

# Continuous Gas Analyzer Specifications

Olivier LAURENT



# ICOS Specifications

Presented at the last ICOS meeting (Biarritz, March 2013):

Component	Guaranteed Specification Range	Precision (1- $\sigma$ )*	Long term variability**	
		1 minute average	Std dev(1- $\sigma$ ); 20' avg. over a month	peak to peak; 20' avg. over a month
CO <sub>2</sub>	300 - 500 ppm	< 0.05 ppm	< 0.05 ppm	< 0.3 ppm
CH <sub>4</sub>	1500 - 2500 ppb	< 1 ppb	< 0.5 ppb	< 2 ppb
CO	0 - 1000 ppb	< 1 ppb	< 0.7 ppb	< 3 ppb
N <sub>2</sub> O	300 - 500 ppb	< 0.05 ppb	?	?

\* Standard deviation of the 1 minute averaged raw data of the gas cylinder measurement during 24h

\*\* Measurement of a gas cylinder during 30' every 7 hours during one month. Data calibration performed at the beginning and the end of the test. Statistics on calibrated data (linear interpolation between the 2 calibrations). data averaged on the last 20' of each 30' injection.

*Table 3: Gas analyzer performance required by ICOS (as of March 2013)*

- Instrument Precision (1 $\sigma$  on 1 minute averaged raw data) : **half** of the total WMO Compatibility goals.
- Long term variability based on test over a month which seems to be a convenient Calibration periodicity (gas consumption, logistic...). However test duration is not suitable for neither ATC nor manufacturers.
- The CO precision seems to be a demanding target for a non GHG.



## Current specifications shown in the *ICOS AS Specifications* Document:

The gas analyzer performance in **dry air** is specified in table below:

Component	Guaranteed Specification Range	Precision <sup>1</sup> <i>Std. dev. (1-σ); 1' / 60' average raw data</i>	Reproducibility <sup>2</sup> <i>Std. dev. (1-σ); 10' average raw data</i>	Response Time <sup>3</sup> <i>10%-90%/90%-10% 1' average raw data</i>
CO <sub>2</sub>	300 - 500 ppm	< 50 ppb / 25 ppb	< 50 ppb	≤ 2' / 2'
CH <sub>4</sub>	1500 - 2500 ppb	< 1 ppb / 0.5 ppb	< 0.5 ppb	≤ 2' / 2'
CO	30 - 1000 ppb	< 2 ppb / 1 ppb	< 1 ppb	≤ 2' / 2'

<sup>1</sup> Measuring a gas cylinder (filled with dry natural air) over 25 hours; first hour rejected (stabilization time).

<sup>2</sup> Measuring alternately a gas cylinder (filled with dry natural air) during 30 minutes and ambient air (not dried) during 280 minutes over 72 hours. Statistics based on the last 10 minute average data of each 30 minute cylinder gas injection (first 20 minute rejected as stabilization time).

<sup>3</sup> Measuring alternately 2 gas cylinders (filled with dry natural air) at 40 minute interval over 2 hours; Minimum difference between the 2 gas concentrations: 10 ppm of CO<sub>2</sub>, 25 ppb of CH<sub>4</sub> and 100 ppb of CO;

All the performance tests are performed under the following conditions:

- Room temperature: 20 °C ± 2°C
- Room pressure: atmospheric pressure (not controlled)
- The component concentration (molar fraction in dry air) in the ambient air and gas cylinder air must be within the guaranteed specification range (cf. column #2) during the test.

- These Specifications have been distributed to Manufacturers (LGR, Picarro).
- Picarro takes these specifications into account for their compliance tests at the end of their production line.



# Picarro G2401

## CO2 Performance

Test	ICOS Specifications		ATC TestLab results								Picarro results	
	First Draft	Spec (Aug. 2013)	2041	2022	2037	2071	2072	2073	2084	2105	2111	2113
Precision: StdDev (1 $\sigma$ ) on 1 min avg data over 24 hours	< 50 ppb	< 50 ppb	19.5	15.1	13.7	19.8	17.1	11	14.2	13	14	13
Long Term Variability: StdDev (1 $\sigma$ ) on 20 min avg data over a month	< 50 ppb							25				
Long Term Variability: Peak-to-peak on 20 min avg data over a month	< 300 ppb							85				
Precision: StdDev (1-sigma) on hour averaged raw data over 24 hr		< 25 ppb	16.3	10.1	8	17.3	14	6.8	8.8	9	9	7
Precision: Peak-to-peak on 1 min avg data over 24 hr		< 200 ppb	104.7	92.9	82.7	104	101.8	75.4	79.8	93	85	88
Precision: Peak-to-peak on 1 hr avg data over 24 hr		< 150 ppb	59.2	36.6	28.6	62.5	54.2	30.5	34.2	40	33	31
Reproducibility: StdDev (1 $\sigma$ ) on 10 min avg data over a 72 hr		< 50 ppb	25	25	25	25	25	15	15	16	17	15.3
Reproducibility: Peak-to-peak on 10 min avg data over a 72 hr		< 200 ppb	55	85	65	85	75	45	75	51	41.1	59.2
Response Time: 10%-90% on minute averaged raw data		$\leq$ 2 minutes	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Response Time: 90%-10% on minute averaged raw data		$\leq$ 2 minutes	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
		STATUS	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
		STATUS	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

## CH4 Performance

Test	ICOS Specifications		ATC TestLab results								Picarro results	
	First Draft	Spec (Aug. 2013)	2041	2022	2037	2071	2072	2073	2084	2105	2111	2113
Precision: StdDev (1 $\sigma$ ) on 1 min avg data over 24 hours	< 1 ppb	< 1 ppb	0.18	0.21	0.2	0.29	0.21	0.15	0.19	0.2	0.2	0.3
Long Term Variability: StdDev (1 $\sigma$ ) on 20 min avg data over a month	< 0.5 ppb							0.16				
Long Term Variability: Peak-to-peak on 20 min avg data over a month	< 2 ppb							0.77				
Precision: StdDev (1-sigma) on hour averaged raw data over 24 hr		< 0.5 ppb	0.11	0.14	0.13	0.26	0.17	0.09	0.12	0.14	0.1	0.2
Precision: Peak-to-peak on 1 min avg data over 24 hr		< 2 ppb	1.35	1.86	1.34	1.55	1.38	0.95	1.04	1.39	1.2	1.6
Precision: Peak-to-peak on 1 hr avg data over 24 hr		< 1.5 ppb	0.46	0.59	0.53	0.88	0.69	0.34	0.39	0.62	0.4	0.7
Reproducibility: StdDev (1 $\sigma$ ) on 10 min avg data over a 72 hr		< 0.5 ppb	0.17	0.24	0.34	0.16	0.2	0.19	0.18	0.24	0.25	0.15
Reproducibility: Peak-to-peak on 10 min avg data over a 72 hr		< 2 ppb	0.57	0.71	1.26	0.58	0.72	0.67	0.93	0.8	0.55	0.8
Response Time: 10%-90% on minute averaged raw data		$\leq$ 2 minutes	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Response Time: 90%-10% on minute averaged raw data		$\leq$ 2 minutes	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
		STATUS	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
		STATUS	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK



## CO Performance

Test	ICOS Specifications		ATC TestLab results								Picarro results	
	First Draft	Spec (Aug. 2013)	2041	2022	2037	2071	2072	2073	2084	2105	2111	2113
Precision: StdDev (1 $\sigma$ ) on 1 min avg data over 24 hours	< 1 ppb	< 2 ppb	1.55	1.37	1.57	1.2	2.12	1.1	2.56	0.99	1.4	0.9
Long Term Variability: StdDev (1 $\sigma$ ) on 20 min avg data over a month	< 0.7 ppb							0.48				
Long Term Variability: Peak-to-peak on 20 min avg data over a month	< 3 ppb							2.39				
Precision: StdDev (1-sigma) on hour averaged raw data over 24 hr		< 1 ppb	0.65	0.55	0.18	0.38	1.84	0.24	2.19	0.15	0.3	0.2
Precision: Peak-to-peak on 1 min avg data over 24 hr		< 15 ppb	10.76	10.11	9.74	7.47	12.38	7.41	15.81	6.1	8.8	6.1
Precision: Peak-to-peak on 1 hr avg data over 24 hr		< 2 ppb	2.48	1.74	0.76	1.58	7.09	0.81	7.65	0.55	1	0.7
Reproducibility: StdDev (1 $\sigma$ ) on 10 min avg data over a 72 hr		< 1 ppb	1.23	1.67	0.35	0.93	2.8	0.74	1.12	0.34	0.55	0.45
Reproducibility: Peak-to-peak on 10 min avg data over a 72 hr		< 3 ppb	4.77	5.02	1	3.03	8.41	2.83	4.4	1.14	1.75	1.75
Response Time: 10%-90% on minute averaged raw data		≤ 2 minutes	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Response Time: 90%-10% on minute averaged raw data		≤ 2 minutes	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
STATUS			NOK	NOK	OK	NOK	NOK	OK	NOK	OK	OK	OK
STATUS			NOK	NOK	NOK	NOK	NOK	NOK	NOK	OK	NOK	OK

For CO<sub>2</sub> and CH<sub>4</sub>: the G2401 (G2301 as well) fulfills the demanding ICOS specifications.

For CO: the latest instruments produced by Picarro (with Hardware upgrade to avoid atmospheric pressure sensitivity) fulfills the ICOS specifications.

Performance confirmed in the field (CFKADS-2073 at ERS station).

Note the inter (heterogeneous) and intra instrument performance result variability.

Reproducibility test must be performed at least twice at the atmospheric pressure (not controlled). Focus on the potential atmospheric pressure sensitivity.

# LGR Analyzer

## CO/N2O Analyzer Performance test results:

CO (ppb)	LGR-EP-38	LGR-EP-40	LGR-DLT100
Precision (1 $\sigma$ , 3 min Avg)	0.08	0.02	0.01
24h Drift (peak to peak)	0.27	0.15	0.35
Repeatability (5 min Avg) 1 $\sigma$ / MaxDrift	0.09 / 0.29	0.03 / 0.08	0.08 / 0.28
Reproducibility (5 min Avg) 1 $\sigma$ / MaxDrift	0.2 / 0.6	0.2 / 0.6	0.7 / 2.4
Temperature Influence (/°C)	0	0.03	0.07
Water vapor correction Bias (up to 2%v H2O)	<0.3	<0.1	<1
Calibration drift (/month)	<5	<1	<4
Linearity (residuals from calibration linear fit)	<0.4	<0.3	<0.9

The LGR CO/N2O analyzer fulfills the ICOS specifications for CO

## CO2/CH4 Analyzer

LGR has developed a new version of its CO2/CH4 (GGA-24EP) analyzer with announced better performance. It will be tested soon at the ATC TestLab.

