Just the Basics

Particulate Matter

What is Particulate Matter?

One of the major components of air pollution is particulate matter, or PM. PM refers to airborne particles that include dust, dirt, soot, smoke, and liquid droplets. These particles can range in size from microscopic to large enough to be seen. PM is characterized by its size, with fine particles of less than 2.5 micrometers in size designated as $PM_{2.5}$ and coarser particles between 2.5 and 10 micrometers in size designated as PM_{10}.

PM arises from many sources, including combustion occurring in factories, power plants, cars, trucks, buses, trains, or wood fires; or through simple agitation of existing particulates by tilling of land, quarrying and stone-crushing, and off-road vehicular movement. Of particular interest is PM generated during diesel combustion, as well as fugitive particulate emissions from engine crankcase ventilations.

This diesel-generated PM is typically composed of unburned carbon (soot) from the fuel, often serving as a nucleus, with additional constituents ranging from sulfuric acid (H_2SO_4) to condensed water to soluble hydrocarbons agglomerating on the outside of the particle. The Department of Energy is concerned about PM because of the implicit relationship between energy efficiency measures (improving fuel economy) and compliance with exhaust emission standards in transportation engines. There are general tradeoffs between the two and they must be addressed together.

Why is Particulate Matter Bad?

If you've ever been behind an older diesel bus, you have seen what PM_{10} looks like—and the thought of breathing it is certainly troublesome. But the finer $PM_{2.5}$—the PM you can't see—may actually be more hazardous to human health. Recent research is indicating it can accumulate in the respiratory tract over time. People at greatest risk from PM-related health problems include those with cardiopulmonary conditions like heart disease, emphysema, or asthma. For these people, elevated PM levels, on days when air quality is poor, greatly increase the risk of hospital admissions and emergency room visits for heart and lung symptoms, decreased lung function, and potentially, death. PM also limits visibility, reduces crop yields, threatens ecosystems, and damages buildings and other exposed surfaces.

Fine, inhalable PM also serves as a platform on which harmful organic toxins condense. The toxins in question have been shown in studies to cause the types of cellular changes that can lead to cancer. As a result, the U.S. Environmental Protection Agency has concluded that long-term (i.e., chronic) inhalation exposure to diesel exhaust is likely to pose a lung cancer hazard.[1]

PM, along with ground-level ozone, contributes to deterioration of air quality that leads to the hazy, unhealthy conditions becoming more prevalent in much

[1]U.S. Environmental Protection Agency (EPA). (2002) *Health Assessment Document For Diesel Engine Exhaust*. Prepared by the National Center for Environmental Assessment, Washington, DC, for the Office of Transportation and Air Quality; EPA/600/8-90/057F. Available from: National Technical Information Service, Springfield, VA; PB2002-107661, and *http://www.epa.gov/ncea*.

Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

AQI Category Index Values, Descriptors, and Colors

Index Values	Descriptor	Color
0 - 50	Good	Green
51 - 100	Moderate	Yellow
101 - 150	Unhealthy for Sensitive Groups	Orange
151 - 200	Unhealthy	Red
201 - 300	Very Unhealthy	Purple
301 - 500	Hazardous	Maroon

The EPA's Air Quality Index (AQI) is used to inform the public about air quality and health risks throughout the year. Many media outlets now include this information with daily weather forecasts. Source: U.S. EPA at http://www.epa.gov/region5/air/naaqs/o3info.htm#aqi

of the U.S, especially during the summer months. Often, levels of both PM and ozone are elevated on these days, and together, the combination can be deadly for people at risk.

How Can Particulate Matter Be Reduced?

In the 1960s, the federal government enacted the first Clean Air Act, followed by two more significantly revised versions in 1970 and 1990. The Clean Air Act was designed to reduce pollution from "criteria" air pollutants such as PM and ozone, in response to growing concern over unhealthy air in many of America's cities. Geographic regions that consistently fail to achieve the air quality standards designated by the Clean Air Act may be subject to enforcement measures (including suspension of federal-source highway construction funds until air quality is restored to acceptable levels). Thus, several federal agencies are working to address the problem of particulate matter, including the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Transportation (DOT), through research, data collection, regulation, and education.

There are many approaches to reducing PM, and government-funded research is exploring how best to implement them. Some of these efforts focus on potential retrofits for existing sources of PM (such as vehicles on the road today), and design modifications for new sources (such as future models of cars, trucks, buses, and trains). Retrofits include filter- and catalyst-based tools that can trap and/or transform PM so it isn't released to the environment in a hazardous form. Fuel-based approaches are designed to make fuel burn cleaner by reducing sulfur and ash content to minimize soot. Future approaches focus more on engine designs and new combustion concepts, as well as building upon advances in PM trap technology.

In vehicles, a combination of oxygenated fuels, low- or ultra-low-sulfur fuels, reduced-aromatic fuels, and particulate filters/catalysts remain among the most promising strategies for reducing PM and toxic pollutants. Efforts are also underway to educate, encourage, and involve drivers in overall efforts to cut down on PM-producing practices, such as idling the engine during lengthy stops.

Nevertheless, many of the vehicles that produce the most PM are off-road construction and farm vehicles, which historically haven't been required to meet the same emissions standards as on-road vehicles. That is about to change as new mandates from the EPA are targeting these classes (e.g. off-road, stationary power, marine) of internal combustion engine applications and their emissions.

Alternative power sources such as fuel cells (which don't rely on combustion) have potential for reducing PM, if they can (1) produce the amount of power required in a manner that makes them acceptable to the communities in which they would be located, and (2) use fuel that can be produced and transported in a clean manner.

Where Can I Find More Information?

U.S. Department of Energy, Energy Efficiency and Renewable Energy— Air Emissions and Standards

http://www.eere.energy.gov/EE/trans_air_emissions.html

U.S. Department of Energy— FreedomCAR and Vehicle Technologies Program

http://www.eere.energy.gov/vehiclesandfuels

U.S. Environmental Protection Agency: Toxic Air Pollutants

http://www.epa.gov/air/toxicair/index.html

U.S. Environmental Protection Agency: Mobile Source Air Toxics

http://www.epa.gov/otaq/toxics.htm

Automobile Emissions: An Overview

http://www.epa.gov/OMSWWW/05-autos.htm

U.S. Department of Transportation, Federal Highway Administration – Transportation Air Quality, Selected Facts and Figures

http://www.fhwa.dot.gov/environment/aqfactbk/factbk13.htm

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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