

Gas analyzer accuracy check statistics

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The procedure for checking the accuracy of measurement of normalized pollutants is performed before and after testing.

The analytical equipment used shall meet to special requirements, since the level of measured concentrations of pollutants in the interior air of the car are from 0,001, to few dozens of ppm or mg/m³ and usually these measurements are taken online on board the test vehicle:

These requirements are:

- Low range of measured pollutants, requiring the use of high-precision analytical equipment.
- Ensuring the required measurement accuracy (error) to obtain correct results in case of determining low concentrations of limited pollutants.
- Work stability of gas analysis equipment in extreme operating conditions, during which instability of the operation of devices may occur.

To ensure compliance with the above requirements, a regulated calibration procedure for the equipment shall be performed before and after testing, in order to make sure that the accuracy of the instruments has not changed after testing and the test results shall be considered reliable.

The procedure for checking the accuracy of measurement of pollutant concentrations

In practice, a typical procedure of laboratory calibration of equipment is carried out using the equipment shown at the next slide.

It is known that routine calibration of equipment with appropriate evaluation criteria used for equipment located at the stationary conditions at room to perform special rules (for example, UN Regulation No. 83) is implemented into a special calibration program in accordance with which daily calibration of equipment is carried out.

In cases when the measurements are carried out using mobile equipment, the calibration of that equipment is carried out and in accordance with the scheme described below and normative values are the accuracy requirements used in a particular country (for example, Russia).

When the results of laboratory calibration before the start and after finishing of testing have been exceeded the required basic relative error β , gas analyzers settings are checked and after that the calibration procedure should be repeated.

The general rule for calibration procedure - the values of relative error β in all cases should not exceed the required values ($\pm 25\%$).

- gas mixture generator mod. 655 GR 05 (dynamic divider) used for the preparation of binary calibration gas mixtures of lower concentration with a dilution factor K from 20 to 2500 within the permissible relative deviation of the dilution ratio from the nominal value within $\pm 2\%$
- calibration gas mixtures (CGS) in a gas cylinder: (NO in nitrogen, NO₂ in nitrogen, CO in nitrogen) with mixing error $\pm 5\%$
- working gas in a gas cylinder (synthetic air, purity required for chromatography, 20% is O₂, N₂ is the rest)

3-4 values of the calibration gas mixtures (CGM) concentration (NO, CO and NO₂ in N₂) calculate with using of ratio of valve numbers of divider and dividing coefficient K_{dil} :

$$K_{dil} = C_{CGM} / C_{calc}, \quad (1)$$

where K_{dil} – dividing coefficient, C_{calc} – specified content of diluted CGM, mg/m³,

C_{CGM} – concentration of CGM in gas cylinder, mg/m³

The concentration C_{CGM} is fed to the input of the divider and further C_{calc} prepared by the divider according to the formula (1) is fed from the output tube of the divider to the input of the gas analyzer.

Readings of gas analyzer are compared with values of C_{calc} . Difference between C_{calc} and the gas analyzer's readings (the basic relative error, β), should not be exceed 25%.

In practice, the meaning of β are at the level of 3-8%.

Calibration equipment and gas analyzers data

In-lab calibration period 06-27/12/2019		Date of mandatory verification
Gas analyzer mod R 310A (NO, NO2) N 72-4-01		21/02/2019 up to 20/02/2020
Gas diluter, mod. 645 GR-03M N		13/05/2019 up to 12/05/2020
Concentration of gas mixture (CGM), NO/N ₂ , ppm	51,9	Up to 26/06/2020
Concentration of gas mixture (CGM), NO ₂ /N ₂ , ppm	51,0	Up to 14/08/2020



Comparison of the error values of the measured pollutants used in Western countries and Russia is shown at the next slide.

The interpretation of β (the limit of the permissible main measurement error) adopted in Russia, represents the sum of the measurement errors in each measurement section:

$$\beta = (\beta_{\text{CGM}} + \beta_{\text{gen.CGM}} + \beta_{\text{anal}}) \times K,$$

where β_{CGM} - the error in the preparation of the calibration gas mixture;

$\beta_{\text{gen.CGM}}$ - error of the generator (diluter) of CGM;

β_{anal} - measurement error of used gas analyzer.

K is the safety factor, usually equal from two to three times.

It is obvious that the gas analyzer Teledyne M201E having an instrumental measurement error of $\pm 1\%$ of the full scale of measurement corresponds to $\beta = \pm 20\%$ - the value of the limit of permissible measurement error.

Technical data for gas analyzer Teledyne M201E

For Europe and countries of the West and East

For Russia and Custom Union Countries

Ranges:

0-50 to 0-2000 ppb in 1 ppb increments (selectable, independent)

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Measurable pollutants:

NH3, NO, NO2, NOx ranges supported)

NH3, NO, NO2, NOx ranges supported)

Measurement units: PPB, PPM, microgram/m³, milligram/m³

the same

**Linearity NO calibration - 1% of full scale
The limit of allowable main reduced error (instrumental error)**

**at the range 0 – 50 ppb - +/- 20%
The limit of allowable main relative error at the range 50 -2000 ppb +/- 20%**

**no position
*(data received while testing the gas analyzer in Russian institute of metrology, Saint Peterburg)**

**Maximal meanings of allowable main reduced error obtained during calibration (verification) *
at the range 0 – 50 ppb + 12%**

no position

**Maximal meanings, of allowable main relative error obtained during calibration (verification) *
at the range higher than 50 - 2000 ppb + 13%**



Test equipment used in the laboratory calibration



The gas cylinder with working gas (synthetic air)



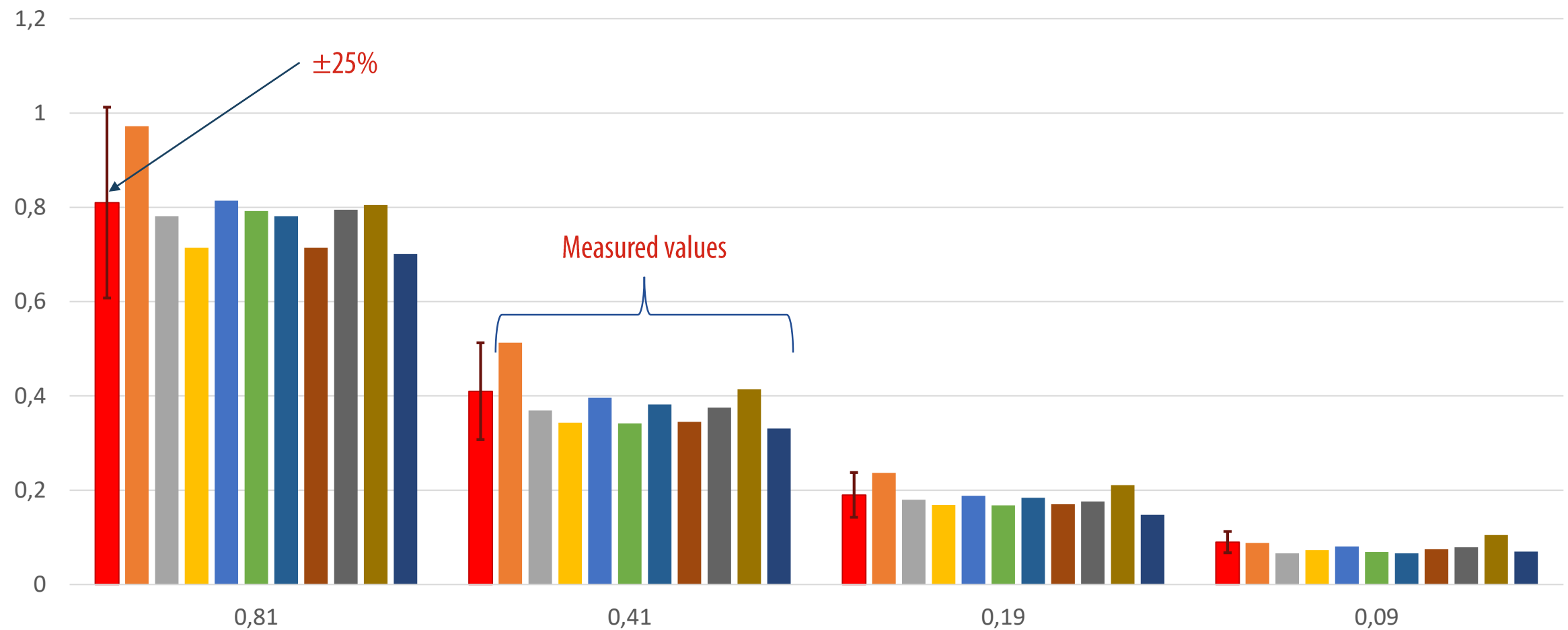
Gas cylinders with calibration gas mixture of calibrated components NO, NO2, CO in nitrogen



Dynamic divider (gas mixture generator) mod.655 GR05

Gas analyzer accuracy check results

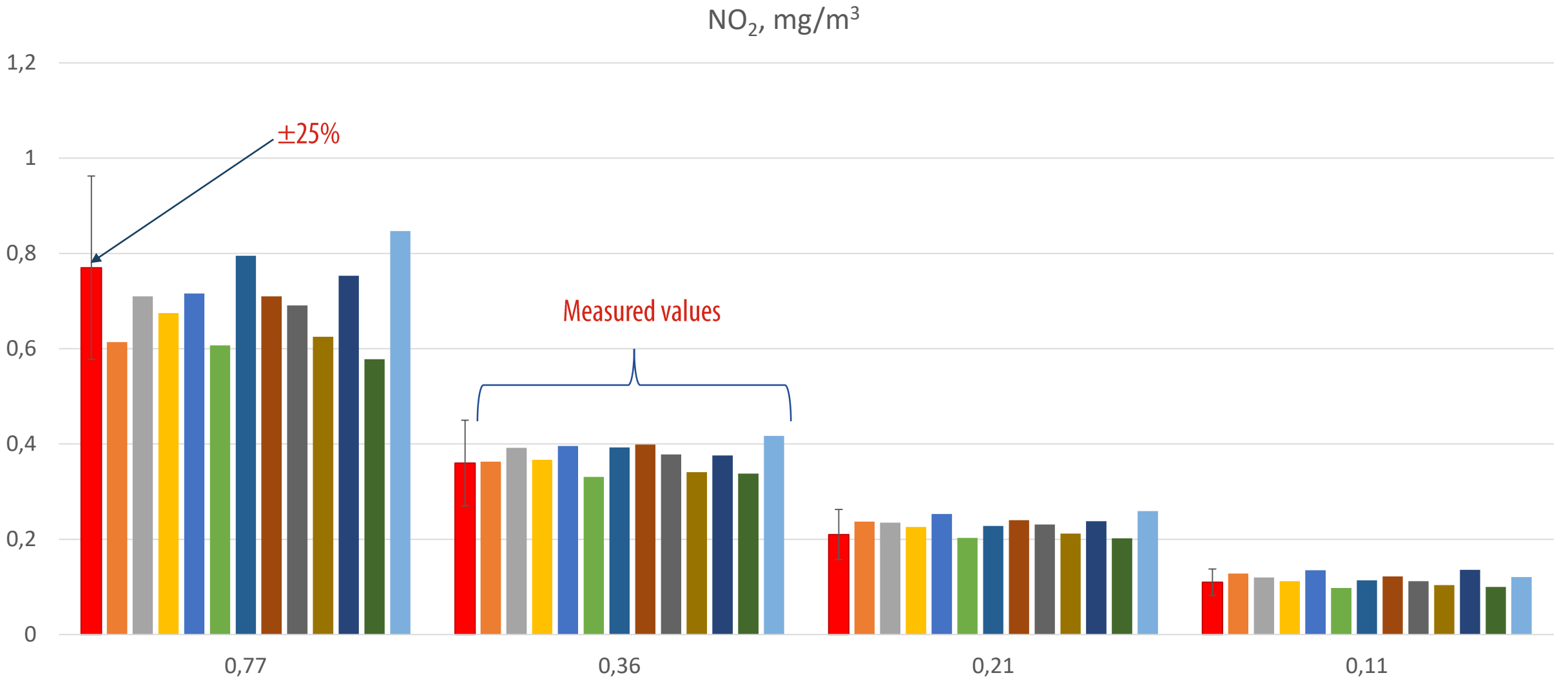
NO, mg/m³



Red rectangles are NO concentration set values, mg/m³



Gas analyzer accuracy check results



Red rectangles are NO₂ concentration set values, mg/m³



1. The procedure of the laboratory calibration of gas analysis equipment is necessary to perform before the beginning and after the end of testing.
2. The criteria "Linearity NO calibration 1% of full scale"
3. and "The limit of allowable main reduced and relative error" are objectively evaluate the accuracy parameters of used gas analyzers.
4. The values of the errors "The limit of allowable main reduced and relative error" when measuring of nitrogen oxides according to the above described laboratory calibration procedure are shown at the slides 13 and 14 do not exceed the regulatory value of 25% before and after the test.

Thank you for your attention!

