Final Report of the Proficiency Testing in Vehicles Emissions 6th Round

Inmetro
Instituto Nacional de Metrologia, Qualidade e Tecnologia

PEP-Inmetro

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PROFICIENCY TESTING IN VEHICLES EMISSIONS - 6TH ROUND

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SUMÁRIO

1. Introduction

The problem of air pollution is a serious threat to human health, decreasing their quality of life. The vehicles are potential agents of pollution worldwide. Gas emissions from vehicles carry several toxic substances which, in some cases, in contact with the respiratory system, can produce several negative health effects and cause traffic accidents due to decreased visibility.

The analysis of pollutants is one of the most delicate items of a vehicle or an engine emission test. The Proficiency Testing Schemes (PT Scheme) of automotive emissions evaluate laboratories by the determination of the compound amounts in vehicle emissions, providing then subsidies to laboratories to identify and solve analytical problems, contributing to the harmonization of emission measurements in the country.

Proficiency testing scheme is a quality tool for the identification of interlaboratory differences, but the assessment is punctual. A PT Scheme aims to compare measurement results from different laboratories, performed under similar conditions, and then obtain an assessment of the technical competence of participating laboratories in order to demonstrate the reliability of their measurement processes. The participating laboratories, in their turn, have the opportunity to review their analysis procedures and implement improvements in their processes, if necessary.

Besides the evaluations of laboratory performances, other main goals of a PT Scheme can be listed:

- Identification of laboratory problems that can lead to improvement actions related measurement procedures, effectiveness of staff training and supervision, or calibration of equipment;
- Confidence to the laboratory customers;
- Establishment of the effectiveness and comparability of test or measurement methods;
- Identification of interlaboratory diferences;
- Improvement of the laboratory processes based on the outcomes obtained during the interlaboratorial comparison;
- Validation of uncertainty claims.

In this round, the following vehicle emission parameters were evaluated: (CO, CO_2, THC, NOx, NMHC, NMHC-ETOH, Total aldehydes (formaldehyde + acetaldehyde) and ETOH) in g/km, urban autonomy and road autonomy in km/L. In this round, a new parameter, the deceleration time of the vehicle in seconds was be introduced, but the evaluation of laboratory performance wasn´t carried, just a comparison of the data analysis among the participating laboratories. The deceleration time of the vehicle was determined in various speed ranges, as shown in the Protocol. The deceleration times were statistically compared with those values provided by CETESB. The points of gear shifts

were established at 25, 40, 65 and 72 km/h. Ten parameters were evaluated with participation of sixteen laboratories, one more than the last round.

This report presents the results of the performance evaluation of participants, the methodology used in the tests and the procedure used for the statistical analysis.

The objectives of this PT scheme were:

- To determine the performance of laboratories for the proposed tests;
- To monitor the ongoing performance of the analytical vehicle emissions laboratories;
- To identify problems in laboratories;
- To increase the confidence of the measuring emission process of the vehicle emission laboratories;
- To improve continuously the measurement techniques of vehicle emissions laboratories.

2. Materials and Methods

2.1. Test Item

The test item is a vehicle supplied by PSA Peugeot Citroën Brazil having the following characteristics: Model Citroen C3 chassis 935SLNFNYEB529146 EC5JP4 engine (1587 cm3, 16 V) of manual 5-speed transmission, Flex Fuel, equivalent inertia of 1247 kg. The test vehicle was correlated without the purge system of the blow-by gas canister and exhaust, since there wasn´t, in this edition, evaporative emission measurement. Each participating laboratory should use its own fuel (E100 – reference hydrated ethanol).

2.2. Methodology

The standard methods used for emission measurements were ABNT NBR 6601, 7024, 12026 and 15598. The tests defined by these standard methods are complementary and were carried out simultaneously. The values of deceleration times (coast down) were provided by the CETESB emission laboratory to the participants in order to adjust their dynamometers and reproduce the deceleration times. The laboratories should replicate the deceleration times in the dynamometer informed of vehicular emission by CETESB.

The laboratories were instructed to start testing at of 25 ℃ temperature in order to minimize the effects of the cold start results.

3. Test Item Conditions

The results of CETESB emission laboratory that were performed in the beginning, in the middle and in the end of the round were used to statistically evaluate the integrity of the test item. For the 10 analyzed parameters (CO, CO2, THC, NMHC, NMHC - ETOH, NOx, Total Aldehydes, ETOH, Urban

Autonomy and Road Autonomy), the results were the same, with *p-value* greater than 0.05. Therefore it can be stated that there is no statistically significant difference between the means at a confidence level of 95%, the sample data can be regarded as arising from the same population. Thus, the vehicle remained intact during the course of this Proficiency Test.

Due to the confidentiality of the results, as Cetesb participates in the PT, these results are not shown.

4. Evaluation of Performance

4.1. *Z*-score

For performance evaluation of the individual participant results, one of the criteria described in ABNT NBR ISO/IEC 17043:2011 was carried out, the *z*-score (measure of the relative distance of the participant measurement result from the assigned value of the PT), that was calculated according to the equation 1.

$$z_i = \frac{x_i - X}{\hat{\sigma}} \quad (1)$$

Where:

x_i = is the average result of each participant

X = is the assigned value for this PT;

$\hat{\sigma}$ = is the standard deviation for the PT, which was calculated in this round based on ISO 13528:2005, a robust standard deviation based on the results of the participants.

The interpretations of the *z*-score are presented as follows:

|z| ≤ 2,0 - Indicates “satisfactory” performance and generates no signal;

2,0 < |z| <3,0 - Indicates “questionable” performance and generates a warning signal;

|z| ≥ 3,0 - Indicates “unsatisfactory” performance and generates an action signal.

5. Assigned Values

According to the available procedures, to establish assigned values in ABNT NBR ISO/IEC 17043:2011, the assigned values of this PT were calculated using statistical methods according to ISO 13528:2005, by consensus values of participants.

ISO 13528: 2005 describes the robust analysis involving the use of the “A” estimation algorithm for the calculation of the assigned value and the standard deviation. Robust statistical techniques are used to minimize the influence that extreme results can have on the average and standard deviation. Therefore, the coordination of this PT adopted the following approach: The assigned value derived from the calculation of robust statistics presented in section 5.6 of the ISO 13528: 2005, which is a specific standard statistical method for use in a PT by interlaboratory comparisons.

Initially, all objects analysis values (values sent by the participants) were placed in ascending order. The following, values of robust average and robust standard deviation of these data by (x*) and (S*) were denoted. The initial values of (x*) and (s*) were calculated according to the following equations:

$$x^* = median\ of\ x_i \tag{2}$$

$$s^* = 1{,}483 \times median\ \left|x_i - x^*\right| \tag{3}$$

The values of (x^*) e (s^*) were updated as follows:

$$\delta = 1{,}5 s^* \tag{4}$$

For each x_i (i = 1, 2,..., p), it was calculated:

$$x_i^* = \begin{cases} x^* - \delta, & if \quad x_i < x^* - \delta \\ x^* + \delta, & if \quad x_i > x^* + \delta \\ x_i, & otherwise \end{cases} \tag{5}$$

new values of (x^*) e (s^*) should be calculated from the equations:

$$x^* = \sum x_i^* \ / \ p \tag{6}$$

$$s^* = 1{,}134 \sqrt{\sum \left(x_i^* - x^*\right)^2 / (p-1)} \tag{7}$$

Where the summation is over i.

The robust estimation (x^*) and (s^*) can be obtained by an iterative calculation, i. e. by updating the values of (x^*) and (s^*) several times using the modified data, until the process converges. Convergence may be assumed when there is no change from one iteration to the next in the third significant figure of the robust standard deviation and of the equivalent figure in the robust average.

The table below presents the average values for robust average calculation (assigned value) and robust standard deviation for each parameter of the PT.

Table 01: Assigned Values and standard deviation of the PT.

Parameter	Assigned Value	Standard Deviation
CO (g/km)	0,732	0,147
CO_2(g/km)	170,3	5,9
THC (g/km)	0,051	0,006
NMHC (g/km)	0,031	0,005
NMHC - ETOH (g/km)	0,012	0,004
NO_x (g/km)	0,026	0,007
Total aldehydes (g/km)	0,0050	0,0004
ETOH (g/km)	0,0490	0,0113
Urban autonomy (km/L)	8,39	0,28
Road autonomy (km/L)	12,57	0,49

6. Dispersion Results

Figures 01 to 10 presents graphically the means and standard deviations of the results reported by the laboratories for each analyzed parameter.

The assigned value is represented by a continuous line and each laboratory is identified only by the last number of its identification code. Dotted lines are representations of Ref ± 1s and ± 2s, where "ref" is the assigned value (robust average) and "s" is the robust standard deviation.

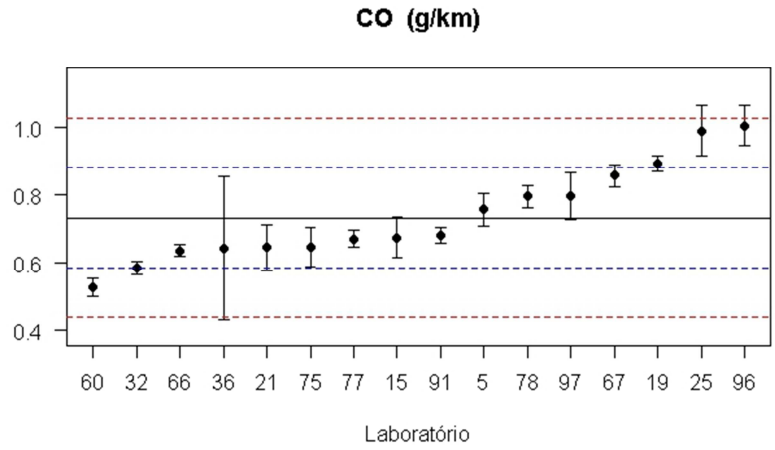

Figure 01 – Scatter plot of the results for CO determination

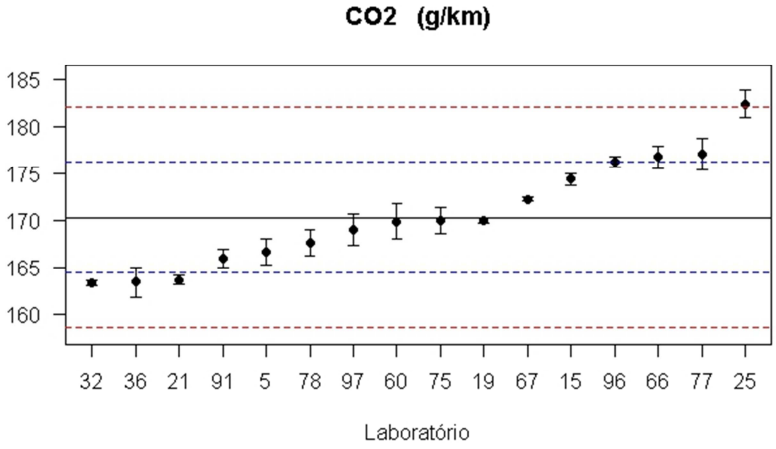

Figure 02 – Scatter plot of the results for CO_2 determination

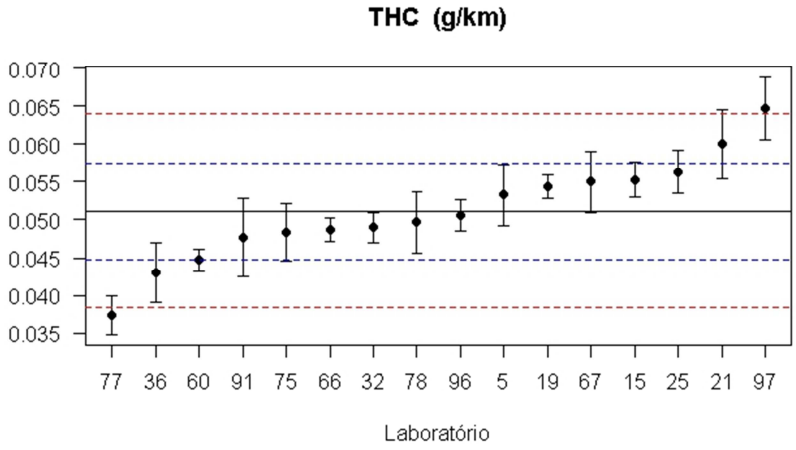

Figure 03 – Scatter plot of the results for THC determination

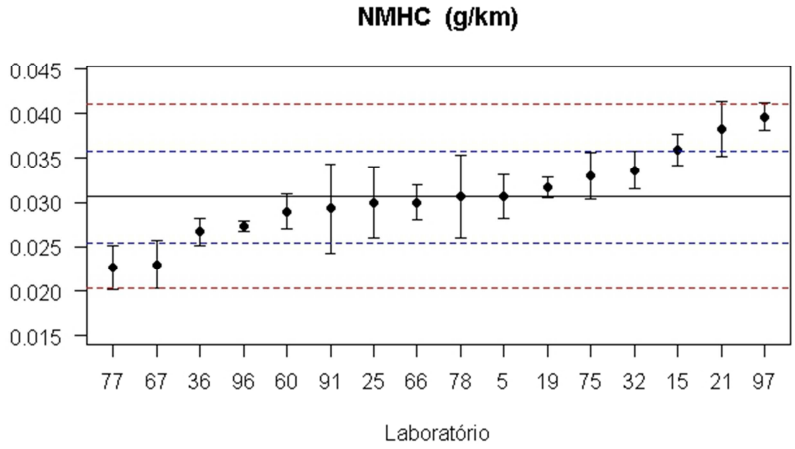

Figure 04 – Scatter plot of the results for NMHC determination

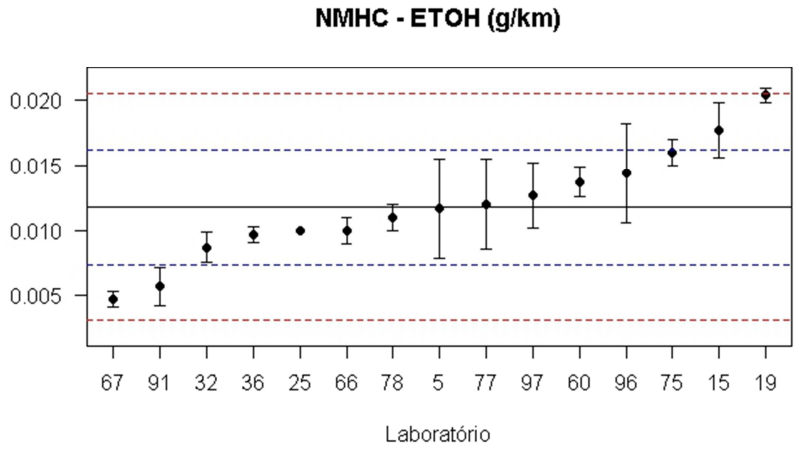

Figure 05 – Scatter plot of the results for NMHC – ETOH determination

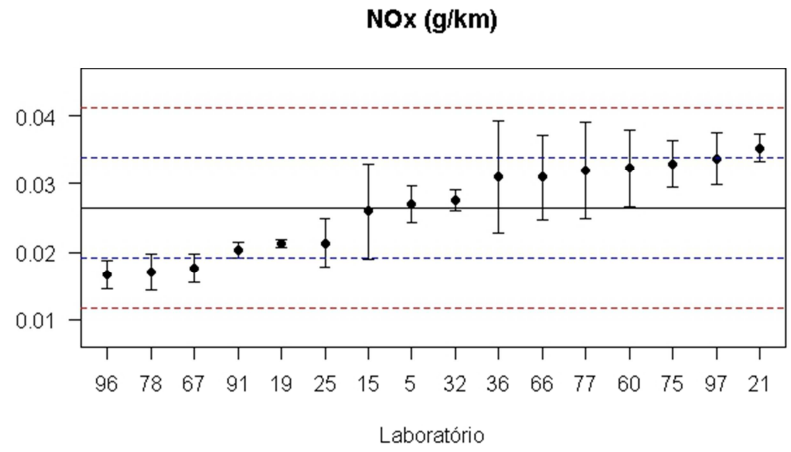

Figure 06 – Scatter plot of the results for NO_x determination

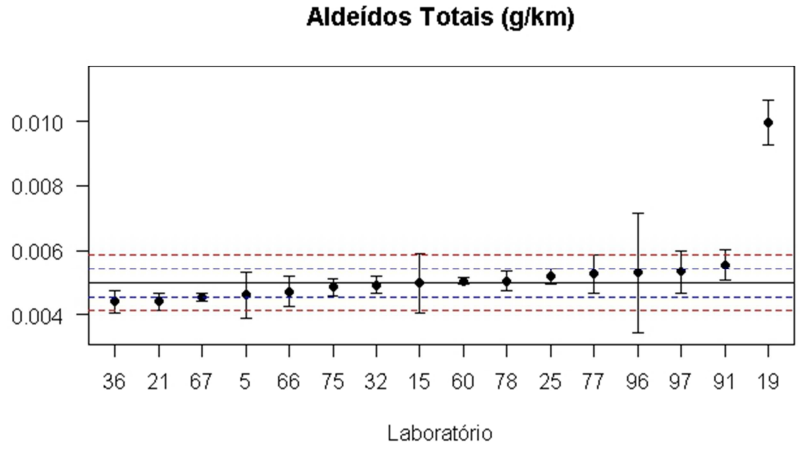

Figure 07 – Scatter plot of the results for Total Aldehydes determination

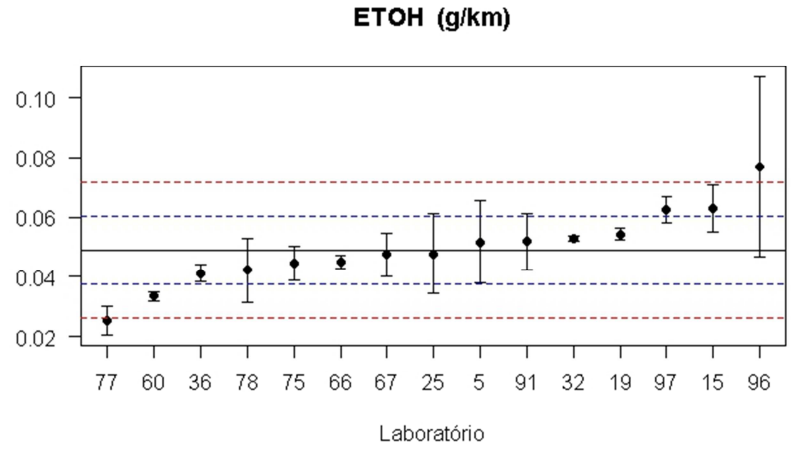

Figure 08 – Scatter plot of the results for ETOH determination

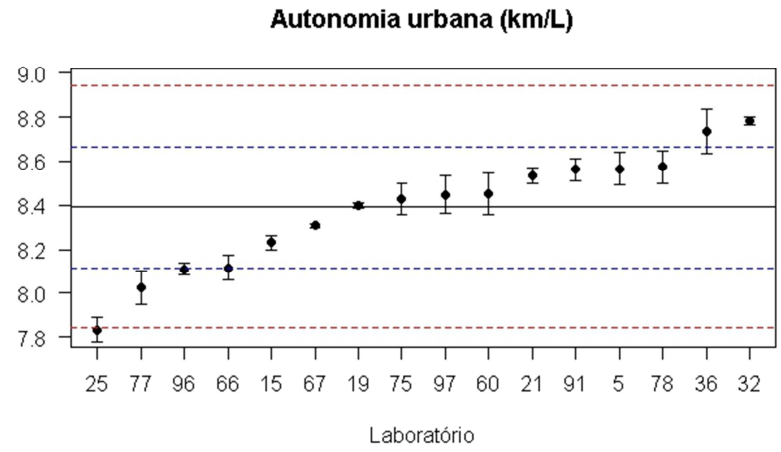

Figure 09 – Scatter plot of the results for Urban Autonomy determination

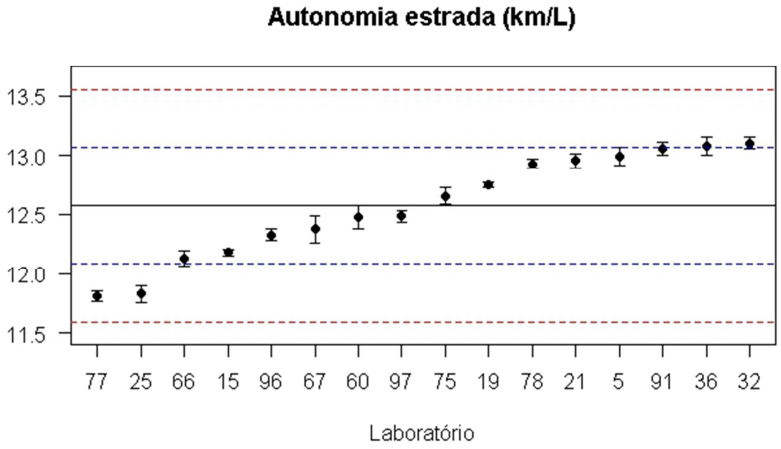

Figure 10 – Scatter plot of the results for Road Autonomy determination

Through the graphs, it can be seen that:

- CO (g/km): All laboratories presented results between the range Ref ± 2*s* and 12 of the 16 laboratories had results between the range Ref ± 1s. The participant 36 had the highest standard deviation for this parameter.
- CO_2 (g/km): Only the participant 25 had a result outside the range Ref ± 2s and 10 laboratories presented results between the range Ref ± 1s. The participant 25 had the highest average for this parameter.
- THC (g/km): Only the participants 77 and 97 had results outside the range Ref ± 2s and 12 laboratories presented results between the range Ref ± 1s.
- NMHC (g/km): All laboratories had results between the range Ref ± 2s and 12 laboratories presented results between the range Ref ± 1s.
- NMHC - ETOH (g/km): All laboratories had results between the range Ref ± 2s and 11 laboratories presented results between the range Ref ± 1s. The participant 21 did not send results for this parameter.

- NO_x (g/km): All laboratories showed results between the range Ref ± 2s and 12 laboratories between the range Ref ± 1s.
- Total Aldehydes (g/km): Only the participant 19 presented the result outside of the range Ref ± 2s and 11 laboratories presented results between the range Ref ± 1s. The participant 96 had the highest standard deviation of the measurements among the laboratories and the participant 19 presented the dispersed average measurements comparing to the other participants.
- ETOH (g/km): Only the participants 77 and 96 showed results outside the range Ref ± 2s and 10 laboratories presented results between the range Ref ± 1s. The participant 21 did not send results for this parameter.
- Urban Autonomy (km/L): Only the participant 25 showed a result outside of the range Ref ± 2s and 12 laboratories presented results between the range Ref ± 1s.
- Road Autonomy (km/L): All laboratories showed results between the range Ref ± 2s and 12 laboratories presented results between the range Ref ± 1s.

7. Laboratories' Results

In this report each participant is identified only by the last number of its identification code in the tables and graphs.

The tables 02 to 04 show the averages and standard deviations for each participant, where the result is the average value of the replicates.

Note: It was considered all the decimal places for calculations, but the values in the tables below were rounded to the same number of decimal places as requested results form.

Table 02 – Average and standard deviation of the participants for the parameters CO, CO_2, THC, NMHC and NMHC - ETOH (g/km)

Labs' Code	CO (g/km)		CO_2 (g/km)		THC (g/km)		NMHC (g/km)		NMHC - ETOH (g/km)	
	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
05	0,757	0,048	166,6	1,4	0,053	0,004	0,031	0,003	0,012	0,004
15	0,675	0,060	174,4	0,7	0,055	0,002	0,036	0,002	0,018	0,002
19	0,893	0,024	170,0	0,3	0,054	0,002	0,032	0,001	0,020	0,001
21	0,644	0,067	163,6	0,5	0,060	0,005	0,038	0,003		
25	0,990	0,076	182,4	1,5	0,056	0,003	0,030	0,004	0,010	0,000
32	0,586	0,020	163,2	0,3	0,049	0,002	0,034	0,002	0,009	0,001
36	0,642	0,211	163,4	1,6	0,043	0,004	0,027	0,002	0,010	0,001
60	0,528	0,026	169,8	1,9	0,045	0,002	0,029	0,002	0,014	0,001
66	0,636	0,018	176,7	1,2	0,049	0,002	0,031	0,002	0,010	0,001
67	0,856	0,034	172,2	0,2	0,055	0,004	0,023	0,003	0,005	0,001
75	0,646	0,057	169,9	1,4	0,048	0,004	0,033	0,003	0,016	0,001
77	0,671	0,024	177,1	1,7	0,037	0,003	0,023	0,003	0,012	0,003
78	0,794	0,032	167,6	1,4	0,050	0,004	0,031	0,005	0,011	0,001
91	0,681	0,022	165,9	1,0	0,048	0,005	0,029	0,005	0,006	0,002
96	1,006	0,060	176,2	0,5	0,051	0,002	0,027	0,001	0,014	0,004
97	0,797	0,070	168,9	1,7	0,065	0,004	0,040	0,002	0,013	0,003

Table 03 – Average and standard deviation of the participants for the parameters NO_x, Total Aldehydes and ETOH (g/km).

Labs' Code	NO_x (g/km)		Total Aldehydes (g/km)		ETOH (g/km)	
	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
05	0,027	0,003	0,0046	0,0007	0,0516	0,0138
15	0,026	0,007	0,0050	0,0009	0,0630	0,0079
19	0,021	0,001	0,0100	0,0007	0,0544	0,0022
21	0,035	0,002	0,0044	0,0003		
25	0,021	0,004	0,0052	0,0003	0,0477	0,0133
32	0,028	0,002	0,0049	0,0003	0,0528	0,0009
36	0,031	0,008	0,0044	0,0003	0,0411	0,0028
60	0,032	0,006	0,0050	0,0001	0,0335	0,0015
66	0,031	0,006	0,0047	0,0005	0,0449	0,0023
67	0,018	0,002	0,0045	0,0001	0,0474	0,0074
75	0,033	0,003	0,0048	0,0003	0,0446	0,0058
77	0,032	0,007	0,0053	0,0006	0,0253	0,0047
78	0,017	0,003	0,0050	0,0003	0,0422	0,0109
91	0,020	0,001	0,0055	0,0005	0,0518	0,0093
96	0,017	0,002	0,0053	0,0019	0,0768	0,0302
97	0,034	0,004	0,0053	0,0007	0,0625	0,0042

Table 04 – Average and standard deviation of the participants for the parameters Urban Autonomy (km/L) and Road Autonomy (km/L)

Labs' Code	Urban Autonomy (km/L)		Road Autonomy (km/L)	
	Average	Standard deviation	Average	Standard deviation
05	8,57	0,08	12,99	0,08
15	8,23	0,03	12,18	0,02
19	8,40	0,01	12,75	0,02
21	8,54	0,04	12,96	0,06
25	7,83	0,06	11,83	0,07
32	8,78	0,02	13,10	0,05
36	8,73	0,10	13,08	0,08
60	8,45	0,10	12,48	0,10
66	8,12	0,06	12,12	0,07
67	8,31	0,01	12,37	0,11
75	8,43	0,07	12,65	0,07
77	8,03	0,08	11,81	0,05
78	8,57	0,08	12,93	0,04
91	8,56	0,05	13,05	0,06
96	8,11	0,03	12,33	0,05
97	8,45	0,09	12,48	0,05

For the performance evaluation of the participants, *z*-score values were calculated, using the robust average and robust standard deviation of the results for each parameter as assigned value and its standard deviation. Tables 05 and 06 and figures 11 to 20 show these results.

Table 05 – *z*-score values

CO (g/km)		CO_2 (g/km)		THC (g/km)		NMHC (g/km)		NMHC - ETOH (g/km)	
Lab	***z* scores**	**Lab**	***z* scores**	**Lab**	***z* scores**	**Lab**	***z* scores**	**Lab**	***z* scores**
05	0,2	05	-0,6	05	0,3	05	0,0	05	0,0
15	-0,4	15	0,7	15	0,7	15	1,0	15	1,4
19	1,1	19	-0,1	19	0,5	19	0,2	19	2,0
21	-0,6	21	-1,1	21	1,4	21	1,5	21	NM
25	1,8	25	2,0	25	0,8	25	-0,1	25	-0,4
32	-1,0	32	-1,2	32	-0,3	32	0,6	32	-0,7
36	-0,6	36	-1,2	36	-1,3	36	-0,8	36	-0,5
60	-1,4	60	-0,1	60	-1,0	60	-0,3	60	0,4
66	-0,7	66	1,1	66	-0,4	66	-0,1	66	-0,4
67	0,8	67	0,3	67	0,6	67	-1,5	67	-1,6
75	-0,6	75	-0,1	75	-0,4	75	0,4	75	1,0
77	-0,4	77	1,2	77	-2,2	77	-1,5	77	0,1
78	0,4	78	-0,5	78	-0,2	78	0,0	78	-0,2
91	-0,3	91	-0,8	91	-0,5	91	-0,3	91	-1,4
96	1,9	96	1,0	96	-0,1	96	-0,6	96	0,6
97	0,4	97	-0,2	97	2,1	97	1,7	97	0,2
Are highlighted in blue questionable values. NM = Not measured									

Table 06 – *z*-score values (continuation)

NO_x (g/km)		Total Aldehydes (g/km)		ETOH (g/km)		Urban Autonomy (km/L)		Road Autonomy (km/L)	
Lab	***z* scores**	**Lab**	***z* scores**	**Lab**	***z* scores**	**Lab**	***z* scores**	**Lab**	***z* scores**
05	0,1	05	-0,9	05	0,2	05	0,6	05	0,9
15	-0,1	15	0,0	15	1,2	15	-0,6	15	-0,8
19	-0,7	19	11,5	19	0,5	19	0,0	19	0,4
21	1,2	21	-1,3	21	NM	21	0,5	21	0,8
25	-0,7	25	0,4	25	-0,1	25	-2,0	25	-1,5
32	0,2	32	-0,2	32	0,3	32	1,4	32	1,1
36	0,6	36	-1,3	36	-0,7	36	1,2	36	1,0
60	0,8	60	0,1	60	-1,4	60	0,2	60	-0,2
66	0,6	66	-0,6	66	-0,4	66	-1,0	66	-0,9
67	-1,2	67	-1,0	67	-0,1	67	-0,3	67	-0,4
75	0,9	75	-0,3	75	-0,4	75	0,1	75	0,2
77	0,8	77	0,7	77	-2,1	77	-1,3	77	-1,5
78	-1,3	78	0,1	78	-0,6	78	0,7	78	0,7
91	-0,8	91	1,3	91	0,2	91	0,6	91	1,0
96	-1,3	96	0,7	96	2,4	96	-1,0	96	-0,5
97	1,0	97	0,8	97	1,2	97	0,2	97	-0,2
Are highlighted in blue questionable values and in red unsatisfactory values. NM = Not measured									

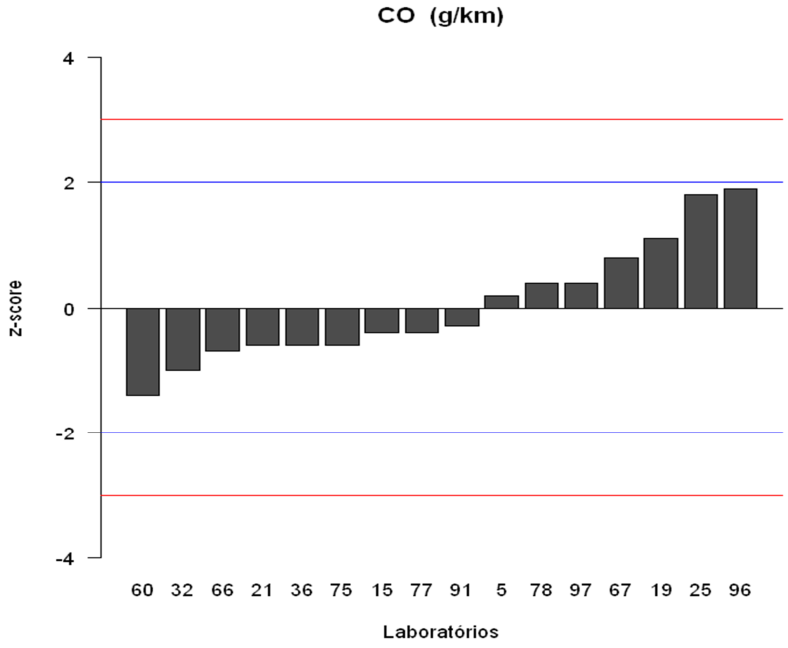

Figure 11 – *z*-score graph for CO measurement

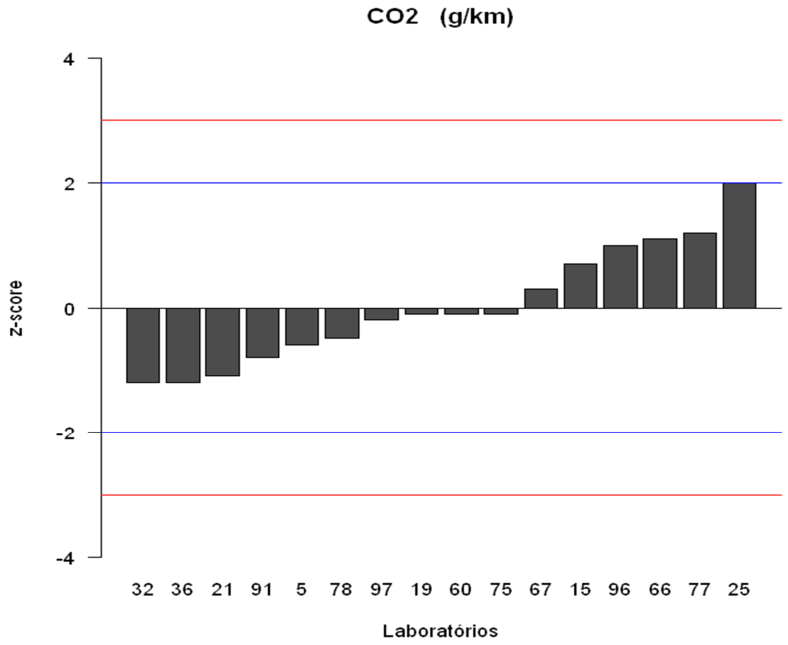

Figure 12 – *z*-score graph for CO_2 measurement

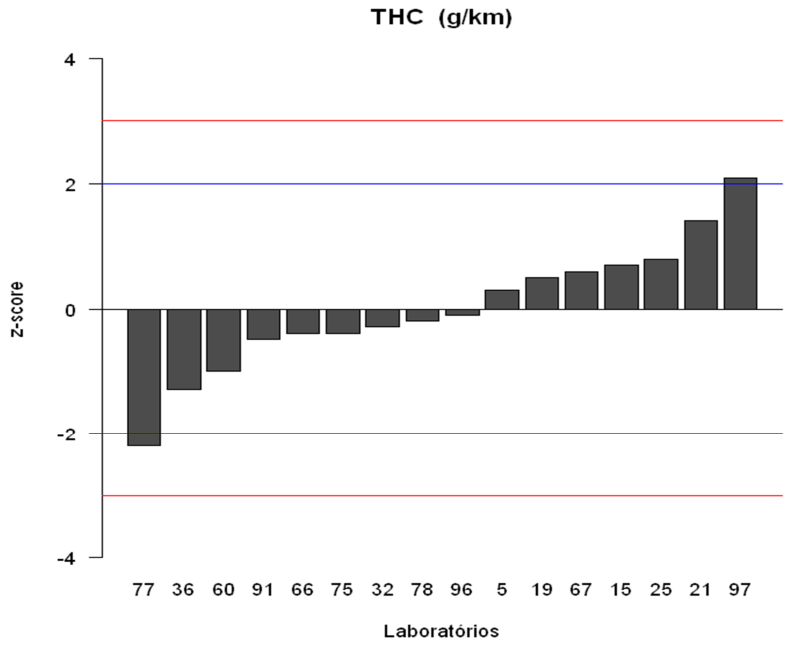

Figure 13 – *z*-score graph for THC measurement

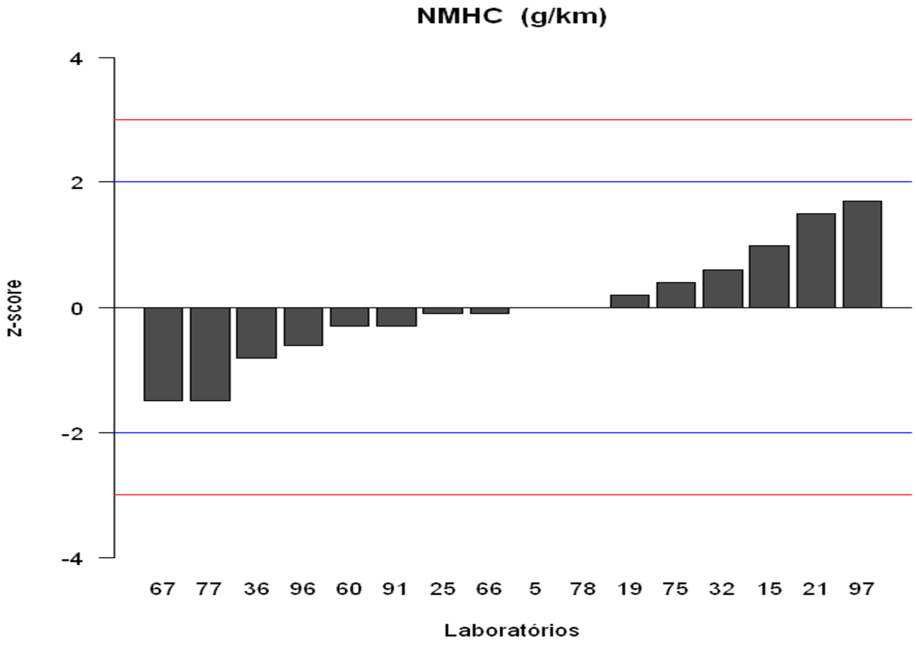

Figure 14 – *z*-score graph for NMHC measurement

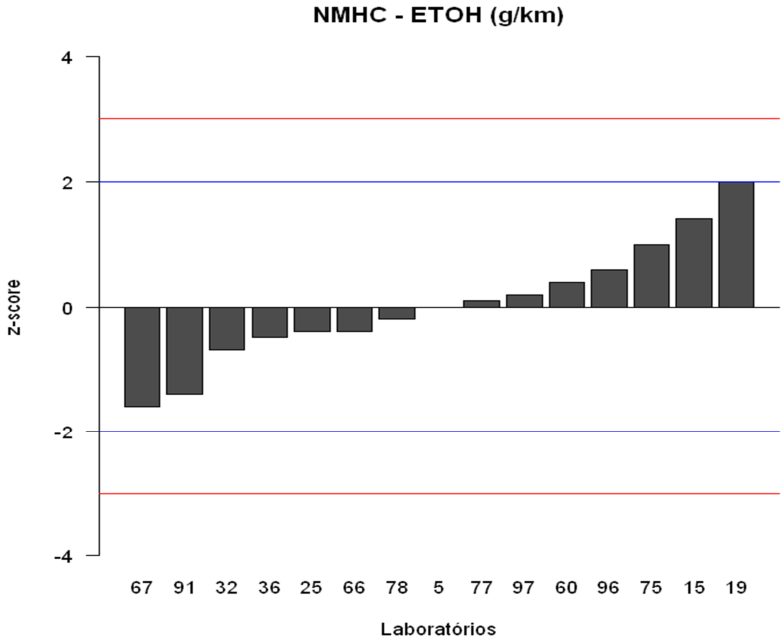

Figure 15 – *z*-score graph for NMHC-ETOH measurement

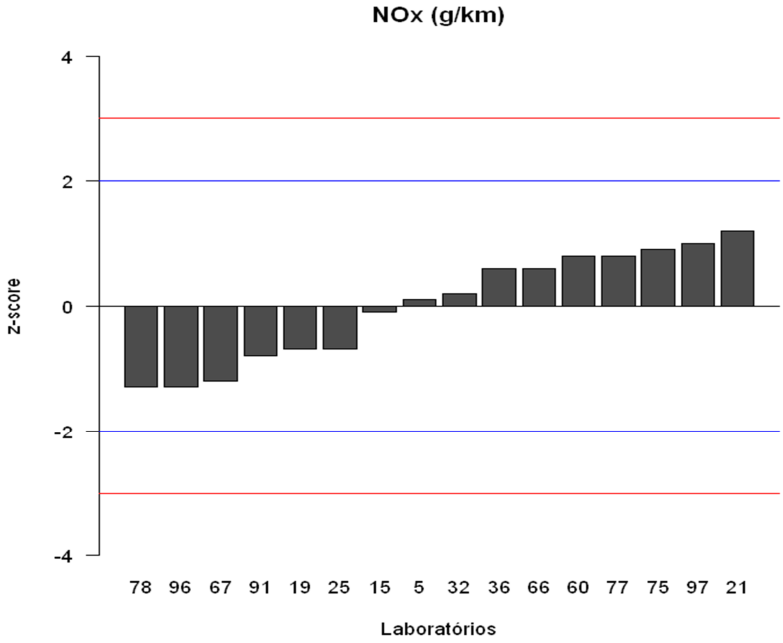

Figure 16 – *z*-score graph of for NO_x measurement

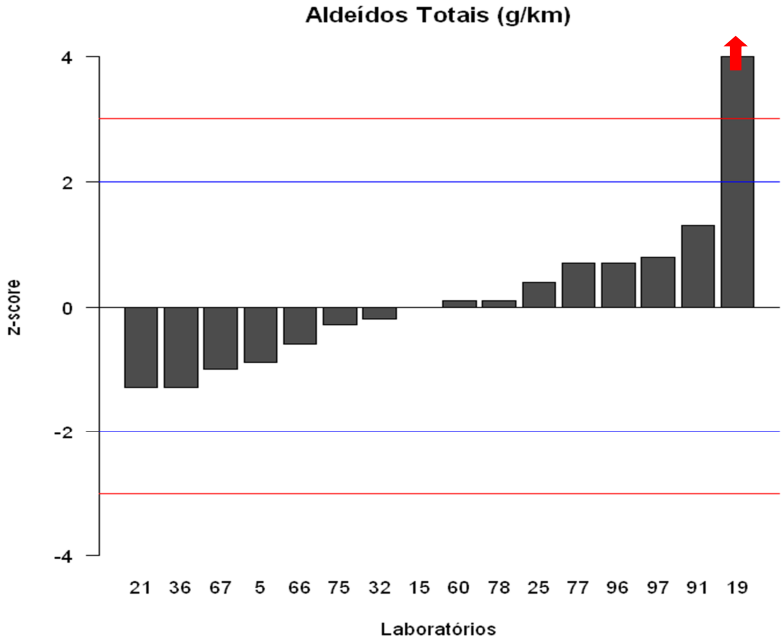

Figure 17 – *z*-score graph for Total Aldheydes measurement

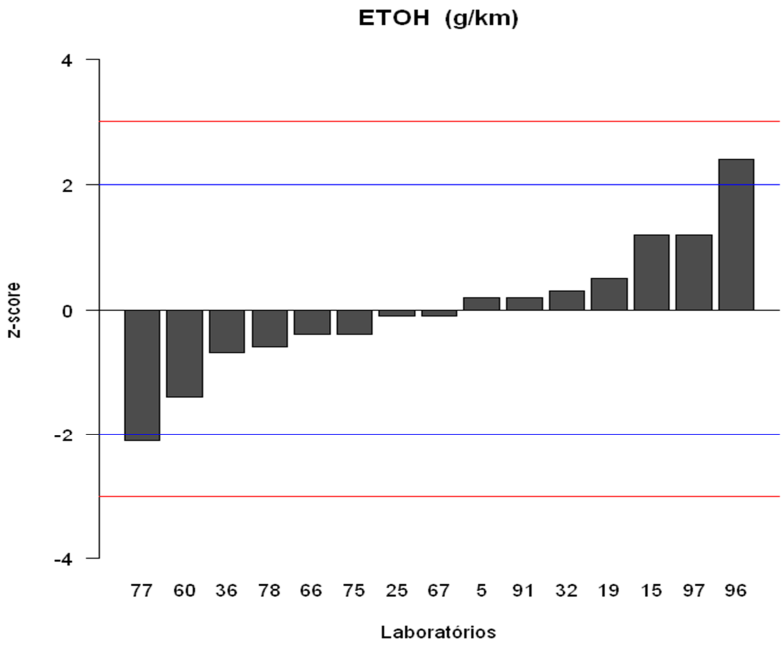

Figure 18 – *z*-score graph for ETOH measurement

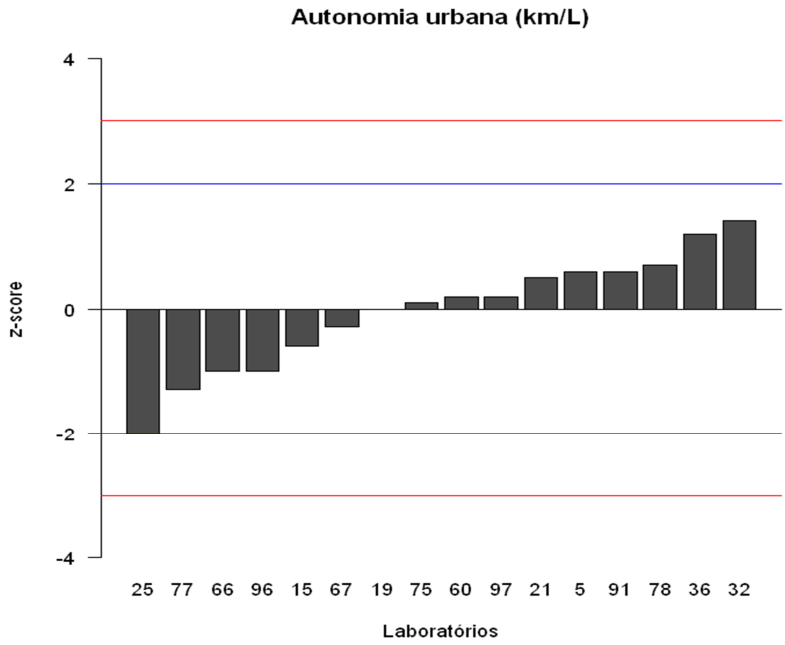

Figure 19 – *z*-score graph for Urban Autonomy measurement

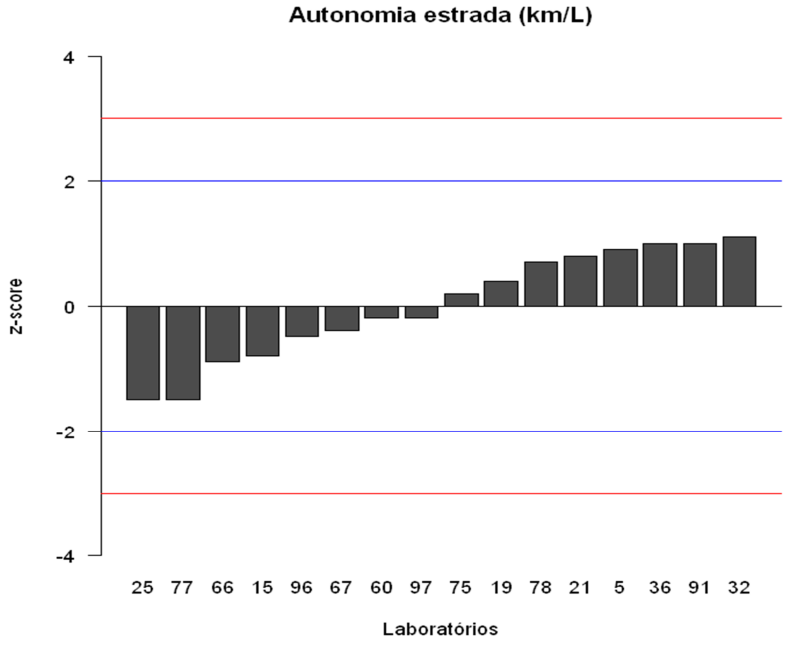

Figure 20 – *z*-score graph of for Road Autonomy measurement

Through *z*-score analysis, it can be seen that:

- CO (g/km): all participants presented satisfactory results.
- CO_2 (g/km): all participants presented satisfactory results.
- THC (g/km): The participants 77 and 97 showed questionable results.
- NMHC (g/km): all participants presented satisfactory results.
- NMHC – ETOH (g/km): all participants presented satisfactory results.

- NO_x (g/km): all participants presented satisfactory results.
- Total Aldehydes (g/km):. Only the participant 19 showed unsatisfactory result.
- ETOH (g/km): The participants 77 and 96 showed questionable results.
- Urban Autonomy (km/L): all participants presented satisfactory results.
- Road Autonomy (km/L): all participants presented satisfactory results.

8. Deceleration times of the vehicle (Coast Down)

Table 07 presents deceleration times of the vehicle (coast down) that were obtained by participants.

Table 07 – Results of the vehicle deceleration times obtained by PT participants.

Speed Range (km/h)	Obtained time (s)															
	Participants Code															
	5	15	19	21	25	32	36	60	66	67	75	77	78	91	96	97
95-85	7,8	7,3	7,6	7,7	7,7	7,9	7,8	7,7	7,0	7,8	7,7	7,5	7,7	7,7	7,6	7,7
85-75	9,0	8,5	9,1	9,0	9,1	9,1	9,1	9,0	8,2	9,0	9,0	8,9	8,9	9,0	8,9	9,0
75-65	10,6	10,0	10,6	10,5	10,7	10,6	10,6	10,5	9,6	10,6	10,5	10,3	10,4	10,6	10,4	10,5
65-55	12,4	11,7	12,5	12,4	12,6	12,6	12,4	12,3	11,2	12,4	12,3	12	12,2	12,4	12,2	12,3
55-45	14,6	13,8	14,6	14,6	14,8	14,8	14,6	14,5	13,2	14,6	14,5	14,1	14,4	14,5	14,3	14,5
45-35	17,0	16,0	17,2	17,0	17,3	17,3	17,2	17,0	15,5	17,1	17,0	16,5	16,8	17,1	16,8	17,0
35-25	19,8	18,8	19,8	19,6	20,0	20	19,9	19,6	18,0	19,8	19,6	18,9	19,5	19,9	19,4	19,8
25-15	22,5	20,7	22,7	22,2	22,4	22,8	23	22,6	20,4	22,5	22,3	22	22,2	22,7	22,1	22,8

Deceleration time values (coast down) were provided by CETESB emission laboratory to the participants in order to adjust their dynamometers and reproduce the deceleration times. The results were statistically verified using statistical tests that depend on the distribution data.

So, the analysis was divided in two steps:

(i) Visual analysis of each curve concerning the normality of the participants' data using the qq-plot graph;

(ii) Individual test (*t* test) to evaluate the existence of a statistical difference between the measured data by the participants and the data obtained by CETESB.

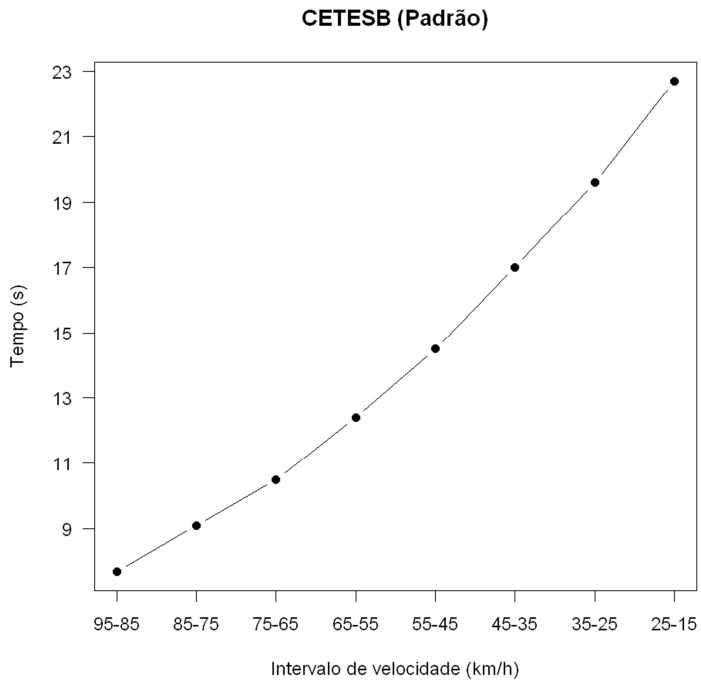

Figure 21 – Deceleration times graph (coast down) provided by the CETESB emission laboratory

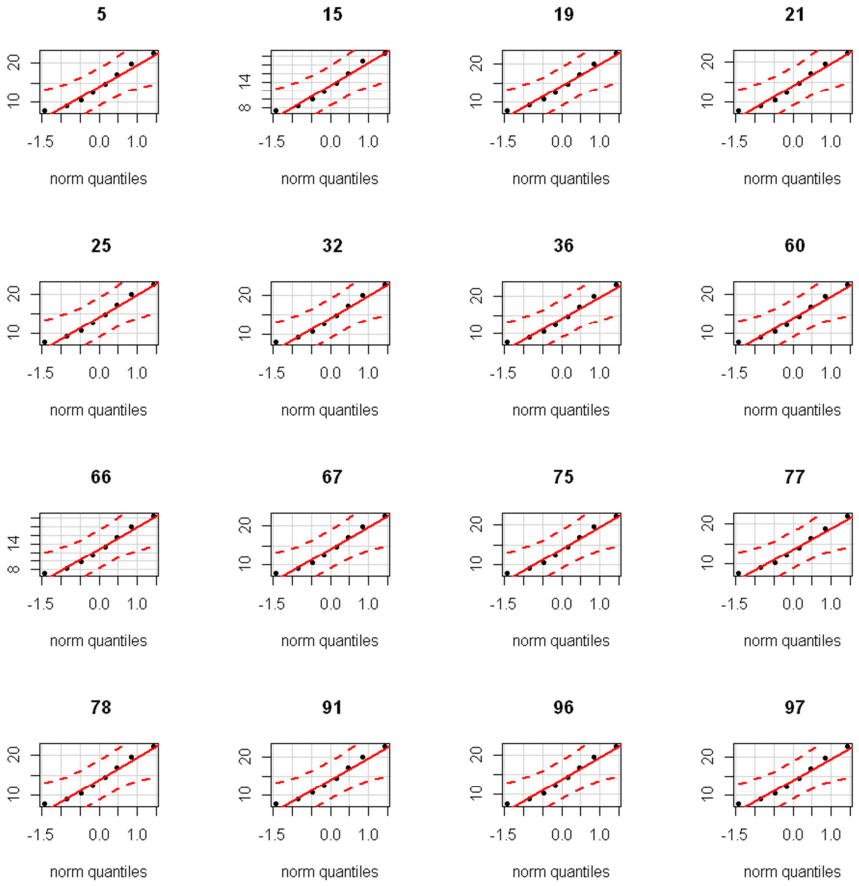

Figure 22 – Individual qq-plot graph for each PT participant

According to the observed results by the qq-plot graphs (Figure 22), it cannot reject the hypothesis of normality in any case, since all measurements are around the abscissa of the graph "quantile-quantile" and within the estimated confidence interval with 95% confidence level.

Thus, were performed tests between average difference between each laboratory and the Cetesb laboratory, showed in table 08.

Table 08 – Values of the *t* test for each participant

Lab	Statistics	p-values
05	-0,01	0,99
15	0,33	0,75
19	-0,03	0,98
21	0,02	0,98
25	-0,05	0,96
32	-0,08	0,94
36	-0,05	0,96
60	0,01	0,99
66	0,52	0,61
67	-0,01	0,99
75	0,03	0,98
77	0,16	0,88
78	0,07	0,95
91	-0,02	0,99
96	0,09	0,93
97	0	1

Table 08 shows a “p-value” for each laboratory and for all of them p> 0,05 with 95% confidence level. We can conclude that there is no statistical difference between the measurements of each laboratory and CETESB.

9. Confidentiality

Each participant was identified by an individual code that is known only by the participant and the coordination of this PT. The participant received, by email, his own code of identification corresponding to the participation in this PT. This code was used to identify the participant in the results registration formulary. The results may be used in studies and publications by INMETRO respecting the confidentiality of each participant.

As established in section 4.10.4 of ABNT ISO/IEC 17043:2011, in exceptional circumstances, a regulatory authority may require the results and the identification of the participants to the PT provider. If this occurs, the provider will notify the PT participants about this action.

10. Conclusions

The Proficiency Testing Schemes in vehicle emissions is a type of study carried out only in Brazil and considering the particular features of such study, we can conclude that the results are very satisfactory and this initiative is very important to the industry and society. The collaboration between Inmetro and AEA has been very productive for all six PT rounds.

The test vehicles emission involves a large number of variables that influence the results, so it is recommended that participants who had questionable performance make a critical analysis of their measurement methods.

In general, the results obtained by the participants showed good performance measurements, where 96,8% of the results were satisfactory. It was observed four questionable results (2,5%) and just one unsatisfactory result (0,6%). Comparing to the previous round, where it was observed 94% of satisfactory results for a total of fifteen participants, the data show that at each round participants are improving their methods of measurement. In the last round 73% of the reported results were in the ranges of *z*-score between ± 1 while this level increased to 75,8% in this round.

Finally, it should be emphasized the importance of participation in a proficiency test scheme since it constitutes an useful tool to monitor the procedures in routine analysis and to evaluate the results of measurements, enabling to improve the quality of results and ensuring greater reliability of the measurements.

It is up to each PT participant to carry out a critical analysis of the results, as well consider the entire process and laboratory experience. Therefore, the participation in a proficiency test, can assure information to the laboratory about the measurement capability and it is very important to validate the routine analysis.

11. Participating Laboratories

Sixteen laboratories were registered in the sixth round of the Car Emissions Proficiency Test. A list of laboratories that sent the results to this PT coordination of is presented in Table 09. It's important to note that the numeration of the laboratories in the table only indicates the number of participants in the PT, not their identification.

Table 09 – Participating Laboratories

	Institution
1.	Companhia Ambiental do Estado de São Paulo Setor de Laboratório de Emissão Veicular
2.	Continental Brasil Indústria Automotiva Ltda Laboratório de Emissões Veiculares – Centro Tecnológico "Geraldo Negri Rangel"
3.	Delphi Automotive Systems do Brasil Ltda
4.	Fiat Automóveis S.A. Laboratório de Emissões e Consumo
5.	Ford Motor Company Brasil Ltda Laboratório de Emissões do Campo de Provas de Tatuí
6.	General Motors do Brasil Ltda Laboratório de Emissões do Campo de Provas da Cruz Alta
7.	Honda Automóveis do Brasil Ltda Laboratório de Emissões Honda Automóveis

8.	Instituto de Tecnologia para o Desenvolvimento – Institutos LACTEC
9.	Magneti Marelli Sistemas Automotivos Indústria e Comércio Ltda
10.	Petróleo Brasileiro S.A. Laboratório de Ensaios Veiculares - CENPES
11.	Renault do Brasil S/A LEV – Laboratório de Emissões Veiculares
12.	Robert Bosch Ltda Laboratório de Emissões Veiculares
13.	SENAI – Serviço Nacional de Aprendizagem Industrial Laboratório de Emissões Veiculares – SENAI/CETEC
14.	Toyota do Brasil Ltda Laboratório de Emissões Indaiatuba - Toyota
15.	Umicore Brasil Ltda Laboratório de Emissões Veiculares - Umicore
16.	Volkswagen do Brasil Ltda Laboratório de Emissões Veiculares da Volkswagen do Brasil Ltda

Total participants: 16 laboratories.

12. References

- ABNT NBR ISO/IEC 17025:2005: General requirements for the competence of testing and calibration laboratories.
- ABNT NBR ISO/IEC 17043:2011: Conformity assessment – General requirements for proficiency testing.
- ISO 13528:2005 (E), *"Statistical methods for use in proficiency testing by interlaboratory comparisons"*.
- Vocabulário Internacional de Metrologia: conceitos fundamentais e gerais e termos associados (VIM 2012). 1ª Edição Luso – Brasileira.

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