VOLVO

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Emissions from Volvo's trucks (standard diesel fuel)

To facilitate emission calculation from transport, Volvo Trucks has summarised emission factors per litre fuel consumed. The summary is applicable primarily for trucks using standard diesel fuel. The stated values are based on certification measurements and can be used for outlined calculations. In an actual traffic situation the values vary due to individual conditions such as vehicle status, driving method, traffic situation etc.

Conclusion

Typical values, based on certification measurements, for the more common Volvo engines, with EU certification diesel fuel (CEC RF-06-99) [g/kWh]						
	Law from	Volvo from	NO_x g/kWh	PM g/kWh	HC g/kWh	CO g/kWh
Typical	1980		16±1	1.0±0.3	1.5±0.5	2±1
Euro 0	1990	1987	10.4-10.8	0.2-0.4	0.4-0.5	0.7-1.5
Euro 1	1993	1991	7.0-8.0	0.05-0.14	0.12-0.30	0.2-2
Euro 2	1996	1993	6.3-6.8	0.05-0.12	0.11-0.24	0.3-1.8
Euro 3, D6	2001	2000	4.8	0.08	0.35	0.7
Euro 3, D7	2001	2000	4.8	0.07	0.10	0.6
Euro 3, D9	2001	2001	4.7	0.08	0.20	0.6
Euro 3, D12, 340-420	2001	2000	4.7	0.07	0.20	0.6
Euro 3, D12, 460-500	2001	2001	4.7	0.07	0.10	0.6
Euro 3, D16, 550-610	2001	2003	4,5	0,07	0,20	1,0

Table 1

Typical values, based on certification measurements, for the more common Volvo engines, with EU certification diesel fuel (CEC RF-06-99) [g/litre fuel]						
	Law from	Volvo from	NO_x g/litre	PM g/litre	HC g/litre	CO g/litre
Typical	1980		58±5	4±2	6±2	8±3
Euro 0	1990	1987	41-44	1.5-1.7	1.5-1.8	3-6
Euro 1	1993	1991	28-32	0.2-0.6	0.5-1.2	2-8
Euro 2	1996	1993	25-28	0.2-0.5	0.4-1.0	1-7
Euro 3, D6, 180-220	2001	2000	18	0.35	1.3	2.6
Euro 3, D6, 250	2001	2000	18	0.25	1.3	2.6
Euro 3, D7, 250	2001	2000	18	0.25	0.4	2.3
Euro 3, D7, 290-310	2001	2000	18	0.30	0.4	2.3
Euro 3, D9, 260	2001	2001	18	0.30	0.8	2.3
Euro 3, D9, 300	2001	2001	18	0.35	0.8	2.3
Euro 3, D9, 340-380	2001	2001	19	0.30	0.8	2.4
Euro 3, D12, 340-420	2001	2000	19	0.25	0.8	2.4
Euro 3, D12, 460	2001	2001	20	0.35	0.4	2.5
Euro 3, D12, 500	2001	2001	20	0.30	0.4	2.5
Euro 3, D16, 550	2001	2003	17	0,25	0,8	2,7
Euro 3, D16, 610	2001	2003	17	0,25	0,8	3,9

Table 2

Legal requirements

The legal requirements for diesel engines have been tightened several times, latest in 2001. Diesel engines are used in various types of vehicles, for various types of traffic, and with varying loads. To be able to measure emissions in a comparable way, they are measured in relation to the work performed by an engine and the units used are grams per kilowatt-hour. For certification, a well-defined fuel is used, very similar to standard fuel but with closer tolerances.

Legal requirements and limit values

	Law from	NOx g/kWh	PM g/kWh	HC g/kWh	CO g/kWh
R49.00	1982	18	-	3.50	14
Euro 0	1990	14.4	-	2.40	11.2
Euro 1	1993	8.0	0.36	1.10	4.5
Euro 2	1996	7.0	0.15	1.10	4.0
Euro 3	2001	5.0	0.10	0.66	2.1

Table 3

Better than legal requirements

Volvo engines comply with the legal requirements with a margin, and in some cases are considerably better than the legal requirements. Several common types of engine have even been introduced a couple of years before the legal requirements have come into force.

Table 1 shows the emissions per kilowatt-hour from some of the commonest types of Volvo engines.

Certification values are converted in various connections into emissions per vehicle kilometre or per ton-kilometre. They are based on assumptions of a certain type of traffic, driving method, and load utilisation, and are therefore uncertain especially as payload is defined differently in different connections. Transporters and transport buyers need better and better data for their environmental reports and calculations. To facilitate this type of work, Volvo has converted the certification values into emissions per litre of fuel, see table 2.

Using fuel consumption as a base, it is possible to calculate the emissions in a better way compared to earlier and to take into consideration load utilisation, road choice, speed, driving method, etc. The data is based on measurements according to the applicable standard for certification that deviates from a real traffic situation. Emissions from vehicles in traffic may differ from these data. The tables should not be used to make direct comparisons between different vehicles. Furthermore, the emissions per litre fuel will be lower when the fuel consumption is high. Therefore, the total emissions from an engine or a vehicle with a low fuel consumption can be lower even if the emissions per litre fuel are greater than for another combination.

Example:
A truck and trailer are fully loaded with a total weight of 40 tons of which the payload is 26 tons. For a certain type of transport on the motorway (freeway), the fuel consumption is 0.35 litres per km. Of course the consumption can be lower for other types of transport and when the truck is not fully loaded. The 1994 truck has an engine that complies with Euro 2. The table shows that the emissions of nitric oxides, for example, are 25-28 g/l fuel. The emissions per ton-km can therefore be calculated as follows:

Nitrogen oxides, NOx	0.35 l/km * {25 to 28} g/l per 26 tons ≈ {0.34 to 0.38 } g/ton-km
Particles, PM	0.35 l/km * {0.2 to 0.4} g/l per 26 tons ≈ {0.003 to 0.005} g/ton-km
Hydrocarbons, HC	0.35 l/km * {0.4 to 1 } g/l per 26 tons ≈ {0.005 to 0.013} g/ton-km
Carbon monoxide, CO	0.35 l/km * {1 to 7 } g/l per 26 tons ≈ {0.01 to 0.09 } g/ton-km

The emissions of carbon dioxide and sulphur depend on the fuel. They can be calculated using the fuel data described in the section Fuel Quality below.

Carbon dioxide, CO_2	0.35 l/km * 2.7 kg/l per 26 tons ≈ 0.036 kg/ton-km
Sulphur, S	0.35 l/km * 0.1 g/l per 26 tons ≈ 0.0013 g/ton-km

Fuel consumption

Fuel consumption varies considerably depending on the type of traffic, roads, driving behaviour, etc. It is therefore advisable to base calculations on the actual fuel consumption for a certain transport. When there is no data available for the fuel consumption, the data in the table can be used as a guiding value for vehicles of today. Please contact your Volvo dealer for information about a specific type of transport.

Typical fuel consumption in litres per 100 km

	Payload in tons	Total weight in tons	litres / 100 km empty	litre / 100 km full load
Truck, distribution traffic	8.5	14	20-25	25-30
Truck, regional traffic	14	24	25-30	30-40
Tractor and semi-trailer, long-haul traffic	26	40	22-27	30-37
Truck with trailer, long-haul traffic	40	60	28-33	45-55

Table 4

More efficient engines, optimisation of vehicles and drive trains, reduced air resistance, better tires etc, have reduced the fuel consumption. At the same time the vehicles load capacity, total weight and frontal area have changed.

For same type and size of vehicle the fuel consumption has been reduced by about 30 percent from 1980 to 1998.

Fuel consumption, over time, for a European tractor and semi-trailer in long-haul traffic

Model year	l / 100 km	Percent
1980	44	100
1990	35	81
1993	33	75
1998	31	70
2001	30	68

Table 5

Importance of the road for fuel consumption and environment

Traffic lights and cross-roads cause extra stoppages and a couple of extra stops every 10 km can increase fuel consumption by about 35%. Ten stops and accelerations every 10 km increases fuel consumption by 130%. The route of course also affects the fuel consumption and environment. As an example, the E6 highway in Sweden can be compared before and after the freeway was built. The new freeway reduced fuel consumption by about 10%.

Maintenance affect fuel consumption and environment

Correct service and maintenance have a decisive effect on both fuel consumption and emissions. Example; with a low tire pressure of 20% below normal, the fuel consumption will increase by about 2%.

Fuel quality

Carbon dioxide is formed by combustion. The carbon content of the fuel determines the amount. One litre of standard diesel fuel (EN590) creates about 2.7 kg carbon dioxide.

Fuel	Carbon dioxide, kg/litre
Standard fuel	~2.7
Class 1 diesel fuel	~2.6

Table 6

Class 1 diesel fuel is the most common fuel in many countries of today and the fuel that Volvo recommends. It reduces the emissions of nitrogen oxides by about 7%, particles by about 20%, and carbon dioxide from 2.7 to 2.6 kg per litre of fuel. Emissions of hydrocarbons are low, but increase by about 5 percent.

Emission reduction with class 1 diesel compared to standard fuel			
	Max reduction	Typical	Min reduction
NOx	-14%	-7%	-7%
PM	-30%	-20%	-10%
HC	-20%	+5%	+32%
CO	-30%	±0%	+19%

Table 7

The aromatic and polyaromatic contents are defined for class 1 fuels. In practice, the contents have been reduced by more than 75%. Therefore, the emissions of hydrocarbons and particles contain less harmful substances. The energy content of class 1 fuel is slightly lower per litre fuel and the fuel consumption therefore increases by about 3%.

Fuel	Class 1	Ref. fuel	Standard (EN590)
Sulphur %, max.	0.0010	0.03	0.035
Sulphur %, average 97/98	0.0002	-	-
Aromatics, vol. %, max.	5	Not defined	(20-30)
PAH vol. %, max.	0.02	Not defined	(1-2)
Density kg/m^3	800-820	833-837	820-845

Table 8

The fuel contains residues of sulphur. The sulphur content must currently not exceed 0.035% according to the EN590 standard and max. 10 ppm for class 1. The average sulphur content of class 1 fuel supplied in Sweden during 1997 was 2±0.5 ppm, resulting into a sulphur emission of 0.0015±0.0005 g per litre. The quality of fuel will continue to improve but there are large variations from one country to another, both in the EU and outside it. Fuel suppliers can provide more detailed information about the quality of fuel.

Transporters and carriers have a key role

The differences in certification values for modern engines are quite small. But the differences depending on how the vehicle is used are often much larger. Therefore it is essential to select the correct type of vehicle with the correct powertrain for the respective transport assignment, the right route, and to have a good load utilisation.

Emissions per ton-kilometre can therefore only be calculated with detailed knowledge about the particular transport, load utilisation, route selection, vehicle, etc.

Comparisons with other modes of transport

Comparisons with other transport modes can be made but it is difficult to make fair comparisons because the definitions are different for different modes of transport and energy. Furthermore, the character of the environmental loadings varies.

Payload is not a clearly defined term. For trucks, the payload is what is loaded into the truck. On the railways, the load and the weight of the semi-trailer are included in the payload. And for ferry transport, the weight of the truck and the trailer are included in the payload.

Payload for various types of traffic, in tons

	Truck	Rail	Ferry
Empty semi-trailer	0	7	14
Laden semi-trailer	26	33	40

Table 9

The transported distance is also often different for different modes of transport. Trucks can transport goods via terminals or directly from door to door. The actual distance that the goods travel is not always a factor of which the customer is aware. The railways depend on goods terminals. Therefore, goods are often transported over a longer distance and additional reloading and other transport modes are necessary. For air-freight, the point-to-point air distance is specified with no consideration taken to holding times while waiting for landing permission, which result in extra fuel consumption and emissions.

Transport work is the product of payload and transported distance. As the terms are defined differently for different modes of transport, the resulting transport work must vary. When making comparisons, it is important to take all aspects into consideration and this can only be done with a detailed knowledge and from case to case.

Energy can be measured in many ways. In the EU and OECD, electrical energy is converted to the equivalent quantities of oil. Sweden has previously compared net energy for electrical energy without taking into consideration the efficiency when converting fuel to electrical energy. The difference between these approaches is a factor of three. However, Sweden has now decided to use the same method as EU in future.

Different forms of energy cannot be directly compared with each other. Therefore, fuel consumption and electricity consumption should be specified separately. The heat content of fuels cannot be compared with electrical energy.

The emissions from an exhaust pipe are only a part of the environmental loading caused by transport. Different forms of energy have their advantages and disadvantages. It is not difficult to report on the emissions from an exhaust pipe but it is no trivial task to compare it with the environmental effects from nuclear or hydro-electric power stations, and therefore the environmental effects are often omitted from the production of electricity. To really determine the environmental load, a complete life cycle assessment must be done.

More information

More information about Volvo Trucks and how we take care of environmental issues can be found at www.volvotrucks.com.

An Environmental Product Declaration is also available for the Volvo FH and Volvo FM on internet.