EURAMET Project 1192
Comparison on BTEX loaded sorbent tubes

Final Report

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May 2013

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Report of EURAMET Project 1192 - Comparison on BTEX loaded sorbent tubes

Field

Amount of substance

Objectives

The EURAMET Project 1192 is supporting CMCs on sorption tubes transfer standards for BTEX. The purpose of the project is:

- Assessing the analytical capabilities of laboratories for BTEX gases for a measurement range of 50-1000 ng (1-200 nmol/mol) loaded onto sorbent tube transfer standards packed with different sorbent materials.
- Providing supporting evidence for NMIs led Proficiency Testing Schemes.

Participants

Five laboratories participated and are listed in table 1.

Table 1 : Lists of participants

Acronym	Country	Institute
JRC	EU	European Commission, Joint Research Centre, Ispra, Italy
NPL	UK	National Physical Laboratory, Teddington, Middlesex, United Kingdom
VSL	NL	Van Swinden Laboratorium BV, Delft, the Netherlands
METAS	CH	Swiss Federal Office of Metrology, Bern-Wabern, Switzerland
LNE	FR	Laboratoire National de métrologie et d'Essais, Paris, France

Conduct of the comparison

LNE and VSL were in charge of the preparation of the samples for this EURAMET comparison. They loaded a known amount of benzene, toluene, ethylbenzene, m-xylene and o-xylene (BTEX) on sorbent tubes and then sent them to each participating laboratory for analysis.

LNE loaded BTEX on two different types of sorbent : Carbopack X and Tenax TA. Tubes loading was performed by using a gravimetric gas mixture prepared by LNE. Each tube had its own amounts of BTEX which could be slightly different from the other tubes. Differently from the comparison protocol which stated BTEX to be in the range 500-700 ng, only benzene amounts were included in this range.
Each laboratory received 7 tubes of Carbopack X (5 loaded and 2 blanks) and 9 tubes of Tenax TA (7 loaded and 2 blanks) for analysis.

VSL loaded BTEX only on Tenax TA sorbent. Tubes loading was performed by pumped sampling of known volumes (ISO 16017-1) from a controlled BTEX standard atmosphere. The latter was prepared using the diffusion method (ISO 6145-part 8).

Thus all the tubes were charged with the same amounts of BTEX, between 50 and 500 ng.
Each laboratory received 7 tubes of Tenax TA (5 loaded and 2 blanks) for analysis.

Analytical methods used by participating laboratories

Participating laboratories measured samples using their own analytical method. They were requested to give details of analytical methods they used and of instrument calibration. The preparation of the calibration samples should be also reported.
An exception has been done for 3 samples of Tenax TA as LNE asked participants to analyse these 3 tubes according to LNE analytical method (cf. table 4).

Each laboratory was also required to express the expanded uncertainty for all submitted results. Parameters taken into account in the uncertainty calculation should be specified.

A summary of the analytical system of each laboratory is given in table 2.

Table 2 : Summary of the analytical system for each laboratory

Laboratory code	Thermodesorption	GC	Detection
JRC	unspecified	unspecified	unspecified
NPL	TurboMatrix 650 ATD Perkin Elmer	Varian 3900	FID
VSL	TurboMatrix 350 ATD Perkin Elmer	Autosystem XL Perkin Elmer	FID
METAS	ATD 350 Perkin Elmer	Clarus 500 Perkin Elmer	FID
LNE	ATD 350 Perkin Elmer	Clarus 600 Perkin Elmer	FID

Traceability of results for samples is made by the calibration of the previous instruments with a reference gas mixture. A summary of the different calibrations performed is available in table 3.

Table 3 : Summary of calibration strategy for each laboratory

<table>
<tr><th>Laboratory code</th><th>Calibration range</th><th>Standard used</th></tr>
<tr><td>JRC</td><td>Calibration curve of 5 points covering an amount range from 30 to 600 ng</td><td><u>Gas mixture concentration</u> (nmol/mol)
Benzene : 9.8 ± 0.2
Toluene : 9.69 ± 0.19
Ethylbenzene : 10.23 ± 0.2
M+P-xylene : 20.95 ± 0.21
O-xylene : 10.38 ± 0.21</td></tr>
<tr><td>NPL</td><td>Single point calibration

Calibration range for each compound
400 - 700 ng</td><td>Reference gas mixture prepared by NPL
<u>Concentration</u> (nmol/mol)
Benzene : 248.53 ± 2.49
Toluene : 251.17 ± 2.51
Ethylbenzene : 253.46 ± 2.53
M-xylene : 250.12 ± 2.50
P-xylene : 251.89 ± 2.52
O-xylene : 252.15 ± 2.52</td></tr>
<tr><td>VSL</td><td><table><tr><th>CX & TA (LNE)</th><th>TA (VSL)</th></tr><tr><td>➢ 400 ng (x3)
➢ 500 ng (x3)
➢ 550 ng (x3)
➢ 600 ng (x3)
➢ 650 ng (x6)
➢ 700 ng (x3)
➢ 800 ng (x3)</td><td>➢ 50 ng (x3)
➢ 70 ng (x3)
➢ 100 ng (x6)
➢ 125 ng (x3)
➢ 150 ng (x6)
➢ 200 ng (x3)</td></tr></table></td><td>5 different gas mixtures depending on the amount of BTEX to load

<u>BTEX mixture concentration</u> (nmol/mol)<table><tr><th>LNE samples</th><th>VSL samples</th></tr><tr><td>➢ 100
➢ 150
➢ 200</td><td>➢ 10
➢ 25</td></tr></table></td></tr>
<tr><td>METAS</td><td>Calibration range per compound (ng)<table><tr><th></th><th>CX & TA (LNE)</th><th>TA (VSL)</th></tr><tr><td>Benzene</td><td>500 – 1060</td><td>50 – 300</td></tr><tr><td>Toluene</td><td>370 – 840</td><td>35 – 585</td></tr><tr><td>Ethylbenzene</td><td>320 – 730</td><td>30 – 505</td></tr><tr><td>M-xylene</td><td>305 – 710</td><td>30 – 490</td></tr><tr><td>O-xylene</td><td>600 – 720</td><td>60 – 600</td></tr></table></td><td>BTEX gas mixtures generated with 5 permeation units (one per compound)</td></tr>
<tr><td>LNE</td><td>Calibration range per compound (ng)
(curve of 5 points duplicated 5 times)<table><tr><th></th><th>CX & TA (LNE)</th><th>TA (VSL)</th></tr><tr><td>Benzene</td><td>400 – 800</td><td>35 – 200</td></tr><tr><td>Toluene</td><td>470 – 940</td><td>45 – 235</td></tr><tr><td>Ethylbenzene</td><td>520 – 1050</td><td>50 – 260</td></tr><tr><td>M-xylene</td><td>530 – 1060</td><td>50 – 265</td></tr><tr><td>O-xylene</td><td>535 – 1080</td><td>50 – 270</td></tr></table></td><td>Reference gas mixture prepared by LNE

<u>Concentration (nmol/mol)</u><table><tr><th></th><th>CX & TA (LNE)</th><th>TA (VSL)</th></tr><tr><td>Benzene</td><td>371.6 ± 1.5</td><td>369.0 ± 1.5</td></tr><tr><td>Toluene</td><td>368.3 ± 1.5</td><td>365.7 ± 1.5</td></tr><tr><td>Ethylbenzene</td><td>357.1 ± 4.3</td><td>354.6 ± 4.3</td></tr><tr><td>M-xylene</td><td>362.3 ± 2.2</td><td>359.8 ± 2.2</td></tr><tr><td>O-xylene</td><td>366.3 ± 2.2</td><td>363.8 ± 2.2</td></tr></table></td></tr>
</table>

Tubes analysis is performed under different conditions (thermodesorption and GC). Tables 4 and 5 give a summary of these conditions for each laboratory.

Table 4 : Summary of the thermodesorption parameters for each laboratory

Thermodesorption parameters		JRC	NPL	VSL	METAS	LNE
First desorption	Time (min)	5	15 CX 10 TA	5	7	20
	Tube temperature (°C)	350 CX 300 TA	400 CX 250 TA	275 CX 250 TA	300	370 CX 230 TA
	Trap temperature (°C)	-30	5	-30	-30	-30
	Desorption flow (mL/min)	50	45	30	30	60
	Inlet split (mL/min)	25.5	0	0	0	30
Second desorption	Time (min)	10	10	3	2	17.5
	Trap temperature (°C)	350	340	225	300	325
	Temperature gradient (°C/s)	unspecified	40	unspecified	40	40
	Outlet split (mL/min)	10.3	20	10	6	30
Carrier gas		unspecified	He	He	He	He
Trap		Air Toxics	Air Toxics	Air Toxics	Tenax TA	Air monitoring trap

Table 5 : Summary of GC parameters for each laboratory

GC parameters		JRC	NPL	VSL	METAS	LNE
Transfer line temperature (°C)		250	200	unspecified	200	220
Valve temperature (°C)		200	225	unspecified	200	215
Column		unspecified	Zb 1701 dimensions 60m x 0.32mm x 0.1µm	CP-wax 52-CB dimensions 60m x 0.32mm	Elite Volatile dimensions 30m x 0.25mm x 1.4µm	VB-5 dimensions 60m x 0.25mm
Temperature program of the oven		unspecified	40°C (5 min) 10°C/min to 80°C (2 min) 10°C/min to 200°C (4 min)	40°C (8 min) 5°C/min to 110°C 10°C/min to 150°C	50°C (2 min) 5°C/min to 75°C (10 min) 10°C/min to 160°C (5 min)	30°C 20°C/min to 60°C (8min) 10°C/min to 110°C 20°C/min to 170°C
FID	H_2 Flow (mL/min)	unspecified	30	unspecified	42	45
	Air Flow (mL/min)	unspecified	300	unspecified	420	450
	Temp (°C)	unspecified	300	350	250	250

Degrees of equivalence

A lateral degree of equivalence in comparisons is defined as

$$\Delta x_i = D_i = x_i - x_{CRV}$$

Here x_{CRV} denotes the EURAMET comparison reference value, and x_i the result of laboratory i.

The standard uncertainty of the reference value comprised only the uncertainty from the loading of the tubes.

Results

In the following sections, the results of the comparison are summarised per sorbent and then per compound. The following data are presented

x_{ref} amount of loading compound (ng)

U_{ref} expanded uncertainty of reference value, at 95% level of confidence (ng)

x_{lab} result of laboratory (ng)

U_{lab} expanded uncertainty of laboratory, at 95% level of confidence (ng)

Δx difference between laboratory result and reference value (ng)

k coverage factor

$U(\Delta x)$ expanded uncertainty of difference Δx, at 95% level of confidence (ng)

In order to improve the readability of the results, global averages per analyte have been calculated for each laboratory. Outliers have been excluded from the calculation.

1. Carbopack X (LNE)

The comparison protocol stated a loading level between 500-700 ng for BTEX whereas most of the samples contain amounts of ethylbenzene and xylenes higher than 700 ng. Thus, VSL results for ethylbenzene, m-xylene and o-xylene have not been submitted as they were out of their calibration range. The VSL large uncertainty of the measurement results for toluene takes into account the uncertainty due to extrapolation.

Benzene

Table 6 : Results for benzene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	6434	500.2	18.2	535.4	31.1	35.2	2	36.0
JRC	6411	550.0	20.0	596.5	34.6	46.5	2	40.0
JRC	6951	599.9	21.8	655.0	39.3	55.1	2	44.9
JRC	5713	650.0	23.6	712.7	42.8	62.7	2	48.9
JRC	5703	700.1	25.4	784.2	47.1	84.1	2	53.5
NPL	6432	699.9	25.4	713	29	13.1	2	38.6
NPL	5699	649.9	23.6	654	26	4.1	2	35.1
NPL	6957	600.1	21.8	613	25	12.9	2	33.2
NPL	5680	549.9	20.0	544	22	-5.9	2	29.7
NPL	6490	500.1	18.2	506	20	5.9	2	27.0
VSL	6956	500.2	18.2	516	13	15.8	2	22.4
VSL	5714	550.0	20.0	565	14	15.0	2	24.4
VSL	6451	600.0	21.8	620	16	20.0	2	27.0
VSL	5769	649.9	23.6	673	17	23.1	2	29.1
VSL	6412	701.0	25.5	723	18	22.0	2	31.2
METAS	6429	552.2	20.1	511.7	4.3	-40.5	2	20.5
METAS	5691	500.2	18.2	496.7	4.3	-3.5	2	18.7
METAS	6444	600.0	21.8	594.3	4.3	-5.7	2	22.2
METAS	6436	650.0	23.6	641.7	4.5	-8.3	2	24.0
METAS	5542	700.1	25.4	693.7	4.7	-6.4	2	25.9
LNE	5715	516.5	18.8	513.4	16.4	-3.1	2	25.0
LNE	6408	549.9	20.0	548.8	17.6	-1.1	2	26.6
LNE	6862	600.0	21.8	594.4	19.0	-5.6	2	28.9
LNE	5545	649.9	23.6	643.0	20.6	-6.9	2	31.3
LNE	4292	699.9	25.4	687.1	22.0	-12.8	2	33.6

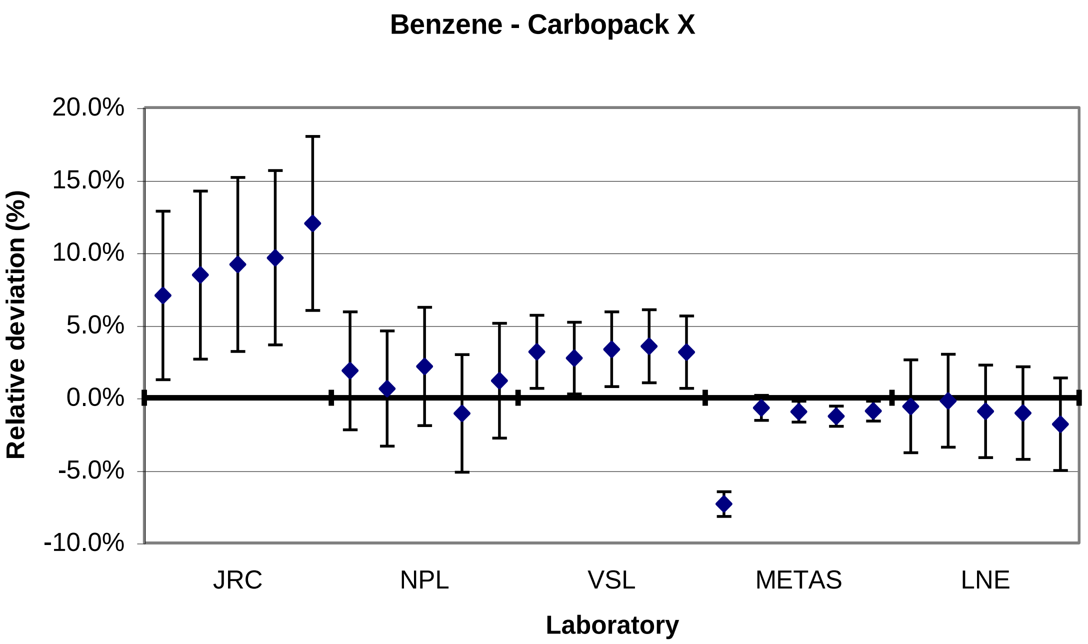

Figure 1 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

Benzene - Carbopack X

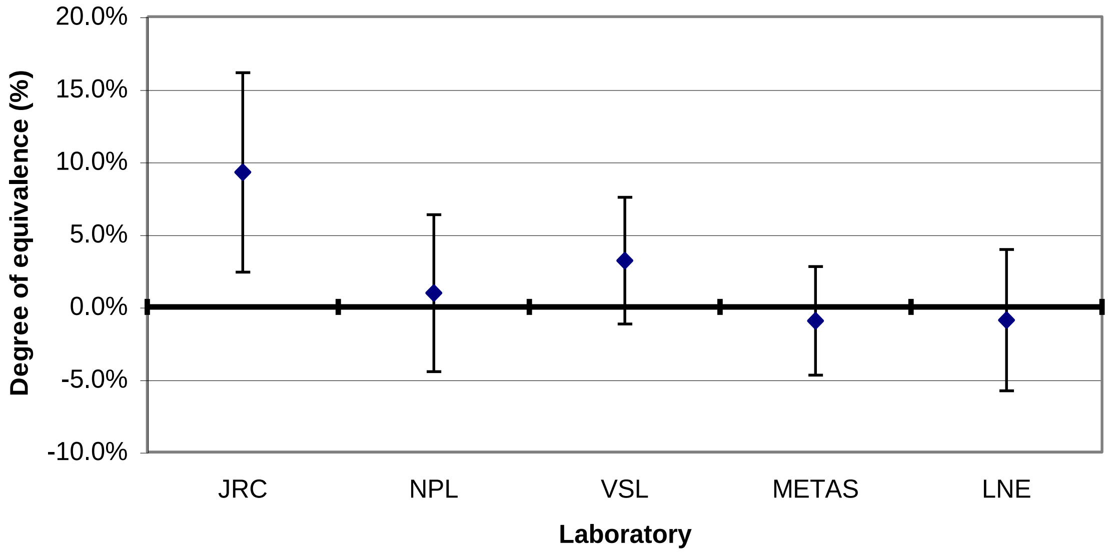

Figure 2 : Relative degrees of equivalence with uncertainties (k=2)

Toluene

Table 7 : Results for toluene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	6434	584.7	21.3	622.8	31.1	38.1	2	37.7
JRC	6411	643.0	23.4	709.0	36.9	66.0	2	43.7
JRC	6951	701.3	25.5	786.4	40.9	85.1	2	48.2
JRC	5713	759.9	27.6	871.1	45.3	111.2	2	53.0
JRC	5703	818.5	29.7	974.5	52.6	156.0	2	60.4
NPL	6432	818.3	29.7	821	33	2.7	2	44.4
NPL	5699	759.8	27.6	763	31	3.2	2	41.5
NPL	6957	701.5	25.5	714	29	12.5	2	38.6
NPL	5680	642.9	23.4	641	26	-1.9	2	35.0
NPL	6490	584.7	21.3	587	24	2.3	2	32.1
VSL	6956	584.7	21.3	596	15	11.3	2	26.0
VSL	5714	643.0	23.4	657	17	14.0	2	28.9
VSL	6451	701.4	25.5	719	18	17.6	2	31.2
VSL	5769	759.8	27.6	784	20	24.2	2	34.1
VSL	6412	819.6	29.8	848	27	28.4	2	40.2
METAS	6429	645.5	23.5	608.6	4.0	-36.9	2	23.8
METAS	5691	584.7	21.3	588.5	3.9	3.8	2	21.6
METAS	6444	701.5	25.5	703.9	4.8	2.4	2	25.9
METAS	6436	759.9	27.6	761.5	5.4	1.6	2	28.1
METAS	5542	818.5	29.7	819.5	5.9	1.0	2	30.3
LNE	5715	603.8	22.0	602.7	19.3	-1.1	2	29.2
LNE	6408	642.9	23.4	644.4	20.6	1.5	2	31.2
LNE	6862	701.4	25.5	699.6	22.4	-1.8	2	33.9
LNE	5545	759.8	27.6	754.4	24.1	-5.4	2	36.7
LNE	4292	818.3	29.7	808.6	25.9	-9.7	2	39.4

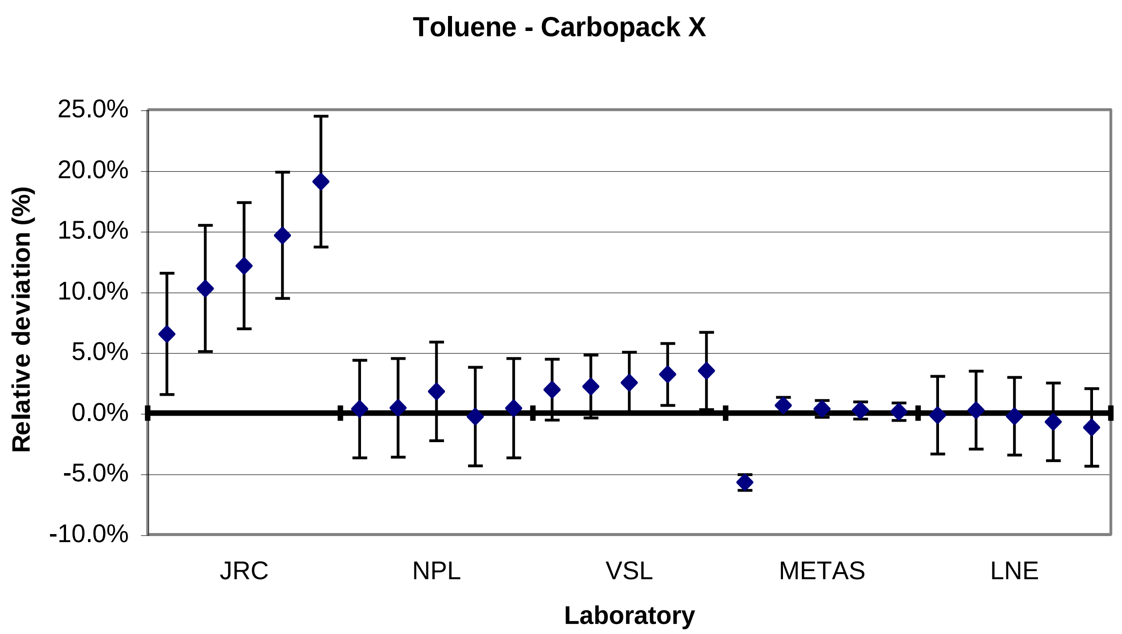

Figure 3 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

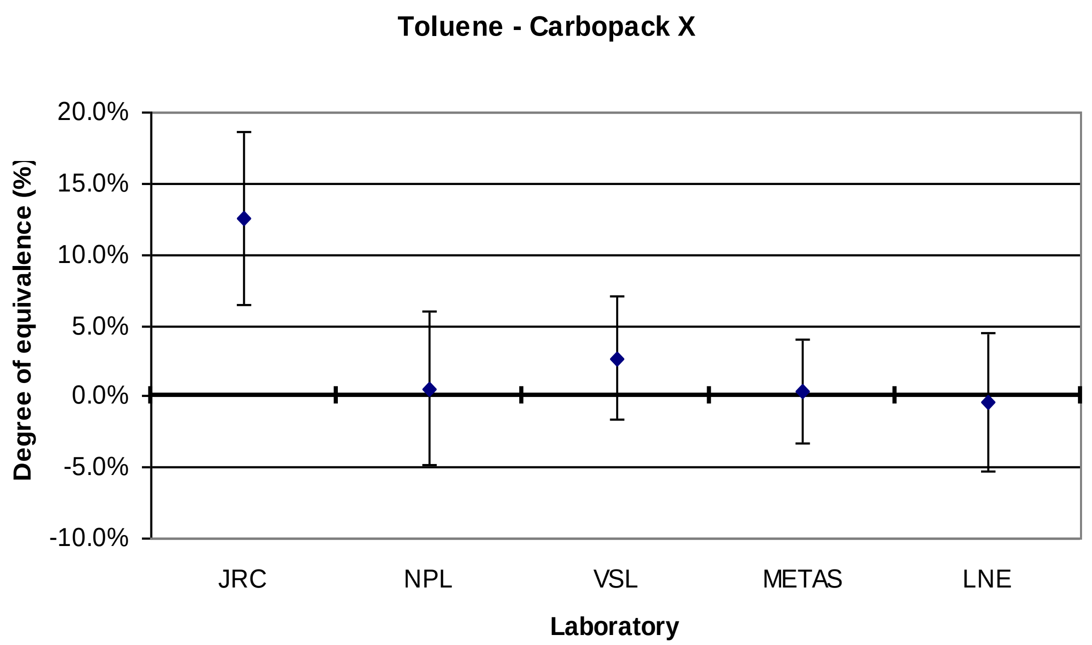

Figure 4 : Relative degrees of equivalence with uncertainties (k=2)

Ethylbenzene

Table 8 : Results for ethylbenzene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	6434	653.2	24.9	605.5	27.9	-47.7	2	37.3
JRC	6411	718.4	27.3	688.5	31.7	-29.9	2	41.8
JRC	6951	783.5	29.8	769.1	36.9	-14.4	2	47.5
JRC	5713	848.9	32.3	845.1	40.6	-3.8	2	51.9
JRC	5703	914.4	34.8	939.7	45.1	25.3	2	57.0
NPL	6432	914.2	34.8	908	36	-6.2	2	50.1
NPL	5699	848.8	32.3	849	34	0.2	2	46.9
NPL	6957	783.7	29.8	792	32	8.3	2	43.7
NPL	5680	718.3	27.3	716	29	-2.3	2	39.9
NPL	6490	653.2	24.9	653	26	-0.2	2	36.0
VSL	6956	653.3	24.9					
VSL	5714	718.3	27.3					
VSL	6451	783.6	29.8					
VSL	5769	848.9	32.3					
VSL	6412	915.6	34.8					
METAS	6429	721.2	27.5	698.9	4.9	-22.3	2	27.9
METAS	5691	653.3	24.9	676.3	4.7	23.0	2	25.3
METAS	6444	783.7	29.8	817.0	7.0	33.3	2	30.6
METAS	6436	848.9	32.3	888.0	8.0	39.1	2	33.3
METAS	5542	914.4	34.8	949.0	8.0	34.6	2	35.7
LNE	5715	674.6	25.7	672.8	21.5	-1.8	2	33.5
LNE	6408	718.2	27.3	727.1	23.3	8.9	2	35.9
LNE	6862	783.7	29.8	785.4	25.1	1.7	2	39.0
LNE	5545	848.8	32.3	843.2	27.0	-5.6	2	42.1
LNE	4292	914.2	34.8	903.0	28.9	-11.2	2	45.2

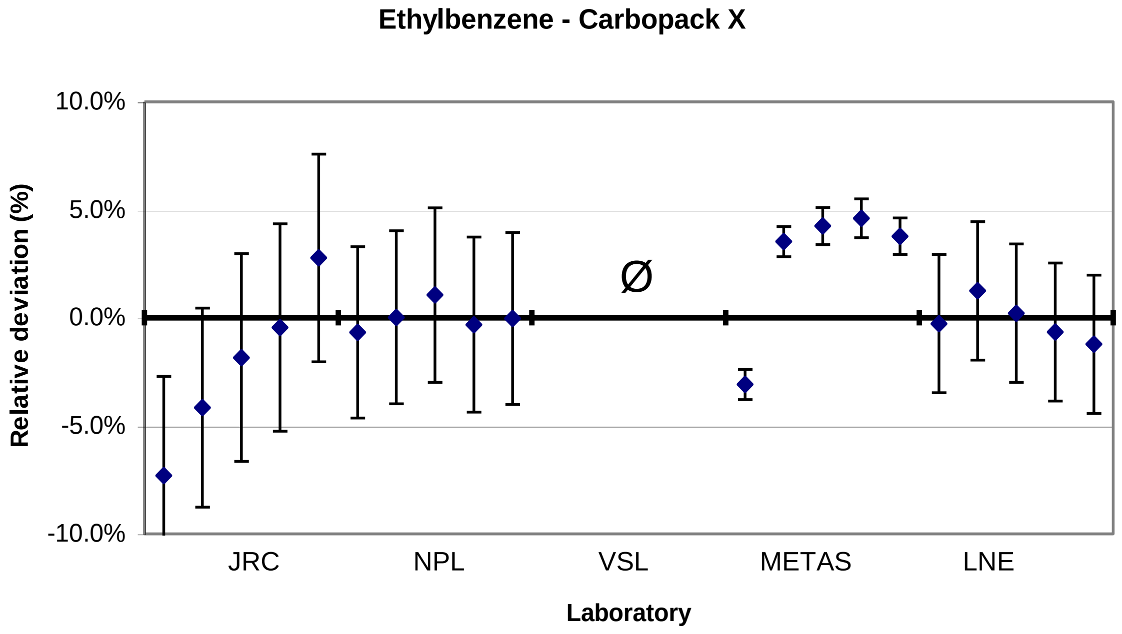

Figure 5 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

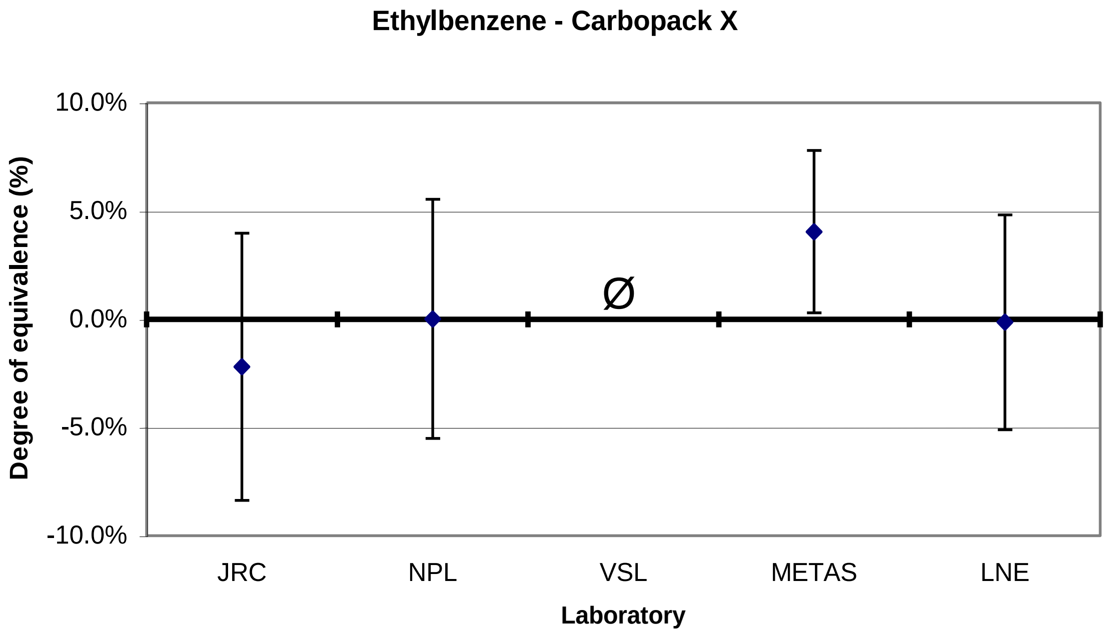

Figure 6 : Relative degrees of equivalence with uncertainties (k=2)

M-xylene

Table 9 : Results for m-xylene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	6434	662.8	24.3	489.3	18.6	-173.5	2	30.6
JRC	6411	728.8	26.7	567.9	22.7	-160.9	2	35.0
JRC	6951	794.9	29.1	642.9	25.7	-152.0	2	38.8
JRC	5713	861.3	31.5	713.5	28.5	-147.8	2	42.5
JRC	5703	927.7	34.0	800.6	33.6	-127.1	2	47.8
NPL	6432	927.5	33.9	913	37	-14.5	2	50.2
NPL	5699	861.2	31.5	856	34	-5.2	2	46.4
NPL	6957	795.1	29.1	799	32	3.9	2	43.3
NPL	5680	728.7	26.7	720	29	-8.7	2	39.4
NPL	6490	662.7	24.3	662	27	-0.7	2	36.3
VSL	6956	662.8	24.3					
VSL	5714	728.8	26.7					
VSL	6451	795.1	29.1					
VSL	5769	861.3	31.5					
VSL	6412	928.9	34.0					
METAS	6429	731.7	26.8	676.9	5	-54.8	2	27.3
METAS	5691	662.8	24.3	646.1	4.7	-16.7	2	24.7
METAS	6444	795.1	29.1	792	7	-3.1	2	29.9
METAS	6436	861.3	31.5	859	7	-2.3	2	32.3
METAS	5542	927.8	34.0	921	8	-6.8	2	34.9
LNE	5715	684.4	25.1	684.2	21.9	-0.2	2	33.3
LNE	6408	728.7	26.7	743.5	23.8	14.8	2	35.7
LNE	6862	795.1	29.1	795.1	25.4	0.0	2	38.7
LNE	5545	861.2	31.5	855.7	27.4	-5.5	2	41.8
LNE	4292	927.5	33.9	913.8	29.2	-13.7	2	44.8

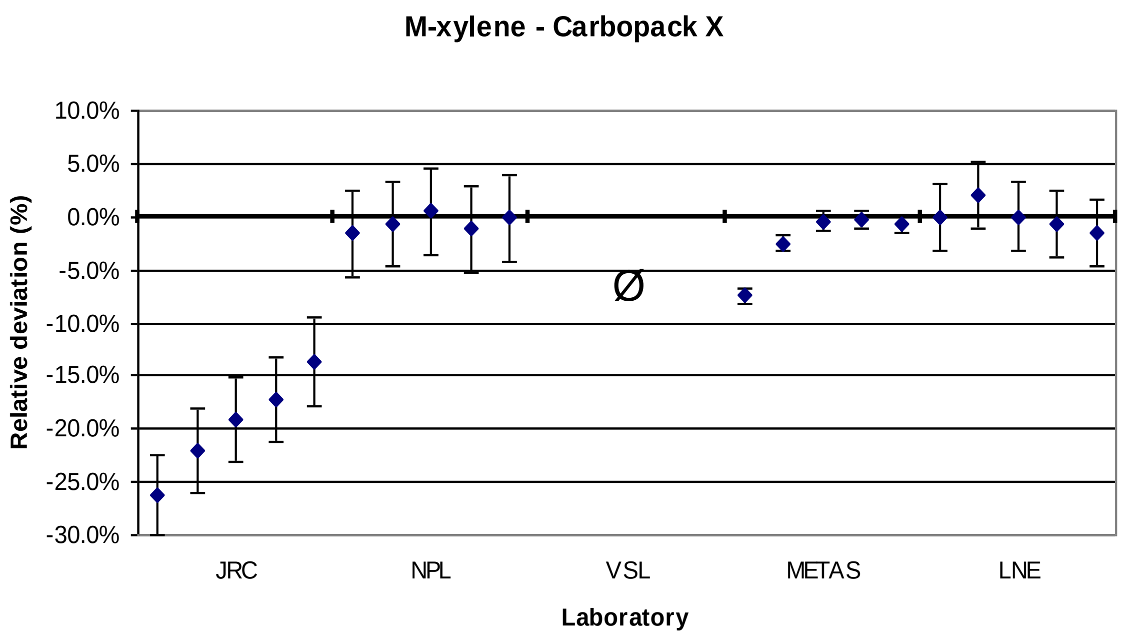

Figure 7 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

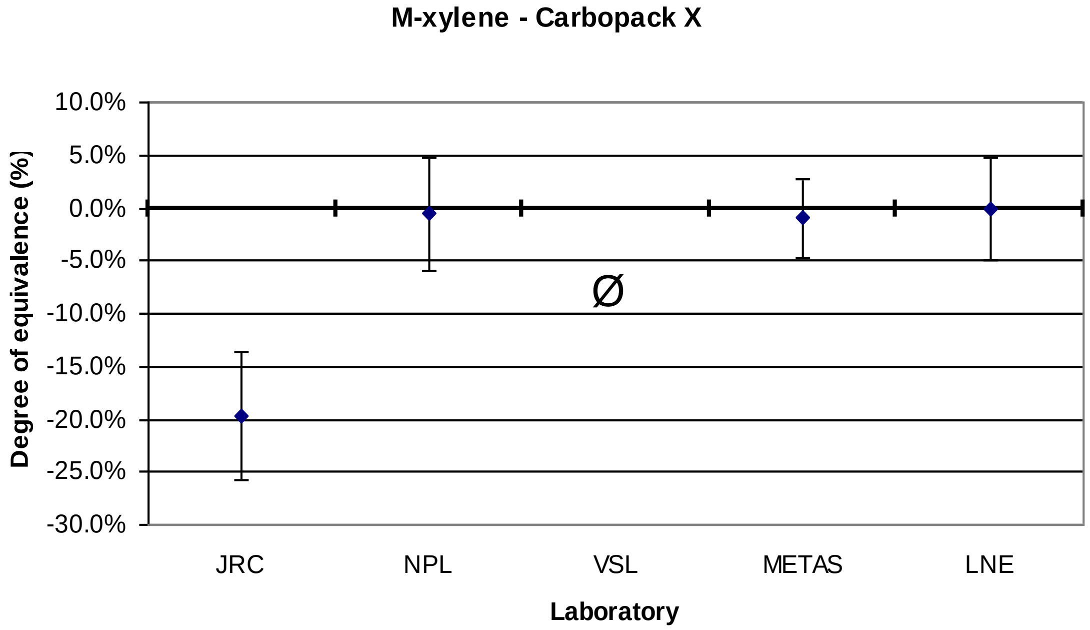

Figure 8: Relative degrees of equivalence with uncertainties (k=2)

O-xylene

Table 10 : Results for o-xylene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	6434	670.1	24.5	635.2	29.2	-34.9	2	38.2
JRC	6411	736.9	27.0	722.7	33.2	-14.2	2	42.8
JRC	6951	803.7	29.4	809.4	38.9	5.7	2	48.7
JRC	5713	870.8	31.9	885.3	42.5	14.5	2	53.1
JRC	5703	937.9	34.3	986.9	47.4	49.0	2	58.5
NPL	6432	937.7	34.3	957	38	19.3	2	51.2
NPL	5699	870.7	31.9	895	36	24.3	2	48.1
NPL	6957	803.9	29.4	836	33	32.1	2	44.2
NPL	5680	736.8	27.0	757	30	20.2	2	40.3
NPL	6490	670.1	24.5	697	28	26.9	2	37.2
VSL	6956	670.1	24.5					
VSL	5714	736.8	27.0					
VSL	6451	803.8	29.4					
VSL	5769	870.8	31.9					
VSL	6412	939.2	34.4					
METAS	6429	739.7	27.1	678	11	-61.7	2	29.2
METAS	5691	670.1	24.5	636	10	-34.1	2	26.5
METAS	6444	803.9	29.4	792	13	-11.9	2	32.2
METAS	6436	870.8	31.9	859	15	-11.8	2	35.2
METAS	5542	938.0	34.3	915	17	-23.0	2	38.3
LNE	5715	691.9	25.3	692.2	22.2	0.3	2	33.7
LNE	6408	736.7	27.0	752.2	24.1	15.5	2	36.1
LNE	6862	803.8	29.4	805.1	25.8	1.3	2	39.1
LNE	5545	870.7	31.9	868.4	27.8	-2.3	2	42.3
LNE	4292	937.8	34.3	924.8	29.6	-13.0	2	45.3

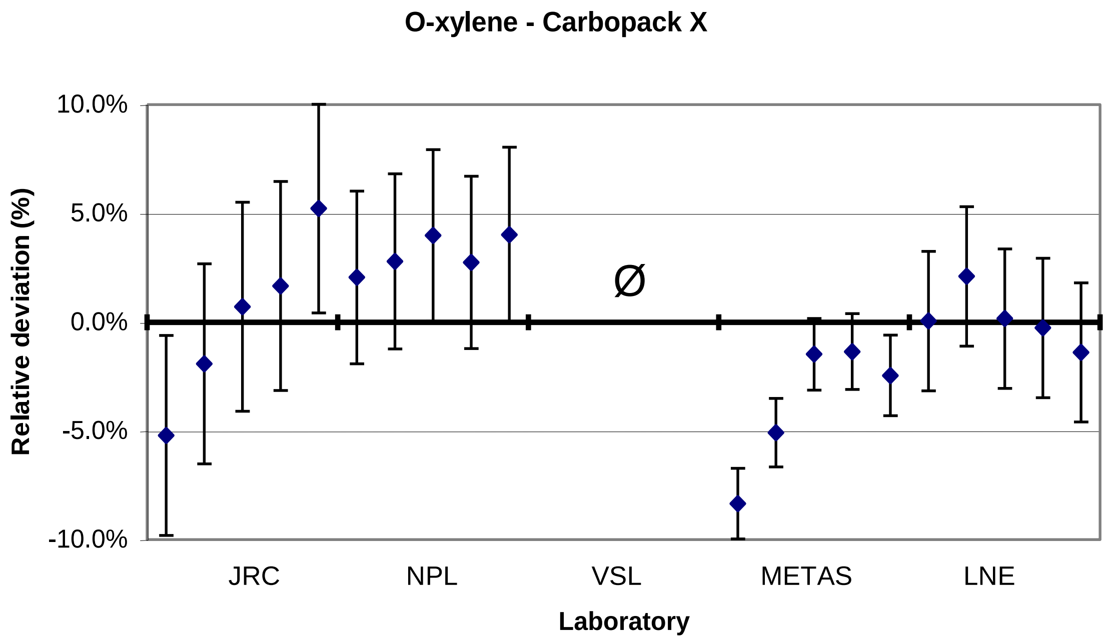

Figure 9 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

O-xylene - Carbopack X

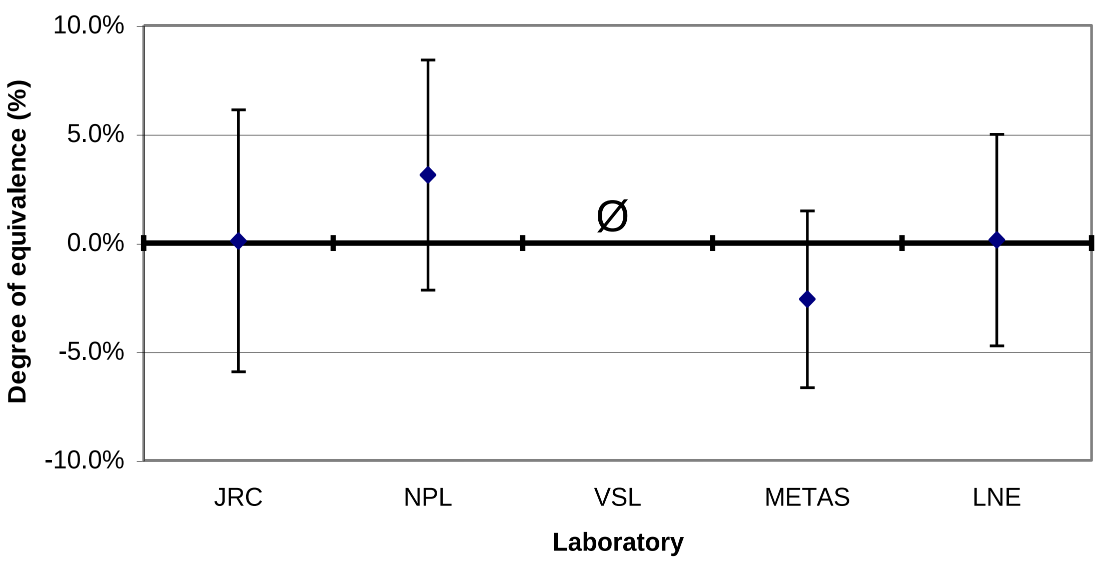

Figure 10 : Relative degrees of equivalence with uncertainties (k=2)

2. Tenax TA (LNE)

As specified in the part “Analysis methods used by participating laboratories”, 3 out of 7 tubes received by each laboratory were analysed according to LNE analytical method. In the following tables, these are highlighted in yellow, and in the graphs in pink.

For VSL, the same approach of taking extrapolation into account is applied but in this case all results were submitted.

Benzene

Table 11 : Results for benzene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi174964	700.6	25.5	682.3	40.9	-18.3	2	48.2
JRC	Mi174963	600.2	21.8	624.1	37.4	23.9	2	43.3
JRC	Mi174962	500.4	18.2	528.4	30.6	28.0	2	35.6
JRC	Mi174981	649.5	23.6					
JRC	3926	500.3	18.2	542.6	31.5	42.3	2	36.4
JRC	Mi174969	550.7	20.0	593.7	34.4	43.0	2	39.8
JRC	Mi174965	500.7	18.2	547.2	31.7	46.5	2	36.6
NPL	Mi174994	700.8	25.5	714	29	13.2	2	38.6
NPL	Mi166802	652.7	23.7	647	26	-5.7	2	35.2
NPL	Mi174982	500.8	18.2	497	20	-3.8	2	27.1
NPL	Mi175000	500.8	18.2	497	20	-3.8	2	27.1
NPL	Mi174976	549.7	20.0	537	22	-12.7	2	29.7
NPL	Mi174992	500.4	18.2	463	19	-37.4	2	26.3
NPL	Mi174995	600.2	21.8	598	23	-2.2	2	31.7
VSL	Mi174987	500.2	18.2	498	11	-2.2	2	21.3
VSL	Mi174985	550.8	20.0	547	12	-3.8	2	23.4
VSL	Mi174989	599.2	21.8	607	13	7.8	2	25.4
VSL	Mi174984	700.4	25.4	706	15	5.6	2	29.5
VSL	3927	500.2	18.2	499	12	-1.2	2	21.8
VSL	Mi174986	505.7	18.4	505	12	-0.7	2	22.0
VSL	Mi174996	656.2	23.8	652	15	-4.2	2	28.2
METAS	Mi174980	700.4	25.4	682.2	4.6	-18.2	2	25.9
METAS	Mi174972	649.4	23.6	635.5	4.4	-13.9	2	24.0
METAS	Mi174998	600.3	21.8	586.1	4.3	-14.2	2	22.2
METAS	Mi174988	549.7	20.0	533.8	4.3	-15.9	2	20.4
METAS	Mi174970	502.8	18.3	508.5	4.3	5.7	2	18.8
METAS	Mi174966	500.1	18.2	505.3	4.3	5.2	2	18.7
METAS	3923	500.2	18.2	456.5	4.4	-43.7	2	18.7
LNE	Mi174961	649.7	23.61	649.2	20.8	-0.5	2	31.4
LNE	Mi166805	600.3	21.82	596.6	19.1	-3.7	2	29.0
LNE	Mi174971	700.7	25.46	705.0	22.6	4.3	2	34.0
LNE	Mi166803	550.7	20.03	434.6	13.9	-116.1	2	24.4

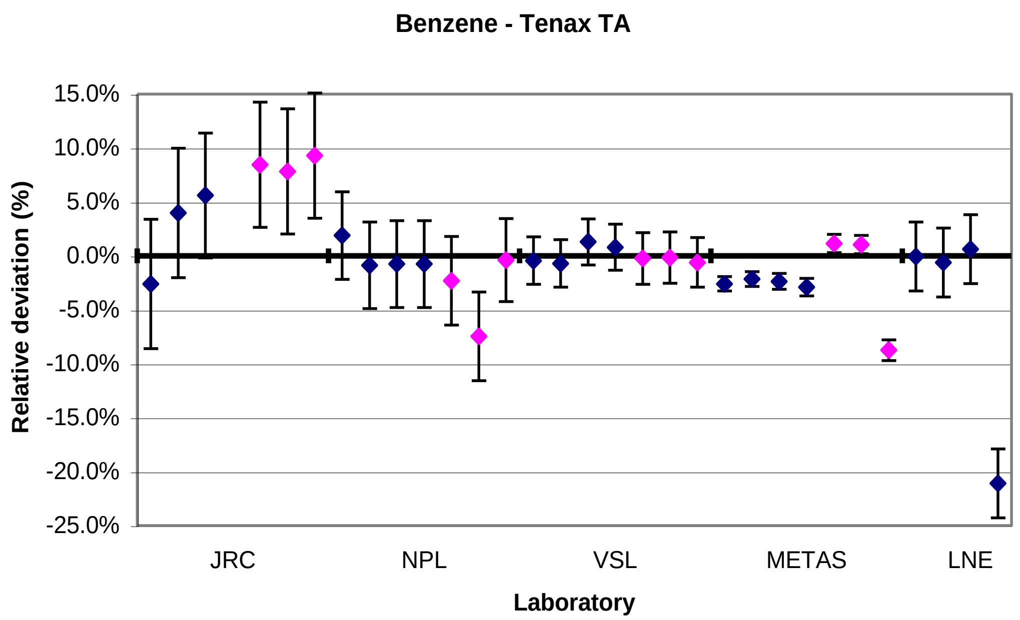

Figure 11 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

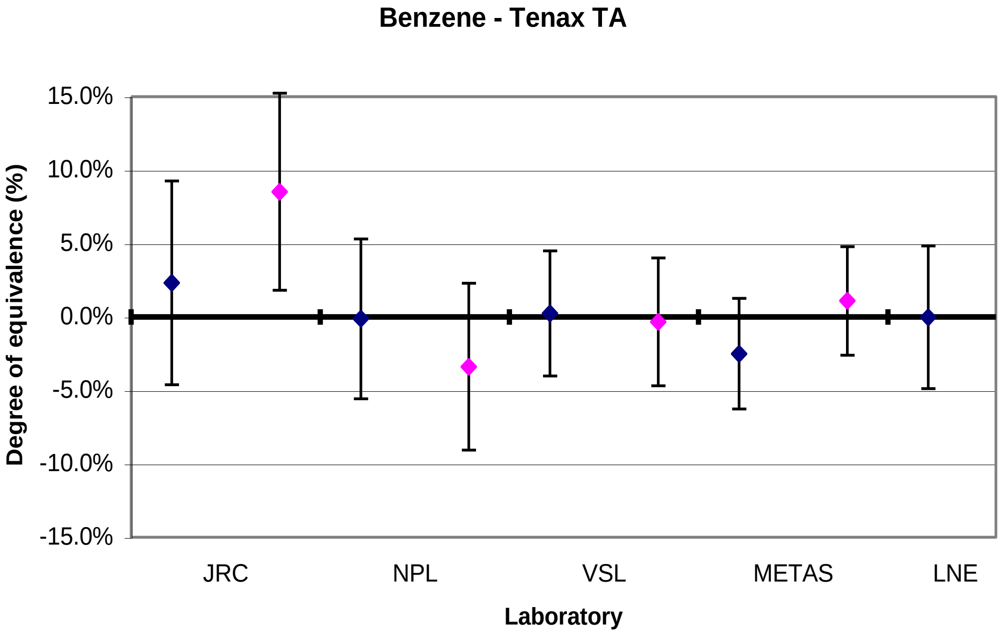

Figure 12 : Relative degrees of equivalence with uncertainties (k=2)

Toluene

Table 12 : Results for toluene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi174964	819.1	29.8	767.7	39.9	-51.4	2	49.8
JRC	Mi174963	701.7	25.5	706.9	36.8	5.2	2	44.7
JRC	Mi174962	585.0	21.3	590.4	29.5	5.4	2	36.4
JRC	Mi174981	759.3	27.6					
JRC	3926	584.9	21.3	618.0	30.9	33.1	2	37.5
JRC	Mi174969	643.8	23.4	672.5	35.0	28.7	2	42.1
JRC	Mi174965	585.4	21.3	623.5	31.2	38.1	2	37.7
NPL	Mi174994	819.3	29.8	841	34	21.7	2	45.2
NPL	Mi166802	763.1	27.7	765	31	1.9	2	41.6
NPL	Mi174982	585.4	21.3	585	23	-0.4	2	31.3
NPL	Mi175000	585.5	21.3	593	24	7.5	2	32.1
NPL	Mi174976	642.7	23.4	632	25	-10.7	2	34.2
NPL	Mi174992	585.0	21.3	608	24	23.0	2	32.1
NPL	Mi174995	701.7	25.5	682	27	-19.7	2	37.1
VSL	Mi174987	584.8	21.3	586	13	1.2	2	24.9
VSL	Mi174985	644.0	23.4	644	14	0.0	2	27.3
VSL	Mi174989	700.5	25.5	713	16	12.5	2	30.1
VSL	Mi174984	818.9	29.7	829	19	10.1	2	35.3
VSL	3927	584.8	21.3	585	13	0.2	2	24.9
VSL	Mi174986	591.3	21.5	596	13	4.7	2	25.1
VSL	Mi174996	767.2	27.9	774	16	6.8	2	32.1
METAS	Mi174980	818.8	29.7	805.4	5.8	-13.4	2	30.3
METAS	Mi174972	759.2	27.6	748.3	5.2	-10.9	2	28.1
METAS	Mi174998	701.8	25.5	688	4.7	-13.8	2	25.9
METAS	Mi174988	642.7	23.4	639.2	4.3	-3.5	2	23.8
METAS	Mi174970	587.8	21.4	597.7	3.9	9.9	2	21.7
METAS	Mi174966	584.7	21.3	594.1	3.9	9.4	2	21.6
METAS	3923	584.8	21.3	554	3.7	-30.8	2	21.6
LNE	Mi174961	759.6	27.60	759.0	24.3	-0.6	2	36.8
LNE	Mi166805	701.8	25.5	696.8	22.3	-5.0	2	33.9
LNE	Mi174971	819.1	29.8	823.8	26.4	4.7	2	39.8
LNE	Mi166803	643.9	23.4	441.6	14.1	-202.3	2	27.3

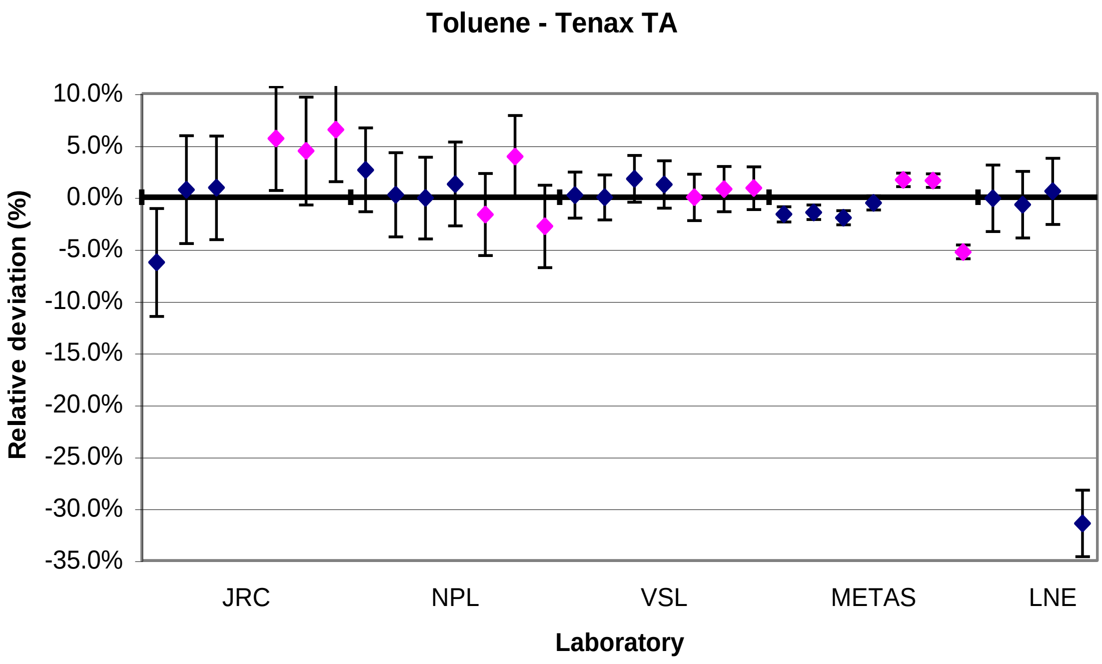

Figure 13 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

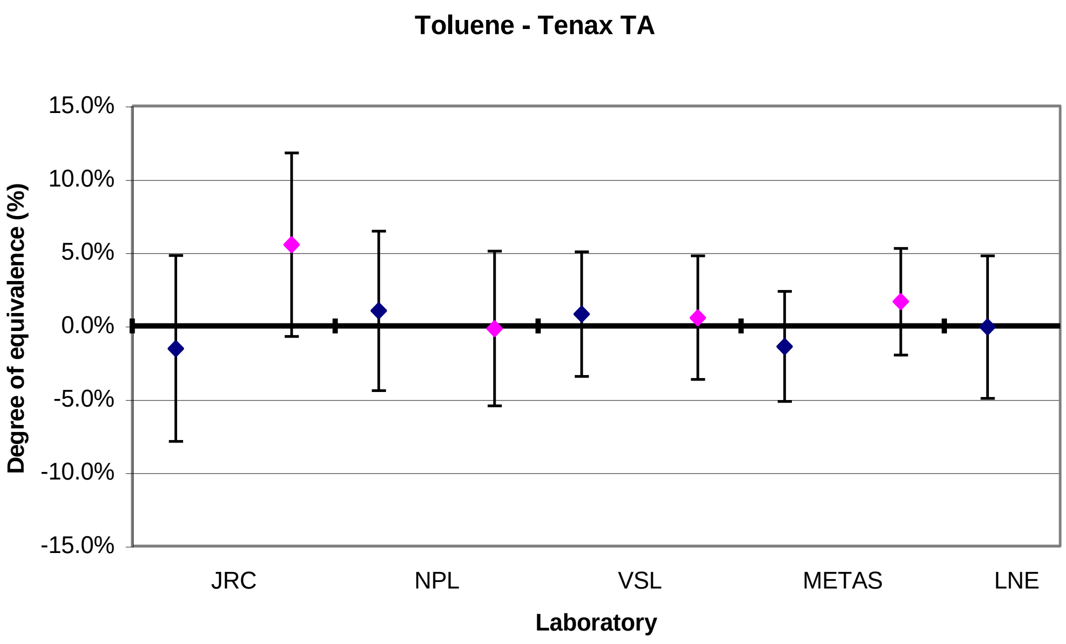

Figure 14 : Relative degrees of equivalence with uncertainties (k=2)

Ethylbenzene

Table 13 : Results for ethylbenzene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi174964	915.0	34.8	784.2	37.6	-130.8	2	51.3
JRC	Mi174963	784.0	29.8	719.6	34.5	-64.4	2	45.6
JRC	Mi174962	653.6	24.9	599.9	27.6	-53.7	2	37.2
JRC	Mi174981	848.3	32.3					
JRC	3926	653.4	24.9	626.9	28.8	-26.5	2	38.1
JRC	Mi174969	719.2	27.4	692.0	33.2	-27.2	2	43.0
JRC	Mi174965	654.0	24.9	627.2	28.9	-26.8	2	38.1
NPL	Mi174994	915.3	34.8	927	37	11.7	2	50.8
NPL	Mi166802	852.6	32.4	846	34	-6.6	2	47.0
NPL	Mi174982	654.0	24.9	648	26	-6.0	2	36.0
NPL	Mi175000	654.1	24.9	652	26	-2.1	2	36.0
NPL	Mi174976	718.0	27.3	706	28	-12.0	2	39.1
NPL	Mi174992	653.6	24.9	641	26	-12.6	2	36.0
NPL	Mi174995	784.0	29.8	763	31	-21.0	2	43.0
VSL	Mi174987	653.3	24.9	652	20	-1.3	2	31.9
VSL	Mi174985	719.5	27.4	718	22	-1.5	2	35.1
VSL	Mi174989	782.6	29.8	795	24	12.4	2	38.2
VSL	Mi174984	914.8	34.8	924	40	9.2	2	53.0
VSL	3927	653.3	24.9	649	20	-4.3	2	31.9
VSL	Mi174986	660.6	25.2	665	20	4.4	2	32.1
VSL	Mi174996	857.1	32.6	865	38	7.9	2	50.1
METAS	Mi174980	914.8	34.8	937.0	8.0	22.2	2	35.7
METAS	Mi174972	848.2	32.3	868.0	7.0	19.8	2	33.0
METAS	Mi174998	784.0	29.8	798.0	6.0	14.0	2	30.4
METAS	Mi174988	718.0	27.3	742.3	5.4	24.3	2	27.9
METAS	Mi174970	656.6	25.0	691.7	4.9	35.1	2	25.5
METAS	Mi174966	653.2	24.9	685.1	4.8	31.9	2	25.3
METAS	3923	653.3	24.9	642.7	4.4	-10.6	2	25.3
LNE	Mi174961	848.6	32.3	851.4	27.2	2.8	2	42.2
LNE	Mi166805	784.0	29.8	783.0	25.1	-1.0	2	39.0
LNE	Mi174971	915.1	34.8	922.4	29.5	7.3	2	45.6
LNE	Mi166803	719.3	27.4	606.2	19.4	-113.1	2	33.6

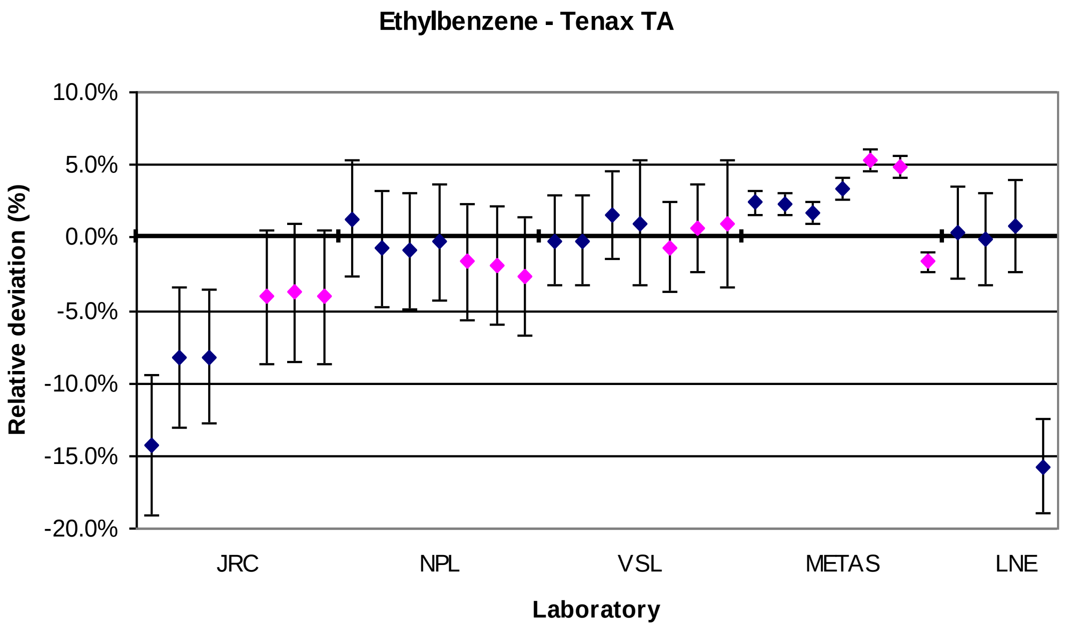

Figure 15 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

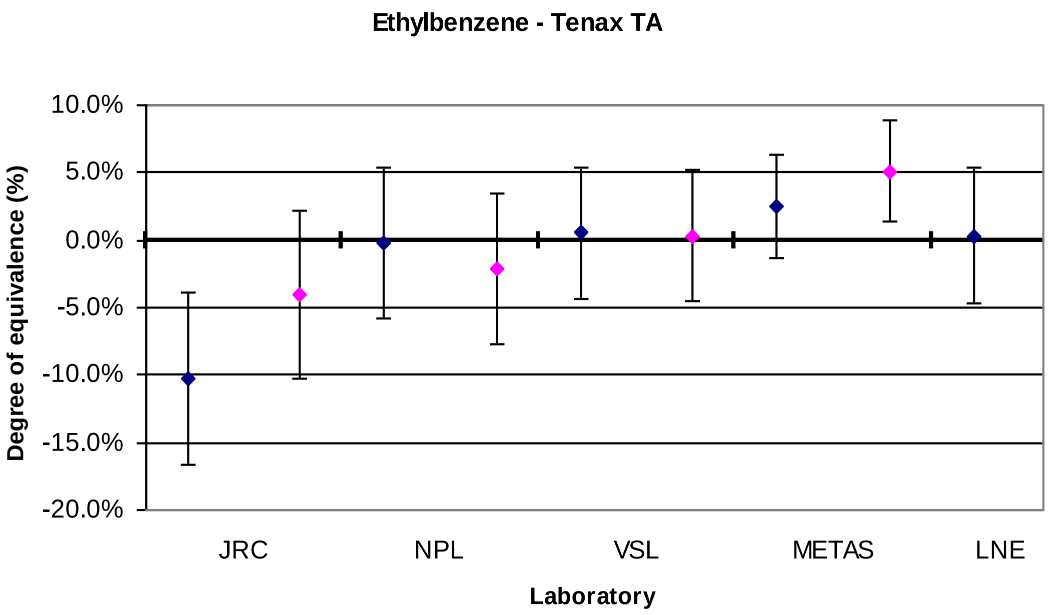

Figure 16 : Relative degrees of equivalence with uncertainties (k=2)

M-xylene

Table 14 : Results for m-xylene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi174964	928.4	34.0	832.5	33.3	-95.9	2	47.6
JRC	Mi174963	795.4	29.1	762.2	30.5	-33.2	2	42.2
JRC	Mi174962	663.1	24.3	640.6	24.3	-22.5	2	34.4
JRC	Mi174981	860.7	31.5					
JRC	3926	662.9	24.3	697.4	26.5	34.5	2	35.9
JRC	Mi174969	729.7	26.7	765.6	30.6	35.9	2	40.6
JRC	Mi174965	663.5	24.3	700.5	26.6	37.0	2	36.0
NPL	Mi174994	928.6	34.0	933	37	4.4	2	50.2
NPL	Mi166802	865.0	31.7	853	34	-12.0	2	46.5
NPL	Mi174982	663.6	24.3	654	26	-9.6	2	35.6
NPL	Mi175000	663.6	24.3	658	26	-5.6	2	35.6
NPL	Mi174976	728.5	26.7	714	29	-14.5	2	39.4
NPL	Mi174992	663.1	24.3	696	28	32.9	2	37.1
NPL	Mi174995	795.4	29.1	770	31	-25.4	2	42.5
VSL	Mi174987	662.8	24.3	674	15	11.2	2	28.5
VSL	Mi174985	729.9	26.7	741	17	11.1	2	31.7
VSL	Mi174989	794.0	29.1	822	19	28.0	2	34.7
VSL	Mi174984	928.1	34.0	955	38	26.9	2	51.0
VSL	3927	662.8	24.3	672	14	9.2	2	28.0
VSL	Mi174986	670.2	24.5	685	14	14.8	2	28.3
VSL	Mi174996	869.6	31.8	892	35	22.4	2	47.3
METAS	Mi174980	928.1	34.0	908	8	-20.1	2	34.9
METAS	Mi174972	860.6	31.5	841	7	-19.6	2	32.3
METAS	Mi174998	795.5	29.1	773	6	-22.5	2	29.7
METAS	Mi174988	728.4	26.7	720.7	5.4	-7.7	2	27.2
METAS	Mi174970	666.2	24.4	668.9	4.9	2.7	2	24.9
METAS	Mi174966	662.7	24.3	665.3	4.8	2.6	2	24.7
METAS	3923	662.9	24.3	629	4.5	-33.9	2	24.7
LNE	Mi174961	861.0	31.5	865.0	27.7	4.0	2	41.9
LNE	Mi166805	795.4	29.1	794.9	25.4	-0.5	2	38.7
LNE	Mi174971	928.5	34.0	935.5	29.9	7.0	2	45.3
LNE	Mi166803	729.8	26.7	621.3	19.9	-108.5	2	33.3

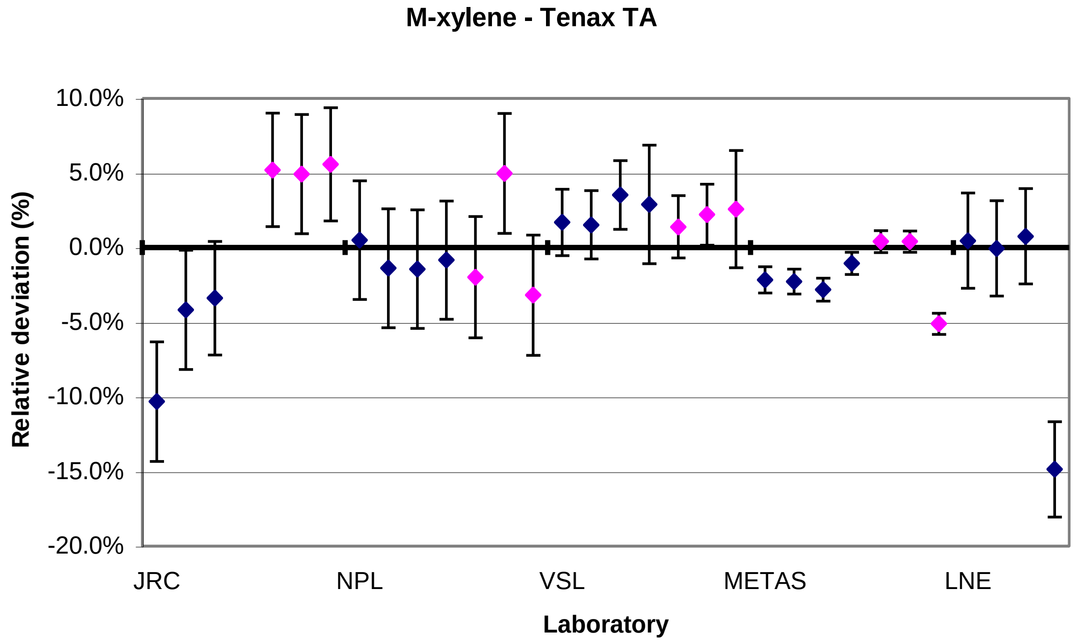

Figure 17 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

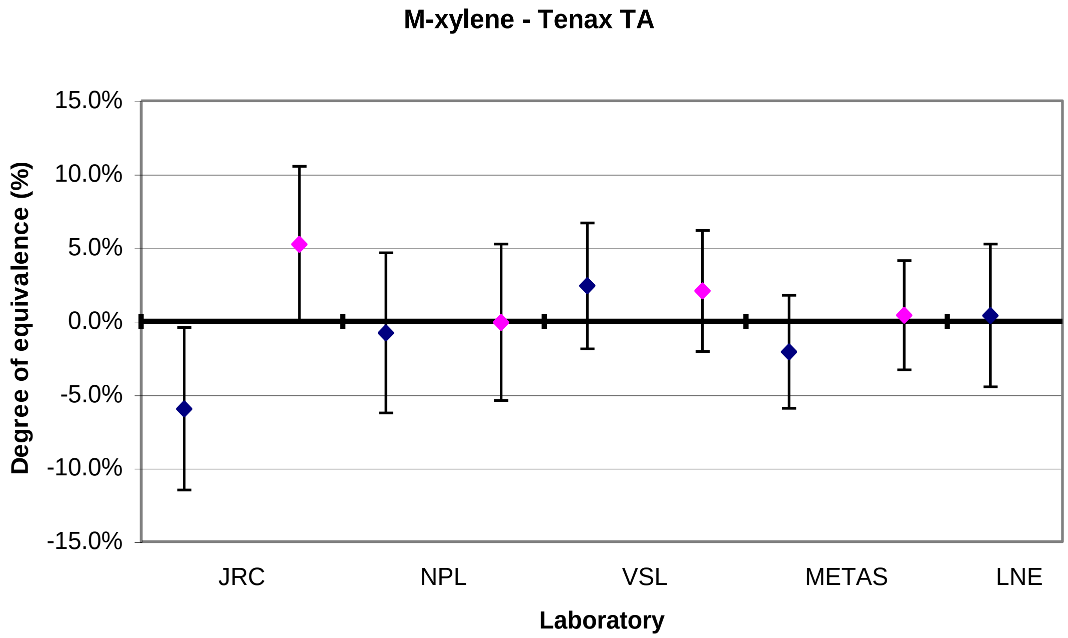

Figure 18 : Relative degrees of equivalence with uncertainties (k=2)

O-xylene

Table 15 : Results for o-xylene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi174964	938.6	34.3	816.7	39.2	-121.9	2	52.1
JRC	Mi174963	804.1	29.4	749.0	34.5	-55.1	2	45.3
JRC	Mi174962	670.4	24.6	627.0	28.8	-43.4	2	37.9
JRC	Mi174981	870.2	31.8					
JRC	3926	670.3	24.5	651.3	30.0	-19.0	2	38.7
JRC	Mi174969	737.8	27.0	717.3	33.0	-20.5	2	42.6
JRC	Mi174965	670.8	24.6	657.1	30.2	-13.7	2	39.0
NPL	Mi174994	938.9	34.3	976	39	37.1	2	52.0
NPL	Mi166802	874.5	32.0	893	36	18.5	2	48.2
NPL	Mi174982	670.9	24.6	685	27	14.1	2	36.5
NPL	Mi175000	670.9	24.6	692	28	21.1	2	37.3
NPL	Mi174976	736.5	27.0	749	30	12.5	2	40.3
NPL	Mi174992	670.4	24.5	688	28	17.6	2	37.2
NPL	Mi174995	804.2	29.4	807	32	2.8	2	43.5
VSL	Mi174987	670.2	24.5	695	18	24.8	2	30.4
VSL	Mi174985	738.0	27.0	763	20	25.0	2	33.6
VSL	Mi174989	802.8	29.4	847	22	44.2	2	36.7
VSL	Mi174984	938.4	34.3	985	80	46.6	2	87.1
VSL	3927	670.1	24.5	701	18	30.9	2	30.4
VSL	Mi174986	677.6	24.8	716	19	38.4	2	31.3
VSL	Mi174996	879.2	32.2	932	38	52.8	2	49.8
METAS	Mi174980	938.4	34.3	908	17	-30.4	2	38.3
METAS	Mi174972	870.1	31.8	842	15	-28.1	2	35.2
METAS	Mi174998	804.2	29.4	775	13	-29.2	2	32.2
METAS	Mi174988	736.5	27.0	721	12	-15.5	2	29.5
METAS	Mi174970	673.6	24.7	670	11	-3.6	2	27.0
METAS	Mi174966	670.0	24.5	666	10	-4.0	2	26.5
METAS	3923	670.2	24.5	634	10	-36.2	2	26.5
LNE	Mi174961	870.5	31.9	875.6	28.0	5.1	2	42.4
LNE	Mi166805	804.2	29.4	805.0	25.8	0.8	2	39.1
LNE	Mi174971	938.7	34.3	945.2	30.2	6.5	2	45.8
LNE	Mi166803	737.8	27.0	651.6	20.9	-86.2	2	34.1

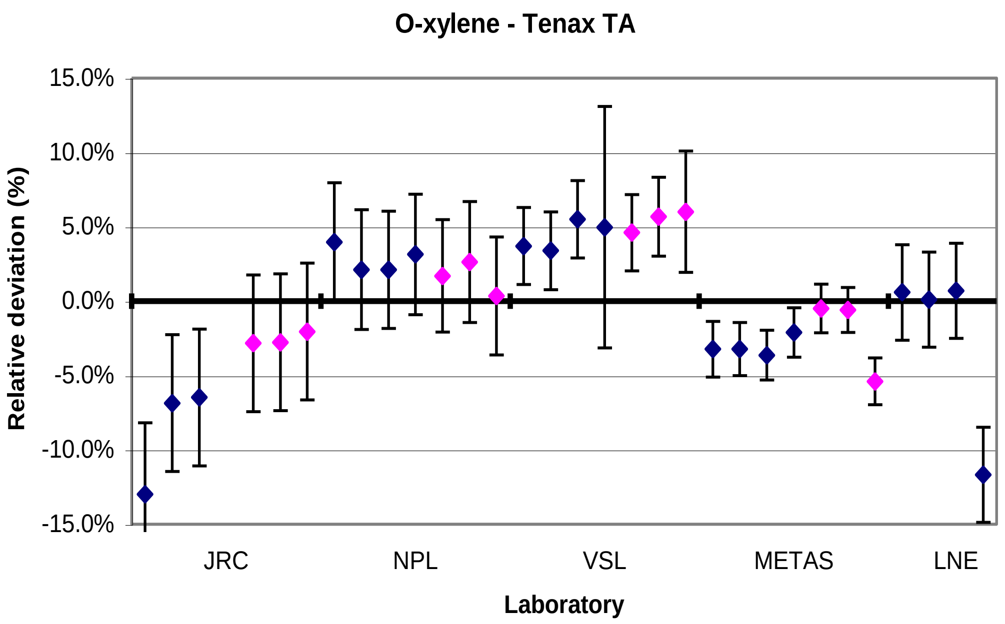

Figure 19 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

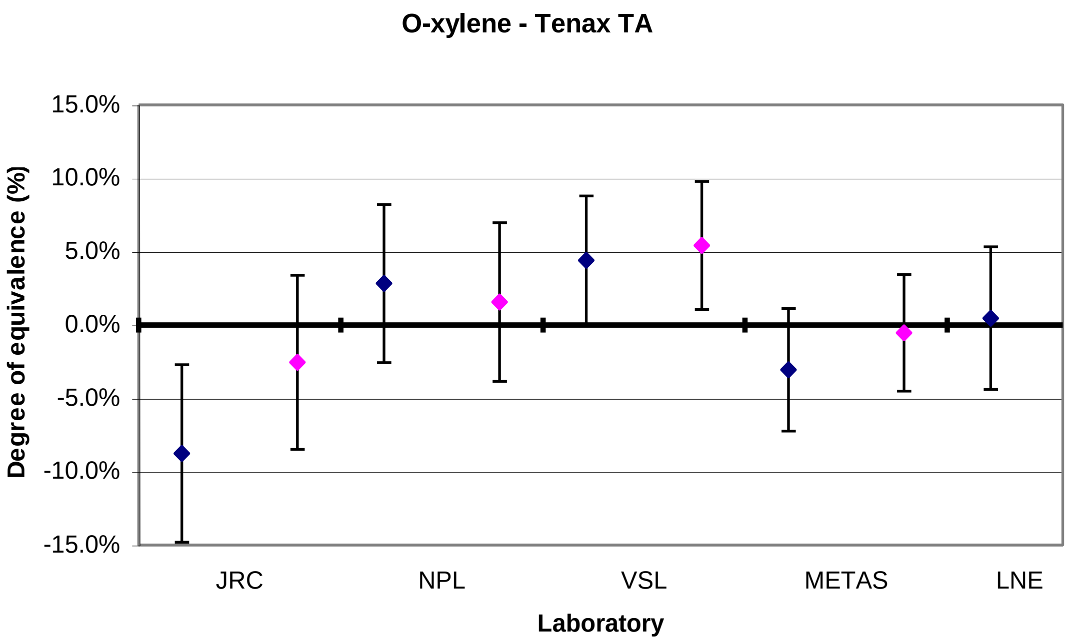

Figure 20 : Relative degrees of equivalence with uncertainties (k=2)

3. Tenax TA (VSL)

Benzene

Table 16 : Results for benzene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi150522	107.5	1.7	114.3	4.8	6.8	2	5.1
JRC	Mi150570	107.5	1.7	116.3	4.9	8.8	2	5.2
JRC	Mi150516	107.5	1.7	116.3	4.9	8.8	2	5.2
JRC	Mi150506	107.5	1.7	115.2	4.8	7.7	2	5.1
JRC	Mi150567	107.5	1.7	116.7	4.9	9.2	2	5.2
NPL	Mi150557	107.5	1.7	104	4	-3.5	2	4.3
NPL	Mi150530	107.5	1.7	103	4	-4.5	2	4.3
NPL	Mi150559	107.5	1.7	104	4	-3.5	2	4.3
NPL	Mi150511	107.5	1.7	105	4	-2.5	2	4.3
NPL	Mi150529	107.5	1.7	107	4	-0.5	2	4.3
VSL	Mi150508	107.5	1.7	107.2	2.1	-0.3	2	2.7
VSL	Mi150564	107.5	1.7	107.9	2.1	0.4	2	2.7
VSL	MI150505	107.5	1.7	108.5	2.1	1.0	2	2.7
VSL	Mi150509	107.5	1.7	107.7	2.1	0.2	2	2.7
VSL	Mi150513	107.5	1.7	106.8	2.1	-0.7	2	2.7
METAS	Mi150551	107.5	1.7	103.4	1.9	-4.1	2	2.5
METAS	Mi150553	107.5	1.7	104.1	1.9	-3.4	2	2.5
METAS	Mi150555	107.5	1.7	103.1	1.9	-4.4	2	2.5
METAS	Mi150561	107.5	1.7	104.5	1.9	-3.0	2	2.5
METAS	Mi150566	107.5	1.7	104.5	1.9	-3.0	2	2.5
LNE	Mi150515	107.5	1.7	106.3	3.4	-1.2	2	3.8
LNE	Mi150527	107.5	1.7	103.6	3.3	-3.9	2	3.7
LNE	Mi150552	107.5	1.7	106.0	3.4	-1.5	2	3.8
LNE	Mi150510	107.5	1.7	106.8	3.4	-0.7	2	3.8
LNE	Mi150507	107.5	1.7	105.0	3.4	-2.5	2	3.8

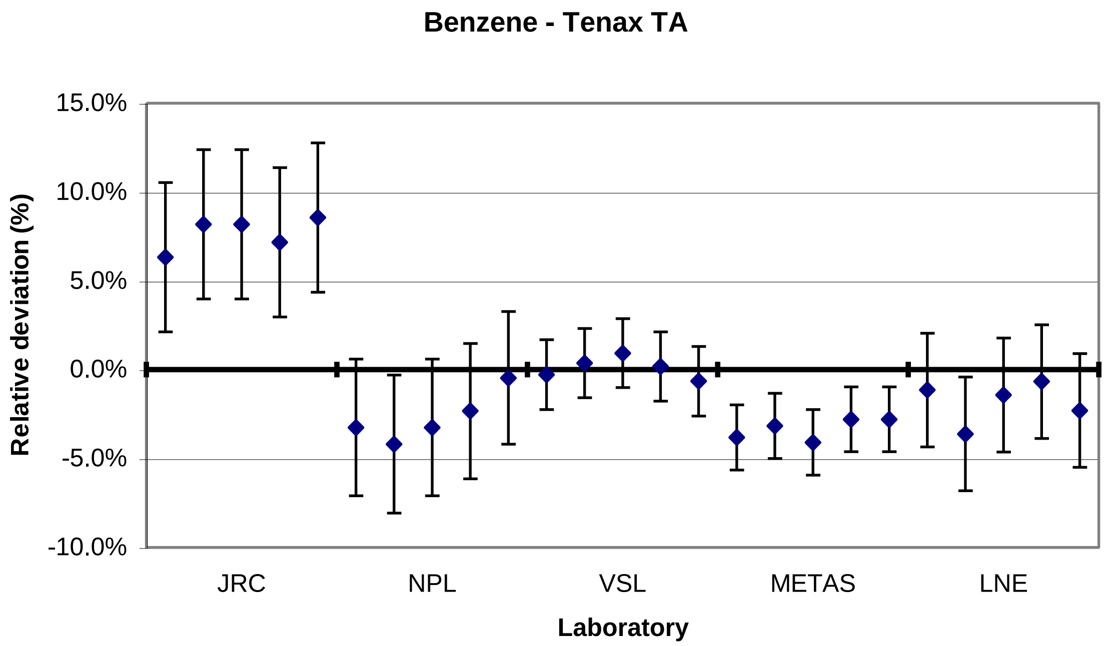

Figure 21 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

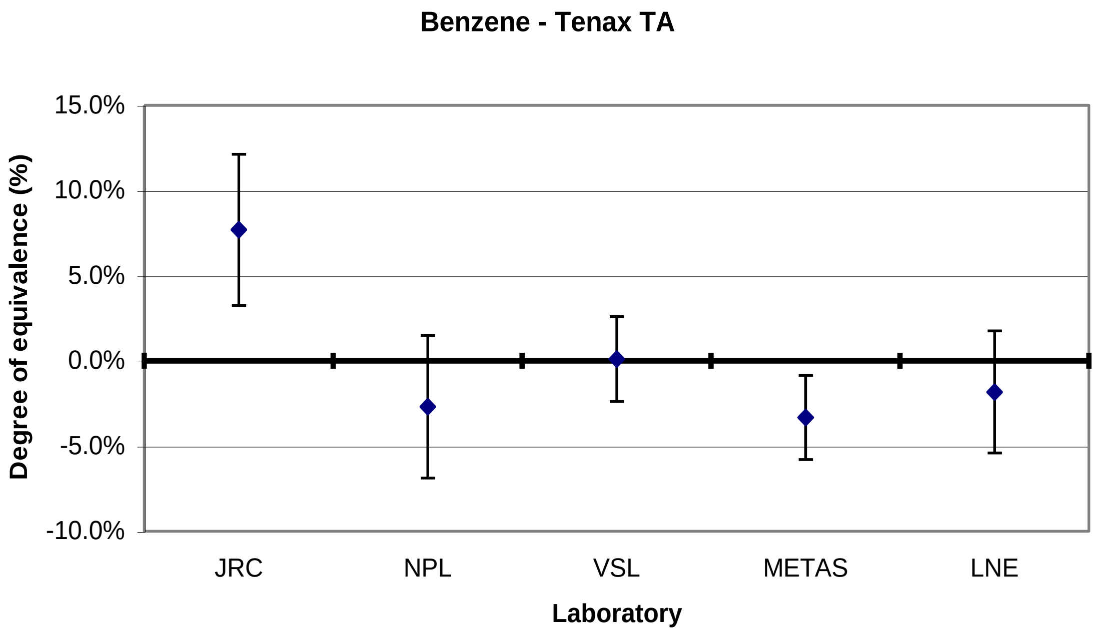

Figure 22 : Relative degrees of equivalence with uncertainties (k=2)

Toluene

Table 17 : Results for toluene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi150522	126.2	2.0	115.7	3.7	-10.5	2	4.2
JRC	Mi150570	126.2	2.0	115.8	3.7	-10.4	2	4.2
JRC	Mi150516	126.2	2.0	116	3.7	-10.2	2	4.2
JRC	Mi150506	126.2	2.0	114.9	3.7	-11.3	2	4.2
JRC	Mi150567	126.2	2.0	116.8	3.7	-9.4	2	4.2
NPL	Mi150557	126.2	2.0	120	5	-6.2	2	5.4
NPL	Mi150530	126.2	2.0	120	5	-6.2	2	5.4
NPL	Mi150559	126.2	2.0	119	5	-7.2	2	5.4
NPL	Mi150511	126.2	2.0	120	5	-6.2	2	5.4
NPL	Mi150529	126.2	2.0	122	5	-4.2	2	5.4
VSL	Mi150508	126.2	2.0	127.4	2.5	1.2	2	3.2
VSL	Mi150564	126.2	2.0	126.3	2.5	0.1	2	3.2
VSL	MI150505	126.2	2.0	127.9	2.5	1.7	2	3.2
VSL	Mi150509	126.2	2.0	125.8	2.4	-0.4	2	3.1
VSL	Mi150513	126.2	2.0	126.2	2.4	0.0	2	3.1
METAS	Mi150551	126.2	2.0	123.1	1.7	-3.1	2	2.6
METAS	Mi150553	126.2	2.0	124.1	1.7	-2.1	2	2.6
METAS	Mi150555	126.2	2.0	124.0	1.7	-2.2	2	2.6
METAS	Mi150561	126.2	2.0	123.5	1.7	-2.7	2	2.6
METAS	Mi150566	126.2	2.0	124.9	1.7	-1.3	2	2.6
LNE	Mi150515	126.2	2.0	123.9	4.0	-2.3	2	4.4
LNE	Mi150527	126.2	2.0	124.4	4.0	-1.8	2	4.5
LNE	Mi150552	126.2	2.0	123.4	3.9	-2.8	2	4.4
LNE	Mi150510	126.2	2.0	125.3	4.0	-0.9	2	4.5
LNE	Mi150507	126.2	2.0	123.9	4.0	-2.3	2	4.4

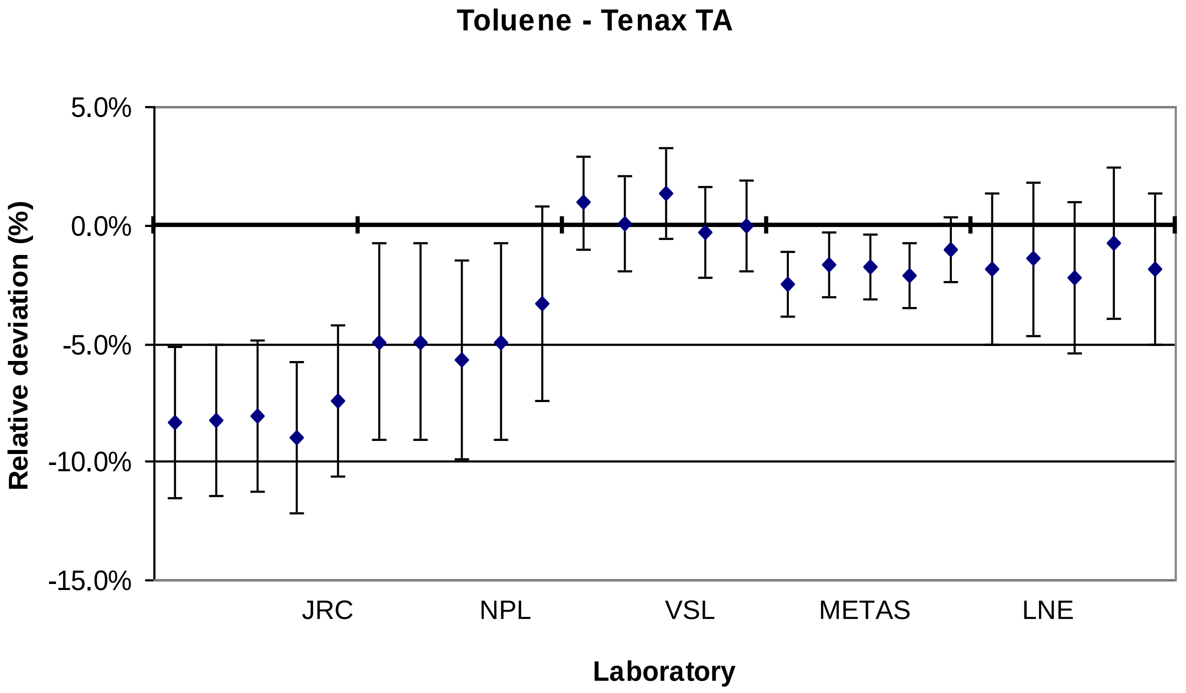

Figure 23 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

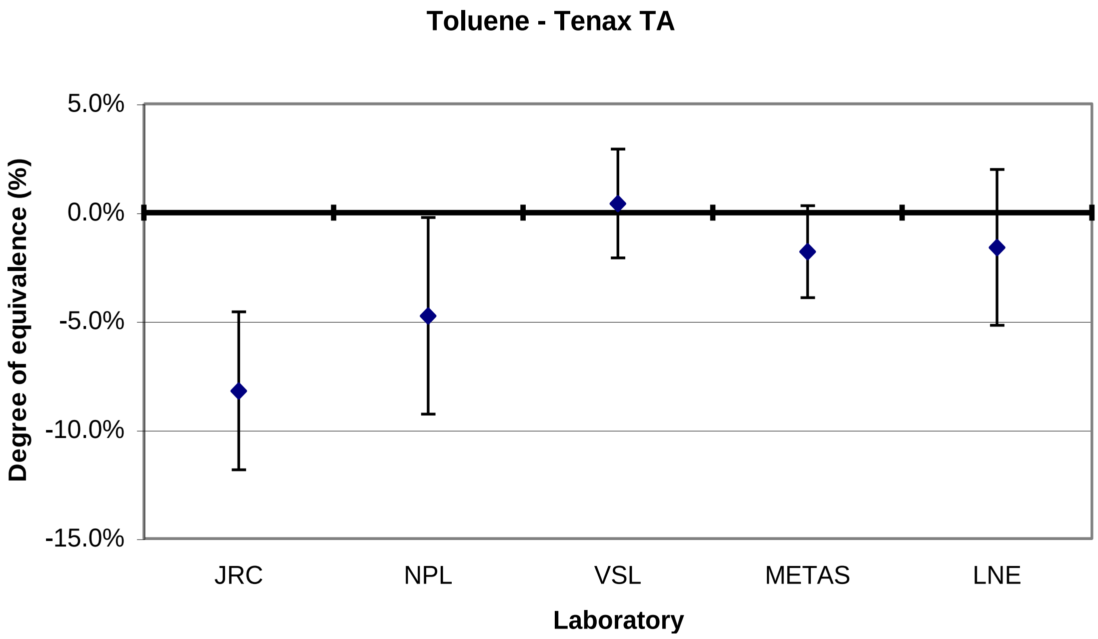

Figure 24 : Relative degrees of equivalence with uncertainties (k=2)

Ethylbenzene

Table 18 : Results for ethylbenzene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi150522	109.3	2.9	93.9	5.3	-15.4	2	6.0
JRC	Mi150570	109.3	2.9	94.3	5.3	-15.0	2	6.0
JRC	Mi150516	109.3	2.9	94.1	5.3	-15.2	2	6.0
JRC	Mi150506	109.3	2.9	93.4	5.2	-15.9	2	6.0
JRC	Mi150567	109.3	2.9	94.7	5.1	-14.6	2	5.9
NPL	Mi150557	109.3	2.9	103	4	-6.3	2	4.9
NPL	Mi150530	109.3	2.9	102	4	-7.3	2	4.9
NPL	Mi150559	109.3	2.9	102	4	-7.3	2	4.9
NPL	Mi150511	109.3	2.9	103	4	-6.3	2	4.9
NPL	Mi150529	109.3	2.9	104	4	-5.3	2	4.9
VSL	Mi150508	109.3	2.9	109.2	3.4	-0.1	2	4.5
VSL	Mi150564	109.3	2.9	108.4	3.4	-0.9	2	4.5
VSL	MI150505	109.3	2.9	109.5	3.4	0.2	2	4.5
VSL	Mi150509	109.3	2.9	108.9	3.4	-0.4	2	4.5
VSL	Mi150513	109.3	2.9	108.2	3.4	-1.1	2	4.5
METAS	Mi150551	109.3	2.9	110.0	1.6	0.7	2	3.3
METAS	Mi150553	109.3	2.9	111.0	1.6	1.7	2	3.3
METAS	Mi150555	109.3	2.9	110.5	1.6	1.2	2	3.3
METAS	Mi150561	109.3	2.9	109.8	1.6	0.5	2	3.3
METAS	Mi150566	109.3	2.9	112.0	1.6	2.7	2	3.3
LNE	Mi150515	109.3	2.9	108.4	3.5	-0.9	2	4.5
LNE	Mi150527	109.3	2.9	107.3	3.4	-2.0	2	4.5
LNE	Mi150552	109.3	2.9	107.6	3.4	-1.7	2	4.5
LNE	Mi150510	109.3	2.9	108.2	3.5	-1.1	2	4.5
LNE	Mi150507	109.3	2.9	107.0	3.4	-2.3	2	4.5

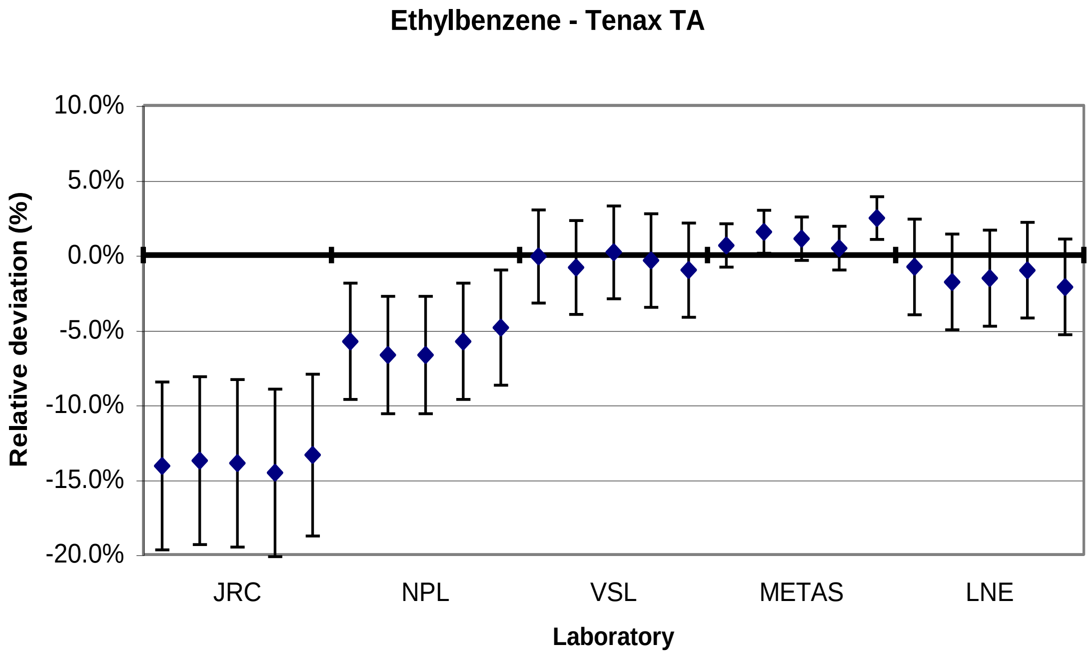

Figure 25 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

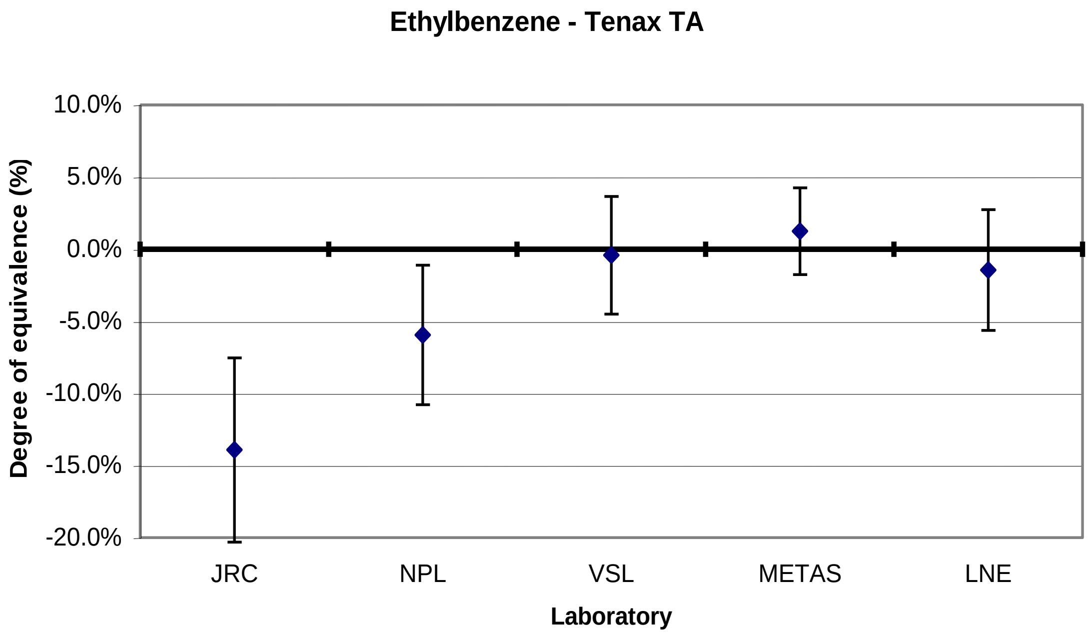

Figure 26 : Relative degrees of equivalence with uncertainties (k=2)

M-xylene

Table 19 : Results for m-xylene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi150522	99.0	1.6	77.9	12.5	-21.1	2	12.6
JRC	Mi150570	99.0	1.6	75.5	12.5	-23.5	2	12.6
JRC	Mi150516	99.0	1.6	77.5	12.4	-21.5	2	12.5
JRC	Mi150506	99.0	1.6	77.4	12.5	-21.6	2	12.6
JRC	Mi150567	99.0	1.6	77.7	12.4	-21.3	2	12.5
NPL	Mi150557	99.0	1.6	92	4	-7.0	2	4.3
NPL	Mi150530	99.0	1.6	92	4	-7.0	2	4.3
NPL	Mi150559	99.0	1.6	92	4	-7.0	2	4.3
NPL	Mi150511	99.0	1.6	93	4	-6.0	2	4.3
NPL	Mi150529	99.0	1.6	94	4	-5.0	2	4.3
VSL	Mi150508	99.0	1.6	99.9	1.5	0.9	2	2.2
VSL	Mi150564	99.0	1.6	99.5	1.5	0.5	2	2.2
VSL	MI150505	99.0	1.6	100.4	1.5	1.4	2	2.2
VSL	Mi150509	99.0	1.6	99.5	1.5	0.5	2	2.2
VSL	Mi150513	99.0	1.6	99.1	1.5	0.1	2	2.2
METAS	Mi150551	99.0	1.6	97.5	1.3	-1.5	2	2.1
METAS	Mi150553	99.0	1.6	98.0	1.3	-1.0	2	2.1
METAS	Mi150555	99.0	1.6	97.3	1.3	-1.7	2	2.1
METAS	Mi150561	99.0	1.6	97.4	1.3	-1.6	2	2.1
METAS	Mi150566	99.0	1.6	98.7	1.3	-0.3	2	2.1
LNE	Mi150515	99.0	1.6	97.1	3.1	-1.9	2	3.5
LNE	Mi150527	99.0	1.6	98.2	3.1	-0.8	2	3.5
LNE	Mi150552	99.0	1.6	97.5	3.1	-1.5	2	3.5
LNE	Mi150510	99.0	1.6	98.4	3.1	-0.6	2	3.5
LNE	Mi150507	99.0	1.6	96.7	3.1	-2.3	2	3.5

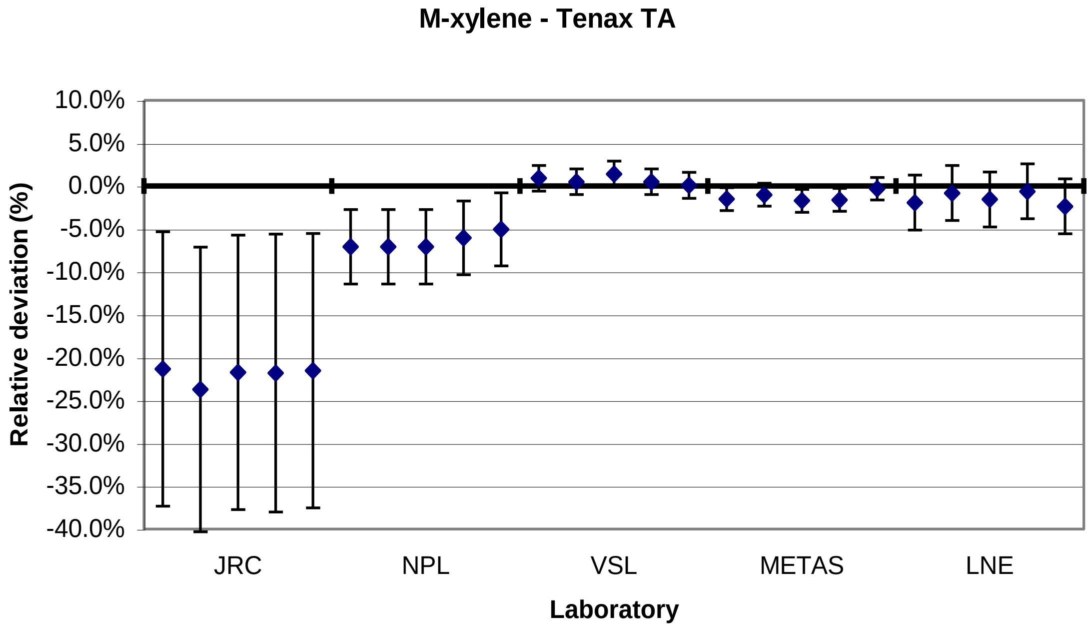

Figure 27 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

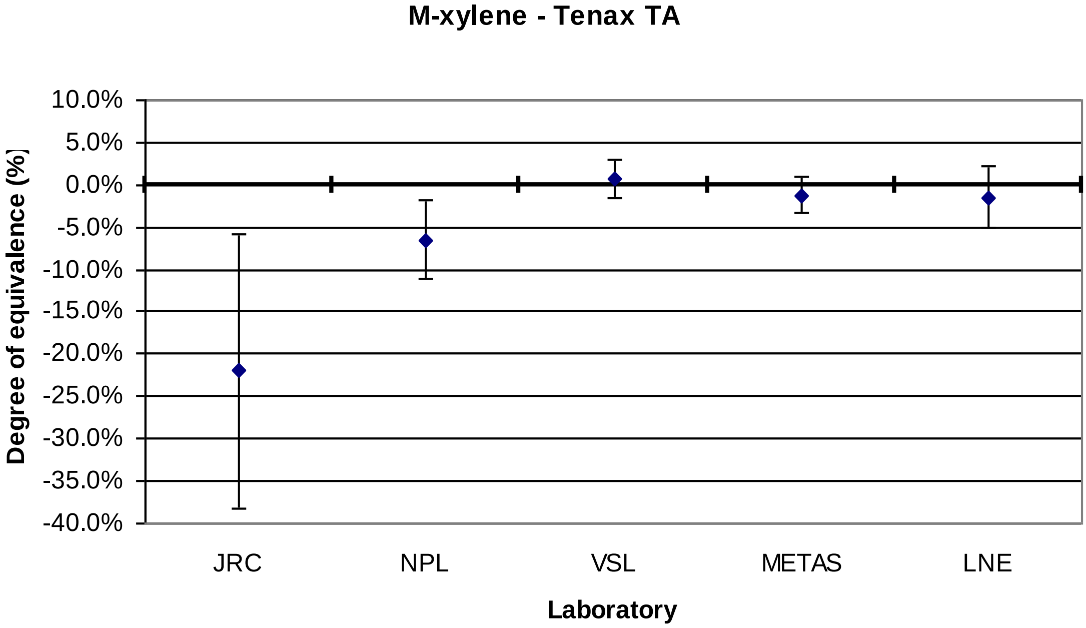

Figure 28 : Relative degrees of equivalence with uncertainties (k=2)

O-xylene

Table 20 : Results for o-xylene

Laboratory	Tube	x_{ref}	U_{ref}	x_{lab}	U_{lab}	Δx	k	U(Δx)
JRC	Mi150522	76.9	1.3	66.3	5.4	-10.6	2	5.6
JRC	Mi150570	76.9	1.3	63.7	5.5	-13.2	2	5.6
JRC	Mi150516	76.9	1.3	64.4	5.5	-12.5	2	5.7
JRC	Mi150506	76.9	1.3	64.9	5.5	-12.0	2	5.6
JRC	Mi150567	76.9	1.3	65.9	5.4	-11.0	2	5.6
NPL	Mi150557	76.9	1.3	73	3	-3.9	2	3.3
NPL	Mi150530	76.9	1.3	73	3	-3.9	2	3.3
NPL	Mi150559	76.9	1.3	72	3	-4.9	2	3.3
NPL	Mi150511	76.9	1.3	74	3	-2.9	2	3.3
NPL	Mi150529	76.9	1.3	74	3	-2.9	2	3.3
VSL	Mi150508	76.9	1.3	77.1	2.2	0.2	2	2.6
VSL	Mi150564	76.9	1.3	76.8	2.2	-0.1	2	2.6
VSL	MI150505	76.9	1.3	77.5	2.2	0.6	2	2.6
VSL	Mi150509	76.9	1.3	76.9	2.1	0.0	2	2.5
VSL	Mi150513	76.9	1.3	76.5	2.1	-0.4	2	2.5
METAS	Mi150551	76.9	1.3	78.7	1.8	1.8	2	2.2
METAS	Mi150553	76.9	1.3	78.8	1.8	1.9	2	2.2
METAS	Mi150555	76.9	1.3	78.1	1.8	1.2	2	2.2
METAS	Mi150561	76.9	1.3	77.9	1.8	1.0	2	2.2
METAS	Mi150566	76.9	1.3	78.9	1.8	2.0	2	2.2
LNE	Mi150515	76.9	1.3	74.0	2.4	-2.9	2	2.7
LNE	Mi150527	76.9	1.3	74.4	2.4	-2.5	2	2.7
LNE	Mi150552	76.9	1.3	74.3	2.4	-2.6	2	2.7
LNE	Mi150510	76.9	1.3	73.7	2.4	-3.2	2	2.7
LNE	Mi150507	76.9	1.3	72.8	2.3	-4.1	2	2.7

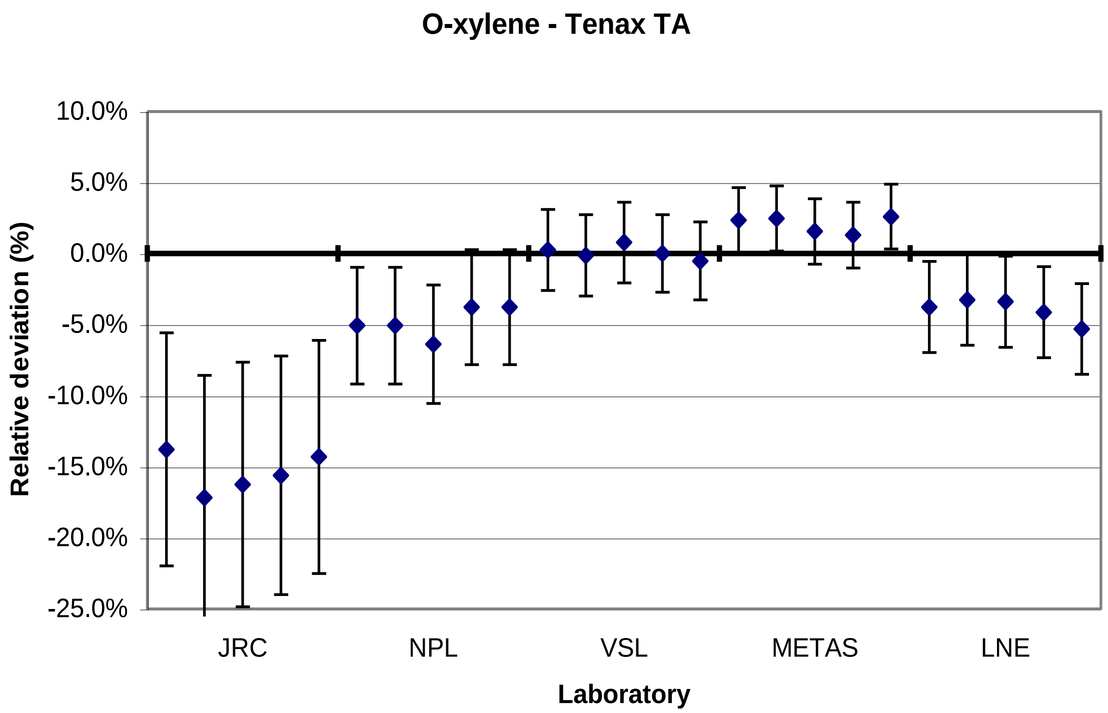

Figure 29 : Relative deviation from the reference value with uncertainties stated by the laboratory (k=2)

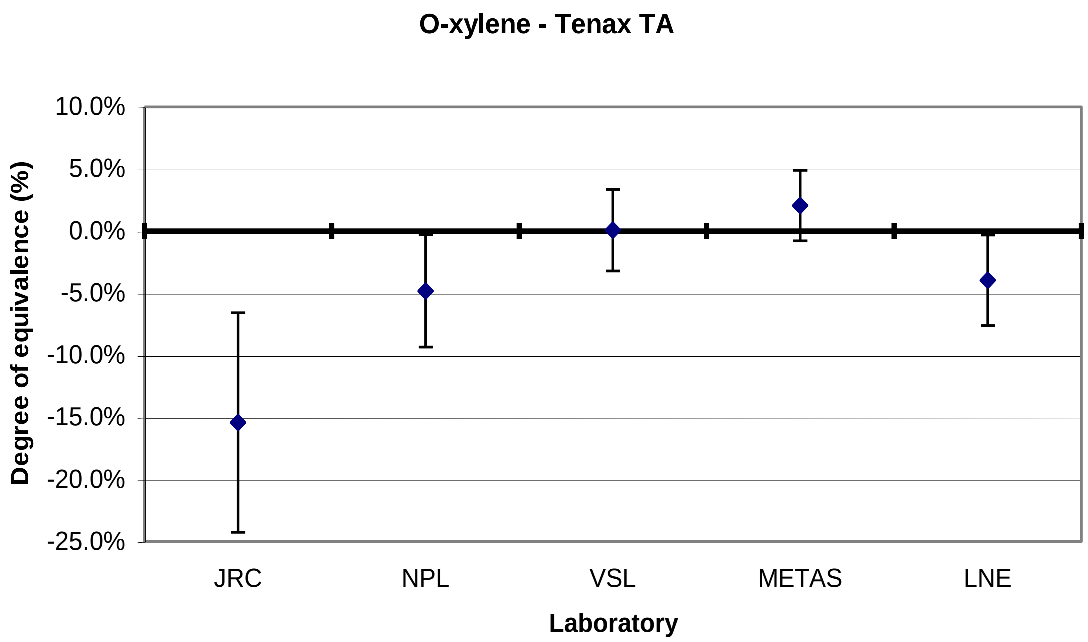

Figure 30 : Relative degrees of equivalence with uncertainties (k=2)

Discussion of results

Carbopack X (LNE)

It should be noted that the first tube of METAS was not considered for the five compounds in the calculation of total average, as the four other tubes have shown good reproducibility, so it seems that this first tube is an outlier.

For benzene (figures 1 and 2), except for JRC, all results agree within less than 4% relative to the assigned reference values. The results of JRC are not consistent with the assigned reference values within the associated uncertainties (overestimation of 10 %). Moreover, for JRC, relative deviations show an trend of increase when loaded amounts increase.

For toluene (figures 3 and 4), except for JRC, all results agree within less than 3% relative to the assigned reference values. The results of JRC are not consistent with the assigned reference values within the associated uncertainties (overestimation of 13%). For JRC, the same trend for benzene results is noticed for toluene results.

For ethylbenzene (figures 5 and 6), apart from METAS, all results agree within less than 3% relative to the assigned reference values. The results of METAS are not consistent with the assigned reference values within the associated uncertainties (overestimation of 4%). Although JRC results are mostly accurate, the same trend as the one observed for benzene and toluene is still noticeable. VSL results were not submitted as they were out of their calibration range.

For m-xylene (figures 7 and 8), except for JRC, all results agree within less than 1% relative to the assigned reference values. The results of JRC are not consistent with the assigned reference values within the associated uncertainties (underestimation of 20%). The linear trend is still observed for JRC. VSL results were not submitted as they were out of their calibration range.

For o-xylene (figures 9 and 10), all results agree within less than 3% relative to the assigned reference values. Linear trend is observed for JRC as it was for other compounds. Moreover, VSL results were not submitted as they were out of their calibration range.

Tenax TA (LNE)

It is important to mention that, for JRC, one tube responded as a blank whereas it should have been loaded, thus it doesn’t appear in the tables and graphs.
The last tube of METAS and LNE was not considered for the five compounds in the calculation of total average. These results can be considered as outliers, since the reproducibility has been good for other tubes.
Moreover, for this sorbent type, a distinction should be done between tubes analysed using analytical method of the participating laboratory (blue points) and those analysed by the participating laboratory with LNE method (pink points).

For benzene (figures 11 and 12), all results agree within less than 4% relative to the assigned reference values, except those of JRC using LNE method (overestimation of 9%). It seems that trend between relative deviation and mass loaded showed again but with the opposite direction of the one observed for Carbopack X sorbent : relative deviations decrease when masses increase. Moreover, reproducibility is better with LNE method than using their own method.

For toluene (figures 13 and 14), all laboratories are in agreement with the assigned reference values whatever analytical method used, within less than 6%. A slight linear trend for JRC and also a better reproducibility using LNE analytical method is still noticeable.

For ethylbenzene (figures 15 and 16), JRC with LNE method, NPL, VSL, METAS with its own method and LNE are in agreement with the assigned reference values within less than 4%. For JRC, tubes analysed using their own method are not consistent with the assigned reference values within the associated uncertainties (underestimation of 10%) whereas for METAS results for tubes analysed using LNE method showed inconsistency with the assigned reference values (overestimation of 5%). A slight linear trend for JRC and also a better reproducibility with LNE analytical method is still noticeable.

For m-xylene (figures 17 and 18), apart from JRC using their own method, all results are in agreement within less than 6% relative to the assigned reference values. The results of JRC using their method are not consistent with the assigned reference values within the associated uncertainties (underestimation of 6%). A slight linear trend for JRC and also a better reproducibility with LNE analytical method is still noticeable.

For o-xylene (figures 19 and 20), except for JRC using its own method and VSL using LNE method, all results agree within less than 5% relative to the assigned reference values. The results of JRC using their analytical method are not consistent with the assigned reference values within the associated uncertainties (underestimation of 9%) and those of VSL using LNE method show overestimation of 6%. A slight linear trend for JRC and also a better reproducibility with LNE analytical method is still noticeable.

Tenax TA (VSL)

For benzene (figures 21 and 22), except for JRC and METAS, all results agree within less than 3% relative to the assigned reference value. The results of JRC and METAS are not consistent with the assigned reference value within the associated uncertainties, with an overestimation of 8% and an underestimation of 3%, respectively.

For toluene (figures 23 and 24), apart from JRC and NPL, all results agree within less than 2% relative to the assigned reference value. For JRC and NPL, results are not consistent with the assigned reference value within the associated uncertainties, with an underestimation of 8% and 5%, respectively.

For ethylbenzene (figures 25 and 26), VSL, METAS and LNE are in agreement with the assigned reference value within less than 2%. The results of JRC and NPL are not consistent with the assigned reference value within the associated uncertainties, with an underestimation of 14% and 6%, respectively.

For m-xylene (figures 27 and 28), VSL, METAS and LNE are in agreement with the assigned reference value within less than 2%. The results of JRC and NPL are not consistent with the assigned reference value within the associated uncertainties, with an underestimation of 22% and 7%, respectively.

For o-xylene (figures 29 and 30), VSL and METAS are in agreement with the assigned reference value within less than 2%. For the 3 remaining laboratories (JRC, NPL, LNE), results are not consistent with the assigned reference value within the associated uncertainties, with an underestimation of 15%, 5% and 4%, respectively.

Conclusion

For Carbopack X (LNE), JRC got good results for ethylbenzene and o-xylene but for other three compounds results are significantly different from the assigned reference values (up to 20% for m-xylene). Masses of benzene and toluene are overestimated whereas masses of ethylbenzene and m-xylène are underestimated. Moreover, relative deviations for the five compounds are more scattered than for the other laboratories. It seems that there is a link between relative deviation and amount of BTEX loaded : it increases when masse increase.
NPL got good results for the five compounds within less than 4% relative to the assigned reference values.
For the two compounds submitted by VSL (benzene and toluene), the agreement is within less than 3% relative to the assigned reference values.
For METAS, all results apart from ethylbenzene are consistent with the assigned reference values within less than 3%. While masses of the four compounds are rather underestimated, masses of ethylbenzene are overestimated. This trend is also visible for Tenax TA sorbent. This can be explained by the error in the calibration of the permeation unit used to produce the reference gas mixture.
LNE got good results for the five compounds within less than 1% relative to the assigned reference values.
Generally, all laboratories except JRC have shown good reproducibility of the results for the five compounds.

For Tenax TA (LNE), there is a distinction between tubes analysed using analytical method of the laboratory and those using LNE analytical method.
For JRC, benzene and toluene results analysed using their own analytical method agree within less than 3% relative to the assigned reference values. For the three other compounds, results are significantly different from the assigned reference values (up to 10% for ethylbenzene). When using LNE analytical method, results are in agreement with the assigned reference values within less than 6%, except for benzene (overestimation of 8%), since it seems there is a link between relative deviation and amount of BTEX loaded but in the opposite side of Carbopack X sorbent : higher masses lead to lower relative deviations.
NPL got good results for the five compounds within less than 4% relative to the assigned reference values whatever analytical method used.
VSL results agree with the assigned reference values within less than 5% except for o-xylene when using LNE analytical method (overestimation of 6%).
METAS results agree with the assigned reference values within less than 3% except for ethylbenzene using LNE analytical method (overestimation of 5%). The explanation for ethylbenzene results is given in the paragraph above.
LNE got good results for the five compounds within less than 1% relative to the assigned reference values.
Generally, all laboratories except NPL using LNE analytical method have shown good reproducibility of the results for the five compounds. NPL results using LNE analytical method are very scattered.
Comparing the results generated using two analytical methods, no difference is noticeable except for JRC and METAS where relative deviations are higher using LNE

method. These results are rather unexpected because for temperatures above 250°C, VOCs and more particularly benzene are known to be released from Tenax TA sorbent. Thus the overestimation of results of JRC and METAS should be more likely using their own method (desorption at 300°C) than when using LNE's one (at 230°C).

For Tenax TA (VSL), JRC results are significantly different from the assigned reference values (up to 22% for m-xylene).
The NPL measurements for benzene are in agreement with the assigned reference values within less than 3%. However, NPL results of the four other compounds disagree with the assigned reference values (largest underestimation for m-xylene by 7%). NPL had anticipated that the tubes would be loaded with a similar mass of each compound to those loaded at LNE. Hence the difference between the mass of each compound loaded onto NPL's reference standard (approximately 800 ng) and the sample tube (approximately 100 ng) was large and explains the discrepancies observed.
VSL got good results for the five compounds within less than 1% relative to the assigned reference values.
METAS results agree within less than 2% relative to the assigned reference values except for benzene (underestimation of 3%).
LNE results agree within less than 2% relative to the assigned reference values except for o-xylene (underestimation of 4%).
Generally, all laboratories have shown good reproducibility of the results for the five compounds.

To conclude, in most cases, measurements of benzene, toluene, ethylbenzene, m-xylene and o-xylene by each of the participating laboratories on the two sorbent types (Carbopack X and Tenax TA) agree within 5% of the assigned reference values. This EURAMET comparison demonstrates very good comparability between institutes.

It can be also interesting to note that according to laboratories, analytical uncertainties are very different. METAS gets the lowest uncertainties and yet they generally agree well with the assigned reference values.