



Winston H. Hickox
Agency Secretary

Air Resources Board

Alan C. Lloyd, Ph.D.
Chairman

9528 Telstar Avenue • P.O. Box 8001 • El Monte, California 91731 • www.arb.ca.gov



Gray Davis
Governor

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Mail Out #MSC 01-08

TO: ALL INTERESTED PARTIES

SUBJECT: CONSIDERATION OF AMENDMENTS TO ADOPT REDUCED EMISSION STANDARDS FOR 2007 AND SUBSEQUENT MODEL YEAR HEAVY-DUTY DIESEL ENGINES AND VEHICLES.

In October of 2000, the United States Environmental Protection Agency (U.S. EPA) adopted a rule that reaffirmed lowered emission standards for 2004 and subsequent model year heavy-duty diesel engines¹. Notably, the rule reduced the current oxides of nitrogen (NOx) emissions standard by 50 percent. This rulemaking also included supplemental test procedures that represented most in-use driving conditions, as compared to the existing Federal Test Procedure (FTP). However, these test procedures are applicable for 2007 and subsequent model years even though several engine manufacturers will be required to produce engines meeting the new test requirements from 2002 through 2004 due to the consent decrees². Consequently, the Air Resources Board (ARB) adopted similar supplemental test requirements in December of 2000 that apply to model year 2005 and subsequent heavy-duty diesel engines.

¹ U.S. EPA's 2004 Final Rule on the Control of Emissions of Air Pollution from 2004 and Later Model Year Heavy-Duty Highway Engines and Vehicles; Revision of Light-Duty On-Board Diagnostics Requirements (65 FR 59896, October 6, 2000). Referred to as the U.S. EPA's 2004 Final Rule or 2004 Final Rule.

² In the 1990s, seven large manufacturers of heavy-duty diesel engines violated certification regulations by turning off, or defeating, emissions control equipment during in-use highway driving. To address this violation, the Department of Justice, the U.S. EPA and the ARB signed consent decrees with the seven engine manufacturers. A consent decree is a judicial decree that recognizes a mutual settlement between the parties — in this case, between the government and the engine manufacturers.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Website: <http://www.arb.ca.gov>.

California Environmental Protection Agency

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In January of 2001, the U.S. EPA followed the 2004 Final Rule with another rule to reduce emission standards for 2007 and subsequent model year heavy-duty diesel engines³. These emission standards represent a 90% reduction of NOx emissions, 72% reduction of non-methane hydrocarbon (NMHC) emissions, and 90% reduction of particulate matter (PM) emissions. In addition to the reduced emission standards, the U.S. EPA adopted minor changes to the previously adopted supplemental test procedures. The ARB is proposing to adopt similar emission standards and test procedures to reduce emissions from 2007 and subsequent model year heavy-duty diesel engines and vehicles. The proposal also includes the U.S. EPA's modifications to the previously adopted supplemental test procedures.

Heavy-duty diesel vehicles, with gross vehicle weight ratings (GVWR) of 14,001 pounds and greater, contribute to a large portion of California's inventory of several key criteria air pollutants including NOx, reactive organic gases (ROG), and PM. On-road heavy-duty diesel vehicles are estimated to account for as much as 13 percent of the statewide NOx inventory and 24 percent of the statewide diesel PM inventory in 2010. This is of particular concern due to the relatively small population of heavy-duty diesel vehicles.

Additional concern is that both NOx and hydrocarbons are precursors to ozone. Ozone is a concern because it has been shown to adversely impact human health. NOx alone can also be harmful to humans by aggravating common respiratory illnesses and even prematurely aging lung tissue.

In August of 1998, diesel PM was identified as a toxic air contaminant. Diesel PM contains over forty substances that are individually identified as toxic air contaminants and is associated with increases in lung disease, heart disease, and mortality. As such, diesel PM was found to cause cancer in both humans and animals. Assessment of carcinogenic risk in California due to diesel PM accounts for approximately 70 percent of all air toxics. Further information on adverse health effects of diesel PM can be found in the ARB's Diesel Risk Reduction Plan⁴.

In comparison to passenger cars, to date heavy-duty diesel vehicles have been relatively uncontrolled. While catalytic converters have been required on passenger cars for over 30 years, diesel exhaust from heavy-duty diesel engines is released

³ U.S. EPA's 2007 Final Rule on the Control of Emissions of Air Pollution from 2007 and Later Model Year Heavy-Duty Highway Engines and Vehicles; Revision of Light-Duty On-Board Diagnostics Requirements (66 FR 5002, January 18, 2001). Referred to as the U.S. EPA's 2007 Final Rule or 2007 Final Rule.

⁴ Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles, Air Resources Board - Stationary Source Division and Mobile Source Control Division, October 2000.

directly into the atmosphere. Currently, there are many demonstration projects ongoing worldwide to show the effectiveness of heavy-duty diesel aftertreatment devices. Additionally, improvements to the effectiveness of these devices occur every day.

1. *Emission Standards*

Currently, 2007 and subsequent model year heavy-duty diesel engines will be subject to the same emission standards as those adopted in 1998 for 2004 and subsequent model year engines. The emission standards are 2.4 grams per brake horsepower-hour of NO_x plus NMHC, 15.5 grams per brake horsepower-hour of carbon monoxide (CO), and 0.10 grams per brake horsepower-hour of PM. There is also an optional NO_x plus NMHC emission standard of 2.5 grams per brake horsepower-hour. When certifying using this option, NMHC emissions are not to exceed 0.5 grams per brake horsepower-hour. Due to performance concerns and possible damage to the engine when crankcase emissions are routed back to the engine intake, currently there is an exemption to control crankcase emissions from turbocharged diesel engines.

2. *Test Procedures*

Similar to current engines, 2007 and subsequent model year heavy-duty diesel engines will be required to test engines using the FTP. During the FTP, an engine operates through a narrowly defined test cycle. Additionally, those engines will be required to conduct the supplemental Not-to-Exceed (NTE) and European Stationary Cycle (ESC) tests. These supplemental tests are identical to those in the heavy-duty diesel consent decrees and were adopted by the Board in 2000. The NTE test includes an emissions cap of 1.25 times the FTP-based emission standard. The test is applicable to operation within the NTE control zone that represents most operation of a heavy-duty diesel vehicle. Emission samples taken during the test are averaged over a period of at least 30 seconds.

The ESC test includes an emissions cap equivalent to the FTP-based emission standard. This test verifies emissions over thirteen combinations of engine speed and power, including idle. The weighted average total of each test point is compared to the emissions cap. The test also includes the maximum allowable emission limit (MAEL) test. This test ensures that there are no excess emissions between the ESC test points. Additional test points are selected to verify compliance with the test.

3. *Averaging, Banking, and Trading (ABT)*

The current ABT program allows averaging among various engine families within an averaging set. Each averaging set depends on the weight classification range of the engines. Further, engine manufacturers may also bank excess credits. These banked credits may be used in future years, or traded to other engine manufacturers.

1. *Emission Standards*

For 2007 and subsequent model year heavy-duty diesel engines, the proposed amendments will include additional and lower emission standards. The emission standards are 0.20 grams per brake horsepower-hour of NO_x, 0.14 grams per brake horsepower-hour of non-methane hydrocarbons (NMHC), 0.01 grams per brake horsepower-hour of PM, and 0.01 grams per brake horsepower-hour of formaldehyde.

Only the NO_x and NMHC emission standards are proposed to be phased-in. The phase-in period for these emission standards is proposed to be four years. The phase-in schedule is proposed to be 50% for model year 2007, 50% for model year 2008, 50% for model year 2009 and 100% for model year 2010 and subsequent. There is no proposed phase-in of the PM and formaldehyde emission standards; therefore, the PM and formaldehyde emission standards are proposed to be fully implemented beginning in the 2007 model year.

Similar to the U.S. EPA's 2007 Final Rule, the proposal includes the elimination of the current exception allowing crankcase emissions. Due to technological advances in crankcase filtration, crankcase emissions can be filtered and returned to the engine inlet or even prior to the emission control device.

Similar to the U.S. EPA's 2007 Final Rule, the proposal provides incentives for early introduction of lower emitting engines. Engines that satisfy the proposed requirements and are introduced into the marketplace, prior to 2007, will receive credits equal to 1.5 times the number of diesel engines required to comply in the future. Each early engine must meet all requirements applicable to model year 2007 engines. If the engine only complies with the PM requirements, the offsets may only be used for PM compliant engine credits. Engines that can meet one half of the proposed NO_x emission standard, or 0.10 grams per brake horsepower-hour, earlier than the phase-in period in addition to all other requirements applicable to model year 2007 engines are classified as "Blue Sky

Series” engines. These engines receive a credit of 2.0 times the number of diesel engines required to comply in the future.

2. *Test Procedures*

The U.S. EPA has previously adopted the supplemental certification test procedures with the 2004 emission standards in the U.S. EPA’s 2004 Final Rule. The test procedures apply to 2007 and subsequent model year heavy-duty diesel engines. These test procedures are slightly different compared to those in the consent decrees and those adopted by the Board. The U.S. EPA’s 2007 Final Rule included several changes to the test procedures that will also apply to 2007 and subsequent model year heavy-duty diesel engines. The major revisions that were adopted are detailed below.

The ESC and Maximum Allowable Emission Limit (MAEL) tests currently include three “mystery points” to verify emissions between the established test points of the ESC test. Due to the lower emission standards proposed, the MAEL test and the three “mystery points” are proposed to be removed from the test procedures for engines with a NO_x family emission limit (FEL) less than 1.5 grams per brake horsepower-hour. Further, the NO_x NTE cap is proposed to be increased from 1.25 to 1.5 times the FTP-based standard for engines with a NO_x FEL less than 1.5 grams per brake horsepower-hour. The PM NTE cap is proposed to be increased from 1.25 to 1.5 times the FTP-based standard. There is no proposed change to the CO and NMHC NTE cap. It should be noted that MAEL test requirements and a NTE cap of 1.25 times the FTP-based standard do still apply to engines with a NO_x family emission limit (FEL) of 1.5 grams per brakehorsepower-hour, or greater.

In addition to the increased NO_x emissions cap for phased-in engines, NO_x and NMHC aftertreatment devices are allowed warm-up time. When exhaust temperature from the aftertreatment device is less than 250 degrees C, the NTE NO_x and NMHC caps do not apply.

Another change is the elimination of the PM carve-out areas of the NTE control zone. Due to the expected effectiveness of advanced diesel PM filters, relief from the NTE is not necessary. Additional relief to the NTE test is provided, by allowing manufacturers to exclude certain regions of the NTE control zone. This is allowed if the vehicle is not capable of operating at the specific conditions or where operation is minimal. The ARB is also proposing to modify the sampling time for the NTE test to account for aftertreatment regeneration events. The sampling time for the NTE test is proposed to be at least 30 seconds. If

regeneration of the aftertreatment device occurs during the NTE test, the averaging period is proposed to be at least as long as the time between the regeneration events multiplied by the number of complete regeneration events that occur in the sampling period. This revised sampling period is only proposed for engines that send an electronic signal indicating the start of the regeneration event. In addition, up to three deficiencies may be approved per engine family for model years 2010 through 2013.

3. *ABT*

The basic structure of the proposed ABT program will be similar to the existing program. Manufacturers will continue to be allowed to certify engine families such that the aggregate average does not exceed the emission standard. Additionally, manufacturers may bank excess emission credits for later use or trade these credits to other manufacturers. Similar to the U.S. EPA's 2007 Final Rule, the ARB is proposing to allow a slightly modified ABT program.

Two averaging sets are proposed. One is the phased-out engines that meet the 2.5 gram per brake horsepower-hour NO_x plus NMHC emission standard. The second is the phased-in engines that meet the 0.2 gram per brake horsepower-hour NO_x emission standard. Credits generated from phased-out engines may be used for phased-in engines. However, these NO_x plus NMHC credits will be subject to a 20% discount.

To be included in the ABT program, engine families shall not exceed the proposed FELs. For phased-in engines subject to the 0.2 gram per brake horsepower-hour emission standard during the 2007 through 2009 model years, the proposed maximum NO_x FEL cap is 2.00 grams per brakehorsepower-hour. After all engines have been phased-in for the 2010 and subsequent model years, the proposed maximum NO_x FEL cap is 0.50 grams per brakehorsepower-hour. The proposed maximum PM FEL cap is 0.02 grams per brakehorsepower-hour for all engines beginning in the 2007 model year.

The ARB is seeking comment on all portions of the proposed amendments including, but not limited to, the proposed emission standards, the proposed modifications to the supplemental test procedures, the proposed ABT program, and the proposed chassis certification program.

Preliminary emission calculations utilized the ARB's EMFAC2000 (version 2.02) modeling software program. This program is used to estimate emissions statewide from

various mobile sources. For this proposal, only on-road heavy-duty diesel vehicles are considered. In EMFAC2000, heavy-duty diesel vehicles are classified as either medium heavy-duty diesel vehicle (similar to a delivery size truck), or heavy heavy-duty diesel vehicle (similar to an 18-wheel, line haul truck) depending upon the GVWR. Medium heavy-duty diesel vehicles include vehicles with a GVWR of 14,001 pounds and greater, but less than 33,000 pounds. Heavy heavy-duty diesel vehicles include vehicles with a GVWR of 33,000 pounds and greater.

PM reductions resulting from the conversion of CARB diesel fuel (141 parts per million by weight of sulfur⁵) to low sulfur diesel fuel (15 parts per million by weight of sulfur) in most vehicles beginning in 2006 have been estimated at approximately 4 percent⁶. These reductions are not proposed for consideration in this rulemaking since changes to diesel fuel requirements are proposed in a separate rulemaking package⁷. ROG and NOx reductions are estimated in accordance with the proposed phase-in schedule of 50% for model years 2007 through 2009, and 100% for model year 2010.

All emission calculations account for California registered vehicles only, even though the U.S. EPA has already adopted similar requirements. Consequently, 100 percent of medium heavy-duty diesel vehicle emissions and 75 percent of heavy heavy-duty diesel vehicle emissions are included in the calculations since only a portion of heavy heavy-duty diesel vehicles are expected to travel between states.

Table 1 shows statewide baseline emissions determined based on the standards adopted for each model year. For 2004 and subsequent model years, the standards include a combined NOx and NMHC emission standard that is segregated into its NOx portion and NMHC portion. This is based on typical heavy-duty diesel engine emission data that show NMHC emissions from these engines are often very small. This results in a NOx baseline of 2.0 grams per brake horsepower-hour and a NMHC baseline of 0.5 grams per brake horsepower-hour (2004 and subsequent model years). Baseline PM emissions are 0.1 grams per brake horsepower-hour (2004 and subsequent model years).

	2000	2005	2010	2015	2020
ROG	32.0	28.3	23.6	19.8	17.8
NOx	556.4	476.1	389.8	333.8	308.8

⁵ A diesel fuel sulfur content of 141 parts per million is used since this is the typical in-use average fuel sulfur content. The regulatory maximum fuel sulfur content is 500 parts per million.

⁶ Risk Reduction Plan to Reduce Particulate Matter Emissions From Diesel-Fueled Engines and Vehicles, Appendix IV, ARB, October 2000.

⁷ More information on the proposed diesel fuel rulemaking modifications can be located on the ARB website (<http://www.arb.ca.gov/fuels/diesel/diesel.htm>).

PM	18.0	14.2	12.0	11.2	11.2
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Table 1 - Statewide Baseline Emissions Inventory (tpd)

The emission reductions are calculated for each air contaminant below using the ratio of the proposed emission standard and the pre-2007 emission standard (“2004 standard”). Each calculation yields the amount of emissions that would be reduced from the baseline emissions inventory.

$$\begin{aligned}
 \text{ROG} &= 1 - (\text{proposed standard} / \text{2004 standard}) \\
 &= 1 - (0.14 \text{ grams per brake horsepower-hour} / 0.5 \text{ grams per brake horsepower-hour}) \\
 &= 1 - 0.28 \\
 &= 0.72 \text{ or } 72\% \text{ reduction}
 \end{aligned}$$

$$\begin{aligned}
 \text{NOx} &= 1 - (\text{proposed standard} / \text{2004 standard}) \\
 &= 1 - (2.0 \text{ grams per brake horsepower-hour} / 0.2 \text{ grams per brake horsepower-hour}) \\
 &= 1 - 0.1 \\
 &= 0.90 \text{ or } 90\% \text{ reduction}
 \end{aligned}$$

$$\begin{aligned}
 \text{PM} &= 1 - (\text{proposed standard} / \text{2004 standard}) \\
 &= 1 - (0.1 \text{ grams per brake horsepower-hour} / 0.01 \text{ grams per brake horsepower-hour}) \\
 &= 1 - 0.1 \\
 &= 0.90 \text{ or } 90\% \text{ reduction}
 \end{aligned}$$

Table 2 shows statewide emissions inventory that would result from the proposed emission standards using the reductions calculated above. The inclusion of out-of-state vehicles will result in an approximate 20 percent increase in the inventory calculations and the resulting emission reductions.

	2000	2005	2010	2015	2020
ROG	32.3	28.3	22.3	15.2	10.1
NOx	556.4	476.1	345.0	202.9	112.9
PM	18.0	14.2	9.4	5.4	3.1

Table 2 - Statewide Emissions Inventory Including Implementation of 2007 Heavy-Duty Diesel Engine Standards (tpd)

Table 3 shows the reductions in the EMFAC2000 model based on the difference of baseline emission inventory (Table 1, above) and the inventory including

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implementation of 2007 heavy-duty diesel engine standards (Table 2, above). By splitting the 2004 NOx plus NMHC standard, we conclude the following reductions.

	2000	2005	2010	2015	2020
ROG	0.0	0.0	1.4	4.6	7.7
NOx	0.0	0.0	44.8	130.9	196.0
PM	0.0	0.0	2.6	5.8	8.1

Table 3 - Statewide Emissions Reductions From 2007 Heavy-Duty Diesel Engine Standards (tpd)

The ARB is seeking comment on the preliminary emission estimates including, but not limited to, methods of calculation and assumptions used.

No regulatory text is included in this mail out since this proposal is identical to the U.S. EPA's 2007 Final Rule. This regulatory proposal is scheduled for consideration, by the Board, on September 20, 2001. Comments to the proposed amendments should be mailed by June 29, 2001 to the following address.

Air Resources Board
Attn: Mr. Michael Carter
Chief, Emission Research and Regulatory Development Branch
9528 Telstar Avenue
El Monte, California 91731

Further inquiries regarding this matter should be directed to Mr. Gregory Ushijima, Air Resources Engineer, On-Road Heavy Duty Diesel Section, at (626) 459-4365.

Sincerely,

Robert H. Cross, Chief
Mobile Source Control Division

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