

# Test equipment calibration procedure

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The next mandatory requirements for gas analytical equipment act both in Russian Federation and countries of Customs Union (Belarus, Kazakhstan, Kyrgyzstan, Armenia):

- all variety of measuring tools (MT) used in the test procedure should be in the list of State Register of Measuring Instruments of the Russian Federation and the countries of the Customs Union;
- all variety of MT used in the test procedure must be verified by the state metrological service, which, using high-precision equipment and certified verification working mixtures, checks the main operating characteristics of the instruments and the limits of measurement errors which shall be at the required tolerances.

In practice, there is a need for additional calibration of analytical equipment, especially when the MT are used in extreme conditions. For a example - carrying out of quantitative measurements of pollutants on board of test vehicles during the road test, when it is possible to violation of gas analyzer's settings during on-line analysis due to possible disruption of the horizontal installation of equipment, the impact of vibration and speed loads and other factors of instability.

In these cases, an additional laboratory calibration of the MT is carried out twice - before and after the test.

- 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, NO<sub>2</sub> in nitrogen, CO in nitrogen) with blending error  $\pm 5\%$
- working gas in a gas cylinder (synthetic air, purity for chromatography, 20% - O<sub>2</sub> is, N<sub>2</sub> is the rest)

## Procedure of in-laboratory calibration

3-4 values of the of CGM's concentration (NO, CO NO<sub>2</sub> in N<sub>2</sub>) calculate with using of ratio of valve numbers of divider and dividing coefficient  $K_{dil}$  :

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

where  $K_{dil}$  – dividing coefficient,  $C_{calc}$  – specified content of diluted CGM, mg/m<sup>3</sup>,

$C_{CGM}$  – concentration of CGM in gas cylinder, mg/m<sup>3</sup>

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 channel 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,  $\beta$ ), should not be exceed 25%.

In practice, the meaning of  $\beta$  are at the level of 3-8%.

One of the results of inter laboratory calibration of working MT participating before and after the test is given at the table on the next slide.

**Calibration equipment and gas analyzers data**

In-lab calibration date 1/02/2018		Date of mandatory verification
Gas analyzer mod R 310A (NO, NO2) N 72-4-01 Gas analyser mod. OPTOGAS 500-4-CO (CO) , N		3/09/2017 up to 3/09/2018
Gas diluter, mod. 645 GR-03M N		28/06/2017 up to 28/06/2018
Concentration of gas mixture (CGM), NO/N <sub>2</sub> , ppm	51,9	03/2017
Concentration of gas mixture (CGM), NO <sub>2</sub> /N <sub>2</sub> , ppm	51,0	03/2017
Concentration of gas mixture (CGM), CO/N <sub>2</sub> , ppm	85,0	06/2017



# Test equipment used in in-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

# Calibration data of gas analyzers

## In lab calibration data of gas analyzers before start and after finish of test

In lab verification of NO <sub>2</sub>								
Specified concentration, mg/m <sup>3</sup>	0.812		0.406		0.206		0.104	
Valve, № for dilution, №	8		5,6		3,5		2,4	
Measured concentration, mg/m <sup>3</sup>	0.814	0.828	0.392	0.396	0.200	0.203	0.098	0.100
Basic relative error, β, %	0.2	1.9	3.4	2.5	2.9	1.4	5.8	3.8
Checks before and after test	before	after	before	after	before	after	before	after
In lab verification of NO								
Specified concentration, mg/m <sup>3</sup>	0.814		0.396		0.201		0.109	
Valve for dilution, №	7,8		5,7		4,6		5	
Measured concentration, mg/m <sup>3</sup>	0.813	0.810	0.416	0.409	0.201	0.203	0.106	0.104
Basic relative error, β, %	0.01	0.05	2.5	2.3	0	0.9	2.7	4.5
Checks before and after test	before	after	before	after	before	after	before	after



**In lab calibration data of gas analyzers before start and after finish of test**

<b>In-lab verification of CO</b>								
Specified concentration, mg/m <sup>3</sup>	0.51		1.02		1.98		5.24	
Valve for dilution, №	4,7		6,8		7,9		8,9,10	
Measured concentration, mg/m <sup>3</sup>	0.5	0.55	1.0	1.08	2.2	2.1	6.0	5.80
Basic relative error, β/ %	1.9	7.7	2.0	5.9	11	5.7	14.5	10.6
Checks before and after test	before	after	before	after	before	after	before	after
<p>Basic relative error, β, % = <math display="block">\frac{\text{Specified concentration, mg/m}^3 - \text{Measured concentration, mg/m}^3}{\text{Specified concentration, mg/m}^3}</math></p>								





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

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

**Thank you for your attention!**

