

Average In-Use Emissions from Urban Buses and School Buses

The amount of pollution that a vehicle emits is dependent on many factors. The U.S. Environmental Protection Agency (EPA) has developed a series of computer models that estimate the average emissions for different types of highway vehicles. This fact sheet is one of a series on highway vehicle emission factors. It presents average in-use emission rates for urban (transit) and school buses. It also presents idle emission rates for urban and school buses.

Introduction

There are a number of factors that affect the rate at which any vehicle emits air pollutants. Some of the most important are:

- vehicle type/size (cars, light-duty trucks, heavy-duty trucks, urban and school buses, motorcycles)
- vehicle age and accumulated mileage
- fuel used (gasoline, diesel, others)
- ambient weather conditions (temperature, precipitation, wind)
- maintenance condition of the vehicle (well maintained, in need of maintenance, presence and condition of pollution control equipment)
- type of driving (e.g., long cruising at highway speeds, stop-and-go urban congestion, typical urban mixed driving)

The most current version of the computer model that EPA uses to estimate average in-use emissions from highway vehicles is MOBILE6.2. EPA, the States, and others use this model to estimate total emissions of pollutants generated by highway vehicles in various geographic areas and over specific time periods. The emission rates (or “emission factors”) presented in this fact sheet are based on national average data representing the in-use fleet as of July 2008.

The emission rates for hydrocarbons (for both volatile organic compounds [VOCs] and Total Hydrocarbons [THC]), carbon monoxide (CO), and nitrogen oxides (NO_x) are presented in the following tables. These emission factors are for both diesel and gasoline urban buses and school buses, although there are very few urban or school buses using gasoline engines. In addition, the emission rates of particulate matter (PM₁₀ and PM_{2.5}) are provided for the diesel buses only because the MOBILE model does not include PM for gasoline buses.¹

These estimates assume an average, properly maintained bus, operating on typical diesel and gasoline fuel, on a warm summer day. Emission rates can be higher in very hot weather (especially HC) or very cold weather (especially CO).

The emission factors produced by MOBILE6.2 are based on national average data on the fraction of total vehicle miles traveled (VMT) accrued on each of four major roadway types, and national average traffic speeds associated with each of these facility types. The four roadway types are:

- limited access highways (freeways, expressways)
- ramps (entrance and exit ramps to and from limited access highways)
- arterials (primary surface roadways)
- local and collector roads (local streets and minor surface roadways)

These emission rates account for the fact that a single value of average speed is not adequate for the characterization of real-world driving patterns. For example, driving patterns associated with an average speed of 40 miles per hour (mph) on a limited access highway are not the same as driving patterns associated with an average speed of 40 mph on an arterial route; in the first case, 40 mph implies heavy traffic with some congestion and varying speeds, while in the latter case 40 mph represents near free-flow conditions. The emission factors developed for the four roadway types include hard acceleration and deceleration rates (up to 6.9 mph/second), which result in significantly higher emission rates for short periods of time, and maximum speeds up to 75 mph for parts of the limited access highway driving patterns.

National average values are used for registration distributions by age (what fraction

Abbreviations and Acronyms Used

CO:	Carbon monoxide; a regulated pollutant
g/hr:	grams per hour
g/min:	grams per minute
HC:	Hydrocarbons; molecules formed of hydrogen and carbon that constitute gasoline, diesel, and other petroleum-based fuels; a regulated pollutant
mph:	miles per hour
NO_x:	Nitrogen oxides; a regulated pollutant
PM₁₀:	Particulate matter under 10 microns diameter; a regulated pollutant
PM_{2.5}:	Particulate matter under 2.5 microns diameter, sometimes referred to as “fine particulate”
ppm:	parts per million
THC:	Total hydrocarbons
VMT:	Vehicle miles traveled
VOC:	Volatile organic compounds; equivalent to THC <u>plus</u> aldehydes <u>minus both</u> methane and ethane

of all buses in use today are of the current model year, are one to two years old, two to three years old, and so forth) and annual mileage accumulation rates by age (newer buses tend to be driven more miles per year than do older buses). Some of the other primary assumptions incorporated in these emission factors are:

- Ambient temperature: 72 to 92° F day time range
- Nominal gasoline volatility: 9.0 psi RVP
- Weathered fuel volatility: 8.6 psi RVP
- Diesel sulfur content: 11 ppm
- Gasoline sulfur content: 30 ppm
- I/M program: No
- Reformulated gasoline: No

Average Emission Rates

Table 1 presents average in-use emission rates for urban buses and school buses while being driven.

Table 1: Average Emission Rates for Urban Buses and School Buses*
(in grams per mile)

Pollutant	Urban Diesel Buses	School Diesel Buses	School Gasoline Buses
VOC	0.349	0.642	7.580
THC	0.353	0.653	7.791
CO	3.376	2.312	89.600
NO _x	14.793	10.536	7.477
PM _{2.5}	.0274	0.556	0.104
PM ₁₀	0.297	0.604	0.145

*See Endnotes

Table 2 presents average idle emission factors expressed as grams per hour (g/hr) and grams per minute (g/min) of idle time.

Table 2: Average Idle Emission Rates for Urban Buses and School Buses*

Pollutant	Urban Diesel Buses		School Diesel Buses		School Gasoline Buses	
	g/hr	g/min	g/hr	g/min	g/hr	g/min
VOC	2.700	0.045	4.968	0.083	48.903	0.815
THC	2.735	0.046	5.055	0.084	52.140	0.869
CO	37.430	0.624	25.630	0.427	1,036.000	17.267
NO _x	61.113	1.019	43.505	0.725	13.373	0.228
PM _{2.5}	1.069	0.018	1.401	0.023	N/A*	N/A*
PM ₁₀	1.161	0.019	1.523	0.025	N/A*	N/A*

*See Endnotes

For More Information

The other fact sheets in this series and additional information are available on the Office of Transportation and Air Quality's Web site at:

Emission factor fact sheets: www.epa.gov/otaq/consumer.htm

Modeling and estimating vehicle emissions: www.epa.gov/otaq/models.htm

Clean School Bus USA Program: www.epa.gov/cleanschoolbus

Idle Reduction Technologies: www.epa.gov/cleandiesel/idle-ncdc.htm

SmartWay Idle Reduction: www.epa.gov/otaq/smartway/transport/what-smartway/idling-reduction.htm

Endnotes

1. Although the MOBILE model includes idling PM estimates for heavy-duty diesel vehicles, it does not include idling PM estimates for gasoline-fueled vehicles. There has been insufficient emission testing of PM from gasoline-fueled vehicles of the type necessary to develop emission rates for these vehicles at idle, since the PM contribution to ambient air quality from gasoline vehicles is normally negligible.
2. Figures presented in this fact sheet are averages only. Individual buses can differ substantially in the amount of pollution emitted per mile from the values indicated here. Values shown may differ slightly from original sources due to rounding.
3. All of the emission estimates provided in this document are consistent, in terms of assumptions made and modeling methodology, with those provided in the other fact sheets in this series: “Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks” (EPA420-F-08-024), “Idling Vehicle Emissions” (EPA420-F-08-025), and “Average In-Use Emissions from Heavy-Duty Trucks” (EPA420-F-08-027).