THE EMISSION FACTOR AND A VEHICLE RUN-IN PERIOD

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Abstract

During operation on road and due to gradual ageing of a vehicle, the formation of gaseous pollutants undergoes certain evolution. At the start of the vehicle life the evolution is influenced mostly by the run-in period of the driving mechanism. Motor vehicle manufacturers state that the vehicle run-in period ends after the vehicle has run from 3,000-15,000 kilometers depending on the engine type and transmission mechanism. During the run-in period the fuel consumption decreases and the production of emissions slightly changes, which consequently influences the emission factor. (The emission factor is understood as the ratio between the pollutant produced and the amount of consumed fuel). A theoretical value of the difference in the fuel consumption between the new and run-in vehicle is about 8% in favor of the run-in vehicle. The European legislation does not specify after how many kilometers the vehicle stops to be considered new. This can lead to disputes when testing emissions from the new vehicle and those from the vehicle having the control software already installed.

The contribution outlines a possibility of determining the coefficient for calculation of emissions and fuel consumption for the first tested vehicle and for the one that has covered from 60 to 300 kilometres. It may contribute to the optimization of the control software installed in the vehicle.

***Keywords:** vehicle run-in period, emission factor, fuel consumption, testing, European legislation*

1. Introduction

R&D centers of motor vehicle manufacturers and companies responsible for emission control in the EU spend a lot of money for research, development and control of combustion engines.

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Motor vehicle manufacturers state that the vehicle run-in period ends after the vehicle has run from 3,000 to 15,000 km depending on the engine type and transmission mechanism. During the run-in period the fuel consumption decreases and the production of emissions slightly changes, which consequently influences the emission factor. (The emission factor is understood as the ratio between the pollutant produced and the amount of consumed fuel). A theoretical value of the difference in the fuel consumption between the new and the run-in vehicle is about 8% in favor of the run-in vehicle.

The European legislation does not specify after how many kilometers the vehicle stops to be considered new. This can lead to disputes when testing emissions from the new vehicle and those from the one having the control software already installed.

Certified workplaces provide emission testing to protect motor-vehicle users. On the basis of emission tests for randomly chosen in-service vehicles the motor-vehicle manufacturer is informed whether the car meets the given emission standards also in service.

The European directive strictly lays down which in-service vehicle can be tested for emissions. The directive lays down the following limitations:

- the motor vehicle cannot be older than 5 years from the day of its first registration,
- the motor vehicle must not have run more than 100,000 kilometres.

For car manufacturers it might be extremely difficult to test all in-service vehicles; therefore, theoretical coefficients of emission deterioration have been introduced. It means that after the vehicle has been first tested according to engine type, it will suffice to multiply the mass of given emission by the deterioration coefficient – Tab. 1 [1].

Directive 70/220/EEC defines the coefficient of emission deterioration at 3,000 kilometers as follows:

$$k = \frac{M_{E3000}}{M_{E0}}, \tag{1}$$

where:

k - coefficient of emission deterioration,
M_{E3000} g.km^{-1} - emission mass after 3,000 km,
M_{E0} g.km^{-1} - emission mass for the first tested vehicle.

Tab. 1. Coefficients of emission deterioration

Engine type	Coefficients for each pollutant				
	CO	HC	NO_x	HC + NO_x	PM
Petrol	1.2	1.2	1.2	-	-
Diesel	1.1	-	1.0	1.0	1.2

2. Methodology

This contribution outlines a possibility of determining the coefficient for calculation of emission production and fuel consumption for the first tested vehicle - *x* km (the limit of zero kilometer was not exceeded) and for the vehicle that has run *5.x* km (which represents approximately the top level of zero kilometer). The determination of the coefficient enables a faster analysis of emission evolution and fuel consumption for the vehicle which has *5.x* km in comparison with the first tested vehicle which has run *x* km. Consequently, it will contribute to the optimization of fitting the control software in the vehicle.

From a theoretical point of view this is actually a solution to the situation and development of numerically expressed “mass” consequences of the phenomenon – emission production.

The basis consists of statistical sets of emission masses or fuel consumptions – results gathered from experiments with the first tested vehicles and with those that have covered *5.x* km.

The forecast is done through the equalization of the set by a curve that is as close as possible to the measured values. Expressing the function of the curve enables to calculate the set indices in others than the measured intervals, i. e. to mathematically forecast the emission evolution. The correlation ratio expressed by means of the correlation coefficient achieving the values -1 ÷ 1. is looked for. The correlation coefficient value defines whether the correlation is weak or strong. The correlation coefficient for the complete indirect linear dependence is -1, its value for the complete direct linear dependence is 1. If the correlation coefficient is equal to zero, the dependence is not linear.

By means of regression analysis it is possible to forecast expected values of observed parameters. The accuracy of such an analysis is proportional to the correlation index. The least squares method is advantageously used to determine the coefficient of the regression function.

Vehicles equipped with both petrol and diesel engines were tested. The test results were compared and the methodology for calculation of coefficients of emission evolution for vehicles with petrol and diesel engines was laid down. The coefficients of emission evolution determined in this way and experimentally verified will be further assessed in service.

After their suitability and accuracy have been proved they will become important data for R&D and test centers. Their use in practical applications will shorten the time needed for design of new engine software, will save the time needed for the vehicle run-in and will reduce costs needed for emission testing.

3. Experiment

The experiment was carried out in compliance with the current EU legislation (test conditions laid down in Directive 98/69/EC). After the vehicles had been prepared for the experiment they were tested on the dynamometer bench and emissions were collected by the CVS method within the EUROTEST driving cycle (ECE Urban a Extra Urban). Particulate matters were monitored gravimetrically. Having run the “stabilization regime” (three subsequent extra urban driving cycles EUDC - 91/441/EHK), a coastdown test was carried out. Its objective was to correct and adjust the dynamometer. During the whole experiment the utmost attention was paid to keeping the methodology as close as possible within the current European legislation framework.

As we have already mentioned vehicles equipped both with petrol and diesel engines were tested. Driving cycles were carried out in two stages. Within the first stage the first tested vehicles having run *x* km were tested and within the second stage the vehicles with *5.x* km were tested.

Fig. 1 and Tab. 2 show the emission test result for the motor vehicle equipped with a petrol engine; Fig. 2 and Tab. 3 present the emission test result for the vehicle equipped with a diesel engine after having run *x* km. Then, Fig. 3 and Tab. 4 present the emission test result for the vehicle equipped with a petrol engine and Fig. 4 and Tab. 5 give the result for the vehicle with a diesel engine after *5.x* km.

Tab. 2 Emission test result for the vehicle with a petrol engine after x km

	HC	CO	NO_x	CO_2	V_{pal}
	g.km^{-1}				l.(100 km)$^{-1}$
Emission mass	0.056	0.388	0.017	157.571	6.61

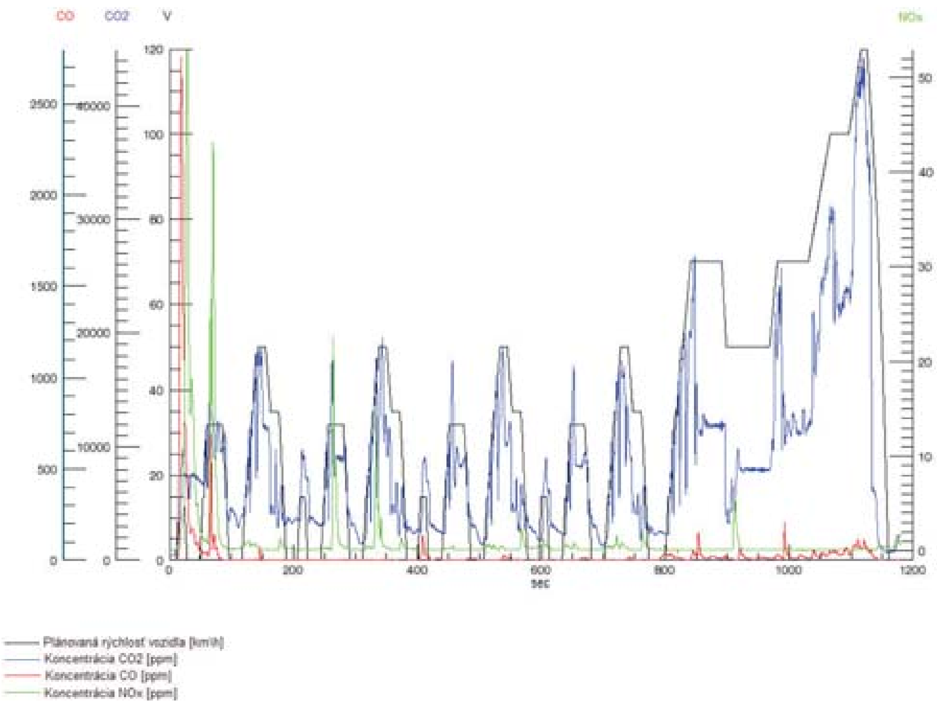

Fig. 1. Emission test results for the vehicle with a petrol engine after x km

Tab. 3. Emission test result for the vehicle with a diesel engine after x km

	HC+NO_x	CO	NO_x	CO_2	PM	V_{pal}
	g.km^{-1}					l.(100 km)$^{-1}$
Emission mass	0.202	0.150	0.180	148.876	0.020	5.63

Tab. 4. Emission test result for the vehicle with a petrol engine after 5.x km

	HC	CO	NO_x	CO_2	V_{pal}
	$g.km^{-1}$				$l.(100\ km)^{-1}$
Emission mass	0.059	0.398	0.016	156.284	6.56

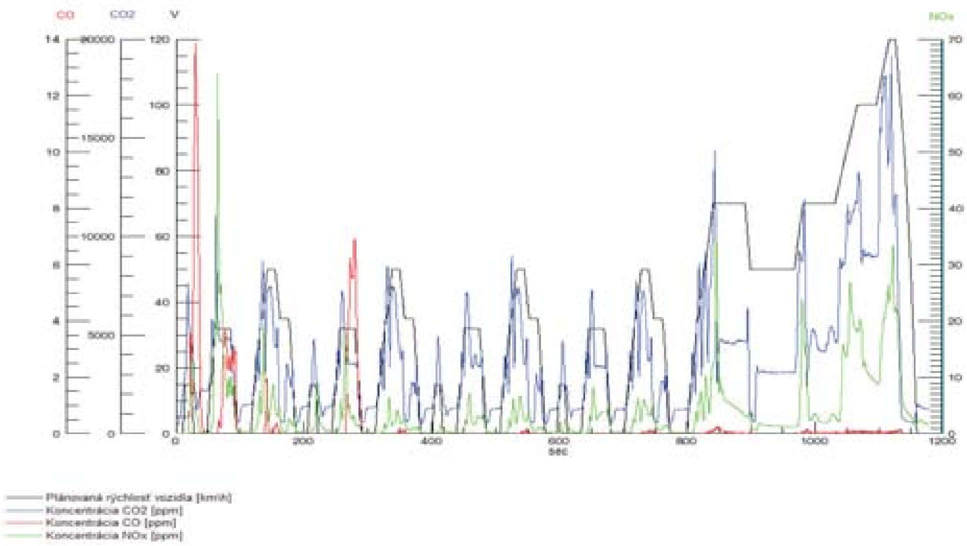

Fig. 2. Emission test results for the vehicle with a diesel engine after x km

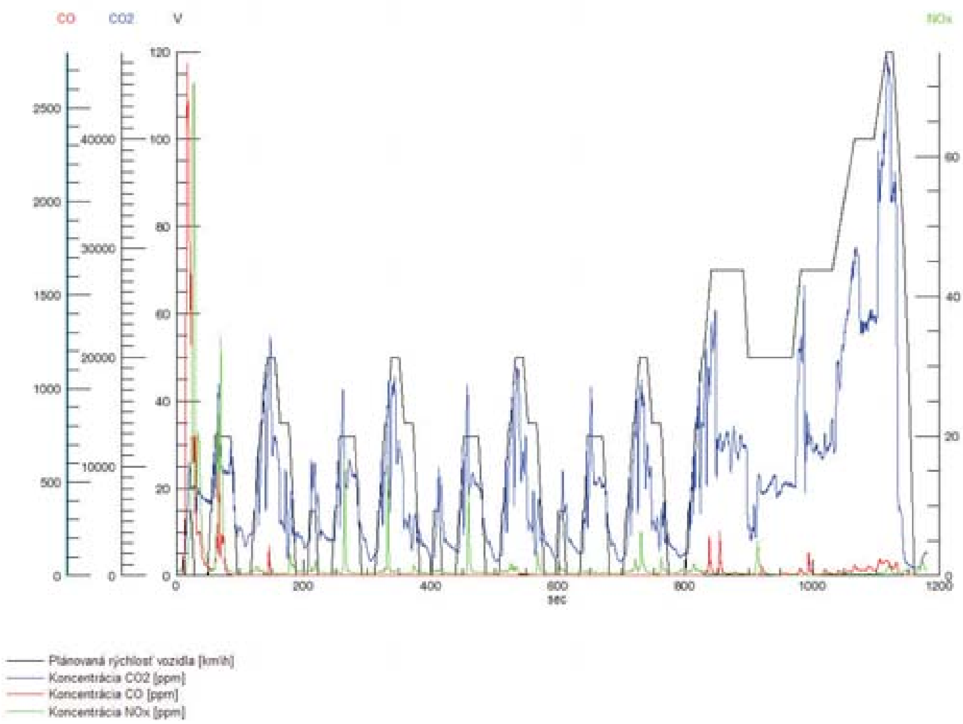

Fig. 3. Emission test results for the vehicle with a petrol engine after 5.x km

Tab. 5. Emission test result for the vehicle with a diesel engine after 5. x km

	$HC+NO_x$	CO	NO_x	CO_2	PM	V_{pal}
	$g.km^{-1}$					$l.(100\ km)^{-1}$
Emission mass	0.193	0.178	0.164	147.410	0.016	5.57

Table 6 gives the calculated values of the coefficient of individual pollutant emission evolution and fuel consumption (determined from measurements at *x* and *5.x* km) for motor vehicles with petrol engines. The resultant coefficients for a particular pollutant are in this case determined as the arithmetic mean of the coefficient of emission evolution for individual tested vehicles. From the coefficients determined in this way it can be seen that the values of hydrocarbons, carbon monoxide, carbon dioxide, and fuel consumption decrease, while the values of nitrogen oxide increase significantly. Individual values of evolution coefficients represent the behavior of mass of emission pollutants and fuel consumption during the vehicle run-in. The values of nitrogen oxide masses show a relatively great dispersion. Considerable deviations in individual measurements are caused by irregular impulses from the λ probe placed in an exhaust pipe system and consequent control of fuel amount injected into the combustion space. The engine control unit applicators try, mostly from the start of the engine life, to adjust nitrogen oxide production as this production grows during the engine run-in.

Tab. 6. Values of emission evolution coefficients for tested vehicles with a petrol engine

	HC	CO	NO_x	CO_2	V_{pal}
Evolution coefficient	0.937	0.978	1.323	0.992	0.992

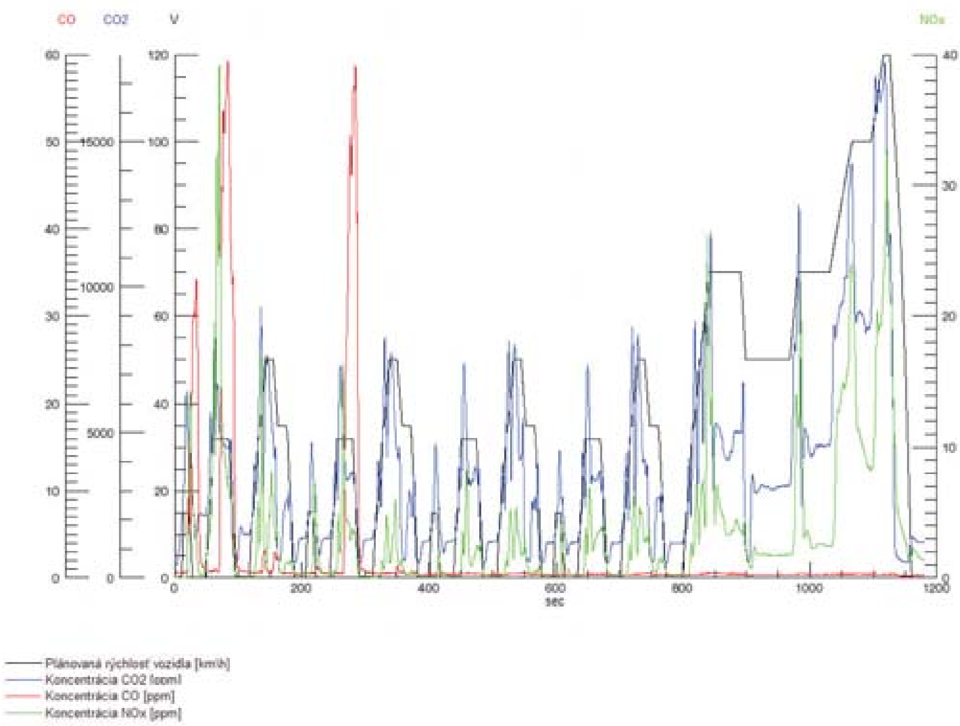

Fig. 4. Emission test results for the vehicle with a diesel engine after 5.x km

Table 7 gives the calculated values of the coefficient of individual pollutant emission evolution and fuel consumption (determined from measurements at *x* and *5.x* km) for motor vehicles with a diesel engine. The resultant coefficients for a particular pollutant are also in this case determined as the arithmetic mean of the coefficient of emission evolution of individual tested vehicles.

Tab. 7. Values of emission evolution coefficients for tested vehicles with a diesel engine

	$HC+NO_x$	CO	NO_x	CO_2	PM	V_{pal}
Emission mass	0.956	1.167	0.929	0.985	0.909	0.985

Fig. 5 and 6 give a comparison of produced NO_x emissions from different vehicles equipped with petrol and diesel engines respectively and having run *x* and *5.x* km within the framework of the European emission test.

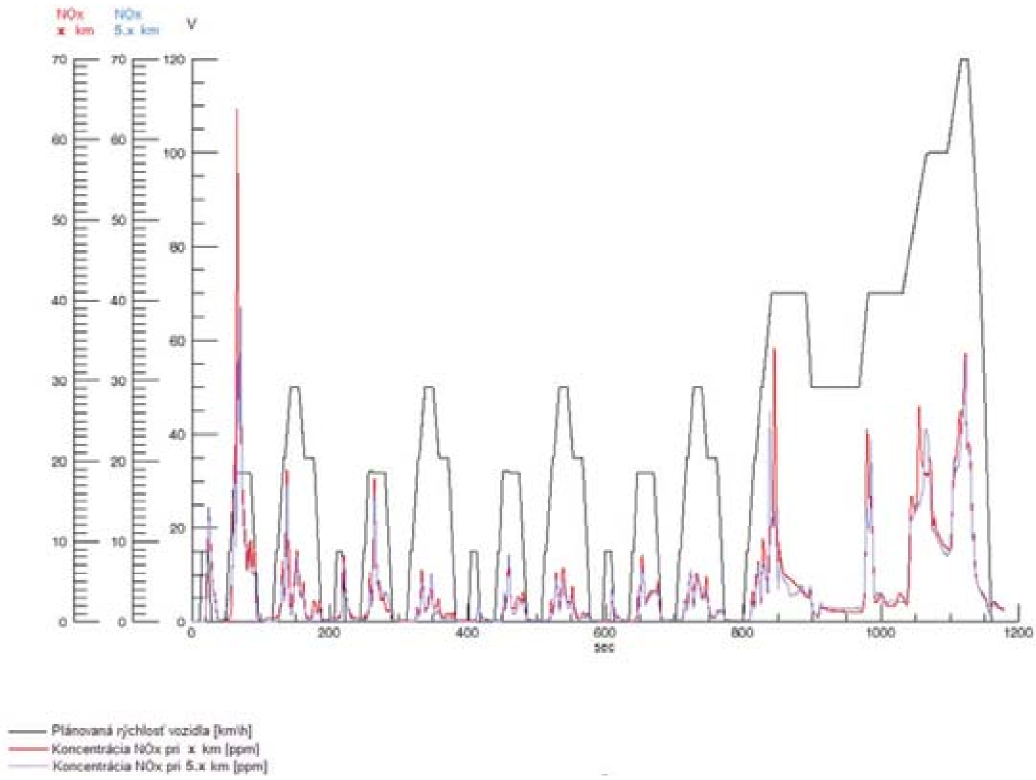

Fig. 5. Comparison of NO_x production from the vehicle with a petrol engine after x and 5.x km

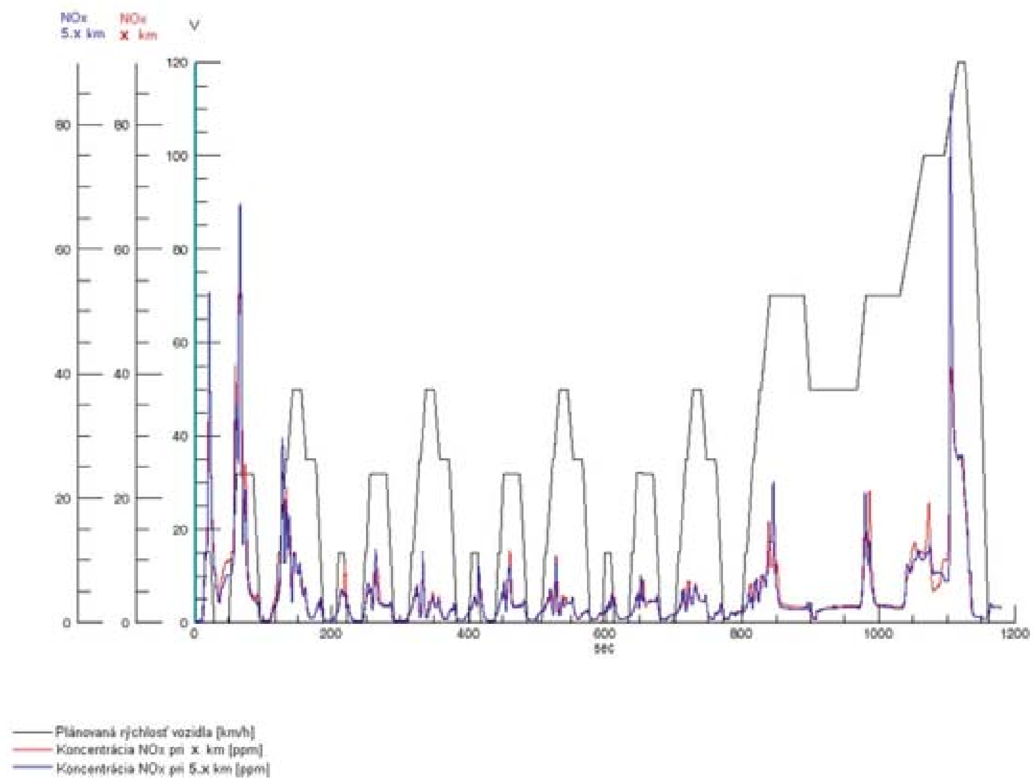

Fig. 6. Comparison of NO_x production from the vehicle with a diesel engine after x and 5.x km

4. Conclusion

All the tests were carried out at the constant temperature of 23°C and relative humidity of 45%. From the test results it is possible to observe changes in emission values and fuel consumption of motor vehicles equipped with petrol and diesel engines after *x* and *5.x* km.

Directive 70/220/EEC and its consequent amendments allow for certain changes in testing vehicles for emissions which are not prohibited and their use can lead to a better test result. The improvement in emissions is, of course, not significant, it is about 1 ~ 5%. Such changes cannot be applied into each motor vehicle. As long as motor vehicle manufacturers want to achieve the acceptable result for all motor vehicles, they can implement the above changes for those vehicles that need the mentioned 1 ~ 5% improvement to meet the limit.

One of the main factors influencing the test result is temperature and humidity of the test room during testing. The temperature range should be 20 ~ 30 °C. If the upper limit is achieved (29 ~ 30 °C), the catalyst gets warmer during testing and this results in reduction of hydrocarbon and carbon monoxide emissions. The range of relative humidity is large (30 ~ 60%). High humidity contributes to a higher hydrocarbon production and also, indirectly, to the production of nitrogen oxide. Software for emission mass calculation considers also the coefficient of NO_x correction. This coefficient depends also on air humidity in the test place. When humidity is high (above 50%), the coefficient value is 1.0 ~ 1.1. When humidity is reduced to 40% the coefficient value is 0.92. We can therefore say that the reduction of humidity in the test place, i.e. change of the coefficient; can lead to NO_x reduction as much as by 9%.

Other influencing factors which can be mentioned are: atmospheric pressure (signals from an air pressure sensor in the air filter influence the quality of air-fuel mixture, thus influencing produced gaseous emissions) and quality of air in the test place (if the emission test methodology does not change, tests in compliance with EURO VI will have to use an ambient air filter).

Practical confirmation of the values of the emission evolution coefficient will enable to determine emission mass by means of calculation thus avoiding the need for running the given number of (*5.x*) km. This will bring a substantial reduction of costs needed for repeated testing of new motor vehicles.

References

[1] *Directive 98/69/EC of the European Parliament and of the Council of 13 October 1998 relating to measures to be taken against air pollution by emissions from motor vehicles and amending*, Council Directive 70/220/EEC 1998.

[2] *Directive 70/220/EEC of 20 March 1970 the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles* 1970.

[3] *Council Directive 91/441/EEC of 26 June 1991 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles* 1991.