

Emissions from the Military Vehicles

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Abstrakt: - The article deals with emission loading from mobile pollution sources in the Army of the Czech Republic. Total emissions are calculated from fuel consumption and establishment emission factors per training year. The sources emitting pollutant into the air are state-wide monitored in the Registry of Emission and Sources of the Air Pollution, which is balance of the national emissions. The military vehicles belong to one part of the Registry. The monitoring of emission levels for department of defence put more precisely estimation of the total emission from mobile pollution source in the Czech Republic.

Key-Words: - Army of the Czech republic, Emissions, Emission factor, Pollutions, Transport, Vehicles

1 Introduction

Air pollution belongs to one of the most significant environmental problems and it is related to all countries in the world. Increasing amount of gas and fixed harmful substances releasing into the air are reflected in abuse of health and human environment.

Human environment and its quality are not influenced by pollutants producing only by technological processes but also in sizable extent by transport. Automobile conveyance, lorry transport, train traffic, shipping or air carrying belong to the classification of mobile pollution source and assessment ratio of emission level from transport is about 42 per cent of pollutants [1]. The sources emitting pollutants in the air are state-wide monitored in the Registry of Emission and Sources of the Air Pollution, which is balance of the national emissions.

The emission balance of the mobile pollution sources is concerned significantly by the department of defence. This department interact the air not only by “classical” vehicles but also special military vehicles typical for every army, such as tanks, infantry fighting vehicles, armoured personnel carriers etc.

2 Problem Formulation

Continuous acceleration of air pollution is detected by:

- monitoring of possible pollution sources,
- monitoring of the most severe pollutants,
- establish the pollutant concentration by the chosen method,
- set up suitable methodology for calculation of air pollutants.

2.1 Air Pollution Monitoring

The main cause of emission from vehicle engine is exhaust gases originating from fuel combustion.

Exhaust gases are complex mixtures containing hundreds chemicals in various concentrations disposing mutagenic, carcinogenic and toxic properties.

Monitoring process and emissions testing are continually developing and heading towards obtaining superior basis for evaluating of quality of air. For the purpose of air quality monitoring in the Czech Republic the following tools is used:

- emissions level account from the air pollution source,
- immission monitoring stations,
- system for monitoring of atmospheric deposition,
- registry of the emissions and sources of the air pollution.

Only air pollution sources originating from human activity are recorded into the registry. According to Air Law [2] the pollution sources are classified into four categories; one of this categories is for mobile pollution source. The sources are divided in accordance to the air quality impact.

The emissions data from mobile sources are processed by Transport Research Centre in Brno for Ministry of Transport including road-, urban-, air- and combine transport. The emission balance of so-called other mobile sources containing agricultural-, forest-, building machine, internal transport and military mobile vehicles is established from data about fuel consumption and from appropriate emission factors.

2.2 Selected Pollutants

The exhaust gases contain hundreds of chemicals in various concentrations by many effects on human health. Among the most significant belong [3]:

- a) Carbon monoxide (CO). It is the product of the incomplete combustion of carbon-containing compounds. Carbon monoxide is a significantly toxic gas. Exposures can lead to significant toxicity of the central nervous system and heart.
- b) Nitrogen oxides (NO_x). In atmospheric chemistry the term NO_x is used to mean the total concentration of NO plus NO₂. NO and NO₂ are also central to the formation of tropospheric ozone.
- c) Particulate matter (PM). Particulate matter is tiny particles of solid or liquid suspended in a gas. The biggest human sources of particles are combustion sources, mainly the burning of fossil fuel in internal combustion engines in automobiles and power plants. Some of these particles are emitted directly to the atmosphere (primary emissions) and some are emitted as gases and form particles in the atmosphere (secondary emissions). The effects of inhaling particulate matter have been widely studied in humans and animals.

2.3 Pollutants Assessment in the Air

It is possible to assess emission level:

- a) direct method – quantity measurement of the pollutants outlet in the outgoing gases,
- b) indirect process – calculation according to detailed methodology or with the aid of approved emission factors.

In the Czech Republic the direct methods are used for assessment of emission levels by radiometric- and gravimetric survey and by optical measurement. The indirect processes are referred to as the fuel balance method or materials balance method. This process is used in these cases when the direct measurement of emission is on the ground of economic and technical reason is inconvenient (if the emission level will be so low that competition of measurement would induce significant expenses with regard to insignificant

source). The indirect processes are used according to detailed methodology issued by the Ministry of Environment e.g. in the emission assessment from the coke-oven plant or in the steam boiler plant, according to the emission factor in the emission assessment in an elected region.

In term of amount and quality entry data is indirect process optimal pro assessment total level of the air pollution caused by Army of the Czech Republic.

2.4 Used Methodology

There are many methodologies used worldwide for calculation of emission factors. In the Czech Republic there is very relevant “Methodology of determination of air polluting emissions from transport” (MESED) to calculate emissions from mobile sources [3]. The methodology includes only emissions from transport and does not include emissions from electricity production used by electricity vehicles. Furthermore it does not include emissions from engine of no-traffic machine and vehicles, so-called other mobile sources. These emissions are till now assessing by estimation but this paper introduce possible modification this methodology and its using for the military vehicles.

The underlying principles of the methodology are:

- categorization of vehicles,
- measured emission factors,
- annual mileages in selected vehicle categories.

2.5 Emission Sources from the Military Vehicles

The department of defence contributes to increase of the total amount of emissions in its activities. The emissions originating during operating of military vehicles are entered to the category other mobile sources and the emission amount is till now only assets.

The military vehicles are for emission calculation divided into category according methodology MESED. The No. of category, labelling and description of category it is possible to see in the Table 1.

Table 1 Vehicle categories for calculation of transport emissions

No. of category	Labelling	Description of category
1	ID.B1	individual transport, gasoline passenger single-track vehicles
2	ID.B2	individual transport, gasoline passenger dual-track vehicles without catalytic convert system
3	ID.B3	individual transport, gasoline passenger dual-track vehicles without catalytic convert system
4	ID.N	individual transport, diesel passenger dual-track vehicles
8	AD.B	public transport, gasoline vehicles
9	AD.N	public transport, diesel vehicles
13	ND.B	gasoline, goods vehicles
14	ND.LDV	diesel, goods vehicles under 3,5 t
15	ND.HDV	diesel, goods vehicles over 3,5 t

The origin of this methodology is base on distribution of vehicles into 23 categories, for the Army of the Czech Republic we will use only 9 categories which you can see in the table. The criteria for distribution are transport mode, fuel, weight of vehicles and equipment with effective catalytic convert system. Every category has attached emission factors of NO_x, N₂O, CO, PM etc., according to available measurements. Emission factors are put in g.kg⁻¹ of fuel and are processed in MS Access database. The emissions factors are reviewed with a help of special tests at the most used Czech and foreign cars. In the Table 2 there are emission factors for chosen pollutants.

Table 2 Emission factor of chosen pollutant

Labelling	Emission factor [g.kg ⁻¹]			
	NO _x	N ₂ O	CO	PM
ID.B1	04,44	0,059	603,00	-
ID.B2	30,21	1,166	210,90	-
ID.B3	04,81	4,497	14,30	-
ID.N	10,90	0,165	08,30	1,30
AD.B	34,75	0,048	x	-
AD.N	42,30	0,122	x	x
ND.B	34,75	0,048	177,00	-
ND.LDV	15,80	0,188	24,50	2,70
ND.HDV	42,30	0,122	19,70	1,10

After that the military vehicles were divided into super-groups, groups and sub-groups according to directive of General staff of the Czech Republic One of the super-group you can see in the Table 3.

Table 3 Partition of military vehicles

Super-group	Group	Sub-group
Tank vehicles	Tank	T-55 chassis
		T-72 armoured
		T-72 commander
		T-72-M4CZ armoured
		T-72-M4CZ commander
	BVP - Infantry fighting vehicles	BVP-1 armoured
		BVP-1 chassis
		BVP-1 commander
		BVP-2 armoured
	OT- Armoured personnel carriers	BVP-SA
		OT wheeled chassis
		OT-90 M
		OT-64 communic.
		OT-64 medical

The vehicles from the sub-groups are consequently classified into category according methodology MESED. It is necessary because some vehicles use gasoline and the others diesel and the emission factors are different.

The emissions for military vehicles are calculated according equation 1-4. Equation 1 is for calculation of emission level for the particular super-group, equation 2 for particular group, equation 3 for particular sub-group. According the equation 4 it is possible to determine the total emissions for selected vehicle.

$$E_z = \sum_{l=1}^{l \max} E_l \quad (1) \quad E_l = \sum_{k=1}^{k \max} G_k \quad (2)$$

$$G_k = \sum_{j=1}^{j \max} P_j \quad (3) \quad P_1 = \sum_{n=1}^{n \max} S_n \cdot \rho_b \cdot Ef_{b,n} \quad (4)$$

- E_z Army contribution to emissions z into the air from the selected vehicles [t.year⁻¹].
- E_l emissions level from supper-group l,
- G_k emissions level from group k,
- P_j emissions level from sub-group j,
- S_n fuel consumption for vehicle n [dm³.year⁻¹],
- ρ_b fuel density b [g.dm⁻³],
- Ef_{b,n} emission factor for vehicle n, fuel b[g.kg⁻¹],

The calculation of emission it is possible to separate into following steps:

1. Determination of fuel consumption per year for chosen vehicle. This item it is possible to set out when we multiple number of annual mileages and average fuel consumption at 1.100 km^{-1} .
2. Then the calculated data are multiple by fuel density. After that the data will be in required units $[\text{dm}^3]$.
3. The following step is to multiple data from step 2 with relevant emission factor. The emission factor depends on pollutant and category of vehicle.

3 Problem Solution

In the following example you can see calculation of emission for the group tank. According the methodology MESED the group belongs to the category ND.HDV - diesel, goods vehicles over 3,5 t.

The calculation for elected pollutant:

1. Calculation of fuel computation is not complicated because the fuel computation is monitored in terms of logistic information system in the Czech army. The computation for the group tank we found when we sum the fuel computation for sub-group.
2. A step 2 involves multiple data from step 1 by fuel density. These two steps represent Table 4.

Table 4 Sub-group TANK

Sub-group	No. of vehicles	Distance [km]	Fuel comp. $[\text{dm}^3]$	Fuel comp. [kg]
T-55 chassis	30	227	3193	2682
T-72 armoured	139	4578	24686	20736
T-72 commander	11	97	630	529
T-72-M4CZ armoured	27	6486	43437	36487
T-72-M4CZ commander	3	726	4680	3931
Total emissions	210	12114	76626	64365

3. The lasted step is multiple fuel computation from step 2 with relevant emission factor for chosen

pollutant. These emission factors are demonstrated in the Table 2.

Table 5 Emission for the sub-group TANK

Pollutant	Emission factor $[\text{g.kg}^{-1}]$	Emission levels [t]
NO_x	42,30	2,72
N_2O	0,122	$7,8 \cdot 10^{-3}$
CO	19,70	1,27
PM	1,10	$7,0 \cdot 10^{-2}$
Total emission	x	4,06

The total emission level is 4,06 t for chosen pollutants. In this manner it is possible to calculate the total emissions for every particular sub-group, group and super-group of vehicle, for every pollutant. That manner is possible for all of fuel – diesel and gasoline – for which there have been determine the emission factors.

4 Conclusion

On the ground of continually increasing amount of vapour and fixed pollutant presenting in the air it is necessary to solve problems of air pollution also for the sources which are not monitored at present. Among these sources belong military vehicles especially tracked and wheeled vehicles such as tank, infantry fighting vehicles or armoured personnel carriers.

There are many possibilities how to determine emission level. Indirect process of calculation was chosen in this paper according to the assumed emission factors. The basis was the “Methodology of determination of air polluting emissions from transport” developed by Transport Research Centre in Brno. The methodology was modified for using in the Czech army.

The method of calculation is demonstrated for the military vehicle tank. It can be used for all of the vehicles and pollutant.

References:

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