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# *Diesel Exhaust and Cancer*

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**Abstract-** Exhaust from diesel engines brings a complex mixture of soot and gases to roadways, cities, farms, and other places. Health concerns about diesel exhaust relate not only to cancer, but also to other health problems such as lung and heart diseases. Studies have raised concerns over the years about the connection between diesel exhaust and cancer in workers with heavy exposure to exhaust from diesel engines. Men with the heaviest and most prolonged exposures, such as railroad workers, heavy equipment operators, miners, and truck drivers, have been found to have higher lung cancer death rates than unexposed workers. The International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), today classified diesel engine exhaust as carcinogenic to humans.

**Index Terms-** Diesel, Exhaust, Cancer

## I. INTRODUCTION

Diesel is a type of fuel derived from crude oil. Diesel fuel is used in most large engines, including those used in many trucks, buses, trains, construction and farm equipment, generators, ships, and in some cars. [1]

In diesel engines, air is introduced into the engine and heated by compression to a temperature in excess of 425°C. The fuel is introduced into the combustion chamber by a high-pressure injection system and is mixed with the hot air until the jet of fuel becomes sufficiently hot for auto-ignition to occur. The centre of this burning jet is very rich in fuel, which leads to the formation of elemental carbon, partially burned fuel, polycyclic aromatic hydrocarbons and carbon monoxide. At the outer edges of the burning jet of fuel, excess air leads to high temperatures and the formation of nitrogen oxides.

Rudolf Diesel patented the diesel engine in 1898. In the early part of the twentieth century, diesel engines were used mainly in marine applications and then installed in

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heavy goods vehicles (HGVs) in Europe in the 1920s. In the 1930s, manufacturers in the USA started to install diesel engines in commercial HGVs, buses and tracked vehicles. The first mass-produced diesel passenger car was introduced in Europe in 1936. Diesel engines had largely replaced steam power in railway (railroad) locomotives by the early 1950s, and had replaced petroleum (gasoline) engines in most HGVs by the 1960s.

Today, diesel engines power all types of automotive vehicles: passenger cars (up to 50% of car sales in some European countries), commercial vehicles, buses and coaches, industrial, agricultural and construction equipment, mine vehicles, locomotives, shops and many stationary power applications.

Until the mid-1980s, a wide variety of diesel engine designs and technologies were available. However, with increasingly stringent regulations on emissions, the industry converged on a common diesel engine architecture. Other technological changes have ensued. Fuel technology has also changed, with the reduction of the sulphur content. After-combustion treatment techniques such as selective catalytic reduction or nitrogen oxide adsorber-based systems and particle filtration in exhaust systems have been introduced to further reduce emissions [2].

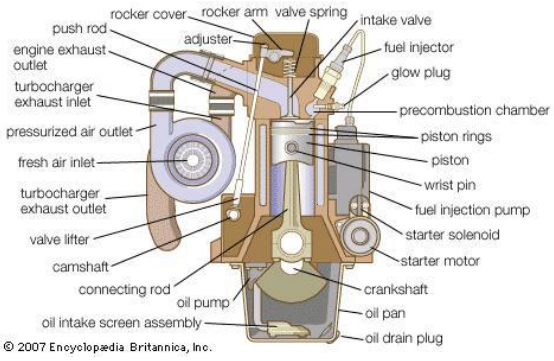


Figure 1. Diesel engine

## II. DIESEL EXHAUST

Diesel exhaust is made up of 2 main parts: gases and soot (particles). Each of these, in turn, is made up of many different substances.

• The gas portion of diesel exhaust is mostly carbon dioxide, carbon monoxide, nitric oxide, nitrogen dioxide, sulfur oxides, and hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs).

• The soot (particulate) portion of diesel exhaust is made up of particles such as carbon, organic materials (including PAHs), and traces of metallic compounds.

Both the gases and the soot of diesel exhaust contain PAHs.

Exhaust from diesel engines brings a complex mixture of soot and gases to roadways, cities, farms, and other places. Health concerns about diesel exhaust relate not only to cancer, but also to other health problems such as lung and heart diseases [1].

Large populations are exposed to diesel exhaust in everyday life, whether through

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their occupation or through the ambient air. People are exposed not only to motor vehicle exhausts but also to exhausts from other diesel engines, including from other modes of transport (e.g. diesel trains and ships) and from power generators.

Increasing environmental concerns over the past two decades have resulted in regulatory action in North America, Europe and elsewhere with successively tighter emission standards for both diesel and gasoline engines. There is a strong interplay between standards and technology – standards drive technology and new technology enables more stringent standards. For diesel engines, this required changes in the fuel such as marked decreases in sulfur content, changes in engine design to burn diesel fuel more efficiently and reductions in emissions through exhaust control technology.

However, while the amount of particulates and chemicals are reduced with these changes, it is not yet clear how the quantitative and qualitative changes may translate into altered health effects; research into this question is needed. In addition, existing fuels and vehicles without these modifications will take many years to be replaced, particularly in less developed countries, where regulatory measures are currently also less stringent. It is notable that many parts of the developing world lack regulatory standards, and data on the occurrence and impact of diesel exhaust are limited. [3]

Figure 2. Heavy truck with visible particulate soot

## III. STUDIES ABOUT DIESEL EXHAUST AND CANCER ASSOCIATION

Studies have raised concerns over the years about the connection between diesel exhaust and cancer in workers with heavy exposure to exhaust from diesel engines. Men with the heaviest and most prolonged exposures, such as railroad workers, heavy equipment operators, miners, and truck drivers, have been found to have higher lung cancer death rates than unexposed workers. [4]

In 1988, the International Agency for Research on Cancer (IARC) classified diesel exhaust as probably carcinogenic to humans (Group 2A). An Advisory Group which reviews and recommends future

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priorities for the IARC Monographs Program had recommended diesel exhaust as a high priority for re-evaluation since 1998.

There has been mounting concern about the cancer-causing potential of diesel exhaust, particularly based on findings in epidemiological studies of workers exposed in various settings. This was re-emphasized by the publication in March 2012 of the results of a large US National Cancer Institute/National Institute for Occupational Safety and Health study of occupational exposure to such emissions in underground miners, which showed an increased risk of death from lung cancer in exposed workers.

In June 12, 2012, after a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), today 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. [3]

The International Agency for Research on Cancer (IARC) is part of the World Health Organization (WHO). Its major goal is to identify causes of cancer. IARC classifies diesel engine exhaust as "carcinogenic to humans," based on sufficient evidence that it is linked to an increased risk of lung cancer. IARC also notes that there is "some evidence of a positive association" between diesel exhaust and bladder cancer.

The National Toxicology Program (NTP) is formed from parts of several different US government agencies, including the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA). The NTP has classified exposure to diesel exhaust particulates as "reasonably anticipated to be a human carcinogen," based on limited evidence from studies in humans (mainly linking it to lung cancer) and supporting evidence from lab studies.

The US Environmental Protection Agency (EPA) maintains the Integrated Risk Information System (IRIS), an electronic database that contains information on human health effects from exposure to various substances in the environment. The EPA classifies diesel exhaust as "likely to be carcinogenic to humans."

The National Institute for Occupational Safety and Health (NIOSH) is part of the CDC that studies exposures in the workplace. NIOSH has determined that diesel exhaust is a "potential occupational carcinogen." [1]

## IV. PEOPLE WHO ARE EXPOSED TO DIESEL EXHAUST

Anyone working with or around diesel-powered equipment or vehicles can be affected. Emissions from diesel vehicles like forklifts, lorries, buses, trains and tractors – particularly in enclosed spaces like garages or workshops – can cause a

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problem. People working with fixed power sources like compressors, generators or power plants in sectors like tunnelling, mining or construction could also be at risk.

Main risk employment areas:

Agriculture, construction, energy extraction, mining, rail, shipping, transport/logistics, tunnelling, vehicle repair, warehousing.

People who could be at risk:

Bridge and tunnel workers, bus, lorry and taxi drivers, car, lorry and bus service and repair workers, construction workers, depot and warehouse workers, farmworkers, heavy equipment operators, loading dock and dockside ferry workers, maritime workers, material handling operators, miners, oil and gas workers, railway workers, refuse collection workers, tollbooth and traffic management workers.


Figure 3. Diesel-powered equipment that is used in underground mines

## V. EFFECTS OF DIESEL EXHAUST ON HEALTH

At the very least, short term, high level exposures to diesel exhaust fumes can irritate the eyes and lungs. Continuous exposure to diesel exhaust fumes can cause long term, or chronic, respiratory ill health with symptoms including coughing and feeling breathless. At worst, if people are exposed to diesel engine exhaust fumes regularly and over a long period, there is an increased risk of getting lung cancer. This is the same type of cancer that's caused by asbestos and some other industrial chemicals, and doesn't just affect people who smoke. There is limited evidence to suggest that chronic exposure is also linked to a higher chance of suffering bladder cancer.

Scientists agree that the risk of cancer is linked with the particulate emissions in the fumes – the soot, rather than the gases or vapours. The particulates are easily inhaled and drawn deep into the lungs. Diesel engine exhaust exposure is now often measured by the elemental carbon concentrations in the air inhaled by workers.

Even if people lead a healthy life, don't smoke and don't have a strong history of cancer in the family, exposure to diesel exhaust fumes may still cause lung cancer, depending on the amount of airborne particulate. [5]

Lung cancer

Lung cancer is the major cancer thought to be linked to diesel exhaust. Several studies

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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 been found to have higher lung cancer death rates than unexposed workers. Based on the number of people exposed at work, diesel exhaust may pose a substantial health risk.

The possible link between lung cancer and exposure to diesel exhaust outside the workplace has not been studied extensively.

Other cancers

Several studies have looked for possible links between diesel exhaust and other cancers, including cancers of the bladder, larynx (voice box), esophagus, stomach, and pancreas. Studies have also looked for links to blood system cancers such as lymphomas and leukemias (including childhood leukemia). While some studies have found possible links, others have not. More research is needed to show if diesel exhaust exposure is linked to any of these other cancers. [1]

## VI. NUMBER OF PEOPLE AFFECTED WITH DIESEL EXHAUST

Around the world, there are limited statistics about the number of workers exposed to diesel exhaust fumes, and the number of cancer cases caused by exposure.

In Europe, the Institute of Occupational Medicine has estimated that there may be more than 3.6 million workers exposed to diesel engine exhaust emissions above the background levels found in our cities. In a single recent year, it was estimated that in the EU there were nearly 4,700 cases of lung cancer, and more than 4,200 deaths, and over 1,000 cases of bladder cancer, with more than 300 deaths, all linked to diesel exhaust exposure.

In the UK, the Health and Safety Executive estimates that more than 100,000 workers could be exposed to high levels of diesel engine exhaust fumes, but Imperial College, the IOM and others put the figure closer to 500,000. It's estimated that in Britain, more than 650 people a year die of lung or bladder cancer as a result of being exposed to diesel exhaust fumes at work. Around 800 new cases of cancer linked to diesel exhaust fume exposure are registered each year.

While people are more likely to be diagnosed with a cancer caused by long term exposure to diesel exhaust fumes in later life, many workers will suffer respiratory symptoms much younger – and they can seriously affect quality of life.

## VII. PREVENTION MEASURES

Engineering controls are the most effective strategy for minimizing worker exposure to diesel exhaust/diesel particle matter. A combination of controls is often required. Examples include:

-Performing routine preventive maintenance of diesel engines to minimize emissions,

-Installing engine exhaust filters,

-Installing cleaner burning engines,

-Installing diesel oxidation catalysts,

-Using special fuels or fuel additives (e.g., biodiesel),

-Providing equipment cabs with filtered air, and

-Installing or upgrading main or auxiliary ventilation systems, such as tailpipe or stack exhaust vents to capture and remove emissions in maintenance shops or other indoor locations.

Administrative controls refer to changes in the way work tasks are performed to reduce or eliminate the hazard. Examples include:

-Limiting speeds and using one-way travel routes to minimize traffic congestion,

-Prohibiting and/or restricting unnecessary idling or lugging of engines,

-Restricting the amount of diesel-powered equipment and total engine horsepower operating in a given area and ensure that the number of vehicles operating in an area does not exceed the capacity of the ventilation system, and

-Designate areas that are off-limits for diesel engine operation and/or personnel travel [6].

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