

Pollution of motor transport highways by particles from tire and road surface wear has a disastrous influence on human health

In addition to the information materials previously submitted by the Russian Federation regarding the urban air pollution by tire and road surface wear (GRPE-65-20; WP-29-160-39; WP-29-161-22 and GRPE-68-10), we present the further research results of the "Vehicle-roadway-environment-human" system.

During motor transport operation, elevated concentrations of solid particles are formed in the air over the roadway as a result of particulate matter emission with exhaust gases of vehicles, emission of tire and road surface wear products, background air pollution and other processes. The content of tire and road surface wear products in the air over the roadway, as it has been specified in the previously submitted materials of the Russian delegation, amounts up to 60% from the total percentage of solid particles (WP-29-160-39).

Due to absence of regulatory requirements to efficiency of air purification from solid particles within passenger compartments of the vehicles, insufficient purification fineness of solid particles by means of cabin filters, their content, especially with dimensions of 1 micron, in the passenger compartments or cabins in actual operating conditions is almost the same as in the outer air (GRPE-68-10). As a result, in dense traffic streams, in traffic jams, tunnels, in open-cast mines etc. their content in the air of vehicle passenger compartments often exceeds the maximum allowable hygienic regulations.

In order to fully estimate the ecological situation in the agreed "vehicle-roadway-environment" system, it is necessary to consider the polluted air effect level onto the population taking into account three components: urban background air pollution; air pollution over the roadway and content of harmful substances in the vehicle passenger compartments.

According to the available data, the content of harmful particles in the air while driving by asphalt highway behind one passenger car is 5-10 mg/m³, behind two cars it is 15-20 mg/m³. When cargo vehicles are moving in convoy with a 35 m interval, the air dust content at the level of the engine air intake for the lead vehicle has been 200 mg/m³, for the 6th one it's been 1000 mg/m³, and 1100 mg/m³ for the 10th one, and that repeatedly exceeds the maximum allowable medical normative standards for the air of population aggregates. It is also established that the maximum air dust content on the highway occurs at the height of 0,5-1,0 m from the roadbed and decreases 3-5 times at the height of 2 m and higher.

The supernormal polluted air in the passenger compartments has almost no smell, color, and the most dangerous dust is thinner than 2-3 micron, not being purified by cabin filters it is not visible to the eye. In view of the foregoing it is possible to ascertain that at seeming and perceived comfortable conditions regarding temperature, humidity, noise in the passenger compartments of

modern vehicles with air conditioning systems, having beautiful interior, various conveniences, electronic and computer support, driver assist intelligent systems, there is an illusion of complete ecological well-being within the passenger compartments. However, the air pollution in the vehicle passenger compartments or cabins is often life-threatening, influencing the driver's fatigability, attention, causing his or her confused consciousness and even drowsiness, and that can be one of the reasons of increasing road and transport accidents.

The main reason for this situation lies in the shortcomings of the existing concept of a "green" transport, in which there is no comprehensive environmental requirements for the design of vehicles for ventilation systems, interior heating, air conditioning and cabin filters.

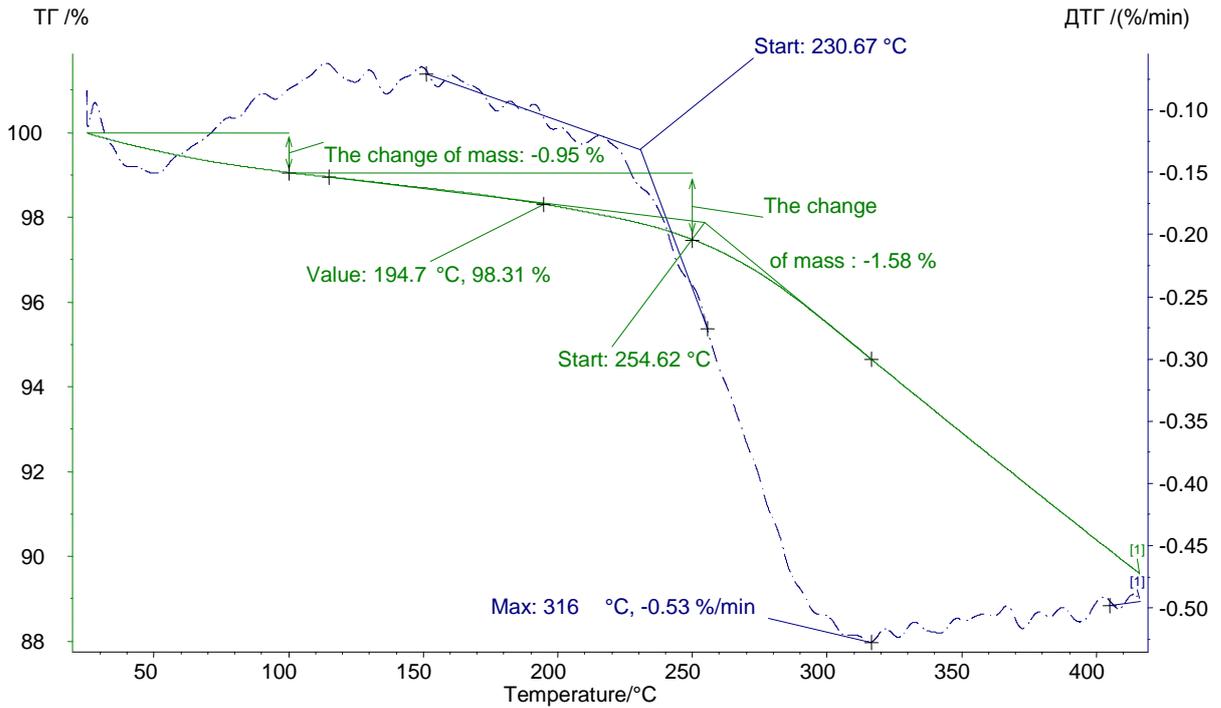
The urban air environment pollution occurs not only at the expense of emission of the solid particles formed as a result of mechanical deterioration of tires, but also due to emission of gaseous harmful substances by tires. The tires' pollutant emission is intensified along with their heating, which is inevitable at interaction of tyres with the road carpet especially within the slipping and skidding modes.

Additionally, an estimation of toxic properties of tire materials and road carpet has been conducted.

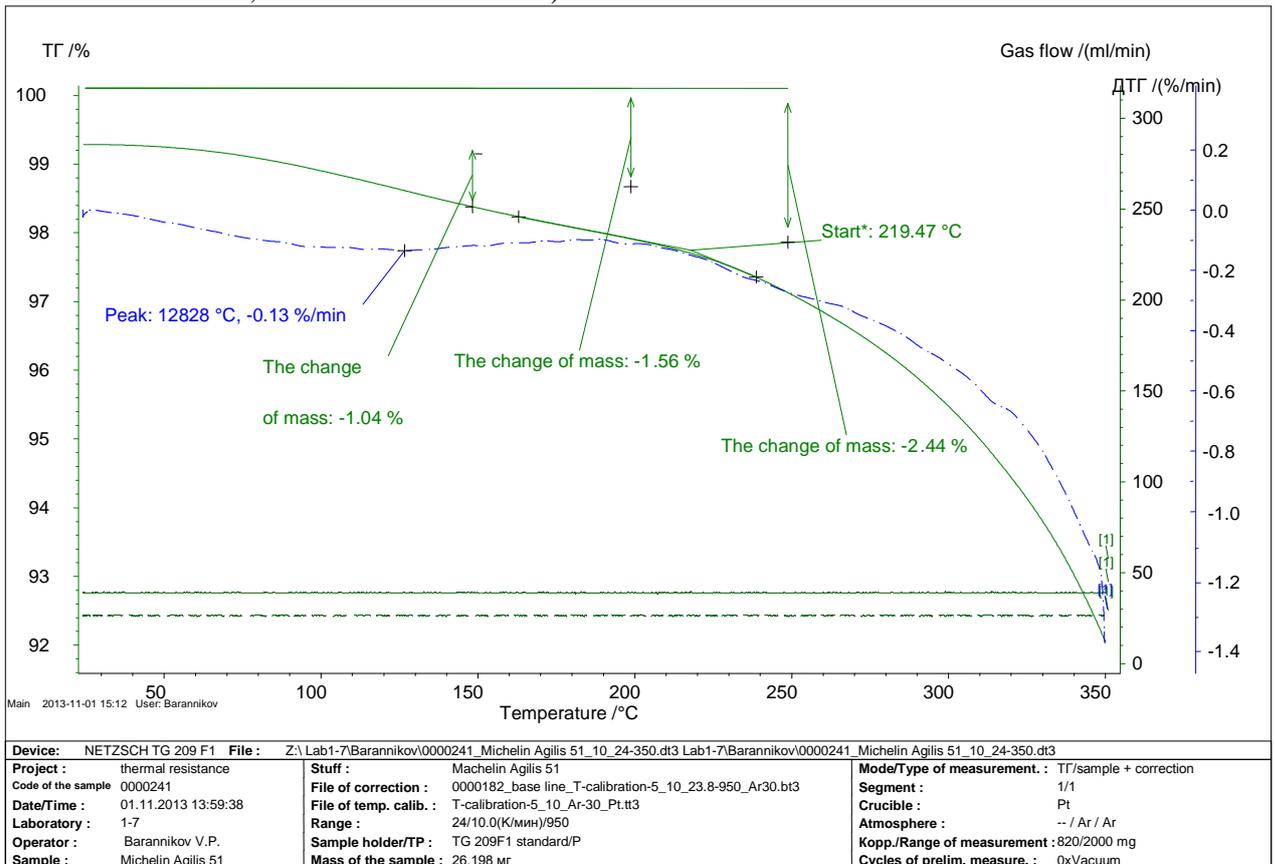
Picture 1 shows the results of a thermogravimetric analysis of a mixture of samples of the asphalt road carpet and the worn out tire Nokia Rollster TS crushed to homogeneous powder. The researches were conducted by a technique developed by the Institute of Solution Chemistry of the Russian Academy of Sciences. The thermogravimetric curve (continuous line) characterizes the test specimen mass loss as a result of thermal destruction at its continuous heating from 20 to 400°C.

As it seen from Drawing 1, the sample mass loss has amounted to 0,95% at heating up to 100°C, and 1,58 % within the temperature range from 100 to 250°C. The sample examination within this particular range is of the maximum interest, as the vehicle wheel and asphalt contact zone temperature created by frictional force does not exceed 300°C even in case of the vehicle emergency braking. The sample mass loss in this case is explained both by tire material pyrolysis, and thermal breakdown of the asphalt petroleum pitch.

Similar researches conducted with three samples of new (not used) tires of different dimension (Michelin Agilis 51, Bridgestone M729 and Michelin XTA2) have shown even more essential loss in weight of the samples up to 2,4%, and that is indicative of more intensive emission of gaseous harmful substances. As an example, Picture 2 shows the results of the thermogravimetric analysis of the sample of Michelin Agilis 51 tire (dimension 175/65 R14), and Table 1 depicts the summary of the researches for all the three new tires.



Picture 1– Fragment of the weight loss curve and its derivative for the mixture powders of asphalt pavement and used tires Nokia Rollster TS (the dimension 185/70 R14, manufacture - Finland)



Picture 2 – Fragment of the weight loss curve and its derivative for the new tires Michelin Agilis 51 (the dimension 175/65 R14, manufacture - United Kingdom)

Table 1 – Results of thermogravimetric analysis of samples of new car tires

Name tire dimension, country of manufacture	Volatile content, %, 20 – 150°C	Start of thermal degradation, °C	Mass loss to 200°C, %	Mass loss to 250°C, %
Michelin Agilis 51, 175/65 R14, United Kingdom	1,0	219,5	1,6	2,4
Bridgestone M729, 11.00 R20, Japan	1,0	226,0	1,4	2,1
Michelin XTA2 Energy, 275/70 R22,5, Spain	0,8	228	1,2	1,95

As seen from table 1, at heating the tire samples up to 150°C the loss of weight by emission of gaseous substances is in the range from 0,8 до 1,0%, and when the temperature rises up to 250°C the loss of weight reaches 2,4%.

The resulting data of thermogravimetric analysis indicates that as a result of sharp increase in the tire temperature (sliding or slipping on the asphalt) holds intense of releasing the harmful gaseous substances in very substantial quantities. For a complete picture of air pollution by the tire and road surface the chemical composition of these substances was analyzed.

Analysis of the chemical composition of the products of thermal degradation of the tire and the road surface was carried out according to the method of RF - MU 2.1.2.1829 sealed in a climatic chamber at the following four temperature conditions - 20 ° C, 40 ° C, 60 ° C and 80 ° C at a humidity of 40%.

Results of chemical analysis of the products of thermal degradation of the sample of asphalt pavement showed that at temperatures above 40 ° C as a result of desorption the asphalt pavement emits unsaturated hydrocarbons and hydrogen chloride in quantities exceeding the maximum allowable maximum one-time standards for air in populated areas (PDKm. p .) , with in a further increase in temperature to 800 C data released into the atmosphere of harmful substances , especially formaldehyde , dramatically increases and reaches 1.2 mg/m3 against PDKm.r. - 0.035 mg/m3.

Chemical analysis of the products of thermal degradation of tires was carried out for the same three samples of imported new tires different dimension was the same as thermogravimetric analysis. According to the research for tires Michelin XTA2 Energy dimension 275/70 R22, 5 limit values set standards for air in populated areas on xylene, styrene and m-cresol at 40 ° C. At a temperature of 80 ° C for the same substance and additionally toluene, ammonia, phenol and ethylbenzene From this we can conclude that the car tires under real operating conditions in the summer can be environmentally hazardous.

Evaluation of the toxic properties of wear of tires and the road surface was produced as the results of tests on the survival of laboratory animals (white mice) on the evaluation of the potential biohazard products of thermal degradation of polymer materials. This methodology is based on the experimental determination of the toxicity index material by burning it in a specialized chamber for a given heat flux density and the impact of the combustion gases in laboratory animals. Indicator of toxicity is the number of

deaths during the exposure time (30 min.) Or in the next 14 days (post-exposure period).

Samples were subjected to tests of asphalt pavement, worn tires Nokia Rollster TS (the dimension 185/70 R14) and new tires Michelin Agilis 51 (175/65 R14) and Michelin XTA2 Energy (275/70 R22, 5). Tests were conducted with an exposure for 30 minutes at a temperature in the combustion chamber 520 - 530 ° C. For the experiment with each sample was selected a group of eight white mice.

The results of tests of tire samples and samples of roadbed by survival rate of laboratory animals are given in table 2.

Table 2.

Sample	Temperature in chamber, °C	Time of exposure	The number of dead animals
New type of tire Michelin Agilis 51, 175/65 R14, United Kingdom	520 – 530	30 min	1
New tire Michelin XTA2 Energy, 275/70 R22,5, Spain	520 – 530	30 min	2
Worn tire Nokia Rollster TS, 185/70 R14, Finland	520 – 530	30 min	2
Pavement (asphalt)	520 – 530	30 min	2

Based on these data it can be stated that the investigated samples of tires, both new and used, as well as a sample of the pavement are potentially biohazardous by survival rate of laboratory animals.

The conclusions

1. The studies have confirmed the fact that, in the formation of environmental safety requirements for vehicles and stricter standards for harmful substances in the exhaust gas of engines have been underestimated the impact of tires on the pavement and ambient air pollution. It is experimentally proved that, during the vehicle operation of vehicle are distinguished in the atmosphere not only abraded tire as solids, but also, together with them, a significant amount of gaseous pollutants, to which number can be attributed formaldehyde, ammonia, phenol, xylene, benzene, methyl methacrylate comprising the material of road surface and tires.

2. Solution to reduce the harmful effects of environmental pollution on the drivers and passengers at this stage is no less relevant and meaningful than the targeted reduction of Euro - 5 and Euro -6 emission explosives in the exhaust gas provided by international UN Rules. An integrated approach is needed for the assessment of the environmental situation in the "Vehicle - Road - environment - people" and the creation of a regulatory framework for "environmental security" cars in the above system. To eliminate this negative process, in the Russian Federation is being developed a GOST R 51206-2015 "Motor vehicles. Cabin filters. Cabin air purifiers. Limits and test methods"