

# Investigations to assess the impact of test and operation of ventilation system modes on pollutant concentrations in vehicle interior air

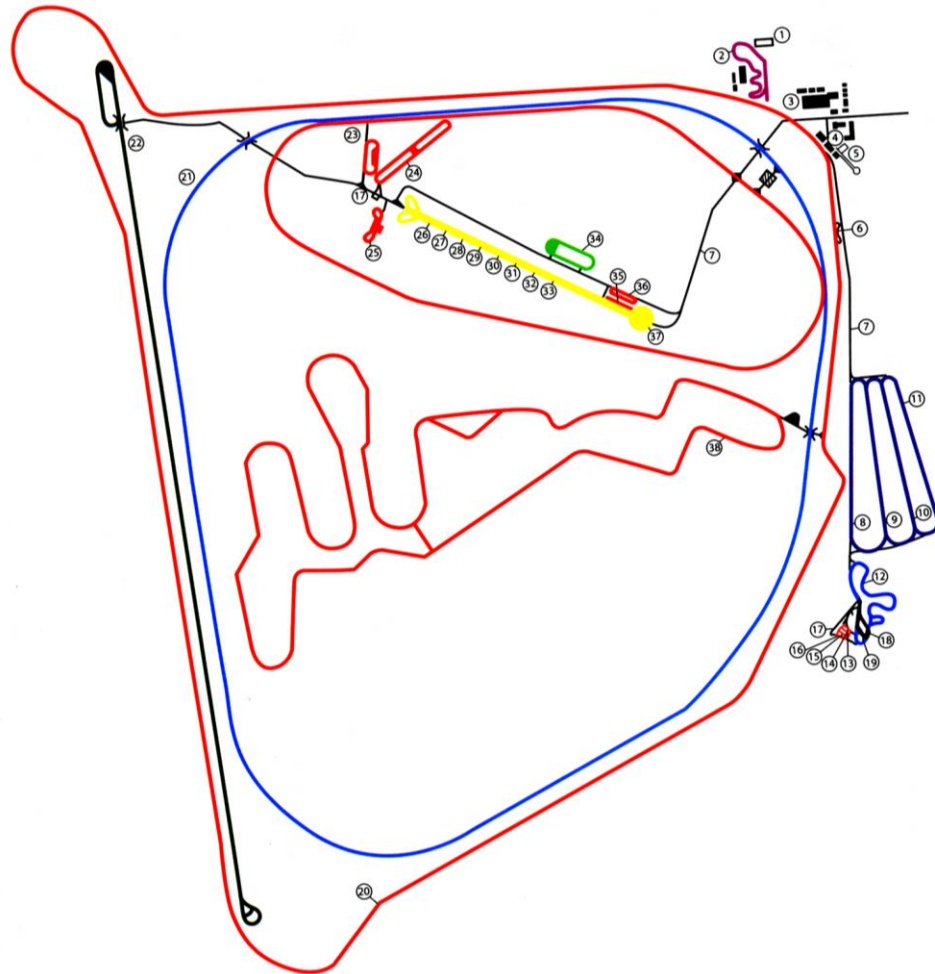
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# Testing Centre

The study was carried out on the Central scientific research automobile and automotive engine institute (NAMI) in its Testing Centre - Dmitrov proving ground



## The list of test roads:

1. **Dynamometric road with length of 5,2 km. (22)**
2. **High-speed road with length of 14 km. (21)**
3. **Open areas in front of the dynamometer and high-speed roads.**

## The important stipulation:

**There should not be other vehicles during the whole test in the vicinity of test vehicle.**

## Data of testing

**5 - 25 October 2017**

# Test modes

**A.1. Movement at constant speed 50 km/h**

**A.2. Movement at constant speed 90 km/h**

**A.3. Movement at constant speed 110 km/h**

**A.4. Movement at constant speed 130 km/h**

**A.5. Idling**

**A.6. Acceleration from a speed of 60 km/h at WOT to a speed of 130 km/h and a free coasting down to a speed of 60 km/h**

**On each of the driving and idling modes, the measurements of the pollutants were made during the performances of the following operating modes of the ventilation and recirculation systems**

# Operation modes of the ventilation and recirculation systems during tests

**B.1 Recirculation and fresh air ventilation system switched off**

**B.2 Recirculation switched on, fresh air ventilation system switched off**

**B.3 Recirculation switched on, blower fan switched on in the minimum position**

**B.4 Recirculation switched on, blower fan switched on in the middle position**

**B.5 Recirculation switched on, blower fan switched on in the maximum position**

**B.6 Recirculation switched off, fresh air ventilation system switched on, blower fan switched on in the minimum position**

**B.7 Recirculation switched off, fresh air ventilation system switched on, blower fan switched on in the middle position**

**B.8 Recirculation switched off, fresh air ventilation system switched on, blower fan switched on in the maximum position**

# The list of tested vehicles

Test car number	Engine type	Mileage before testing, km	Type of gearbox
1	gasoline	6450	manual
2	gasoline	35600	automatic
3	gasoline	29650	manual
4	diesel	8800	automatic
5	diesel	21000	manual

# Test equipment

Next pollutants: NO, NO<sub>2</sub>, CO and aromatic hydrocarbons in terms of benzene have been determined in the interior air of tested vehicles. All equipment were working in express regime (on-line measurement).

## Technical data of test equipment

Equipment, model, type of detector	Purpose of equipment	Limits, mg/m <sup>3</sup>	Minimal value measurable concentrations, mg/m <sup>3</sup>	Error of measurements, %	Range of measurable concentrations, mg/m <sup>3</sup>	Date of verification
Gas analyzer "Kolion 1B" with photo-ionization detector	Determination of aromatic hydrocarbons in terms of benzene	0,3 for benzene 0,6 for methylbenzene (toluene)	0,01	$\gamma - \pm 15$	0 – 10	30.06.2017
Gas analyzer "Opto gas 500.4-CO" with electro-chemical detector	Determination of carbon monoxide, CO	5,0	0,1	$\gamma - \pm 20$	0 - 3	3.09.2017
Gas analyzer "R-310A" with chemiluminescent detector	Determination of nitrogen oxides, NO, NO <sub>2</sub>	0,2 for NO <sub>2</sub> 0,4 for NO	0,001	$\gamma - \pm 25$ $\delta - \pm 25$	NO (0- 0,08) NO <sub>2</sub> (0- 0,08) NO (0,08 - 1,0) NO <sub>2</sub> (0,08 -1,0)	28.09.2017

Note :  $\gamma$  - limit of the allowed basic reduced measurement error;  
 $\delta$  - limit of the permissible basic relative error of measurements;



# Test equipment



Location of instruments during testing



Gas analyzer "R-310A" with chemiluminescent detector for determination of nitrogen oxides NO, NO<sub>2</sub>



Gas analyzer "Kolion 1B" with photo-ionization detector for determination of aromatic hydrocarbons in terms of benzene



Gas analyzer "Optogas 500.4-CO" with electro-chemical detector for determination of carbon monoxide, CO

# Test procedure

- 1. Car refueling for 12 h before the test.**
- 2. Preparation of gas analyzers for testing - in-laboratory calibration of equipment before and after testing.**
- 3. Departure to the test track - warming up the vehicle at a speed of 60 km/h for 15 min.**
- 4. Performing each of the modes for 15 min after which the measurement of pollutants have been hold.**
- 5. The measurements of pollutants were carried out after 10-12 min of operation on each of the driving and idling modes.  
(no less than 5-6 measurements of each of the above-mentioned pollutants were carried out at each of the modes of motion, idling and operation modes of ventilation systems.**
- 6. The ventilation of the vehicle's saloon was carried out after the end of each mode of moving and idling.**



# Example of an in-lab calibration of gas analyzers before the start and after finish of the test

In-lab calibration date 17. 10. 2017				Date of verification
Gas analyzer, model R-310A, N 607-2-12, model Optogas 500.4-CO				3.09.2017/ 28.09.2017
Diluter, model 645 GP-03M				28.06.2017
Concentration of calibration gas mixture (CGM), NO/N <sub>2</sub> , ppm				51,9
Concentration of calibration gas mixture (CGM), NO <sub>2</sub> /N <sub>2</sub> , ppm				51,0
Concentration of calibration gas mixture (CGM), CO/N <sub>2</sub> , ppm				85,0
<b>NO<sub>2</sub></b>				
Specified concentration of CGM, mg/m <sup>3</sup>	0,812	0,406	0,206	0,104
Valve N° for dilution	8	5,6	3,5	2,4
Measured concentration, mg/m <sup>3</sup>	0,797	0,391	0,195	0,093
Basic relative error,%	2,2	3,7	5,3	10,5
<b>NO</b>				
Specified concentration of CGM, mg/m <sup>3</sup>	0,814	0,396	0,201	0,109
Valve N° for dilution	7,8	5,7	4,6	5
Measured concentration, mg/m <sup>3</sup>	0,821	0,424	0,210	0,107
Basic relative error,%	0,8	7,0	4,4	1,8
<b>CO</b>				
Specified concentration of CGM, mg/m <sup>3</sup>	0,51	1,02	1,98	5,24
Valve N° for dilution	4,7	6,8	7,9	8,9,10
Measured concentration, mg/m <sup>3</sup>	0,50	0,9	1,8	5,2
Basic relative error,%	1,9	9,0	9,0	0,8

$$\Delta - \text{basic relative error, \%} = \frac{\text{Specified concentration} - \text{Measured concentration}}{\text{Specified concentration}}$$

Δ - must be less than 25%



Thank you for your attention!  
We are ready to answer your questions.

