

Interior air quality testing at idling mode: methodology and equipment

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Test aim and measured pollutants

The aim of the test is improvement of the methodology for measurement of pollutant concentration in vehicle interior air at idling mode

The list of measured pollutants in vehicle interior air under test:

- ✓ Carbon dioxide (CO₂)
- ✓ Carbon monoxide (CO)
- ✓ Nitric oxide (NO)
- ✓ Nitrogen dioxide (NO₂)

and in the exhaust gases of the tested vehicle:

- ✓ Carbon dioxide (CO₂)
- ✓ Carbon monoxide (CO)

Test objects

Vehicle	Type of engine	Mileage, km	Type of gear box
Car#1	petrol	28800	automatic
Car#2	diesel	12230	automatic

The sequence of testing

- Temperature conditioning of the test vehicle during at least 6 h at ambient temperature before starting the test.
- Preparation of analytical equipment for testing - carrying out inter laboratory calibration procedure of gas analyzers before beginning of the test.
- Installing the test vehicle on the rotary balance of the wind tunnel, installation of test equipment inside the vehicle.
- Starting and warming up the engine for 15–20 min. The ventilation system of the wind tunnel should be switched on and be working during the entire test period.
- Carrying out the quantitative measurements of pollutants at the interior of tested vehicle after warming up of engine for 15-20 minutes at each operation mode of ventilation system, the air flow rates (0, 1, 2, 3, 4, 5) m/s and the angle of rotation (0, 45, 90) deg. of the test vehicle relative to the direction of air flow .
- Vehicle's engine should be switched off after finishing of each test mode, the vehicle's interior should be ventilated for 5-10 min.

Test conditions

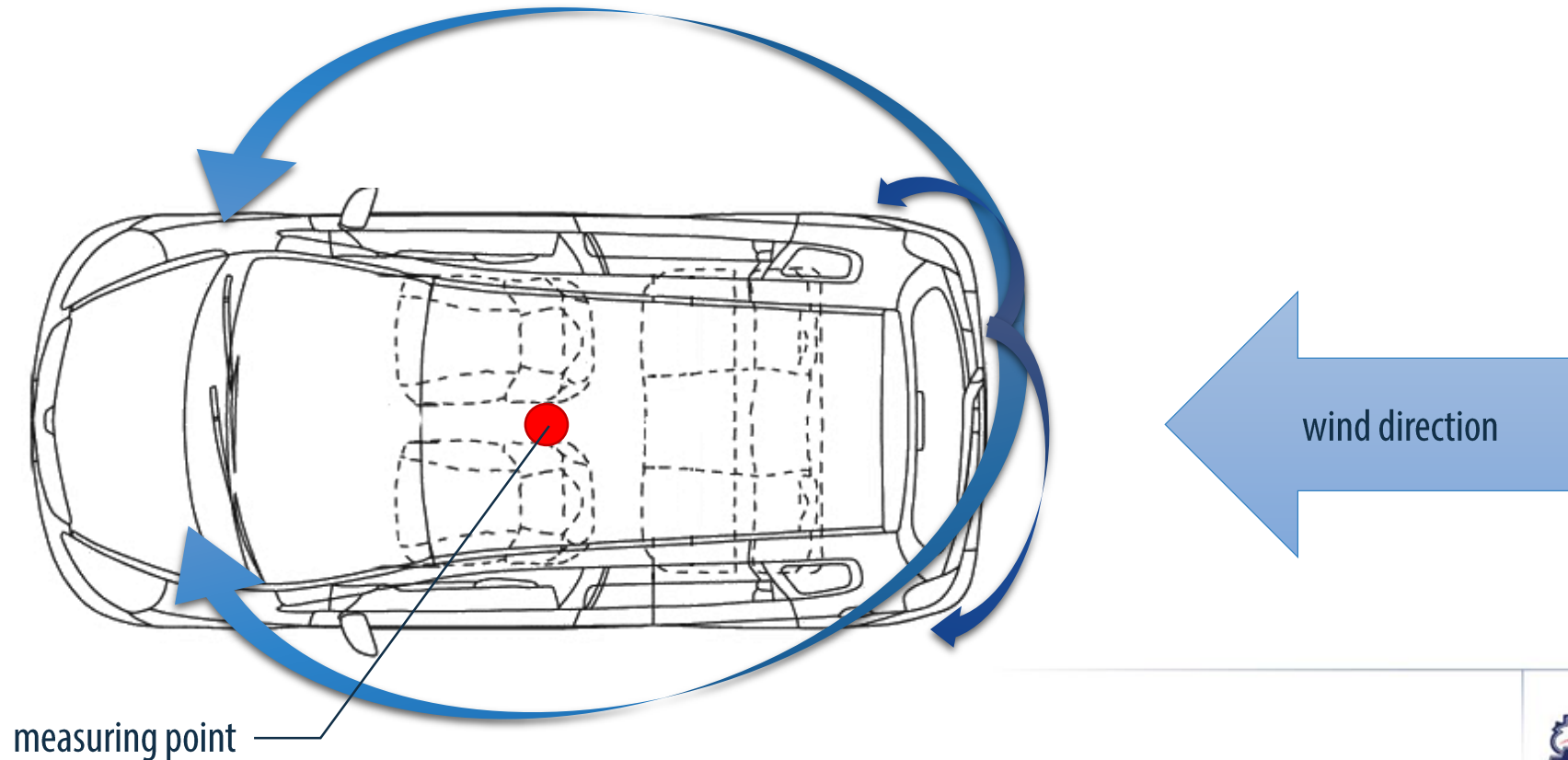
- It is important! There should be no people inside the test vehicle during the test.
- Windows, doors, quarter lights, ventilation hatches of test vehicle should be closed. At the beginning of each series of measurements, it should be determined the concentrations of CO, CO₂, NO and NO₂ in the atmospheric air near the vehicle and then inside the test vehicle.
- The test result represents the difference between the measured pollutant concentrations inside and outside test vehicle.
- At least 5 - 10 of gas analyzer readings of each pollutant should be fixed during each test mode.

Test aim and program

HVAC operation modes:

1. Recirculation – ON, Ventilation speed = 0 (HVAC system - OFF)
2. Recirculation – ON, Ventilation speed = maximal
3. Recirculation – OFF, Ventilation speed = maximal

Requirements to the temperature: (no heating or cooling of interior air)
temperature inside a car shall be equal to ambient temperature



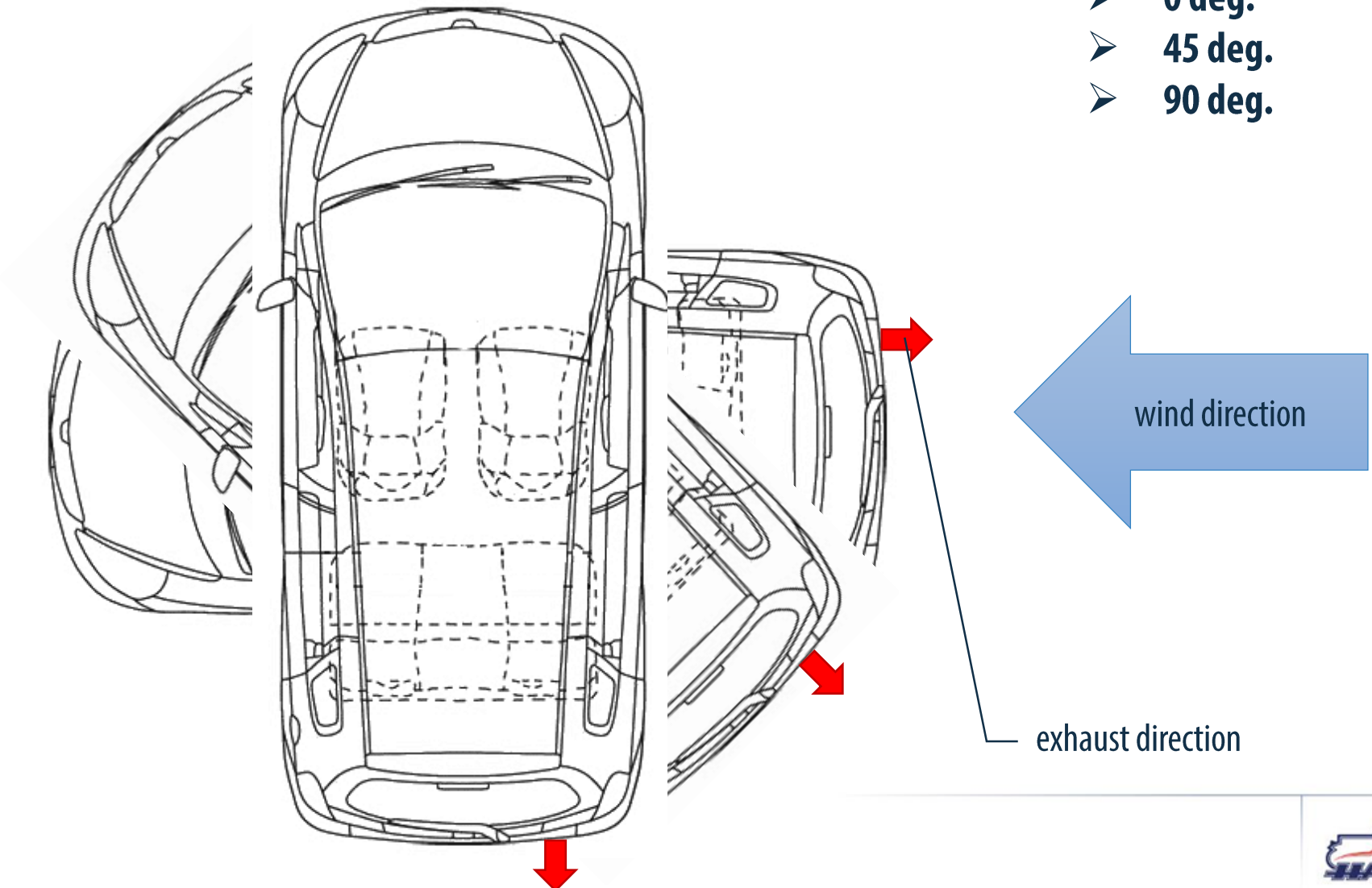
Wind speed and direction

Wind speed:

- 0 m/s
- 1 m/s
- 2 m/s
- 3 m/s
- 4 m/s
- 5 m/s

Wind direction:

- 0 deg.
- 45 deg.
- 90 deg.



Test facility

The model of the wind tunnel



Test facility: wind tunnel
Total tunnel length 120 m
Fan diameter 7.5 m
Cross-sectional area 27 m²
Working area W/H/L 6.0/4.5/18.0 m

Test car in the wind tunnel



The test will be carried out on the Central scientific research automobile and automotive engine institute (NAMI) in its Testing Centre - Dmitrov proving ground (Moscow region)

Installation of the test car#1 at the angle of 45 deg to the direction of air flow



Installation of the test car#1 at the angle of 90 deg. to the direction of air flow



Installation of the test car#2 at the angle of 0 deg to the direction of air flow



Installation of the test car#2 at the angle of 90 deg to the direction of air flow



The location of the exhaust pipe of test car#1



The location of the exhaust pipe of test car#2



Measurement equipment

Measurement equipment installation inside a test cars



interior air:

**NO,NO₂ – gas analyzer mod. R310
with chemiluminescent detector**

**CO - gas analyzer mod. OPTOGAS 500-4-CO
with electrochemical detector**

**CO₂ – gas analyzer mod. Testo 315-3 with
Infrared spectroscopy detector**



vehicle exhaust:

**CO,CO₂ – gas analyzer mod. BOSCH BEA 460
Infrared spectroscopy detector**

Anemometer to measure the speed of air flow directed to the test vehicle



Testo 410-2 - Vane anemometer

Measuring range:

- wind velocity 0.4 to 20 m/s
- ambient temperature -10 to +50 °C
- humidity 0 to 100 %RH

Characteristics of toxic exposure of determined pollutants

Name of pollutants	MPCwz/MPCatm, mg/m ³	Ccritical concentration in salon, mg/m ³	Exposition	Symptoms	Toxicologic characteristic
Carbon oxide, CO	20/5	6 30	25 min 3 h	reduced light sensitivity of the eyes, reduced night vision, losing attention, fatigue	blocks tissue respiration, blood poison
Nitrogen oxide, NO	2,0/0,4	0,1	continuously	losing attention, fatigue	blocks tissue respiration, blood poison
Nitrogen dioxide, NO ₂	2,0/0,2	0,056	continuously	shortness of breath, the possibility of bronchitis, respiratory diseases.	sensory, functional, pathological effects
Carbon dioxide, CO ₂	-	800 -1200 ppm	continuously	loss of attention, in-creased drowsiness, increased asthma attacks	hypercapnia (carbon dioxide blood saturation) – a particular case of hypoxia

Limit values are indicators of the harmful effects of measurable pollutants on the human body:

MPC wz - maximum permissible concentrations of pollutants in the air of working zones, mg/m³

MPCatm - maximum permissible maximum one-time concentrations of pollutants in the atmosphere of populated areas, closed premises, mg/m³

Main results

It was tested two vehicles with 89 (total) variants of various operation modes of ventilation system, air flow rates (0, 1, 2, 3, 4, 5) m/s at different angles (0, 45, 90) deg. of vehicle's position relative to the direction of air flow.

The measured concentrations of pollutants are varied widely:

NO from 0 to 1700 $\mu\text{g}/\text{m}^3$; (Limit value – 400 $\mu\text{g}/\text{m}^3$);

NO₂ from 0 up to 670 $\mu\text{g}/\text{m}^3$; (Limit value – 200 $\mu\text{g}/\text{m}^3$);

CO from 0 up to 1,1 mg/m^3 ; (Limit value – 5 mg/m^3);

CO₂ from 570 up to 820 ppm (Unlimited)

Conclusions

- It was founded that exhaust gases of test vehicle itself penetrate inside the cabin airspace during testing in idling regime at the absence of other vehicles.
- The carbon dioxide content of CO_2 was 15.9%, the carbon monoxide content of CO was insignificant - less than 0.001% in the exhaust gases of a petrol vehicle.
- It was established the significant effect of the tested parameters on the quantitative content of limited pollutants in the cabin air.
- The pollution degree of the vehicle's interior air is depended on the chemical composition and the content of measured pollutants in the exhaust gases of the tested vehicles.
- It has been established a significant more great effect of tested parameters on the air pollution degree of the vehicle's interior air while testing a vehicle with diesel engine, in particular, increasing of NO , NO_2 - which are the characteristic components of a diesel exhaust.
- An insignificant amount of NO , NO_2 were found in the air of vehicle's interior with petrol engine, there were CO and CO_2 as a main air pollutants in this case.
- A more detailed analysis of the research results will be presented to the next report.

Thank you for your attention!

