filters, beginning in January 2007. Catalyzed PM filters are commonly used to comply with the ARB's in-use diesel emission reduction regulations. If the limit is not changed, many diesel trucks and equipment will be forced to use less

effective devices, resulting in smaller emission reductions. Staff estimates this will reduce the health benefits of the regulations by approximately 50 percent.

The alternative is to increase the allowable $NO_2$ emissions in order to allow the continued use of catalyzed PM filters. The higher $NO_2$ emissions will result in a small increase in peak ozone and ozone exposure, on the order of one percent. Modeling shows ambient $NO_2$ concentrations will increase, but not sufficiently to cause a health problem or exceedance of the ambient air quality standard for $NO_2$.

Staff believes on balance that the benefits of lower PM exposure clearly outweigh the adverse impact of increased ozone exposure. This supports its proposal to continue using devices effective in reducing PM emissions. Staff's proposal to reduce the allowable $NO_2$ increase from 30 to 20 percent in 2009 further mitigates the tradeoff.

### 6.2 Fuel-borne Catalysts and $NO_2$

Staff views the proposal as a balance between diesel PM and $NO_2$ because $NO_2$ is a byproduct of the most prevalent diesel particulate filters on the market today. They rely on $NO_2$ to burn off PM collected in the filter. Restricting emissions of $NO_2$ hampers the basic mechanism that allows these technologies to operate properly.

During $NO_2$ working group discussions, it was pointed out that there are filter technologies that do not rely on this mechanism. In particular, a working group member indicated that there are metallic fuel-borne catalysts (FBCs) designed to regenerate filters that do not increase $NO_2$ emissions. One of the issues with this technology is that it faces considerable federal and state testing requirements. Unlike the filter technologies being used in California today, FBC systems introduce metals into the fuel. This triggers special testing requirements at the federal level and multimedia evaluation requirements at the state level. Fulfilling both requirements can be costly and time-consuming; as a result, many manufacturers choose not to undergo testing. There are no FBC-based systems verified at present. Thus, FBC-based systems cannot be relied upon to fulfill the need for devices that reduce PM emissions, at least not in the current timeframe.

### 6.3 Fewer Verified Products

The proposed $NO_2$ limit will likely cause the de-verification of two filters. On the other hand, if the current $NO_2$ limit were to remain in effect, all but two filters would be de-verified. The latter situation would be acceptable if several compliant, proven, and viable alternatives had emerged to meet California's need to reduce diesel PM emissions. Industry, however, has not yet been able to supply such products.

## 7 REGULATORY ALTERNATIVES

While developing the proposal, staff considered numerous regulatory alternatives, two of which are described below.

### 7.1 No Change to the $NO_2$ Limit

One alternative to staff's proposal is to retain the current $NO_2$ emission limit. Doing so may lead to lower $NO_2$ emissions, but it would also cause most of the currently approved filters to be de-verified and hinder the verification of other systems for the reasons described in Section 4. Because the success of the Diesel Risk Reduction Plan depends on having effective diesel emission control systems verified for a wide range of diesel engines and applications, staff does not recommend this option.

### 7.2 Do Not Regulate $NO_2$ Emissions

The most effective option for maximizing the number of verified emission control systems available to support the Diesel Risk Reduction Plan would be to remove any limit on $NO_2$ emissions. Under this alternative, all currently verified systems would remain verified, and systems with higher $NO_2$ could become verified in the future. The problem with this option is that increased $NO_2$ emissions will lead to greater ozone increases and associated health impacts. It is also possible that higher $NO_2$ emissions, allowed under staff's proposal, could cause localized exceedances of the ambient air quality standard for $NO_2$. Staff's proposal to limit $NO_2$ emissions assures increases in ozone and ambient $NO_2$ are minimized. Staff, therefore, does not recommend removing the $NO_2$ limit altogether.

## 8 ECONOMIC IMPACTS

The proposed amendments to the Procedure would modify a protocol for evaluating in-use diesel emission control technologies and make it less stringent than it now is, or will become as of January 1, 2007. Overall, participation in the verification program is purely voluntary, and businesses participate in the verification process only if they believe it to be financially advantageous to do so. The proposed amendments will not change the voluntary nature of the Procedure. At the same time, staff expects the relaxation of the $NO_2$ emissions limit to benefit manufacturers and users of diesel emission control systems because staff's proposal would result in fewer (if any) de-verifications of currently verified products than the existing $NO_2$ limit.

In developing this regulatory proposal, ARB staff evaluated the potential economic impacts on representative private persons or businesses. The ARB is not aware of any cost impacts that a representative private person or business would necessarily incur in reasonable compliance with the proposed action. The Executive Officer has also determined, pursuant to title 1, CCR, section 4, that the proposed regulatory action will not affect small businesses because participation in the Procedure is purely voluntary. There are no cost impacts that a representative private person or business would necessarily incur in reasonable compliance with the proposed action. However, under certain circumstances, where the proposed amendments may have an economic effect, the staff believes that this effect will be positive, as described below.

As noted, participation in the Procedure is purely voluntary both in its current form and as amended under the proposed action. While it is true that participation in the verification process is voluntary and there is no prohibition against selling diesel

emission control strategies in California that have not been verified by the ARB, the ARB has adopted and may in the future adopt regulations requiring reductions of PM from in-use diesel vehicles. (See, e.g. title 13 CCR section 2020, et seq., Solid Waste Collection Vehicles; 13 CCR section 1956.2, Fleet Rule for Transit Agencies; 13 CCR section 2477, Transportable Refrigeration Units; 17 CCR section 93115, Airborne Toxic Control Measure for Stationary Compression Ignition Engines; 17 CCR section 93116, Airborne Toxic Control Measure for Diesel Particulate Matter from Portable Engines Rated at 50 Horsepower and Greater). One of the compliance options available to entities that must comply with these regulations is the application of verified, retrofitted diesel emission control strategies in specific situations. Entities subject to these retrofit requirements may then, under certain circumstances, be obliged to use verified diesel emission control strategies to comply with these requirements, perhaps because it is the compliance option most attractive to them. Consequently, these entities will only purchase systems from manufacturers that have obtained ARB's verification. The proposed regulatory action would make the requirements for verification less stringent than they are now, allowing for more systems to become verified and avoiding the loss of verifications by most currently verified systems on January 1, 2007. Accordingly, the proposed amendments will have the positive economic effect of keeping more manufacturers in the business of producing verified systems. This will guarantee that the market for verified devices remains competitive, giving consumers the benefits of this competition in terms of increased product choices, technological innovation and price restraint. Moreover, the proposed amendments will also have the positive economic impact of avoiding the situation where previously-installed verified retrofit systems no longer meet verification requirements, driving current manufacturers out of the market and possibly necessitating either the system's removal and the installation of one of the few systems that would meet the unamended requirements, or the pursuit of one of the other less attractive compliance options. For all of the foregoing reasons, staff does not expect the proposal will result in adverse economic impacts and instead expects that the proposal will result in positive economic impacts. Several aspects of the expected economic impact of the proposed regulations are discussed below.

### 8.1 Legal Requirement

Section 11346.3 of the Government Code requires State agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include a consideration of the impact of the proposed regulation on California jobs, business expansion, elimination or creation, and the ability of California business to compete with business in other states.

State agencies are also required to estimate the cost or savings to any State or local agency and school district in accordance with instructions adopted by the Department of Finance. The estimate shall include any non-discretionary cost or saving to the local agencies and the cost or saving in federal funding to the State.

## 8.2 Affected Businesses

Participation in California's diesel emission control verification program is not mandatory. However, any business or individual that chooses to participate in the program will have to satisfy the requirements of the Procedure. Businesses that choose to participate and thus follow the Procedure include manufacturers and marketers of diesel emission control technologies. Also, some businesses may be indirectly affected, such as system installers and suppliers of raw materials or equipment to participants. Overall, staff expects that the economic impacts of the proposal will be positive, because more systems will be able to meet the requirements for verification, while few, if any, systems that are currently verified will need to be de-verified. Users of verified systems will have a greater variety of products to choose from either to satisfy a compliance option or by purely voluntary action, fostering competition, keeping prices down and improving the quality of the systems available. Users who currently may be using verified systems will avoid the possible expense and inconvenience of removing their current, verified systems and replacing them with systems that would meet the requirements of the regulation if it were not amended, or pursing another possibly less desirable compliance option. The amendments may have a negative economic effect in the very limited situation where a manufacturer would be able to meet the current $NO_2$ limit, while others are driven out of the market by their inability to do so. Under such a scenario, the remaining manufacturer could enjoy a competitive advantage in selling one of the few verified systems available. This proposal would deprive a manufacturer of such an advantage and the staff believes that any adverse economic impact experienced by a manufacturer in this position is outweighed by the positive impacts the proposal would have in terms of keeping more manufacturers and products in the market, thereby enhancing competition along with the technological innovation and price restraint that enhanced competition brings.

## 8.3 Potential Impact on California Businesses

The proposed amendments should have no disparate economic impact on California businesses, except for the positive impacts noted above. The requirements for verification under the Procedure apply to any business that wishes to sell its products in California, regardless of its location. The proposed amendments do not alter that universality. Should any manufacturer or marketer elect to participate in the verification program, it would need to provide detailed information and data on the product in accordance with the Procedure. The testing required by the Procedure may require significant expenditures of capital on the part of a company. The proposed amendments to the Procedure will either cause no change in the cost of testing or slightly increase the cost due to the additional pre-conditioning requirements for certain technologies. Relative to the current $NO_2$ limit, staff's proposal will also enable more of the currently verified products to continue to be sold in California. Several California manufacturers and installers therefore stand to benefit.

Should a business choose not to participate in the verification program, there are other avenues by which its products may be sold in California. A business having a Vehicle Code 27156 exemption can legally sell the product in California, but can claim no

emissions reductions. The product would not be a verified diesel emission control strategy, and would not satisfy the requirements of the fleet rules.

### 8.4 Potential Impact on Employment

The proposed amendments to the Procedure are not expected to cause a noticeable change in California employment and payroll. Participation in the program is voluntary, and presumably only businesses that can afford the program would participate. Any effect on employment is expected to be positive, given the fact that the overall economic effect of the proposed amendments is expected to be positive.

### 8.5 Potential Impact of Business Creation, Elimination or Expansion

The proposed amendments to the Procedure will enable more of the currently verified products to remain verified and continue to participate in the California market. This will have a beneficial impact on businesses, but staff does not expect considerable business creation, elimination, or expansion. Any effect on business creation, elimination or expansion is expected to be positive, given the fact that the overall economic effect of the proposed amendments is expected to be positive.

### 8.6 Potential Impact on Business Competitiveness

The proposed amendments to the Procedure would have no impact on the ability of California's businesses to compete with businesses in other states. Staff's proposals do not change the voluntary nature of the Procedure or its applicability to all businesses that manufacture or market diesel emission control technologies regardless of their location. Any impact on business competitiveness is expected to be positive, given the fact that the overall economic effect of the proposed amendments is expected to be positive.

### 8.7 Potential Impact to California State or Local Agencies

The proposed amendments to the Procedure will not create costs or savings, as defined in Government Code Section 11346.5 (a)(6), to any State agency or in federal funding to the State, costs or mandate to any local agency or school district whether or not reimbursable by the State pursuant to Part 7 (commencing with Section 17500, Division 4, Title 2 of the Government Code), or other non-discretionary savings to local agencies. The staff has not encountered information that indicates that any of these impacts is to be expected.

### 8.8 Estimated Costs

As noted previously, the proposed amendments do not change the voluntary nature of the Procedure. Those manufacturers that wish to market diesel emission control systems in California would find verification under the Procedure desirable. The proposed amendments to the Procedure would cause either no change in the cost of testing or a minor increase in cost due to the additional pre-conditioning requirements for certain technologies. The proposed amendments should keep the costs of verified

systems down, due to their effect of keeping more verified products in the marketplace, but this effect is difficult to quantify.

## 9 ENVIRONMENTAL IMPACTS

A complete discussion of the environmental impacts of the proposed amendments can be found in Chapters 4, 6 and 7 of this report. As discussed in these portions of the report, staff's proposal will increase $NO_2$ emissions. Modeling has shown this will result is a small increase in peak ozone and exposure and this increase constitutes an adverse environmental impact. Ambient $NO_2$ concentrations will also increase, but modeling has shown there will be no exceedance of the health protective ambient $NO_2$ air quality standard.

The revised $NO_2$ limit will assure that highly effective devices that reduce PM emissions will continue to be available for use by diesel vehicle operators facing ARB regulations or other pressures to reduce diesel emissions. Health assessments show that the lower PM emissions result in substantially reduced exposure to diesel PM, and at least several hundred premature deaths in southern California will be avoided annually by continued use of PM filters. The staff believes that this benefit clearly outweighs the small increase in ozone and associated adverse health impacts from this increase.

### 9.1 Legal Requirements Applicable to the Analysis

The California Environmental Quality Act (CEQA) and ARB policy require an analysis to determine the potential adverse environmental impacts of proposed regulations. Since the ARB's program involving the adoption of regulations has been certified by the Secretary of Resources (see Public Resources Code section 21080.5), the CEQA environmental analysis requirements are allowed to be included in the Initial Statement of Reasons for a rulemaking in lieu of preparing an environmental impact report or negative declaration. In addition, the ARB will respond in writing to all significant environmental issues raised by the public during the public review period or at the Board hearing. These responses will be contained in the Final Statement of Reasons for the proposed amendments.

Public Resources Code section 21159 requires that the environmental impact analysis conducted by ARB include the following: (1) an analysis of the reasonable foreseeable environmental impacts of the methods of compliance; (2) an analysis of reasonably foreseeable mitigation measures; and, (3) an analysis of reasonably foreseeable alternative means of compliance with the proposed revisions to the Regulation. Regarding reasonably foreseeable mitigation measures, CEQA requires an agency to identify and adopt feasible mitigation measures that would minimize any significant adverse environmental impacts described in the environmental analysis.

### 9.2 Ozone Impacts

The ozone increases described in Chapters 4, 6 and 7 constitute an adverse environmental impact. Staff evaluated alternatives to these proposed amendments

(see: Chapters 4, 6 and 7). However, staff was not able to identify any feasible alternatives that would substantially reduce the potential adverse impacts of these proposed amendments while at the same time ensuring that the positive environmental impacts (i.e. a reduction in exposure to diesel particulate) would be achieved. Staff was also unable to identify any feasible mitigation measures that would substantially reduce the potential adverse impacts, while at the same time ensuring that the positive environmental impacts would be achieved. Staff believes that reducing diesel particulate exposure is a consideration that overrides the small ozone impacts that may occur as a result of the proposed amendments.

### 9.3 Reasonably Foreseeable Alternative Means of Compliance with the Proposed Amendments

The ARB is required to do an analysis of reasonable foreseeable alternative means of compliance with the proposed amendments. Alternatives to the proposed amendments are discussed in Chapters 4 and 7. ARB staff has concluded that the proposed amendments provide the greatest degree of flexibility and the least burdensome approach to reducing public exposure to diesel particulate consistent with protection of public health.

### 9.4 Environmental Justice

The ARB is committed to evaluating community impacts of proposed regulations, including environmental justice concerns. Because some communities experience higher exposures to toxic pollutants, it is a priority of the ARB to ensure that full protection is afforded to all Californians. The proposed amendments are not expected to result in significant negative impacts in any community. The proposed amendments are designed to support the DRRP reduce emissions of diesel particulate throughout the state. The result of the proposed amendments will be reduced exposures to potential diesel particulate emissions for all communities in the state, with associated lower potential health risks.

## 10 COST-EFFECTIVENESS

Because no direct emissions benefits are associated with staff's proposal, no cost effectiveness analysis could be performed. More detailed estimates will be provided when staff develops future rules that incorporate in-use controls.

## 11 CONCLUSION

The proposed amendments to the Procedure, as described herein, would help ARB to implement the Diesel Risk Reduction Plan while keeping emissions of $NO_2$ from retrofitted diesel engines under control. ARB staff recommends that the Board adopt the proposed amendments to Sections 2702, 2703, 2704, 2706, 2707, and 2709, Title 13, of the California Code of Regulations, as set forth in the proposed Regulation Order in Appendix A.

## 12 REFERENCES

Air Resources Board (ARB) Diesel Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles. October 2000.

Air Resources Board (ARB) Staff Report: Initial Statement of Reasons – Proposed Regulation for the Verification Procedure for In-Use Strategies to Control Emissions from Diesel Engines. March 29, 2002.

Dabdub, D. and Knipping, E.M. "Impact of Altering $NO/NO_2$ Splits in NOx Emissions of Diesel Sources," University of California, Irvine, Report to ARB, May 13, 2002.

Fruin, S., Ayala, A., and Croes, B. "Assessment of Possible Worst-case $NO_2$ Exposure Scenarios Related to Catalyst-based Diesel Trap Aftertreatment," Air Resources Board, September 2004. http://www.arb.ca.gov/diesel/no2/no2exposurescenarios.pdf

Fruin, S., Westerdahl, D., Kozawa, K., Herner, J., and Ayala, A. "In-Vehicle Exposure Research in California," Air Resources Board presentation, 9th ETH International Conference on Combustion-Generated Nanoparticles, 15-17 August 2005, Zurich.

Lloyd, A.C. and Cackette, T.A. "Diesel engines: Environmental impact and control," Journal of the Air & Waste Management Association, Volume 51, p. 809-847. June 2001.

ten Berge, W.F., Zwart, A., Appelman, L.M. "Concentration-time mortality response relationship of irritant and systemically acting vapours and gases," Journal of Hazardous Materials, Volume 13, p.301-309, 1986.

# APPENDIX A

# PROPOSED REGULATION ORDER

# Appendix A. Proposed Regulation Order

NOTE: This document is printed in a style to indicate changes from the adopted regulation. All original language is indicated by plain type. The proposed amendments are shown in underline to indicate additions to the original language and ~~strikeout~~ to indicate deletions. The symbol "******" means that the remainder of the text of the regulation for a specific section is not shown, but has been incorporated by reference, unchanged.

**NOTE:** Adopt Title 13, California Code of Regulations, sections 2702, 2703, 2704, 2706, 2707, and 2709 to read as follows:

**Chapter 14. Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines**

* * * * *

**§ 2702. Application Process**

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(f) Within 60 days after an application has been deemed complete, the Executive Officer shall determine whether the diesel emission control strategy merits verification and shall classify it as shown in Table 1:

Table 1. Verification Classifications for Diesel Emission Control Strategies

| Pollutant | Reduction | Classification |
|---|---|---|
| PM | < 25% | Not verified |
| | ≥ 25% | Level 1 |
| | | Level 1 Plus* |
| | ≥ 50% | Level 2 |
| | | Level 2 Plus* |
| | ≥ 85%, or ≤ 0.01 g/bhp-hr | Level 3 |
| | | Level 3 Plus* |
| NOx | < 15% | Not verified |
| | ≥ 15% | Verified in 5% increments |

*The diesel emission control strategy complies with the 20 percent $NO_2$ limit before January 1, 2009 (and after January 1, 2007).

* * * * *

(g) Extensions of an Existing Verification. If the applicant has verified a diesel emission control strategy with one emission control group and wishes to extend the verification to include additional emission control groups, it may apply to do so using the original test data, additional test data, engineering justification and analysis, ~~and~~ or any other information deemed necessary by the Executive Officer to address the differences between the emission control group already verified and the additional emission control group(s). Processing time periods follow sections (e) and (f) above.

(h) Design Modifications. If an applicant modifies the design of a diesel emission control strategy that has already been verified or is under consideration for verification by the Executive Officer, the modified version must be evaluated under this Procedure. The applicant must provide a detailed description of the design modification along with an explanation of how the modification will change the operation and performance of the diesel emission control strategy. To support its claims, the applicant must submit additional test data, engineering justification and analysis, ~~and~~ or any other information deemed necessary by the Executive Officer to address the differences between the modified and original designs. Processing time periods follow sections (e) and (f) above.

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**§ 2703. Emission Testing Requirements.**

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(b) Test Engine Requirements and Pre-conditioning. The applicant may tune-up or rebuild test engines prior to, but not after, baseline testing unless rebuilding the engine is an integral part of the diesel emission control strategy. All testing should be performed with the test engine in a proper state of maintenance. Emissions of $NO_2$ from the test engine must not exceed 15 percent of the total baseline NOx emissions by mass. If there is a special category of engines with $NO_2$ emission levels that normally exceed 15 percent, this requirement may be adjusted for those engines at the discretion of the Executive Officer.

(c) Diesel Emission Control System Pre-conditioning. The engine or vehicle installed with a diesel emission control system must be operated for a break-in period of between 25 and 125 hours before emission testing. Note that special pre-conditioning requirements may apply. See section 2706(a)(4) for details.

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**§ 2704. Durability Testing Requirements**

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(b) Engine Selection. Subject to the approval of the Executive Officer, the applicant may choose the engine and application to be used in the durability demonstration. The engine and application must be representative of the emission control group for which verification is sought. The selected engine need not be the same as the engine used for emission testing, but if the applicant does use the same engine, the emission testing may also be used for the initial durability tests. Emissions of $NO_2$ from the emissions test engine must not exceed 15 percent of the total baseline NOx emissions by mass. If there is a special category of engines with $NO_2$ emission levels that normally exceed 15 percent, this requirement may be adjusted for those engines at the discretion of the Executive Officer.

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(g) Test Run. The requirements for emissions reduction testing are summarized in Table 4, below. Note that special pre-conditioning requirements may apply. See section 2706(a)(4) for details.

* * * * *

**§ 2706. Other Requirements.**

* * * * *

(a) Limit and Procedure for Measuring Nitrogen Dioxide ($NO_2$).

(1) In order for a diesel emission control strategy to be verified, effective January 1, 2007, the diesel emission control strategy must not increase emissions of $NO_2$ by more than an increment equivalent in mass to 30 percent of the baseline NOx emission level. Effective January 1, 2009, the increment is reduced to 20 percent of the baseline NOx emission level. The average of $NO_2$ emission levels from both the initial and final emissions tests described in Section 2704(g) is used to determine compliance with the $NO_2$ limit. For chassis dynamometer testing, only the $NO_2$ emission level over the UDDS cycle is used. ~~The post-control $NO_2$ emissions must not exceed 20 percent of the total baseline (pre-control) NOx emissions on a mass basis, from the same test cycle(s) for emission testing from section 2703 (e). This~~ The first $NO_2$ emission limit takes effect beginning on January 1, 2007. Diesel emission control strategies verified and installed prior to January 1, 2007 are exempted from this

requirement. Those verified prior to January 1, 2007 will no longer be allowed for installation after January 1, 2007 unless they meet the appropriate $NO_2$ emission limit. After January 1, 2007, all diesel emission control strategies verified and installed must meet this requirement.

(2) $NO_2$ emissions are to be quantified by one of the following methods:
(A) Two chemiluminescence analyzers,
(B) A dual-path chemiluminescence analyzer, or
(C) An alternative method approved by the Executive Officer.

(3) Analyzer configuration and determination of $NO_2$ emission level. For (2)(A) and (2)(B), the analyzers are to be fed from a heated and conditioned sample path. If two chemiluminescence analyzers are employed, they are to be simultaneously fed from a common heated sample path. One instrument (or path) shall be set to NOx mode, while the second shall be set to nitric oxide (NO) mode. The instrument (or path) set to NOx mode receives a sample that has passed through an $NO_2$-to-NO converter, and the resultant concentration is designated as total NOx ($NO+NO_2$) in the sample. The instrument (or path) that is set to NO mode receives a sample that has not passed through the converter and quantifies the amount of NO only. The difference between NO and NOx is the amount of $NO_2$ in the sample. Both NO and NOx signals are recorded by an external data acquisition system at 1 Hertz. Using the average concentrations of NO and NOx over the entire test cycle, the conventional equation for calculating total NOx (Code of Federal Regulations, Title 40, part 86, Subpart N) is then used to generate a gram per mile or g/bhp-hr value for both NO and NOx. The resulting value for NO is then subtracted from that for NOx to determine the gram per mile or g/bhp-hr value for $NO_2$. The instrument for measuring NO and NOx must be calibrated in accordance with the NOx calibration procedure as described in the Code of Federal Regulations, Title 40, part 86, Subpart N.

(4) Pre-conditioning requirements. If the Executive Officer determines that $NO_2$ emissions from a diesel emission control system could be affected by the presence of particulate matter or ash (as with a catalyzed diesel particulate filter), the system must be preconditioned according to the following procedure:
(A) Initial test (prior to service accumulation). Before conducting the initial emissions test, the unit being tested must be pre-conditioned as follows:
1. Install the unit on an engine that is an appropriate size for the unit, in a good state of maintenance, and certified to a PM standard equal to or more stringent than that of the engines in the emission control group for which the applicant seeks verification.
2. Operate the engine on one of the test cycles specified below for 25 to 30 hours. For on-road verifications, use either the FTP (hot-start) or UDDS cycle as identified in 2703(e), or the 13-mode Supplemental Emissions Test (SET) in the Code of Federal Regulations, Title 40, Part 86. For off-road and stationary

verifications, use either the steady-state test cycle from ARB off-road regulations or the Nonroad Transient Cycle (NRTC) in the Code of Federal Regulations, Title 40, Part 1039. For up to 10 hours of the 25 to 30 hour period, an applicant may alternatively:

a. Run the engine at high load such that the exhaust temperature is between 350 and 450 degrees Celsius, or

b. Alternate back and forth between high and low loads such that the exhaust temperature never exceeds 525 degrees Celsius and the low load operation does not result in significant soot accumulation at the end of the pre-conditioning period.

3. Measure and record the backpressure on a second-by-second basis (1 Hertz) for at least the first three of the repeated test cycles (when the unit is brand new) and the last three (which follow the optional high load operation of up to 10 hours). Determine the average backpressure for each run.

4. Following the 25 to 30 hour period of operation, run three test repetitions (hot-start) of the emissions test cycle with the unit installed on the emissions test engine. If using a chassis dynamometer, run the UDDS. For each run, measure and record the backpressure on a second-by-second basis (1 Hertz) and determine the average. Proceed with the emissions test.

(B) Final test (after the service accumulation). Before conducting the final emissions test, the aged unit may need to be pre-conditioned. Run three repetitions (hot-start) of the emissions test cycle with the unit installed on the emissions test engine. If using a chassis dynamometer, run the UDDS. For each run, measure and record the backpressure on a second-by-second basis (1 Hertz) and determine the average. Proceed with the emissions test if the average backpressure is within 30 percent of the average backpressure recorded for the initial test unit. If the backpressure is too high, burn off excess soot or clean out excess ash as necessary. Run an additional repetition of the emissions test cycle (hot-start) to check if the unit complies with the backpressure criterion. Repeat as necessary.

(C) In-use compliance testing. Before conducting the first phase of in-use compliance emissions testing, the test units may need to be pre-conditioned. Using the required test cycle, measure and record the backpressure on a second-by-second basis (1 Hertz) of a cleaned (or pre-conditioned per subsection (A) above) reference unit installed on the engine to be used for in-use compliance testing. The reference unit must be identical to the test units. Measure and record the backpressure of the test units retrieved from the field using the same engine and test cycle as used with the reference unit. If the backpressure of the test units is within 30 percent of the average backpressure recorded for the reference unit, they do not require pre-conditioning. Otherwise, the test units must be pre-conditioned

following subsection (B) above. Other units may not be substituted for the selected test units.

(5) Determination of compliance with the $NO_2$ limit. Compliance with the $NO_2$ limit is based on the average incremental increase in $NO_2$ emissions as determined by the following equation:

$$\text{Percent Increase} = 100\% \times 0.5 \times [(NO_2^{\,i} - NO_2^{\,b}) + (NO_2^{\,f} - NO_2^{\,b})] / NOx^{b}$$

Where "$NO_2$" and "NOx" stand for the mass-based emission rates of $NO_2$ and NOx, respectively, as determined in subsection (a)(3) above, and the superscripts "i", "f", and "b" stand for "initial test", "final test", and "baseline test", respectively. For in-use compliance testing, the equation is:

$$\text{Percent Increase} = 100\% \times (NO_2^{\,c} - NO_2^{\,b}) / NOx^{b}$$

Where the superscript "c" stands for the in-use compliance emissions testing conducted with the unit installed on the test engine.

~~(4)~~(6) Alternative Method to Measure $NO_2$. The applicant may request the Executive Officer to approve an alternative method in place of the required methods. In reviewing this request, the Executive Officer may consider all relevant information including, but not limited to, the following:

(A) Correlation of the alternative method with the methods stated in 2(A) or 2(B).

(B) Body of existing data generated using the alternative method.

* * * * *

(g) System Labeling.

(1) The applicant must ensure that a legible and durable label is affixed on both the diesel emission control system and the engine on which the diesel emission control system is installed except as noted in (3) below. The required labels must identify the name, address, and phone number of the manufacturer, the diesel emission control strategy family name (defined in (2) below), a unique serial number, and the month and year of manufacture. The month and year of manufacture are not required on the label if this information can be readily obtained from the applicant by reference to the serial number. A scale drawing of a sample label must be submitted with the verification application. Unless an alternative is approved by the Executive Officer, the label information must be in the following format:

**Name, Address, and Phone Number of Manufacturer**
**Diesel Emission Control Strategy Family Name**
**Product Serial Number**
**ZZ-ZZ** (Month and Year of manufacture, e.g., 06-02)

(2) Diesel Emission Control Strategy Family Name. Each diesel emission control strategy shall be assigned a family name defined as below:

**CA/MMM/YYYY/PM#/N##/APP/XXXXX**

CA: Designates a diesel emission control strategy verified in California
MMM: Manufacturer code (assigned by the Executive Officer)
YYYY: Year of verification
PM#: PM verification level 1, 1+, 2, 2+, ~~or~~ 3, or 3+ (e.g., PM3 means a level 3 PM emission control system).
N##: NOx verified reduction level in percent, if any (e.g., N25 means NOx reduction of 25 percent).
APP: Verified application which may include a combination of On-road (ON),Off-road (OF),or Stationary (ST)
XXXXX: Five alphanumeric character code issued by the Executive Officer

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(l) Verification of a diesel emission control strategy by the Air Resources Board does not release the applicant from complying with all other applicable legal requirements.

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**§ 2707. Warranty Requirements.**

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(c) Diesel Emission Control Strategy Warranty Report. The applicant must submit a warranty report to the Executive Officer by ~~February~~ April 1 of each calendar year. The applicant must also submit a warranty report within 30 calendar days if warranty claims exceed four percent of the number of diesel engines using the diesel emission control strategy. The warranty report must include the following information:

* * * * *

**§ 2709. In-Use Compliance Requirements**

* * * * *

(d) Number of Diesel Emission Control Systems to be Tested. The number of diesel emission control systems an applicant must test in each of the two test phases will be determined as follows:

(1) A minimum of four diesel emission control systems in each diesel emission control strategy family must be tested. For every system tested that does not reduce emissions by at least 90 percent of the lower bound of its initial verification level (or does not achieve an emission level less than or equal to 0.011 g/bhp-hr of PM) or does not meet the $NO_2$ requirement in section 2709(i), two more diesel emission control systems from the same family must be obtained and tested. The total number of systems tested shall not exceed ten per diesel emission control strategy family.

(2) At the discretion of the Executive Officer, applicants may begin by testing more than the minimum of four diesel emission control systems. Applicants may concede failure of an emission control system before testing a total of ten diesel emission control systems.

* * * * *

(e) In-use Compliance Emission Testing. Applicants must follow the testing procedure used for emission reduction verification as described in Section 2703 (both baseline and control tests are required), and special pre-conditioning requirements may apply (see section 2706(a)(4) for details). In addition, applicants must select the same test cycle(s) that they used to verify the diesel emission control strategy originally. If a diesel emission control strategy verified by U.S. EPA must perform engine dynamometer testing with the Heavy-duty Transient FTP cycle to fulfill the in-use compliance requirements of that program, but was verified by the Executive Officer with chassis dynamometer testing, the Executive Officer will also accept testing with the Heavy-duty Transient FTP cycle for the in-use compliance requirements of this Procedure. If a diesel emission control strategy fails catastrophically during the in-use compliance testing, the applicant must provide an investigative report detailing the causes of the failure to the Executive Officer within 90 days of the failure.

* * * * *

(j) Conditions for Passing In-Use Compliance Testing. For a diesel emission control strategy to pass in-use compliance testing, emission test results must indicate that the strategy reduced emissions by at least 90 percent of the lower bound of the emission reduction level the Executive Officer originally verified it to. In addition, the strategy must meet the requirements of section 2706(a) with the exception that the strategy must not increase emissions of

$NO_2$ by more than an increment equivalent in mass to 33 or 22 percent of the baseline NOx emission level for systems verified under the 30 or 20 percent $NO_2$ limits, respectively. If the first four diesel emission control systems tested within a diesel emission control strategy family meet ~~this standard~~ both of these standards, the diesel emission control strategy passes in-use compliance testing. If any of the first four diesel emission control systems tested within a diesel emission control strategy family fail to meet either of these standards ~~reduce emissions by at least 90 percent of the lower bound of the emission reduction level the Executive Officer originally verified it to~~, and more than four units are tested, at least 70 percent of all units tested must ~~pass the 90 percent standard~~ meet both standards for the diesel emission control strategy family to pass in-use compliance testing. For each failed test, for which the cause of failure can be attributed to the product and not to maintenance or other engine-related problems, two additional units must be tested, up to a total of ten units per diesel emission control strategy family.

* * * * *

# APPENDIX B

# ENGINE-OUT $NO_2$ EMISSIONS

## Appendix B. Engine-out $NO_2$ Emissions

### 1. Emissions Data

Emissions of nitrogen dioxide ($NO_2$) from diesel engines are not well characterized. Staff has, nevertheless, gathered what it believes to be a sufficient amount of data for the purposes of this rulemaking. The data come primarily from demonstration programs, mining engine certification data, and applications for verification of diesel emission control systems. In total, staff has gathered $NO_2$ emissions data from 80 distinct engines operated over various emissions test cycles, including a range of engine makes used in different applications. The data set includes 40 on-road engines, 31 off-road engines, and 9 stationary engines. Emission rates of $NO_2$ were not determined via direct measurement, but rather estimated by subtracting the measured NO from the total measured NOx (both of which were measured using chemiluminescence analyzers). Figure B-1 shows $NO_2$ emissions in terms of percent of total NOx emissions by mass. Figure B-2 shows the distribution of $NO_2$ fractions.

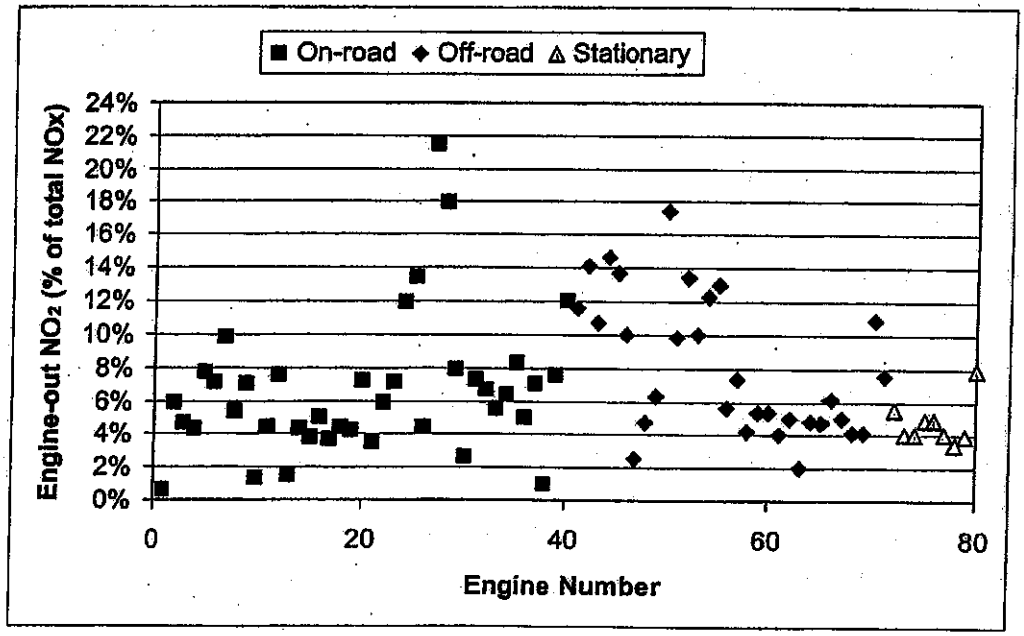


**Figure B-1. Engine-out $NO_2$ data for 80 diesel engines**

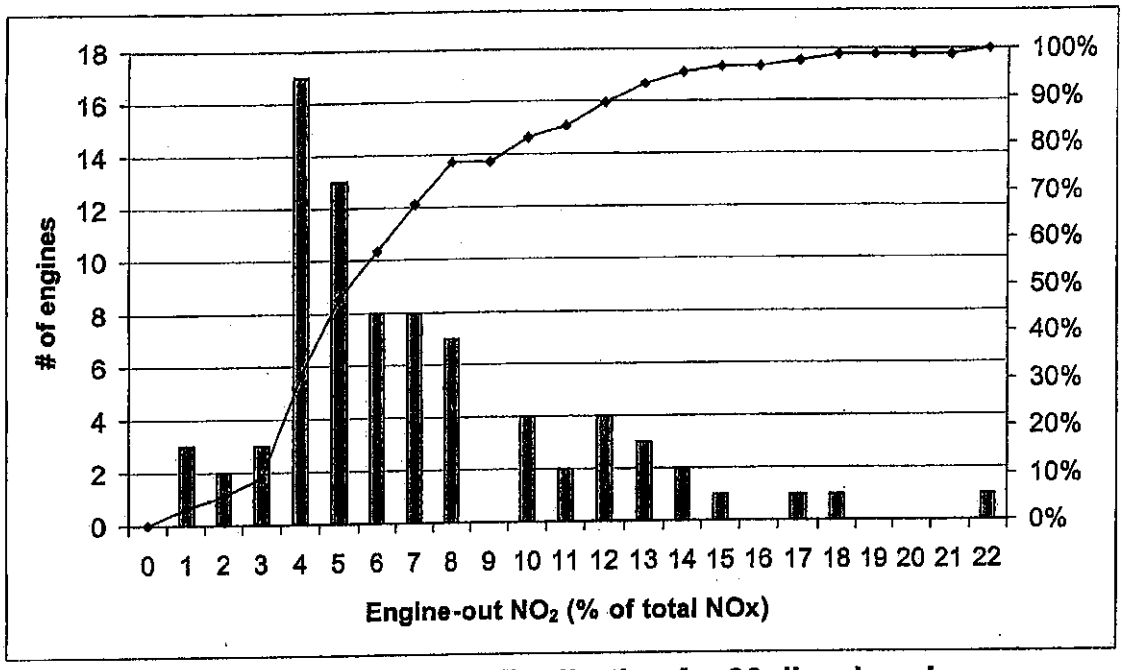


**Figure B-2. Population distribution for 80 diesel engines based on engine-out $NO_2$**

The average engine-out $NO_2$ emission level for all of the engines is 6.9 percent with a standard deviation of 4.1 percent. About 80 percent of the engines have $NO_2$ emissions less than or equal to 10 percent of total NOx emissions, and two-thirds are between 4 and 8 percent. About 96 percent are less than or equal to 15 percent, which is two standard deviations from the mean (only three engines exceed 15 percent $NO_2$).

## 2. Test Engine $NO_2$ Emissions Limit

While casting the $NO_2$ limit in terms of a maximum incremental increase helps to isolate the effect of an emission control system on $NO_2$ emissions, there is still the possibility of obscuring this effect depending on the choice of test engine. If a test engine has unusually high baseline $NO_2$ emissions, it is conceivable that an emission control system could increase the $NO_2$ fraction by a smaller increment than if the baseline $NO_2$ level had been lower, all other variables being equal (such as residence time, temperature, soot loading, etc). With a higher initial concentration of $NO_2$ (the reaction product) and a lower initial concentration of NO (one of the reactants), a lower overall oxidation rate of NO could result. As a result, testing a single engine with high $NO_2$ may not reveal the effect of a system on more typical diesel engines.

Staff proposes, therefore, that the test engine's $NO_2$ emission level serve as one of the criteria by which a given test engine is approved for verification testing. Specifically, staff proposes that the test engine must not have engine-out $NO_2$ emissions that exceed 15 percent of the total NOx emissions by mass, as measured over the emissions test cycle. Staff arrived at the value 15 percent by adding two standard deviations to the

mean value of 7 percent. Based on the dataset presented here, a cut-off at 15 percent would exclude only a small number of engines with uncharacteristically high $NO_2$ emissions. If there is a special category of engines with $NO_2$ emission levels that normally exceed 15 percent, staff proposes that ARB be able to adjust the test engine $NO_2$ requirement for those engines at its discretion.

# APPENDIX C

# REGIONAL-SCALE MODELING SUPPLEMENTARY INFORMATION

## Appendix C. Regional-scale Modeling Supplementary Information

### 1. Characterization of the Technology Mix

The mix of emission control options that staff assumed for the revised scenario in Section 4.2.1 includes $NO_2$-generating filters, non-catalyzed filters, flow-through filters, diesel oxidation catalysts (DOCs), and engine repowers or vehicle/equipment replacements. The first two are Level 3 systems (85 percent or more PM reduction) based on wall-flow filter technology. The $NO_2$-generating filters include both passive and active filters that use a substantial amount of precious metal catalyst. The non-catalyzed filters require external energy input to regenerate (active filters) and do not increase $NO_2$ emissions. Flow-through filters are Level 2 systems (50 percent or more PM reduction) that have a variety of substrate designs that generally induce some amount of turbulence and partially filter the exhaust. They are typically less heavily catalyzed than conventional passive filters, but have a greater loading than typical DOCs, which are Level 1 systems (25 percent or more PM reduction). Like passive filters, flow-through filters will typically increase $NO_2$ emissions, but to a lesser degree. The repower or replace option (Level 3 PM reduction) involves either installing a new engine or a piece of equipment into an existing vehicle or replacing an existing vehicle with a new one. Although several retrofit systems achieve NOx reductions in addition to PM (such as exhaust gas recirculation, selective catalytic reduction, and lean-NOx catalyst systems), staff only assigned NOx reductions to the repower/replace option to be conservative. Performance assumptions for the key pollutants are shown in Table C-1.

**Table C-1. Control Technology Performance Assumptions**

| Control option | Emission Reductions | | | | |
|---|---|---|---|---|---|
| | NO$_2$** | PM | HC* | NOx | CO |
| $NO_2$-generating filters | -300% | 85% | 90% | 0% | 90% |
| Non-catalyzed filters | 0% | 85% | 0% | 0% | 0% |
| Flow-through filters | -200% | 50% | 70% | 0% | 70% |
| Diesel oxidation catalysts | 0% | 25% | 50% | 0% | 50% |
| Repower/Replacement | 0% | 85% | 90% | 75% | 90% |

*Reductions of total carbonyls, formaldehyde, acetaldehyde, benzene, total polyaromatic hydrocarbons (PAH) and nitro-PAH are all taken to be commensurate with the HC and CO reductions.
**Negative values represent emissions increases.

### 2. Background on the Air Quality Model

Staff used the Comprehensive Air Quality Model with Extensions (CAMx) by ENVIRON with the SAPRC99 photochemistry to simulate the regional air quality impacts of staff's

proposal[1]. The model used the meteorological conditions from the August 3-7, 1997, ozone episode. These conditions are conducive to ozone formation and were used in the 2003 South Coast SIP update. The modeling region covers most of Southern California. The region is divided into 100 east-west by 74 north-south 5 kilometer cells. Details of this modeling episode and baseline inventory can be found on the South Coast Air Quality Management District's website: http://www.aqmd.gov/aqmp/AQMD03AQMP.htm.

## 3. Additional Discussion on Table 5

Staff used modeled percent changes from baseline concentrations to estimate the annual premature deaths avoided from reducing $PM_{2.5}$ and ozone in the South Coast Air Basin. Three to five episode days were modeled on a regional scale for ozone, reflecting high and moderate ozone levels. In contrast, only two episode days were modeled for $PM_{2.5}$. Annual total health impacts due to $PM_{2.5}$ and ozone exposures above background (assumed to be 2.5 micrograms per cubic meter for $PM_{2.5}$ and 40 ppb for ozone) were calculated using standard methodologies outlined in the ARB staff reports for both standards. The percent changes in premature deaths were then applied to the total deaths. Premature death is the focus of this health impacts assessment because it has the greatest economic valuation among all health effects from air pollutant exposures. Note that regional-scale modeling results probably underestimate the benefits of reductions of near-source exposures to diesel PM. Also, assuming the percent changes based on limited modeled days would occur on all days in the year may not be true; however, it was necessary for staff to make this assumption to estimate the annual health impacts. The ranges shown for the avoided death estimates in Table 5 indicate the range of results from multiple episode days. In addition, there is a plus or minus 50 percent uncertainty behind each estimate due to the uncertainty in the concentration-response relationships between air pollution exposure and premature death.

## 4. Additional Discussion on Table 6

Staff used several parameters to show the impact of the different retrofit scenarios on ozone. The modeling domain covers most of Southern California and is composed of 5-kilometer square grid cells. Peak 1-hour ozone is the highest 1-hour averaged concentration out of all the cells in the modeling domain. Peak 8-hour ozone is similar, except that concentrations are averaged over an 8-hour period and so tend to be lower. Simulated changes for both are quite small for the revised scenario (about 1 percent). For reference, the baseline peak 1-hour ozone concentration is 146.6 ppb and the increase for the revised scenario is 1.1 ppb for a total of 147.7 ppb.

[1] The modeling conducted at the time of the adoption of the verification procedure in 2002 used the Calgrid photochemistry model.

Exposure in a given cell is the product of the cell's population and the time-averaged concentration above some threshold. The cumulative daily 1-hour exposure over 90 ppb is the sum of exposures for all cells for each of the 24 hours in a day. One cell can therefore contribute as many as 24 numbers to overall exposure. The maximum daily 8-hour exposure over 70 ppb, however, is based on the single, maximum 8-hour concentration over 70 ppb that occurs in a day for each cell. Therefore, one cell can contribute a maximum of one number to overall exposure. The changes in the 1-hour and 8-hour exposures are different because the metrics are defined quite differently.

# APPENDIX D

# PROPOSED PRE-CONDITIONING REQUIREMENTS

## Appendix D. Proposed Pre-Conditioning Requirements

One of the issues raised by members of the $NO_2$ working group is that $NO_2$ emissions from a catalyzed emission control system can be very sensitive to the amount of soot and ash present in the system at the time of testing. For instance, if a filter has a substantial bed of soot present, the $NO_2$ that forms during an emissions test would have ample opportunities to be reduced to NO. If it had a substantial amount of ash, and the catalyst was on the filter itself, the ash could cover active sites, thereby reducing the amount of $NO_2$ formed (see Appendix E for additional discussion).

To ensure some control over the state of a system prior to emissions testing, staff proposes various additional pre-conditioning requirements. Staff's proposal covers pre-conditioning for the new and aged devices for the original verification as well as the units involved in the first phase of in-use compliance testing. The additional requirements would apply to any system for which the Executive Officer determines that $NO_2$ emissions could be affected by the presence of PM or ash.

At present, the Procedure only specifies a pre-conditioning requirement of 25 to 125 hours of operation on an engine. Nothing further is specified. To control the amount of PM and ash in the new device, staff proposes a more specific pre-conditioning procedure. The device must be operated on a diesel engine for between 25 and 30 hours using standard, repeated test cycles appropriate for the application. For on-road applications, the Federal Test Procedure (FTP) heavy-duty transient cycle, Urban Dynamometer Driving Schedule (UDDS), or 13-mode Supplemental Emissions Test (SET) cycle may be used. For off-road applications, the 8-mode certification test cycle or the Non-Road Transient Cycle (NRTC) may be used. For stationary applications, the appropriate modal stationary test cycle may be used.

During discussions with manufacturers, staff learned that repeating standard test cycles may be insufficient to stabilize the performance of a catalyst. Manufacturers indicated that standard practice involves ten hours of engine operation with temperatures higher than those generated by the standard test cycles. The engine could undergo constant, high-load operation and cyclic operation between low and high loads. For the purposes of stabilizing catalyst performance, staff proposes that an applicant may choose, as part of the 25 to 30 hour period, to run the engine for up to ten hours either (1) at high load such that the exhaust temperature is between 350 and 450 degrees Celsius, or (2) by alternating back and forth between high and low loads such that the exhaust temperature never exceeds 525 degrees Celsius, and low load operation does not result in significant soot accumulation following the stabilization period.

After the 25 to 30 hour pre-conditioning period, the device must be run on the emissions test engine for three repetitions of the emissions test cycle, and the backpressure must be recorded. The device would then be ready for testing.

The proposed pre-conditioning for the aged device consists of running the device on the emissions test engine for three repetitions of the emissions test cycle. If the average

backpressure is within 30 percent of the average backpressure recorded for the new device, it is ready to be tested. The 30 percent criterion was recommended by MECA as an intermediate backpressure between a new filter and a filter that needs to be cleaned. If the backpressure is too high, the applicant may burn off excess soot and clean out excess ash as necessary until the backpressure requirement is met.

The proposed pre-conditioning for devices undergoing the first phase of in-use compliance testing is similar. For reference, the backpressure of a cleaned or pre-conditioned unit is recorded over the required test cycle with the unit installed on the test engine. This reference unit must be identical to the test units. The backpressure of the test units retrieved from the field must be measured and recorded using the same engine and test cycle as used with the reference unit. If the backpressure of the test units is within 30 percent of the average backpressure recorded for the reference unit, they do not require pre-conditioning. Otherwise, the test units must be pre-conditioned in the same manner as the aged unit described above. A unit other than one of the selected test units that appears to meet the backpressure requirement without any pre-conditioning may not be substituted for a selected test unit that does not meet the requirement.

There is no backpressure limit for the second phase of testing which involves units at 60 to 80 percent of their minimum warranty period (e.g., between 90,000 and 120,000 miles or 3 and 4 years for heavy-heavy duty vehicles). At that point, the unit would likely have accumulated substantial ash, resulting in elevated backpressure. Staff proposes that these units be tested purely "as is."

# APPENDIX E

# THE INFLUENCE OF SOOT AND ASH ON $NO_2$ EMISSIONS

## Appendix E. The Influence of Soot and Ash on $NO_2$ Emissions

Emissions of $NO_2$ from an emission control system using a platinum-based catalyst can be very sensitive to the amount of soot and ash present in the system at the time of testing. For instance, if a filter has a substantial bed of soot present, the $NO_2$ that forms during an emissions test would have ample opportunities to reduce to NO. If it had a substantial amount of ash, and the catalyst was on the filter itself (as opposed to in an upstream oxidation catalyst), the ash could cover active catalytic sites, thereby reducing the amount of $NO_2$ formed. A clean filter, however, would produce more $NO_2$ than is needed, resulting in elevated $NO_2$ emissions into the atmosphere.

The significance of the state of a filter during testing was demonstrated experimentally in a recent study by Umicore and partners (Soeger et al, 2005). A number of identical catalyzed filters were subjected to different aging environments, and their $NO_2$ formations were compared. A filter installed on a truck for 75,000 miles had $NO_2$ emissions equal to half the emissions of a new, conditioned filter. The aged filter was retested following a cleaning, and its $NO_2$ emissions doubled, reaching the level of the new filter. This shows that without control over the state of a system prior to emissions testing, it is possible to get a wide range of results.

A good example of how a single filter make and model can give a wide range of $NO_2$ fractions can be found in the EC-Diesel Technology Validation Program (LeTavec, 2000). All of the vehicles in the program were in the same emission control group. They were powered by on-road heavy-duty diesel engines certified to the 0.1 g/bhp-hr PM standard which were turbocharged and did not have EGR. In spite of having similar engines and identical retrofits, the resulting $NO_2$ emissions were far from consistent, as demonstrated by Figures D-1 and D-2[1].

The data are sorted by test cycle in Figure D-1 and by engine in Figure D-2. In each case, a wide spectrum of $NO_2$ fractions is observed, often ranging 30 to 40 percentage points for each subgroup. The spread is probably not due to variations in engine-out $NO_2$ emissions because data from other vehicles in the same fleets with the same engines showed a low engine-out $NO_2$ fraction with little absolute variation (5.0±0.8 percent[2]). It is quite likely the state of the filter at the time of the testing played a significant role, as in the case of the Umicore study. All of the vehicles in the program were pulled from the field as is and tested following a 10 minute warm-up procedure (LeTavec et al, 2002). No special efforts to control the soot and ash content of the filters were made.

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[1] $NO_2$ fractions were calculated by staff using NO and NOx emissions data from the ECD Technology Validation Program's Master Spreadsheet (Vertin, 2002).

[2] Based on data from (Vertin, 2002), as above. This result is for a 95 percent confidence interval and excludes three instances where staff found negative $NO_2$ fractions.

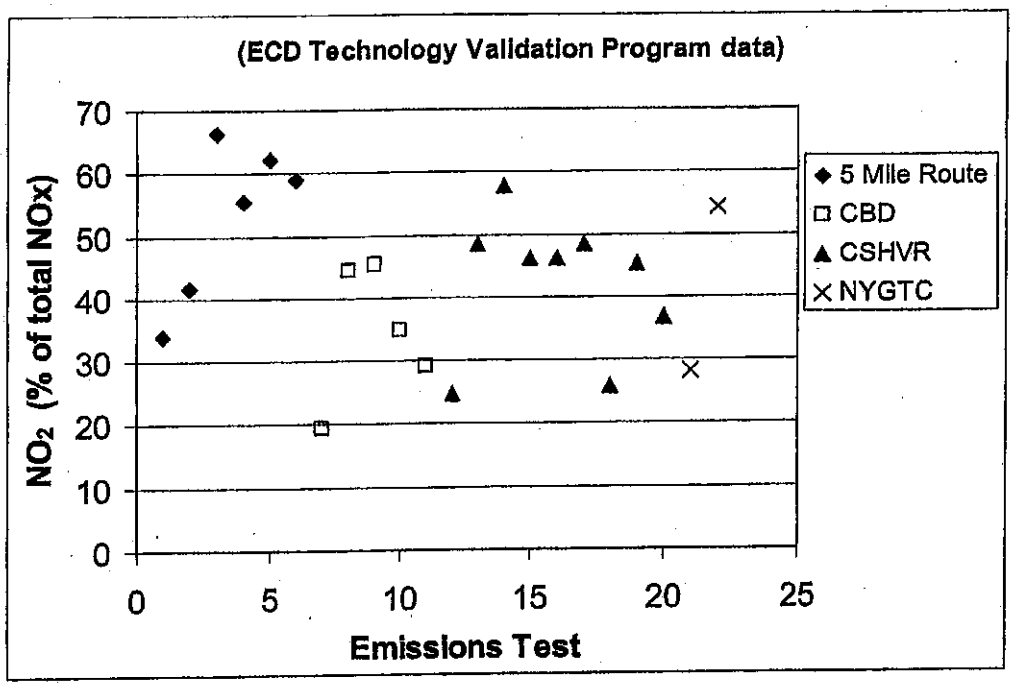


**Figure D-1. DPF $NO_2$ fractions by test cycle**
**CBD = Central Business District, CSHVR = City Suburban Heavy Vehicle Route, and NYGTC = New York Garbage Truck Cycle.**

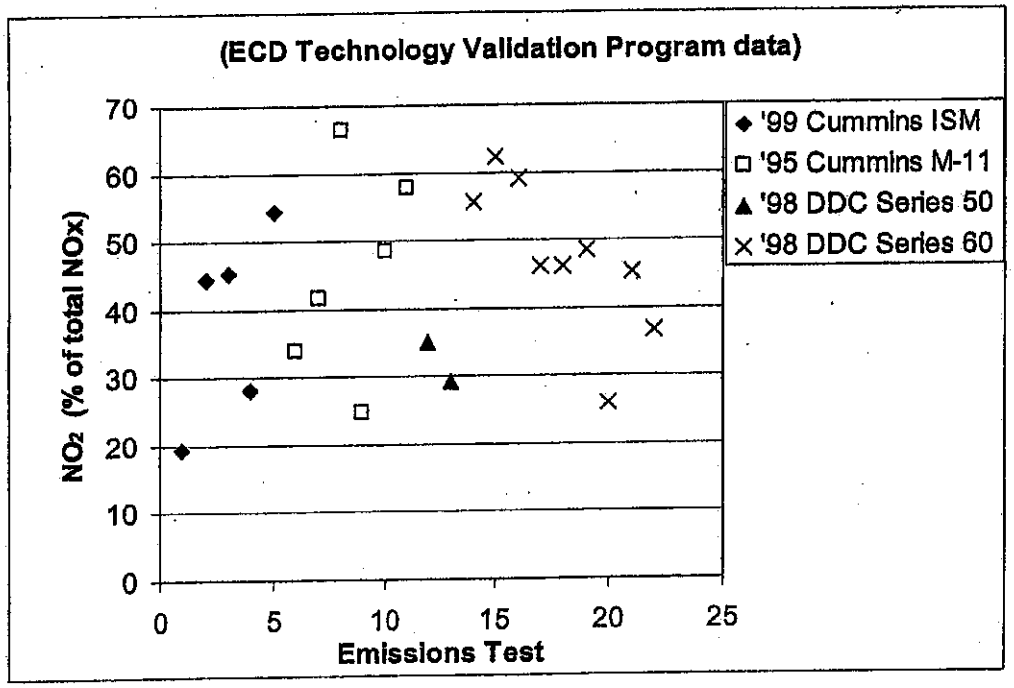


**Figure D-2. DPF $NO_2$ fractions by engine series**

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Soeger, N., Mussmann, L., Sesselmann, R., Leippe, G., Gietzelt, C., Bailey, O., and Hori, M. "Impact of Aging and NOx/Soot Ratio on the Performance of a Catalyzed Diesel Particulate Filter for Heavy Duty Diesel Applications," SAE 2005-01-0663, Society of Automotive Engineers, 2005.

Vertin, K. EC-Diesel Technology Validation Program Master Spreadsheet, Round 2. National Renewable Energy Laboratory. Updated August 21, 2002. Requests for the spreadsheet should be sent to: teresa_alleman@nrel.gov