ISSUES CONCERNING AIR QUALITY INSIDE THE VEHICLE

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It is well known, that automobiles create a dangerous environment for human beings.

One of the solutions to eliminate the ecological effect created by vehicles is to estimate the safety of the interior and exterior materials used by modern manufactures.
The goal of this presentation is to focus on a different approach considering the quality of air inside the vehicle.

The concentration of dangerous substances inside various types of vehicles exceeds the safety levels, resulting in drivers and passengers inhaling polluted air.

Numerous studies have shown that interior cabin air contains a significant concentrations of CO, NO, NO_2, SO_2, different classes of hydrocarbons including volatile organic compounds (VOC), formaldehyde, aldehydes, carcinogenic polycyclic aromatic hydrocarbons (PAH) and other toxicants.

The contamination of cabin interior air is a result of exhaust gases penetrating through the air-conditioning and ventilation systems of the vehicle, cracks of hardening elements, and the emissions of pollutants from vehicle interior parts and materials.

Toxic effects of vehicles exhaust gases to humans are shown in Table 1.

Table 1 Examples of pollutants harmful effects on human metabolism

Pollutant	Limits MAC, mg/m^3	Pollutants concentra-tions inside the vehicle mg/m^3	Period of expo-sition min, h	Symptoms	Toxic description
~~H~~ ∫	5,0	6	25 min	**Reduction of light and color sensitivity of eyes**	**Blood poison, replace oxygen from hemoglobin of red blood cell**
		30	3 h	**Decreased night vision**	
NO	0,4	Any con-centration	Constant	**Blood poison. Cause intoxication, lack of oxygen in tissues.**	**Binds to hemoglobin, replace oxygen from red blood cells**
NO_2	0,2	0,056	Constant	**Increased respiratory load**	**Sensory and functional damage of respiratory tract**
		0,23	10 min	**Olfactory sensitivity thre-shold**	
~~H~~ l 2∫	0,05	Vapor in the air 0,07	Several hours	**Carcinogenic properties Causes dermatitis and eczema negative impact on the respiratory tract, eyes, skin.**	**Mutagenic and carcinogenic properties Negative impact on the genetic material, reproductive or or-gans, central nervous system**
~~H~~ mHn	50,0	300	Several hours	**Narcotic influence, central nervous system in-stability**	**Strong narcotics of indifferent influence, smog forming agents**

Inhalation of CO and NO bind to blood hemoglobin, where the Fe + + ion passes into Fe + + +. Ion Fe + + + can reversibly bind O_2 and exit from the blood transfer.

NO, produced during the burning of diesel fuels oxidizes to NO_2 ï which become an exceptionally dangerous mix. Nitrogen dioxide irritates the mucous membranes of the

respiratory tract. Functional effect due to the action of NO_2 is increased airway resistance - increasing the effort spent on the breath. This reaction was observed in healthy individuals at concentrations of 0.056 mg/m3, and people with chronic lung disease - at concentrations of 0, 038mg/m3 , which is 5 times below limit values.

Pathological effect NO_2 appears that it makes a person more susceptible to pathogens causing respiratory illness. Furthermore NO_2 by itself can be the cause of various illnesses. Once in the body, NO_2 contacts with moisture and forms nitrous and nitric acid, which corrodes the walls of the alveoli. This results in increased permeation causing the blood serum to pass into the lung cavity. This fluid dissolves the inhaled air, forming foam that prevents further gas exchange, resulting in pulmonary edema, which leads to death.

The presence of the above pollutants in the air of passenger compartment (cab) of vehicle deteriorates adaptive responses of the human body. Even at the level of hygienic standards the content of pollutants in the air of vehicles causes adverse reactions such as: tiredness, drowsiness, discomfort, irritation of eyes, nose and throat, headache, worsening neuro-behavioral responses. All of the above has a negative impact on road safety.
It is important to note that the problem of polluted air in vehicles equipped with "air", "climate control" is not solved.
Cabin air filters installed in ventilation and air conditioning systems do not purify cabin air from the CO, NO, NO_2 . The effectiveness of air purification from the various classes of hydrocarbons is not more than (15 ï 40) %. Since even high concentrations of the CO, NO, C_mH_n (methane - heptanes) and others have no smell. The operation of the vehicleĝs air conditioning and climate control provided only the specified conditions of temperature and humidity, creating the illusion of prosperity, and safety. In fact, the above concentrations of pollutants can be much higher than the levels required by the hygienic standards and can negatively affect on the health of passengers.

It is evident, that the programs to create a ñgreen vehicleòwith zero content of exhaust emission, including the electric vehicles are far from completion. The problems of safety for the drivers and passengers of these cars were not solved. Different types of pollutants may accumulate in the cabin air of so-called ñgreen carò from the interior materials and from the atmosphere.
The concentrations of pollutants measured in interior air of the vehicles during their operation on public roads are shown in Table 2.

Table 2 The average concentrations of pollutants in the interior air of the vehicles during their operation

Pollutant	Author, (KATRI, R.Korea), mg/m^3	Own research, mg/m^3	Limits (MAC),mg/m^3	Comment
Carbon monoxide	1-30 (min. ï max.)	1-22 (min. ï max.)	5,0	Limit of RF
Nitrogen oxide	0,01-2.5	0.05- 4.8	0,4	Limit of RF
Nitrogen dioxide	0,003-0,9	0,003-1,5	0,2	Limit of WHO (World Health Organization)
Formaldehyde	0,0208 *	0,01 ï 0,09	0,05 0,25	Limit of RF Limit of R. Korea
Benzene	0,007 *	0,001*	0,03	Limit of R. Korea
Toluene	0,328*	0,206 *	1,0	Limit of R. Korea
Xylene	0,199 *	0,080 *	0,87	Limit of R. Korea
Styrene	0,033 *	0,005 *	1,6	Limit of R. Korea
Ethyl benzene	0,066 *	0,028 *	0,3	Limit of R. Korea

Note * - average data values

As you can see, the concentrations of CO, NO, NO_2 CH_2O from the interior air exceed their limits - the maximum allowed concentrations (MAC) and they are more dangerous for humans, than volatile organic compounds (VOC) which concentrations are within limits.
Another important factor is that highest concentrations of VOC are observed in the first months of vehicle operation and decrease significantly during the first 6 months or a year of operation.

In other words, it is necessary to consider the task of creating the international standard for evaluating the content of pollutants penetrating from the exhaust and power systems of the vehicle and background air pollution during vehicle operation.

At the present time the standard ñMotor vehicles. Content the pollutants in the air of passenger compartment and cabin. Limits, testing methods and determinationò applicable in Russian Federation and Customs Unions.

The standard is included in the list of rules, evaluating the design of the vehicle to meet the requirements of the Technical Regulations of safety of wheeled vehicles and also used for their certification.
The test procedure consists of two types modes:
I - Steady-state regime at the speed of 50±5km/h
II - Idling with minimal rpm (declared by manufacture)

Nomenclature of pollutants to be measured depending on the engine type and their maximum allowable concentrations (limits) are given in Table 3.

Table 3 Nomenclature and limits of pollutants depending on the engine type

Pollutant	Limits of Russia, MAC mg/m^3	The type of engines*
Formaldehyde	0,05	3,4,5
Nitrogen dioxide	0,2	1,2,3,4,5
Nitrogen oxide	0,4	1,2,3,4,5
Carbon monoxide	5,0	1,2,3,4,5
Aliphatic hydrocarbons (C_6H_{12} ï $C_{16}H_{34}$)	50	1,2,3
Methane	50	3,5

Comment. * The types of engines:
1 ï Positive ignition engines
2 ï Positive ignition engines working on liquefied petroleum gas
3 ï Positive ignition engine working on natural gas
4 ï Diesel engines
5 ï Gas diesel engines

During the last 10 years more than 1500 vehicles of M and N categories were tested based on the existing standard. The main reasons of incompatibilities are shown (%) in Figure 1.
Basic reasons of incompatibility- constructive defects:

1- disregulation of the engine during idling regime;
2- not optimal location of the exhaust pipe;
3- not optimal construction of fuel tank and its elements;
4- different defects of vehicles assembly ;
5- disrepair of the exhaust system;
6- penetration of the exhaust gases from ventilation or air conditioning system;
7- insufficient hermetic properties of doors, windows, hatches;
8- disrepair of autonomous heater;

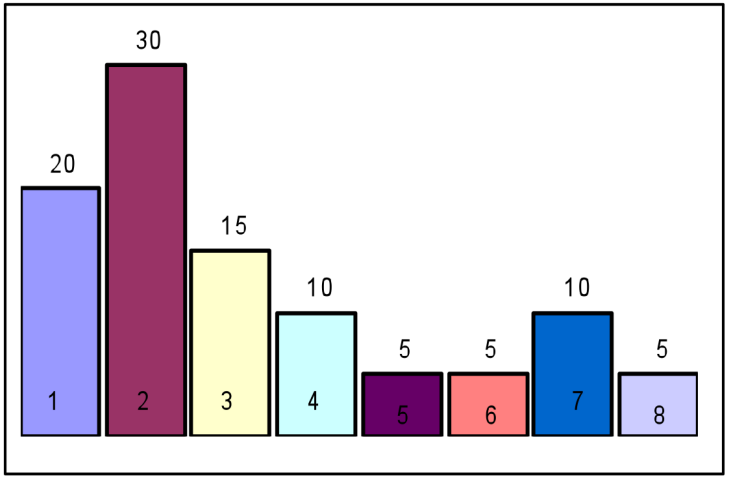

Figure 1. 10 ï year statistics of incompatibilities (in %) for vehicles categories of M and N.

Table 4. Annual statistic data of total vehicles incompatibilities

Year	The sum of tested vehicles	The quantity of incompatibilities		% of incompatibilities
		Categories of vehicles		
		M	N	
2002	142	16	4	11,2
2003	131	15	12	20,6
2005	214	19	10	13,5
2007	301	4	4	2,7
2012	195	4	2	3,1
2013	247	4	3	2,8

One can see that the total % of incompatibilities has been decreased. This is the evidence of efforts, that auto manufactures put in construction of vehicles and ecological requirements based on the limits of pollutants in the cabin interiors.

Conclusion

1 Providing air quality in the interior of the vehicles is one of the most important elements of road traffic safety.

2 Standard ñMotor vehicles. Content of pollutants in the air of passenger compartment and cabin. Norms and test methodsò is in action since 2004 in Russian Federation and since 2011 in Custom Union countries.

3 If the joint working group is interested in establishing this draft standard, Russian specialists are ready to take part in this project.