Diesel Fumes Now Classified as Carcinogenic

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In June 2012, the World Health Organisation's International Agency for Research on Cancer (IARC) upgraded the classification of diesel engine exhaust from "probably carcinogenic to humans" to "carcinogenic to humans." International experts have determined that there is sufficient evidence of a link between exposure to fumes from diesel engine exhausts and the incidence of lung cancer. Petrol engine exhaust fumes were also reviewed but the classification remains unchanged from "possibly carcinogenic to humans."

Studies found the risk of lung cancer for highly exposed workers increased by three times that of low exposure workers and very highly exposed workers had nearly 6 times the risk of associated cancer mortality.

Diesel exhaust is a combination of a number of chemicals and particles, however exhaust as a whole can be classed as exposure to particulate matter, diesel exhaust being primarily composed of very small particles. Whilst many people would associate the black smoke from exhausts as the harmful substance, in diesel exhausts, it is actually the invisible nano particles that are created by diesel engines which can be inspired deep into the lungs which present the most risk for lung cancer.

Workplaces where workers are in close proximity diesel fuelled equipment or in enclosed spaces with diesel fuelled equipment present the greatest risk to worker health.

How to reduce the risk:

Diesel exhaust fumes

There are several actions that employers can take to reduce the exposure such as: limiting operation of diesel fuelled vehicles in enclosed spaces, using extraction systems or other methods of increasing ventilation to indoor or enclosed areas, using low emission engines and fuels.

Whilst there is no Australian exposure standard for diesel exhaust fumes or an indication from IARC on what levels may be safe, it is recommended that exposure to fumes be limited as much as possible. The Australian National Pollutant Inventory has set occupational exposure limits for diesel exhaust (prior to the new carcinogen classification). These limits are 10 mg per m3 of air averaged over an 8 hour shift, and public exposure limits at 8 µg/m3/yr. Workplace exposures should be minimised to reflect that workers are still members of the public and their average yearly exposure should also not exceed these levels. There are also exposure limits for individual exhaust components such as carbon monoxide, benzene, and sulphur dioxide however the IARC has not indicated which chemicals specifically contribute to cancer risk.

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The following are classes of chemical compounds that have been found in diesel exhaust.

Class of chemical contaminant	Note
antimony compounds	Toxicity similar to arsenic poisoning
beryllium compounds	IARC Group 1 carcinogens
chromium compounds	IARC Group 3 carcinogens
cobalt compounds	
cyanide compounds	
dioxins and dibenzofurans	
manganese compounds	
mercury compounds	IARC Group 3 carcinogens
nitrogen oxides	5.6 ppm or 6500 µg/m³
polycyclic organic matter, including polycyclic aromatic hydrocarbons (PAHs)	
selenium compounds	
sulfur compounds	

The following are classes of specific chemicals that have been found in diesel exhaust.

Chemical contaminant	Note	Concentration, ppm
acetaldehyde	IARC Group 2B (possible) carcinogens	
acrolein	IARC Group 3 carcinogens	
aniline	IARC Group 3 carcinogens	
arsenic	IARC Group 1 carcinogens, endocrine disruptor	
benzene	IARC Group 1 carcinogens	
biphenyl	Mild toxicity	
bis(2-ethylhexyl) phthalate	Endocrine disruptor	
1,3-Butadiene	IARC Group 2A carcinogens	

cadmium	IARC Group 1 carcinogens, endocrine disruptor	
chlorine	Byproduct of urea injection	
chlorobenzene	"[L]ow to moderate" toxicity	
cresol§		
dibutyl phthalate	Endocrine disruptor	
1,8-dinitropyrene	Strongly carcinogenic	
ethylbenzene		
formaldehyde	IARC Group 1 carcinogens	
inorganic lead	Endocrine disruptor	
methanol		
methyl ethyl ketone		
naphthalene	IARC Group 2B carcinogens	
nickel	IARC Group 2B carcinogens	
3-nitrobenzanthrone (3-NBA)	Strongly carcinogenic	0.6-6.6
4-nitrobiphenyl	Irritant, damages nerves/liver/kidneys	2.2
phenol		
phosphorus		
Pyrene		3532–8002
Benzo(e)pyrene		487–946
Benzo(a)pyrene	IARC Group 1 carcinogen	208–558
Fluoranthene	IARC Group 3 carcinogens	3399–7321
propionaldehyde		
styrene	IARC Group 2B carcinogens	
toluene	IARC Group 3 carcinogens	
xylene	IARC Group 3 carcinogens	

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Legal diesel-exhaust levels cause cancer

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Another major study – this time from Australia – has found a significant association between legal levels of workplace diesel exhaust (DE) and lung cancer, prompting calls for more stringent occupational exposure limits.

The researchers found that while the Australian Institute of Occupational Hygienists recommends a DE exposure limit of 100ug/m^3 (micrograms per cubic metre) EC (elemental carbon) over eight hours, exposure to an EC level of just 44ug/m^3 across an entire underground mining career equates to 38 extra lung cancer deaths per 1000 male workers.

"When working for 45 years as an underground diesel loader operator (at 59ug/m^3 EC), the excess number of lung cancer deaths would be 79 and 46 per 1000 men and women, respectively," they say.

Workers exposed to much lower EC levels (like 14ug/m^3 – the mean for Western Australian surface miners), or exposed to DE across short underground mining careers of five years, are also at an increased risk of lung cancer, they found.

As reported by *OHS Alert* last month, Cancer Council Australia warned that about 130 Australian workers a year are diagnosed with DE-related lung cancer (see related article), while a Dutch study found safe occupational exposure limits are far lower than everyday exposures and can't be achieved by pre-2007 diesel equipment (see related article).

The new study was led by Dr Susan Peters of the University of Western Australia's Department of Occupational Respiratory Epidemiology, and her co-authors include Utrecht University's Dr Roel Vermeulen, who led the Dutch study.

They examined more than 8600 EC personal monitoring samples collected from 124 Western Australian mine sites, and covering 146 occupations, between April 2003 and January 2015.

Focusing on 2011, they found underground goldminers experienced the highest exposure to DE, with levels of up to 59ug/m^3, while surface miners experienced lower "but still substantial" exposures of 10 to 19ug/m^3 on average.

Previous Queensland and international studies identified similar levels in the mining industry, they say.

"Worldwide, DE exposure levels are expected to decrease over time as a result of increasingly stringent emission standards. US and European regulations are driving the conversion from older to newer diesel engine technology," the researchers say.

But Australia "lags behind", with traditional diesel engines still used in off-road heavy-duty equipment and many on-road vehicles, which are "likely to be responsible for ongoing and substantial emission of DE, adversely affecting the health of exposed workers", they say.

DE exposures are particularly high for underground mine workers, and could have considerable adverse health effects, including bronchial irritation and neurophysiological symptoms, in addition to cancer, the researchers say.

"Further exposure regulation is therefore warranted," they say.

"Control of DE exposure could be focused at different stages: replacement of diesel machinery, emission controls... transmission controls... and exposure controls.

"Employee information and training are also important for controlling exposure."

Estimation of quantitative levels of diesel exhaust exposure and the health impact in the contemporary Australian mining industry. Susan Peters, et al, Australia, *Occupational and Environmental Medicine*, Online first November 2016, doi:10.1136/oemed-2016-103808.

Diesel Particulates

Lung cancer is the major cancer thought to be linked to diesel exhaust. Most of the recent evidence comes from studies looking at cancer rates among populations that have high levels of exposure to diesel exhaust. Several studies of workers exposed to diesel exhaust have shown small but significant increases in risk of lung cancer. Men with the heaviest and most prolonged exposures, such as railroad workers, heavy equipment operators, miners, and truck drivers, have higher rates of death from lung cancer than men who are not exposed to diesel exhaust fumes as a result of their occupation.

Emissions from diesel engines are a mix of gaseous compounds and particulate matter. Gaseous compounds include carbon dioxide, water vapour, oxygen, sulphur and nitrogen compounds, carbon monoxide, and low molecular weight hydrocarbons and their derivatives. Particulate matter can contain elemental carbon, organic compounds (including Polycyclic aromatic hydrocarbons, a number of which are known or suspected carcinogens (cancer causing substances)), metals, and other trace compounds. These particles are a public health concern due to their small size (Particulate Matter of ~10 micrometers or less [PM_{10}]) which makes them easy to inhale and able to reach the deep lung.

Reducing your exposure

You can help protect yourself by taking clean transport such as electric trains and light rail whenever possible, and when driving in high traffic areas, closing your car windows and setting the ventilation system to re-circulate the inside air. Additionally, avoid doing regular strenuous exercise in diesel polluted and high traffic areas.

Reducing occupational exposure

Higher exposures to engine exhausts may occur in some occupations, such as transportation and garage work, vehicle maintenance and examination, mining, traffic control and heavy equipment operation. Clear, thoroughly documented workplace practices and training can help reduce diesel exposure. Wherever diesel equipment is operated indoors, the area should be well ventilated. Roof vents, open doors and windows, roof fans, or other mechanical systems can be used to move fresh air through work areas. Respirators should be an interim measure to control exposure to diesel emissions as required.

Diesel equipment operators should use enclosed cabins equipped with high efficiency particulate air filters to reduce exposure to diesel fumes. Routine inspection and regular maintenance of diesel engines is essential to reduce exhaust emissions. The manufacturer's recommended maintenance schedule and procedures should be strictly followed.

For more information on how to reduce occupational exposure to diesel, please visit the diesel section of kNOw workplace cancer resource developed by Cancer Council.

Diesel Particulate Matter (DPM)

In June 2012 International Agency for Research on Cancer (IARC) classified diesel engine exhaust as carcinogenic to humans (Group 1), based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

One of the components of diesel exhaust (DE) is DPM which includes soot particles made up primarily of carbon and other solid particles made up of ash, metallic abrasion particles, sulfates and silicates. Diesel soot particles have a solid core consisting of elemental carbon, and are usually less than 1 micron in size, they have other substances attached to the surface, including organic carbon compounds.

Nearly all DPM is respirable in size and can be deposited deep in the lungs. The adverse health effects from DPM exposure include eye and respiratory irritation up to lung cancer if exposure is to high concentrations over a prolonged period of time.
High DPM concentrations can occur and can depend on the age of the equipment, the type of diesel engine and/or engine maintenance. The only way to determine the level of exposure experienced by people is to measure personal exposure.

There is no current Worksafe Australia Occupational exposure standard for DPM, however, the Australian Institute of Occupational Hygiene, DPM levels should be controlled to below 0.1 mg/m3 as an 8 hour time weighted average value, measured as submicron elemental carbon.

The value has been determined as being a balance of the factors such as primarily minimising eye and respiratory irritation, then secondarily minimising any potential for risk of lung cancer to a level that is not detectable in a practical sense in the work environment, and finally on providing a level that is achievable as best practice by industry and government.