Gasoline Engine Exhaust

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Diesel and gasoline engines are the major sources of power used in motor vehicles. Both are internal combustion engines, but differ fundamentally in terms of their fuel-air mixture preparation and ignition and in the fuels they use. Diesel fuel is composed of petroleum fractions with a higher boiling range than those of gasoline.

Exhaust emissions from combustion engines comprise a complex and varied mixture. These include:

- Gases - Carbon monoxide and nitrogen oxides
- Particles - Elemental and organic carbon, ash, sulfate and metals
- Volatile organic compounds – Benzine
- Semi-volatile organic compounds
- Polycyclic aromatic hydrocarbons (PAHs) - Oxygenated and nitrated PAH derivatives

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The following table represents some compounds and classes of compounds in vehicle engine exhaust [IARC].

Gas Phase	Particulate Phase
Acrolein	Heterocyclics and derivatives[a]
Ammonia	Hydrocarbons (C_{14}-C_{35}) and derivatives[a]
Benzene	Inorganic sulfates and nitrates
1,3-Butadiene Formaldehyde	Metals (e.g. lead and platinum)
Formic acid	Polycyclic aromatic hydrocarbons and derivatives[a]

Gas Phase	Particulate Phase
Heterocyclics and derivatives[a]	Heterocyclics and derivatives[a]
Hydrocarbons (C_1-C_{18}) and derivatives[a]	
Hydrogen cyanide	
Hydrogen sulfide Methane	
Methanol	
Nitric acid	
Nitrous acid Oxides of nitrogen	
Polycyclic aromatic hydrocarbons and derivatives[a]	
Sulfur dioxide	
Toluene	

[a] Derivatives include acids, alcohols, aldehydes, anhydrides, esters, ketones, nitriles, quinones, sulfonates, halogenated and nitrated compounds, and multifunctional derivatives.

Diesel engine exhaust previously contained larger amounts of particulate matter, whereas gasoline engines contained higher levels of certain gases such as carbon monoxide [IARC].

Usage and exposure

Combustion engines are used in a variety of off-road vehicles and equipment in different industrial sectors, such as mining, construction and transport. Both gasoline and diesel engines are used in lighter vehicles, and gasoline engines are used in power generators as well as hand-held equipment such as chain saws, leaf blowers, hedge trimmers, brush cutters and clearing saws [IARC].

Occupational exposure to gasoline engine exhaust occurs in a wide variety of professions. Exposure from on-road vehicles can occur in the following occupations, which are listed in the order of relative risk:

- Professional drivers
- Border inspectors
- Tollbooth workers
- Car mechanics
- Service station attendants

- Street workers
- Policemen
- Car park attendants
- Shopkeepers

In addition to road traffic-related sources, exposure to gasoline engine exhaust may also occur during the use of gasoline engine-powered portable equipment such as power chain saws [IARC]. Using such equipment in enclosed areas leads to rapid accumulation of dangerous or even fatal concentrations of carbon monoxide within minutes [CDC].

The most widely used forklifts have an internal combustion engine powered by fuels that include gasoline, diesel fuel, and compressed natural gas. If the engine is not combusting fuel properly the exhaust may contain high levels of carbon monoxide. The most dangerous situation occurs when forklifts are used in enclosed areas. Newer forklifts with internal combustion engines have on-board sensors that monitor and adjust emissions and have catalytic converters that help reduce emissions [OSHA].

Exposure of the general population to traffic emissions is dependent on proximity to traffic, the volume and characteristics of the traffic and the presence of past traffic emissions in regional pollutants [IARC].

New standards and technology have significantly influenced exposure to engine exhaust gases and particles. There is a strong link between emission standards and engine technology in which standards give impetus to new technology and technology enables more stringent standards.For example, in the United States the Clean Air Act of 1970 granted the United States Environmental Protection Agency (EPA) authority to regulate motor vehicle pollution and the Agency's emission control policies have become progressively more stringent since the act's inception. This was followed by technological improvements such as introduction of the "Two-Way" catalytic conversion technology in 1975, and "Three-Way Catalyst" in 1981, which significantly reduced hydrocarbon and carbon monoxide emissions. The evolution of emissions reduction technology in gasoline engines has occurred in three principle arenas:

1) Engine design

2) Fuel related technologies

3) Exhaust gas after-treatment [Sabertec].

Gasoline engine technologies have evolved significantly in the last few decades. Tetraethyl lead was been banned as a fuel additive in most

countries by the year 2000, although it is still used in aircraft gasoline. Most gasoline automotive engines are now fitted with complex electronic feedback control systems, port fuel injection and three-way catalyst systems that reduce emissions of particulate matter, nitrogen oxides, carbon monoxide and non-methane hydrocarbons, as well as unregulated emissions [IARC].

Routes of Exposure

Inhalation is the main route of exposure to gasoline engine exhaust.

Health hazards

Acute Effects

Self-asphyxiation using car exhaust was previously a common method of suicide. However, the introduction of catalytic converters in the early 1990s resulted in lower toxicity of car exhaust, particularly carbon monoxide, and there has been a decline in the number of suicide incidents since then [Amos].

Information is limited for characterizing the potential health effects associated with acute or short-term exposure to engine exhaust.

Carbon monoxide poisoning is the main hazard of gasoline exhaust exposure, especially when gasoline powered equipment is used in enclosed areas.

Chronic Effects

Evidence provided by the experimental and epidemiological data base for non-cancer pulmonary effects of exhaust exposure in humans is limited, but it suggests that heavy exposures probably affect respiratory function and contribute to symptoms and development of chronic respiratory disease [Mauderly].

Carcinogenicity

Combustion by-products of diesel and gasoline engines represent thousands of chemical components present in the gas and particulate phases. Some also have carcinogenic properties. The following table shows some chemicals and metals found in diesel and gasoline engine exhaust and their carcinogenicity evaluation [IARC].

Agent	CAS no.	IARC Evaluation
Metals		

Agent	CAS no.	IARC Evaluation
Antimony compounds	1309-64-4 (Trioxide)	2B
Arsenic and inorganic arsenic compounds	007440-38-2	1
Beryllium and beryllium compounds	007440-41-7	1
Cadmium and cadmium compounds	007440-43-9	1
Chromium (VI)	018540-29-9	1
Cobalt and cobalt compounds	007440-48-4	2B
Lead compounds	Inorganic/organic	2A/3
Nickel	Metallic/compounds	2B/1
Organic chemicals		
1,3-Butadiene	106-99-0	1
Acetaldehyde	75-07-0	2B
Benzene	71-43-2	1
Bis(ethylhexyl)phthalate	117-81-7	2B
Ethylbenzene	100-41-4	2B
Formaldehyde	50-00-0	1
Propylene oxide	75-56-9	2B
Halogenated and other chemicals		
Dioxin/dibenzofurans	1746-01-6 (TCDD)*	1
Polycyclic aromatic hydrocarbons		
Benz[*a*]anthracene	56-55-3	2B
Benzo[*b*]fluoranthene	205-99-2	2B
Benzo[*k*]fluoranthene	207-08-9	2B
Benzo[*a*]pyrene	5-32-8	1
Chrysene	218-01-9	2B
Dibenz[*a,h*]anthracene	53-70-3	2A
3,7-Dinitrofluoranthene	105735-71-5	2B

Agent	CAS no.	IARC Evaluation
3,9-Dinitrofluoranthene	22506-53-2	2B
1,3-Dinitropyrene	75321-20-9	2B
1,6-Dinitropyrene	42397-64-8	2B
1,8-Dinitropyrene	42397-64-9	2B
Indeno[*1,2,3-cd*]pyrene	193-39-5	2B
Naphthalene	91-20-3	2B
3-Nitrobenzanthrone	17 117-34-9	2B
6-Nitrochrysene	7496-02-8	2A
2-Nitrofluorene	607-57-8	2B
1-Nitropyrene	5522-43-0	2A
4-Nitropyrene	57835-92-4	2B
Styrene	100-42-5	2B

*TCDD, 2,3,7,8-tetrachlorodibenzodioxin

In 2012 The International Agency for Research on Cancer (IARC) concluded that there is currently inadequate evidence in human studies for the carcinogenicity of gasoline engine exhaust. Meanwhile, there is sufficient evidence in experimental animal studies for the carcinogenicity of condensates of gasoline engine exhaust.

Gasoline engine exhaust is *possibly carcinogenic to humans (Group 2B)* [IARC].

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