INDUSTRY WIDE LABOR-MANAGEMENT SAFETY COMMITTEE

SAFETY BULLETIN #13

GASOLINE OPERATED EQUIPMENT

As a reminder, the following information was disseminated to the Industry in 1974:

Internal combustion engine driven equipment shall be operated inside of buildings or enclosed structures only when such operation does not result in harmful exposure to concentrations of dangerous gas or fumes in excess of threshold limit values except as permitted by Cal/OSHA General Industry Safety Orders Sec. 5146.

Exhausted by Diesel

How America's Dependence on Diesel Engines Threatens Our Health

Top of Report

HIGHLIGHTS

- Diesel exhaust is a mixture containing over 450 different components, including vapors and fine particles coated with organic substances.[10] Over 40 chemicals in diesel exhaust are considered toxic air contaminants by the State of California (see Table 1). Exposure to this mixture may result in cancer, respiratory effects, and other health problems.

- California's Scientific Review Panel has unanimously endorsed the official listing of diesel exhaust as a toxic air contaminant, due to its cancer and non-cancer health effects.

- Diesel exhaust has been listed as a known carcinogen under California's Safe Drinking Water and Toxic Enforcement Act (Prop. 65) since 1990.[2] Many components of diesel exhaust, such as benzene, arsenic, dioxins, and formaldehyde, are also known carcinogens in California. Other components, such as toluene and dioxins, are known reproductive toxicants.

- For the same load and engine conditions, diesel engines spew out 100 times more sooty particles than gasoline engines.[10] As a result, diesel engines account for an estimated 26 percent of the total hazardous particulate pollution (PM_{10}) from fuel combustion sources in our air, and 66 percent of the particulate pollution from on-road sources.[11]

- Diesel engines also produce nearly 20 percent of the total nitrogen oxides (NO_x) in outdoor air and 26 percent of the total NO_x from on-road sources.[12] Nitrogen oxides are a major contributor to ozone production and smog.

- The health risk from diesel exposure is greater for children, the elderly, people who have respiratory problems or who smoke, people who regularly strenuously exercise in diesel-polluted areas, and people who work or live near diesel exhaust sources.

- According to an expert estimate, lifetime exposure to diesel exhaust at the outdoor average concentration (2.2 micrograms per cubic meter ($\mu g/m^3$) may result in about one in every 2,000 people developing cancer due to this exposure. This estimate increases to as many as one in every 1,200 at levels

found in the South Coast Air Basin in Southern California (3.6 µg/m^3), and to even higher risks for those living near freeways or in highly polluted urban communities.[13]

- Dozens of studies link airborne fine particle concentrations to increased hospital admissions for respiratory diseases, chronic obstructive lung disease, pneumonia, heart disease and death.[14] Recent evidence indicates that diesel exhaust exposure may contribute to asthma.[15]

- About 127 million Americans -- half of the nation's population -- live in regions with air quality that does not meet federal standards for certain air pollutants.[16] More than 60 percent of preadolescent children, including children with asthma, live in "nonattainment" areas. In the United States, there are an estimated 10.3 million people living with asthma.[17]

- In California, there are six million children under the age of fourteen, 90 percent of whom live in areas that fail to meet state and federal air quality standards.[18] According to the American Lung Association, there are over a half million children with asthma in California.

- Asthma is on the rise. In the United States, age-specific death rates from the disease increased 118 percent between 1980 and 1993.[19] African-American and Latino children have a higher risk of asthma than white children.[20] Moreover, African-American children are four times more likely to die from asthma compared to Caucasian children.[19]

- Cleaner alternatives to diesel engines are readily available. Alternatives include electric, liquefied natural gas (LNG) or compressed natural gas (CNG) buses and trucks.

- Although initial purchase prices may be higher for alternative fuel buses and trucks, federal, state, and local funds are available to offset these higher costs. These funds are specifically earmarked for clean technologies and would not otherwise be available for these purchases.

- For transit authorities, use of alternative fuel buses can generate operational cost savings. Sacramento RTD's CNG bus fleet is currently demonstrating cost savings of 20-40% per mile when compared to diesel counterparts. Over its lifetime, a CNG bus will save 190,000 gallons of diesel fuel compared to a new diesel bus, decreasing our dependency on petroleum.[21]

- Diesel buses and trucks are important contributors to smog (ground-level ozone) and fine toxic soot, two pollutants that have recently come under increased scrutiny because of their important public health impacts. Purchasing alternative fuel vehicles will reduce smog and fine soot emissions considerably. For example, operating a natural gas bus instead of a new diesel bus is equivalent to eliminating the smog and soot from 17-55 passenger cars.

Notes

2. Cal EPA, Chemicals Known to the State to Cause Cancer or Reproductive Toxicity, Revised May 1, 1997.

10. Mauderly JL. Diesel Exhaust in Lippman M. (ed.) Environmental Toxicants: human

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Top of Report

Chapter 2

HUMAN HEALTH IMPACTS

The scientific evidence is clear: diesel exhaust is a complex mixture comprised of hazardous particles and vapors, some of which are known carcinogens and others probable carcinogens. Diesel exposure poses a significant and avoidable increase in human health risks. Compelling evidence from dozens of well-designed studies supports the conclusion that diesel exhaust causes cancer. In addition, fine particles from diesel exhaust aggravate respiratory illnesses such as bronchitis, emphysema and asthma and are associated with premature deaths from cardio-pulmonary disorders.[9] The evidence of health effects is derived from extensive studies of human workers as well as some studies in animals, and observations of various kinds of mutagenic activity in culture systems. Based on extensive evidence, 41 constituents of diesel exhaust have been listed by the State of California as Toxic Air Contaminants, as shown in Table 1. The only reasonable conclusion one can draw from the massive scientific evidence is that exposure to diesel exhaust significantly increases human health risks.

Table 1: Substances in Diesel Exhaust Listed by Cal EPA as Toxic Air Contaminants

acetaldehyde	inorganic lead
acrolein	manganese compounds
aniline	mercury compounds
antimony compounds	methanol
arsenic	methyl ethyl ketone
benzene	naphthalene
beryllium compounds	nickel

biphenyl	4-nitrobiphenyl
bis[2-ethylhexyl]phthalate	phenol
1,3-butadiene	phosphorus
cadmium	polycyclic organic matter, including
chlorine	polycyclic aromatic hydrocarbons (PAHs)
chlorobenzene	and their derivatives
chromium compounds	propionaldehyde
cobalt compounds	selenium compounds
creosol isomers	styrene
cyanide compounds	toluene
dibutylphthalate	xylene isomers and mixtures
dioxins and dibenzofurans	o-xylenes
ethyl benzene	m-xylenes
formaldehyde	p-xylenes

Note: California Health and Safety Code section 39655 defines a "toxic air contaminant" as "an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health."

Diesel Exhaust and Cancer: Beyond a Reasonable Doubt

Many studies have shown that diesel exhaust causes mutations in chromosomes and damage to DNA, processes which are believed to be important in the causation of cancer.[10] There is also overwhelming evidence from studies of workers occupationally exposed to diesel exhaust revealing an increased cancer risk. Most of the over two dozen well-designed worker studies found lung cancer increases in those exposed to diesel exhaust for over a decade.[46] Similar increases in risk are found in studies that controlled for cigarette smoking, as in those where information about smoking was unavailable. A recent analysis shows that consistent findings of an approximately 30 percent increase in risk of lung cancer among diesel exposed workers is highly unlikely to be due to chance, confounders (such as smoking), or bias.[47] Unfortunately, many of these studies are limited by imprecise estimates of exposure levels, particularly for occupational exposures that occurred in the past.' The task of studying exposure to diesel exhaust is further complicated by the fact that there is no standard methodology for measurement of exposure, and there is uncertainty about which component or components of diesel exhaust may be most significant in inducing disease.

Despite these difficulties, the occupational studies consistently demonstrate that exposure to diesel exhaust for ten years or more does significantly increase the human incidence of lung cancer, and possibly of bladder cancers. U.S. EPA, Cal EPA, the National Institute of Occupational Safety and Health, and the International Agency for Research on Cancer have all consistently agreed on the relationship between diesel exhaust exposure and lung cancer.[48] Numerous independent analyses of the data by top scientists have come to the same conclusions.[49]

Many animal studies also indicate that inhalation of diesel exhaust causes cancer.[50] The studies primarily found tumors of the lung, but some also noted increased tumors at other sites.[51] However, the relevance of these studies has been questioned since the animals were exposed to very high diesel exhaust levels and the resulting inflammation and cell proliferation does not appear to occur at occupational or ambient diesel exposure levels.

Quantifying the Cancer Risk from Diesel Exhaust

Despite the extensive scientific data available, there is still uncertainty concerning exactly how potent a carcinogen diesel exhaust really is. Dale Hattis, Ph.D., a nationally recognized expert on diesel exhaust from Clark University, performed an independent calculation, based on the Cal EPA draft analysis, that sought to characterize the current uncertainty and estimate the diesel cancer risk.[52] Among a million people exposed chronically to 1 microgram per cubic meter ($\mu g/m^3$) of diesel exhaust, Dr. Hattis's estimated 90 percent confidence range indicates that 34 to 650 people might be expected to develop lung cancer. The average estimate is 230 per million so exposed.[53]

Unfortunately, most people are exposed to more than 1 $\mu g/m^3$ of diesel exhaust every day. In fact, the California Air Resources Board estimates that the average total exposure for Californians who spend most of their time indoors is 1.54 $\mu g/m^3$ of diesel exhaust, while the average outdoor air concentration of diesel exhaust in California in 1995 is 2.2 $\mu g/m^3$. These estimates were arrived at by averaging levels in both rural and urban areas.[54] Estimates of diesel exhaust exposure levels in urban areas range as high as 23 $\mu g/m^3$. Chronic exposure at these levels would potentially result in many more lung cancer cases. We expect exposure levels in rural and urban areas throughout the country to be similar to those found in California.

The U.S. EPA suggests that a cancer risk may be "negligible" if a substance induces one excess cancer out of a million people exposed over a lifetime. Using the mean value in Dr. Hattis's uncertainty distribution for diesel exhaust potency, the expectation is that exposure to the average levels of diesel exhaust found in California-of 1.54 μ/m^3 of diesel exhaust-is likely to result in an excess risk over a person's lifetime of about 350 cancers per million exposed.[55] This risk is far above U.S. EPA's "negligible risk" level. Applying these risk estimates, over a lifetime, exposure to diesel exhaust may cause 12,000 *or more* additional cancer cases in California alone.[56] The potential health risks nationally are staggering.

Moreover, these risk estimates are for the "average" person who breathes less than the statewide outdoor average concentration levels of diesel exhaust. People who are exposed to higher than average levels of diesel exhaust, such as urban residents, people living near major roads, distribution centers and other diesel "hot spots," and occupationally exposed individuals, would have higher risks of lung cancer from diesel. These estimates indicate the magnitude of the task before us in reducing the diesel risk and only hint at the enormous human tragedy due to diesel exposure. Lung cancer has a poor prognosis; the five-year survival rate is less than 14 percent.[57] Thus if 350 excess lung cancers are projected per million people exposed, 300 of these victims would likely die within five years.

Beyond Cancer: Other Health Impacts from Diesel Exhaust

Airborne particulate matter smaller than 10 microns in size, also called PM_{10}, are respirable particles, meaning that they can make their way deep into our lungs. Even smaller particles, smaller than 2.5 microns in size ($PM_{2.5}$), are even more likely to lodge and linger in the deepest air sacs of the lung. More than 98 percent of the total number of particles in diesel exhaust are $PM_{2.5}$.[31] PM_{10} has been regulated by the Air Resources Board since 1982 and by U.S. EPA since 1987. However, efforts to control PM_{10} alone will not suffice to reduce diesel exhaust concentrations to safe levels. Because measures of PM_{10} are mass-based, control strategies emphasize reductions of larger, heavier particles, such as those occurring from earth-moving in construction and agriculture, and are unlikely to focus on reducing the $PM_{2.5}$ from diesel combustion. Recognizing the significant risks posed by tiny particles, U.S. EPA adopted new National Ambient Air Quality Standards for particles under 2.5 microns in size, which went into effect on September 16, 1997.[58]

Lung Damage

Great advances have been made in the 1990s in understanding the health effects of fine particles. Since 1987, more than two dozen community health studies have linked respirable particle concentrations below the level of the current air quality standards to reductions in lung function, and increased hospital and emergency room admissions. Long-term exposure has been related to decreases in lung function in both children[59] and adults.[60] Recurrent respiratory illnesses in children are associated with increased particulate exposures, and such a pattern of childhood illness may be a risk factor for later susceptibility to lung damage.[61]

Particulate matter exposure causes changes in lung function and inflammation of the small airways.[62] Furthermore, exposure to acidic particles may cause constriction of the bronchi and impair clearance processes which normally remove particles and infectious organisms from the airways.[63] The consequences may include aggravation of existing respiratory problems, more frequent or severe damage to tissues, or greater loss of lung function.

Infections and Asthma

Particulate exposure may increase susceptibility to bacterial or viral respiratory infections, and may increase the incidence of respiratory disease in vulnerable members of the population, including the elderly, people with chronic pulmonary diseases, and people with immune system dysfunction.[64] In the presence of pre-existing heart or lung disease, respiratory exacerbations induced by air pollutants may lead to death.

Recent research indicates that diesel exhaust may increase the frequency and severity of asthma exacerbations and may lead to inflammation of the airways that can cause or worsen asthma.[65] This information is quite new and extremely important in light of the fact that the incidence of asthma is on the rise, increasing nearly 40 percent among U.S. children between 1981 and 1988.[66] There are an estimated 10.3 million people in the United States with asthma.[67] The death rate from asthma has increased by 118 percent from 1980 to 1993.[68] Asthma occurs far more frequently in African-American and Latino children;[69] indeed, African-American

children are four times more likely to die from asthma than white children.[70] Children of Latino mothers have a rate of asthma two-and-a-half times higher than whites and more than one-and-a-half times higher than African-Americans.

Premature Death

In December 1993, Harvard researchers published the results of a sixteen-year-long community health study that tracked the health of 8,000 adults in six U.S. cities with differing levels of air pollution. After adjusting for age and smoking, researchers found that residents of the most polluted city had a 26 percent higher mortality rate than those living in the least polluted city.[71] This translated into a one- to two-year shorter lifespan for residents of the most polluted cities.[72] Another major study corroborated these findings. The study correlated American Cancer Society data on the health of 1.2 million adults with air pollution data in 151 U.S. metropolitan areas. The study found that people living in the most polluted area had a 17 percent greater risk of mortality than people living in the least polluted city.[73]

A number of prestigious international panels, including a British Committee on the Medical Effects of Air Pollutants and a Committee of the Health Council of the Netherlands, have concluded that there is a cause-and-effect relationship between particulate pollution and premature death.[74] Such a conclusion is warranted based on the consistency of the association in different studies and situations, the dose-response relationship, and the biological plausibility.

In 1996, U.S. EPA published a risk assessment focusing on Southeast Los Angeles County. The U.S. EPA estimates over 3,000 excess deaths occur annually due to levels of particle pollution above the current federal standards in this particular area of Los Angeles alone.[75] The federal agency estimated more than 52,000 episodes of respiratory symptoms each year-including about 1,000 hospital admissions-from the particle levels observed in 1995 in Southeast Los Angeles. U.S. EPA estimates more than 40,000 particle-related health effects (including 300 to 700 deaths) would occur in Los Angeles even if the area brought pollution down to the current federal particle standards.

NRDC performed a study entitled *Breath Taking: Premature Mortality Due to Particulate Air Pollution in 239 American Cities,* which was based on the risk relationships identified in the American Cancer Society and Harvard studies. In this study, released in May, 1996, NRDC applied the known risk relationships to a variety of urban areas where particle levels had been adequately monitored. We found that nationally over 50,000 premature deaths per year may be attributable to the existing levels of particles in the air.

Other Non-Cancer Impacts

Many of the individual constituents of diesel exhaust are known to produce harmful effects. Benzene, for example, is known to cause disorders of the blood and the blood-forming tissues.[76] Formaldehyde and acetaldehyde can cause irritation of the eyes, nose, and throat.[77] Toluene, lead, cadmium, and mercury are known to cause birth defects and other reproductive problems.[78] Dioxins are toxic to the immune system, interfere with hormone function, and are toxic to reproduction.[79] These non-cancer effects of diesel exhaust components can also be serious and damaging. The extent to which these effects may occur from current exposure levels is unclear.

Exposure to diesel exhaust in combination with other cancer causing substances may increase your risk of developing lung cancer even more. Other exposures that are known to cause lung cancer include cigarette smoke, welding fumes and asbestos. All of these exposures may interact with diesel exhaust to magnify your risk of lung cancer, and should be kept to a minimum.

Some studies have suggested that workers exposed to diesel exhaust are more likely to have chronic respiratory symptoms (such as persistent cough and mucous), bronchitis, and reduced lung capacity than unexposed workers.

People with preexisting diseases, such as emphysema, asthma, and heart disease, may be more susceptible to the effects of diesel exhaust.

Studies in animals suggest that diesel exhaust may have other effects as well:

- Mice developed skin cancer when extracts of diesel exhaust were applied to their skin.
- Diesel exhaust caused lung injury in exposed laboratory animals.
- Exposure to diesel exhaust reduced animals' resistance to bacterial infection.
- Laboratory animals exposed to high concentrations of diesel gases showed a reduced level of activity and coordination.

In addition, many of the individual components of diesel exhaust are known to be hazardous. For example, nitrogen oxides can damage the lungs, and carbon monoxide can aggravate heart disease and affect coordination.

Control of Diesel Exhaust

Substitution

Where possible, replace diesel engines with propane-burning engines. Propane burns more completely and more cleanly than diesel fuel.

Ventilation

Diesel exhaust in garages, warehouses, or other enclosed areas should be controlled using ventilation.

Local exhaust ventilation is the best way to reduce potential hazards to diesel exhaust. A good ventilation system should include both intake and exhaust fans that remove harmful fumes at their source. Tailpipe or stack exhaust hoses should be provided for any vehicle being run in a maintenance shop.

General ventilation uses roof vents, open doors and windows, roof fans, or floor fans to move air through the work area. This is not as effective as local exhaust ventilation, and may simply spread the fumes around the work area. General ventilation may be helpful, however, when used to supplement local exhaust ventilation.

Isolate the Worker

Another way of controlling diesel exhaust exposures is to isolate the worker from diesel fumes.

- Trucks should have air-conditioned cabs to isolate the driver from fumes (Windows should be rolled up so that fumes do not seep inside).
- Toll booth collectors can be protected from fumes by working in air-conditioned booths.

FACT SHEET HEALTH AND SAFETY

Diesel Exhaust

Diesel engines are used by an increasing number of automobiles, generators, light-duty and heavy-duty vehicles, and railroad locomotives. When diesel fuel burns in an engine, the resulting exhaust is made up of soot and gases which may contain thousands of different chemical substances.

The soot consists of very small particles that can be inhaled and deposited in the lungs. Diesel exhaust contains 20-100 times more particles than gasoline exhaust. These particles carry cancer-causing substances known as polynuclear aromatic hydrocarbons (PAHs). Gases in diesel exhaust, such as nitrous oxide, nitrogen dioxide, formaldehyde, benzene, sulfur dioxide, hydrogen sulfide, carbon dioxide, and carbon monoxide can also create health problems.

Those most likely to be exposed to diesel exhaust include bridge, tunnel, and loading dock workers, auto mechanics, toll booth collectors, truck and forklift drivers, and people who work near areas where these vehicles are used, stored or maintained.

Health Effects of Diesel Exhaust

Short-Term (Acute) Effects

Workers exposed to high concentrations of diesel exhaust have reported the following short-term health symptoms:

- irritation of the eyes, nose, and throat
- lightheadedness
- feeling "high"
- heartburn
- headache
- weakness, numbness, and tingling in extremities
- chest tightness
- wheezing
- vomiting

Long-Term (Chronic) Effects

Although there have been relatively few studies on the long-term health effects of diesel exhaust, the available studies indicate that diesel exhaust can be harmful to your health.

According to the National Institute for Occupational Safety and Health (NIOSH), human and animal studies show that diesel exhaust should be treated as a human carcinogen (cancer-causing substance). These findings are not surprising since several substances in diesel exhaust are known to cause cancer. It may take many years after the first exposure for diesel-related cancer to develop.

Safe Work Practices

Following the safe work practices below can also reduce exposure to diesel exhaust:

- Fuel grade 1K should be used instead of Diesel 1. Grade 1K is more expensive but burns more cleanly.
- All diesel equipment should have regular maintenance and frequent tune-ups. The exhaust system should be checked for leaking fumes.
- Vehicles should be fitted with emission control devices (air cleaners), such as collectors, scrubbers, and ceramic particle traps. Air cleaners should be checked regularly and replaced when they get dirty.
- Prolonged idling of machinery should be avoided. A worker should not be in the vehicle when it is idling for a long period.
- Any cracks in the vehicle should be fitted with weather stripping to prevent fumes from seeping in.
- The floor of the vehicle should not have any holes.

Personal Protective Equipment

Respirators are usually the least effective method of controlling exposures, and they should be used only as a last resort. For diesel exhaust, a combination air-purifying respirator that protects against acid gases, organic vapors, and particulates should be used.

It is not enough for your employer to toss you a respirator and tell you to go to work. Respirators must be specific to the hazard, and fitted, cleaned, stored, inspected, and maintained in accordance with OSHA's respirator standard (see the AFSCME Fact Sheet on Respirators). In addition, you must be trained on how to use a respirator properly, and receive a medical exam to assure that you are physically fit to wear a respirator.

Prevent skin contact with diesel exhaust by wearing protective clothing (gloves, long pants, long-sleeved shirts, and face and eye protection) if necessary.

OSHA Standards

There is no OSHA standard for diesel exhaust. However, OSHA does have workplace exposure limits for individual components of diesel exhaust, such as carbon monoxide, sulfur dioxide, benzene, carbon dioxide, nitrogen dioxide, acrolein, and formaldehyde.

In addition, OSHA has a standard for "nuisance" dust that is applicable to the soot in diesel exhaust. The standard limits "respirable" dust exposures (particles that are small enough to lodge in the lung) to 5 milligrams per cubic meter of air (5 mg/m3) averaged over eight hours.

Because diesel exhaust has been shown to cause cancer, NIOSH recommends that diesel exhaust exposures be reduced to the lowest feasible limits.