CLEAN AIR TASK FORCE

December 8, 2009

Clerk of the Board
Air Resources Board
1001 I Street
Sacramento, CA 95814

Re: Review of Truck and Bus Regulation; and of
In-Use Off-Road Diesel-Fueled Fleet Regulation

To the Clerk of the Board:

The Clean Air Task Force ("CATF") appreciates the opportunity to provide comments on the upcoming Board review of two recently adopted rules to reduce deadly diesel pollution—the Truck and Bus Regulation and the In-Use Off-Road Diesel-Fueled Fleet Regulation (hereinafter "the Diesel Rules"). CATF is actively engaged in national, regional and local efforts to reduce harmful air pollution from in-use diesel engines.

CATF urges the Board to reaffirm the Diesel Rules without any weakening or delay in implementation. While we understand and sympathize with those in the regulated community who have been adversely impacted by the economic downturn over the past year, we believe that it is extremely important to protect the health of the people that are—through no fault of their own—exposed to deadly diesel pollution. CATF believes that the Board struck the right balance between the economy and public health in its original Diesel Rules, and any current attempts to disrupt that balance to the detriment of people's health must be rejected.

The Diesel Rules will reduce diesel emissions of deadly particulate matter (PM) and ozone smog-forming nitrogen oxides (NOx) in California from a significant and largely unregulated sector—in-use on-road and off-road diesel engines. Furthermore, ARB's regulation of in-use nonroad diesel emissions is also extremely important to states other than California, because it will provide one of the few opportunities available to them to mandate emission reductions from off-road diesel vehicles. California's leadership in the regulation of in-use highway diesels is also important nationally.

California is in a unique position with respect to the regulation of emissions of existing nonroad diesel engines and equipment. Several years ago, the US Circuit Court of Appeals for the District of Columbia effectively ruled that under Section 209(e) of the federal Clean Air Act, California is the only government in the US that can implement emissions standards in the first instance for existing nonroad engines (*EMA v. EPA*, 88

F.3d 1075 (DC Cir. 1996)). The court stated that EPA has no authority to do so, and that other states can only enact standards that are identical to those adopted by California. While CATF believes that this case was wrongly decided, it remains existing case law at present, and substantially limits the regulatory actions that states other than California can take (at least as a practical matter).

We reiterate that the Diesel Rules are vital in the efforts of California and other states to protect their populations from the health and environmental ravages of diesel pollution. The remainder of our comments is therefore focused on detailing the public health and environmental (including climate) impacts of diesel particulate emissions.

A. Overview

Air pollution from diesel engines is a major source of harmful fine and ultrafine particles in the U.S. Locally, diesel particles are even more important because they are emitted at ground-level where the toxic emissions may be inhaled by workers, nearby communities and commuters. Exposure to particulate matter is the subject of thousands of medical studies. These studies have linked particle exposures to morbidity and mortality, including death due to lung cancer and cardiopulmonary disease including myocardio infarction and stroke. In children, particulate matter has been associated with asthma attacks and asthma onset, lung growth retardation and crib death. In addition, particulate matter exposure has been associated with decreased lung function, increased respiratory symptoms such as coughing and breathing difficulties, allergy sensitization, DNA damage and chronic bronchitis. People with heart or lung disease, the elderly and children are at highest risk from exposure to particulate pollution. [1]

A substantial portion of ambient particulate pollution in the U.S. is emitted by highway diesel engines. According to recent EPA estimates, highway diesel vehicles emitted about 110,000 tons of fine particulates ($PM_{2.5}$) in 2001, or about 22% of all mobile source $PM_{2.5}$ emissions., and nonroad diesels emitted over 164,000 tons of $PM_{2.5}$ (33%).[2]

Diesel exhaust also adversely affects public welfare causing, among other things, soiling of buildings and atmospheric warming. Black carbon soot particles—the primary component of diesel exhaust—are strong climate forcing pollutants in the atmosphere because of their ability to absorb light and radiate it back into the atmosphere as heat. In fact, black carbon was historically one of strongest warming agents in the 20th century.

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[1] EPA, Particulate Matter: Health and Environment, http://www.epa.gov/oar/particlepollution/health.html (last visited December 7, 2009). *See also*, US EPA (2008), Integrated Science Assessment for Particulate Matter (First External Review Draft), EPA/600/R-08/139; US EPA (2004) Air Quality Criteria for Particulate Matter (October 2004), Vol I Document No. EPA600/P-99/002aF and Vol II Document No. EPA600/P-99/002bF.

[2] *See, e.g*,, US EPA, "Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder; Proposed Rule," 72 Fed. Reg. 69522 (December 7, 2007) (the "C3 Marine Engine ANPR"), at 69546.

B. Public Health Impacts

The health effects of diesel exhaust have been clearly documented by ARB[3] and others.[4] Diesel exhaust is highly respirable and contains a plethora of toxic substances that typically condense on the tiny diesel particles, nanoparticles, tiny enough (0.1 microns or smaller) to penetrate into the blood system from the lung.

1. Diesel exhaust is highly toxic

Dozens of toxic air contaminants are found in diesel exhaust, including a variety of highly toxic carbon-core particulate and gas phase organic carbon compounds such as benzene, formaldehyde, acetaldehyde, 1,3-butadiene, acrolein and polyaromatic hydrocarbons. These compounds are known or suspected human or animal carcinogens, or have serious non-cancer health effects. Every one of these compounds has been listed by EPA as both an Urban Hazardous Air Pollutant ("HAP") for the Integrated Urban Air Toxics Strategy under Section 112(b) of the Clean Air Act,[5] and a Mobile Source Air Toxic under Section 202(l)(2) of the Act.[6]

Of particular concern in diesel exhaust are a broad array of polycyclic aromatic hydrocarbons (PAH) which are emitted as gases and also are adsorbed onto the surface of diesel exhaust particles where they may be carried deep into the lung and bloodstream. Medical studies suggest PAH compounds are genotoxic and form DNA adducts that have been associated with increased the risk of a variety of cancers, including lung,[7] prostate,[8]

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[3] California Air Resources Board, *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*, October 2000.
See also, U.S. EPA, National Center for Environmental Assessment, Office of Research and Development, Health Assessment Document for Diesel Engine Exhaust (2002), *available at* http://www.epa.gov/iris (Search for EPA/600/8-90/057F).

[4] National Institute for Occupational Safety and Health, "Carcinogenic Effects of Exposure to Diesel Exhaust," *Current Intelligence Bulletin* 50 (August 1988), *available at* http://www.cdc.gov/niosh/88116_50.html.
International Agency for Research on Cancer (IARC), *Diesel and Gasoline Engine Exhausts and Some Nitroarenes.* IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, no. 46 (Lyons: World Health Organization, 1989), pp. 41–185.
Health Effects Institute, *Diesel Exhaust: A Critical Analysis of Emissions, Exposure and Health Effects* (Cambridge, MA: Health Effects Institute, 1995), *available at* http://www.healtheffects.org/Pubs/diesum.htm.
International Programme on Chemical Safety, World Health Organization, "Diesel Fuel and Exhaust Emissions," *Environmental Health Criteria* 171 (1996).

[5] *See* 64 Fed. Reg. 38706, July 19, 1999.

[6] *See* 66 Fed. Reg. 17230, March 29, 2001.

[7] Vineis P, Husgafvel-Pursiainen K. (2005) Air pollution and cancer: biomarker studies in human populations. Carcinogenesis. 26:1846-1855.

[8] Rybicki BA, Neslund-Dudas C, Nock NL, Schultz LR, Eklund L, Rosbolt J, Bock CH, Monaghan KG. (2006) Prostate cancer risk from occupational exposure to polycyclic aromatic

and breast.[9] In addition, the American Cancer Society Study, a long term cohort study tracking more than a million people over 16 years in 150 metropolitan areas, has identified an association between lung cancer and exposure to fine particle matter.[10]

In view of all of the harmful substances contained within diesel exhaust, it is not surprising that diesel exhaust itself and diesel particulate matter increasingly have become recognized as being among the most serious health and environmental hazards in the United States today. In 1998, the Board listed particulate matter from diesel engines as a toxic air contaminant under California law.[11] In 2001, EPA listed diesel particulate matter and diesel exhaust organic gases as mobile source air toxics.[12] And EPA recently stated that it "has concluded that diesel exhaust ranks with the other emissions that the national-scale assessment suggests pose the greatest relative risk."[13] In fact, one recent study suggests that unmeasured pollutants may have a significant contribution on adverse health effects based on studies that associate health damages with traffic proximity.[14] Clearly, toxic diesel emissions are part of a group of compounds that pose the greatest danger to human health, especially in urban areas where diesel engines and emissions are concentrated in populated neighborhoods.[15]

In addition to increasing the risk of adverse pulmonary effects,[16] most toxicological reviews consider diesel exhaust to be, or likely to be, a human carcinogen.

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hydrocarbons interacting with the GSTP1 Ile105Val polymorphism. Cancer Detect Prev. 30:412-422.

[9] Gammon MD, Santella RM, Neugut AI, Eng SM, Teitelbaum SL, Paykin A, Levin B, Terry MB, Young TL, Wang LW, Wang Q, Britton JA, Wolff MS, Stellman SD, Hatch M, Kabat GC, Senie R, Garbowski G, Maffeo C, Montalvan P, Berkowitz G, Kemeny M, Citron M, Schnabel F, Schuss A, Hajdu S, Vinceguerra V. (2002) Environmental toxins and breast cancer on Long Island. I. Polycyclic aromatic hydrocarbon DNA adducts. Cancer Epidemiol Biomarkers Prev. 11:677-685.
Bonner MR, Han D, Nie J, Rogerson P, Vena JE, Muti P, Trevisan M, Edge SB, Freudenheim JL. (2005) Breast cancer risk and exposure in early life to polycyclic aromatic hydrocarbons using total suspended particulates as a proxy measure. Cancer Epidemiol Biomarkers Prev. 14:53-60.
Brody JG, Moysich KB, Humblet O, Attfield KR, Beehler GP, Rudel RA. (2007) Environmental pollutants and breast cancer: epidemiologic studies. Cancer. 109:2667-2771

[10] New York University, Press Release, "Most Definitive Study Yet Shows Tiny Particles in Air Are Linked to Lung Cancer," March 5, 2002; Pope. C.A., Burnett, R.T., Thun, M.J, Calle, E.E., Krewski, D., Ito, Kaz, and Thurston, G.D., *Lung Cancer*, *Cardiopulmonary Mortality, and Long Term Exposure to Fine Particulate Air Pollution*, Journal of the American Medical Association, Vol. 287, (2002), p. 1132-1141.

[11] California Air Resources Board Resolution 98-35, August 27, 1998.

[12] *See* 66 Fed. Reg. 17230, March 29, 2001.

[13] *See, e.g.,* Locomotive and Marine Rule, 73 Fed. Reg. at 25111.

[14] Jerrett M. (2007) Does traffic-related air pollution contribute to respiratory disease formation in children? Europ. Resp. Journal. 29:825-826.

[15] *See, e.g.,* Locomotive and Marine Rule, 73 Fed. Reg. at 25110-13; C3 Marine ANPR, 72 Fed. Reg. at 69532-34 .

[16] Peden DB. (2002) Pollutants and asthma: role of air toxics. Environ. Health Perspect. 110:565-568.

The National Institute for Occupational Safety and Health, International Agency for Research on Cancer, Health Effects Institute, World Health Organization, U.S. Department of Health and Human Services National Toxicology Program, and the U.S. Environmental Protection Agency have all determined that diesel exhaust is a probable or likely human carcinogen—that is, it is likely to cause lung cancer.[17] Diesel air pollution adds to cancer risk all around the country. Studies conducted by California as well as the South Coast Air Quality Management District have estimated that the average cancer risk from diesel particulate matter is about *70%* of the cancer risk from *all air toxics.*[18]

2. Harmful fine particulate matter is a major constituent of diesel exhaust

Diesel particulate matter pollution is a mixture of directly-emitted "primary" particles formed during combustion, and secondary particles formed post-combustion. Directly emitted particles are complex aggregates of carbon compounds, metals and toxics. Secondary particles are the byproducts of exhaust gas emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X) combining respectively with ammonia in the atmosphere to form sulfate and nitrate particles.

The toxicity of diesel particles is hypothesized, in part, to be a function of the extremely small size of the particles. Diesel exhaust is characterized by some of the smallest submicron particles (ultrafine particles) in the 5-100 nanometer (0.005-0.005 micron) range. Recent studies suggest that these ultrafine particles may be among the most toxic, with the ability to pass from the lung into the bloodstream where they may impact the cardiovascular system. Particulate matter's toxicity has been linked to inflammatory responses caused by the invasion of particles (and adsorbed chemicals) into human tissues and organs.[19]

Thousands of new studies assembled for the 2004 EPA review of Air Quality Criteria for Particulate Matter, as well as the 2008 EPA draft Integrated Science Assessment for Particulate Matter, link particulate matter with numerous adverse health effects.[20] Studies have failed to detect a lower threshold for the impacts of particulate matter,

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Delfino RJ. (2002) Epidemiologic evidence for asthma and exposure to air toxics: linkages between occupational, indoor, and community air pollution research. 110:573-589.

[17] *See, e.g.*, U.S. EPA, National Center for Environmental Assessment, Office of Research and Development, Health Assessment Document for Diesel Engine Exhaust (2002), *available at* http://www.epa.gov/iris (Search for EPA/600/8-90/057F).

9th Report on Carcinogens (2000), U.S. Department of Health and Human Services, Research Triangle Park, NC

[18] *See* California Air Resources Board, *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*, October 2000.

[19] Schlesinger RB, Kunzli N, Hidy GM, Gotschi T, Jerrett M. (2006) The health relevance of ambient particulate matter characteristics: coherence of toxicological and epidemiological inferences. Inhal. Toxicol. 18:95-125.

[20] U.S. EPA (2004) Air Quality Criteria for Particulate Matter, and EPA (2008) Integrated Science Assessment for Particulate Matter (First External Review Draft), *supra* note 1.

suggesting that there is no safe level to breathe. Children are especially vulnerable because their lungs are still developing.

Despite the considerable regional variability in the constituents of particulate matter, the epidemiological evidence that ambient exposures to particulate matter are associated with numerous adverse health effects is remarkably clear and consistent. The consistency of the data makes it feasible to quantify the benefits for a suite of health indicators, including: premature mortality, bronchitis, hospital admissions for both respiratory and cardiovascular events, emergency room visits for asthma, nonfatal heart attacks, lower and upper respiratory illness, minor restricted-activity days, work loss days, asthma exacerbations, respiratory symptoms (asthmatic population), and infant mortality.[21] For example, Abt Associates, for Clean Air Task Force has, using EPA Science Advisory Board approved methods, associated diesel exhaust particle exposure in the U.S. with an estimated 21,000 annual premature deaths, 27,000 heart attacks, 21 million work loss days.[22] Diesel particles are also associated with asthma, respiratory infections, chronic bronchitis and allergic sensitization. [23] For example, Abt Associates estimates an annual 12,000 cases of chronic bronchitis, 15,000 emergency room visits for asthma and 600,000 cases of respiratory symptoms.

Recent studies suggest that the gravest risk from long term and short term exposure to particles is the impact on the cardiovascular system. Over the past decade, studies have uncovered a link between exposure to fine particles and heart disease including arrhythmias, stroke and myocardio infarction (heart attack) and related death. For example, diesel exhaust particles may raise the risk of blood clots and stroke[24] with risk more than doubled within 2 hours of exposure in one Japanese study.[25]

Three major cohort studies including recent studies sponsored by the Health Effects Institute—an EPA-industry jointly funded group—have consistently associated fine particulate matter with premature death throughout the United States.[26] With the

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[21] Schlesinger, et al, supra, note 26.
See also, e.g , Cohen, A.J. and Nikula K., *The Health Effects of Diesel Exhaust*, in Air Pollution and Health, 1999, Holgate, S., Samet J., Koren, H. and Maynard, R., eds.
[22] Abt Associates (December 2004) Diesel Particulate Matter Related Health Damages. Available at: http://www.catf.us/projects/diesel/dieselhealth/20041216-REMSAD_No_Diesel_Report.pdf
[23] *See e.g.*, Brauer, M et al. (2002). Air pollution from traffic and the development of respiratory infections and asthmatic and allergic symptoms in children. American Journal of Respiratory and Critical Care Medicine, v. 166, p. 1092-1098.
Brown, J., and Frew, A. (2002). Diesel exhaust particles and respiratory allergy. European Respiratory Mon. v. 21, p. 180-192.
[24] Nemmar, A., Hoet, P., Dinsdale, D.,Vermylen, J., Hoylaerts,M., and Nemery, B., *Diesel Exhaust Particles in Lung Acutely Enhance Experimental Peripheral Thrombosis,* Circulation. Vol. 107, (2003), pp.1202-1208.
[25] Yamazaki, S, Nitta, H., Ono, M., Green, J., Fukuhara, S. (2006) Intracerebral hemmorrage associated with hourly concentration of ambient particulate matter: case-crossover analysis. Journal of Occupational and Environmental Medicine September 2006 online.
[26] *See, e.g.,* Pope, C.A., Thun, M.J., Namboordiri, M.M. and Dockery, D.W., et al.; *Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults.* 151 American

even more recent publication of several additional studies involving the collection of data over an extended period of time,[27] the evidence linking particulate matter with premature mortality, significant lung damage, and other significant adverse health effects is growing stronger. The extended observational period of these studies, combined with more sophisticated exposure assessments, continue to strengthen the evidence that particulate matter poses a significant health threat at current levels of exposure.

C. Diesel Exhaust and Occupational Health

Approximately 40 medical studies over the past three decades have investigated and documented a link between the exposure to diesel exhaust and lung, bladder and colon cancer in occupational settings. In fact, worker exposure to diesel exhaust provided the first medical evidence that breathing diesel exhaust is unhealthful. Moreover, diesel's classification as a likely carcinogen is largely based on occupational health studies of truckers and railroad workers.[28] These studies have lead international, federal and state agencies to identify whole diesel exhaust as a probable or likely carcinogen (e.g. U.S. EPA, the State of California and the International Agency for Research on Cancer (IARC).[29, 30, 31] Individually, gaseous and particulate compounds in diesel exhaust, such as polycyclic aromatic hydrocarbons and formaldehyde, are also known as carcinogens based on worker exposure.

Journal of Respiratory and Critical Care Medicine (1995). Available at http://ajrccm.atsjournals.org/search.shtml. Krewski, D., Burnett, R.T., Goldberg, M.S., Hoover, K., Siemiatycki, J., Jerrett, M., Abrahamowicz, A. and White, W.H., *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Matter and Mortality;* Special Report to the Health Effects Institute, Cambridge, MA (July 2000). Samet, J.M., Dominici, F., Zeger, S.L., Schwartz, J. and Dockery, D.W.; *National Morbidity, Mortality and Air Pollution Study, Part II: Morbidity, Mortality and Air Pollution in the United States;* Health Effects Institute Research Report No. 94, Cambridge MA (June 2000).Dockery, D.W., Pope, C.A., Xu, S. and Spengler, J.D., et al; *An Association Between Air Pollution and Mortality in Six U.S. Cities;* 329 New England J. Medicine 1753-59 (1993). Available at http://nejm.org/content/1993/0329/0024/1753.asp.

[27] Laden F, Schwartz J, Speizer FE, Dockery DW. (2006) Reduction in fine particulate air pollution and mortality extended follow-up of the Harvard Six Cities Study. Am. J. Respir. Crit. Care Med. 173:667–672.
Gauderman WJ, Vora H, McConnell R, Berhane K, Gilliland F, Thomas D, Lurmann F, Avol E, Kunzli N, Jerrett M, Peters J. (2007) Eff ect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study. Lancet. 369(9561):571-577.
Brauer M, Hoek G, Smit HA, de Jongste JC, Gerritsen1 J, Postmae DS, Kerkhof M, Brunekreef B. (2007) Air pollution and development of asthma, allergy and infections in a birth cohort. Eur. Resp. J. 29: 879–888.

[28] Lipsett, M., Campleman, S., (1999). Occupational exposure to diesel exhaust and lung cancer: a meta-analysis. American Journal of Public Health v. 89, no 7, p. 1009-1017.

[29]EPA, Health Assessment Document for Diesel Exhaust: Office of Research and Development, EPA/600/8-90/057F May 2002. P. 9-14;

[30] California Air Resources Board (1998): Resolution 98-35--Identification of diesel exhaust as a toxic air contaminant. Go to: http://www.arb.ca.gov/regact/diesltac/diesltac.htm;

[31] International Agency on Cancer, Monograph 46. See at: http://monographs.iarc.fr/ENG/Monographs/vol46/volume46.pdf

For example, in a study of 55,000 railroad workers over 38 years, Harvard researchers found an overall 40% increased risk of lung cancer for workers in 30 job categories.[32] A meta-analysis of exposure to diesel exhaust and bladder cancer published in 2001 found a positive association in 10 of 12 studies, with a collective average excess risk of 13%.[33] A 50% excess risk of colon cancer in men was related to exposure to diesel engine emissions in a 2001 study.[34]

Workers are not only exposed to higher cancer risk, but also risk from heart disease and nervous system impairment. For example, a 2004 study of highway patrolmen particulate matter was linked to irregular heartbeats and increases in blood inflammatory markers.[35] A study of railroad workers exposed to diesel exhaust concluded: "crews may be unable to operate trains safely."[36]

A number of studies have explicitly focused on exposure to emissions from diesel trucks, such as those that are the subject of one of the Board's Diesel Rules now under review. For example, a 1998 study of diesel exposure in the trucking industry concludes that the lifetime excess risk for workers adjusted for smoking was ten times the one-in-a-thousand excess risk allowed by OSHA.[37] A study of 54,000 truckers from 1985-2000 published by Harvard in 2007 found a 10 % higher risk for lung cancer in drivers and dock workers compared to the general U.S. population. The same study also found a higher risk in heart disease in the trucking industry compared to the general U.S. population: a 49 % higher risk in drivers, a 32% higher risk in dock workers, and a 34% higher risk in shop workers.[38]

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[32] Garshick, E., Laden, F., Hart, J., Rosner, B., Smith T., Dockery, D. And Spiezer, F. (2004). Lung cancer in railroad workers exposed to diesel exhaust. Environmental Health Perspectives, v. 122, no. 15, November, 2004.
Garshick, E., Schenker, M, Munoz, A., Segal, M., Smith, T., Woskie, S., Hammond, S., and Speizer, F. (1988). A retrospective cohort study of lung cancer and diesel exhaust exposure in railroad workers. American Review of. Respiratory Disease v. 135, p. 820-825.
[33] Boffetta, P., Silverman, D.T. (2001). A meta-analysis of bladder cancer and diesel exhaust exposure. Epidemiology. January 2001, v.12. no. 1.,p. 125-130.
[34] Goldberg, M., Parent, M., Siemiatycki, J, Desy, M., Nadon, M., Richardson, L., Lakhani, R., Latreille, B., and Valois, M. (2001) A case-control study of the relationship between the risk of colon cancer in men and exposures to occupational agents. American Journal of Industrial Medicine, v. 39, p. 531-546.
[35] Riediker, M., Cascia, W., Griggs, T., Herbst, M.m Bromberg, P., Neas, L., Williams, R., and Devlin, R. (2004). Particulate matter exposure in cars is associated with cardiovascular effects in healthy young men. American Journal of Respiratory and Critical Care Medicine, v. 169, p. 934-940.
[36] Kilburn, K.H. (2000). Effects of diesel exhaust on neurobehavioral and pulmonary functions. Archives of Environmental Health, v. 55, no. 1, p. 11-17.
[37] Steenland, K. Deddens, J., Stayner, L. (1998). Diesel exhaust and lung cancer in the trucking industry: exposure-response analyses and risk assessment. American Journal of Industrial Medicine, v. 43, no. 3, p. 220-228.
[38] Laden, F., Hart, J., Smith, T., Davis, M., and Garshick, E. (2007) Cause-specific mortality in the trucking industry. Environmental Health Perspectives, v. 115, no. 8. p. 1192-1196.

These studies suggest that reducing exposure to diesel exhaust from trucks should be an occupational health priority.

C. Public Welfare—Including Climate—Impacts

1. General

Diesel emissions also contribute to numerous adverse welfare and environmental effects. These include acid deposition, watershed eutrophication and nitrification, adverse impacts on vegetation and ecosystems, materials damage and soiling and regional haze.[39]

However, in addition to these "traditional" environmental impacts, the important climate impacts associated with diesel emissions are now becoming better understood and recognized as important. On-road and off-road diesel engines are significant emitters of several pollutants associated with climate change, including most significantly black carbon. Its climate linkages are briefly described below. We urge the Board to consider the benefits of reducing climate impacts in its review, along with other environmental and public health benefits commonly cited.

2. Climate Impacts of Black Carbon

Black carbon, also known as soot, consists of microscopic light absorbing solid particles of incompletely combusted organic matter.[40] Black carbon is a potent climate forcing agent, exerting effects on the global climate both while suspended in the atmosphere and when deposited on snow and ice. As an aerosol, there is no standardized formula for developing global warming potentials (GWP) for black carbon. However, attempts to derive GWP_{100} range from 190 - 680 relative to CO_2.[41,42,43] A higher GWP for black carbon in fossil fuel soot has been calculated at 1500-2240.[44] The most pernicious characteristic of black carbon from a climatic perspective is its dark color and

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[39] *See, e.g.,* Locomotive and Marine Rule, 73 Fed. Reg. at 25115-17; also C3 Marine ANPR, 72 Fed. Reg. at 69534-36.

[40] See W. Chameides and M. Bergin, Soot Takes Center Stage, 297 SCIENCE 2214 (Sept. 27, 2002), (explaining that "BC is produced through incomplete combustion of biomass, coal, and diesel fuel").

[41] Jacobson M Z 2005 Correction to `control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming' *J. Geophys. Res.* **110** D14105.

[42] Hansen, J., Mki. Sato, P. Kharecha, G. Russell, D.W. Lea, and M. Siddall, 2007: Climate change and trace gases. Phil. Trans. Royal. Soc. A, 365, 1925-1954, doi:10.1098/rsta.2007.2052.

[43] Bond, T. and Haolin, Sun, "Can Reducing Black Carbon Emissions Counteract Global Warming?" ES&T, August 2005. p. 5921.

[44] Jacobson, M. Testimony for the Hearing on Black Carbon and Climate Change, U.S. House Committee on Oversight and Government Reform 12 (18 October 2007), *available at* http://oversight.house.gov/documents/20071018110606.pdf.

correspondingly low albedo, or reflectivity. Because of this dark coloring, black carbon absorbs heat from sunlight.[45]

When suspended in the air, black carbon warms by trapping heat in the top of the atmosphere.[46] The IPCC estimates that atmospheric black carbon exerts a positive radiative forcing effect of +0.3 W/m^2.[47] A more recent estimate has placed the black carbon forcing at 0.9 W/m^2.[48]This direct warming leads to feedback effects that magnify its overall global warming contribution.[49] For example, as black carbon particles absorb sunlight, they warm the air around them, decreasing the relative humidity of the air and thus the liquid water content of other particles suspended in the air.[50] The drying out of these other particles reduces *their* reflectivity, and as they absorb more sunlight the air warms even more.[51] Further, the water evaporated from such particles remains in the air as water vapor, which is itself a greenhouse gas.[52]

When deposited out of the air onto a lighter surface, the darker black carbon causes the surface to absorb more of the sun's energy. Thus, when deposited on snow or ice, black carbon can reduce the snow's reflectivity and accelerate the melting process.[53] As when suspended in the atmosphere, black carbon's deposition onto ice and snow creates positive feedback effects that lead to even greater warming. For example, as snow and ice around them melt away, the deposited black carbon particles can become even more concentrated on and near the surface, further reducing the reflectivity of the remaining snow and ice.[54] Thus, although the IPCC estimates the radiative forcing effect of black carbon deposition on snow and ice to be +0.1 W/m^2, of the +0.3 W/m^2, it acknowledges that the radiative forcing metric may not accurately capture the climatic impacts of black carbon deposition on snow and ice. In the words of the IPCC, "the

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[45] Chameides and Bergin, *supra* note 47, at 2214 (noting that while "greenhouse gases warm by absorbing infrared or terrestrial radiation," "BC warms by absorbing sunlight").
[46] M. Shekar Reddy and Olivier Boucher, Climate Impact of Black Carbon Emitted from Energy Consumption in the World's Regions, 34 GEOPHYSICAL RESEARCH LETTERS L11802 (2006) at 1 (stating that "Black carbon (BC) exerts a positive forcing at the top of the atmosphere").
[47] IPCC (2007): T*echnical Summary. In: Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, (*Solomon, S.; Qin, D.; Manning, M; et al, eds.) at 30, 32 (hereinafter "IPCC Technical Summary"), available on the Internet at: http://ipcc-wg1.ucar.edu/wg1/wg1-report.html.
[48] Ramanathan, V.; Carmichael, G. Global and Regional Climate Changes Due to Black Carbon; *Nat. Geosci.* 2008, *1*, 221-227.
[49] Mark Z. Jacobson, Control of Fossil-Fuel Particulate Black Carbon and Organic Matter, Possibly the Most Effective Method of Slowing Global Warming, 107 JOURNAL OF GEOPHYSICAL RESEARCH 4410 (2002), at 6-8 (discussing twelve ways in which suspended BC affects climate).
[50] Id. at 6.
[51] Id.
[52] Id. at 7.
[53] Reddy and Boucher, supra note 53, at 2.
[54] Flanner, Mark G., et al., Present-Day Climate Forcing and Response from Black Carbon in Snow, 112 JOURNAL OF GEOPHYSICAL RESEARCH D11202 (2007) at 2.

'efficacy' may be higher" for black carbon radiative forcing, as it produces a temperature response 1.7 times greater than an equivalent radiative forcing due to carbon dioxide.[55]

Black carbon may be responsible for 7 to 30 percent of the observed global warming.[56,57] Black carbon is a component of the particulate matter emitted from trucks and other combustion engines. In fact, approximately 66 percent of anthropogenic black carbon emissions come from the burning of fossil fuels.[58] According to EPA, approximately 75% of the mass of PM emissions from heavy-duty diesel vehicles is black carbon, with the balance organic carbon and sulfate.[59] We also note that plumes of black carbon can travel great distances and deposit on areas far away from the initial emission site. Some modeling has shown black carbon from sources in Asia being deposited on snow in the Arctic.[60]

Conclusion.

We commend ARB for taking strong action to reduce toxic diesel emissions from the in-use fleet of nonroad and on-road engines in California. We urge ARB to reaffirm each of the Diesel Rules under review without qualification, weakening or delaying implementation.

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[55] IPCC (2007): Forster, P., et al. *Changes in Atmospheric Constituents and in Radiative Forcing*, at 184-85. *In: Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, available on the Internet at: http://ipcc-wg1.ucar.edu/wg1/wg1-report.html.
Because black carbon can accelerate the melting of snow and ice, it may play a particularly important role in Arctic climate change. Moreover, the radiative forcing of suspended black carbon particles may be amplified at the poles, where there is more light reflected from the Earth's surface, and thus more light available for the black carbon particles to absorb (see Forster, *Id*, at 163. "Additionally, the presence of BC in the atmosphere above highly reflective surfaces such as snow and ice, or clouds, may cause a significant positive RF"). Because the Arctic has warmed at around twice the rate of the rest of the world over the last 100 years, (IPCC (2007): Trenberth, K.E, et al., *Observations: Surface and Atmospheric Climate Change*, at 237. *In: Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, available on the Internet at: http://ipcc-wg1.ucar.edu/wg1/wg1-report.html), controlling and reducing black carbon emissions is particularly important.
[56] Hansen, J., Mki. Sato, R. Ruedy, L. Nazarenko, A. Lacis, G.A. Schmidt, G. Russell, I. Aleinov, M. Bauer, S. Bauer, N. Bell, B. Cairns, V. Canuto, M. Chandler, Y. Cheng, A. Del Genio, G. Faluvegi, E. Fleming, A. Friend, T. Hall, C. Jackman, M. Kelley, N.Y. Kiang, D. Koch, J. Lean, J. Lerner, K. Lo, S. Menon, R.L. Miller, P. Minnis, T. Novakov, V. Oinas, Ja. Perlwitz, Ju. Perlwitz, D. Rind, A. Romanou, D. Shindell, P. Stone, S. Sun, N. Tausnev, D. Thresher, B. Wielicki, T. Wong, M. Yao, and S. Zhang, 2005: Efficacy of climate forcings. J. Geophys. Res., 110, D18104, doi:10.1029/2005JD005776.
[57] Ramanathan, *supra*, note 55.
[58] Reddy and Boucher, *supra* note 53, at 1.
[59] *See, e.g.* http://www.epa.gov/ttn/chief/emch/speciation/pm25_prof_titles_revised.xls.
[60] Koch, D., and J. Hansen, 2005: Distant origins of Arctic black carbon: A Goddard Institute for Space Studies ModelE experiment. *J. Geophys. Res.*, **110**, D04204, doi:10.1029/2004JD005296.

Respectfully submitted,

David Marshall, Senior Counsel
Clean Air Task Force
PO Box 950
41 Liberty Hill Road
Building #2, Suite #205
Henniker, NH 03242
dmarshall@catf.us