TORONTO STAFF REPORT

June 25, 2002

To: Board of Health

From: Dr. Sheela V. Basrur, Medical Officer of Health

Subject: Assessing the Health Impact of Diesel Exhaust in Toronto

Purpose:

To review the health effects of diesel exhaust and assess the potential impact in Toronto.

Financial Impact:

There are no financial implications arising from this report.

Recommendations:

It is recommended that:

(1) the Board of Health urge the federal Minister of the Environment to approve the proposed regulation to establish a 15-ppm sulphur standard for on-road diesel effective June 2006;

(2) the Board of Health reiterate its request to the federal Minister of the Environment to take additional steps to reduce the public health risks arising from diesel emissions by:

(a) harmonizing sulphur standards for off-road diesel with those for on-road fuels;
(b) providing incentives for the early introduction of low-sulphur diesel;

(3) the Board of Health encourage the federal Minister of the Environment and the federal Minister of Transport to negotiate the early introduction of low-sulphur diesel and the early adoption of low-emission diesel technology with the industry;

(4) the Commissioner of Works and Emergency Services, as Chair of the Toronto Inter-departmental Environment Committee, ensure that the City's Air Quality Strategy

includes consideration of measures that can be taken to reduce emissions from, and exposure to, diesel exhaust;

(5) the Board of Health forward this report to the GTA Clean Air Council and the Toronto Cancer Prevention Coalition for their information; and,

(6) the appropriate City Officials be authorized and directed to take the necessary action to give effect thereto.

Background:

At its meeting of May 29, 2000, the Board of Health endorsed the Toronto Cancer Prevention Coalition Action Plan which included actions to reduce exposure to carcinogens in Toronto workplaces and the environment. At that meeting the Board requested that the Medical Officer of Health submit a report on the current literature with regard to the relationship between diesel exhaust and cancer and to investigate the policy options available to the City to reduce air pollution from key contributors within Toronto such as diesel-fuelled vehicles and off-road diesel engines. At its meeting of June 2001, the Board of Health adopted a report entitled, "Air Quality and Federal Standards for Sulphur in On-Road Diesel". That report supported the proposal by the federal Minister of the Environment to establish a 15-ppm sulphur standard for on-road diesel by June 2006. It also urged the Minister to introduce incentives to promote the early introduction of low-sulphur diesel and to harmonize sulphur standards for off-road diesel with those for on-road fuels.

At its meeting of April 8, 2002, the Board of Health received a report entitled "Ten Key Carcinogens in Toronto Workplaces and Environment". That report considered the exposure to benzene, 1,3-butadiene, dioxins, formaldehyde and polyaromatic hydrocarbons (PAHs) that are components of diesel exhaust. This report reviews the health impact of diesel exhaust as a whole.

This report was prepared in consultation with Works and Emergency Services and with the Toronto Interdepartmental Environment (TIE) Committee.

Comments:

Diesel exhaust has been classified by various agencies as a probable human carcinogen. Recent research has shown an association between airborne levels of fine particles ($PM_{2.5}$) and deaths from lung cancer. The U.S. Environmental Protection Agency estimates that diesel exhaust contributes between 10 and 36 percent of $PM_{2.5}$ in urban centres.

Like exhaust from gasoline engines, diesel exhaust is a complex mixture of hundreds of different compounds that are emitted either as gases or particulate matter. The gaseous components of diesel exhaust include toxic substances such as formaldehyde, acetaldehyde, acrolein, benzene, 1,3-butadiene, and polyaromatic hydrocarbons (PAHs) and nitro-PAHs. The particles in diesel exhaust are made up of elemental carbon, adsorbed organic compounds, and small amounts of other substances. While the types of pollutants emitted from gasoline and diesel engines are

similar, particle emissions from diesel engines can be 20 times greater than emissions from gasoline engines.

Levels of Diesel Exhaust in Toronto:

There are no data available on the levels of diesel exhaust in Toronto. As a result, information on public exposures must be extrapolated from U.S. studies, where it has been shown that diesel exhaust is emitted from "on-road" diesel engines (e.g. buses, cars, and trucks) and "off-road" engines (e.g. heavy-construction equipment, locomotives, marine vessels, etc.).

In the early to mid-1990s, annual average exposure to exhaust from on-road diesel engines in the U.S. ranged from 0.5 to 1.0 $\mu g/m^3$ of inhaled air in many rural and urban areas, respectively. People who spend a large amount of time outdoors in urban areas are more exposed at higher than average levels. Some people such as workers in the transportation sector may be more at risk of high exposures, and studies in the U.S. have highlighted the potential of high exposure to children in school buses.

There is little data on emission levels from off-road diesel exhaust. While in recent years there has been a reduction in on-road diesel exhaust in the U.S. resulting from the use of emission control technology and the introduction of cleaner fuels, diesel exhaust from off-road sources may have increased. The U.S. Environmental Protection Agency estimates that off-road sources contribute about half of all diesel exhaust emissions.

Health Effects of Diesel Exhaust:

(a) Non-cancer effects

Short-term exposure to high levels of diesel exhaust has been associated with eye, nose, and throat irritation as well as with nausea, cough and phlegm. There is some evidence that diesel exhaust may affect the immune system and exacerbate allergies. Although studies in experimental animals have shown lung damage after long-term exposure, most studies in humans have not found significant non-cancer effects related to long-term exposure to diesel exhaust. Epidemiological studies have shown an association between air pollution and day-to-day changes in mortality, hospital emergency visits for lung and heart disease and changes in lung function. However, the contribution of diesel exhaust to these effects is not known.

(b) Cancer effects

There is general consensus among various agencies around the world that diesel exhaust is a probable human carcinogen by inhalation. Studies have found an increase in risk of developing cancer among railway workers, truck drivers, heavy equipment operators and professional drivers. Several studies in rats have also resulted in an increase in lung tumours, but the evidence in other animals is weak. Lung cancer is the cancer most often associated with exposure to diesel exhaust.

The way in which diesel exhaust may cause cancer and the component that may be most responsible for cancer effects are not known. At high exposure levels the particle component appears to be most responsible for cancer effects. Whether this is also the case at lower levels generally found in the environment is unknown. Several attempts have been made to estimate the cancer potency of diesel exhaust, however, these have severe limitations and no consensus exists on an acceptable approach. Many of the organic compounds present in diesel exhaust are known to have mutagenic and carcinogenic properties. The April 2002 staff report "Ten Key Carcinogens in Toronto Workplaces and Environment" estimated that total exposures to several of these compounds in Toronto approached or exceeded the one in one million cancer risk.

Although the U.S. Environmental Protection Agency has not calculated a cancer potency for diesel exhaust, it estimates that overall exposure to diesel exhaust in the U.S. may pose a lifetime cancer risk ranging from 1 in 100,000 and 1 in 1,000.

Estimating Health Risk from On-road Diesel Exhaust in Toronto:

The main source of exposure to diesel exhaust is through inhalation, thus only this route of exposure was considered in estimating the risk of cancer due to diesel exhaust in Toronto. As there are insufficient data on off-road sources, only exposure to on-road diesel exhaust was considered.

Diesel exhaust is a complex mixture. There are two basic approaches to estimating the risk caused by complex mixtures: adding the risk of the individual components of the mixture (Method 1) and assessing the mixture as a whole based on the level of an indicator substance (Method 2). Each approach has its advantages and disadvantages. Toronto Public Health estimated the risk using both of these methods.

One way to estimate if exposure levels are of concern is to calculate an exposure ratio. This compares pollutant concentrations in the environment against the health benchmark. Exposure ratios greater than one suggest that exposures are above the benchmark and could be a concern. More details on the derivation of these risk estimates are available in the report entitled, "Estimated Human Health Risk from Exposure to Diesel Exhaust in Toronto", which was prepared by ToxProbe Inc. for Toronto Public Health.

Using Method 1, the exposure ratio for non-cancer effects ranged between 0.17 and 0.38. For cancer effects, comparing these to a one in a million excess cancer risk benchmark, the exposure ratio ranged from 0.06 to 1.12. Using this method, only outdoor workers exposed to diesel exhaust at relatively high levels would have a lifetime cancer risk above one in one million. However, Method 1 likely underestimates risk for a number of reasons. While the diesel mixture is made up of hundreds components, data are available only on a few of these. Further, this method include the risk of only a small number of the many contaminants in diesel exhaust, does not consider possible interaction between the various components, and does not consider exposure to off-road diesel sources. As such, the cancer risk estimates derived by Method 1 can be considered a lower bound.

Using Method 2, the exposure ratios for non-cancer effects were smaller than those estimated in Method 1 and ranged between 0.03 and 0.055. However, the exposure ratios for cancer were much higher and ranged from 12 for the least exposed to 205 for the most exposed. This is equivalent to an excess cancer risk of about one in 100,000 to two in 10,000. It is likely that Method 2 overestimates the potential risk of cancer from diesel exhaust in Toronto, when one considers that about 1,000 people die from lung cancer per year in Toronto, and that cigarette smoking is the major cause of these deaths.

In short, it is possible that the lifetime excess risk of cancer from exposure to diesel exhaust in Toronto ranges from one in one million and one in 100,000. This is lower than the U.S. Environmental Protection Agency estimate, which may be a reflection that, when it comes to air pollution, Toronto is in "the middle of the pack". While some sub-populations in Toronto may be at higher risk due to occupational exposures, there are insufficient data to assess this.

The California Environmental Protection Agency has compared the potential risk from different activities using diesel-fuelled engines. Of the activities considered, idling school buses and the maintenance of emergency vehicles were associated with lower risks than situations with an intermediate ranking such as truck stops and low-volume expressways. Distribution centres and off-road engines were estimated to pose a somewhat higher risk, while areas close to high volume expressways (20,000 heavy-duty trucks per day) were identified as posing the highest risk.

Initiatives to Reduce Emissions from Diesel Engines:

(a) Emission control in the U.S.

Until the 1990s regulation of mobile sources focussed on light-duty motor vehicles. The passage in 1990 of amendments to the U.S. Clean Air Act spurred regulation of emissions from other types of vehicles. Since then, a series of regulations has been adopted that is expected to reduce emissions, including carcinogens, from both on-road and off-road diesel engines by 90-95 percent. As well, programmes are in place to encourage the retrofitting of existing engines.

There are several technologies, such as catalytic converters and diesel hybrid engines, that reduce emissions from diesel engines. The use of these technologies in conjunction with ultra low-sulphur diesel (15-ppm sulphur) can result in emissions from diesel engines similar to those from new gasoline or compressed natural gas engines. To enable on-road vehicles to meet the U.S. 2007 emission standards, sulphur content for on-road diesel in the U.S will be reduced to 15-ppm between 2006 and 2009.

The U.S. Environmental Protection Agency is still evaluating the need to control off-road sources beyond the regulations adopted in 1998. Meanwhile, California has already adopted rules that set the maximum allowable sulphur content in both on-road and off-road diesel sold in California to 15 ppm by 2006.

(b) Emission control in Canada

As part of its commitment to implement the Ozone Annex to the 1991 Canada-United States Air Quality Agreement, Environment Canada has announced several initiatives related to diesel fuel and diesel engines. Environment Canada has proposed regulations for heavy-duty vehicles and engines with some provisions to come in effect in 2004 and others in 2006. It has also indicated that is considering the control of exhaust from diesel engines used in construction and in agriculture in 2004. This will ensure that Canadian standards are as stringent as those of the U.S. Environmental Protection Agency. Environment Canada has also implemented voluntary agreements with manufacturers of off-road diesel engines to supply cleaner engines to the Canadian market before new regulations are in place.

Transport Canada is the authority that regulates the locomotives and marine engines of greater than 50 horsepower in Canada, such as ferries and cargo ships. An agreement between the Canadian government and the Railway Association of Canada provides for new locomotives to meet the U.S. emission standards, and additional legislative controls are being planned.

(c) City of Toronto initiatives

The City has already taken a number of initiatives to reduce emissions from its own vehicles (both diesel-operated and others), in order to reduce the levels of pollutants linked to smog and climate change. These include the Corporate Green Fleets Strategy, the route optimization initiatives of the Solid Waste Management Services of Works and Emergency Services, and the City's low-sulphur fuel purchasing practice.

As part of the implementation of the Environmental Plan and with funding from the Toronto Atmospheric Fund, the City is developing an inter-departmental Air Quality Strategy. This strategy should consider measures to further reduce emissions of, and exposure to, diesel exhaust.

Conclusions:

Diesel exhaust contributes to the overall level of air pollution in Toronto. Air pollution is associated with an increase in premature mortality and hospitalisation for heart and lung disease. Recent studies have linked air pollution with an increase in lung cancer and diesel exhaust has been classified as a probable human carcinogen. Therefore, although the data is insufficient to accurately estimate the risk, it is likely that diesel exhaust contributes to the burden of cancer in Toronto.

There have been many advances in diesel engine technology that can result in significant reductions in emissions. Many of these need low sulphur diesel to ensure their optimal performance. The U.S. has already introduced legislation that will reduce emissions from both on-road and off-road diesel engines. The federal government has proposed but not yet approved new regulations to harmonize vehicle emission standards and on-road sulpher diesel standards with those of the U.S.

The Board of Health has previously expressed its support for the adoption of a 15-ppm limit for sulphur in diesel as proposed by the federal Minister of the Environment. The federal government should also negotiate with the industry to expedite the availability of cleaner, low-sulphur diesel in order to facilitate the use of low-emission vehicle technology.

The reduction of exposure to diesel exhaust has focussed on regulating emissions from diesel engines. Strategies aimed at reducing vehicle use, increasing fuel efficiency and switching to alternative fuels can equally play a role in reducing diesel exhaust. During the development of its Air Quality Strategy, the City can also consider additional opportunities to reduce emission of, and exposure to, diesel exhaust.

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List of Attachments:

(1) Toronto Public Health. “Estimating the Health Impact of Exposure to Diesel Exhaust in Toronto,” June 2002.