

traffic emission, technical stage of vehicles, age structure of vehicles

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## THE IMPACT OF SELECTED FACTORS ON INCREASING LEVEL OF EXHAUST EMISSION FROM VEHICLES

**Summary.** The article presents the results of the investigations of the influence of different factors on the traffic exhaust emission. The measurements of the test group of 300 different vehicles have been made. Those measurements provided information about the level of emission from each vehicle. Additionally, the investigations provided information about factors such as mileage, model year etc. of vehicles. Next, the percentage of fault vehicles and the type of faults were estimated. The relation between exhaust emission, vehicle age and mileage of vehicles have been made.

The simulation of the traffic emission from vehicles was made, taking into consideration the fact that the vehicles are all in good technical conditions and for the case of real technical conditions of vehicles. This investigation has shown that the technical conditions of the vehicles have an important influence on the estimated emission level. Additionally, it has been shown how the exhaust emission depends on the age structure and the mileage of vehicles.

## WPLYW WYBRANYCH CZYNNIKÓW NA WZROST POZIOMU EMISJI SZKODLIWYCH SKŁADNIKÓW SPALIN PRZEZ SAMOCHODY

**Streszczenie.** W artykule zaprezentowano wyniki badań wpływu wybranych czynników na wzrost poziomu emisji toksycznych składników spalin. Przeprowadzono badania stanu technicznego pojazdów z uwzględnieniem poziomu emisji poszczególnych składników spalin dla grupy 300 pojazdów. Dodatkowo uwzględniony został przebieg oraz wiek badanych pojazdów. W wyniku przeprowadzonych badań uzyskano informacje dotyczące liczby pojazdów, które przekraczają dopuszczalny poziom emisji.

Wykonano charakterystyki przedstawiające zależności pomiędzy emisją poszczególnych składników spalin a wiekiem pojazdów oraz przebiegiem. Dodatkowo, przeprowadzono badania symulacyjne wpływu stanu technicznego pojazdu na obliczany poziom emisji gazów spalinowych. Wyniki przeprowadzonej symulacji pokazują, iż stan techniczny pojazdów wpływa na szacowany poziom emisji spalin.

Rezultaty przeprowadzonych badań wykazały, że uwzględnienie stanu technicznego pojazdów może mieć znaczący wpływ na szacowany poziom emisji w ruchu drogowym.

## 1. INTRODUCTION

Motor vehicles are a significant source of air pollution, despite considerable improvements in engine technology and the quality of fuel. It is a very important problem to determine the emission from road transport thoroughly. The total emission level is heavily dependent on many factors including driver's behavior, the type of road, the number of vehicles, the type of vehicles and also their age structure, average speed per vehicle type and per road, the fuel type and the fuel consumption etc. Traffic emission is increasing all the time because the number of vehicles is also growing.

In many papers, the authors have described a lot of different methodologies to estimate emissions from road transport [1-3]. The vehicle emission is calculated depending on many factors like the type of road, the type of vehicles and their age structures for different types of road, the average speed of vehicles etc. The methodologies are used for calculating the emission from road transport taking into account driving patterns [4], instantaneous traffic emission [5], concentration of car exhaust pollutants in street canyons [6] and the influence of turbulence produced by traffic on car exhaust pollutant concentration [7].

Nowadays, it is a very important problem to estimate the number of vehicles which are in poor technical conditions and their influence on motor vehicle emission. In many countries, the methodologies to identify the failed and gross polluting vehicles, have been elaborated and applied [8]. The way of determining the effect of age and technical change on motor vehicle emission has been developed [9]. The influence of the engine construction and the engine technical conditions on traffic emission is also a very important factor [10].

## 2. METHODOLOGY

This article presents the results of investigations of the exhaust emission from vehicles. The measurements of exhaust emission for 300 different vehicles have been made. The measurements have been made in accordance with ECE Regulations and methodology of periodical car inspection. Those measurements provided information about the level of emission from each vehicle. Those measurements also provide information about the percentage of faulty vehicles of total number of cases.

Firstly, the relation between the exhaust emission and the age of vehicles has been elaborated for the test group. Secondly, the dependence of exhaust emission on the mileage of these vehicles has been worked out as well.

Next, the calculations of the traffic emission have been made. The traffic emission has been calculated using methodology from COPERT [1]. Those calculations were made for vehicles from the test group. At first, the simulation of the traffic emission from vehicles was made taking into consideration the fact that the vehicles are in good technical conditions and next taking into consideration the real results of tests.

## 3. THE RESULTS OF INVESTIGATIONS

The measurements of exhaust emission have been made for the test group of 300 different vehicles. In Fig. 1 the structure of vehicles from the test group has been shown. These vehicles have been categorized into the appropriate groups of cars with European emission standards. The appropriated emission standard is connected with the age of vehicle.

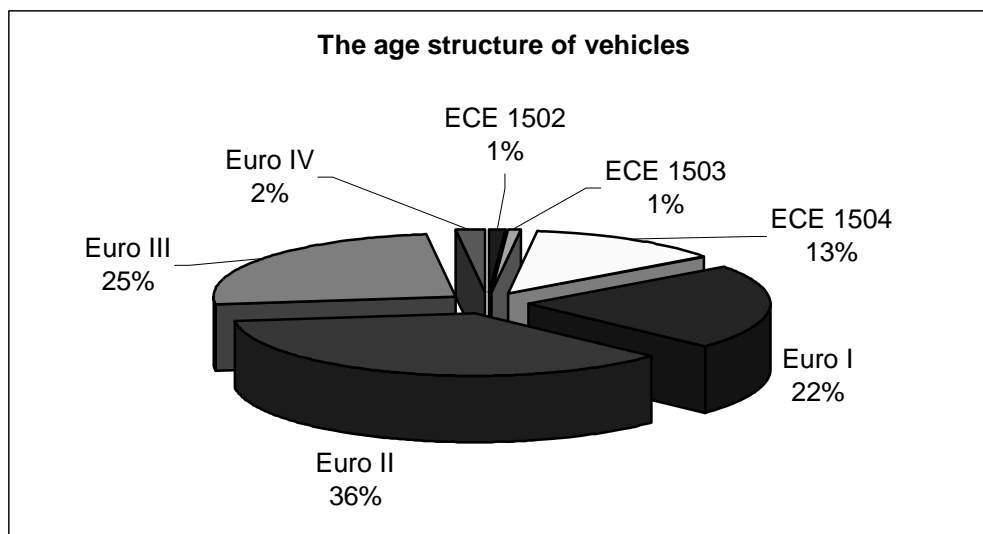


Fig. 1. The structure of vehicles from the test group  
Rys. 1. Struktura badanych pojazdów

Approximately 36 % of those vehicles should meet the requirements of Euro II. Euro II refer to the vehicles which were produced between 1996 and 2000. About 25 % of vehicles should meet the requirements of Euro III (2000 – 2005 year) and about 22 % of vehicles should meet Euro I requirements. All vehicles should meet the requirements of Polish legislation.

### 3.1. The influence of the age of vehicles

For the test group the measurements have been made in accordance with ECE Regulations and methodology of periodical car inspection. Those measurements provided information about the level of emission from each vehicle. Next, the relationship between the average CO (carbon monoxide) emission and vehicle age have been made. The results for CO emission have been shown in Fig. 2.

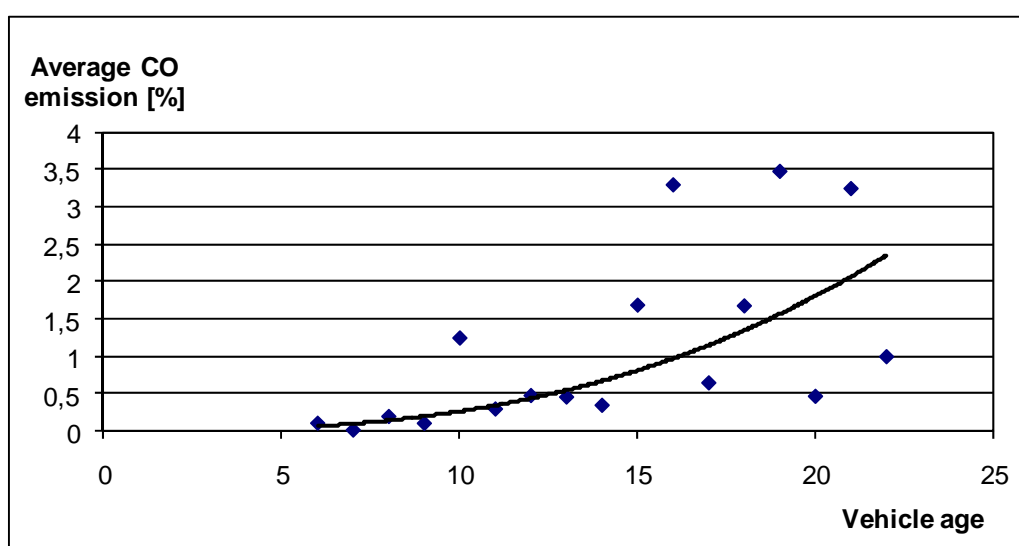


Fig. 2. Average CO emission for a particular vehicle age  
Rys. 2. Poziom emisji CO w zależności od wieku pojazdów

As the vehicles become older, CO emission increases. According to Polish legislation, since 1995 CO emission from vehicles should not exceed 0,5 %. The graph shows that for vehicles older than 12, 13 years the CO emission is higher than 0,5 %. Figure 3 shows average emission of HC (hydrocarbons).

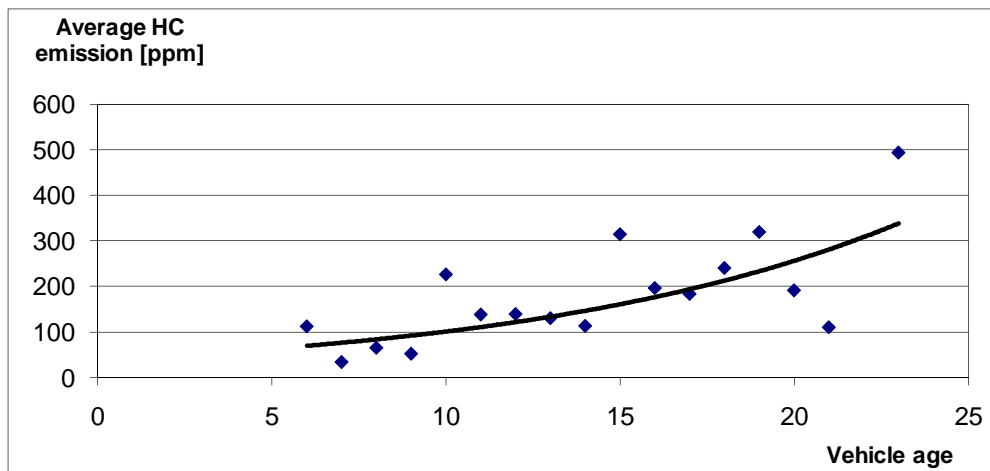


Fig. 3. Average HC emission for a particular vehicle age  
Rys. 3. Poziom emisji HC w zależności od wieku pojazdów

Similar to CO emission, also HC emission is growing when vehicles become older. According to Polish legislation, since 1995 HC emission from vehicles should not exceed 100 ppm. For vehicles older than 10 years the emission is higher than 100 ppm.

The number of vehicles which did not meet the emission requirements of Polish legislation has been estimated. The percentage of vehicles which did not meet these requirements has been shown in Fig. 4 and 5.

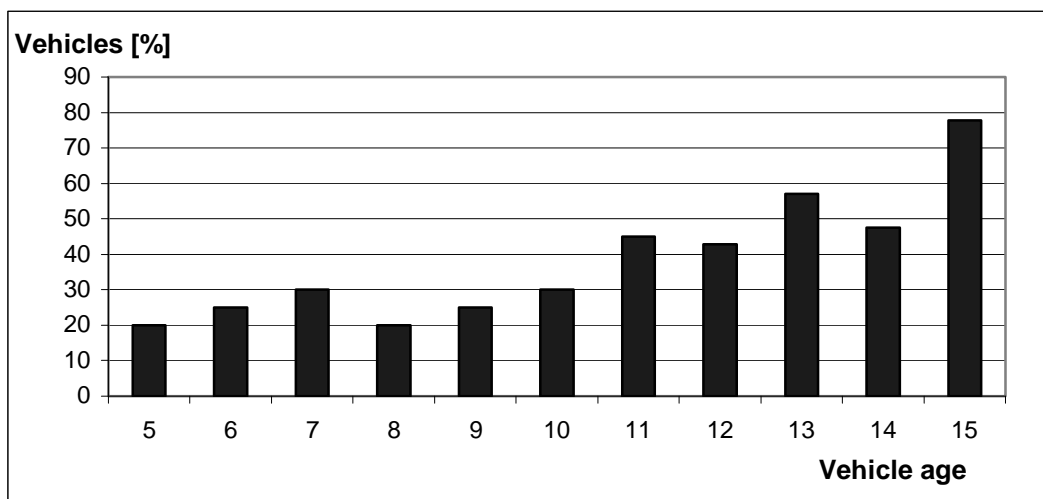


Fig. 4. The percentage of vehicles which did not meet the requirements  
Rys. 4. Procent pojazdów, które przekraczają dopuszczalny poziom emisji

The amount of vehicles which did not meet the requirements is higher as the vehicles became older. Figure 4 shows that it is important to determine the technical conditions of vehicles. As much as

20% of vehicles produced in 2005 have not met the requirements and for vehicles produced in 1994 80% have not met the requirements.

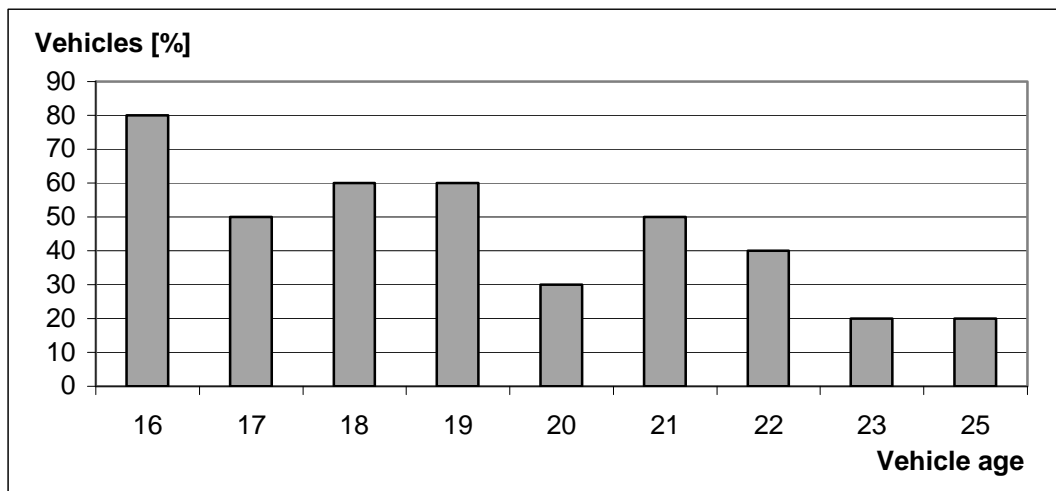


Fig. 5. The percentage of vehicles which did not meet the requirements

Rys. 5. Procent pojazdów, które przekraczają dopuszczalny poziom emisji

For vehicles older than 16 years the amount of vehicles which did not meet the requirements, is smaller as the vehicles became older. The first reason of such results is that for older vehicles the requirements are not as strict as for younger vehicles. Secondly, the owners of the older vehicles are often the vehicle hobbyists or car collectors and they take care of technical conditions of their vehicles.

### 3.2. The influence of the mileage of vehicles

The relationship between average CO (carbon monoxide) emission and vehicle mileage has been elaborated. The results for CO emission have been shown in Fig. 6.

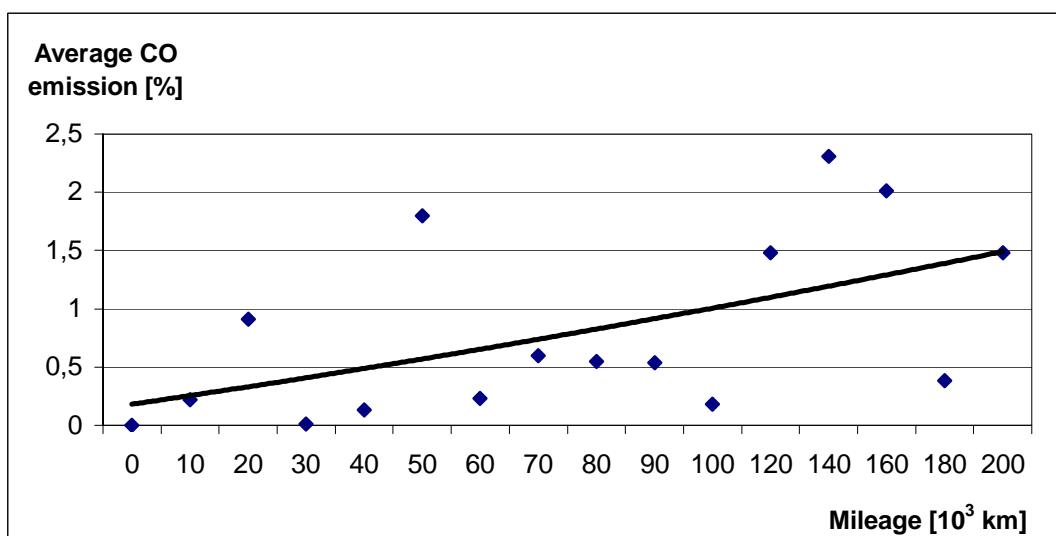


Fig. 6. Average CO emission depending on the vehicle mileage

Rys. 6. Poziom emisji CO w zależności od przebiegu pojazdów

As mileage gets higher, CO emission grows. For mileage higher than 40 000 km, CO emission has exceeded 0,5%. Figure 7 shows average emission of HC (hydrocarbons) depending on the mileage.

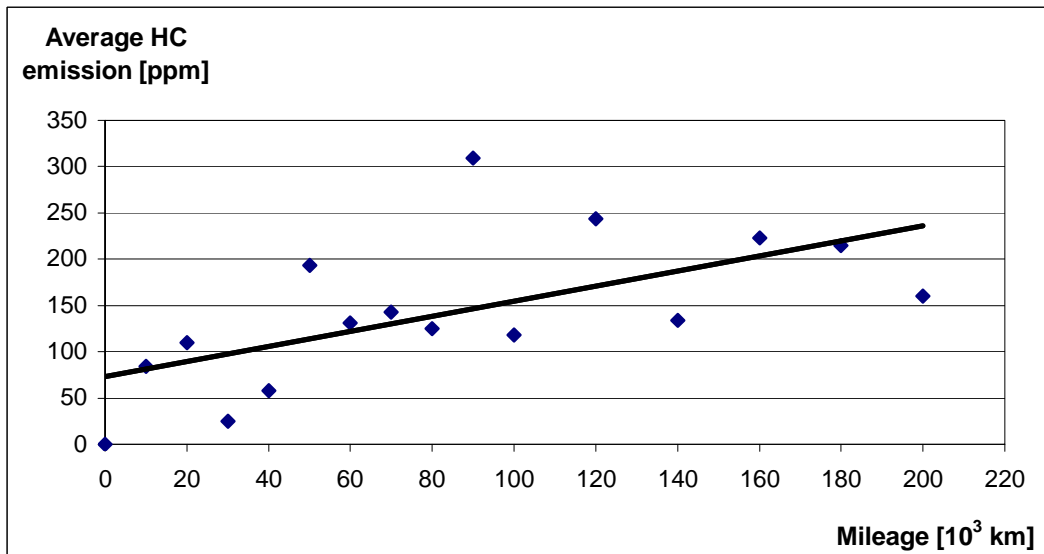


Fig. 7. Average HC emission depending on the vehicle mileage  
Rys. 7. Poziom emisji HC w zależności od przebiegu pojazdów

Also HC emission grows when the mileage of vehicles is higher. Similar to CO emission, HC emission has exceeded the permissible level for mileage higher than 40 000 km.

### 3.3. The influence of technical conditions

For the test group of vehicles the simulation was made. During simulation the exhaust emission was calculated for three cases. The emission has been calculated using methodology from COPERT [1]. The results of simulation for CO for passenger cars with spark ignition engine were presented in previous papers [11 - 13].

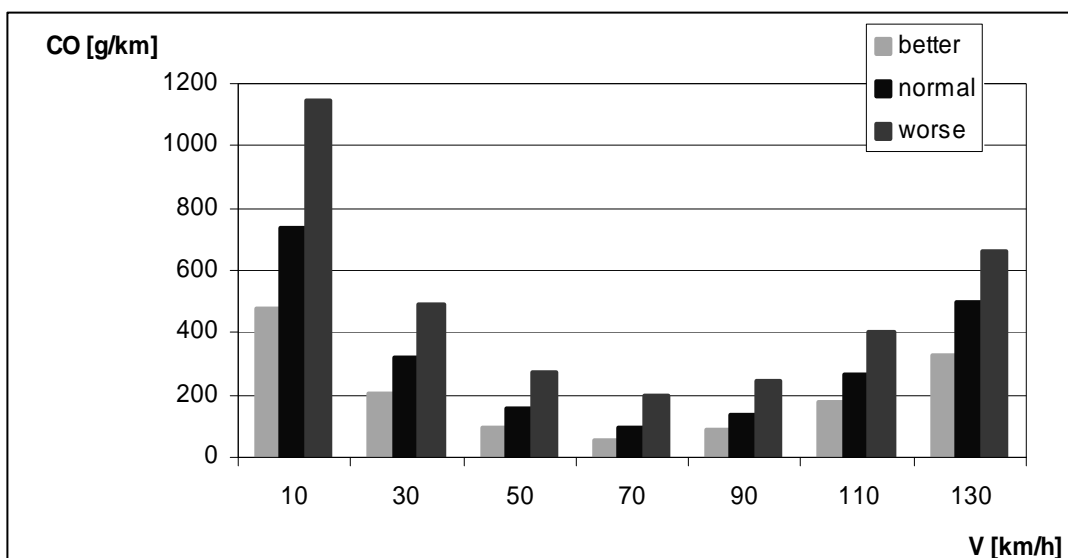


Fig. 8. The results of calculation of the CO emission depending on the technical conditions of vehicles  
Rys. 8. Wyniki obliczeń emisji CO w zależności od stanu technicznego pojazdów

The simulation was made for three cases. In one case the calculations have been made assuming that all vehicles of the test group meet the requirements of European emission standards.

Secondly, the calculations have been made for real technical conditions of cars. These vehicles which met the requirements of Polish legislation were categorized into the appropriate group of cars with European emission standards. These vehicles which did not meet the requirements were categorized into group of cars which met these requirements. These vehicles have been categorized into a group of European emission standards with higher level of emission. The estimated emission in this case is much higher than the emission in the first case.

In some instances, the vehicles met the appropriate emission standards, but also have met the better (newer) emission standards. In these cases, the vehicles were categorized into a better standard group. The rest of vehicles were categorized into an appropriate group, connected with the date of production and European emission standards.

This simulation has shown that the results of the estimated level of exhaust emission depend on the classification of vehicles in each class of emission legislation. The simulation has shown that the level of emission depend on the technical conditions of vehicles.

#### 4. CONCLUSIONS

This article presents the results of investigations of the exhaust emission from vehicles. The results of measurements of exhaust emission for 300 different vehicles have been presented. The measurements have been made in accordance with ECE Regulations and methodology of periodical car inspection. The results have shown that the emission of CO (carbon monoxide) and HC (hydrocarbons) depends on the vehicle age and on the mileage of vehicles. These investigations have also shown that with the increase of age and mileage the exhaust emission became worse and it was connected with technical conditions.

Next, the simulation of exhaust emission was made. This simulation has shown that the technical conditions of the vehicles have the important influence on the estimated emission level.

Therefore, the vehicle age, the mileage and, first of all, technical conditions should be taken into consideration while estimating exhaust emission in traffic.

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