STATEMENT
Synopsis of Research Report 107

HEALTH EFFECTS INSTITUTE

Emissions from Diesel and Gasoline Engines Measured in Highway Tunnels

INTRODUCTION

Emissions from motor vehicles have substantially changed over the last decade because of new fuels, changed engine designs, and improved emission-control technology. Studies of the health effects associated with exposure to motor vehicle exhaust increasingly are complicated by the changing nature of emissions over time. Both studies described in this report measured emissions from diesel and gasoline engines in highway tunnels. One study analyzed particulate matter and gaseous emissions and compared these data with previous measurements; the other focused on aldehyde emissions.

Ambient particulate matter comes from many sources and varies in size, chemical composition, and other physical and chemical properties depending on the source of the particles and the changes they undergo in the atmosphere. Emissions from engines powered by diesel, gasoline, and jet fuels are major sources of ambient particles. Diesel exhaust particulate matter has been declared a probable human carcinogen by the US Environmental Protection Agency, the International Agency for Research on Cancer, the World Health Organization, and the US National Institute of Occupational Safety and Health. The state of California designated it as a toxic air contaminant. Most health effects research on diesel emissions has focused on their possible contribution to lung cancer. Recently, concerns have also been raised about the potential effect of diesel particulate matter on enhancing human allergic responses and exacerbating asthma. Gaseous pollutants also pose threats to human health, either directly, as with carbon monoxide, or indirectly by the contribution of nitrogen oxides to smog formation.

In the first study described in this report, Dr Alan Gertler and colleagues of the Desert Research Institute in Reno, Nevada, proposed to measure the contribution of diesel and gasoline engine emissions to the ambient mixture of particulate matter and gaseous pollutants. They also planned to identify the number of particles and particle size distribution and to compare their results with those of earlier studies to assess how diesel emissions have changed with improved diesel engine design.

Other components of the exhaust mixture, such as aldehydes, also have been targeted as air toxics because they are highly reactive and, when inhaled, can participate in oxidation and reduction reactions. Many aldehydes are irritants and some, such as formaldehyde, are classified as probable human carcinogens. In the second study described in this report, Dr Daniel Grosjean of DGA, Inc, proposed to identify the concentrations of a large number of carbonyls (aldehydes and ketones) in air samples from urban areas. After the study began, Grosjean proposed to measure carbonyls in the ambient air of two tunnels in addition to urban Los Angeles air. Because both studies present data on pollutants in tunnel air, the HEI Review Committee decided to publish the two reports together.

APPROACH

Dr Gertler studied particulate matter emissions in the Tuscarora Mountain Tunnel located on the Pennsylvania Turnpike. Dr Grosjean studied carbonyl emissions in the Tuscarora Mountain Tunnel and in the Caldecott Tunnel in California. The advantages of tunnel studies include measuring emission rates averaged over many vehicles (in contrast to emission rates from dynamometer measurements, which are derived from fewer vehicles), determining the physical and chemical character of emissions under ambient conditions, and in some instances, being able to compare current emissions with past emissions at the same location. Both groups of investigators also measured emissions at times when the proportions of gasoline engine vehicles and diesel engine vehicles differed, allowing them to estimate the differences between emissions from the two sources.

Continued

This Statement, prepared by the Health Effects Institute, summarizes two research projects conducted by Dr Alan W Gertler of the Desert Research Institute, Reno, Nevada, and Dr Daniel Grosjean of DGA, Inc, Ventura, California. The complete report, *Emissions from Diesel and Gasoline Engines Measured in Highway Tunnels*, can be requested from HEI (see reverse side).

RESULTS AND INTERPRETATION

Dr Gertler and colleagues found, as expected, that diesel engines emitted particles at a greater rate per mile than did gasoline engines and that ultrafine particles (less than 0.1 µm in aerodynamic diameter) dominated the number of particles from both sources. The authors suggest that because gasoline-powered vehicles predominate in the on-road vehicle fleet, their contribution to particle levels in ambient air may exceed that of diesel-powered vehicles. This remains a question for study because the method used to estimate the light-duty vehicles' particulate emissions from the tunnel measurements did not allow a precise determination of their magnitude.

The investigators also reported substantial decreases in diesel emissions of particles, hydrocarbons, carbon monoxide, and carbon dioxide (the latter an indication of improved fuel economy) between their current study and earlier studies. Levels of nitrogen oxides, which are precursors of ground-level ozone, remained essentially unchanged. The authors suggest that newer diesel engines are being operated in a manner to improve fuel economy at the cost of emitting nitrogen oxides.

Dr Grosjean identified about 100 carbonyls in the Tuscarora Mountain and Caldecott Tunnels. Total carbonyl emission factors from diesel-powered trucks were found to be about 4 times those from gasoline-powered cars when both were calculated on a distance-traveled basis. On a fuel-consumed basis, total carbonyl emission factors for diesel trucks were slightly less than for cars. Formaldehyde, acetaldehyde and acetone were the three major carbonyls present. There were distinct differences between emissions of diesel trucks and cars for some carbonyls, such as aromatic carbonyls. Future studies should compare the carbonyl levels reported here with ambient measurements in cities throughout the United States.

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Real-World Particulate Matter and Gaseous Emissions from Motor Vehicles in a Highway Tunnel

Alan W Gertler, John A Gillies, William R Pierson, C Fred Rogers, John C Sagebiel, Mahmoud Abu-Allaban, William Coulombe, Leland Tarnay, and Thomas A Cahill

Airborne Carbonyls from Motor Vehicle Emissions in Two Highway Tunnels

Daniel Grosjean and Eric Grosjean

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