

Average In-Use Emissions from Heavy-Duty Trucks

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 emission rates for gasoline-fueled and diesel heavy-duty vehicles.

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 (passenger 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 for gasoline-fueled and diesel heavy-duty trucks in this fact sheet are based on national average data representing the in-use fleet as of July 2008. These estimates are suitable for use in obtaining first-order approximations of vehicle emissions.

The emission rates (or “emission factors”) for hydrocarbons (both volatile organic compounds [VOCs] and total hydrocarbons [THC]), carbon monoxide (CO), nitrogen oxides (NO_x), and particulate matter (PM₁₀ and PM_{2.5}) are presented in the following tables. The hydrocarbon numbers include both tailpipe and evaporative emissions, whereas the rates for the other pollutants are for tailpipe emissions only.

The emission rates assume an average, properly maintained heavy-duty truck operating on typical gasoline or diesel 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 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

Abbreviations and Acronyms Used

CO:	Carbon monoxide; a regulated pollutant
g/bhp-hr:	grams per brake horsepower-hour; the unit used in establishing emission standards and measuring emissions from heavy-duty engines
g/mi:	grams per mile; a standard form of expressing highway vehicle emission rates
GVW:	Gross vehicle weight
HC:	Hydrocarbons; molecules formed of hydrogen and carbon that constitute gasoline, diesel, and other petroleum-based fuels; a regulated pollutant
HDDV:	Heavy-duty diesel vehicle
HDGV:	Heavy-duty gasoline-fueled vehicle
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 “fine particulate”
ppm:	parts per million
psi:	pounds per square inch
RVP:	Reid vapor pressure; a standardized method for expressing the volatility, or tendency to evaporate, of gasoline
THC:	Total hydrocarbons including methane
VMT:	Vehicle miles traveled
VOC:	Volatile Organic Compounds; equivalent to THC <u>plus</u> aldehydes <u>minus both</u> methane and ethane

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 of all vehicles of each specific type, in use today, are of the current model year, one to two years old, two to three years old, and so forth up to 25 years old) and annual mileage accumulation rates by age (newer vehicles tend to be driven more miles per year than do older vehicles) and by gross vehicle weight (GVW) class. Some of the other primary assumptions made in developing 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
- Gasoline sulfur content: 30 ppm
- Diesel fuel sulfur content: 11 ppm
- I/M program: No
- Reformulated gasoline: No

To estimate in-use emission rates from heavy-duty trucks, the emission rates from heavy-duty engines, expressed and regulated in terms of grams per brake horsepower-hour (g/bhp-hr), must be converted to units of grams per mile (g/mi). Heavy-duty engines emission standards are stated in g/bhp-hr to account for the fact that the same engines may be used in a wide range of final vehicle applications. The work performed by a heavy-duty engine installed in a truck of GVW Class III, for example, is much less than the work that engine would be required to do if installed in a truck of GVW Class VII.

This conversion, from mass pollutant emitted per unit work to mass pollutant emitted per unit distance traveled, is performed in MOBILE6.2 through the use of “conversion factors” that express the average amount of work required to move a given heavy-duty truck over one mile (brake horsepower-hour per mile, or bhp-hr/mi).

Average In-use Emission Rates for Heavy-Duty Trucks

Table 1 presents emission rates for gasoline-fueled and diesel-powered heavy-duty trucks that are averages for the entire in-use fleet as of July 2008. Heavy-duty trucks are vehicles that are greater than 8,500 lb gross vehicle weight and are equipped with heavy-duty engines, a distinct category under EPA’s highway vehicle pollution control regulations. The heaviest trucks (heavy-duty diesel trucks in GVW classes VIIa and VIIb) are used mostly for the interstate transport of goods, and in some cases accumulate more than 250,000 miles annually. Those trucks at the lighter end of the heavy-duty vehicle category (gasoline-fueled and diesel trucks in GVW Classes III-V) are used more in short-haul applications, and generally average under 30,000 miles annually. The overall average emission factors presented for each category are weighted to account for the distribution of vehicles across the different weight classes.

Table 1: Average In-Use Emission Rates for Heavy-Duty Vehicles*
(in grams per mile)

Pollutant	HDGV (gasoline)	HDDV (diesel)
VOC	1.586	0.447
THC	1.635	0.453
CO	13.130	2.311
NO _x	2.914	8.613
PM _{2.5}	0.044	0.202
PM ₁₀	0.051	0.219

* See Endnotes

Table 2 presents average in-use emission rates for heavy-duty gasoline trucks and heavy-duty diesel trucks, separated by various weight classes. The GVW weight classes are:

Heavy-Duty Vehicle Classifications

(Gross Vehicle Weight Rating)

- IIb:** 8,501-10,000 lb (e.g., full-size pick-up trucks, very large passenger vans)
- III:** 10,001-14,000 lb (e.g., panel trucks, small enclosed delivery trucks)
- IV:** 14,001-16,000 lb (e.g., city delivery trucks, rental trucks)
- V:** 16,001-19,500 lb (e.g., bucket utility trucks, large walk-in delivery trucks)
- VI:** 19,501-26,000 lb (e.g., rack trucks, single axle vans)
- VII:** 26,001-33,000 lb (e.g., tow truck, garbage collection trucks)
- VIIIa:** 33,001-60,000 lb (e.g., long-haul semi-tractor trailer rigs)
- VIIIb:** > 60,000 lb (e.g., double long-haul semi-tractor trailer rigs)

Table 2: Average Heavy-Duty Truck Emission Rates by GVW Class*
(in grams per mile)

Pollutant	Fuel	IIb	III	IV	V	VI	VII	VIIIa	VIIIb
VOC	gas	1.353	1.667	4.234	2.632	2.477	2.857	3.628	⁽¹⁾
	diesel	0.189	0.201	0.262	0.274	0.365	0.453	0.455	0.545
	gas	1.400	1.713	4.319	2.693	2.535	2.920	3.704	⁽¹⁾
	diesel	0.194	0.204	0.266	0.278	0.370	0.459	0.461	0.552
CO	gas	11.220	15.810	33.860	19.580	18.130	23.130	28.560	⁽¹⁾
	diesel	0.839	0.908	1.163	1.189	1.367	1.719	2.395	3.109
NOx	gas	2.734	2.920	4.133	3.735	3.650	4.199	4.892	⁽¹⁾
	diesel	3.088	3.298	4.352	4.548	5.990	7.471	9.191	10.990
PM2.5	gas	0.043	0.045	0.058	0.046	0.045	0.046	0.049	⁽¹⁾
	diesel	0.091	0.073	0.089	0.079	0.172	0.177	0.215	0.238
PM10	gas	0.049	0.051	0.074	0.055	0.054	0.056	0.061	⁽¹⁾
	diesel	0.099	0.079	0.096	0.085	0.186	0.192	0.233	0.259

⁽¹⁾ There are no gasoline-fueled heavy trucks in this weight category.

* 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

Converting heavy-duty engine emission rates to in-use heavy-duty truck emission rates:

www.epa.gov/otaq/models/mobile6/r02006.pdf

www.epa.gov/otaq/models/mobile6/r02005.pdf

Endnotes

1. Figures presented in this document are averages only. Individual trucks may differ substantially in terms of pollution emitted per mile from values indicated here. Values may differ slightly from original sources due to rounding.

2. These emission factors are averages for the entire in-use fleet as of July 2008. Newer trucks generally will have lower emissions, as they are built to comply with more stringent emission standards and have not yet accumulated high odometer mileages, while older trucks generally

will have higher emissions, as they were built to comply with more lenient emission standards in effect for past years and generally have accumulated much higher odometer mileages.

3. All emission estimates provided in this fact sheet 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 Emission Factors for Urban Buses and School Buses” (EPA420-F-08-026).