Current issues of ensuring human safety in process of vehicles operation

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Abstract. Based on the new cases of lung cancer registered by the World Health Organization, which number is annually increasing worldwide, development of activities and acceptance of additional emergency measures on reduction of emissions of particulate matters from wear of tyres and roadway in cities and megalopolises are necessary. The pilot studies results are given revealing the increased level of emissions of particulate matters (PM) less than 10 microns from wear of tyres and asphalt roadway, but not from exhaust gases of the vehicles with diesel engines.

The paper deals with a problem of air pollution from vehicles operation in cities and megalopolises leading to smog formation both in Europe and in the Russian Federation. Creation and development of vehicles in order to support human life and activities is followed not only by improvement of living and transport conditions for the population but also by negative effects connected with highly significant contamination of the air environment in cities to the levels dangerous for the health of the population.

The topic and material of the document are focused on justification of the need to regulate the emissions of hazardous substances and particulate matters from the wear of tyres and roadway, which at present significantly pollute urban atmosphere during the vehicle operation.

Current development of requirements for vehicle design is regulated in the international legislation by UNECE Regulation 148, which, in general, improves all design elements and functional characteristics step by step within the last 50 years increasing overall integrated safety of the vehicles.

The global indicators in improving vehicle design within the current period are quite impressive because of modern digital technologies penetrating into the transport industry more and more deeply. Transport automation becomes the main trend of advanced technology developments creating the competitive advantages of modern automotive products. Improvement of vehicle design has already reached such amazing heights that the vehicles become driverless and no ancient vehicles spreading clouds of smoke are seen on the roads anymore!

However, at present, it is impossible to definitely say that these new technologies fully ensure human safety.

The efficiency of implementing the requirements of the UN Regulations in force is not yet sufficient. According to the WHO data, today, up to 1.5 million people all over the world die annually in road accidents, and up to 1.5 million people of urban population also die annually due to air pollution in cities [1].

As an example, the results of efficient implementation of the UN Regulations in case of the Russian Federation in terms of design safety (passive and active safety) with regards to both road and
environmental safety are shown in figures 1 and 2.

Figure 1. Dynamics of road accidents indicators in Russia for the period of 1985 to 2018.

Figure 2. Fleet growth and dynamics of HS emissions by the RF vehicle fleet.

It should be noted that it is the present time period when additional environmental issues were
revealed. Back in 2012, the World Health Organization (WHO) proposed to prohibit the usage of diesel-engined vehicles due to the high emission of particulate matters (PM) in their exhaust gases within European cities.

Therefore, today European countries look for effective ways to reduce smog formation in large cities in order to decrease the ambient air pollution there.

According to experts, the program of conversion to vehicle electrification forecasts a share of electric vehicles in the total global output of at least 17% by 2020, of which 75% will be hybrid vehicles, and the total number in the global vehicle fleet will reach 20 mln or only 1.7%[2].

It shall be specifically noted that against the backdrop of intense search (or sometimes its imitation) for the transport ecological problem solution by means of electric vehicles (EV) and alternative fuels, attention to the enormous growth of PM emissions from roadway and tyre wear has been weakened. In our opinion, use of electric vehicles in cities – insignificant at the moment – will not ensure an essential decrease in PM emissions since these vehicles will be driven with the same tyres and on the same asphalt-concrete roadway. This is confirmed by the data of the PM emission surveys carried out in the Russian Federation. Dynamics of the PM emissions from other vehicles systems (braking systems, tyres) and from the roadway wear are shown in Fig. 3 as an example for comparative analysis with regards to the standards of UN Regulations No. 49 and 83 for PM emissions with exhaust gases in case of operation in the megalopolis of Moscow.

![Graph showing PM emissions from various sources](image_url)
Figure 3. Dynamics and forecast of annual PM emissions from wear of tyres, braking mechanisms and roadway in Moscow, in tons, compared to the emissions of and emissions standards for PM with exhaust gases.

The series of activities with research and development aimed at improvement of design of vehicles' internal combustion engines carried out by manufacturers and legislators all over the world in the past 50 years ensured a significant decrease of PM emissions with exhaust gases, however, in this period, due to the increasing vehicle fleet in all major cities of the developing countries, the air is being polluted because of the dramatical increase in particulate matters emissions, first of all from tyres and roadway wear.

One should pay attention to highly representative materials in the report of the UK submitted in November 2018 at the Working Party on Pollution and Energy (WP.29/GRPE, UNECE Inland Transport Committee) which emphasizes the emissions of particulate matters of 2.5 micrometers and less, which by penetrating into lungs and blood can be transported through the body remaining in human organs and therefore reduce life expectancy [3].

Fig. 4 shows the results of surveys of actual values of emissions of PM less than 2.5 micrometers from various road transport systems in the UK which, by the values of PM emissions from the wear of tyres, roadway and even braking systems, are essentially comparable by level and correspond to the results of the Russian research data shown in figures 3.

Figure 4. Dynamics of actual 2.5 micrometer PM emissions from different vehicle sources in the UK.

Highly interesting and important data should be especially noted in the document which was provided earlier at GRPE sessions by European Tyre & Rubber Manufacturers Association (ETRMA), in which the results of the PM chemical analysis are shown for the content of polycyclic aromatic hydrocarbons (PAH) in them that contain cancerogenic substances causing human cancer diseases [4].
Table 1 provides information on polycyclic aromatic hydrocarbons (PAH) content in PM. The values are expressed in parts per million (ppm) in the matters mix, sampled behind a moving vehicle.

| Chemical substance               | Road particles (RP) | Tyre wear particles (TWP) | Tyre (tread) particles (TP) |
|----------------------------------|---------------------|---------------------------|----------------------------|
| Acenaphthene                     | 4.08                | 0.04                      | 0.13                       |
| Phenantrene                      | 53.4                | 1.66                      | 1.21                       |
| Pyrene                           | 54.84               | 4.77                      | 0.06                       |
| Anthracene                       | 7.36                | 0.1                       | 0.11                       |
| Benzantracene                    | 38.65               | 0.18                      | 2.87                       |
| Benzo(a)pyrene                   | 12.51               | 0.28                      | N.D.                       |
| Benzo(k)fluoranthene             | 7.4                 | 0.02                      | 0.92                       |
| Chrysene                         | 17.72               | 0.36                      | 2.95                       |
| Dibenz(a,h)anthracene            | 2.56                | 0.1                       | 0.87                       |
| Fluaranthenne                    | 82.13               | 0.98                      | 1.62                       |
| Indeno-1,2,3(c,d)pyrene          | 5.36                | 0.21                      | N.D.                       |

This list is not an exhaustive one, but it contains the PAHs most widely spread in the environment and considered cancerogenic and able to provoke cancerous diseases of people according to the International Agency for Research on Cancer (IARC) [4].

Due to the differences in evaluation of amounts of PM emissions from the tyre and roadway wear, there has risen a global ecological conflict between the transport and environment in big cities, which by the current time period has become critical both by its level and violent growth.

The comparative results of determination of PM emissions from various vehicle systems in 2015 according to the materials of the Russian Federation (figure 3) and the UK (figure 4) are given in figure 5.
Thus, the most important issue currently is regulation of PM emissions not only with the exhaust gases, but especially from the asphalt roadway and tyre wear, as the PM emissions from the roadway wear are twice higher than the PM emissions with the exhaust gases, and if considering the tyre and brake system wear, almost thrice, and it is these non-exhaust emissions which influence the air pollution in the urban environment most significantly today.

Based on the abovementioned, there is a need to promote discussion of the following issues of concern by the national and international legislators and vehicle manufacturers:

I. In the current situation, where the urban atmosphere is polluted by hazardous PM, it is necessary for our Governments to initiate and sponsor serious research developments related to reduction of the content of hazardous substances in materials used for production of tyres and roadway, while the international community needs to develop the respective regulatory requirements.

II. Tyre manufacturers and road construction services shall revise the existing technology for production of tyres and roadway considering the potential of ongoing research and development in terms of new materials and technologies.

III. Therefore, we consider it necessary to promote and advance the works on the new problem issues of regulation of integrated environmental safety at vehicles operation within the World Forum (WP-29) starting from 2020.

References
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