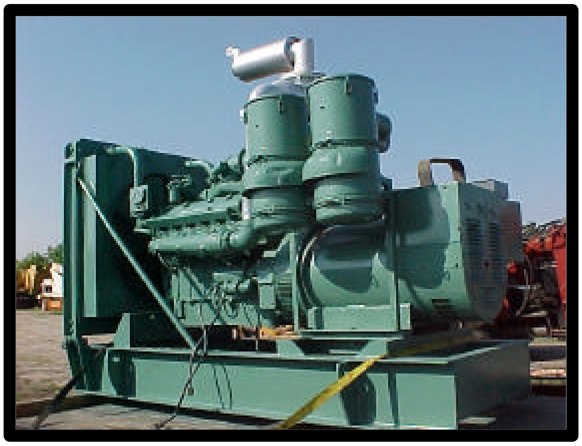
Risk Management Guidance for the Permitting of New Stationary Diesel-Fueled Engines



California Environmental Protection Agency

Air Resources Board

Stationary Source Division
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I. Overview

A. What is the purpose of this document?

This document is the Air Resources Board (ARB/Board) staff's proposed guidance to assist local air pollution control districts and air quality management districts (districts) in making risk management decisions associated with the permitting of new stationary diesel-fueled engines. In the guidance, we specifically address the further control of diesel particulate matter (diesel PM) emissions from diesel-fueled engines. We suggest two options for diesel PM control, either compliance with diesel PM exhaust emission performance standards or compliance with minimum technology requirements for reducing diesel PM. We also suggest that a site-specific health risk assessment (HRA) be conducted and considered prior to issuing a permit for engines that operate extended hours.

It is important to note that the guidance is a *non-regulatory* document that is a tool for districts to use in carrying out their new source permitting programs to address new stationary diesel-fueled engines. Nothing in our guidance precludes districts from adopting different or more stringent requirements or from varying from the guidance to consider permit specific situations. Further, this guidance does not require districts to amend their new source review rules.

We also intend this guidance to serve as a starting point for developing an airborne toxic control measure (ATCM) for new stationary diesel-fueled engines. The control options presented in this guidance will be explored in much more detail during ATCM development, with emphasis given to establishing state-of-the-art engine certification levels, defining in-field compliance test methods, and researching the technological feasibility, durability, and costs of controls. Unlike the guidance, the ATCM will be a regulatory document and once adopted, districts will either be required to implement the ATCM or develop their own more stringent new stationary diesel-fueled engine rule.

B. How does the guidance presented in this document differ from the guidance presented in the ARB's <u>Risk Management Guidelines for New and Modified Sources of Toxic Air Pollutants</u> (Guidelines), July 1993?

The 1993 Guidelines suggest the use of a combination of specific risk levels and a risk action range to evaluate new and modified sources of toxic air pollutants. Specific risk levels are suggested for triggering the installation of toxic best available control technology (T-BACT) and for establishing an upper level maximum risk. A risk action range is suggested for providing flexibility when considering, in addition to risk, other factors such as site-specific meteorology, the proximity to residences, and potential impact on sensitive receptors. These other factors are presented and discussed in a Specific Findings Report. The Air Pollution Control Officer (APCO) reviews this report and prepares findings supporting a decision to approve or deny the permit to operate.

The guidance presented in this document defines a technology-based approach that retains a risk-based review under certain conditions. The guidance suggests all new stationary diesel-fueled engines meet either minimum technology requirements or engine performance standards. For most engines, we suggest that the permit to operate the engine is approvable once the appropriate minimum technology requirement or performance standard is met. For engines that operate more than 400 hours per year, we recommend that a site-specific HRA be required prior to permit approval. A discussion of the results of the HRA, as well as other factors, may be provided in a Specific Findings Report prepared by either the source or the district. The public then has an opportunity to review the Specific Findings Report and the proposed permitting action. The APCO then reviews the Specific Findings Report and the public's comments, and then prepares findings supporting a decision to approve or deny the permit to operate.

C. What are the key recommendations in this guidance?

The key recommendations in this guidance are:

- ♦ Approve permits for Group 1 diesel-fueled engines if they meet the appropriate performance standards or minimum technology requirements (see Table 1, page 11). We anticipate most (90 percent) new stationary diesel-fueled engines will fall in Group 1 based on the current inventory and average hours of operation of stationary diesel-fueled engines (ARB, September 2000). This excludes agricultural engines which are exempt from permitting requirements. Meeting the appropriate minimum technology requirements or performance standards will result in the application of the best available control technologies (BACT) and the lowest achievable risk levels, in consideration of costs, uncertainty in the emissions and exposure estimates, and uncertainties in the approved health values. For these engines, a site-specific HRA is not required.

- ♦ Require a site-specific HRA prior to approval of diesel-fueled engines that fall within the Group 2 category; basically engines operated over 400 hours per year (see Table 1, page 11). We anticipate relatively few (10 percent) new non-agricultural stationary diesel-fueled engines will fall in Group 2 based on the current inventory and average hours of operation of stationary diesel-fueled engines (ARB, September 2000). For these sources, we believe a site-specific risk analysis is appropriate prior to making a permitting decision. Because of the potential elevated risk associated with the high usage of these engines, the risk assessment will allow the district to fully evaluate the various factors such as risk, sensitive receptors, and alternatives that go into a site-specific permitting decision. We further recommend the public be provided the opportunity to review and comment on the proposed permit action. The APCO would consider the public's comments in making the final permitting decision. We believe establishing an upper level maximum risk would be too restrictive, not allowing for the approval of sources with well-controlled diesel-fueled engines that perform critical functions (i.e., emergency power generation) or for which there is no economically or technically feasible substitute.

- For Group 2 engines, conduct risk assessments consistent with the *California Air Pollution Control Officers Association (CAPCOA), Air Toxics "Hot Spots" Program, Revised 1992 Risk Assessment Guidelines* (Risk Assessment Guidelines), dated October 1993[1], and the risk assessment guidance presented in Appendix 4 of this document. Use diesel PM as a surrogate for all toxic air contaminant emissions from diesel-fueled engines when determining the potential cancer risk and the noncancer chronic hazard index for the inhalation pathway.

- Estimate risk using the Scientific Review Panel's (SRP) recommended unit risk factor of 300 excess cancers per million per microgram per cubic meter of diesel PM [$3 \times 10^{-4} (\mu g/m^3)^{-1}$] based on 70 years of exposure.[2]

- Consider the need for the project in addition to the uncertainty in the risk assessment information when making risk management decisions.

D. What is the statutory basis for developing this guidance?

The statutory authority for the ARB to develop this guidance document is found in Health and Safety Code (H&SC) sections 39605 and 39620(a). Section 39605 states that the ARB may provide assistance to any district. Section 39620(a) states that the ARB shall implement a program to assist districts in implementing permits. This guidance provides assistance to districts for permitting new stationary diesel-fueled engines and is part of the ARB's program to assist districts in implementing permits. Further, the general authority for districts to control air pollution from all sources, other than emissions from motor vehicles, is found in H&SC section 40000.

This guidance document references the Risk Assessment Guidelines when defining how site-specific risk assessments should be conducted. These risk assessment guidelines are required to be developed by OEHHA under the "Hot Spots" program, HSC section 44360(b)(2). However, the statutory requirements (e.g., emission inventory, notification, audits and plans) associated with the "Hot Spots"

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1 The Office of Environmental Health Hazard Assessment (OEHHA) is currently revising the CAPCOA Risk Assessment Guidelines. It is expected that districts will use the OEHHA risk assessment guidelines when completed later this year (2000).

2 For Group 2 engines, the Specific Findings Report should also report the full range of potential cancer risk using the range of unit risk factors (URF) identified by the SRP; 130 to 2400 excess cancers per million per microgram per cubic meter of diesel particulate matter. The URF of $3 \times 10^{-4} (\mu g/m^3)^{-1}$ is commonly expressed as 300 excess cancers per million per microgram per cubic meter of diesel particulate matter.

program, H&SC sections 44300 through 44394, are not applicable to the implementation of this guidance.

II. Applicability

This section discusses the types of engines and fuels addressed by this guidance.

A. What types of diesel-fueled equipment are addressed by this guidance?

This guidance specifically addresses all new stationary, compression-ignition, internal combustion, diesel-fueled engines greater than 50 horsepower (hp). This guidance does not address: 1) mobile equipment, 2) portable equipment, 3) military tactical support equipment, and 4) stationary and portable agricultural engines.

Mobile equipment, on-road and off-road vehicles, are not addressed in this guidance because they are not stationary equipment and are not required to obtain district operating permits.

Portable engines are engines that are designed and capable of being carried or moved from one location to another and do not remain at a single location for more than 12 consecutive months. The technology requirements contained in this guidance were developed for stationary engine applications, and may not be achievable for portable applications at this time. ARB staff will propose to the Board as expeditiously as possible appropriate diesel PM control requirements for portable equipment. The portable equipment regulation is planned to be presented to the Board for adoption by March 2002.

Military tactical support equipment as well as stationary and portable agricultural equipment are exempted from permitting requirements through state law and are not addressed by this guidance. The Federal Clean Air Act also prevents states from regulating new construction and farm equipment with engines less than 175 hp.

In addition, we do not recommend using the health values contained in this guidance for assessing the risk from diesel-fueled equipment such as turbines, boilers, heaters, kilns, or flares.

B. Why aren’t diesel-fueled engines less than or equal to 50 hp addressed in this guidance?

Most districts currently exempt stationary diesel-fueled engines 50 hp or less (small engines) from obtaining a permit. Since ARB plans to regulate small engines as part of a statewide rulemaking in 2002, we are not recommending that districts revise their new source review requirements to address this category at this time. However, owner/operators who elect to install small engines during this period should be encouraged to voluntarily meet minimum technology requirements. Such actions will minimize their need to retrofit these engines under the statewide rulemaking.

We suggest that owners/operators be encouraged to purchase new small engines meet the most stringent PM emission level currently achievable and to fuel those engines with CARB diesel. Available small engine certification data shows that a 0.2 g/bhp-hr (steady-state) emission level is achievable (U.S. EPA, August 8, 1997). For districts that do permit these engines, we recommend they only permit small engines meeting this performance level.

C. Why are diesel-fueled turbines or external combustion engines <u>not</u> addressed in this guidance?

The health effects data used to develop the unit risk factor for diesel PM is based on compression-ignition engines. Currently, there is insufficient information to determine the toxicity of particulate emissions from diesel-fueled turbines or external combustion engines (boilers, heaters, kilns, or flares). As a result, we do not recommend using the health values contained in this guidance for permitting diesel-fueled turbines or external combustion engines at this time. We will continue to evaluate the appropriateness of excluding turbines and external combustion engines as more data becomes available.

D. Are stationary compression-ignition engines using jet fuel addressed in the guidance?

Yes. Stationary, compression-ignition engines using jet fuel should be treated the same as stationary, compression-ignition engines using diesel fuel. Jet fuel has properties very similar to diesel fuel (i.e., sulfur content, cetane number, T-90 temperature, and aromatic content). Jet fuel can be used in compression-ignition engines without any significant adjustments to the engine. Because of the similarity in fuel properties and the ease of fuel switching, we believe treating new stationary compression-ignition engines using jet fuel or diesel fuel the same is appropriate and necessary.

III. Background

A. What action has the ARB taken concerning the identification of emissions from diesel-fueled engines as toxic air contaminants?

In August, 1998, the ARB identified particulate matter emissions from diesel-fueled engines as a toxic air contaminant with no threshold exposure level. The Board accepted the OEHHA's cancer unit risk factor range of 130 to 2400 excess cancers per million per microgram per cubic meter of diesel PM. Final approval of ARB's action by the Office of Administrative Law and the Secretary of State occurred in July, 1999.

B. What are the uncertainties associated with the risk assessment?

The three main areas of uncertainty, which may underestimate or overestimate the risk from exposure to toxic air contaminants from diesel-fueled engines, are uncertainty in the emissions estimation techniques (emission factors and source test results); uncertainty in air dispersion modeling techniques used to assess exposure; and uncertainty in the techniques used to determine health risk values (cancer unit risk factor and the noncancer reference exposure level). The uncertainties in the emissions estimation techniques and in air dispersion modeling techniques are well known and discussed in numerous publications. The uncertainty in the techniques used to determine health risk values is discussed in more detail in Appendix 4. Appendix 4 contains excerpts from the Risk Assessment Guidelines and the *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix III, Part B, Health Risk Assessment for Diesel Exhaust.*

IV. Key Terms

A. **Diesel Fuel:** Fuel meeting the following specification:

ASTM D975 – 98, Standard Specification for Diesel Fuel Oils; includes No. 1-D, No. 1-D low sulfur, No. 2-D, No. 2-D low sulfur, and No. 4-D.

All diesel fuel sold or supplied in California for motor vehicle use (CARB diesel) must have a sulfur content of 500 ppmw or less (13 CCR 2281). In addition, the average aromatic hydrocarbon content of CARB diesel, except that produced by California small refiners, must not exceed 10 percent by volume. ARB-certified alternative formulations are allowed (13 CCR 2282).

B. **Jet Fuel:** Fuel meeting the following specification

ASTM D 1655 – 98, Standard Specification for Aviation Turbine Fuels; includes Jet A, Jet A-1, and Jet B.

MIL-DTL-5624T, Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP8 ST.

MIL-T-83133D, Turbine Fuel, Aviation, Kerosene Types, NATO F-34 (JP-8) and NATO F-35; NATO F-35 similar to (JP-8).

C. **Diesel-Fueled Engine:** For purposes of this guidance, any internal combustion, compression-ignition (diesel cycle) engine that is fueled by diesel fuel or jet fuel.

D. **Emergency Standby Engine:** An internal combustion engine used only as follows: 1) when normal power line or natural gas service fails; or 2) for the emergency pumping of water for either fire protection or flood relief. An emergency standby engine may not be operated to supplement a primary power source when the load capacity or rating of the primary power source has been either reached or exceeded. An emergency standby engine may not be operated more than 100 hours per year during maintenance or testing runs.

E. **New Diesel-Fueled Engine:** A new diesel-fueled engine is either:

1) A new diesel-fueled engine installed at a new or existing source. An exact replacement is considered the addition of a new diesel-fueled engine;
2) A diesel-fueled engine relocated from an off-site location; or
3) A reconstructed diesel-fueled engine, where the cost of reconstruction is greater than or equal to 50 percent of the purchase price of a new similarly sized engine (basic equipment only).

F. **Catalyst-based Diesel Particulate Filter (DPF):** A DPF that incorporates a catalyst or an uncatalyzed DPF that incorporates a fuel-borne catalyst or is used in conjunction with an oxidation catalyst to effectively lower the soot burn-off temperature.

V. The Basic Approach

The basic approach consists of two options: 1) complying with minimum technology requirements; or 2) complying with performance standards.

A. Minimum Technology Requirement Option

1. *Since diesel PM has been identified as a non-threshold carcinogen, we are suggesting in this guidance that new stationary diesel-fueled engines meet the most stringent particulate matter emission level that is currently being met by on-road and off-road engines.*

   In determining the most stringent particulate matter emission level that is currently being met, we looked at both on-road and off-road certification data. Comparison of on-road and off-road standards is not straightforward, since off-road test procedures are done in accordance with International Standards Organization (ISO) 8178 steady-state test procedures and on-road diesel-fueled engines are tested in accordance with Federal Test Procedures (FTP) transient test cycles. The limited engine test results we have seen show that an engine tested on both transient and steady-state test cycles will generally show a lower diesel PM emission rate during the steady-state test cycles. Therefore, we believe that an engine that can achieve a certain emission level during an on-road test (transient test) will be able to achieve a similar emission level during an off-road test (steady-state test).

2. *We are suggesting in this guidance that add-on control equipment be required on new stationary diesel-fueled engines, in consideration of engine size, cost, operating scenario, and technical feasibility.*

   In general, engines that are operated for extended periods of time emit the most diesel PM and pose the greatest potential risk. We have conducted air dispersion modeling analysis varying the hp and annual hours of operation for representative stationary diesel-fueled engines operating in California. We have analyzed the results of our modeling efforts and we recommend that add-on controls be required on all engines that are greater than 50 hp.

   Add-on control equipment available for on-road diesel engine applications is expected to be utilized in off-road stationary diesel-fueled engine applications. We recommend catalyst-based diesel particulate filters (DPFs). Some unique aspects of the operating environment or performance requirements of an off-road engine may govern the application of the control equipment. For example, particulate traps require engine exhaust to meet a certain temperature to facilitate filter regeneration. A stationary diesel-fueled engine that operates at a low load and cyclical speeds may not generate an exhaust temperature that is sufficient to regenerate the filter, even when the filter is catalyzed. For these cases, an electrically powered heater for filter regeneration may be the preferred option. Electrically regenerated DPFs are not as effective in reducing diesel PM. However, an electrically regenerated DPF used in tandem with an oxidation catalyst may reduce diesel PM as much as a catalyst-based DPF. We believe, in almost all situations, that DPFs are both technically and economically feasible for new engine applications.

3. *We are suggesting the requirement for add-on control on diesel-fueled engines used in emergency standby applications become effective March 2002, or until the analysis supporting the Emergency Standby Retrofit ATCM is complete, whichever is sooner.*

   The Emergency Standby Retrofit ATCM is scheduled to be presented to the Board in March 2002. As part of the ATCM's development, staff will fully demonstrate that emergency standby engines can generate an exhaust temperature sufficiently high to regenerate a filter during scheduled maintenance runs. ARB staff believes the remaining technical issues associated with the application of catalyst-based DPFs on emergency standby engines will be resolved within a short period of time. ARB staff will gather additional information to determine if there are any technical issues that may limit the effectiveness and application of catalyst-based DPFs on emergency standby engines.

After March 2002, or when the Emergency Standby Retrofit ATCM analysis is complete, we suggest all emergency standby engines be treated as any other stationary diesel-fueled engine and be required to meet the permitting requirements discussed in this guidance.

4. *We are suggesting in this guidance that very low-sulfur CARB diesel fuel be used in new stationary diesel-fueled engines with add-on control equipment.*

   The most effective add-on control equipment that incorporates a catalyst can generate excessive sulfate particles when high sulfur diesel fuel is used. The increase in sulfate particles could offset the reduction in other particulate matter species and could adversely affect trap operation. To ensure that the most effective controls are used, we recommend that very low-sulfur CARB diesel fuel be used. Very low-sulfur CARB diesel fuel is CARB diesel fuel with a sulfur content of less than or equal to 15 parts per million by weight (ppmw). CARB diesel currently limits sulfur content to 500 ppmw. Currently, some refiners are marketing very low-sulfur CARB diesel. However, if the owner/operator of a new stationary diesel-fueled engine can adequately justify to the district that very low-sulfur CARB diesel is not available, staff believes that significant reductions in diesel PM emissions can still be achieved through the application of available sulfur-tolerant catalyst-based DPFs.

5. *We are suggesting in this guidance that a site-specific HRA be conducted on diesel-fueled engines that are greater than 50 hp and operate over 400 hours a year to ensure the lowest achievable risk level will be achieved, in consideration of cost and technical feasibility of control.*

   Our air dispersion modeling results indicate that diesel-fueled engines operated over 400 hours per year may result in nearby receptors being exposed to elevated levels of diesel PM. HRA results, as well as other site-specific findings such as the location of sensitive receptors, should be considered when permitting these engines. We suggest that the public be allowed to review and comment on the proposed permit action prior to the district's final decision.

B. Performance Standard Option

1. *We are suggesting in this guidance that owner/operators be allowed to meet a performance standard in lieu of meeting the new engine diesel PM emission levels/add-on control/very low-sulfur CARB diesel requirements.*

   The performance standards identified in the guidance are based on the anticipated diesel PM reductions achieved by engines meeting the engine certification/add-on control/very low sulfur CARB diesel requirements. New stationary diesel-fueled engines operated over 400 hours per year that meet the performance standard would still be subject to site-specific HRA requirements.

VI. Permitting Requirements

This section identifies and discusses the suggested minimum technology requirements for permitting new or relocated diesel-fueled engines operating at stationary sources. The suggested minimum technology requirements are based on current engine, add-on control, and fuel technologies. These requirements will need to be reevaluated if engine certification standards or diesel fuel specifications change significantly. Table 1 summarizes these requirements.

Table 1: Permitting Requirements for New Stationary Diesel-Fueled Engines

Engine Category	Annual Hours of Operation	Group	Performance Standard[1] (g/bhp-hr)	Minimum Technology Requirements			Additional Requirements	
				New Engine PM Emission Levels[1] (g/bhp-hr)	Fuel Technology Requirements	Add-On Control	HRA Required	SF Report
Emergency/ Standby > 50 hp[2]	≤ 100 hours[3]	1	0.1	0.1	CARB Diesel or equivalent	No	No	No
All Other Engines > 50 hp	≤ 400 hours	1	0.02	0.1	Very low-sulfur CARB Diesel or equivalent [4]	Catalyst-based DPF or equivalent	No	No
	> 400 hours	2	0.02	0.1	Very low-sulfur CARB Diesel or equivalent [4]	Catalyst-based DPF or equivalent	Yes	If HRA shows risk > 10/million

HRA - Health Risk Assessment; SF - Specific Findings; DPF - Diesel Particulate Filter

1. ISO 8178 test procedure IAW *California Exhaust Emission Standards and Test Procedures for New 1996 and Later Off-Road Compression–Ignition Engines, May12, 1993.*
2. The emergency standby engine category is valid until March 2002, or until the analysis supporting the Emergency Standby Retrofit ATCM is complete, whichever is sooner. At that time, emergency standby engines will be required to meet the A*ll Other Engine >50 hp* requirements. New emergency standby engines must be "plumbed" to facilitate the installation of a catalyst-based DPF at a later date.
3. The annual hours of operation for emergency standby engines include the hours of operation for maintenance and testing runs only.
4. Very low sulfur (≤ 15 ppmw) CARB diesel or equivalent is only required in areas where the district determines it is available in sufficient quantities and economically feasible to purchase. CARB diesel is required to be used in all other areas.

We have established two categories of stationary diesel-fueled engines: emergency standby engines with horsepower ratings greater than 50 and all other engines with horsepower ratings greater than 50. We know from reviewing air dispersion modeling results that engine horsepower, or size, does not have as significant an impact on the maximum offsite risk as does the diesel PM emission certification level and the hours of operation. (See Appendix 2 for more details.) Therefore, we recommend permitting requirements for diesel-fueled engines that are the same for all engine sizes, with the exception of emergency standby engines. However, we recommend slightly more stringent permitting requirements for diesel-fueled engines that operate in excess of 400 hours annually.

For new stationary diesel-fueled engines that are required to install a catalyst-based DPF, we suggest using very low-sulfur (≤ 15 ppmw S) CARB diesel or an equivalent fuel, where available. All diesel fuel sold or supplied in California for motor vehicle use (CARB diesel) must have a sulfur content of 500 ppmw or less. Currently stationary engines are exempt from meeting CARB diesel requirements, but may be required under local district rule to use CARB diesel. We believe all stationary diesel-fueled engines should use CARB diesel. Further, where available in sufficient quantities, we believe districts should require stationary diesel-fueled engines with catalyst-based DPFs to use very low-sulfur CARB diesel to ensure the most effective control of diesel PM. In areas where very low-sulfur CARB diesel is not available, owners/operators of new stationary diesel-fueled engines should install fuel-sulfur tolerant catalyst-based DPFs. In CARB's recently adopted regulation for a public transit bus fleet rule, transit agencies will be required to purchase very low-sulfur CARB diesel fuel with a cap of 15 ppmw beginning July 1, 2002. In-field compliance sampling and analysis indicates that diesel fuel meeting the 15 ppmw sulfur content requirement has already been marketed in California for general use.

The following paragraphs discuss in more detail the two categories of diesel-fueled engines and the basis for the new engine particulate matter certification levels, add-on control requirements, and performance levels. A detailed discussion of the suggested process for making permitting decisions is contained in Section VII, Approval Process.

A. Emergency Standby Engines Greater than 50 hp

1. Description

This category addresses emergency standby engines. Emergency standby engines are used to either provide emergency electrical power or the emergency pumping of water for flood relief or fire protection. Several types of facilities are required to have standby engines to provide emergency power systems. These include hospitals, airports, correctional facilities, city sewage, and water plants. Many large office buildings and apartment complexes also have emergency standby engines. Emergency standby engines can range from 50 hp to over 1000 hp.

Currently, many emergency standby engines are exempt from new source permitting requirements. We suggest that permitting rules include emergency standby engines since a significant amount of diesel PM emissions can be emitted during maintenance operations. Many facilities with emergency standby engines are required to conduct maintenance runs to ensure the operational readiness of the engine. ARB staff obtained information on typical maintenance runs from district databases and facility surveys. About half of the facilities surveyed run their emergency standby engines under load. The load varies depending on the specific application of the engine. For example, a cable station surveyed runs its standby generator engine at full load during its maintenance run; a hospital surveyed runs its standby generator engine only at 50 percent load; and a utility provider surveyed runs its standby generator engine at no load. Maintenance runs typically last from five minutes to an hour. The frequency of maintenance runs can vary from once a week to once every six months. ARB estimates that existing emergency standby engines comprise approximately 70 percent of the stationary diesel-fueled engines located throughout the state and emit approximately 140 tons of diesel PM a year (ARB, July 2000).

2. New Engine Emission Levels

We suggest that new permits for emergency standby diesel-fueled engines rated at greater than 50 hp require the applicant to use engines that have an emission level of 0.1 g/bhp-hr or less as determined during a steady-state engine certification test (ISO 8178). We base this suggestion on existing PM emission standards and engine certification data for model year 2000 engines.

PM Emission Standards

Table 2 lists the existing California diesel engine emission standards for both on-road and off-road diesel-fueled vehicles and engines. As shown in Table 2, the most stringent off-road engine PM emission standards for diesel-fueled engines greater than 50 hp for the year 2000 range from 0.60 to 0.15 g/bhp-hr, depending on the engine's horsepower rating.

However, for engines in the 200-500 hp range, the year 2000 on-road PM emission standards are significantly more stringent than the comparable off-road standards (0.1 g/bhp-hr as compared to 0.4 g/bhp-hr). As mentioned previously, the on-road standards are FTP transient test certification levels while the off-road standards are ISO 8178 steady state certification levels. The limited engine test information we have seen indicates that an engine that is certified to 0.1 g/bhp-hr via a transient test would certify to less than 0.1 g/bhp-hr via a steady-state test. This supports our suggestion that a 0.1 g/bhp-hr (steady-state) emission level is achievable by engines within the 200-500 hp range.

Table 2: California Diesel Engine Particulate Matter (PM) Emission Standards
(1991 to 2006 & Later)

Category	Engine Rating hp	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006 & later
		PM Emission Standard															
Passenger cars and light-duty trucks*	120-200	0.08 g/mile		0.08 g/mile (TLEV &LEV)												0.04 g/mile (TLEV)	
(continued)	120-200	NA		0.04 g/mile (ULEV)												0.01 g/mile (LEV,ULEV,SULEV)	
Medium-duty*	200-300	NA	0.1 g/bhp-hr (LEV & ULEV)														
(continued)	200-300	NA				0.1 g/bhp-hr (Tier I)											
(continued)	200-300	NA					0.05 g/bhp-hr (SULEV)										
Heavy-duty*	250-500	0.25 g/bhp-hr			0.1 g/bhp-hr												
Off-road	0-11	NA					0.9 g/bhp-hr				0.75 g/bhp-hr					0.6 g/bhp-hr	
(continued)	11-25	NA					0.9 g/bhp-hr				0.6 g/bhp-hr						
(continued)	25-50	NA								0.6 g/bhp-hr					0.45 g/bhp-hr		
(continued)	50-100	NA													0.3 g/bhp-hr		
(continued)	100-175	NA												0.22 g/bhp-hr			
(continued)	175-300	NA					0.4 g/bhp-hr							0.15 g/bhp-hr			
(continued)	300-600	NA					0.4 g/bhp-hr					0.15 g/bhp-hr					
(continued)	600-750	NA					0.4 g/bhp-hr						0.15 g/bhp-hr				
(continued)	>750	NA									0.4 g/bhp-hr						0.15 g/bhp-hr
Urban Bus Engines*	250-300	0.1 g/bhp-hr			0.07 g/bhp-hr										0.01 g/bhp-hr		

*Transient Test

Note: Table does not include optional standards for heavy-duty vehicles or urban bus engines.
Table is supplied for comparison purposes only. Refer to regulations for compliance questions.

Similarly, we believe a standard of 0.1 g/bhp-hr (steady-state) is appropriate for stationary diesel-fueled engines within the 120-200 hp range based on current on-road standards. On-road diesel-fueled vehicles equipped with engines in the 120-200 hp range must comply with 0.08 and 0.04 gram/mile emission standards. These vehicles are tested on a vehicle chassis dynamometer. The 0.08 and 0.04 gram/mile vehicle standards are roughly equivalent to the 0.1 and 0.05 g/bhp-hr transient engine test standards, respectively.

<u>Engine Certification Data</u>

Appendix 5 is a list of over 200 U.S. EPA certified non-road and on-highway diesel-fueled engines, model year 2000, that are currently meeting 0.15 g/bhp-hr or less emission levels. Of the 212 engines listed, 140 are non-road engines and 34 of those non-road engines were tested on the ISO 8178 D2 cycle. These 34 engines ranged from 18 to 3000 hp. The D2 cycle is appropriate for applications which include generator sets with intermittent loads, refrigerating units, welding sets, chippers, etc. Of the 34 engines tested on the D2 cycle, the low diesel PM emission rate achieved was 0.04 g/bhp-hr from a 685 hp engine. The high diesel PM emission rate was 0.145 from a 1124 hp engine. We believe this test data supports our suggestion that a 0.1 g/bhp-hr (steady-state) standard emission level is currently achievable.

3. Add-on Control

We suggest that the installation of add-on controls be a permit requirement for new emergency standby engines issued a permit after March 2002 or sooner. As discussed in section V. A. 3., The Basic

Approach, we suggest delaying the requirement for emergency standby engines to apply add-on controls until March 2002. After March 2002, we suggest that all emergency standby engines be treated as any other stationary diesel-fueled engine and be required to meet the permitting requirements discussed in this guidance. However, from now until March 2002, we recommend that all new emergency-standby engines be configured in such a way as to allow the installation of a catalyst-based DPF at a later date.

4. Fuel Requirement

We suggest CARB diesel or equivalent be required to be used in all emergency standby engines that are permitted prior to March 2002. For those engines permitted after March 2002, we suggest very low sulfur fuel ($\leq$ 15 ppmw S) CARB diesel or an equivalent fuel be required in areas where the district determines it is available in sufficient quantities and economically feasible to purchase. If very low sulfur CARB diesel is not available, then CARB diesel should be used.

5. Performance Standard

Until March 2002, the performance standard for new emergency standby engines is 0.1 g/bhp-hr, which is equivalent to the new engine diesel PM emission level. After March 2002, the performance standard will be equivalent to that of all other engines greater than 50 hp, 0.02 g/bhp-hr. See section C. 4. below for discussion.

6. Permitting Mechanism

We suggest that Districts use the current new source review requirements to address engines in these categories with the inclusion of the following provision. We suggest that any emergency standby engine that increases the permitted operating hours of that engine to greater than 100 hours per year or operates in a non-emergency standby capacity meet the requirements of engines permitted under the "All Other Engine" category described below.

B. All Other Engines Greater than 50 hp

1. Description

This category includes all stationary diesel-fueled engines with horsepower ratings greater than 50 hp. There is a multitude of uses for engines in this category. Typically, stationary diesel-fueled engines are used in the following types of applications: cranes, pumps, welding, woodchippers, power generation, compressors, and rockcrushing.

2. New Engine Emission Levels

   We suggest that new permits for stationary diesel-fueled engines rated at 50 hp or greater require the applicant to use engines that have an emission level of 0.1 g/bhp-hr or less as determined during a steady-state engine certification test (ISO 8178). We base this suggestion on existing PM emission standards and engine certification data for model year 2000 engines. See above section B. 2. for further discussion.

3. Add-on Control

   We suggest that stationary diesel engines greater than 50 hp be required to install a catalyst-based DPF or equivalent control technology. DPFs are exhaust treatment devices that have shown through testing and in-use applications to be effective at reducing PM emissions. In general, a properly sized and installed catalyst-based DPF used with very low-sulfur fuel ($\leq$ 15 ppmw S) can reduce PM emissions by 85 percent or more.

4. Fuel Requirement

   We suggest very low sulfur fuel ($\leq$ 15 ppmw S) CARB diesel or an equivalent fuel be required in areas where the district determines it is available in sufficient quantities and economically feasible to purchase. If very low sulfur CARB diesel is not available, CARB diesel should be used.

5. Performance Standard

   We suggest that stationary diesel-fueled engines greater than 50 hp meet a performance standard of 0.02 g/bhp-hr. The 0.02 standards are based on the anticipated PM emission levels from new stationary diesel-fueled engines meeting the proposed certification levels, using very low-sulfur fuel, and incorporating a catalyst-based DPF. In general, a properly sized and installed catalyst-based DPF can reduce PM emissions about 85 percent when used with very low sulfur fuel.

6. Permitting Mechanism

   We suggest that districts use the current new source review requirements to address engines in these categories.

C. Diesel Particulate Filter (DPF)

   DPFs reduce PM emissions by trapping the particles in a flow filter substrate where it is oxidized, or burned off, once the filter reaches a certain temperature. This burn-off process is referred to as filter regeneration. DPFs remove the solid, dry carbon (soot) from the exhaust stream. DPFs also reduce carbon monoxide (CO) and hydrocarbon emissions, if catalyzed.

For most applications, passive regeneration of the filter at exhaust temperatures produced during normal operating conditions is difficult to achieve. For this reason, most DPFs incorporate a catalyst that effectively lowers the soot burn-off temperature. Most DPF manufacturers apply a catalytic coating directly to the filter element, others manufacture systems that incorporate a fuel-borne catalyst or electrically powered heating units used in conjunction with an uncatalyzed filter. Catalyzed DPFs, fuel-borne catalysts, and electrically regenerated DPFs are discussed in more detail in Appendix 1. The catalyst not only promotes the burn-off of soot, but also reduces the soluble organic fraction (SOF), hydrocarbons (HC), and CO.

The formation of sulfate particles increases at higher temperatures and with the presence of sulfur in the fuel. This effect can be minimized by using diesel fuel with very low sulfur content.

Steady-state emissions testing of older diesel-fueled engines equipped with catalyst-based DPFs have shown overall reduction in diesel PM of up to 85 percent using very low-sulfur diesel. Transient tests of a hybrid diesel-electric engine and of a diesel-fueled engine used in a wheel loader application have shown reductions in diesel PM of 92 percent and 97 percent, respectively. The results of the Manufacturers of Emission Controls Association (MECA) study indicate that a catalyst-based DPF can reduce emissions at least 70 percent while using a fuel with a sulfur content of 368 ppmw. The average sulfur content of CARB diesel is about 140 ppmw. Because electrically regenerated DPFs do not typically incorporate catalyst material, ARB staff expects lower control efficiencies than the catalyst-based DPF. Reduction of the SOF of diesel PM is increased in the presence of a catalyst.

Table 3 provides information on the estimated capital and annualized costs associated with retrofitting stationary engines with catalyst-based DPFs (catalyzed DPFs or uncatalyzed DPFs used with fuel-borne catalysts). For comparison, the table also provides similar information on the estimated costs for new engines. The range in capital costs was obtained from representative manufacturers, and is intended to represent the range in the retail costs at this time. For stationary engines 100 hp and larger, the catalyst-based DPF capital cost is consistent with the $30 to $50 per horsepower range reported by the MECA in “Emission Control Technology for Stationary Internal Combustion Engines” dated July, 1997.

Table 3: Estimated Costs of Catalyst-Based DPFs and New Engines					
Technology	**40 hp**	**100 hp**	**275 hp**	**400 hp**	**1,400 hp**
C-DPF[1]					
Capital Cost	N/A	$2,000 - $7,500	$3,500 - $9,000	$7,000- $10,500	$30,000 - $44,000
Annualized Cost[2]	N/A	$620 - $1,630	$1,090 - $2,480	$1,790- $3,500	$6,670 $10,980
New Engine					
Capital Cost[3]	$4,290	$6,960 - $18,840	$12,440 - $32,150	$23,100 - $48,370	$186,890
Annualized Cost	$1,040	$1,770 - $3,620	$2,480 - $5,970	$4,910 - $8,850	$32,800

1. Some catalyst-based DPFs require, and all catalyst-based DPFs would benefit from, the use of very-low sulfur diesel fuel. The incremental cost of this fuel is projected to be less than $ 0.05 per gallon.
2. Annualized cost estimates include capital costs, installation costs, maintenance costs and operating costs, and they are based on an interest rate of 9 percent and a maximum economic life of 10 years.
3. Capital cost estimates for new engines are based on information provided by engine suppliers and data submitted with applications for the Carl Moyer incentive program.

VII. Approval Process

A. Overview

This section identifies the suggested approach for permitting new stationary diesel-fueled engines. As discussed in the previous section, we are suggesting grouping all stationary diesel-fueled engines into three categories: engines with horsepower ratings 50 hp or less, emergency standby engines with horsepower ratings greater than 50 hp, and all other engines with horsepower ratings greater than 50 hp. The source would identify the appropriate category for the engine they plan to install and the maximum number of hours a year the engine will operate.

Minimum technology requirements or performance standards would be required to be met before a permit is approvable.[3] These requirements are summarized in Table 1. For engines that will operate over 400 hours a year, a site-specific HRA must be completed prior to the district approving the permit. A Specific Findings (SF) report would also be required if the HRA shows the potential cancer risk from the engine is greater than 10 excess cancers per million. Engines whose permits would be approvable without a site-specific HRA being prepared are referred to in this report as Group 1 engines. Engines for which the district requires an HRA be prepared are referred to as Group 2 engines. The following text and Figure 1 describe in more detail the suggested approach for permitting new stationary diesel-fueled engines.

3 Assuming source meets all other district requirements and all applicable state or federal requirements.

It is important to note that this guidance does not limit a district's ability to develop a permitting program for stationary diesel fueled engines that differs from our suggested approach. From our meetings with districts, we anticipate that some districts will adopt new stationary diesel-fuel engine permitting rules that differ from our suggested approach in the following areas:

- Require existing diesel-fueled engines that increase their permitted diesel PM emission levels to use CARB diesel fuel (very low sulfur ($\leq$ 15 ppmw S) where available) and apply add-on controls.
- Have the option to require an HRA at any point in the permitting process.
- Have the option to require more stringent minimum technology requirements and performance standards

Figure 1. Conceptual Decision Flow Chart for Permitting New Stationary Diesel-Fueled Engines

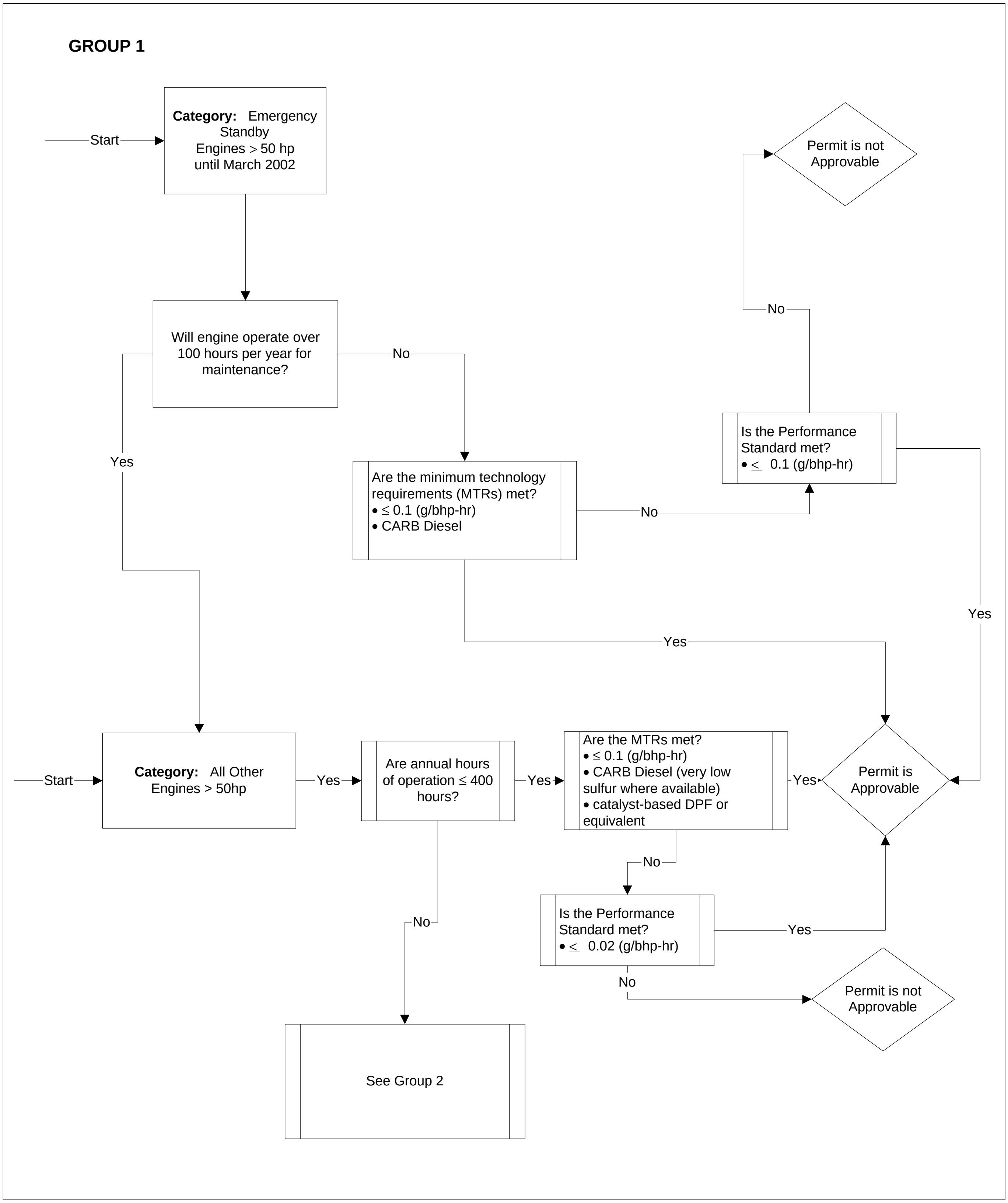
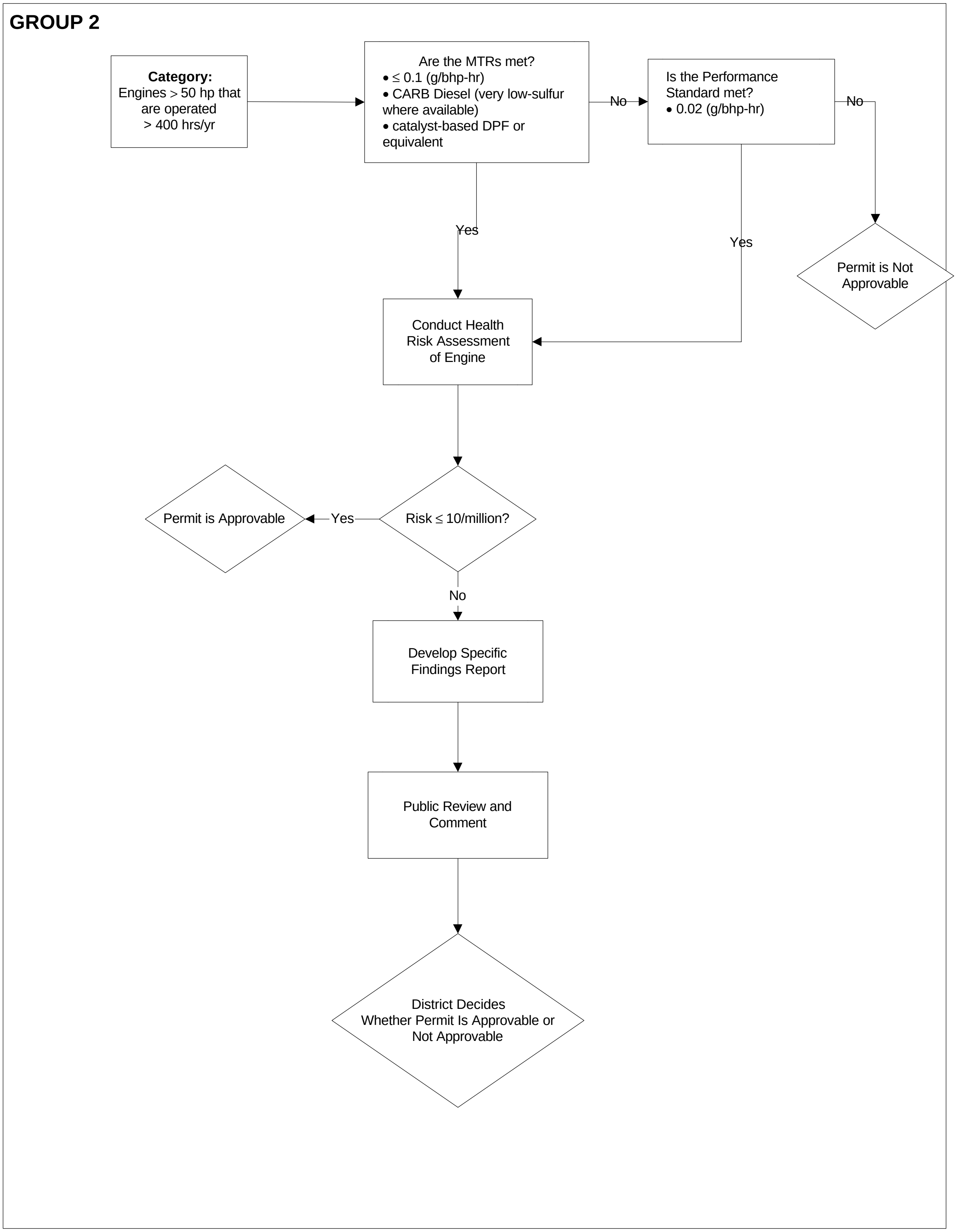


Figure 1 (continued)



B. Tiered Approach

All diesel-fueled engines required to obtain a district operating permit fall into one of two groups of categories, Group 1 or 2.

We suggest that engines from Group 1 categories be approved if they meet or exceed the appropriate minimum technology requirement or performance standard. We believe that most permitted stationary diesel-fueled engines will be Group 1 engines. Group 1 includes all emergency standby engines and all other engines with horsepower ratings greater than 50 that are operated 400 hours a year or less (see Table 1). For emergency standby engines, the annual hours of operation are defined as the scheduled hours the engine is operated to insure its readiness in times of emergency.

Group 2 engine categories represent those stationary diesel-fueled engines operated more than 400 hours per year (see Table 1). Engines from the Group 2 category are required to meet or exceed the appropriate minimum technology requirements or performance standard and perform a site-specific screening HRA. Based on the screening HRA, the district can then determine if a more detailed analysis or a Specific Findings Report will be necessary. Criteria for determining if a more detailed analysis or a Specific Findings Report is necessary includes factors such as:

- availability of electricity or natural gas (note: not applicable to emergency standby engines);
- proximity of sensitive receptor location, (i.e., school or daycare center);
- existing risk posed by facility;
- multiple engines being installed at the same location;
- screening HRA that shows the potential cancer risk from diesel PM emissions from the engine is significant (e.g., diesel PM inhalation cancer risk is greater than 10 in a million); or
- availability of cleaner diesel fuel.

The screening HRA need only evaluate the potential inhalation cancer risk posed by the emissions of diesel PM from stationary diesel-fueled engines. In identifying diesel PM emissions as a toxic air contaminant, the SRP recommended a reasonable unit risk factor of $3x10^{-4}$ $(\mu g/m^3)^{-1}$, or 300 chances in a million, be used to determine the potential cancer risk from inhalation, and a reasonable reference exposure level (REL) of 5 $\mu g/m^3$ be used when evaluating chronic noncancer health impacts. An acute noncancer risk REL was not recommended at this time; however, acute RELs for several of the TACs found in the diesel exhaust have been approved by the SRP. Therefore, potential cancer risk and noncancer chronic health impacts from the inhalation of diesel PM and acute noncancer health impacts from other TACs which are found in diesel exhaust can be estimated for diesel exhaust exposure.

Our analysis shows that the potential cancer risk from inhalation is the critical path when comparing cancer and noncancer risk. In other words, a cancer risk of 10 per million from the inhalation of diesel PM will result from diesel PM concentrations that are much less than the diesel PM or TAC concentrations that would result in chronic or acute noncancer hazard index values of 1 or greater.

For engines requiring a more detailed analysis and Specific Findings Report, we suggest allowing the public to review and comment on the proposed permitting action. The type of information needed for a more detailed analysis is presented in the following section.

D. Detailed Analysis - Specific Findings Report

This section only applies to Group 2 categories of engines. We suggest that the district review site-specific information when making a permitting decision for a Group 2 engine. Listed below are examples of the type of information we believe should be reviewed by the district. The district's analyses can be discussed and summarized in a Specific Findings Report, which can be made available to the public for review and comment.

The following information may be included in the Specific Findings Report:

- An evaluation of the technical and economic feasibility using cleaner diesel fuel or a non-diesel-fueled (i.e., electric or natural gas) engine.

- A site-specific HRA of the stationary diesel-fueled engine(s). The OEHHA is currently developing risk assessment guidelines that, when complete, should be used when conducting site-specific risk assessments. Until the OEHHA completes its work on the guidelines, we believe that risk assessments should be done in accordance with the most current version of the *CAPCOA Air Toxics "Hot Spots" Program Risk Assessment Guidelines*. Appendix 4 of this guidance, Adjustment to the Risk Assessment Methodology, identifies adjustments that can be made in conducting risk assessments of stationary diesel-fueled engines.

- An evaluation of site-specific design considerations that would be employed to minimize the impact of particulate matter emissions from stationary diesel-fueled engine(s) on near source receptors. Table 3 presents a list of possible options.

Table 3: Source Design Options

Optimizing diesel engine stack height	Maximizing buffer zones via diesel engine location
Operating at times of day that have the least impact	Locating engine to take advantage of meteorology
Non-full load testing	Inspection/maintenance program

- An evaluation of the technical and economic feasibility of emission reduction options that would provide particulate emission reductions beyond the minimum technology requirements.
- An evaluation of the technical and economic feasibility of emission reduction options that are likely to be available in the next three years which would provide particulate emission reductions beyond the minimum technology requirement.
- An evaluation of the risk contributed by other proposed or existing diesel-fueled engines at the facility.
- An evaluation of the risk contributed by other non-diesel-fueled equipment at the source.
- A facility-wide risk assessment.
- A discussion of the uncertainty associated with the emissions, exposure, or risk estimates.
- A discussion of the benefits associated with the proposed project.
- A discussion of any existing federal, state, or local mandates that require the proposed project.
- A discussion of facility risk relative to ambient levels.
- A discussion of the impacts of the proposed project on media other than air.

The date when public comments on the Specific Findings Report are due to the district and the date when the final permitting decision is to be made should be included in the Specific Findings Report. If the district is planning to conduct a public meeting to discuss the proposed permitting action and Specific Findings Report, information on when and where the meeting or meetings will be held should be included in the Specific Findings Report.

D. Evaluation of Alternatives to Add-On Control Requirements

The suggested minimum technology requirements for diesel-fueled engines require that a catalyst-based DPF, or equivalent, add-on control technology be installed on diesel-fueled engines that meet certain horsepower and annual hours of operation criteria. We suggest a PM emission reduction of 85 percent or greater be demonstrated.

In order to ensure that the diesel PM emission reductions associated with the alternative add-on control technology meet or exceed the 85 percent emission reduction criteria, we suggest that these diesel-fueled engines and the alternative control systems be source tested. Appendix 3 is a draft source test protocol that was developed by the ARB to test the effectiveness of two DPFs at a specified source. The section of the protocol that evaluates the effectiveness of add-on control equipment is applicable here. The source test requires the diesel-fueled engine to be run at speeds and loads that would reflect the engine's operating scenario. The source test protocol involves collecting diesel PM emissions samples from the engine's exhaust stream before and after the add-on control technology. The percent reduction of diesel PM emissions resulting from the alternative add-on control equipment can then be calculated using the sampled diesel PM emissions. This calculated diesel PM percent reduction would then be compared to the 85 percent PM emission reduction criteria to determine if the alternative is approvable.

Another important consideration when choosing an alternative control technology is the control technology's effect on NOx emissions. Alternative control technologies should not be approved if they result in a NOx emission rate that exceeds the engine's certification level.

VIII. References

ARB, *Public Meeting to Consider Approval of California's Emissions Inventory for Off-Road Large Compression-Ignited Engines (CI) (>25 hp), Table 5: Light-Duty Commercial Equipment Breakdown Percentages,* January 2000.

ARB, *Appendix II, Stationary and Portable Diesel-Fueled Engines: Appendix to the Diesel Risk Reduction Plan*, September 2000.

U.S. EPA , *Certification Data for Nonroad Diesel Engines,* memorandum from Phil Carlson to Docket A-96-40*,* August 8, 1997.

APPENDIX 1

Catalyzed Diesel Particulate Filter, Fuel-borne Catalyst, and
Electrically Regenerated Particulate Filter
Control Technology Evaluations

Control Technology Evaluation

Item	Response
Technology:	Catalyzed Diesel Particulate Filter
Technology Description: (How does it work?)	The technology is a passive, self-regenerating catalyzed diesel particulate filter (C-DPF). The technology reduces particulate matter, carbon monoxide and hydrocarbon emissions through catalytic oxidation and filtration. The C-DPF collects diesel particulate matter and oxidizes it during hot duty cycle operations. (This process of cleaning the C-DPF is called regeneration.) Typically, the filter media consists of ceramic wall-flow monoliths which capture the diesel particulates. These ceramic monoliths are either coated with a catalyst material or a separate catalyst is installed upstream of the C-DPF. The catalyst reduces the temperature at which the collected particulate matter oxidizes, and it oxidizes the soluble organic, carbon monoxide and hydrocarbon emissions.
Applicability: (What types of engines can the product be installed on?)	The technology is available for stationary and portable diesel engines rated at 5,000 hp or less and can be retrofitted to existing equipment. However, the technology is not appropriate for an application where an engine and its associated duty cycle do not generate enough heat to oxidize the collected particulate matter and regenerate the filter. For example, C-DPFs may not be appropriate for engines used in severe cyclic operations.
Achieved Emission Reductions:	**Product** / **Test Cycle** / **PM Reduction** Nett SF Soot Filter / CBD Transient / 92% Engelhard DPX / Special Transient / 97% CleanDiesel Soot Filter / ISO 8178 C1 / 85%
Emission Reduction Guarantee:	The emission reduction efficiency of this technology depends on the associated engine's baseline emissions, fuel sulfur content and emission test method / cycle. As such, diesel particulate filter manufacturers do not provide emission reduction guarantees.
Costs: Initial Retail:	The initial cost is: $3300 - $5000 for a 40 hp engine; $5000 - $7500 for a 100 hp engine; $6900 - $9000 for a 275 hp engine; $10,500 for a 400 hp engine; and $32,000 - $44,000 for a 1,400 hp engine.
Installation:	$167 - $518 (Assuming 1.5 - 6 hours x $78/hr + $50 in misc parts.)
Operating:	Fuel consumption may increase by one to one and a half percent due to additional backpressure.
Maintenance:	$156 - $312 (Assuming 2 - 4 hours labor per year.)
Comments:	Diesel particulate filters should be cleaned regularly. Because of their higher backpressures (e.g., 20 – 70+ in. wc.) and the potential for masking by lube oil ash, ARB staff expect that the periodic maintenance of DPFs will be necessary. ARB staff expect that the maintenance costs listed above reflect the minimum.

Certifications:	
Durability: (How long can the technology be expected to function under normal operating conditions and still achieve the specified emission reductions?)	Manufacturers claim that the useful life of the technology can be as high as 8,000 to 12,000 service hours if properly maintained. However, this may be reduced when a C-DPF is installed on a poorly maintained engine with leaking fuel injectors, a dirty intake air cleaner, excessive oil consumption and/or lubricating oil in the exhaust. In addition, particulate matter can build up on a C-DPF when an engine does not achieve the proper regeneration temperature for the proper duration (i.e. soot overloading). With this build up, if the C-DPF subsequently begins to regenerate, the collected particulate can oxidize uncontrollably and destroy the particulate filter.
Warranty:	Diesel particulate filters typically carry a 2,000 service hour warranty.
Affect on Engine Warranty: (When possible, identify any impact the technology may have on an engine's warranty.)	The technology imposes additional exhaust flow restrictions of between 20" to 70" of water column or more. In some applications, such as severe cyclic operations, the engine may not generate enough heat to oxidize the collected particulate matter and regenerate the filter. This can lead to soot overloading and backpressures beyond the manufacturer's recommended limit. The specific impact on an original equipment manufacturer (OEM) engine warranty is not known.
Adverse Impacts: **Environmental:**	See "Special Operating Requirements" section below.
Safety:	No known adverse safety impacts.
Special Operating Requirements: (e.g., very-low sulfur fuel or minimum exhaust temperature, etc...)	As is the case with most processes that incorporate catalytic oxidation, the formation of sulfates increases at higher temperatures. Depending on the exhaust temperature and the sulfur content of the fuel, the increase in sulfate particles may offset a portion of the C-DPF's particulate reductions. In addition, sulfur dioxide can counteract the effect of the catalyst material and increase the C-DPF's regeneration temperature. Diesel fuel with a very low sulfur content will maximize the emission reduction capability of this technology.
	C-DPFs must be selected for the specific engine and its associated duty cycle. All engines must be able to maintain the minimum regeneration temperature (which varies by product) for at least 20% - 50% of the engine's duty cycle.
Current Status: (Is the technology commercially available, or is it still under development? How many engines has the technology been installed on, and how long has the technology been in use?)	The technology is commercially available. According to the VERT study [1999], C-DPFs have been installed on several thousand mobile diesel engines. The technology has also been installed on a few stationary diesel engines.

Other: (e.g., fuel penalty, reduced product life, weight, affect on engine performance, etc...)	The size and weight of one manufacturer's C-DPFs are as follows: **<u>HP</u>** **<u>Diameter</u>** **<u>Length</u>** **<u>Weight</u>** 40 8.1" 18.5" 17 lb 100 9.6" 25.5" 34 lb 275 11.9" 30.6" 47 lb 400 15.7" 34.2" 87 lb 1,400 2@ 20.7" 38.2" 151 lb
	The determination of whether or not a used C-DPF would be considered a "hazardous waste" depends on the material(s) used in the catalytic coating. C-DPFs can be manufactured with catalytic coatings such that the product would not be considered a hazardous waste at the end of its useful life. Further, the Department of Toxic Substances Control currently regulates used automotive catalytic converters as scrap metal as long as the catalyst is left in the converter shell during collection and transport and the converters are going for recycling.
	The ash residue associated with cleaning and maintaining a C-DPF would need to be tested before a hazardous waste determination could be made.
Impacts of Lower Sulfur Diesel Fuel	Use of diesel fuel with a very low sulfur content will improve the technology's particulate reduction efficiency. A recent study sponsored by the U.S. Department of Energy (DOE) found that fuel sulfur levels have a significant impact on the ability of C-DPFs to reduce particulate emissions. The study also concluded that fuel sulfur levels of less than 150 ppm are necessary in order to achieve reductions in particulate emission from some C-DPFs.
Comments: (Address other issues relevant to the use of this technology, including other advantages/disadvantages of using the technology.)	In addition to reducing particulate emissions, the technology also reduces carbon monoxide and hydrocarbon emissions.

List of Applications

Technology Name: Catalyzed Diesel Particulate Filter

Facility / Operator	Engine Information	Permit / Registration	Number of Applications	Time in Service	PM Emission Limit	PM Emission Test Results
Sierra Nevada Brewing Company, Inc. Chico, CA	Make: Caterpillar Model: 3412 Application: Generator Fuel Type: Shell Amber 363 DPF: Engelhard DPX	Authority to Construct No. SNB-99-09-AC Issued by Butte County AQMD	Two C-DPFs installed on each of two emergency backup generators.	Recent Installation	0.0584 lb/hr	Emission testing completed in March 2000. Results pending.
New York Metropolitan Transportation Authority[1]	Make: Detroit Diesel Model: Series 50 Application: Transit Bus Fuel Type: Reduced Sulfur Diesel (30 ppm S) DPF: Johnson Matthey CRT	n/a	22	Since February 2000	n/a	Pending
San Diego School District[2]	Make: International Model: 530E Application: School Bus Fuel Type: ARCO EC-D DPF: Engelhard DPX & Johnson Matthey CRT	n/a	5 w/ DPX 5 w/ CRT	Since December 1999	n/a	See List of Emission Test Results

[1] New York MTA Clean Diesel Demonstration Program. As part of this program, the New York MTA intends to evaluate the technology on twenty-five DDC Series 50 and twenty-five DDC 6V92 transit bus engines over a one year period.

[2] Fleet managed by Navistar as part of the ARCO EC-D Demonstration Program.

ARCO Distribution[3]	Make: Cummins Model: M11 Application: Tanker Truck Fuel Type: ARCO EC-D DPF: Engelhard DPX & Johnson Matthey CRT	n/a	5 w/ DPX 5 w/ CRT	Unknown	n/a	See List of Emission Test Results
Ralphs Grocery[4]	Make: Detroit Diesel Model: Series 60 Application: Grocery Truck Fuel Type: ARCO EC-D DPF: Engelhard DPX & Johnson Matthey CRT	n/a	5 w/ DPX 5 w/ CRT	Unknown	n/a	See SAE paper 2000-01-1854 for detailed emission test results.
Swedish Public Transportation Association	Make: Unknown Model: Unknown Application: Transit Bus Fuel Type: Low Sulfur Diesel DPF: Johnson Matthey CRT	n/a	1994: 10 Buses 1996: 1,000 Buses 1999: 2,000 Buses 1999: 1,000 Trucks		Unknwon	Unknown

3 Fleet managed by ARCO as part of the ARCO EC D-Demonstration Program.

4 Fleet managed by the National Renewable Energy laboratory (NREL) as part of the ARCO EC-D Demonstration Program.

List of Emission Test Results

Technology Name: Catalyzed Diesel Particulate Filter

Method & Type of Test	Source Test Company	Product Information	Engine Information	Pollutant	Baseline Emissions	Emission Rate w/ Controls	Control Efficiency
Central Business District (CBD)	Environment Canada, Emission Research and Measurement Division, Report #97-26771-3 (Unpublished)	Nett SF Soot Filter Mfg. by Nett Technologies	Make: Navistar Model: T444 Diesel-Electric Year: Not known BHP: Not known Application: Hybrid Diesel-Electric Transit Bus Configuration: Not known Engine Hours: Not known Fuel Type: Certification Diesel D2 Fuel Use: Not known Exhaust Temp: Not known	 PM NOx CO HC	w/ oxidation catalyst 0.318 g/mile 10.66 g/mile 1.78 g/mile 0.22 g/mile	600 rpm Config. 0.036 g/mile 11.16 g/mile 0.12 g/mile 0.04 g/mile	 92% -5% 93% 82%
				  PM NOx CO HC	w/ oxidation catalyst 0.318 g/mile 10.66 g/mile 1.78 g/mile 0.22 g/mile	750 rpm Config. 0.027 g/mile 10.62 g/mile 0.13 g/mile 0.13 g/mile	 89% 0% 93% 41%
Special transient cycle designed for a specific wheel loader application.[5]	Emissions Research and Measurement Division, Environment Canada	DPX Particulate Filter Mfg. by Engelhard Corporation	Make: Caterpillar Model: 988 Year: Unknown BHP: 320 Application: Wheel loader Configuration: Unknown Engine Hours: Unknown Fuel Type: 530 ppm S Diesel Fuel Use: 15.8 kg/hr Exhaust Temp: Unknown	PM NOx CO HC	17.38 g/hr 290.72 g/hr 112.65 g/hr 9.32 g/hr	0.59 g/hr 224.96 g/hr 35.67 g/hr 2.96 g/hr	97% 23% 68% 68%

5 Study reported in SAE Technical Paper #1999-01-0110 entitled “The Impact of Retrofit Exhaust Control Technologies on Emissions from heavy-Duty Diesel Construction Equipment.”

ISO 8178 C1	AB Svensk Motor Test Center	CleanDiesel Soot Filter Mfg. by Clean Air Systems	Make: Volvo Model: TD61-G Year: Unknown BHP: 78 hp Application: Mobile Source Configuration: Unknown Engine Hours: Unknown Fuel Type: 50 ppm S MK-1 Diesel Fuel Use (lb/hp-hr): 0.376 / 0.380 Exhaust Temp: Unknown	PM NOx CO HC	0.14 g/bhp-hr 9.55 g/bhp-hr 2.33 g/bhp-hr 0.22 g/bhp-hr	0.02 g/bhp-hr 9.17 g/bhp-hr 0.02 g/bhp-hr 0.01 g/bhp-hr	85% 4% 99% 97%

European Stationary Cycle (OICA)[6]	Engineering Test Services, Charleston, SC	Catalyzed Diesel Particulate Filter	Make: Caterpillar Model: 3126 Year: 1998 or 1999 BHP: 275 hp Application: N/A Configuration: Turbocharged & Aftercooled Engine Hours: Not Reported Fuel Type: Diesel w/ varying fuel sulfur levels Fuel Use (lb/hp-hr): 0.35 - 0.36 Exhaust Temp: Not Reported	PM NOx CO HC	3 ppm Sulfur 0.0613 g/hphr 4.94 g/hphr 0.98 g/hphr 0.0542 g/hphr	3 ppm Sulfur 0.0031 g/hphr 4.92 g/hphr 0.06 g/hphr 0.0228 g/hphr	95% 0% 94% 58%
				PM NOx CO HC	30 ppm Sulfur 0.063 g/hphr 4.98 g/hphr 0.96 g/hphr 0.056 g/hphr	30 ppm Sulfur 0.0166 g/hphr 4.8 g/hphr 0.02 g/hphr 0.0182 g/hphr	74% 4% 98% 68%
				PM NOx CO HC	150 ppm S 0.0708 g/hphr 4.85 g/hphr 1.04 g/hphr 0.0586 g/hphr	150 ppm Sulfur 0.0707 g/hphr 4.87 g/hphr 0.02 g/hphr 0.0105 g/hphr	0% 0% 98% 82%
				PM NOx CO HC	350 ppm S 0.0793 g/hphr 4.91 g/hphr 0.94 g/hphr 0.0565 g/hphr	350 ppm Sulfur 0.176 g/hphr 4.69 g/hphr 0.03 g/hphr 0.0194 g/hphr	-122% 4% 97% 66%

[6] Emission test results reported in "Diesel Emission Control - Sulfur Effects (DECSE) Program, Phase I Interim Data Report No. 4: Diesel Particulate Filters - Final Report," January 2000.

European Stationary Cycle (OICA)[7]	Engineering Test Services, Charleston, SC	Continuously Regenerating Diesel Particulate Filter	Make: Caterpillar Model: 3126 Year: 1998 or 1999 BHP: 275 hp Application: N/A Configuration: Turbocharged & Aftercooled Engine Hours: Not Reported Fuel Type: Diesel w/ varying fuel sulfur levels Fuel Use (lb/hp-hr): 0.35 - 0.36 Exhaust Temp: Not Reported	 PM NOx CO HC	<u>3 ppm Sulfur</u> 0.0613 g/hphr 4.94 g/hphr 0.98 g/hphr 0.0542 g/hphr	<u>3 ppm Sulfur</u> 0.0032 g/hphr 4.96 g/hphr 0.1 g/hphr 0.0136 g/hphr	 95% 0% 90% 75%
				 PM NOx CO HC	<u>30 ppm Sulfur</u> 0.063 g/hphr 4.98 g/hphr 0.96 g/hphr 0.056 g/hphr	<u>30 ppm Sulfur</u> 0.0176 g/hphr 4.84 g/hphr 0.06 g/hphr 0.0052 g/hphr	 72% 3% 94% 91%
				 PM NOx CO HC	<u>150 ppm S</u> 0.0708 g/hphr 4.85 g/hphr 1.04 g/hphr 0.0586 g/hphr	<u>150 ppm Sulfur</u> 0.0729 g/hphr 4.88 g/hphr 0.06 g/hphr 0.0189 g/hphr	 -3% -1% 94% 68%
				 PM NOx CO HC	<u>350 ppm S</u> 0.0793 g/hphr 4.91 g/hphr 0.94 g/hphr 0.0565 g/hphr	<u>350 ppm Sulfur</u> 0.2025 g/hphr 4.81 g/hphr 0.05 g/hphr 0.0064 g/hphr	 -155% 2% 95% 89%

7 Emission test results reported in "Diesel Emission Control - Sulfur Effects (DECSE) Program, Phase I Interim Data Report No. 4: Diesel Particulate Filters - Final Report," January 2000.

Federal Test Procedure[8]	Southwest Research Institute, Inc.	One Individual Diesel Particulate Filters	Make: Detroit Diesel Corporation Model: DDC 6067TK60 (DDC Series 60) Year:1998 BHP: 400 hp Application: Heavy Duty Vehicle Configuration: Turbocharged & Aftercooled Engine Hours: Not Reported Fuel Type: 368 ppm S Diesel Fuel Use (lb/bhp-hr): 0.393 - 0.401 Exhaust Temp: Approx 100-800°F	PM NOx CO HC	0.073 g/bhp-hr 3.991 g/bhp-hr 1.111 g/bhp-hr 0.115 g/bhp-hr	DPF "A" 0.022 g/bhp-hr 3.960 g/bhp-hr 0.403 g/bhp-hr 0.006 g/bhp-hr	70% 1% 64% 95%
Federal Test Procedure [2]	Southwest Research Institute, Inc.	Two Individual Diesel Particulate Filters	Make: Detroit Diesel Corporation Model: DDC 6067TK60 (DDC Series 60) Year:1998 BHP: 400 hp Application: Heavy Duty Vehicle Configuration: Turbocharged & Aftercooled Engine Hours: Not Reported Fuel Type: 54 ppm S Diesel Fuel Use (lb/bhp-hr): 0.396 - 0.402 Exhaust Temp: Approx 100-800°F	PM NOx CO HC	0.063 g/bhp-hr 3.836 g/bhp-hr 1.200 g/bhp-hr 0.109 g/bhp-hr	DPF "B" 0.008 g/bhp-hr 3.901 g/bhp-hr 0.077 g/bhp-hr 0.005 g/bhp-hr	87% -2% 94% 95%
				PM NOx CO HC	0.063 g/bhp-hr 3.836 g/bhp-hr 1.200 g/bhp-hr 0.109 g/bhp-hr	DPF "A" 0.006 g/bhp-hr 4.062 g/bhp-hr 0.267 g/bhp-hr 0.019 g/bhp-hr	90% -6% 78% 83%

8 The FTP emission test information was presented in the May 1999 report "Demonstration of Advanced Emission Control Technologies Enabling Diesel-Powered Heavy-Duty Engines to Achieve Very Low Emission Levels" prepared for the Manufacturers of Emission Controls Association by Southwest Research Institute, Inc.

Federal Test Procedure[9]	Southwest Research Institute, Inc.	Continuously Regenerating Trap (CRT) by Johnson Matthey	Make: Detroit Diesel Corporation Model: 6V92TA MUI Year: 1986 BHP: 253 hp Application: Transit Bus Configuration: Turbocharged & Aftercooled Engine Miles: Over 300,000 miles Fuel Type: 2-D Certification Diesel Fuel Use (lb/hr): 64.8 - 66.6 Exhaust Temp: Not Reported Note: Pre-Rebuild w/ CRT & Uninsulated	 PM NOx CO HC	<u>500 ppm S</u> 0.44 g/bhp-hr 10.5 g/bhp-hr 1.0 g/bhp-hr 0.7 g/bhp-hr	<u>100 ppm S</u> 0.03 g/bhp-hr 10.3 g/bhp-hr 0.1 g/bhp-hr 0.1 g/bhp-hr	 93% 2% 90% 86%
City-Suburban heavy Vehicle Route (CSHVR)[10]	West Virginia University	Engelhard DPX Particulate Filter	Make: International Model: 530E Year: 1988 BHP: 275 hp Application: School Bus Configuration: Not Reported Engine Miles: Not Reported Fuel Type: ARCO EC-D Fuel Use (mpg): 4.68/5.09 4.46/4.49 Exhaust Temp: Not Reported	 PM NOx CO HC	<u>Bus 3</u> 0.180 g/mile 18.14 g/mile 2.06 g/mile 0.466 g/mile	<u>Bus 3</u> 0.000 g/mile 16.05 g/mile 0.11 g/mile 0.000 g/mile	<u>Bus 3</u> 100% 11% 95% 100%
				 PM NOx CO HC	<u>Bus 4</u> 0.192 g/mile 18.11 g/mile 2.45 g/mile 0.487 g/mile	<u>Bus 4</u> 0.000 g/mile 16.45 g/mile 0.18 g/mile 0.000 g/mile	<u>Bus 4</u> 100% 9% 93% 100%

9 The emission test information was submitted to support Johnson Matthey's application for certification of a Low Sulfur 0.1 g/bhp-hr PM Emissions Reduction Rebuild Kit for all transit engines.

10 Emission test results reported in SAE paper 2000-01-1854 entitled "EC-Diesel Technology Validation Program Interim Report." (Unpublished)

City-Suburban heavy Vehicle Route (CSHVR)[11]	West Virginia University	Johnson Matthey CRT Particulate Filter	Make: Cummins Model: M11 Year: 1995-96 BHP: 330 hp Application: Tanker Truck Configuration: Not Reported Engine Miles: Not Reported Fuel Type: ARCO EC-D Fuel Use (mpg): 5.92/5.53 & 4.79/4.95 Exhaust Temp: Not Reported	 PM NOx CO HC	<u>Truck 3</u> 0.510 g/mile 14.05 g/mile 3.25 g/mile 1.026 g/mile	<u>Truck 3</u> 0.015 g/mile 12.49 g/mile 0.49 g/mile 0.068 g/mile	<u>Truck 3</u> 97% 11% 85% 93%
				 PM NOx CO HC	<u>Truck 4</u> 0.613 g/mile 15.26 g/mile 2.53 g/mile 1.456 g/mile	<u>Truck 4</u> 0.037 g/mile 15.37 g/mile 0.15 g/mile 0.153 g/mile	<u>Truck 4</u> 94% -1% 94% 89%

[11] Emission test results reported in SAE paper 2000-01-1854 entitled “EC-Diesel Technology Validation Program Interim Report.” (Unpublished)

List of Emission Test Results

Technology Name: Diesel Particulate Filter

Method & Type of Test	Source Test Company	Product Information	Engine Information	Pollutant	Baseline Emissions	Emission Rate w/ Controls	Control Efficiency
Central Business District (CBD) - Heavy Duty Chassis Dynamometer Emission Test	Environment Canada, Emission Research and Measurement Division, Report #97-26771-3 (Unpublished)	Nett SF Soot Filter Mfg. by Nett Technologies	Make: Navistar Model: T444 Diesel-Electric Year: Not known BHP: Not known Application: Hybrid Diesel-Electric Transit Bus Configuration: Not known Engine Hours: Not known Fuel Type: Certification Diesel D2 Fuel Use: Not known Exhaust Temp: Not known	 PM NOx CO HC	w/ oxidation catalyst 0.318 g/mile 10.66 g/mile 1.78 g/mile 0.22 g/mile	600 rpm Config. 0.036 g/mile 11.16 g/mile 0.12 g/mile 0.04 g/mile	 92% -5% 93% 82%
				  PM NOx CO HC	w/ oxidation catalyst 0.318 g/mile 10.66 g/mile 1.78 g/mile 0.22 g/mile	750 rpm Config. 0.027 g/mile 10.62 g/mile 0.13 g/mile 0.13 g/mile	 89% 0% 93% 41%
Special transient cycle designed for a specific wheel loader application.	Emissions Research and Measurement Division, Environment Canada[12]	DPX Particulate Filter Mfg. by Engelhard Corporation	Make: Caterpillar Model: 988 Year: Unknown BHP: 320 Application: Wheel loader Configuration: Unknown Engine Hours: Unknown Fuel Type: 530 ppm S Diesel Fuel Use: 15.8 kg/hr Exhaust Temp: Unknown	PM NOx CO HC	17.38 g/hr 290.72 g/hr 112.65 g/hr 9.32 g/hr	0.59 g/hr 224.96 g/hr 35.67 g/hr 2.96 g/hr	97% 23% 68% 68%

12 Study reported in SAE Technical Paper #1999-01-0110 entitled "The Impact of Retrofit Exhaust Control Technologies on Emissions from heavy-Duty Diesel Construction Equipment."

ISO 8178 C1	AB Svensk Motor Test Center	CleanDiesel Soot Filter Mfg. by Clean Air Systems	Make: Volvo Model: TD61-G Year: Unknown BHP: 78 hp Application: Mobile Source Configuration: Unknown Engine Hours: Unknown Fuel Type: 50 ppm S MK-1 Diesel Fuel Use (lb/hp-hr): 0.376 / 0.380 Exhaust Temp: Unknown	PM NOx CO HC	0.14 g/bhp-hr 9.55 g/bhp-hr 2.33 g/bhp-hr 0.22 g/bhp-hr	0.02 g/bhp-hr 9.17 g/bhp-hr 0.02 g/bhp-hr 0.01 g/bhp-hr	85% 4% 99% 97%

Control Technology Evaluation

Item	Response
Product Name:	Platinum Plus® DFX Fuel Borne Catalyst + Diesel Particulate Filter
Product Vendor:	Clean Diesel Technologies, Inc.
Vendor Address:	300 Atlantic Street, Suite 702 Stamford, CT 06901-3522
Product Description: (What is the product, and how does it work?)	The technology involves combining the use of a concentrated liquid fuel-borne catalyst (FBC) with an uncatalyzed or lightly catalyzed Diesel Particulate Filter (DPF). The technology reduces particulate matter emissions through catalytic oxidation and filtration. The FBC contains low doses (i.e., 4 - 8 ppm) of platinum and cerium that work together to improve particulate oxidation within the combustion chamber and to lower the temperature at which regeneration occurs within a DPF. While similar to a catalyzed DPF, an FBC enhances DPF regeneration by encouraging better contact between the particulate matter and the catalyst material. The FBC+DPF combination reduces both the carbonaceous and soluble organic fractions of DPM.
Applicability: (What types of engines can the product be installed on?)	The technology can be applied to all stationary and portable diesel engines rated at 5,000 hp or less, and can be retrofitted to existing equipment. However, the technology may not be appropriate for applications where an engine and its associated duty cycle do not generate enough heat to oxidize the collected particulate matter and regenerate the filter. For example, the FBC+DPF combination may not be appropriate for engines with exhaust temperatures routinely below 540°F. The FBC manufacturer recommends that an FBC+DPF equipped engine operate such that the exhaust gas temperatures reach 660°F for at least 20 minutes during each 8 hour period of operation.
Manufacturer's Emission Reduction Claim: (What level of emission reduction can be achieved?)	The manufacturer claims that the technology reduces particulate emissions by 70 - 95%.
Emission Reduction Guarantee:	The manufacturer's emission reduction guarantee depends on the engine's baseline emission level.
Certifications: (Identify certifications the product has received, and explain any limits on those certifications.)	Platinum Plus is registered by the U.S. Environmental Protection Agency as a diesel fuel additive.
Emission Test Results: (Summarize emission test results and describe in detail on the attached table.)	**Engine Make/Model** / **Test Cycle** / **PM Reduction** DDC Series 60 / FTP Transient / 57% - 96% Cummins 6BTA / FTP Transient / 95% Cummins N-14 / FTP Transient / 79%

Costs: Initial Retail:	The cost of uncatalyzed or lightly catalyzed particulate filters varies by engine size as follows: $1,300 for a 40 hp engine; $2,000 for a 100 hp engine; $3,500 for a 275 hp engine; $7,000 for a 400 hp engine; and $30,000 for a 1,400 hp engine. The cost of on -board dosing systems is approximately $1,500 - $3,000 for a field retrofit, and $500 - $1,000 if factory installed.
Installation:	$167 - $518 (Assuming 1.5 - 6 hours x $78/hr + $50 in misc parts.)
Operating:	The cost of the FBC is $0.05 - $0.10 per gallon of diesel for bulk treatment or on-board dosing, and $0.10 - $0.15 per gallon of diesel for individually packaged products (quart or gallon containers).
Maintenance:	$156 - $312 (Assuming 2 - 4 hours labor per year.)
Comments:	Diesel particulate filters should be cleaned regularly. Because of higher backpressures and the potential for masking by lube oil ash, ARB staff expects that the periodic maintenance of DPFs will be more frequent and possibly more extensive than that of diesel oxidation catalysts. ARB staff expects that the maintenance costs listed above reflect the minimum.
Durability / Product Life: (How long can the technology be expected to function under normal operating conditions and still achieve the specified emission reductions?)	The manufacturer states that the shelf life of Platinum Plus, when packaged individually, is 24 months, and that its shelf life is 12 - 18 months when mixed with diesel fuel.
	Manufacturers claim that the useful life of a DPF can be as high as 8,000 to 12,000 service hours if properly maintained. However, this may be reduced when a DPF is installed on a poorly maintained engine with leaking fuel injectors, a dirty intake air cleaner, excessive oil consumption and/or lubricating oil in the exhaust. In addition, particulate matter can build up on a DPF when an engine does not achieve the proper regeneration temperature for the proper duration (i.e., soot overloading). With this build up, if the DPF subsequently begins to regenerate, the collected particulate matter can oxidize uncontrollably and destroy the filter. Because the product lowers particulate oxidation temperatures, it can reduce the risk of plugging and uncontrolled regeneration.
Product Warranty:	DPFs typically carry a 2,000 service hour warranty.
Affect on Engine Warranty: (When possible, identify any impact the technology may have on an engine warranty.)	The engine manufacturer should be contacted to determine the specific impact of an FBC+DPF combination on an OEM engine warranty.
Adverse Impacts: **Environmental:**	One FTP emission test suggests that the application of the FBC+DPF combination on an engine equipped with exhaust gas recirculation (EGR) may increase hydrocarbon emissions. See Comments section.
Safety:	There are no known adverse safety impacts.

Special Operating Requirements: (e.g., very-low sulfur fuel or minimum exhaust temperature, etc...)	The FBC manufacturer recommends that an FBC+DPF equipped engine operate such that the exhaust gas temperatures reach 660°F for at least 20 minutes during each 8 hour period of engine operation. In addition, the exhaust temperature should be maintained below 930°F to avoid and/or minimize sulfation.
Current Status: (Is the technology commercially available, or is it still under development? How many engines has the technology been installed on, and how long has the technology been in use?)	The technology is commercially available and has been applied to over 100 city buses in Taiwan, six buses in Hong Kong, and twelve pieces of construction and mining equipment in Germany and Switzerland.
Other: (e.g., fuel penalty, reduced product life, weight, affect on engine performance, etc...)	The available emission test data shows that fuel economy varies from an increase of 2% to a decrease of 3%.
Impacts of Lower Sulfur Diesel Fuel	Although the technology can be applied to existing California diesel fuel formulations with sulfur contents up to 500 ppm, the use of low sulfur diesel fuel should improve the emission reduction efficiency of this technology.
Comments: (Address other issues relevant to the use of this technology, including other advantages / disadvantages of using the technology.)	The FBC+DPF technology appears to have a variable effect on hydrocarbon emissions. When tested on a DDC Series 60 engine equipped with EGR, hydrocarbon emissions increased by approximately 150% although the emissions did not exceed the applicable NOx+HC standard. However, other tests on the same engine without EGR show hydrocarbon reductions of 57% - 82%. When tested on a Cummins N-14 engine, hydrocarbon emissions were reduced by 80%, and when tested on a Cummins 6BTA engine, they were reduced by 64%.
	The manufacturer suggests that, when used with a lightly catalyzed DPF, the FBC+DPF combination can dramatically reduce both hydrocarbon and carbon monoxide emissions. In addition to selecting a precatalyzed DPF, a filter can be lightly catalyzed by conditioning it for 20 hours on FBC treated fuel.

List of Stationary &/or Portable Applications

Technology Name: Platinum Plus Fuel Borne Catalyst + Diesel Particulate Filter

Facility / Operator	Engine Information	Permit / Registration	Number of Applications	Time in Service	PM Emission Limit	PM Emission Test Results
There are no known stationary or portable applications of this technology.	Make: Model: Application: Fuel Type:					

List of Emission Test Results

Technology Name: Platinum Plus Fuel Borne Catalyst + Diesel Particulate Filter

Method & Type of Test	Source Test Company	Product Information	Engine Information	Pollutant	Baseline Emissions	Emission Rate w/ Controls	Control Efficiency
FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + Diesel Particulate Filter	Make: Detroit Diesel Corporation Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged, Aftercooled, EGR Engine Hours: Not Reported Fuel Type: No. 2 Diesel (368 ppm S) Fuel Use (lb/hp-hr): 0.408 / 0.400 Exhaust Temp: Not Reported	PM NOx CO HC	0.204 g/bhp-hr 2.492 g/bhp-hr 2.528 g/bhp-hr 0.063 g/bhp-hr	0.009 g/bhp-hr 2.312 g/bhp-hr 1.863 g/bhp-hr 0.156 g/bhp-hr	96% 7% 26% -148%
FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + Diesel Particulate Filter	Make: Detroit Diesel Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged Engine Hours: Not Reported Fuel Type: Diesel (350 ppm S) Fuel Use (lb/hp-hr): 0.403 / 0.409 Exhaust Temp: Not Reported	PM NOx CO HC	0.074 g/bhp-hr 4.051 g/bhp-hr 1.128 g/bhp-hr 0.146 g/bhp-hr	0.014 g/bhp-hr 4.048 g/bhp-hr 0.658 g/bhp-hr 0.049 g/bhp-hr	81% 0% 42% 66%

FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + Diesel Particulate Filter	Make: Detroit Diesel Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged Engine Hours: Not Reported Fuel Type: Diesel (350 ppm S) Fuel Use (lb/hp-hr): 0.403 / 0.416 Exhaust Temp: Not Reported	PM NOx CO HC	0.074 g/bhp-hr 4.051 g/bhp-hr 1.128 g/bhp-hr 0.146 g/bhp-hr	0.017 g/bhp-hr 3.969 g/bhp-hr 0.665 g/bhp-hr 0.071 g/bhp-hr	77% 2% 41% 51%
FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + *Catalyzed* Diesel Particulate Filter	Make: Detroit Diesel Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged Engine Hours: Not Reported Fuel Type: Diesel (350 ppm S) Fuel Use (lb/hp-hr): 0.403 / 0.400 Exhaust Temp: Not Reported	PM NOx CO HC	0.074 g/bhp-hr 4.051 g/bhp-hr 1.128 g/bhp-hr 0.146 g/bhp-hr	0.032 g/bhp-hr 3.953 g/bhp-hr 0.411 g/bhp-hr 0.032 g/bhp-hr	57% 2% 64% 78%
FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + *Lightly* *Catalyzed* Diesel Particulate Filter	Make: Detroit Diesel Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged Engine Hours: Not Reported Fuel Type: CARB Diesel (50 ppm S) Fuel Use (lb/hp-hr): 0.390 / 0.408 Exhaust Temp: Not Reported	PM NOx CO HC	0.060 g/bhp-hr 0.681 g/bhp-hr 0.927 g/bhp-hr 0.098 g/bhp-hr	0.013 g/bhp-hr 3.786 g/bhp-hr 0.342 g/bhp-hr 0.018 g/bhp-hr	78% 3% 63% 82%

FTP Transient	Cummins Engine Company	Clean Diesel Technology Platinum Plus 3100C & Rhone-Poulenc Eolys DPX9 + Diesel Particulate Filter	Make: Cummins Model: Encore 6BTA Year: 1996 BHP: 225 Application: Medium Duty Vehicle Configuration: EGR Engine Hours: 400 hrs Fuel Type: Diesel (350 ppm S) Fuel Use (lb/hp-hr): Not Reported Exhaust Temp: Not Reported	PM NOx CO HC	0.231 g/bhp-hr 2.64 g/bhp-hr 1.44 g/bhp-hr 0.22 g/bhp-hr	0.011 g/bhp-hr 2.14 g/bhp-hr 1.39 g/bhp-hr 0.08 g/bhp-hr	95% 19% 3% 64%
FTP Transient (Hot Start Only)	Southwest Research Institute	Platinum Plus DFX + Diesel Particulate Filter	Make: Cummins Model: N-14 Year: 1998 BHP: 370 Application: Heavy Duty Vehicle Configuration: Not Reported Engine Hours: 1000 Fuel Type: Diesel Fuel Use (lb/hp-hr): 0.393 / 0.391 Exhaust Temp: Not Reported	PM NOx CO HC	0.100 g/bhp-hr 3.869 g/bhp-hr 0.505 g/bhp-hr 0.174 g/bhp-hr	0.021 g/bhp-hr 3.628 g/bhp-hr 0.487 g/bhp-hr 0.035 g/bhp-hr	79% 6% 4% 80%

Control Technology Evaluation

Item	Response
Product Name:	Unikat Combifilter
Product Vendor:	Engine Control Systems
Vendor Address:	165 Pony Drive Newmarket, Ontario Canada, L3Y 7V1
Product Description: (How does it work?)	The product is a diesel particulate filter system which incorporates electrical regeneration. Typically, the particulate filter media consists of either a ceramic wall-flow monolith (e.g., cordierite or silicon carbide) or woven ceramic fibers. The ceramic wall-flow monoliths capture diesel particulate matter primarily through surface filtration, and the woven ceramic fibers capture diesel particulate matter though depth filtration. To prevent plugging of the filter media and to minimize system backpressure, particulate filters must be periodically cleaned. This process of cleaning a particulate filter, termed regeneration, involves the oxidation of the collected particulate matter. Where passive particulate filter systems incorporate catalyst material to lower the temperature at which the collected particulate matter oxidizes, this technology actively regenerates the particulate filter via an electrical heating element. The regeneration is electronically controlled and can be completed in either 30 minutes or 8 hours, depending upon the system chosen.
Applicability: (What types of engines can the product be installed on?)	Individual particulate filter systems are available for diesel engines rated at between 25 and approximately 200 hp. Multiple filter elements can be used together for larger applications.
Achieved Emission Reductions:	**Product** / **Test Cycle** / **PM Reduction** Unikat Combifilter / Special Transient / 81% Unikat Combifilter with oxidation catalyst / ISO 8178 / 95%
Emission Reduction Guarantee:	The manufacturer guarantees that their product will reduce DPM emissions by at least 80%.
Costs: Initial Retail:	The initial cost is approximately: $4,450 for a 40 hp engine; $5,780 for a 100 hp engine; $11,690 for a 275 hp engine; $14,000 for a 400 hp engine; and $40,250 for a 1,400 hp engine.
Installation:	For single and dual filter systems: $206 - $518 (Assuming 2 - 6 hours x $78/hr + $50 in misc parts.)

Operating:	For a generator larger than 275 hp, the cost to regenerate the filter is about 1% of the energy produced. The regeneration cost is higher for smaller engine generator sets--up to 7% for a 40 hp engine. In addition, fuel consumption may increase by one to one and a half percent due to additional backpressure.
Maintenance:	$312 for prime engine (assume 2 cleanings at 2 hours labor each - total of 4 hours labor per year) and $156 for emergency backup engine every five years (assume 2 hours labor).
Comments:	The particulate filter systems must be cleaned every 1,000 - 1,500 hours of service to remove accumulated ash. The exact interval is dependent on lube oil consumption.
Certifications:	**Product** **Certification** **Agency** Unikat Combifilter 80% DPM Removal Swiss VERT Program Unikat Combifilter 80% DPM Removal Sweden Environmental Zones--Off-road
Durability / Product Life: (How long can the technology be expected to function under normal operating conditions and still achieve the specified emission reductions?)	Some installations have been in operation over 20,000 hours. The manufacturer does not provide a guarantee for product life.
Product Warranty:	The manufacturer provides a twelve month limited warranty covering manufacturing defects and workmanship. Other warranties may be provided on a case by case basis.
Affect on Engine Warranty: (When possible, identify any impact the technology may have on an engine's warranty.)	The engine manufacturer should be contacted to determine the specific impact of the product on an OEM engine warranty. However, the technology is sized to stay within OEM backpressure limitations.
Adverse Impacts: **Environmental:**	There are no known adverse environmental impacts.
Safety:	There are no known adverse safety impacts.
Special Operating Requirements: (e.g., very-low sulfur fuel or minimum exhaust temperature, etc...)	230V or 400V electrical service is required.

<table>
<tr><td>Current Status:
(Is the technology commercially available, or is it still under development? How many engines has the technology been installed on, and how long has the technology been in use?)</td><td>The technology is commercially available in Europe and Asia and has been employed on captive fleet vehicles such as fork lifts and front end loaders, stationary and mining engines with total installation base of 3,000. According to the manufacturer, the product will be marketed in the United States as of September 1, 2000.</td></tr>
<tr><td>Other:
(e.g., fuel penalty, reduced product life, weight, affect on engine performance, etc...)</td><td>The size and weight of actively regenerated DPF’s are as follows:
<table><tr><th>HP</th><th>Diameter</th><th>Length</th><th>Weight</th></tr><tr><td>40 hp</td><td>13.8" - 25.7"</td><td>7.4" - 10.8"</td><td>53 lb - 64 lb</td></tr><tr><td>100 hp</td><td>12.2" - 14.5"</td><td>14.6" - 28.4"</td><td>64 lb - 179 lb</td></tr><tr><td>275 hp</td><td>- -</td><td>- -</td><td>- -</td></tr><tr><td>400 hp</td><td>2 @ 13.8"</td><td>2 @ 20"</td><td>2 @ 86 lb</td></tr></table></td></tr>
<tr><td>Impacts of Lower Sulfur Diesel Fuel:</td><td>The product can be used with California’s existing diesel fuel formulations.</td></tr>
<tr><td>Comments:
(Address other issues relevant to the use of this technology, including other advantages / disadvantages of using the technology.)</td><td>The product regenerates independently of engine exhaust temperature and is suitable for any size engine working under any duty cycle including long idle or light load conditions.</td></tr>
</table>

List of Stationary &/or Portable Applications

Technology Name: Unikat Combifilter

Facility / Operator	Engine Information	Permit / Registration	Number of Applications	Time in Service	PM Emission Limit	PM Emission Test Results
There are no known portable or stationary applications Unikat Combifilter in U.S.	Make: Model: Application: Fuel Type:					
However, a Combifilter system is operational in Welland, Ontario, Canada.	Make: Cummins Model: B5.9 Application: Taylor lift truck Fuel Type: Diesel, unknown S concentration		1	27 Months		

List of Emission Test Results

Technology Name: Unikat Combifilter

Method & Type of Test	Source Test Company	Product Information	Engine Information	Pollutant	Baseline Emissions	Emission Rate w/ Controls	Control Efficiency
Special transient cycle designed for a specific backhoe application.	Emission Research and Measurement Division, Environment Canada[13]	Combifilter Mfg. by Engine Control Systems	Make: Caterpillar Model: 3054DIT Year: 1994 BHP: 84 Application: Backhoe Configuration: Unknown Engine Hours: Unknown Fuel Type: 530 ppm S Diesel Fuel Use: 4.66 kg/hr Exhaust Temp: Unknown	PM NOx CO HC	8.46 g/hr 93.79 g/hr 41.66 g/hr 5.47 g/hr	1.77 g/hr 98.70 g/hr 37.56 g/hr 5.17 g/hr	79% -5% 10% 5%
ISO 8178 C1	AB Svensk Bilprovning	Combifilter with oxidation catalyst Mfg. by Engine Control Systems	Make: Perkins Model: 1004T Year: Unknown BHP: about 44 (for 33.7 kw) Application: Unknown Configuration: Unknown Engine Hours: Unknown Fuel Type: 30 ppm S Diesel Fuel Use: 234-236 g/kwh Exhaust Temp: Unknown	PM NOx CO HC	0.59 g/kwh 13.1 g/kwh 4.71 g/kwh 0.48 g as $CH_{1.85}$/kwh	0.03 g/kwh unk 0.11 g/kwh 0.04 g as $CH_{1.85}$/kwh	95% NA 98% 92%

[13] Study reported in SAE Technical Paper #1999-01-0110 entitled "The Impact of Retrofit Exhaust Control Technologies on Emissions from Heavy-Duty Diesel Construction Equipment."

ISO 8178 C1	AB Svensk Bilprovning	Combifilter with oxidation catalyst Mfg. by Engine Control Systems	Make: Scania Model: Unknown Year: Unknown BHP: 150 (for 114.9 kw) Application: Unknown Configuration: Unknown Engine Hours: Unkown Fuel Type: 30 ppm S Diesel Fuel Use: 223-225 g/kwh Exhaust Temp: Unknown	PM NOx CO HC	0.21 g/kwh 9.65 g/kwh 0.98 g/kwh 0.89 g as $CH_{1.85}$/kwh	0.01 g/kwh 9.68 g/kwh 0.12 g/kwh 0.07 g as $CH_{1.85}$/kwh	95% -0.3% 88% 92%

APPENDIX 2

Potential Cancer Risk Associated
with the Air Dispersion Modeling Results

Air Resources Board staff used the U.S. EPA's Industrial Source Complex-Short Term (ISCST3) air dispersion model to estimate the annual average concentration of particulate matter (PM) emitted from standby stationary diesel-fueled engines of different horsepower ratings. This Appendix identifies the potential cancer risk associated with being exposed to those annual average concentrations. Section I identifies the air dispersion modeling assumptions and inputs. Section II is a series of graphs that illustrate the risk associated with the annual average concentrations of PM. Section III presents our study of the effect of hours of operation on risk.

The estimated potential cancer risks and assumptions presented in this Appendix do not necessarily represent any specific source of diesel PM. The estimated cancer risks reported are based on the diesel PM concentration at the point of maximum impact as determined using air dispersion modeling. The estimated risk estimates as presented in Sections II and III provide a "qualitative" assessment of potential risk levels near sources of diesel PM. These estimates are based use of the ISCST3 air dispersion model and assumptions identified in Sections I and III. Actual risk levels from these types of sources will vary due to site specific parameters, including equipment technologies and emission rates, fuel properties, operating schedules, meteorology, and actual location of off-site receptors.

I. MODELING ASSUMPTIONS AND INPUTS

A. Horsepower ratings
We estimated the diesel PM emissions from diesel-fueled engines with the following horsepower ratings: 100, 200, 300, 400, 500, 750, 1000, and 1400.

B. Emission Factor
0.1 g/bhp-hr

C. Annual hours of operation
Each standby engine operates 50 hours per year for routine maintenance or testing to ensure it is operating properly.

D. Time of Day
Testing or maintenance of standby engines typically occurs during the daytime (i.e., 6 a.m. to 6 p.m.).

E. Hour of Day
The hour of the day that presents the highest concentration of PM emissions is 3 p.m. (See Section H. Meteorological Data for the determination of when this "hour of day" occurs.)

F. Load
Load factor is equal to 100%.

G. Modeling Inputs
See Table 1 below.

Table 1: Standby Diesel Engine Parameters										
					QS	HS	TS		DS	VS
Engine	calculated Fuel Use	Load	Exhaust Flow	Exhaust Flow	emission rate	stack height	stack temp	stack diameter	stack diameter	stack velocity
HP	(gal/hr)	(%)	(dscfm)	(acfm)	g/s	meters	K	inches	meters	m/s
50	2.8	100	124	282	0.00139	3	622	2	0.051	65.7
100	5.2	100	225	514	0.00278	3	622	3	0.076	53.2
200	10.4	100	450	1028	0.00556	3	622	4	0.102	59.9
300	15.5	100	675	1541	0.00833	3	622	5	0.127	57.5
400	20.7	100	900	2055	0.01111	3	622	5	0.127	76.6
500	25.9	100	1125	2569	0.01389	3	622	6	0.152	66.5
600	31.1	100	1350	3083	0.01667	3	622	6	0.152	79.8
700	36.3	100	1575	3597	0.01944	3	622	7	0.178	68.4
750	38.9	100	1688	3854	0.02083	3	622	7	0.178	73.3
800	41.5	100	1800	4111	0.02222	3	622	8	0.203	59.9
900	46.6	100	2025	4624	0.02500	3	622	8	0.203	67.3
1000	51.8	100	2250	5138	0.02778	3	622	9	0.229	59.1
1100	57.0	100	2475	5652	0.03056	3	622	10	0.254	52.7
1200	62.2	100	2700	6166	0.03333	3	622	10	0.254	57.5
1300	67.4	100	2925	6680	0.03611	3	622	11	0.279	51.4
1400	72.6	100	3150	7194	0.03889	3	622	12	0.305	46.6
1500	77.7	100	3376	7707	0.04167	3	622	13	0.330	42.5

1. Stack velocity (VS):

   VS was calculated as follows:

VS = (Actual exhaust cubic feet per minute (acfm) x (1/stack cross-sectional area)

Acfm = (dscfm)(exhaust temp) / (ambient temp)(1-[% moisture by vol])

Dscfm (dry standard exhaust cubic feet per minute) calculated using U.S. EPA Method 19 "F" factors (An "F" factor is the ratio of combustion gas volumes to heat inputs.)

Where:

Dscfm = (fuel use)("F" factor)(O_2 correction)(load)(diesel heat content)
Fuel use (gal/hr) = (7100 btu/bhp-hr)(1 gal/137,000btu)(hp)
"F" factor = 9190 dscf/1,000,000 btu
O_2 correction = 20.9/(20.9-10.8)
Load = 100%
Diesel heat content =137,000 btu/gal
Exhaust temperature = 622 K
% moisture by volume = 7.10%

2. Emission rate (QS) = (hp rating)(emission factor)(load)(1hr/3600 sec)

3. Stack height (HS): 3.0 meters

4. Stack temperature (TS): 622 K

5. Stack diameter (DS): Note: stack diameter was interpolated from known engine configurations

6. Setting: Urban

H. **Meteorological Data:** Offsite representative meteorological data from Anaheim (1981) and West Los Angeles (1981) was used. The worst case hour is the hour of the day that results in the highest modeled concentrations of PM. The worst case hour was determined as follows:

1. The worst case hour was assumed to occur between 6 a.m. and 6 p.m.

2. The ISCST3 model was run for a 100-hp engine emitting during the 6 a.m. and 12 noon hours and during the 1 p.m. to 6 p.m. hours.

3. Modeling inputs for the 100 hp engine are as follows:
   - QS = 0.00278 g/sec
   - HS = 3.0 meters
   - TS = 622^0K
   - VS = 53.2 m/sec
   - DS = 0.076 meters

4. The fraction of each hour (duration) during which PM emissions occurred was set to be 0.137. (50 emission days/year/365 days/year = 0.137).

5. The highest annual average concentration value was in the afternoon hours.

6. Next, each afternoon hour was run individually.
   For example, the ISCST3 model was run for the 100-hp engine emitting at 1 p.m.
   This was repeated for the 2 p.m. hour, the 3 p.m. hour, the 4 p.m. hour, the 5 p.m. hour, and finally the 6 p.m. hour.

7. This procedure was completed for the 100-hp engine using the Anaheim and the West Los Angeles (LA) meteorology.

8. This procedure was completed for the 1400-hp engine using the Anaheim and the West Los Angeles (LA) meteorology.

9. Modeling inputs for the 1400 hp engine are as follows:
   - QS = 0.0389 g/sec
   - HS = 3.0 meters
   - TS = 622^0K
   - VS = 46.5 m/sec
   - DS = 0.305 meters

10. The highest annual average concentration value was at the 3 p.m. hour. Therefore, the worst case hour for both the Anaheim and the West LA meteorology data is considered to be the 3 p.m. hour.

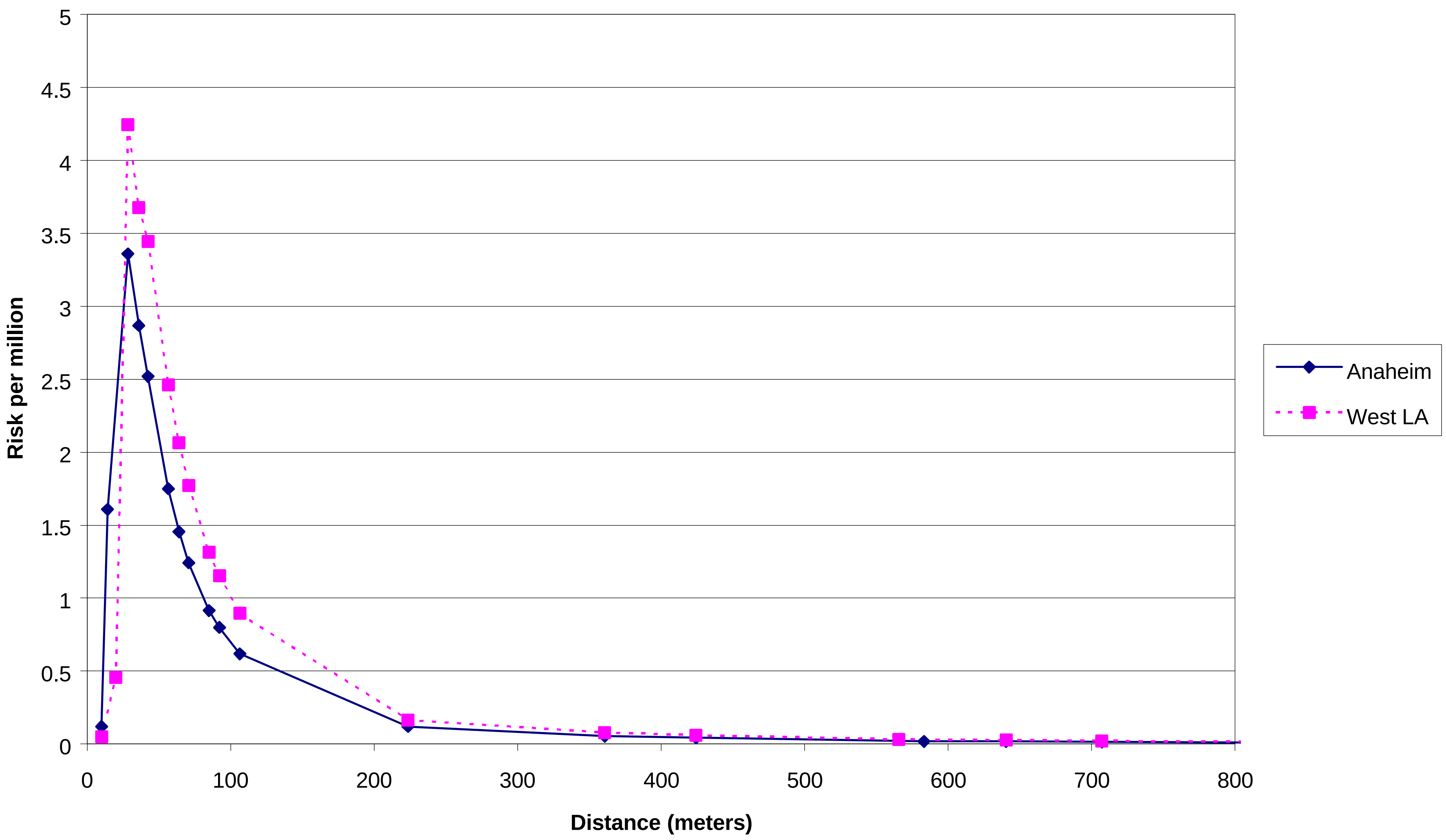
II. RISK CALCULATIONS

The ISCST3 air dispersion model was used to estimate the annual average concentration ($\mu g/m^3$). The potential cancer risk to nearby receptors was estimated by multiplying the annual average concentration by the reasonable unit risk factor (URF) for diesel particular matter, 300×10^{-6} $(\mu g/m^3)^{-1}$.

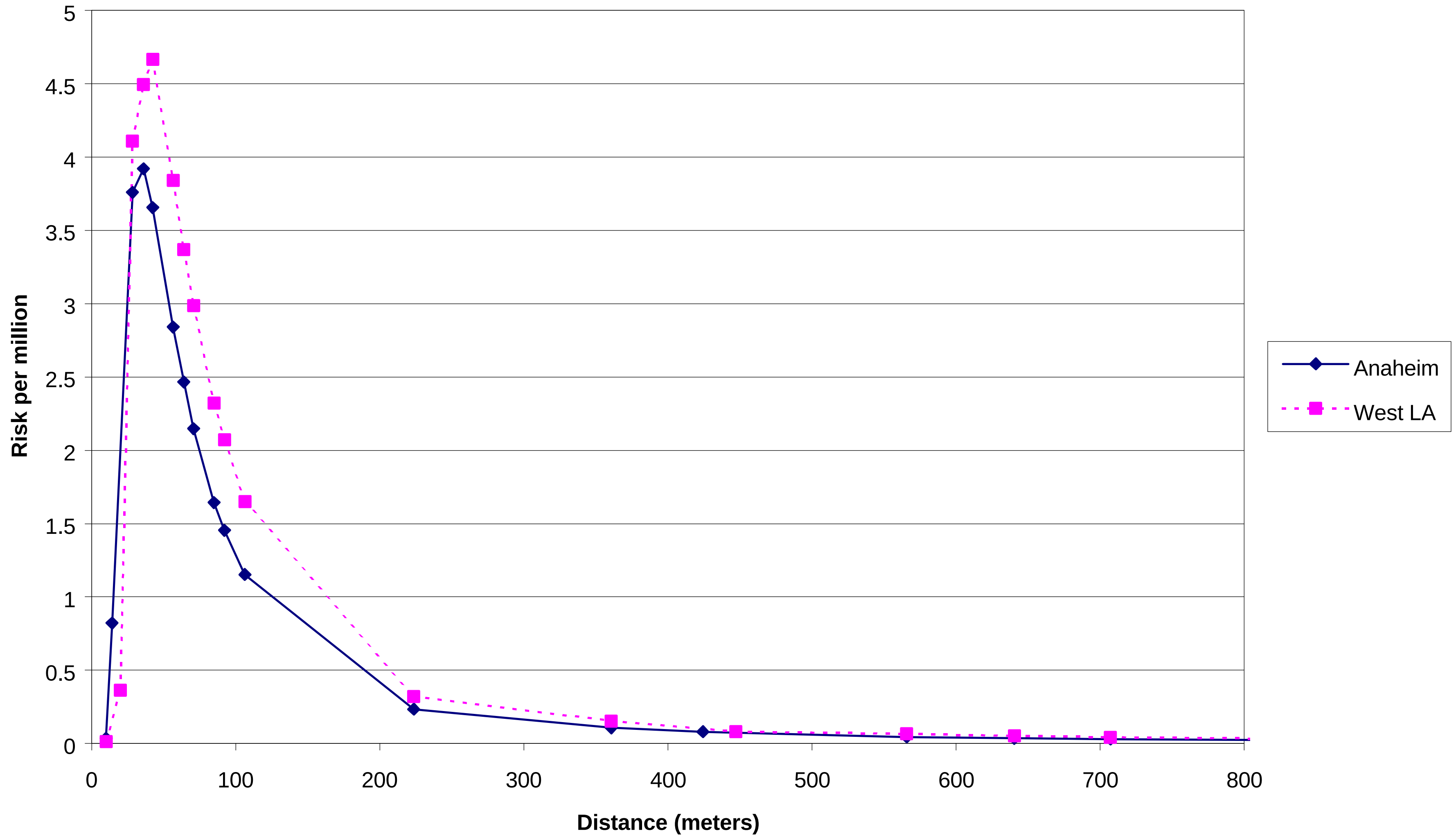
A. **Eight individual engine emission graphs:** Graphs 1 through 8 show the potential cancer risk at several receptor distances for the eight different horsepower engines modeled (100, 200, 300, 400, 500, 750, 1000, 1400 hp).

B. **Summary Graph:** Graph 9 is a summary of graphs 1 through 8. Each engine's maximum potential cancer risk was plotted at the distance where the highest concentration was modeled to have occurred. In addition to the eight engines, a 50 hp engine was modeled using the West Los Angeles meteorology and included on the graph.

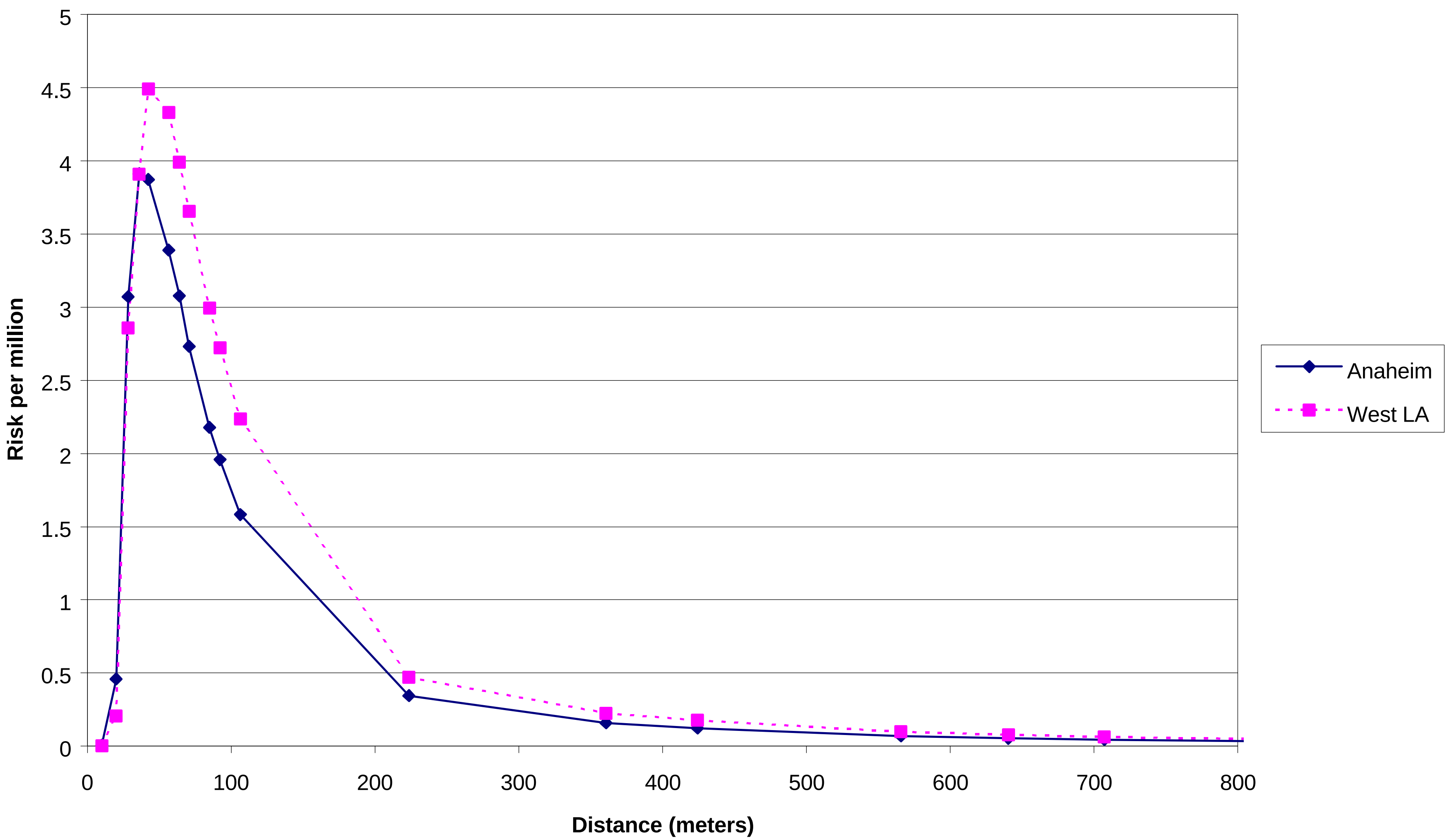
Graph 1: 100 Horsepower Standby Diesel Engine
0.1 g/bhp-hr and 50 Hours/year at 100% Load



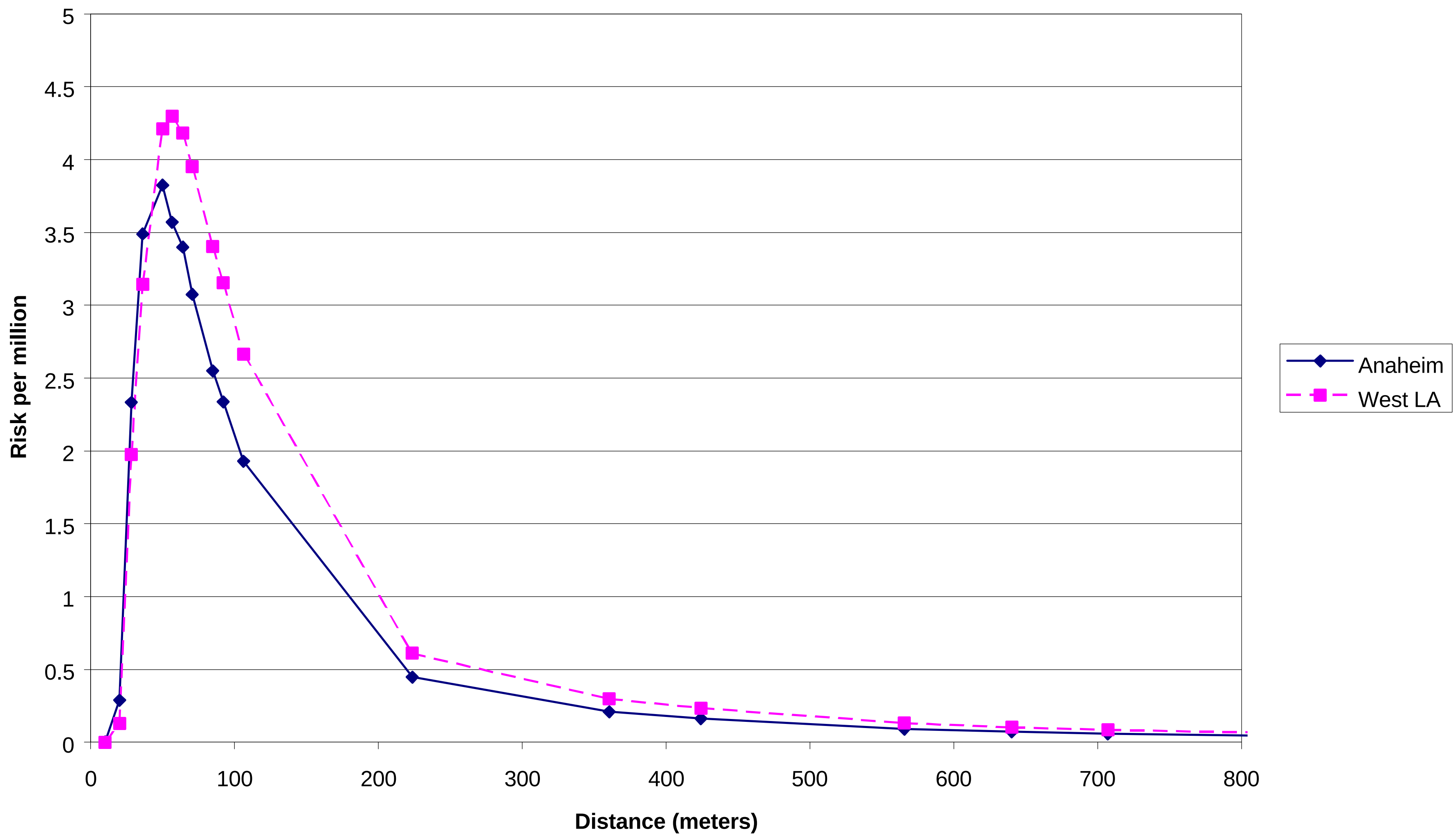
Graph 2: 200 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load

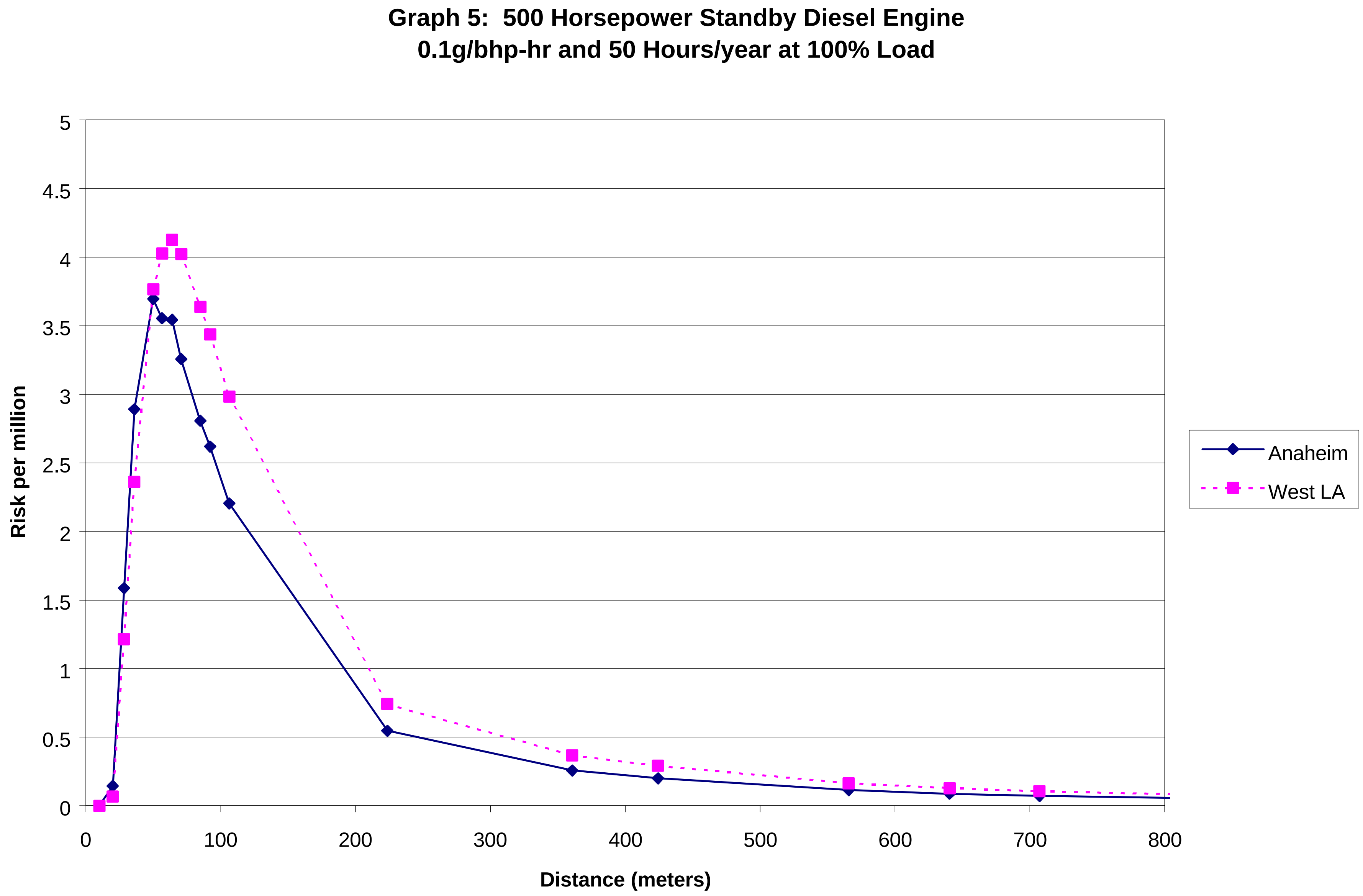


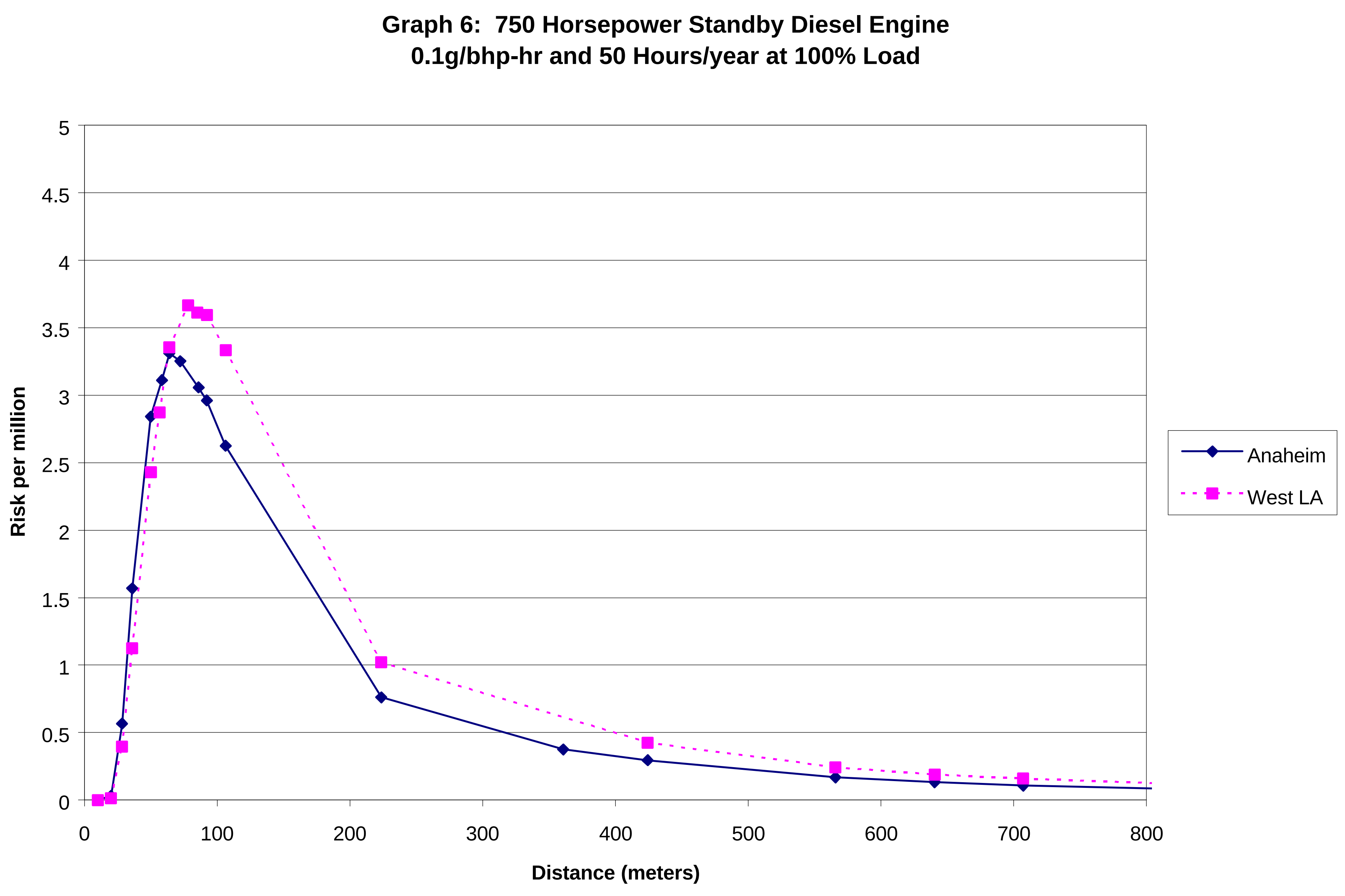
Graph 3: 300 HorsepowerStandby Diesel Engine
0.1 g/bhp-hr and 50 Hours/year at 100% Load



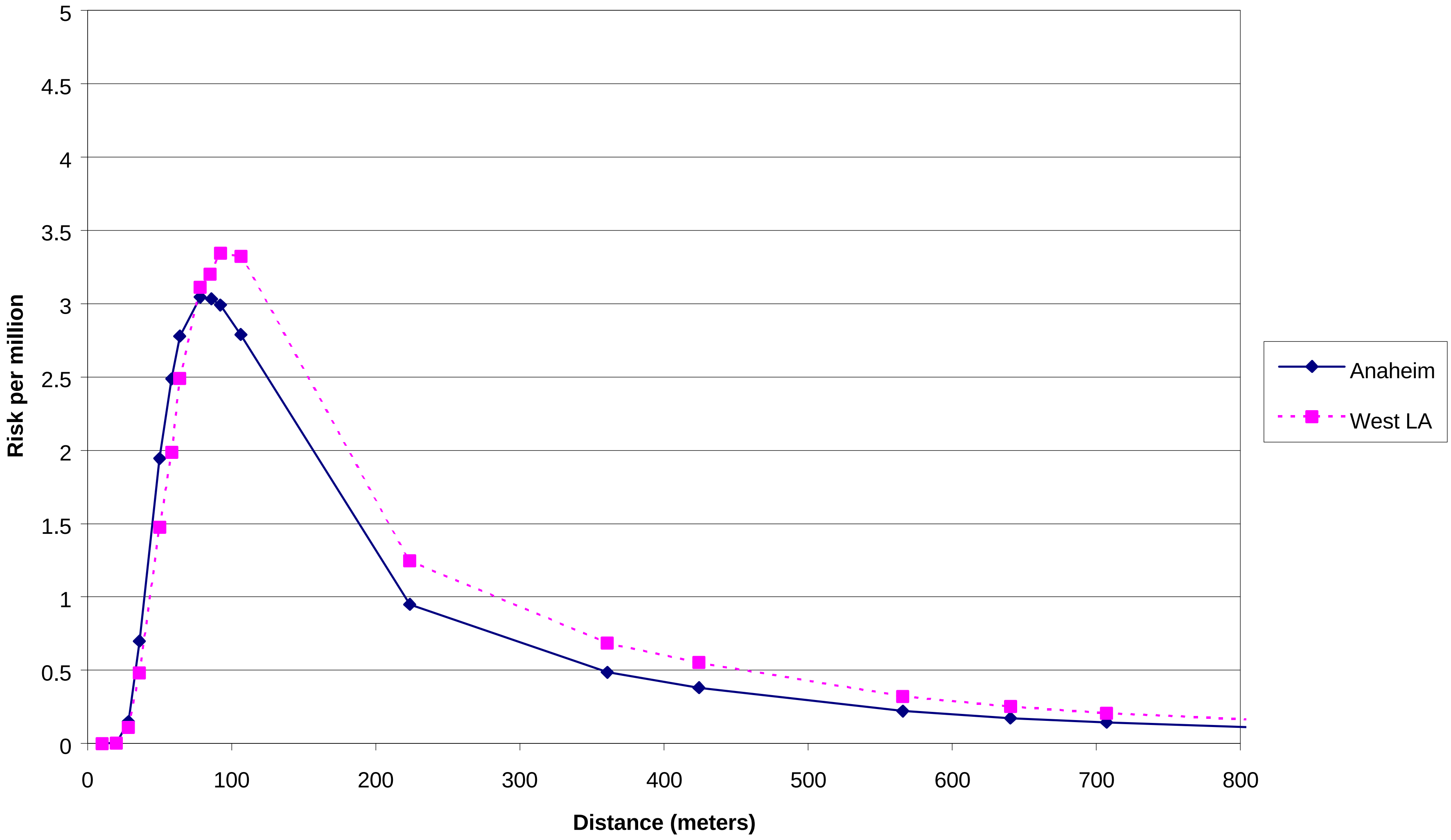
Graph 4: 400 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load



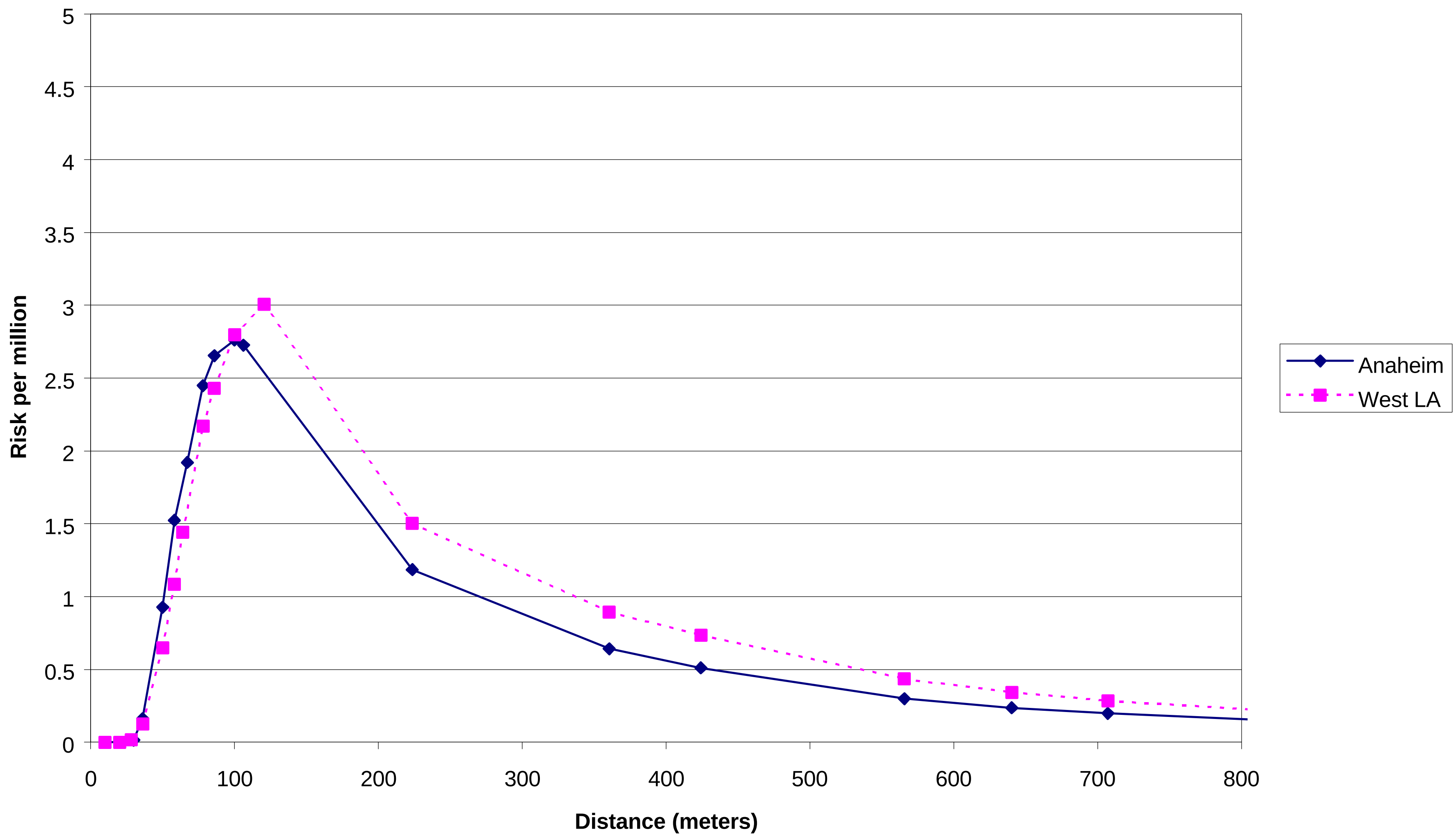

Graph 5: 500 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load
Risk per million
Distance (meters)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
100
200
300
400
500
600
700
800
Anaheim
West LA

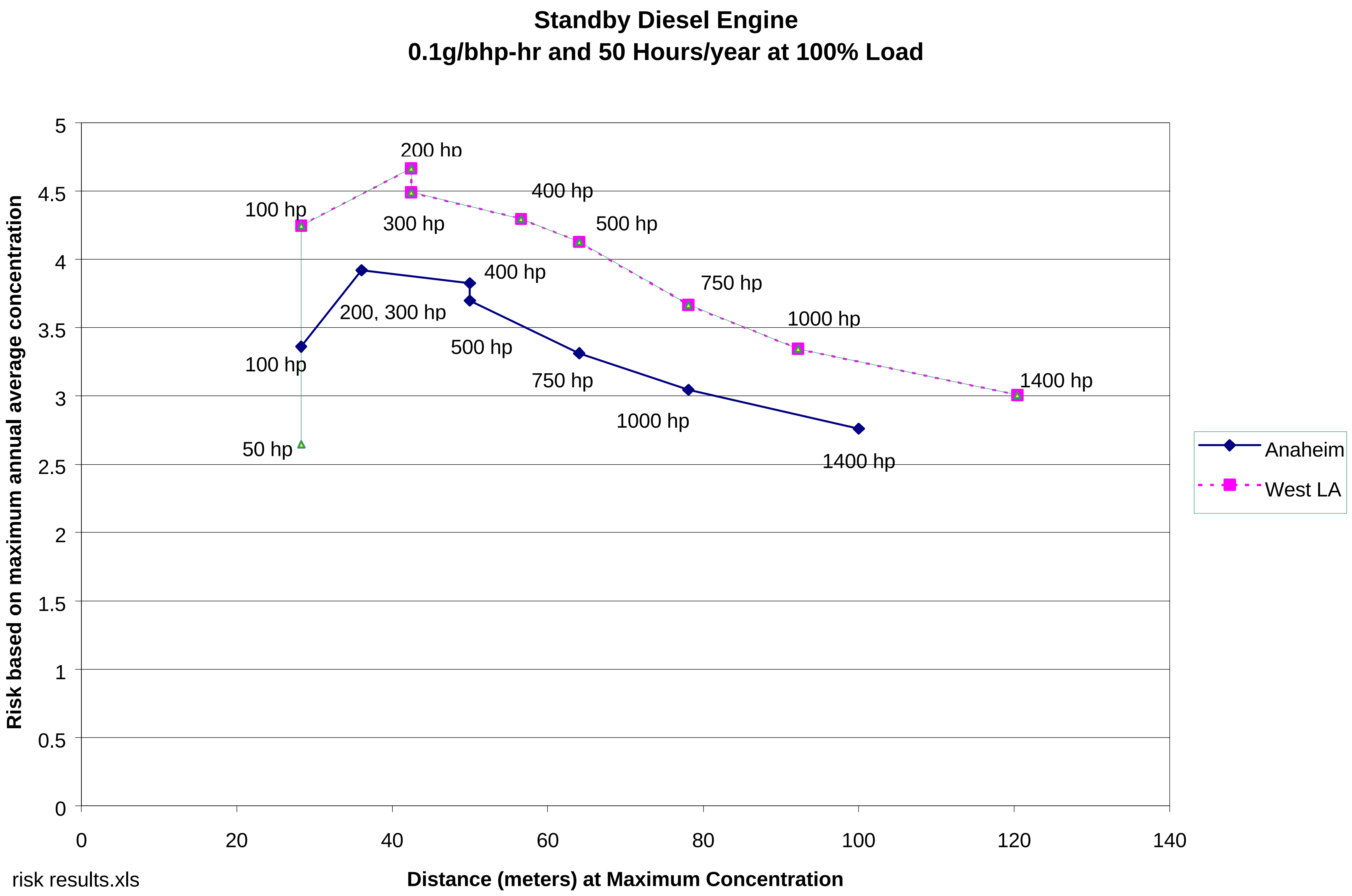

Graph 6: 750 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load
Risk per million
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
100
200
300
400
500
600
700
800
Distance (meters)
Anaheim
West LA

Graph 7: 1000 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load



Graph 8: 1400 Horsepower Standby Diesel Engine
0.1 g/bhp-hr and 50 hours/year at 100% Load




Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load
Risk based on maximum annual average concentration
Distance (meters) at Maximum Concentration
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20
40
60
80
100
120
140
200 hp
400 hp
100 hp
300 hp
500 hp
400 hp
750 hp
200, 300 hp
1000 hp
500 hp
100 hp
750 hp
1400 hp
1000 hp
50 hp
1400 hp
Anaheim
West LA
risk results.xls

III. Hours of Operation

A. Worst Case Modeling

Once we established that the size of the engine did not necessarily drive the risk of cancer, we evaluated increasing hours of operation. Specifically, we evaluated a 500 hp engine operating at 50, 100, 300 500 and 1000 hours of operation. We utilized the same modeling inputs as already described for a 500 hp engine.

We used the West Los Angeles meteorological data. West Los Angeles meteorology has a predominant wind direction that drives higher risk results. We chose West Los Angeles meteorology as a worst case meteorology.

The fraction of each hour (duration) during which PM emissions occurred was set to be 0.137 for the 50 hour per year scenario only. (50 emission days/year/365 days/year = 0.137.) Since the hours of operation increased, so did the fraction of each hour during which PM emissions occurred. The maximum duration input value is 1, for any given hour. The fraction of each hour during which PM emissions occurred is presented in Table 2 below.

Table 2: Fraction of each hour during which PM emissions occurred

A	B	C	D
Hours of Operation per year	Hours of Operation per year/ 365 days per year	B/2	B/3
50	**0.137** (3 p.m.)		
100	**0.274** (3 p.m.)		
300	**0.822** (3 p.m.)		
500	1.37 (greater than 1, so divided between 2 hours)	**0.685** (2 & 3 p.m.)	
1000	2.74 (greater than 2, so divided among 3 hours)		**0.913** (2, 3, & 4 p.m.)

As the hours of operation exceeded multiples of 365, the duration of the emission had to be divided into an additional hour.

To model an engine emitting a total of 500 hours per year requires adding another 0.37 of an hour. Rather than model the emissions with 1 in the 3 p.m. hour and 0.37 in the 2 p.m. hour, we distributed the 1.37 equally between the 2 p.m. and the 3 p.m. hour. Hence, the 0.0685 input from column C. Likewise, the 1000 hour of operation per year engine required three hours to share the total emission time.

From this exercise, we established that hours of operation does drive the risk of cancer.

B. Uniform Distribution Modeling

Our next exercise was to distribute the emissions across the 12 daytime hours or 6 a.m. to 5 p.m. Our last exercise was to distribute the emissions across all 24 hours of the day. We did this for both the 500 hp engine and the 1000 hp engine.

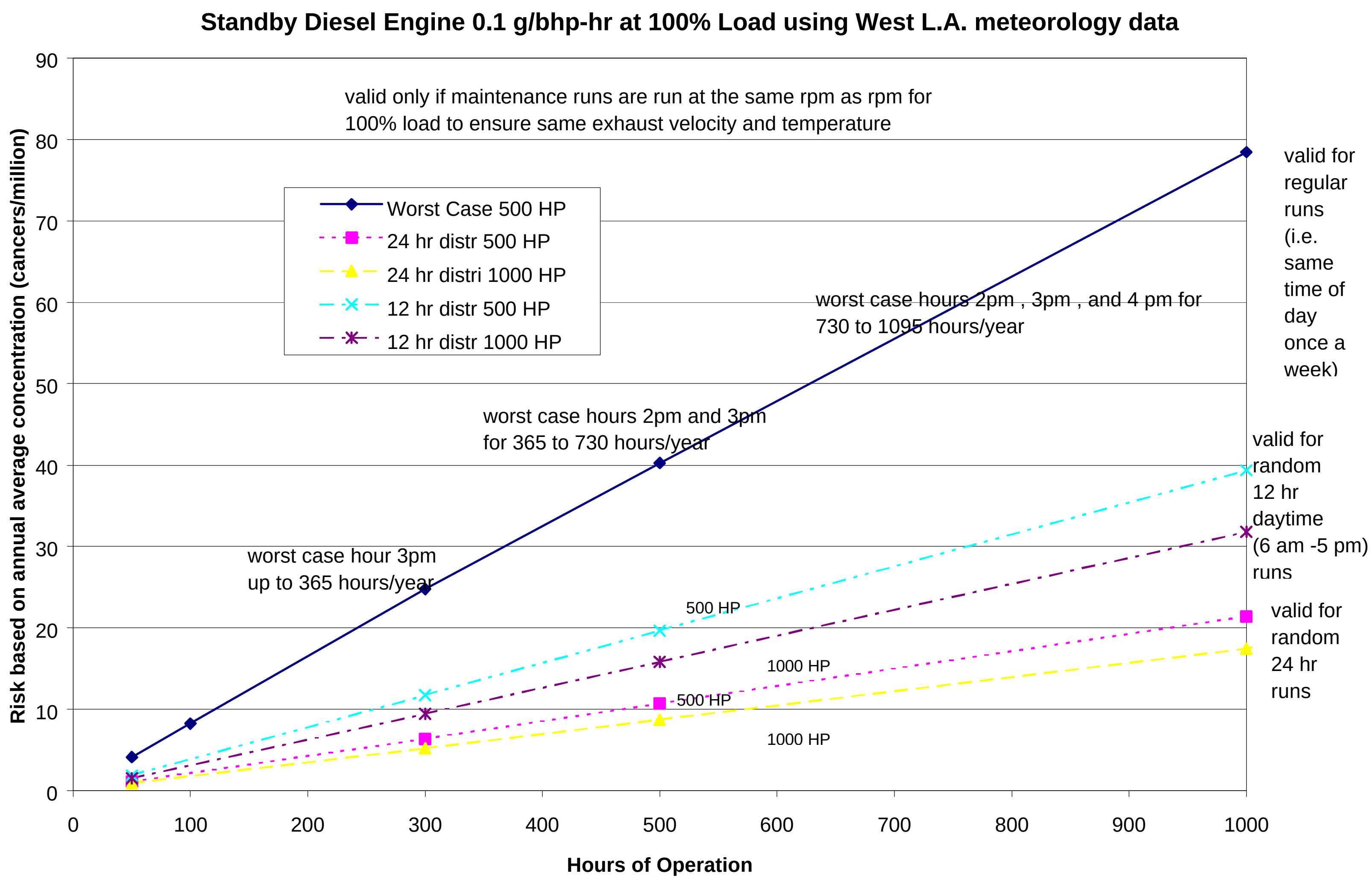
The fraction of each hour during which PM emissions occurred is presented in Table 3 below.

Table 3: Fraction of each hour during which PM emissions occurred			
A	**B**	**C**	**D**
Hours of Operation per year	Hours of Operation per year/ 365 days per year	B/12	B/24
300	0.822	0.068	0.034
500	1.37	0.114	0.057
1000	2.74	0.228	0.114
8760	24	X	24

Because the results are linear, i.e. concentration is proportional to emission rate, only one engine was modeled for the 12-hour distribution and only one engine was modeled for the 24-hour distribution. The concentration and risk for the other engine sizes were calculated with the following equation:

$$\frac{\text{X (concentration in } \mu g/m^3)}{\text{Fraction of each hour}} = \frac{\text{known concentration in } \mu g/m^3 \text{ from modeled run}}{\text{fraction of each hour from modeled run}}$$

The results are presented graphically below.


Standby Diesel Engine 0.1 g/bhp-hr at 100% Load using West L.A. meteorology data
Risk based on annual average concentration (cancers/million)
Hours of Operation
0
10
20
30
40
50
60
70
80
90
0
100
200
300
400
500
600
700
800
900
1000
Worst Case 500 HP
24 hr distr 500 HP
24 hr distri 1000 HP
12 hr distr 500 HP
12 hr distr 1000 HP
valid only if maintenance runs are run at the same rpm as rpm for 100% load to ensure same exhaust velocity and temperature
worst case hours 2pm , 3pm , and 4 pm for 730 to 1095 hours/year
worst case hours 2pm and 3pm for 365 to 730 hours/year
worst case hour 3pm up to 365 hours/year
valid for regular runs (i.e. same time of day once a week)
valid for random 12 hr daytime (6 am -5 pm) runs
valid for random 24 hr runs
500 HP
1000 HP
500 HP
1000 HP

APPENDIX 3

Draft Sierra Nevada Brewery Source Test Protocol

Sierra Nevada Brewery Source Test Protocol

Purpose

- Determine the emission of particulate emissions, NO_x, CO, HC, and SO_2 from two 1100 hp diesel-fired engines

- Ensure that the emissions meet district permit conditions

- Evaluate the effectiveness of add-on control equipment applied to two 1100 hp diesel-fired engines by determining the particulate matter concentration output before and after add-on controls with Method 5

- Evaluate the change in particulate emissions from using SHELL AMBER 363 vs. CARB Diesel at load

- Evaluate the change in particulate emissions from operating at a weekly level (1 hour /week, no load, 1800 RPMs) vs. operating continuously (with maximum load - facility may rent load bank to simulate load - 1800 RPMs) on CARB Diesel

- Measure sulfur level and other parameters of fuel (SHELL AMBER 363 and CARB Diesel)

Quality Assurance Objectives

Accuracy – include data quality objectives for calibrations, method detection limits, and quality assurance samples

Precision – provide for duplicate analytical samples

Completeness – plan two runs of each test method

Representativeness

- sample at ports away from flow disturbances, sample from a sufficient number of sample points at defined positions across stack traverses, and check that flow is parallel to sample nozzles

- collect sample during normal source operation and collect over as long a period as practical to include any normal variation in operation

Source Test Protocol For
1100 Horsepower Diesel Generators at Sierra Nevada Brewery

	Fuel	**Operation**	**Before or After Control**	**Test Method**	Engine	# of Samples
Particulate Emission Source Test for Continuous (load) Operation for Engine #1 **And CO, O_2, NO_x, and HC Determination** (Remember to take fuel sample to test sulfur content and aromatic HC)						
1.	SHELL AMBER 363	(load)	Before	ARB Method 5 and Method 100 *	#1	2
2.	SHELL AMBER 363	(load)	After Catalyst #1	ARB Method 5 and Method 100	#1	2
3.	SHELL AMBER 363	(load)	After Catalyst #2	ARB Method 5 and Method 100	#1	2
Perform Method 5 and Method 100 for both catalysts (2 outlets).						
Particulate Emission Source Test for Continuous (load) Operation for Engine #2 And CO, O_2, NO_x, and HC Determination						
4.	SHELL AMBER 363	(load)	Before	ARB Method 5 and Method 100 *	#2	2
5.	SHELL AMBER 363	(load)	After Catalyst #1	ARB Method 5 and Method 100	#2	2
6.	SHELL AMBER 363	(load)	After Catalyst #2	ARB Method 5 and Method 100	#2	2
Perform Method 5 and Method 100 both catalysts (2 outlets).						
Comparison of CARB Diesel to Shell Amber 363 Particulate Emissions at Load **And comparison of no load to load on CARB Diesel** **And CO, O_2, NO_x, and HC Determination** (Remember to take fuel sample to test sulfur content and aromatic HC)						
7.	CARB Diesel	(no load)	Before	ARB Method 5 and Method 100 *	#1	2
8.	CARB Diesel	(no load)	After Catalyst #1	ARB Method 5 and Method 100	#1	2
9.	CARB Diesel	(no load)	After Catalyst #2	ARB Method 5 and Method 100	#1	2
Perform Method 5 and Method 100 for both catalysts (2 outlets).						
10.	CARB Diesel	(load)	Before	ARB Method 5 and Method 100 *	#1	2
11.	CARB Diesel	(load)	After Catalyst #1	ARB Method 5 and Method 100	#1	2
12.	CARB Diesel	(load)	After Catalyst #2	ARB Method 5 and Method 100	#1	2
Perform Method 5 and Method 100 for both catalysts (2 outlets).						

***** Measure RPM and brake-hp/hr during tests and take fuel sample for sulfur content and aromatic HC)

Additional Measurements

Measure RPM during tests
Measure brake-horse power/hour during tests
Report results in lbs/hr and g/brake-horse power/hour
Analyze each fuel for sulfur content and aromatic HC

Participants and Stakeholders

ARB
Butte County Air Quality Management District
Sierra Nevada Brewery
Caterpillar
Engelhard

Source Description

1100 hp Caterpillar Model 3412 DISTA diesel-fired generator
emissions rating = 0.109 g/bh-p of particulate emissions without control
Cost: $92,000 ea

Control Equipment

Engelhard DPX soot trap (a combination catalytic converter and soot filter)
The catalyst allows the soot to be burned at exhaust temperatures to CO_2 and H_20.
Metals collect in the catalyzed filter.
Cost: 15,550 ea

Low Sulfur Fuel

Shell Amber 363 (5ppmw S)
Cost: $3.00/gallon for 1300 gallons

Sampling Location

Conduct a pre-test site inspection
Conduct a velocity traverse
Verify parallel or non-cyclonic flow per ARB Method 1

Sampling Equipment

As specified in each test method
Must be calibrated and inspected for proper operation prior to use in the field

Testing Dates

March 2000

Sampling and Analytical Procedures

- Sample and Velocity Traverses using ARB Method 1 “Sample and Velocity Traverse for Stationary Sources”

- Stack gas velocity and volumetric flow rate using U.S. EPA Method 2A “Determination of Stack Gas Velocity and Volumetric Flow Rate”

- Moisture content using ARB Method 4 “Determination of Moisture Content in Stack Gases”

- Continuous Emissions Monitoring (CO, O_2, NO_x, HC, and SO_2) using ARB method 100 “Procedures for Continuous Gaseous Emissions Stack Sampling”

- Stack Gas Molecular Weight using ARB Method 3 “Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight”

- Particulate Matter using ARB Method 5 “Determination of Particulate Matter Emissions from Stationary Sources”

Process Parameters

Stack height
Stack temperature
Stack exit velocity (flow rate)
Stack diameter
Inlet, outlet temperature

Building dimensions
Time of day emissions collected
Ambient air temperature
Engine horsepower
Setting (i.e., rural vs. urban)
Receptor distance
Plot plan

APPENDIX 4

Adjustments to the Risk Assessment Methodology and a
Discussion of Uncertainty Associated with Risk Assessments

I. Adjustments to the Risk Assessment Methodology

A. Use of Exposure Adjustment Factors from Draft OEHHA Risk Assessment Guidelines

This guidance recommends risk assessments be conducted in accordance with the *CAPCOA , Air Toxics "Hot Spots" program, Revised 1992 Risk Assessment Guidelines*, October 1993. However, the OEHHA is currently revising these guidelines and is expected to complete them in 2001. The revised guidelines should be used when they are finalized.

During the development of this guidance, a number of issues were raised regarding the appropriateness of using some of the risk characterization exposure assessment parameters found in the draft OEHHA Risk management Guidelines prior to their approval. Table 1 identifies the exposure assessment issue and ARB's perspective on the issue.

Table 1: Risk Characterization Exposure Assessment Issues for Consideration in OEHHA's New Risk Assessment Guidelines

Issue	ARB's Perspective
Use of Stochastic Analysis Techniques Found in OEHHA's Draft Exposure Assessment Document	Completion of public and peer review process is needed before OEHHA can recommend using probabilistic approaches. Districts may consider stochastic analyses provided as supplemental information to the standard risk assessment information. Permit applicants may provide stochastic analysis as a supplement to the analysis recommended by the existing risk assessment guidelines. Information and comments concerning stochastic analysis should be provided to OEHHA.
Use of Exposure Assessment Parameters Found in OEHHA's Draft Exposure Assessment Document: **Breathing Rate**	Breathing Rate: Completion of public and peer review process is needed before OEHHA can recommend using probabilistic approaches addressed in the draft revised risk assessment guidelines. Districts may consider alternative breathing rate information as supplemental information to the standard risk assessment information Permit applicants may submit alternative information based on breathing rate as supplemental information to the risk assessment.

Table 1: Risk Characterization Exposure Assessment Issues for Consideration in OEHHA's New Risk Assessment Guidelines	
Issue	**ARB's Perspective**
Use of Exposure Assessment Parameters Found in OEHHA's Draft Exposure Assessment Document: **Exposure Duration—Years per Lifetime** **Project Duration More Than Two Years.**	Completion of public and peer review process is needed before OEHHA can recommend using a lifetime exposure duration different than 70 years. Districts may consider alternative lifetime exposure duration information as supplemental information to the standard risk assessment. Permit applicants may submit information based on less than 70 years exposure as supplemental information to the risk assessment.
Exposure Assessment Issue **Exposure Duration—Hours per Day**	The draft risk assessment guidelines do not propose using alternative exposure duration for hours per day exposure. Districts may consider alternative daily exposure duration information as supplemental information to the standard risk assessment information.

B. Use of Site-Specific Exposure Adjustments

In addition to the risk characterization exposure assessment issues addressed in Table 1, there were a number of site-specific risk assessment issues identified during the development of this guidance. Table 2 identifies the site-specific exposure assessment issue and ARB's perspective on the issue.

Table 2: Site-Specific Exposure Assessment Issues to be Addressed by the ARB	
Issue	**ARB Perspective**
Application of an Indoor/Outdoor Correction Factor	Generic use of an indoor/outdoor correction is not appropriate. Methodology is needed to determine appropriate correction factor on a site-specific or situation-specific basis.
Particle Size Correction	Exposure and risk calculations for permitting decisions should be based on the PM_{10} concentration. .
Application of a Wet Deposition Correction Factor	It may be appropriate to include a wet deposition in site-specific risk assessment. Rain will affect dispersion by removing PM from the air. It could also impact the non-inhalation pathway by increasing near-source deposition. Currently, there is no ARB approved methodology for estimating the reduction in PM concentration due to the scavenging of PM via precipitation. However, permit applicants may submit supplemental information to the risk assessment that includes the application of a wet deposition correction factor.
Use of Representative Off-Site Meteorological Data	It is appropriate to use representative off-site meteorological data in risk assessment where available, provided it is appropriate for use. ARB has identified 30 meteorological data sets that are acceptable for use. We would encourage/support a research project to identify additional data sets and/or an analysis to extend the use of existing met data without measurements of key parameters at 30 meter elevations. We strongly recommend district's contact ARB staff to discuss the appropriateness of using meteorological data sets that are not among the 30 sets identified.
Use of Stack-Configuration Information	It is appropriate to adjust for stack configuration in site-specific risk assessment. However, new sources should require vertical stacks without fixed rain caps. ARB will examine existing methodology for modeling non-vertical stacks and stacks with rain caps to determine if it is appropriate for use.
Accounting for Different Dispersion Parameters Based on the Time-of-Day of the Emissions	It may be appropriate to take into consideration the time-of-day of periodic emissions in site-specific risk assessment. Permit applicants can use modeling based on time of day of emissions, but permit needs to have an enforceable time-of-day limit.

Table 2: Site-Specific Exposure Assessment Issues to be Addressed by the ARB (continued)	
Issue	**ARB Perspective**
Application of a Pre-1993 Diesel-Fuel Correction Factor	It is appropriate to use a correction for emission factors developed prior to the introduction of CARB Diesel (1993). ARB recommends using the on-road fuel correction factor. For 1994+ engines the correction factor is 0.8972.
Use of Other Dispersion Models	Models other than those listed in the CAPCOA guidelines that reflect state-of-the-science air dispersion modeling techniques should be allowed to be used. ARB will evaluate and authorize the use of new models as they become generally available. If there are specific models not currently authorized for use by ARB, a request for evaluation/authorization should be provided.
Use of Existing Models within 100 meters of Source	Continue to use existing approved models for assessing the exposure/risk within 50 meters of an emission point. Acknowledge model performance more uncertain within 50 meters. ARB is preparing a research proposal for a study to evaluate the applicability of existing models for air concentrations within 50 meters of an emission point. We are seeking additional funding for model validation work. ARB's position is that use of modeling results down to 20 meters is appropriate for most models.
Additional Worker Exposure Correction Factors	Teachers would receive 46/70 correction plus additional site-specific corrections based on scheduled hours of engine operation.
Evaluating future changes in emissions/risk due to current regulatory requirements	For long-term projects, it is appropriate to take into consideration future reductions that are required by regulation or permit. Develop methodology for a time-weighted risk analysis. This is being evaluated as part of the "Risk Characterization Scenarios Analysis".

II. Discussion of the Uncertainty Associated with Risk Assessment

(from the *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix III, Part B, Health Risk Assessment for Diesel Exhaust*, pages 1-13 through 1-14)

Results based on the human data and those based on the animal data are both subject to considerable uncertainty. The strengths and weaknesses of calculating population risks using the human studies (Garshick et al., 1987a; Garshick et al., 1988) and the animal bioassay (Mauderly et al. 1987a; Brightwell et al., 1989; Heinrich et al., 1995; Ishinishi et al., 1986a; Nikula et al., 1995) are summarized in Table 7-6.

The principal uncertainties in using the rat data are their application to humans in terms of response, the choice of dose-response model to extrapolate the risk to environmental concentrations, and the range of dose extrapolation involved.

The principal uncertainties in using the human data are the representativeness of railroad workers for the general population, the choice of the analytical model, and the lack of knowledge of the exposure history of the railroad workers including possible exposure to unknown confounders. The historical reconstruction here is based upon the Woskie et al. (1988b) exposure data for railway workers and the rate of dieselization for U.S. railroads. Using a range of reduced emission assumptions, alternative exposure patterns are considered. This reconstruction takes into account to some degree the likely higher exposure levels in the past. If actual exposures were higher than assumed here, then our estimates of the risk would be lower. If exposures were lower, then the estimated risks would be higher. The range of extrapolation from these estimated occupational exposure levels to the California population-weighted annual average exposure of 1.54 µg diesel exhaust particulate/m^3 is not large.

Table 7-6 Human and Animal Information for Quantitative Estimates of Risk.

Information/Advantage[a]	Animal[b]	Human[c]
Accuracy of exposure estimate in study A++	Numerically precise for rats exposed to automobile exhaust	Uncertain for the railroad workers
Ratio of study exposure to human environmental exposure H++	300	7
Similarity of study exposure to present day exhaust A+	Some uncertainty	Some uncertainty. Uncertain quantitative control for smoking and other pollutants
Model to predict risks at human environmental levels H+	Uncertainty of biological responses such as cell proliferation	Some uncertainty of biological responses such as cell proliferation
Applicability to the human process H++	Much uncertainty in pharmacokinetics and pharmacodynamics	No uncertainty
Consistency of results 0	Consistent with other rat results	Consistent with other human results
Accounting for heterogeneity of human population H+	Uncertainty in ability of the rat model to protect sensitive humans	The railroad study considered only white male workers, who may not be most sensitive
OVERALL CONCLUSION H+	Data quality is strong, but applicability to humans at environmental concentrations is uncertain	Exposure data are weak, but unlikely to greatly overstate or understate risks

[a] Symbols: H for human, A for animal, 0 for neither has the advantage. + and ++ represent the strength of the advantage.

[b] Mauderly *et al*. (1987a), Brightwell *et al*. (1989), Heinrich *et al*. (1995), Ishinishi *et al*. (1986a), Nikula *et al*. (1995)

[c] Garshick *et al*. (1988), Garshick *et al*. (1987a)

The presence or absence of a dose-response threshold is another source of uncertainty. The in vitro and in vivo genotoxicity of diesel exhaust suggests that a non-threshold mechanism for carcinogenesis may be involved. The Moolgavkar quantitative analyses of the rat cancer bioassay did not suggest there was a threshold for the carcinogenicity of diesel exhaust in the rat. In addition, as discussed in the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix III, Part B, Health Risk Assessment for Diesel Exhaust, epidemiological studies have observed increases in the relative risk for lung cancer in association with exposures of the general population to ambient particulate matter. On the other hand, evidence that diesel exhaust particulate matter at high concentrations exceeds pulmonary clearance capabilities and causes chronic inflammation so as to increase production of inflammatory cytokines and cell proliferation may suggest the presence of a threshold. However, at present, the limited evidence available does not allow a threshold value for carcinogenesis to be identified.

On balance, the human data lend more confidence in the prediction of human risks than the data from the rat studies because of the uncertainties of extrapolating from rats to humans, especially in the context of a substantial particle effect. The uncertainties of extrapolating from rats to humans appear to outweigh the uncertainties of using the epidemiological results, namely, the uncertainties of the actual exposure history, modeling, and data selection. The exposure reconstructions bracket the overall exposure and therefore they bracket the risk. The uncertainty in the extrapolation from animal data is difficult to quantify, but is likely to be much greater. Extrapolations of either the animal or human data involve additional sources of uncertainty with respect to both model and data selection.

A number of individuals and organizations have indicated that the epidemiological studies are limited in their application to environmental risk assessment. OEHHA recognizes that the limited exposure information available does contribute to the overall uncertainty of the dose response risk assessment for diesel exhaust based upon the epidemiological findings. However, the overall magnitude of the associated uncertainty is not unduly large. The greater than unusual uncertainty in the exposure estimates is substantially offset by the much smaller than usual range of extrapolation from the occupational exposures of interest to the ambient levels of concern here. The availability of human data obviates the need to use animal data thus avoiding uncertainties of animal-to-human extrapolation. OEHHA provided a tabular range of risk so as to fairly capture the scope of the uncertainty in these analyses.

Appendix 4: References

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APPENDIX 5

List Of U.S. EPA Certified Engines
Meeting the Proposed 0.1 G/Bhp-Hr Emission Limit

* May 10, 2000 data, On-Highway and Nonroad Compression-Ignition Certification Data, U.S. EPA Office of Transportation and Air Quality

Manufacturer	Engine Category	Engine Family	Engine Model	Rated Power (HP)	Test Procedure	PM g/bhp-hr
AB Volvo Penta	Nonroad CI	YVPXL16.0ABA	TD164KEA	496	2.	0.06975
AB Volvo Penta	Nonroad CI	YVPXL12.0ABA	TWD1230/1VE	415	2.	0.0825
AB VOLVO PENTA	Nonroad Over 50 Hp	YVPXL12.0ACB	TAD1232GE	526	3.	0.1125
AB VOLVO PENTA	Nonroad Over 50 Hp	YVPXL09.6ACB	TAD1030GE	362	3.	0.117
AB VOLVO PENTA	Nonroad Over 50 Hp	YVPXL12.0ACB	TAD1232GE	526	3.	0.1185
AB VOLVO PENTA	Nonroad Over 50 Hp	YVPXL09.6ACB	TAD1030GE	362	3.	0.12
AB VOLVO PENTA	Nonroad Over 50 Hp	YVPXL09.6ABA	TWD1031VE	310	2.	0.123
AB VOLVO PENTA	Nonroad Over 50 Hp	YVPXL06.7ABA	TWD731VE	230	2.	0.1275
AB VOLVO PENTA	Nonroad Over 50 Hp	YVPXL09.6ABA	TWD1031VE	310	2.	0.13125
AB Volvo Penta	Nonroad CI	YVPXL07.3ACB	TAD740GE	301	3.	0.1395
AB Volvo Penta	Nonroad CI	YVPXL07.3ACB	TAD740GE	301	3.	0.1395
AB Volvo Penta	Nonroad CI	YVPXL07.3ABB	TWD740GE	249	3.	0.141
AB Volvo Penta	Nonroad CI	YVPXL07.3ABB	TWD740GE	249	3.	0.141
AB Volvo Penta	Nonroad CI	YVPXL12.0ABA	TWD1230/1VE	415	2.	0.1425
AB Volvo Penta	Nonroad CI	YVPXL07.3ACB	TAD740GE	301	3.	0.144
Case Corporation	Nonroad CI	YX9XL0359ABB	QSB5.9-C	240	2.	0.074475
Case Corporation	Nonroad CI	YX9XL0239ACA	B3.9-C	125	2.	0.08625
Case Corporation	Nonroad CI	YX9XL0505ABC	6TAA-8304	340	2.	0.0915
Case Corporation	Nonroad CI	YX9XL0359ABA	B5.9-C	200	2.	0.13875
CATERPILLAR INC	Nonroad CI	YCPXL69.0ERK	3516	3230	3.	0.09
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL15.8ERK	3456	800	2.	0.039
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL07.2HRK	3126	300	2.	0.053
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL14.6ERK	3406	660	2.	0.064
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL27.0HRP	3412	1082	2.	0.068
CATERPILLAR INC.	On-highway HDDE	YCPXH0729ERK	C-12	445	1.	0.073
CATERPILLAR INC.	On-highway HDDE	YCPXH0893ERK	C-15	550	1.	0.075
CATERPILLAR INC.	On-highway HDDE	YCPXH0629ERK	C - 10	370	1.	0.079
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL10.3ERK	3176	425	2.	0.079
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL27.0HRK	3412	758	2.	0.08
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL18.0HRK	3408	750	2.	0.084
CATERPILLAR INC.	On-highway HDDE	YCPXH0967ERK	C-16	600	1.	0.085
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL14.6MRC	3406	455	2.	0.09

Manufacturer	Engine Category	Engine Family	Engine Model	Rated Power (HP)	Test Procedure	PM g/bhp-hr
Caterpillar Inc.	On-highway MHDD	YCPXH0442HRK	3126	330	1.	0.094
CATERPILLAR INC.	Nonroad CI	YCPXL34.5ERK	3508	1676	3.	0.105
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL27.0HRN	3412	730	2.	0.108
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL10.5MRD	3306	397	2.	0.114
CATERPILLAR INC.	Nonroad CI	YCPXL12.0ERM	3196	322	2.	0.114
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL27.0MRT	3412		3.	0.121
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL27.0MRS	3412	1210	3.	0.13
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL10.5MRG	3306	362	2.	0.135
CATERPILLAR INC.	Nonroad Over 50 Hp	YCPXL10.5MRF	3306	225	2.	0.146
Cummins Engine Company, Inc.	Nonroad CI	YCEXL060.AAA	QSK60-C	2750 HP	2.	0.09225
Cummins Engine Company, Inc.	Nonroad CI	YCEXL060.AAA	QSK60-C	2750 HP	2.	0.09675
Cummins Engine Company, Inc.	Nonroad CI	YCEXL060.ABA	QSK60-G6	3067	3.	0.12225
Cummins Engine Company, Inc.	Nonroad CI	YCEXL060.ABA	QSK60-G6	3067	3.	0.13725
Cummins Engine Co., Inc.	Nonroad CI	YCEXL0359ABB	QSB5.9-C	240	2.	0.074475
Cummins Engine Company	Nonroad CI	YCEXL0661AAB	M11-C	430	2.	0.0492
Cummins Engine Company	On-highway HDDE	YCEXH0239BAA	B3.9-130	120	1. (40CFR86 diesel test proc.)	0.057
Cummins Engine Company	Nonroad CI	YCEXL0855AAA	N14-C, N14-G2	480 535	2. 3.	0.08025
Cummins Engine Company	Nonroad CI	YCEXL0239ACA	B3.9-C	125	2.	0.08625
Cummins Engine Company	Nonroad CI	YCEXL0855AAB	N14-C	525	2.	0.08775
Cummins Engine Company	Nonroad CI	YCEXL0855AAA	N14-C, N14-G2	480 535	2. 3.	0.099
Cummins Engine Company	Nonroad CI	YCEXL0661AAA	M11-C, M11-G2	350 330	2.	0.111
Cummins Engine Company	Nonroad CI	YCEXL0661AAA	M11-C, M11-G2	350 330	2.	0.12
Cummins Engine Company	Nonroad CI	YCEXL0505ACA	C8.3-C,6CTAA8.3-G1	280 272	2. 3.	0.13275
Cummins Engine Company	Nonroad CI	YCEXL0359ABA	B5.9-C,6BTA5.9-G1	200 156	2.	0.13725
Cummins Engine Company	Nonroad CI	YCEXL0359ABA	B5.9-C,6BTA5.9-G1	200 156	2.	0.13875
Cummins Engine Company Inc.	Nonroad CI	YCEXL03.3AAB	B3.3	82	3.	0.12825
Cummins Engine Company Inc.	Nonroad Over 50 Hp	YCEXL03.3AAB	B3.3	82	3.	0.12825

Manufacturer	Engine Category	Engine Family	Engine Model	Rated Power (HP)	Test Procedure	PM g/bhp-hr
Cummins Engine Company Inc.	Nonroad Over 50 Hp	YCEXL03.3AAB	B3.3	82	3.	0.12825
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0661MAG	ISM 330	330	1.	0.043
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0505CAF	ISC 280	289	1.	0.0471
Cummins Engine Company, Inc.	Nonroad CI	YCEXL1015.ACA	QSX15-C	440	2.	0.0536025
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0912XAE	Signature 600	625	1.	0.067
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0505CAG	ISC 350	350	1.	0.0681
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0912XAD	ISX 450	458	1.	0.07
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0912XAC	ISX 500	530	1.	0.071
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0661MAH	ISM 599	500	1.	0.072
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0359BAI	ISB 215	215	1.	0.074
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0661MAH	ISM 599	500	1.	0.074
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0505CAH	ISC 315	315	1.	0.0746
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0912XAE	Signature 600	625	1.	0.075
Cummins Engine Company, Inc.	On-highway HDDE	YCEXA0359BAZ	ISB 245	245	1.	0.0778
Cummins Engine Company, Inc.	Nonroad CI	YCEXL015.ABA	QSX15-G	765 HP	3.	0.081
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0540LAA	ISL 330	345	1.	0.0818
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0661MAI	ISM 335V	350	1.	0.082
Cummins Engine Company, Inc.	Nonroad CI	YCEXL030.AAA	QST30-C	1200 HP	2.	0.0825
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0359BAA	ISB 235	235	1.	0.0837
Cummins Engine Company, Inc.	Nonroad CI	YCEXL015.ABA	QSX15-G	765 HP	3.	0.08475
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0855NAE	N14-460E+	475	1.	0.086
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0359BAY	ISB 235	235	1.	0.0867
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0505CAI	ISC 260	260	1.	0.0884
Cummins Engine Company, Inc.	Nonroad CI	YCEXL0505ABC	QSC8.3-C	340	2.	0.0915
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0855NAD	N14-525E+	525	1.	0.093
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0855NAF	N14-425E+	410	1.	0.093
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0359BAX	ISB 245	245	1.	0.0961
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0359BAP	ISB 260	260	1.	0.1039
Cummins Engine Company, Inc.	On-highway HDDE	YCEXH0359BAO	ISB 275	275	1.	0.105
Cummins Engine Company, Inc.	Nonroad CI	YCEXL030.ABA	QST30-G5	1525	3.	0.12975
Cummins Engine Company, Inc.	Nonroad CI	YCEXL0359ACA	B5.9-C	98	2.	0.13125
Daewoo Heavy Industries Co Ltd	Nonroad CI	YDWXL21.9AYA	P222LE	770.7	3.	0.069

Manufacturer	Engine Category	Engine Family	Engine Model	Rated Power (HP)	Test Procedure	PM g/bhp-hr
Daewoo Heavy Industries Co Ltd	Nonroad CI	YDWXL14.6AZA	P158LE	555.6	3.	0.086
Daewoo Heavy Industries Co Ltd	Nonroad CI	YDWXL18.3ASA	P180LE	665.2	3.	0.093
Daewoo Heavy Industries Co. Ltd.	Nonroad CI	YDWXL11.1BIA	DE12TI	335.5	2.	0.08
Daewoo Heqvy Industries Co Ltd	Nonroad CI	YDWXL11.1DJA	P126TI	365.1	3.	0.087
DaimlerChrysler AG	Nonroad Over 50 Hp	YMBXL15.9RJA	OM 502 LA	563 // 600	2.	0.0375
DaimlerChrysler AG	Nonroad Over 50 Hp	YMBXL12.0RJA	OM 501 LA	422 (315 kW)	2.	0.042
DaimlerChrysler AG	Nonroad Over 50 Hp	YMBXL15.9RJA	OM 502 LA	563 // 600	2.	0.0435
DaimlerChrysler AG	Nonroad Over 50 Hp	YMBXL4.25RJA	OM 904 LA	168	2.	0.057
DaimlerChrysler AG	Nonroad Over 50 Hp	YMBXL6.37RJA	OM 906 LA	275	2.	0.0615
DaimlerChrysler AG	On-highway HDDE	YMBXH4.25DJA	OM 904 LA	190	1.	0.087
DaimlerChrysler AG	On-highway HDDE	YMBXH12.0DJA	OM 457 LA	355	1.	0.088
DaimlerChrysler AG	On-highway HDDE	YMBXH6.37DJA	OM 906 LA	280	1.	0.089
DaimlerChrysler AG	Nonroad Over 50 Hp	YMBXL12.9R6A	OM 401 LA	308	2.	0.1035
Deere Power Systems Group of Deere & Company	Nonroad CI	YJDXL12.5002	6125A	401	2. 3.	0.068
Deere Power Systems Group of Deere & Company	Nonroad CI	YJDXL12.5020	6125H	431.3	2. 3.	0.069
Deere Power Systems Group of Deere & Company	Nonroad CI	YJDXL10.5004	6105A	339	2. 3.	0.072
Deere Power Systems Group of Deere & Company	Nonroad CI	YJDXL10.5022	6105H	399	2. 3.	0.073
Deere Power Systems Group of Deere & Company	Nonroad CI	YJDXL12.5021	6125H	361	2. 3.	0.086
Deere Power Systems Group of Deere & Company	Nonroad CI	YJDXL08.1008	6081A	285	2. 3.	0.145
Detroit Diesel Corp.	On-highway HDDE	YDDXH12.7EGL	Series 60, 12L	500	1.	0.088
Detroit Diesel Corporation	On-highway HDDE	yDDXH08.5fjn	Series 50 Bus	250	1.	0.037
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL15.9TRE	8V-S2000 (SCCC)	685	2.	0.04
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL15.9TRE	8V-S2000 (JWCC)	610	3.	0.047
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL15.9TRE	8V-S2000 (SCCC)	605	2.	0.048
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL23.9TRE	12V-S2000	750	2.	0.051
Detroit Diesel Corporation	Nonroad Over 50 Hp	Yddxl14.0tld	Series 60, 14L	635	3.	0.062
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL31.8VRE	12V-2000 SCCC	1110	2.	0.062

Manufacturer	Engine Category	Engine Family	Engine Model	Rated Power (HP)	Test Procedure	PM g/bhp-hr
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL11.1THD	SERIES 60, 11.1L	340	2.	0.07
Detroit Diesel Corporation	On-highway HDDE	Yddxh03.8c1N	Turbotronic 638	160	1.	0.078
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL08.5TJD	SERIES 50	350	2.	0.083
Detroit Diesel Corporation	On-highway HDDE	YDDXH14.0ELL	Series 60, 14L	575	1.	0.087
Detroit Diesel Corporation	On-highway HDDE	YDDXH08.5EJL	Series 50	320	1.	0.09
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL12.1TFM	6V-92TA	360	2.	0.093
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL12.7TGD	SERIES 60, 12.7L	500	2.	0.097
Detroit Diesel Corporation	Nonroad Over 50 Hp	YDDXL65.0VTE	8V-4000	1500	2.	0.119
DEUTZ AG	Nonroad CI	YDZXL05.7019	BF4M2013C	109	2.	0.0555
DEUTZ AG	Nonroad CI	YDZXL07.1005	BF6M1013E	194	2.	0.0885
Deutz AG	Nonroad CI	YDZXL15.9003	BF6M1015	322	2.	0.0945
Deutz AG	Nonroad CI	YDZXL15.9002	BF8M 1015C	563	2.	0.10125
Deutz AG	Nonroad CI	YDZXL07.1004	BF6M1013EC	261	2.	0.14925
Escorts Ltd.	Nonroad CI	YAELL3.14FTD	F3.315	46.8 HP Net ISO 2288@2000	2.	0.09
Escorts Ltd.	Nonroad CI	YAELL2.86FTD	F3.287	38.87 HP NET(ISO 2288) @ 2000	2.	0.112
GENERAC Corporation	Nonroad CI	YGNXL13.3HTA	200ekW	280	3.	0.142
Generac Power Systems Inc.	Nonroad CI	YGNXL03.0KTA	30ekW	46	3.	0.134
General Engine Products	On-highway HDDE	YGEPH06.5524	L57	160	1.	0.069
General Motors Corporation	On-highway HDDE	YGMXH06.5526	L 57	160	1.	0.067
GENERAL MOTORS CORPORATION	On-highway HDDE	YGMXH06.5528	L 65	195	1.	0.067
GENERAL MOTORS CORPORATION	On-highway HDDE	YGMXH06.5529	L 65	195	1.	0.067
General Motors Corporation	On-highway HDDE	YGMXH06.5524	L 57	160	1.	0.069
General Motors Corporation	On-highway HDDE	YGMXH06.5521	L 65	195	1.	0.077
General Motors Corporation	On-highway HDDE	YGMXH06.5522	L 65	190	1.	0.08
Isuzu Motors Limited	On-highway HDDE	YSZXH04.83AA	4HE1XN	137	1.	0.084
Isuzu Motors Limited	On-highway HDDE	YSZXH07.84RA	6HK1XS	227	1.	0.088
Isuzu Motors Limited	On-highway HDDE	YSZXH07.84RA	6HK1XN	197	1.	0.091
Isuzu Motors Limited	Nonroad CI	YSZXL06.5FXA	AA-6BG1T	139	2.	0.14

Manufacturer	Engine Category	Engine Family	Engine Model	Rated Power (HP)	Test Procedure	PM g/bhp-hr
Isuzu Motors Limited	Nonroad CI	YSZXL06.5FTA	BB-6BG1T	164	2.	0.146
IVECO N.V.	Nonroad CI	YVEXL09.5DAR	8465.41	326	2.	0.144
Komatsu	Nonroad CI	YKLXL030.AAA	SAA12V140ZE-2	1200 HP	2.	0.0825
Komatsu	Nonroad CI	YKLXL0239ACA	SA4D102E-1	125	2.	0.08625
Komatsu	Nonroad CI	YKLXL0359ACA	B5.9-C	98	2.	0.13125
Komatsu	Nonroad CI	YKLXL0359ABA	SA6D102E-1	200	2.	0.13875
Komatsu Ltd.	Nonroad Over 50 Hp	YKLXL30.5GE1	SDA12V140E-1	899	2.	0.07875
KOMATSU LTD.	Nonroad CI	YKLXL11.0DC1	SA6D125E-2	334	2.	0.09375
KOMATSU LTD.	Nonroad Over 50 Hp	YKLXL15.2EC1	SA6D140E-2	375	2.	0.12525
KOMATSU Ltd.	Nonroad CI	YKLXL03.3JB1	S4D95LE-2	82	3.	0.12825
KOMATSU Ltd.	Nonroad Over 50 Hp	YKLXL03.3JB1	S4D95LE-2	82	3.	0.12825
KOMATSU Ltd.	Nonroad Over 50 Hp	YKLXL03.3JB1	S4D95LE-2	82	3.	0.12825
KOMATSU Ltd.	Nonroad Over 50 Hp	YKLXL15.2EB1	S6D140E-2	330	2.	0.12825
KOMATSU LTD.	Nonroad CI	YKLXL7.15CB1	S6D108E-2	211	3.	0.1425
KOMATSU LTD.	Nonroad CI	YKLXL30.5GC1	SA12V140E-1	1124	3.	0.1485
KUBOTA Corporation	Nonroad CI	YKBXL01.1BCB	D1105-CTM-1	22.33	4.	0.115
KUBOTA Corporation	Nonroad CI	YKBXL01.9FCC	V1903-BG-ONAN-1	29.13	3.	0.123
KUBOTA Corporation	Nonroad CI	YKBXL01.0BCB	D1005-CTM-1	23.49	4.	0.138
LIEBHERR MACHINES BULLE SA	Nonroad Over 50 Hp	YLHAL9.96ATA	D 926 TI-E	327	2.	0.057
LIEBHERR MACHINES BULLE SA	Nonroad Over 50 Hp	YLHAL9.96ARA	D926TI-E	327	2.	0.06
LIEBHERR MACHINES BULLE SA	Nonroad Over 50 Hp	YLHAL17.2ATA	D 9406 TI-E	475	2.	0.0705
LIEBHERR MACHINES BULLE SA	Nonroad Over 50 Hp	YLHAL17.2ARA	D9408 TI-E	571	2.	0.0975
LIEBHERR MACHINES BULLE SA	Nonroad Over 50 Hp	YLHAL9.96ASA	D926T-E	244	2.	0.1005
Mitsubishi Motors Corporation	On-highway HDDE	YMTXH03.9D4A	4D34-3AT3B	145 HP	1.	0.086
Mitsubishi Motors Corporation	On-highway HDDE	YMTXH05.8D6A	6D34-1AT2	175 HP	1.	0.086
Mitsubishi Motors Corporation	On-highway HDDE	YMTXH07.5D6A	6D16-3AT2	230 HP	1.	0.086
Mitsubishi Motors Corporation	Nonroad CI	YMTXL07.5D6A	6D16-TLEB	251	2.	0.11
Navistar International Trans. Corp.	Nonroad CI	YNVXL0530ANC	GCB330	330	3.	0.0543
Navistar International Trans. Corp.	Nonroad CI	YNVXL0530AND	GCB215	215	3.	0.080325
Navistar International Trans. Corp.	Nonroad CI	YNVXL0530ANB	IC225D	225	2.	0.08265

Manufacturer	Engine Category	Engine Family	Engine Model	Rated Power (HP)	Test Procedure	PM g/bhp-hr
Navistar International Trans. Corp.	On-highway HDDE	YNVXH0530ANA	C280	280	1.	0.093
Navistar International Trans. Corp.	On-highway HDDE	YNVXH0466ANA	CH215	215	1.	0.101
Navistar International Trans. Corp.	On-highway HDDE	YNVXH0530ANB	CH330	330	1.	0.102
Navistar International Trans. Corp.	On-highway HDDE	YNVXH0466ANB	CH250	250	1.	0.103
Navistar International Trans. Corp.	Nonroad CI	YNVXL0466ANA	IC210D	210	2.	0.1065
Navistar International Trans. Corp.	Nonroad CI	YNVXL0530ANA	IC330D	330	2.	0.129225
Navistar International Transportation Corp.	On-highway HDDE	YNVXH0444ACT	C230HV	230	1.	0.047
Navistar International Transportation Corp.	On-highway HDDE	YNVXH0444ACD	C210CF	210	1.	0.092
Navistar International Transportation Corp.	On-highway HDDE	YNVXH0444ANC	B250	250	1.	0.093
Navistar International Transportation Corp.	On-highway HDDE	YNVXH07.3ANC	B235CF	235	1.	0.093
Navistar International Transportation Corp.	On-highway HDDE	YNVXH0444ANA	H210A	210	1.	0.094
Navistar International Transportation Corp.	On-highway HDDE	YNVXH07.3FNB	B215F	215	1.	0.094
Navistar International Transportation Corp.	On-highway HDDE	YNVXA07.3CND	B215C	215	1.	0.096
Navistar International Transportation Corp.	On-highway HDDE	YNVXH0444ANB	C210	210	1.	0.097
Navistar International Transportation Corp.	On-highway HDDE	YNVXH07.3ANA	B235	235	1.	0.101
Nissan Diesel Motor Co., Ltd.	On-highway HDDE	YNDXH04.6FAB	FD46TA-U1	175	1.	0.085
RENAULT VI	On-highway HDDE	YR3XH0377KWC	MIDR60226AB711	180	1.	0.037
RENAULT VI	On-highway HDDE	YR3XH0377KWC	MIDR60226AB711	180	1.	0.074
RENAULT VI	On-highway HDDE	YR3XH0377BWF	MIDR60226L711	190	1.	0.08
SCANIA AB	Nonroad	YY9XL11.7ABB	DI12 46 A	338 (see email)	2.	0.092
SCANIA AB	Nonroad	YY9XL11.7ABB	DI12 46 A	338 (see email)	2.	0.092
SCANIA AB	Nonroad	YY9XL11.7ABB	DI12 46 A	338 (see email)	2.	0.092
SCANIA AB	Nonroad	YY9XL11.7ABB	DI12 46 A	338 (see email)	2.	0.092
SCANIA AB	Nonroad	YY9XL11.7ABA	DI12 40 A	430	2.	0.113
SCANIA CV AB	On-highway HDDE	YY9XH11.7202	DC12 02	396	1.	0.069
SCANIA CV AB	On-highway HDDE	YY9XH10.6106	DC11 06	337	1.	0.087
Sisu Diesel Inc.	Nonroad Over 50 Hp	YSIDL07.4D4A	634.146 DSBAE	217	2.	0.14175
Sisu Diesel Inc.	Nonroad Over 50 Hp	YSIDL08.4F3A	645.142 DSBIE	272	2.	0.14775
Volvo Construction Equipment Components	Nonroad CI	YVSXL09.6CE1	TD104KAE	312.5	2.	0.063

Manufacturer	Engine Category	Engine Family	Engine Model	Rated Power (HP)	Test Procedure	PM g/bhp-hr
AB						
Volvo Construction Equipment Components AB	Nonroad CI	YVSXL16.0CE1	TD164KAE	496	2.	0.06975
Volvo Construction Equipment Components AB	Nonroad CI	YVSXL12.0CE1	TD122KIE	381	2.	0.0825
Volvo Construction Equipment Components AB	Nonroad CI	YVSXL06.7CE1	TD73KCE	255	2.	0.1275
VOLVO TRUCK CORPORATION	On-highway HDDE	YVTXH12.150S	VE D12C465	465	1.	0.082
VOLVO TRUCK CORPORATION	On-highway HDDE	YVTXH07.350S	VE D7C 300	300	1.	0.091
Yanmar Diesel Engine Co.,Ltd.	Nonroad CI	YYDXL0.75P2N	2V78-EDM1	18.8	4.	0.08475
Yanmar Diesel Engine Co.,Ltd.	Nonroad CI	YYDXL1.01T3N	3TNE74-ECH1	27.6	3.	0.14475

1. On-Hwy Diesel
2. Nonroad, 8 Mode & Smoke
3. Nonroad, D2 (Special Procedure)
4. Nonroad, 6 Mode & Smoke