



Automobile Emissions: An Overview

Cars and Pollution

Emissions from an individual car are generally low, relative to the smokestack image many people associate with air pollution. But in numerous cities across the country, the personal automobile is the single greatest polluter, as emissions from millions of vehicles on the road add up. Driving a private car is probably a typical citizen's most "polluting" daily activity.

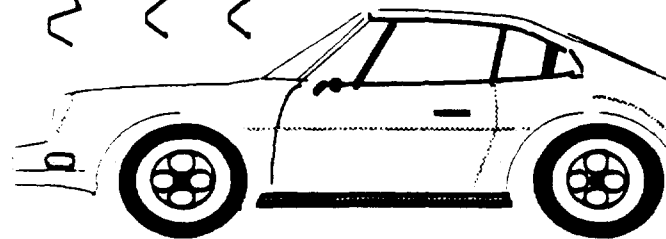
Sources of Auto Emissions

The power to move a car comes from burning fuel in an engine. Pollution from cars comes from by-products of this combustion process (exhaust), and from evaporation of the fuel itself.

• Evaporative Emissions



• Refueling Losses



• Exhaust Emissions

The Combustion Process

Gasoline and diesel fuels are mixtures of hydrocarbons, compounds which contain hydrogen and carbon atoms. In a "perfect" engine, oxygen in the air would convert all the hydrogen in the fuel to water and all the carbon in the fuel to carbon dioxide. Nitrogen in the air would remain unaffected. In reality, the combustion process cannot be "perfect," and automotive engines emit several types of pollutants.

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"Perfect" Combustion

FUEL (hydrocarbons) + AIR (oxygen and nitrogen) \longrightarrow
CARBON DIOXIDE + water + unaffected nitrogen

Typical Engine Combustion

FUEL + AIR \longrightarrow UNBURNED HYDROCARBONS + NITROGEN OXIDES
+ CARBON MONOXIDE + CARBON DIOXIDE + water

Exhaust Pollutants

• HYDROCARBONS

Hydrocarbon emissions result when fuel molecules in the engine do not burn or burn only partially. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ozone, a major component of smog. Ozone irritates the eyes, damages the lungs, and aggravates respiratory problems. It is our most widespread and intractable urban air pollution problem. A number of exhaust hydrocarbons are also toxic, with the potential to cause cancer.

• NITROGEN OXIDES (NO_x)

Under the high pressure and temperature conditions in an engine, nitrogen and oxygen atoms in the air react to form various nitrogen oxides, collectively known as NO_x. Nitrogen oxides, like hydrocarbons, are precursors to the formation of smog. They also contribute to the formation of acid rain.

• CARBON MONOXIDE

Carbon monoxide (CO) is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized rather than fully oxidized to carbon dioxide (CO₂). Carbon monoxide reduces the flow of oxygen in the bloodstream and is particularly dangerous to persons with heart disease.

• CARBON DIOXIDE

In recent years, EPA has started to view carbon dioxide, a product of "perfect" combustion, as a pollution concern. Carbon dioxide does not directly impair human health, but it is a "greenhouse gas" that traps the earth's heat and contributes to the potential for global warming.

Evaporative Emissions

Hydrocarbon pollutants also escape into the air through fuel evaporation. With today's efficient exhaust emission controls and today's gasoline formulations, evaporative losses can account for a majority of the total hydrocarbon pollution from current model cars on hot days when ozone levels are highest. Evaporative emissions occur several ways:

DIURNAL: Fuel evaporation increases as the temperature rises during the day, heating the fuel tank and venting fuel vapors.

RUNNING LOSSES: The hot engine and exhaust system, as well as hot pavement, can vaporize fuel when the car is running.

HOT SOAK: The engine remains hot for a period of time after the car is turned off, and fuel evaporation continues when the car is parked.

REFUELING: Gasoline vapors are always present in fuel tanks. These vapors are forced out when the tank is filled with liquid fuel.

What Has Been Done to Control Automobile Emissions?

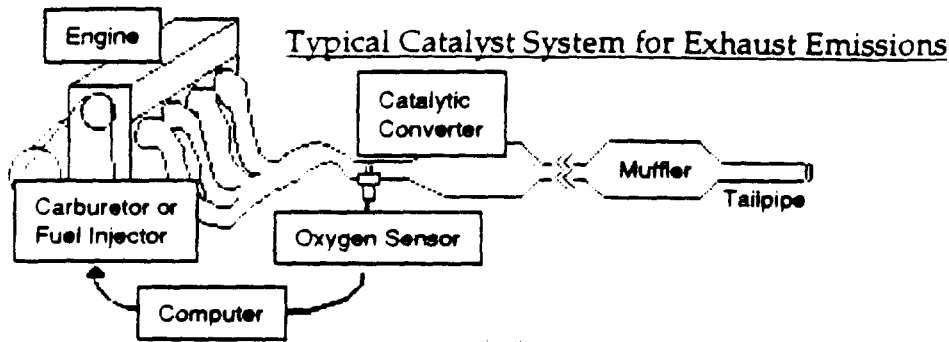
The Clean Air Act of 1970 gave EPA broad authority to regulate motor vehicle pollution, and the Agency's emission control policies have become progressively more stringent since the early 1970s.

EPA standards dictate how much pollution autos may emit but automakers decide how to achieve the pollution limits. The emission reductions of the 1970s came about because of fundamental improvements in engine design, plus the addition of charcoal canisters to collect hydrocarbon vapors and exhaust gas recirculation valves to reduce nitrogen oxides.

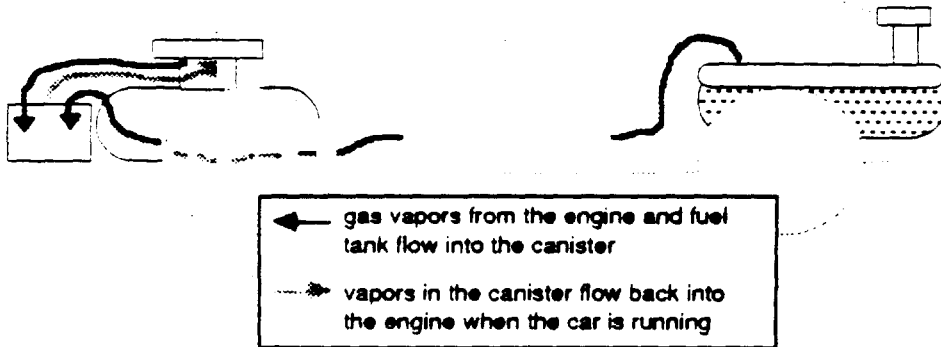
The advent of "first generation" catalytic converters in 1975 significantly reduced hydrocarbon and carbon monoxide emissions. The use of converters provided a huge indirect benefit as well. Because lead inactivates the catalyst, 1975 saw the widespread introduction of unleaded gasoline. This resulted in dramatic reductions in ambient lead levels and alleviated many serious environmental concerns associated with lead pollution.

The next major milestone in vehicle emission control technology came in 1980-81. In response to tighter standards, manufacturers equipped new cars with even more sophisticated emission control systems. These systems generally include a "three-way" catalyst (which converts carbon monoxide and hydrocarbons to carbon dioxide and water, and also helps reduce nitrogen oxides to elemental nitrogen and oxygen), plus an on-board computer and oxygen sensor. This equipment helps optimize the efficiency of the catalytic converter.

Basic Controls for Exhaust and Evaporative Emissions



Typical Canister System for Evaporative Emissions



What Has Emission Control Meant for Air Quality?

Efforts by government and industry since 1970 have greatly reduced typical vehicle emissions. In those 20 years, however, the number of cars and miles they drive have nearly doubled. The increase in miles traveled has offset much of the emission control progress.

The net result is a modest reduction in each automotive pollutant except lead, for which aggregate emissions have dropped by more than 95%.

With ozone continuing to present a persistent urban air pollution problem, future vehicle emission control programs will focus on hydrocarbon and nitrogen oxide reductions. Carbon monoxide control will remain critical in many cities, and limits on vehicle-generated carbon dioxide may become important in the future.

For Further Information

The EPA National Vehicle and Fuel Emissions Laboratory is the national center for research and policy related to auto pollution. Contact the lab at 2565 Plymouth Road, Ann Arbor, MI 48105, or call 313/668-4333.