

## Particulate Matter Emissions by Tyres

At the 158<sup>th</sup> session of the UNECE World Forum for Harmonization of Vehicle Regulations (WP.29) in November 2012 it was announced that the World Health Organization had suggested to ban the use of diesel vehicles due to their high particulate matter emissions, regardless despite constantly becoming tougher pollutant emission limits in the UN Regulations Nos. 49 and 83 (Tables 1 and 2).

Table 1

Particulate matter emission limits for vehicles over 3.5 tons  
according to the UN Regulation No. 49

| Level  | Enforcement year | Limit (g/kWh) |
|--------|------------------|---------------|
| Euro-3 | 2000             | 0.1           |
| Euro-4 | 2005             | 0.02          |
| Euro-5 | 2008             | 0.02          |
| Euro-6 | 2013             | 0.01          |

Table 2

Particulate matter emission limits for cars according to the UN Regulation No. 83

| Level  | Enforcement year | Limit (g/km) |
|--------|------------------|--------------|
| Euro-5 | 2009             | 0.005        |
| Euro-6 | 2014             | 0.005        |

Nevertheless, automobile tyres as a source of deterioration products till now remain out of sight of the experts engaged in technical rationing. For a long time was considered, that tyre protector deterioration product particle sizes are large enough and do not pose a health hazard. However, research of the American doctors [1], who noticed a higher sensibility to allergic and oncology diseases of inhabitants of the houses located near to motorways in cities, had allowed to assume, that at natural wear of automobile tyres significant amount of aerosol is emitted to the atmosphere. After thorough research of the air at highway with moderate traffic, the researchers found between 3,800 and 6,900 tyre particles per cubic meter of air while more the 58% of them are under 10 microns in size and therefore are able to penetrate into human lungs causing bronchial asthma, allergic reactions, as a result of skin and mucosa contact – rhinitis, conjunctivitis and urticaria. Such tyre particles almost cannot be excreted from the body.

According to the research carried out in Moscow [2] the core pollutant of the city air (up to 60% of hazardous matter) is the rubber of automobile tyre used up in a small dust.

The performed analysis of various tyres in operation, had allowed to define weights of a worn out parts of tyres of different sizes, which are resulted in the Tables 3, 4 and 5.

Table 3

## Passenger car tyres

| Tyre      | Mass of a worn out part of a protector (kg) | Average tyre mileage( thousand km) |
|-----------|---|------------------------------------|
| 175/70R13 | 1.43  | 45                                 |
| 185/70R14 | 1.65  | 50                                 |
| 185/60R14 | 1.65  | 50                                 |
| 205/70R14 | 1.92  | 50                                 |
| 205/70R14 | 1.56  | 50                                 |
| 195/65R15 | 1.86  | 50                                 |
| 205/60R15 | 1.87  | 50                                 |
| 205/65R15 | 1.72  | 50                                 |
| 215/65R16 | 1.78  | 60                                 |

Table 4

## Light commercial vehicle tyres (up to 3.5 tons)

| Tyre       | Mass of a worn out part of a protector (kg) | Average tyre mileage( thousand km) |
|------------|---|------------------------------------|
| 215/85R15C | 4.01  | 65                                 |
| 195R16C    | 3.21  | 75                                 |
| 215/80R16C | 3.74  | 65                                 |
| 225/60R16  | 3.53  | 75                                 |

Table 5

## Commercial vehicle tyres

| Tyre        | Mass of a worn out part of a protector (kg) | Average tyre mileage( thousand km) |
|-------------|---|------------------------------------|
| 9.00R20     | 12.69                                       | 80                                 |
| 10,00R20    | 13.86                                       | 85                                 |
| 10.00R20    | 14.28                                       | 80                                 |
| 11.00R20    | 15.72                                       | 80                                 |
| 12.00R20    | 17.70                                       | 80                                 |
| 315/70R22,5 | 15.94                                       | 80                                 |
| 10R22,5     | 14.61                                       | 80                                 |

So, at vehicle operation during tyre service life, small disperse tyre dust and fine aerosol as a result of deterioration is thrown out into environment on the average of (Tables 3, 4 and 5):

- 1.4 – 1.9 kg from passenger car tyres;
- 3.2 – 4.0 kg from light commercial vehicle tyres;
- 12.7 – 17.7 kg from commercial vehicle tyres.

These results allowed determining average intensity of wear of a protector of investigated tyres. The results are presented in the Table 6.

Table 6

## Intensity of wear of a tyre protector

| Tyre designation | Intensity of wear (g/km) |
|------------------|--------------------------|
| Passenger car    | 0.033                    |
| Light commercial | 0.051                    |
| Commercial       | 0.178                    |

As shown in the above analysis, tyre dust emissions due to tyre protector wear (in g/km) significantly (by 6-7 times) exceeds emissions of particulate matters with exhaust gases of passenger car engines.

Emissions of firm particles as a result of wear of tyres protector on vehicles of up to 3.5 tons GVW reach 0.,051 g/km, which already almost 5 times exceeds the provisions of the UN Regulation No. 83 on emissions of particle matters for the engines installed on those vehicles.

Comparison for commercial vehicles cannot be made due to difference in test methods and estimation of emission value in g/kWh for compression ignition engines. However, it can be expected that tyre deterioration particle emissions should exceed engine particle matter emissions by 6-10 times.

The rubber and tyre industry enterprises are listed as carcinogenic hazard by the International Agency on Cancer Research and in the Russian Federation by the Federal Center of State Sanitary Epidemic Monitoring Agency. It has been determined that tyre wear dust contains more than 140 different chemicals with different toxicity but the biggest threat to human health is poly-aromatic hydrocarbons and volatile carcinogens N-nitrosamines.

The source of carcinogens N-nitrosamines and poly-aromatic hydrocarbons in rubber is highly aromatic petroleum oils, used as plasticizers in rubber manufacturing. The research, accomplished in Russia by Carcinogenesis Institute in conjunction with the Tyre Industry Research Institute, had shown that the value of carcinogenic N-nitrosomorpholine reaches 2128 µg/kg. Due to their volatility, carcinogens such as N-nitrosamines, which cause cancer, are able to segregate from tyre rubber into the atmosphere as dust and fine aerosol during tyre use.

The research of chemical content of tyre dust and fine aerosol from different tyres (manufactured by domestic and foreign manufacturers), performed in the Russian Federation in 1999-2000 [2], allowed to determine that each kilogram of tyre dust and fine aerosol may contain different value of volatile N-nitrosamines, which may reach up to 70µg.

Thus, during vehicle operation with wear of tyres considerable values of not only tyre dust, but also the carcinogenic substances causing various oncology diseases are allocated in environment.

Recently there had been an increase in focus on ecological hazards, posed by the use of pneumatic tyre in the European Union. The Directive 76/769/EEC bans the use of Distillate Aromatic Extracts (DAE), known to be carcinogenic, as plasticizing agents in tyre production.

In modern manufacturing, DAE is replaced by TDAE (Treated Distillate Aromatic Extract), however, they are 30% more expensive than traditional DAE, which constrains their wider application.

In March 2012, ETRMA (European Tyre and Rubber Manufacturers' Association) announced the results of its research for presence of polycyclic aromatic hydrocarbons in rubber compound. It had been investigated that 8 of the polycyclic aromatic hydrocarbons are known to be carcinogenic and are banned in the EU in accordance with REACH Regulation of 1 January 2010.

ETRMA had investigated samples of 110 tyres manufactured under 45 trademarks, which are presented on the biggest tyre markets. The tests were carried out in 16 countries. 12 tyres manufactured under 9 different brands had shown incompliance of value of polycyclic aromatic hydrocarbons with REACH Regulation.

Despite of tightening the requirements for vehicle tyres in terms of noise emission, wet grip and rolling resistance stipulated by the UN Regulation No. 117, the problem of reduction of tyre dust and its carcinogenic substance emissions due to tyre wear remains unaddressed.

### **Conclusions:**

1. The intensity of automobile tyre protector deterioration during its service life exceeds the limits of emission of particulate matters with the engine exhaust gases by 5-10 times.
2. New technical requirements and related test procedures, which would limit the emissions of tyre dust and its carcinogenic substances into the environment, have to be developed.

### **References:**

1. Montague, Peter. Tire Dust // Rachel's Environment & Health Weekly. 1995. № 439 (April 27).
2. Национальная безопасность и геополитика России //, №10-11 (51-52), 2003 г., А.И. Хесин, М.Е. Скудатин, В.Н. Ушмодин: «Канцерогенная опасность автомобильных шин».