Diesel Engine Exhaust

Health-based recommended occupational exposure limit

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Executive summary

Health Council of the Netherlands

At the request of the Minister of Social Affairs and Employment, the Health Council of the Netherlands has derived occupational exposure concentrations to diesel engine emissions (DEE) that correspond to predetermined (target and prohibition) risk levels for death from lung cancer due to occupational exposure to diesel engine emissions. It concerns the emission of diesel engines powered by petroleum-diesel fuels. The exposure concentrations are derived to set an occupational exposure limit by the Minister. The concentrations corresponding to the target risk level is 0.011 micrograms (µg) of respirable elemental carbon particles in DEE per cubic metre (m^3) of air. The exposure concentration corresponding to the prohibition risk level is 1.03 µg/m^3. The data from which these exposure concentrations were estimated are obtained from studies in workers who had been exposed to emissions from diesel engines with no effective emission reduction systems.
The Health Council has a permanent role in giving scientific advice to help protecting workers against the potentially harmful effects of any substances that they may encounter in the course of their work. In this connection, the Health Council assesses the toxic properties and health effects of these substances, and makes recommendations for health-based occupational exposure limits. These recommendations form the basis for an legally-binding occupational exposure limit to be set by the government. Further details concerning the Health Council's role with regard to healthy working conditions can be found at www.gezondheidsraad.nl.
The recommendations were formulated by the Dutch Expert Committee on Occupational Safety (DECOS) – a permanent committee of the Health Council. The Committee has evaluated the toxicity of diesel engine emissions on a previous occasion, in collaboration with the Nordic Expert Group for Criteria Documentation of Health Risks from Chemicals (NEG). That evaluation, which was published by the NEG in 2016, can be viewed at the Health Council website. The Committee has based its recommendations in the current advisory report on that 2016 evaluation.

Diesel engine emissions pose a wide range of health risks to a wide range of workers

Health risks
Emissions from diesel engines powered by petroleum-diesel fuels consist of various gases and particles, which are produced by the combustion of diesel fuel in the engine. Such emissions contain substances that, when inhaled, are harmful to health. Their potential health effects are inflammatory reactions in the lungs, disorders of the heart and blood vessels, allergic disorders, aggravated symptoms of asthma, and various types of cancer – especially lung cancer and bladder cancer.

Exposure in the workplace
Throughout the world, diesel engines are used for transport (powering trucks, trains, ships,

buses, tractors, and cars) and in the power industry (compressors, pumps and small generators). Workers can be subjected to occupational exposure to diesel engine emissions in industries such as the transport sector, the construction sector, shipping, agriculture, forestry, waste treatment, and railways.

Diesel engines are available in various sizes and types, depending on their intended use. They also differ in the extent to which emission reduction systems are used. One function of these systems is to reduce the emission of soot particles. As a result, the composition of the actual emission (and, thus, the exposure involved) differs from that of diesel engines that are equipped with inadequate emission reduction systems, or none at all.

Lung cancer as the starting point for deriving risk-based exposure levels

The Committee has chosen to derive risk-based exposure levels, because exposure to diesel engine emissions – especially exposure to the soot particles in such emissions – can lead to cancer.

Diesel engine emissions contain carcinogenic substances that can damage cells' genetic material (DNA). In the case of substances like this, it is not possible to identify an exposure level at which no cancer at all occurs. Thus, it is assumed that every level of exposure, however low, involves a certain risk of developing cancer. In this case, the approach focuses on limiting the cancer risk involved. The Minister of Social Affairs and Employment has established two risk levels in advance: a target risk level and a prohibition risk level. In terms of cancer due to occupational exposure over a 40-year period, these risk levels correspond to four additional cancer cases, which are added to the number of cancer death cases per 100,000 and per 1,000 overall death cases in the general population, respectively. By way of illustration, in the Netherlands, if every 100,000 men who die 34,000 died from cancer, the target risk level corresponds to 34,004 (4 plus 34,000) deaths due to cancer per 100,000 overall deaths. The prohibition level would then be no more than 344 (4 plus 340) death cases of cancer per 1,000 overall deaths. The Committee estimates at which exposure concentrations the risk of cancer correspond to the target and prohibition risks levels.

Three large epidemiological studies used

The Committee's preferred approach is based on epidemiological studies. It has identified three large-scale cohort studies that are suitable for this purpose. One of these studies focuses on miners, and the other two involve transport company workers. All of these subjects were, in the past, exposed to diesel engines that emitted soot particles. These studies explored the relationship between lung cancer mortality and quantitative exposure to diesel engine emissions. No such studies have been published with regard to bladder cancer. Accordingly, the Committee has focused on the lung cancer studies. In the cancer studies, uncertainties on actual historical exposure levels, smoking or co-exposure to known

carcinogenic substances from other sources than diesel engines, may have influenced the outcome. However, according to the DECOS, these uncertainties are sufficiently accurate addressed, and, therefore, the DECOS considers the data from the studies suitable to derive risk-based occupational exposure levels.

Respirable elemental carbon particles as exposure parameter

In all three studies, exposure to diesel engine emissions was expressed in terms of respirable elemental carbon particles. According to the Committee, this is the best exposure marker for diesel engine emissions. Although it does not itself cause cancer, elemental carbon is a specific and sensitive indicator of exposure to soot particles from diesel engine emissions. Its suitability as an indicator derives from the fact that it is easy to measure and that it gives an accurate representation of the concentration of particles (including soot particles) in the emission. Furthermore, in most workplaces, diesel engines are the only source of elementary carbon emissions. Accordingly, specific sampling can be used to differentiate between elemental carbon from different sources.

Data on diesel engines with no effective emission reduction systems

The three studies were performed on workers who had been exposed to diesel engines with no effective emission reduction systems. Between 2006 and 2013, stricter European standards were introduced to cut diesel engine emissions, with the aim of reducing atmospheric air pollution. These emission standards apply to new diesel engines. It will, however, be many years before all of the diesel engines now being used for transport and in the power industry have been replaced by engines that meet current emission standards. For this reason, the evaluations conducted by the NEG and the Committee examined every single item of data, including data on exposure to the emissions of diesel engines with no effective emission reduction systems. As yet, there is insufficient scientific data to quantify the efficacy of the latest emission reduction systems, in terms of mitigating or eliminating the risk of cancer or of other adverse health effects incurred by long-term occupational exposure to diesel engine emissions.

Meta-analysis

The Committee derived risk-based exposure levels by using a meta-analysis that combined these three studies. If a number of studies are combined (a meta-analysis), this can deliver a more reliable outcome. Based on the meta-analysis, the Committee estimated that the concentrations of respirable elemental carbon from DEE, which correspond to 4 extra cases of lung cancer death due to 40 years of occupational exposure to DEE, per 100,000 and 1,000 death cases, equals to 0.011 µg/m^3 and 1.03 µg/m^3, respectively. The exposure levels are 8-hour time-weighted average concentrations.

Advice to the minister

The Committee estimates that the exposure concentrations of respirable elemental carbon in the air, which serve as parameter for exposure to diesel engine exhaust powered by petroleum-diesel fuels, and which corresponds to:

- 4 extra death cases of lung cancer per 100,000 (target risk level), for 40 years of occupational exposure, equals to 0.011 µg REC/m^3,
- 4 extra death cases of lung cancer per 1,000 (prohibition risk level), for 40 years of occupational exposure, equals to 1.03 µg REC/m^3.

The exposure levels are 8-hour time-weighted average concentrations.

The Health Council of the Netherlands, established in 1902, is an independent scientific advisory body. Its remit is “to advise the government and Parliament on the current level of knowledge with respect to public health issues and health (services) research...” (Section 22, Health Act).
The Health Council receives most requests for advice from the Ministers of Health, Welfare and Sport, Infrastructure and Water Management, Social Affairs and Employment, and Agriculture, Nature and Food Quality. The Council can publish advisory reports on its own initiative. It usually does this in order to ask attention for developments or trends that are thought to be relevant to government policy.
Most Health Council reports are prepared by multidisciplinary committees of Dutch or, sometimes, foreign experts, appointed in a personal capacity.
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