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NPL REPORT ENG 14

Report on EUROMET key comparison of pressure measurements standards in the range 80 kPa to 7 MPa (EUROMET.M.P-K3.b)

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NOT RESTRICTED

March 2009

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Department for **Innovation, Universities** & **Skills**

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Industry & Innovation Division

ABSTRACT

A comparison of pressure measurements standards in the range 80 kPa to 7 MPa has been carried out between twelve National Measurement Institutes under the auspices of EUROMET. The results of this comparison, designated EUROMET.M.P-K3b, have been linked to those of a CCM comparison (CCM.P-K1.c), organized by the Consultative Committee for Mass (CCM), via two common participants. The results presented here demonstrate the metrological equivalence, within the quoted uncertainties, of all of the participant laboratories in this pressure range.

ISSN 1754-2987

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1 INTRODUCTION

The technology used to realise national standards of pressure above the barometric region is that of the pressure balance (sometimes called a dead-weight tester or piston gauge) [1]. A worldwide key comparison of standards (CCM.P-K1.c)[2] covering the pressure range 80 kPa to 6.8 MPa was carried out between 1998 and 1999. In that comparison a Ruska 2465 pressure balance base, a mid-range piston-cylinder, a high-range piston-cylinder and a set of ring weights were circulated around the participants. The results of a European comparison covering a similar pressure range using the same type of equipment are presented here. The comparison was piloted by the National Physical Laboratory (NPL), UK which also provided the transfer standards.

Two participants in the European comparison, the INRIM[1] and the PTB[2], also participated in the CCM comparison. The results of these two National Measurement Institutes (NMIs) were used to link those of the other participants to the key comparison reference values defined in the CCM comparison. The degrees of metrological equivalence can then be calculated for pairs of laboratories participating in either comparison.

The schedule was devised to minimise transportation problems by considering the geographical location of each participant. Two additional participants were added to the comparison once the circulation of the transfer standards had begun (NML-CSIR of South Africa and NCM of Bulgaria). This was done with the agreement of all the participants. Measurements were made at FFA in Sweden but these were withdrawn following the transfer of the Swedish pressure facilities to SP[3].

2 PARTICPANTS AND TIMETABLE

The following NMIs participated in this comparison at the times shown in Table 1.

National Measurement Institute	**Start Date**	**Finish Date**
National Physical Laboratory (NPL) –Pilot	February 2000	February 2000
NPL (Pilot)	March 2000	March 2000
Force Institute (FI) - DK	July 2000	August 2000
Aeronautical Research Institute of Sweden (FFA) – SE[4]	August 2000	September 2000
Centre for Metrology and Accreditation (MIKES) - FI	September 2000	September 2000
Physikalisch-Technische Bundesanstalt (PTB) – DE	October 2000	October 2000
NPL (UK and pilot)	November 2000	December 2000

[1] Istituto Nazionale di Ricerca Metrologica
[2] Physikalisch-Technische Bundesanstalt
[3] Swedish National Testing and Research Institute
[4] FFA results withdrawn following transfer of Swedish Pressure standards to SP

TÜBİTAK Ulusal Metroloji Enstitüsü (UME) - TR	January 2001	January 2001
Slovak Institute of Metrology (SMU) -SK	February 2001	February 2001
National Metrology Laboratory – Enterprise Ireland (NML-EI) - EI	March 2001	April 2001
Istituto Nazionale di Ricerca Metrologica (INRIM) - IT	May 2001	May 2001
Central Office of Measures (GUM) - PL	June 2001	July 2001
National Office of Measures (OMH) -HU	July 2001	August 2001
National Metrology Laboratory - CSIR (NML-CSIR) - ZA	August 2001	September 2001
NPL (Pilot)	November 2001	November 2001
National Centre of Metrology (NCM) - BG	March 2002	April 2002
NPL (Pilot)	October 2002	November 2002

Table 1: Participants in EUROMET M.P-K3.b

3 TRANSFER STANDARDS

Both the Ruska 2465 mid-range and high-range piston cylinder assemblies used as transfer standards in this comparison are manufactured from cobalt bonded tungsten carbide. The mid-range piston (C-71) has a nominal effective area of 84 mm^2 while the high range assembly (V-832) has a nominal effective area of 8.4 mm^2. A set of stainless steel ring weights was also circulated as part of the package.

4 CIPM KEY COMPARISON CCM.P-K1.C

The corresponding CCM comparison was carried out between 1998 and 1999. The participants in that comparison were BNM-LNE (FR), INRIM (IT), NIST (US), NRLM (JP) and PTB (DE). Measurements were carried out by each participant at nine nominal pressures between 80 kPa and 781 kPa using a Ruska 2465 mid-range piston cylinder assembly as a transfer standard. A Ruska high-range piston cylinder was used as a transfer standard in the realisation of nine nominal pressures between 622 kPa and 6.8 MPa. The participants in the EUROMET comparison made measurements at the same nominal pressures using similar Ruska 2465 mid-range and high-range piston cylinders.

5 REFERENCE VALUES

The INRIM and the PTB both participated in key comparison CCM.P-K1.c as well as this regional comparison. Therefore, in order to calculate reference values that can be readily compared to the CCM comparison, it was decided to use the weighted means of the INRIM and PTB results as the EUROMET reference values.

However, between the CCM comparison and the EUROMET comparison, the INRIM standards were re-assessed causing a relative increase in effective area of 6×10^{-6} at all pressures. In order not to create a false offset when linking the CCM and EUROMET comparisons, the INRIM results used in the linking process have therefore been decreased by this amount. Note that this was only carried out for the linking process and the results for INRIM throughout the remainder of the report are as originally submitted.

The EUROMET reference values have been calculated from the following equations:

$$R = \frac{A_{\mathrm{INRIM}} u_{\mathrm{PTB}}^2 + A_{\mathrm{PTB}} u_{\mathrm{INRIM}}^2}{u_{\mathrm{INRIM}}^2 + u_{\mathrm{PTB}}^2}$$

$$u(R) = \sqrt{s_A^2 + s_B^2}$$

where

$$s_A^2 = 2\frac{u_{\mathrm{PTB}}^2 (A_{\mathrm{INRIM}} - R)^2 + u_{\mathrm{INRIM}}^2 (A_{\mathrm{PTB}} - R)^2}{u_{\mathrm{INRIM}}^2 + u_{\mathrm{PTB}}^2}$$

$$s_B^2 = \frac{u_{\mathrm{INRIM}}^2 \times u_{\mathrm{PTB}}^2}{u_{\mathrm{INRIM}}^2 + u_{\mathrm{PTB}}^2}$$

The reference values and their calculated uncertainties are shown in Table 2 and Table 3. Note that these reference values have been used solely to provide a link to the CCM reference value: all deviations given in subsequent tables and figures are with respect to the CCM reference value.

Nominal pressure / kPa	EUROMET reference value / mm^2	Reference value uncertainty (k=1) / mm^2
80	83.976 35	0.000 58
138	83.976 46	0.000 47
197	83.976 33	0.000 49
255	83.976 30	0.000 48
313	83.976 26	0.000 47
430	83.976 27	0.000 41
547	83.976 22	0.000 41
664	83.976 22	0.000 39
781	83.976 28	0.000 37

Table 2: EUROMET reference value for mid-range piston-cylinder

Nominal pressure / kPa	EUROMET reference value / mm^2	Reference value uncertainty (k=1) / mm^2
622	8.389 014	0.000 079
739	8.389 015	0.000 075
1 078	8.389 030	0.000 058
1 768	8.389 062	0.000 053
2 938	8.389 129	0.000 071
4 107	8.389 166	0.000 075
5 277	8.389 182	0.000 071
6 446	8.389 199	0.000 071
6 797	8.389 193	0.000 073

Table 3: EUROMET reference value for high-range piston-cylinder

6 LINK TO CCM.P-K1.C

The linking laboratories between EUROMET.M.P-K3b and CCM.P-K1c are PTB and INRIM. The degrees of equivalence D_i of PTB and INRIM obtained in both comparisons at similar pressures are given in the following tables.

EUROMET.M.P-K3b Piston-cylinder C-71	PTB		INRIM	
Nominal pressure /kPa	D_i / 10^{-6}	U_i / 10^{-6}	D_i / 10^{-6}	U_i / 10^{-6}
80	-1.3	9.1	+6.7	15.3
138	-0.9	7.6	+5.0	13.5
197	-1.1	7.6	+6.2	13.2
255	-1.0	7.5	+5.7	12.7
313	-1.0	7.3	+5.8	12.6
430	-0.7	6.8	+3.9	12.1
547	-0.6	6.8	+3.6	12.1
664	-0.6	6.6	+3.0	11.9
781	-0.2	6.4	+1.2	11.7

Table 4: Degrees of equivalence D_i for PTB and INRIM in EUROMET.M.P-K3b, C-71

CCM.P-K1c Piston-cylinder C-415	PTB		INRIM	
Nominal pressure /kPa	D_i / 10^{-6}	U_i / 10^{-6}	D_i / 10^{-6}	U_i / 10^{-6}
79	+2.3	4.6	+4.2	12.1
138	+1.7	5.5	+6.3	10.3
196	+0.4	5.4	-2.1	12.1
255	+0.1	5.3	-2.6	11.8
313	+0.9	5.2	-0.5	11.4
430	+1.1	5.2	-1.3	11.0
546	+1.9	5.2	-2.6	10.9
663	+2.5	5.2	-3.6	10.7
780	+2.1	5.2	-3.7	10.9

Table 5: Degrees of equivalence D_i for PTB and INRIM in CCM.P-K1c, C-415

EUROMET.M.P-K3b Piston-cylinder V-832	PTB		INRIM	
Nominal pressure /kPa	D_i / 10^{-6}	U_i / 10^{-6}	D_i / 10^{-6}	U_i / 10^{-6}
622	-2.7	12.9	+2.4	12.6
739	-2.9	11.8	+3.4	12.2
1 078	-1.5	9.4	+2.6	11.0
1 768	-1.5	8.3	+3.8	10.7
2 938	-1.1	11.8	+1.3	12.3
4 107	-2.1	12.2	+2.7	12.9
5 277	-0.8	11.9	+1.0	12.7
6 446	-0.3	12.0	+0.4	13.0
6 798	+1.1	12.2	-1.5	13.3

Table 6: Degrees of equivalence D_i for PTB and INRIM in EUROMET.M.P-K3b, V-832

CCM.P-K1c Piston-cylinder V-762	PTB		INRIM	
Nominal pressure /kPa	D_i / 10^{-6}	U_i / 10^{-6}	D_i / 10^{-6}	U_i / 10^{-6}
622	-1.9	8.7	-1.0	13.1
739	-0.8	8.6	-5.6	13.1
1 078	+0.4	8.5	-5.6	13.1
1 767	+2.8	8.5	-5.8	15.0
2 936	+7.3	10.3	-1.6	14.9
4 104	+7.1	10.3	-1.3	14.9
5 273	+5.2	10.3	-5.0	15.0
6 442	+3.6	10.9	-3.0	15.1
6 792	+3.1	11.0	-4.0	15.7

Table 7: Degrees of equivalence D_i for PTB and INRIM in CCM.P-K1c, V-762

The combined differences $D_{\mathrm{PTB+INRIM}}$ have been calculated at each corresponding pressure using the equation:

$$D_{\mathrm{PTB+INRIM}} = \frac{(u_{\mathrm{PTB}}^2 D_{\mathrm{INRIM}} + u_{\mathrm{INRIM}}^2 D_{\mathrm{PTB}})}{(u_{\mathrm{PTB}}^2 + u_{\mathrm{INRIM}}^2)}$$

Nominal pressure	EUROMET.M.P-K3b Piston-cylinder C-71	CCM.P-K1c Piston-cylinder C-415	Offset from EUROMET.M.P-K3b to CCM.P-K1c
/ kPa	$D_{\mathrm{PTB+INRIM}}$ / 10^{-6}	$D_{\mathrm{PTB+INRIM}}$ / 10^{-6}	/ 10^{-6}
79	+0.81	+2.57	+1.8
138	+0.53	+2.64	+2.1
196	+0.74	-0.02	-0.8
255	+0.69	-0.37	-1.1
313	+0.69	+0.68	0.0
430	+0.41	+0.68	+0.3
546	+0.36	+1.07	+0.7
663	+0.29	+1.39	+1.1
780	+0.11	+1.08	+1.0

Table 8: Combined differences $D_{\mathrm{PTB+INRIM}}$ for mid-range piston-cylinders

Nominal pressure	EUROMET.M.P-K3b Piston-cylinder V-832	CCM.P-K1c Piston-cylinder V-762	Offset from EUROMET.M.P-K3b to CCM.P-K1c
/ kPa	$D_{PTB+INRIM}$ / 10^{-6}	$D_{PTB+INRIM}$ / 10^{-6}	/ 10^{-6}
622	-0.08	-1.62	-1.5
739	+0.12	-2.24	-2.4
1 078	+0.26	-1.42	-1.7
1 767	+0.50	+0.73	+0.2
2 936	+0.05	+4.43	+4.4
4 104	+0.14	+4.38	+4.2
5 273	+0.05	+1.91	+1.9
6 442	+0.02	+1.34	+1.3
6 792	-0.10	+0.76	+0.9

Table 9: Combined differences $D_{PTB+INRIM}$ for high-range piston-cylinders

The degrees of equivalence of all participants in the EUROMET comparison have been calculated by adding the calculated offsets to the deviations from the EUROMET reference values. This makes it possible to extend the CCM.P-K1c matrices of equivalence to include all participants in EUROMET.M.P-K3b.

7 PILOT LABORATORY MEASUREMENTS

Measurements were made on each of the transfer standards on five separate occasions by the NPL, on the dates given in Table 1. As can be observed from Figure 1 and Figure 2 these measurements demonstrate that there is no significant temporal drift in the operation of the piston-cylinders. Rather, there appears to be a random scatter with time. This is further supported by examination of the participant data which does not give any indication of systematic change in effective areas during the period of the comparison.

In the case of the mid-range piston cylinder, there appears to be a problem with the first two sets of NPL measurements. These are at the extremes of the NPL data and are also of different shape to the later three sets of data. The last three sets of data show much greater consistency. This discrepancy is difficult to explain as the same reference standard was used for all five sets of measurements.

There is a greater proportional spread in the pilot measurements on the high range piston cylinder assembly (V-832), up to sixteen parts per million at the two highest pressures. Since the completion of this comparison NPL has ceased to use the standard that was used to carry out the monitoring measurements at the time of the comparison. The piston-cylinder assembly began to exhibit anomalous behaviour at the highest pressures and comparison with other NPL standards indicated that it was non-linear at pressures above 5.5 MPa.

As was agreed at the start of the comparison the set of measurements made in December 2000, denoted as NPL(2), were considered to be NPL's measurements as a participant.

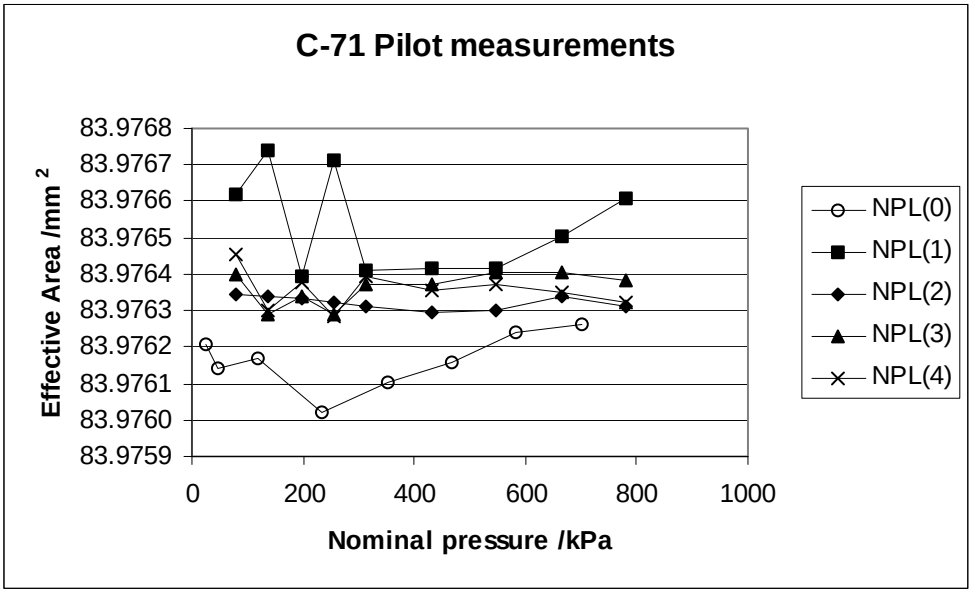

Figure 1: Pilot laboratory measurements using mid-range piston cylinder C-71

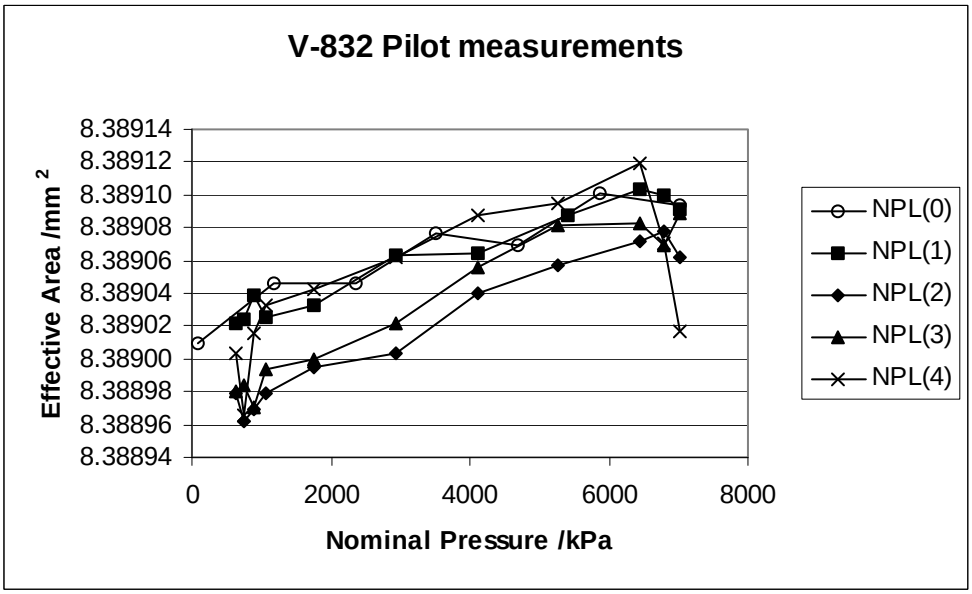

Figure 2: Pilot laboratory measurements using high-range piston-cylinder V-832

8 PARTICIPANT RESULTS

8.1 Mid-Range Piston Cylinder (C-71)

Ten of the twelve participants made measurements using the mid-range piston cylinder at nine nominal generated pressures, while the Force Institute made measurements at the eight lowest pressures. GUM did not make any measurements in this range. No problems were reported with the operation of the transfer standard.

In all cases measurements were made with the cylinder rotating in both a clockwise and counter-clockwise sense. No systematic offset was observed due to the direction of rotation.

An overview of the results obtained by the participants is shown in Figure 3. As can be seen the general trend observed for the performance of the transfer standard is consistent for most of the participants. The OMH measurements show an anomalous shift between 197 kPa and 255 kPa, with the data above 197 kPa being more consistent with the other participants than that at the lowest three points.

The equivalence of the participants with each other and with the CCM comparison reference value at each nominal pressure is shown in tabular form in Table 10 to Table 18 while the deviation of each participant from the mean value is shown graphically in Figure 5 to Figure 13. Each graph shows the deviation from the CCM reference value for each participant at a particular nominal pressure. The uncertainties shown in graphs and the tables are for a coverage factor of k=2.

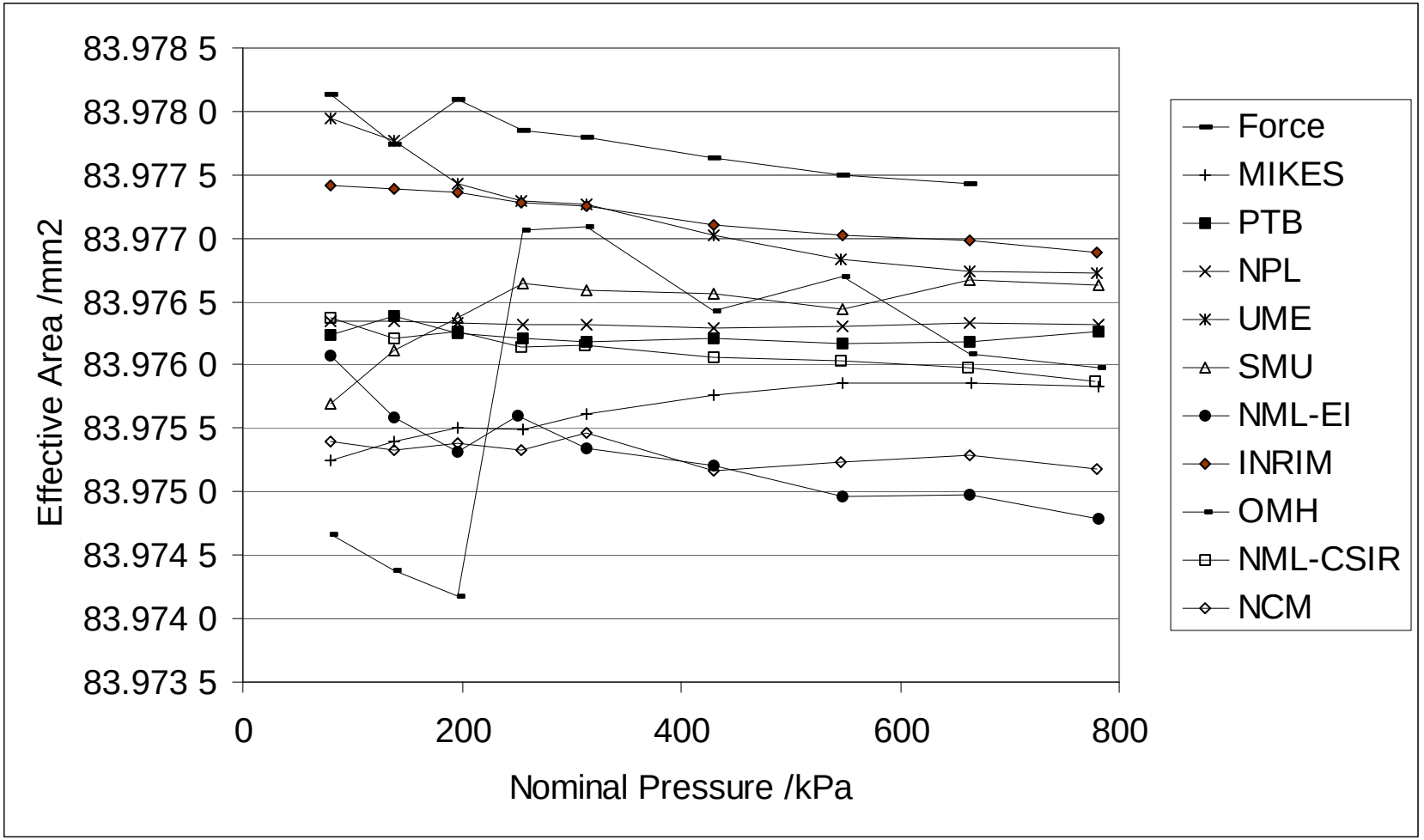

Figure 3:Overview of Participant Results using Piston-Cylinder C-71

8.2 High-Range Piston Cylinder (V-832)

All twelve of the participants made measurements at eleven nominal pressures ranging from 622 kPa to 7.03 MPa using the high range piston-cylinder assembly. No problems were reported with the operation of the transfer standard. The corresponding CCM comparison only included measurements at nine of these pressures (902 kPa and 7.03 MPa were not included). Only the results at the nine nominal pressures common to both comparisons have been included in the equivalence analysis as it is not possible to directly link the two additional points with the CCM comparison. However, the data from the additional points are shown in the graphical overview of the results in Figure 4. It may be observed from this figure that the general trends associated with the performance of the transfer standard were similar for all participants.

In all cases measurements were made with the cylinder rotating in both a clockwise and counter clockwise sense. No systematic offset was observed due to the direction of rotation.

Virtually all of the data submitted by the participants deviate less from the CCM reference value than the estimated combined uncertainty. It is interesting to note that there are several occurrences where the difference between pairs of participants is greater than the estimate of the combined uncertainty. These may be observed as the italicized data in Table 19 to Table 27. The deviation of the participants from the CCM comparison reference value at each pressure is shown in Figure 14 to Figure 22. The uncertainties shown in the tables and the graphs are for a coverage factor of k=2.

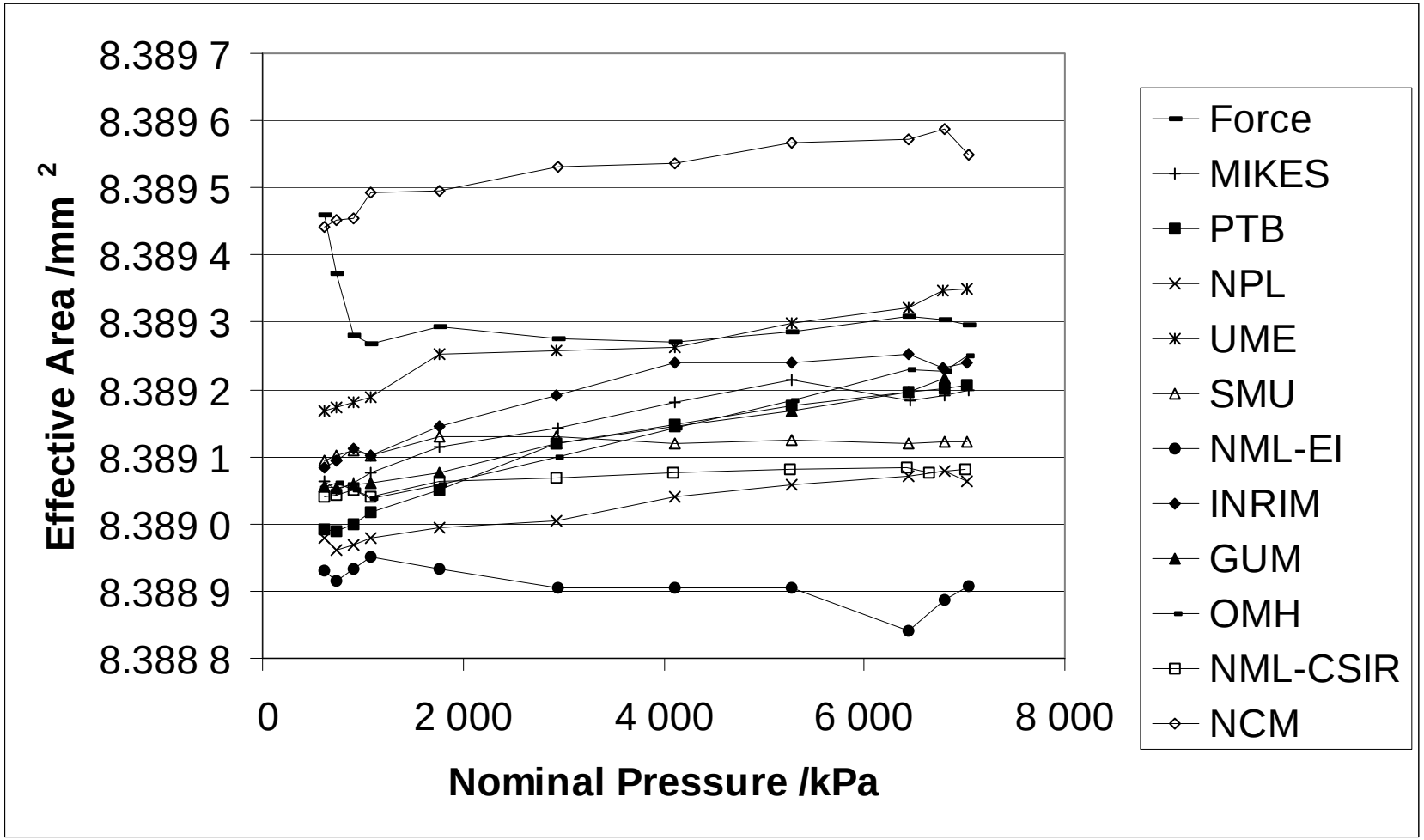

Figure 4: Overview of Participant Results using Piston-Cylinder V-832

9 CONCLUSIONS

This comparison demonstrates the equivalence of the majority of participants with reference values at eighteen nominal pressures from the corresponding CCM comparison. However, there is a relatively large uncertainty in the transferred reference values which limits the ability of the participants working at the highest metrological level to use the comparison to validate CMC table entries. It is more relevant to study the equivalence between individual laboratories in order to gain an appreciation of their equivalence.

Four laboratories with independently realized primary standards took part in this comparison. This gave the opportunity to use the data they generated to produce a set of independent reference values. These were compared with those imported from the CCM comparison and found to be in good agreement. This can be regarded as a validation of the process used to import the reference value from the CCM comparison.

All participants are equivalent to each other over a majority of the comparison range. There are thirteen examples for the mid-range piston cylinder where pairs of participants show a greater deviation between their measurements than the combined uncertainty in this figure. There are twenty-four examples of this for the high-range piston cylinder. When it is considered that there are four hundred and ninety-four entries in each of the two equivalence tables this demonstrates a good overall equivalence for the comparison.

10 REFERENCES

[1] The Pressure Balance: Theory and Practice, Dadson R.S, Lewis S.L, Peggs G.N, 1982, ISBN 0 11 480048 0

[2] IMGC Technical Report 42, Molinar G, Legras J.C, Jäger J, Ooiwa A, Schmidt J, 2000

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(I-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force	19.5	42.7																						
MIKES	-15.0	22.3	-32.7	44.1																				
PTB	-3.0	18.2	-20.7	42.1	11.9	21.3																		
NPL	-1.8	18.2	-19.5	42.1	13.1	21.3	1.2	16.9																
UME	17.3	19.8	-0.4	42.9	*32.2*	22.7	*20.3*	18.6	*19.1*	18.6														
SMU	-9.6	39.5	-27.3	54.8	5.4	41.0	-6.5	38.9	-7.7	38.9	-26.8	39.7												
NML-EI	-5.0	35.1	-22.7	51.7	10.0	36.8	-1.9	34.4	-3.2	34.4	-22.2	35.3	4.6	49.1										
INRIM	11.0	30.7	-6.7	48.8	25.9	32.6	14.0	29.9	12.8	29.9	-6.3	30.9	20.5	46.1	16.0	42.3								
OMH	-21.9	26.1	-39.6	46.1	-6.9	28.4	-18.8	25.2	-20.0	25.2	*-39.1*	26.4	-12.3	43.2	-16.9	39.2	-32.8	35.3						
NML-CSIR	-7.4	28.5	-25.1	47.5	7.5	30.6	-4.4	27.7	-5.6	27.7	-24.7	28.8	2.1	44.7	-2.4	40.8	-18.4	37.1	14.4	33.5				
NCM	-13.0	91.1	-30.7	98.7	1.9	91.8	-10.0	90.8	-11.2	90.8	-30.3	91.2	-3.5	97.4	-8.1	95.7	-24.0	94.1	8.8	92.8	-5.6	93.5		

Table 10: Equivalence at 80 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force	13.1	38.0																						
MIKES	-14.8	20.4	-28.0	40.1																				
PTB	-3.0	15.1	-16.1	37.7	11.9	19.9																		
UME	-3.6	16.4	-16.7	38.2	11.2	20.9	-0.6	15.9																
NPL	13.3	19.0	0.2	39.4	*28.2*	23.0	16.3	18.5	16.9	19.6														
SMU	-6.3	38.7	-19.4	51.8	8.5	40.8	-3.3	38.4	-2.7	39.0	-19.6	40.1												
NML-EI	-12.5	34.1	-25.6	48.5	2.3	36.5	-9.5	33.8	-8.9	34.4	-25.8	35.7	-6.2	49.1										
INRIM	8.9	27.0	-4.2	43.9	23.7	30.0	11.9	26.7	12.5	27.5	-4.5	29.1	15.2	44.5	21.4	40.6								
OMH	*-27.0*	24.8	-40.1	42.5	-12.2	28.0	-24.0	24.4	-23.4	25.3	*-40.3*	27.0	-20.7	43.2	-14.5	39.1	-35.9	33.2						
NML-CSIR	-7.9	27.4	-21.1	44.1	6.9	30.3	-5.0	27.0	-4.4	27.8	-21.3	29.4	-1.7	44.7	4.5	40.8	-16.8	35.1	19.0	33.4				
NCM	-15.6	90.7	-28.8	97.1	-0.8	91.6	-12.7	90.6	-12.0	90.8	-29.0	91.3	-9.4	97.3	-3.2	95.6	-24.5	93.3	11.3	92.7	-7.7	93.4		

Table 11: Equivalence at 138 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force	21.7	40.5																						
MIKES	-9.1	20.4	-30.8	42.3																				
PTB	-0.3	15.2	-22.0	40.0	8.8	19.5																		
NPL	0.8	16.8	-21.0	40.6	9.8	20.8	1.1	15.7																
UME	13.8	19.4	-7.9	41.8	22.9	22.9	14.1	18.4	13.1	19.8														
SMU	1.2	38.8	-20.6	53.6	10.3	40.7	1.5	38.3	0.4	39.0	-12.6	40.2												
NML-EI	-11.4	34.2	-33.2	50.4	-2.4	36.3	-11.1	33.6	-12.2	34.4	-25.3	35.7	-12.6	49.0										
INRIM	12.9	26.3	-8.8	45.4	22.0	29.0	13.2	25.6	12.2	26.6	-0.9	28.3	11.7	43.9	24.4	39.9								
OMH	-25.0	25.0	*-46.7*	44.7	-15.9	27.8	*-24.7*	24.2	*-25.8*	25.3	*-38.8*	27.1	-26.2	43.1	-13.5	39.0	-37.9	32.4						
NML-CSIR	-2.7	27.6	-24.5	46.1	6.3	30.1	-2.4	26.9	-3.5	27.8	-16.6	29.5	-3.9	44.7	8.7	40.7	-15.7	34.4	22.3	33.4				
NCM	-10.5	90.8	-32.2	98.0	-1.4	91.6	-10.2	90.6	-11.3	90.9	-24.3	91.4	-11.7	97.4	1.0	95.6	-23.4	93.1	14.5	92.7	-7.7	93.4		

Table 12: Equivalence at 197 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force	19.6	40.2																						
MIKES	-8.5	20.3	-28.1	42.0																				
PTB	0.0	14.9	-19.6	39.7	8.5	19.4																		
NPL	1.4	16.7	-18.2	40.4	9.9	20.8	1.4	15.6																
UME	13.0	19.4	-6.6	41.6	21.5	23.0	13.0	18.5	11.6	19.9														
SMU	5.2	38.7	-14.4	53.4	13.7	40.7	5.2	38.3	3.8	39.0	-7.8	40.2												
NML-EI	-7.2	34.4	-26.8	50.4	1.3	36.6	-7.2	33.9	-8.6	34.7	-20.2	36.1	-12.4	49.2										
INRIM	12.8	25.5	-6.8	44.8	21.3	28.3	12.8	24.8	11.4	25.9	-0.2	27.7	7.6	43.5	20.0	39.7								
OMH	10.2	37.8	-9.4	52.8	18.7	39.8	10.2	37.4	8.8	38.1	-2.8	39.3	5.0	51.7	17.4	48.5	-2.6	42.7						
NML-CSIR	-1.8	27.5	-21.4	45.9	6.7	30.1	-1.8	26.8	-3.2	27.8	-14.8	29.5	-7.0	44.7	5.4	41.0	-14.6	33.8	-12.0	43.9				
NCM	-10.4	90.8	-30.0	98.0	-1.9	91.6	-10.4	90.6	-11.8	90.9	-23.4	91.4	-15.6	97.4	-3.2	95.7	-23.2	92.9	-20.6	97.0	-8.6	93.5		

Table 13: Equivalence at 255 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		NML-CSIR		NCM
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force	18.2	40.6																						
MIKES	-7.7	20.2	-25.9	42.5																				
PTB	-1.0	14.7	-19.2	40.2	6.7	19.3																		
NPL	0.6	16.6	-17.6	40.9	8.3	20.8	1.6	15.5																
UME	11.9	19.3	-6.3	42.1	19.6	23.1	12.9	18.4	11.3	20.0														
SMU	3.8	38.7	-14.3	53.8	11.5	40.7	4.9	38.2	3.2	39.0	-8.1	40.2												
NML-EI	-10.9	33.9	-29.1	50.5	-3.2	36.2	-9.9	33.4	-11.5	34.3	-22.8	35.7	-14.8	48.9										
INRIM	11.8	25.2	-6.4	45.1	19.5	28.2	12.8	24.5	11.2	25.7	-0.1	27.6	7.9	43.4	22.7	39.2								
OMH	9.8	39.7	-8.4	54.5	17.5	41.6	10.8	39.3	9.2	40.0	-2.1	41.2	6.0	53.1	20.7	49.8	-2.0	44.3						
NML-CSIR	-1.3	27.4	-19.5	46.3	6.4	30.1	-0.3	26.8	-1.9	27.8	-13.2	29.6	-5.1	44.7	9.6	40.6	-13.1	33.7	-11.1	45.6				
NCM	-9.5	90.7	-27.7	98.1	-1.8	91.6	-8.5	90.5	-10.1	90.9	-21.4	91.4	-13.3	97.3	1.5	95.6	-21.2	92.8	-19.3	97.8	-8.2	93.4		

Table 14: Equivalence at 313 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force	15.9	39.9																						
MIKES	-6.4	19.5	-22.3	42.2																				
PTB	-1.0	13.6	-16.9	39.8	5.4	19.3																		
NPL	0.0	15.8	-15.8	40.6	6.4	20.8	1.0	15.5																
UME	8.7	18.7	-7.2	41.8	15.1	23.1	9.7	18.5	8.7	20.1														
SMU	3.2	38.3	-12.6	53.5	9.6	40.7	4.2	38.2	3.2	39.0	-5.5	40.3												
NML-EI	-12.9	33.5	-28.8	50.2	-6.5	36.2	-11.9	33.4	-13.0	34.3	-21.7	35.7	-16.2	48.9										
INRIM	9.7	24.3	-6.2	44.6	16.1	27.9	10.7	24.1	9.6	25.4	0.9	27.3	6.4	43.2	22.6	39.0								
OMH	1.6	39.3	-14.3	54.3	8.0	41.6	2.5	39.2	1.5	40.0	-7.2	41.3	-1.7	53.1	14.5	49.8	-8.1	44.1						
NML-CSIR	-1.9	26.9	-17.8	46.0	4.5	30.1	-0.9	26.7	-1.9	27.9	-10.6	29.6	-5.1	44.7	11.1	40.6	-11.5	33.4	-3.4	45.6				
NCM	-13.5	90.6	-29.4	98.0	-7.1	91.6	-12.5	90.5	-13.5	90.9	-22.2	91.4	-16.7	97.3	-0.6	95.5	-23.2	92.7	-15.1	97.7	-11.6	93.4		

Table 15: Equivalence at 430 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force	14.5	41.4																						
MIKES	-5.1	19.2	-19.6	43.5																				
PTB	-1.4	13.5	-15.9	41.3	3.7	19.1																		
NPL	0.2	15.7	-14.3	42.0	5.3	20.7	1.6	15.5																
UME	6.5	18.7	-8.0	43.3	11.6	23.0	7.9	18.5	6.3	20.2														
SMU	1.9	38.3	-12.6	54.6	7.0	40.6	3.3	38.2	1.7	39.0	-4.6	40.3												
NML-EI	-15.8	33.5	-30.3	51.4	-10.7	36.1	-14.4	33.4	-16.0	34.3	-22.3	35.8	-17.7	49.0										
INRIM	8.8	24.2	-5.7	45.9	13.9	27.7	10.2	24.1	8.6	25.4	2.3	27.3	6.9	43.2	24.6	39.0								
OMH	5.0	39.3	-9.6	55.3	10.0	41.5	6.3	39.2	4.7	40.0	-1.6	41.3	3.0	53.1	20.7	49.7	-3.9	44.0						
NML-CSIR	-0.2	26.8	-14.8	47.3	4.8	30.0	1.1	26.7	-0.5	27.9	-6.8	29.7	-2.2	44.7	15.5	40.6	-9.1	33.4	-5.2	45.5				
NCM	-12.6	90.5	-27.1	98.6	-7.5	91.5	-11.2	90.5	-12.8	90.9	-19.1	91.4	-14.5	97.3	3.2	95.6	-21.4	92.7	-17.5	97.7	-12.3	93.4		

Table 16: Equivalence at 547 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force	13.3	40.3																						
MIKES	-5.5	19.1	-18.8	42.6																				
PTB	-1.7	13.2	-14.9	40.3	3.8	19.1																		
NPL	0.2	15.5	-13.0	41.1	5.7	20.7	1.9	15.5																
UME	4.9	18.5	-8.3	42.3	10.4	23.1	6.6	18.5	4.7	20.2														
SMU	4.2	38.2	-9.1	53.9	9.7	40.6	5.9	38.2	4.0	39.0	-0.8	40.3												
NML-EI	-16.0	33.3	-29.2	50.6	-10.5	36.1	-14.3	33.4	-16.2	34.3	-20.9	35.8	-20.2	48.9										
INRIM	7.9	23.7	-5.3	44.8	13.4	27.4	9.6	23.7	7.7	25.1	3.0	27.1	3.7	43.0	23.9	38.7								
OMH	-2.7	39.7	-16.0	55.0	2.8	42.0	-1.1	39.7	-3.0	40.5	-7.7	41.8	-6.9	53.5	13.2	50.2	-10.7	44.3						
NML-CSIR	-1.3	26.7	-14.6	46.5	4.2	30.0	0.3	26.7	-1.6	27.9	-6.3	29.7	-5.5	44.7	14.7	40.6	-9.2	33.2	1.4	46.0				
NCM	-12.2	90.5	-25.5	98.2	-6.7	91.5	-10.5	90.5	-12.4	90.9	-17.1	91.4	-16.4	97.3	3.8	95.5	-20.1	92.6	-9.4	98.0	-10.9	93.4		

Table 17: Equivalence at 664 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																								
Force																								
MIKES	-6.4	19.0																						
PTB	-1.2	12.8			5.2	19.3																		
NPL	-0.6	15.1			5.8	20.9	0.6	15.5																
UME	4.3	18.3			10.7	23.3	5.5	18.6	4.9	20.2														
SMU	3.2	38.0			9.6	40.7	4.4	38.2	3.8	39.0	-1.2	40.3												
NML-EI	-18.8	33.2			-12.4	36.2	-17.6	33.4	-18.2	34.3	-23.1	35.8	-21.9	48.9										
INRIM	6.3	23.5			12.7	27.6	7.5	23.7	6.9	25.1	2.0	27.1	3.1	43.0	25.1	38.7								
OMH	-4.6	39.1			1.8	41.7	-3.4	39.2	-4.0	40.1	-9.0	41.3	-7.8	53.1	14.2	49.8	-10.9	43.9						
NML-CSIR	0.2	26.5			6.6	30.2	1.4	26.7	0.8	27.9	-4.2	29.7	-3.0	44.7	19.0	40.6	-6.1	33.2	4.8	45.6				
NCM	-14.2	90.4			-7.8	91.6	-13.0	90.5	-13.6	90.9	-18.5	91.4	-17.3	97.3	4.6	95.5	-20.5	92.6	-9.5	97.8	-14.3	93.4		

Table 18: Equivalence at 781 kPa

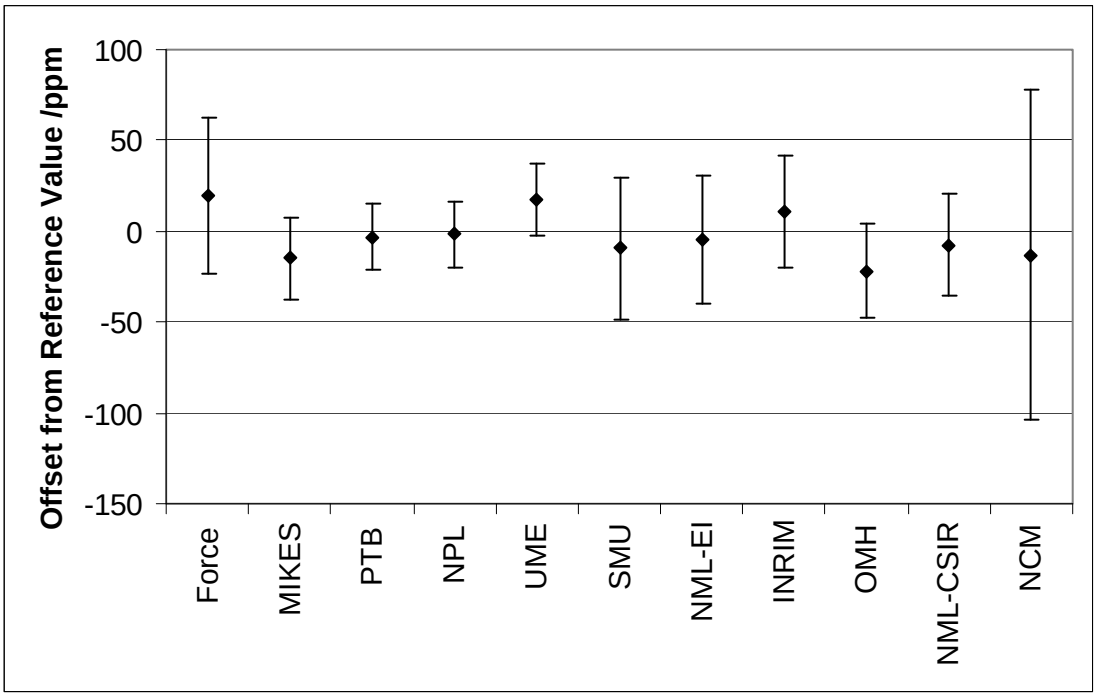

Figure 5: Deviation from Reference Value at 80 kPa

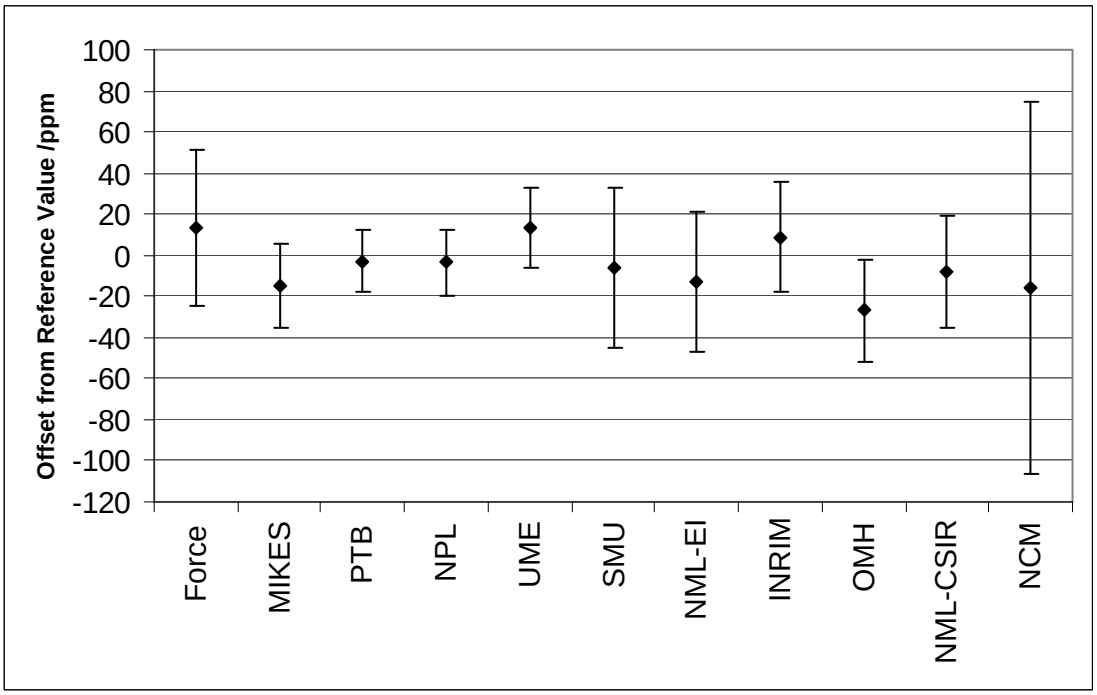

Figure 6: Deviation from Reference Value at 138 kPa

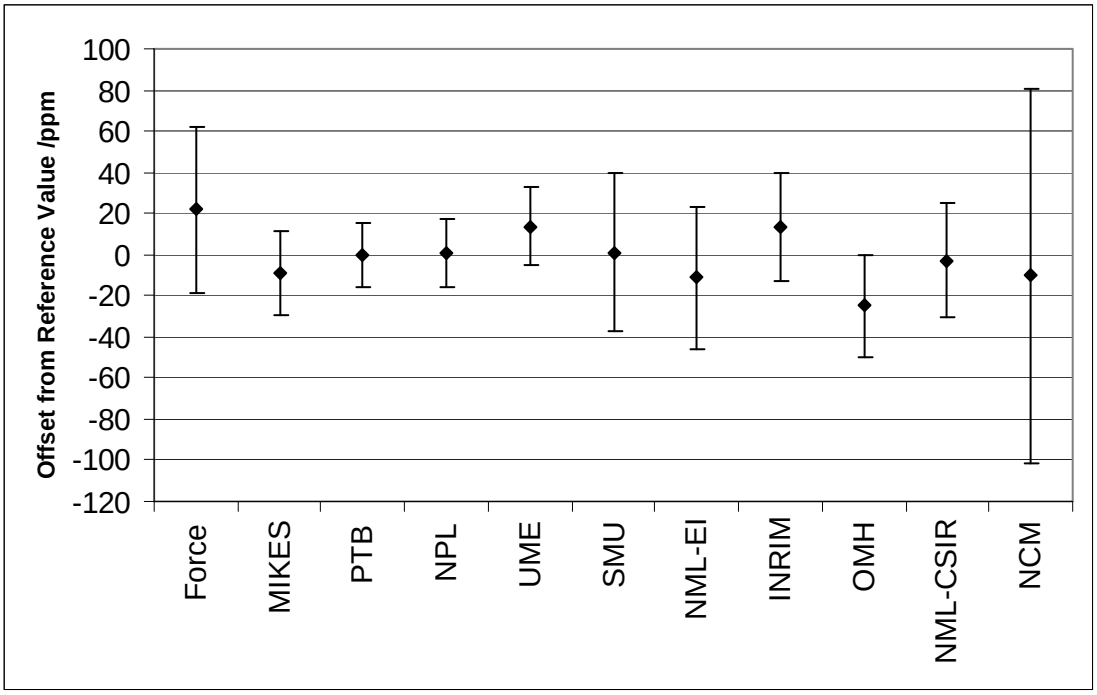

Figure 7: Deviation from Reference Value at 197 kPa

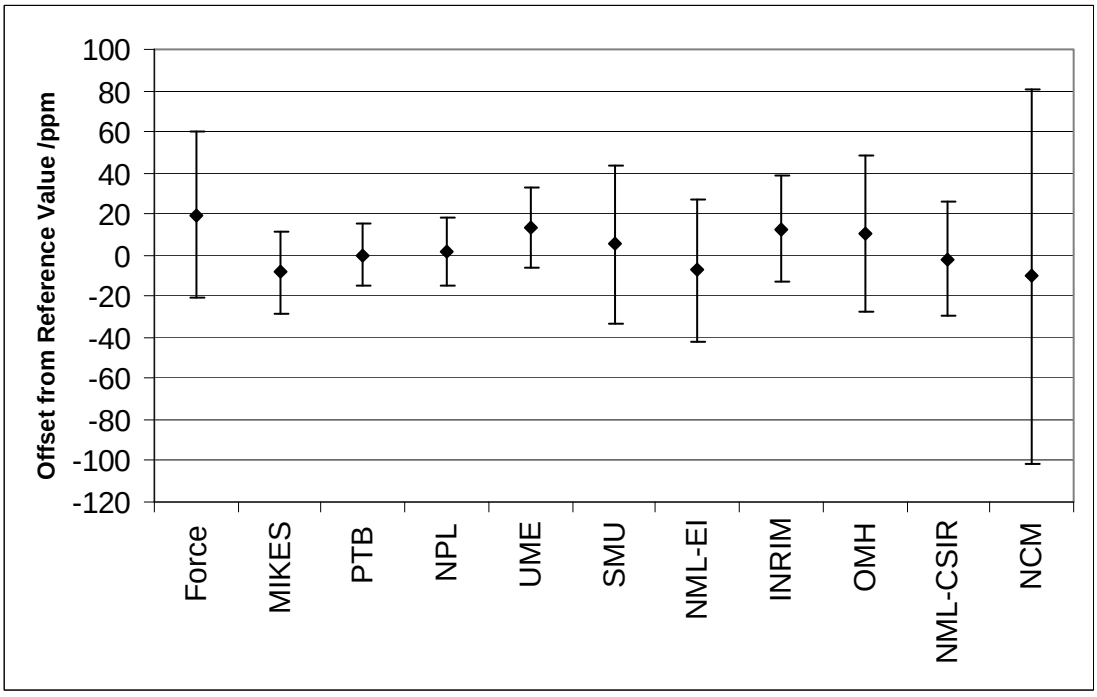

Figure 8: Deviation from Reference Value at 255 kPa

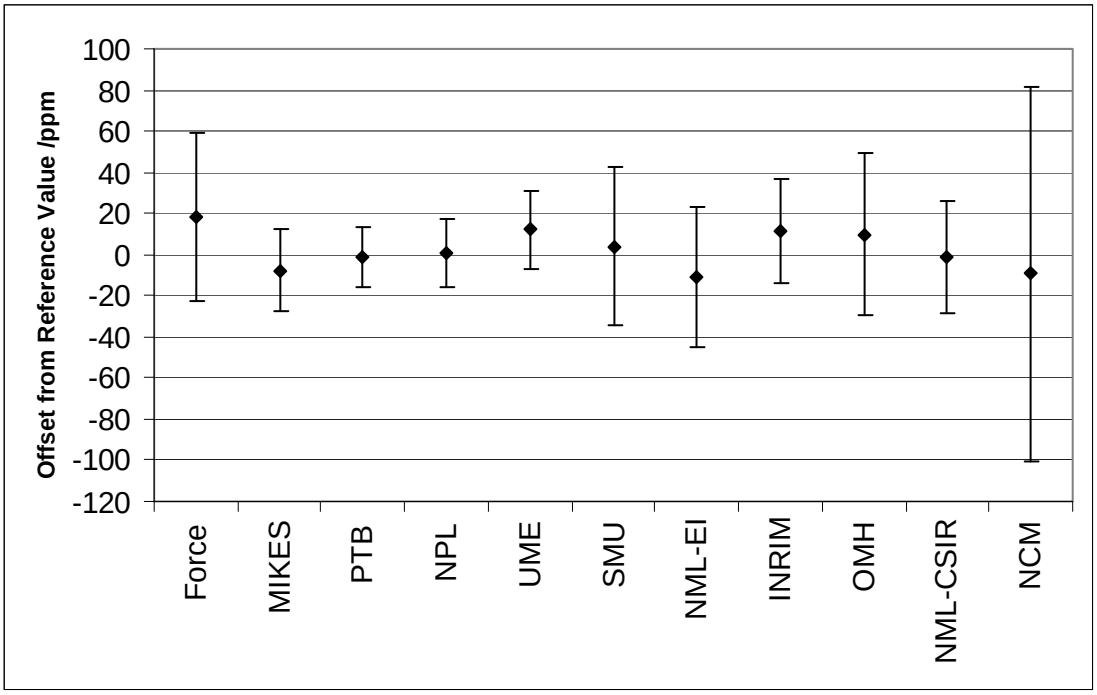

Figure 9: Deviation from Reference Value at 313 kPa

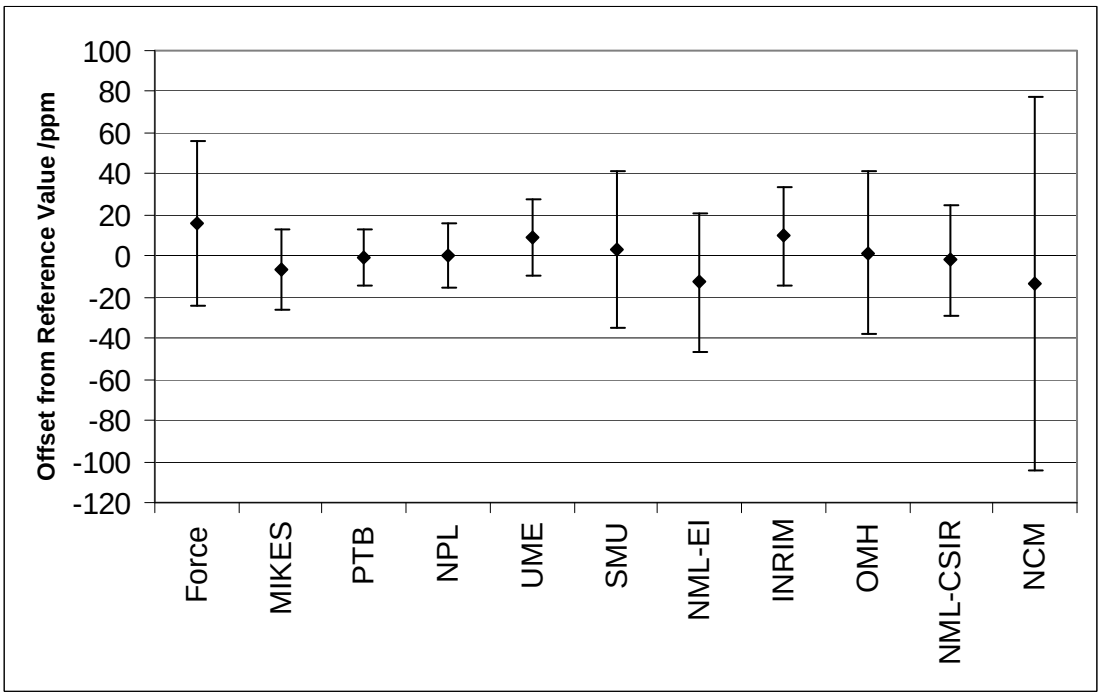

Figure 10: Deviation from Reference Value at 430 kPa

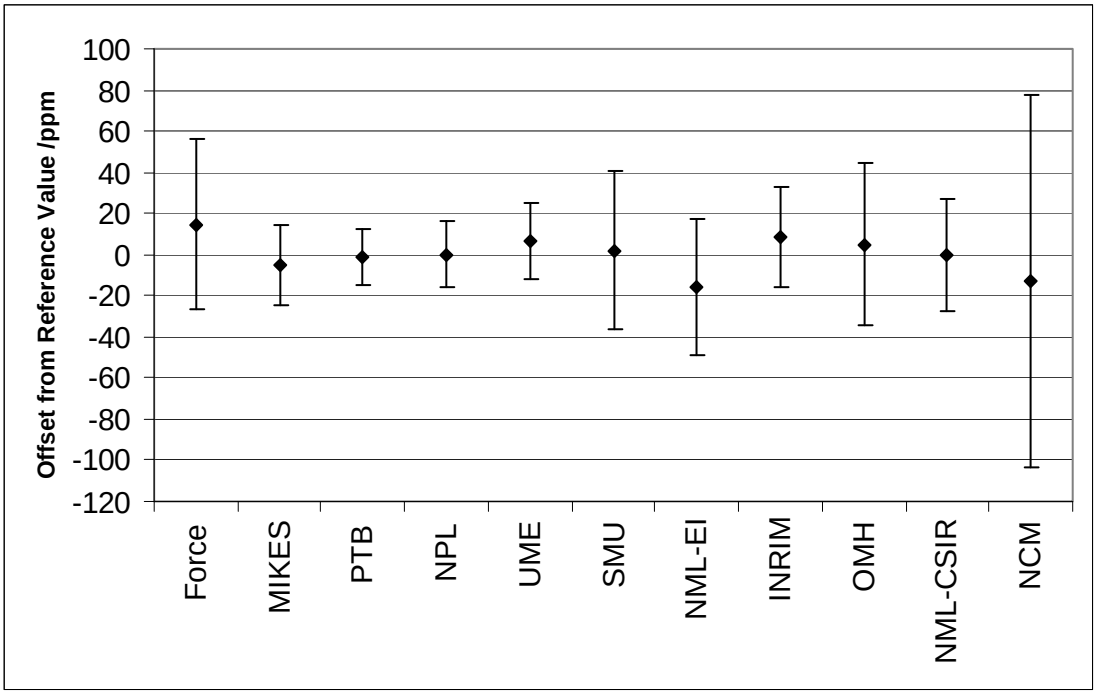

Figure 11: Deviation from Reference Value at 547 kPa

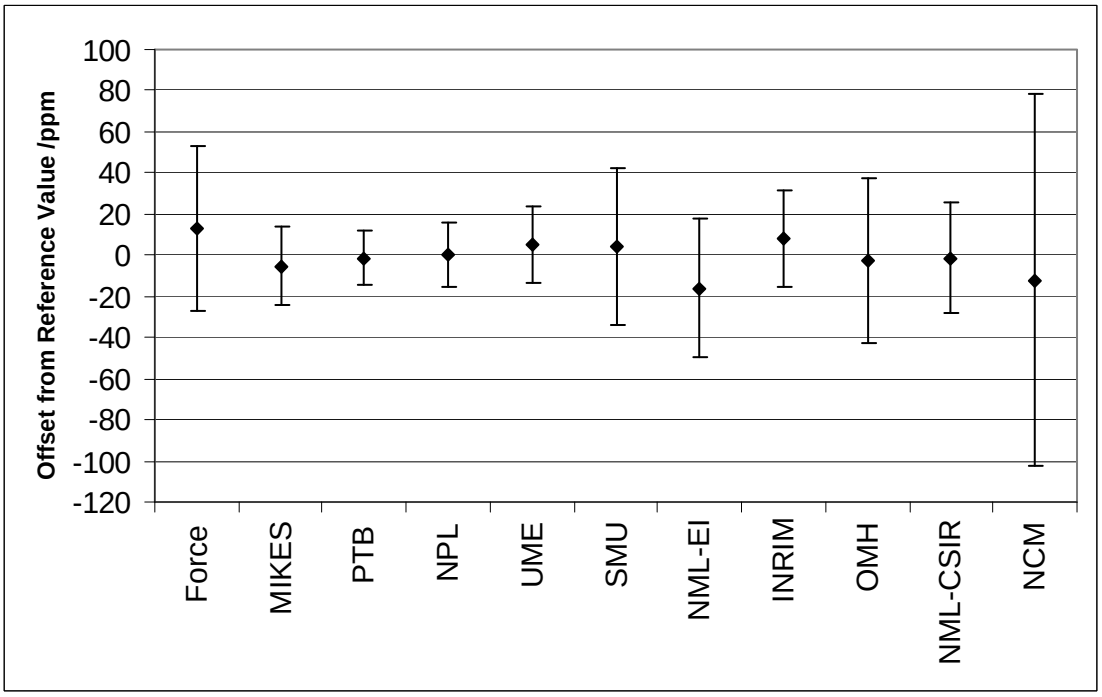

Figure 12: Deviation from Reference Value at 664 kPa

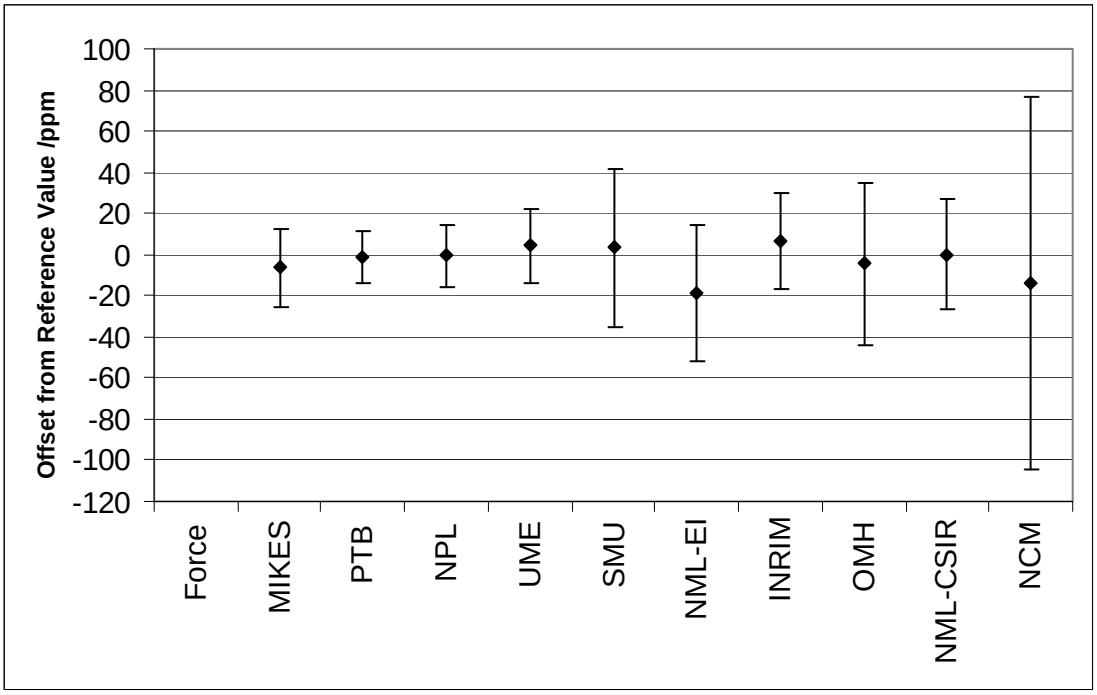

Figure 13: Deviation from Reference Value at 781 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	54.6	210.7																								
MIKES	7.3	26.0	-47.4	210.6																						
PTB	-1.1	25.8	-55.8	210.6	-8.4	25.0																				
NPL	-2.6	25.1	-57.2	210.5	-9.9	24.3	-1.5	24.1																		
UME	20.0	25.2	-34.7	210.5	12.7	24.4	21.1	24.2	22.6	23.5																
SMU	11.1	41.6	-43.5	213.1	3.8	41.1	12.3	40.9	13.7	40.5	-8.8	40.6														
NML-EI	-8.4	35.6	-63.0	212.0	-15.7	35.1	-7.2	34.9	-5.8	34.4	-28.4	34.5	-19.5	47.7												
INRIM	9.9	32.0	-44.7	211.4	2.7	31.4	11.1	31.2	12.5	30.7	-10.0	30.8	-1.2	45.1	18.3	39.7										
GUM	6.4	36.0	-48.2	212.1	-0.9	35.4	7.5	35.3	9.0	34.8	-13.6	34.9	-4.7	48.0	14.8	43.0	-3.6	40.0								
OMH	6.2	42.5	-48.4	213.3	-1.0	42.0	7.4	41.9	8.8	41.5	-13.7	41.5	-4.9	53.1	14.6	48.5	-3.7	46.0	-0.1	48.8						
NML-CSIR	9.6	37.2	-45.0	212.3	2.4	36.6	10.8	36.5	12.2	36.0	-10.3	36.1	-1.5	48.9	18.0	44.0	-0.3	41.1	3.3	44.3	3.4	49.7				
NCM	52.4	92.1	-2.2	228.4	45.1	91.9	53.5	91.8	55.0	91.6	32.4	91.7	41.3	97.4	60.8	95.0	42.5	93.7	46.0	95.2	46.2	97.8	42.8	95.6		

Table 19: Equivalence at 622 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	45.1	177.3																								
MIKES	6.6	24.8	-38.5	177.2																						
PTB	-0.6	23.7	-45.6	177.0	-7.1	23.2																				
NPL	-4.0	24.4	-49.1	177.1	-10.6	24.0	-3.4	22.8																		
UME	21.4	24.6	-23.7	177.2	14.8	24.2	22.0	23.0	*25.4*	23.8																
SMU	12.8	41.1	-32.2	180.2	6.3	40.8	13.4	40.1	16.8	40.6	-8.6	40.7														
NML-EI	-9.4	35.1	-54.5	178.9	-16.0	34.8	-8.8	34.0	-5.4	34.5	-30.8	34.7	-22.2	47.8												
INRIM	11.7	31.1	-33.4	178.2	5.1	30.7	12.3	29.8	15.7	30.4	-9.7	30.6	-1.1	44.9	21.1	39.5										
GUM	6.8	35.4	-38.3	179.0	0.2	35.1	7.4	34.3	10.8	34.8	-14.6	35.0	-6.0	48.0	16.2	43.0	-4.9	39.8								
OMH	7.9	42.0	-37.2	180.4	1.3	41.7	8.5	41.1	11.9	41.5	-13.5	41.6	-4.9	53.1	17.3	48.6	-3.8	45.7	1.1	48.8						
NML-CSIR	9.6	36.7	-35.5	179.2	3.0	36.4	10.2	35.6	13.6	36.1	-11.8	36.2	-3.2	48.9	19.0	44.0	-2.1	40.9	2.8	44.3	1.7	49.7				
NCM	54.6	91.9	9.5	198.1	48.0	91.8	55.2	91.5	58.6	91.7	33.2	91.7	41.8	97.5	64.0	95.1	42.9	93.7	47.8	95.2	46.7	97.8	45.0	95.7		

Table 20: Equivalence at 739 kpa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	30.1	121.9																								
MIKES	7.1	21.7	-23.0	122.3																						
PTB	0.2	18.9	-29.9	121.8	-6.9	21.0																				
NPL	-4.3	21.9	-34.4	122.3	-11.4	23.8	-4.5	21.2																		
UME	20.7	22.3	-9.5	122.4	13.6	24.0	20.5	21.5	*25.0*	24.3																
SMU	10.3	39.5	-19.8	126.7	3.2	40.6	10.1	39.2	14.6	40.7	-10.3	40.9														
NML-EI	-7.7	33.2	-37.8	124.8	-14.8	34.4	-7.9	32.7	-3.4	34.6	-28.4	34.8	-18.0	47.7												
INRIM	10.3	28.5	-19.8	123.6	3.2	29.9	10.1	27.9	14.6	30.1	-10.3	30.3	0.0	44.6	18.0	39.1										
GUM	5.3	33.6	-24.8	124.9	-1.8	34.8	5.1	33.2	9.6	35.0	-15.4	35.2	-5.0	48.0	13.0	43.0	-5.0	39.4								
OMH	2.8	40.5	-27.4	127.0	-4.3	41.5	2.6	40.1	7.1	41.6	-17.9	41.8	-7.5	53.1	10.5	48.5	-7.5	45.4	-2.5	48.8						
NML-CSIR	7.7	34.9	-22.4	125.3	0.6	36.1	7.5	34.5	12.0	36.2	-12.9	36.4	-2.6	48.9	15.4	44.0	-2.6	40.5	2.4	44.3	5.0	49.7				
NCM	56.8	91.1	26.6	150.9	49.7	91.6	56.6	91.0	61.1	91.6	36.1	91.7	46.4	97.4	64.5	95.0	46.4	93.4	51.5	95.1	54.0	97.8	49.0	95.6		

Table 21: Equivalence at 1078 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	27.3	75.0																								
MIKES	6.1	20.4	-21.2	75.6																						
PTB	-1.7	16.6	-28.9	74.7	-7.8	19.3																				
NPL	-8.2	21.4	-35.5	75.9	-14.3	23.6	-6.5	20.3																		
UME	*22.4*	21.8	-4.8	76.0	16.3	23.9	*24.1*	20.7	*30.7*	24.7																
SMU	7.8	39.1	-19.5	82.7	1.7	40.3	9.5	38.5	16.0	40.8	-14.7	41.0														
NML-EI	-15.7	32.6	-43.0	79.8	-21.8	34.0	-14.0	31.9	-7.5	34.6	*-38.1*	34.9	-23.5	47.7												
INRIM	9.5	27.5	-17.7	77.9	3.4	29.2	11.2	26.7	17.8	29.9	-12.9	30.2	1.8	44.3	25.3	38.7										
GUM	1.6	33.1	-25.7	80.0	-4.5	34.5	3.3	32.4	9.8	35.1	-20.9	35.3	-6.2	48.0	17.3	42.9	-8.0	39.1								
OMH	-0.6	40.1	-27.9	83.1	-6.7	41.2	1.1	39.5	7.6	41.7	-23.0	41.9	-8.4	53.0	15.1	48.4	-10.1	45.2	-2.2	48.8						
NML-CSIR	1.5	34.4	-25.8	80.6	-4.6	35.8	3.2	33.8	9.7	36.4	-21.0	36.6	-6.3	48.9	17.2	43.9	-8.1	40.3	-0.1	44.3	2.1	49.7				
NCM	51.5	90.9	24.3	116.5	45.4	91.4	53.2	90.7	59.8	91.7	29.1	91.7	43.8	97.3	67.3	94.9	42.0	93.3	50.0	95.1	52.1	97.7	50.1	95.5		

Table 22: Equivalence at 1768 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	13.3	61.0																								
MIKES	-2.7	23.3	-16.0	60.8																						
PTB	-5.5	23.7	-18.8	60.9	-2.8	23.0																				
NPL	-19.3	24.6	-32.6	61.3	-16.6	24.0	-13.8	24.4																		
UME	11.1	25.3	-2.1	61.6	13.9	24.7	16.7	25.1	*30.4*	26.0																
SMU	-4.3	40.7	-17.6	69.3	-1.6	40.3	1.2	40.5	15.0	41.1	-15.5	41.5														
NML-EI	-31.0	34.7	-44.3	66.0	-28.3	34.3	-25.5	34.5	-11.7	35.2	*-42.2*	35.7	-26.7	47.8												
INRIM	3.0	29.7	-10.3	63.5	5.7	29.2	8.5	29.5	22.3	30.3	-8.2	30.8	7.3	44.3	34.0	38.9										
GUM	-5.4	35.0	-18.7	66.1	-2.7	34.5	0.1	34.8	13.9	35.5	-16.6	35.9	-1.1	48.0	25.6	43.1	-8.4	39.2								
OMH	-8.0	41.6	-21.2	69.9	-5.2	41.3	-2.4	41.5	11.3	42.0	-19.1	42.4	-3.6	53.0	23.1	48.6	-10.9	45.2	-2.5	48.8						
NML-CSIR	-11.6	36.2	-24.8	66.8	-8.8	35.8	-6.1	36.0	7.7	36.7	-22.7	37.1	-7.2	48.9	19.5	44.1	-14.5	40.3	-6.2	44.3	-3.6	49.7				
NCM	43.6	91.6	30.3	107.4	46.3	91.5	49.1	91.5	62.9	91.8	32.4	92.0	47.9	97.3	74.6	95.0	40.6	93.3	49.0	95.1	51.5	97.7	55.2	95.6		

Table 23: Equivalence at 2938 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	8.2	61.1																								
MIKES	-2.4	24.0	-10.6	60.6																						
PTB	-6.4	24.3	-14.6	60.7	-3.9	23.0																				
NPL	-19.3	25.7	-27.5	61.3	-16.9	24.5	-12.9	24.9																		
UME	7.2	26.5	-1.0	61.6	9.6	25.3	13.5	25.6	26.5	27.0																
SMU	-9.7	41.1	-17.9	69.2	-7.2	40.3	-3.3	40.5	9.6	41.4	-16.8	41.9														
NML-EI	*-35.2*	34.9	-43.4	65.7	-32.8	34.1	-28.9	34.3	-15.9	35.3	*-42.4*	35.8	-25.6	47.7												
INRIM	4.4	30.1	-3.8	63.3	6.8	29.1	10.8	29.3	23.7	30.5	-2.8	31.1	14.1	44.2	39.7	38.6										
GUM	-6.6	35.4	-14.8	66.0	-4.2	34.5	-0.3	34.8	12.7	35.8	-13.8	36.3	3.0	48.0	28.6	42.9	-11.0	39.0								
OMH	-7.0	42.0	-15.3	69.7	-4.6	41.3	-0.7	41.5	12.3	42.3	-14.2	42.8	2.6	53.0	28.2	48.5	-11.5	45.1	-0.4	48.8						
NML-CSIR	-16.4	36.6	-24.7	66.6	-14.0	35.8	-10.1	36.0	2.9	37.0	-23.6	37.5	-6.8	48.9	18.8	43.9	-20.9	40.1	-9.8	44.3	-9.4	49.7				
NCM	40.0	91.8	31.8	107.4	42.4	91.5	46.3	91.6	59.3	91.9	32.8	92.2	49.6	97.4	75.2	94.9	35.5	93.3	46.6	95.1	47.0	97.8	56.4	95.6		

Table 24: Equivalence at 4107 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	10.6	59.3																								
MIKES	1.9	23.6	-8.6	59.2																						
PTB	-2.6	23.8	-13.2	59.3	-4.6	23.4																				
NPL	-16.7	25.4	-27.3	60.0	-18.7	25.2	-14.1	25.3																		
UME	12.0	25.6	1.4	60.0	10.1	25.3	14.6	25.5	*28.7*	27.1																
SMU	-8.8	40.7	-19.4	67.8	-10.7	40.5	-6.1	40.6	8.0	41.6	-20.8	41.7														
NML-EI	-34.8	36.8	-45.3	65.6	*-36.7*	36.6	-32.1	36.7	-18.0	37.8	*-46.8*	38.0	-26.0	49.4												
INRIM	5.2	29.5	-5.4	61.8	3.2	29.3	7.8	29.4	21.9	30.8	-6.8	30.9	13.9	44.2	39.9	40.7										
GUM	-3.4	35.0	-14.0	64.6	-5.3	34.7	-0.8	34.9	13.3	36.0	-15.4	36.2	5.4	48.0	31.3	44.8	-8.6	39.0								
OMH	-1.8	43.4	-12.4	69.5	-3.7	43.3	0.8	43.4	14.9	44.3	-13.8	44.4	7.0	54.5	33.0	51.7	-6.9	46.8	1.6	50.4						
NML-CSIR	-18.7	36.2	-29.2	65.3	-20.6	36.0	-16.0	36.1	-1.9	37.2	-30.7	37.4	-9.9	48.9	16.1	45.8	-23.8	40.1	-15.3	44.3	-16.9	51.2				
NCM	44.1	91.8	33.5	106.6	42.2	91.7	46.7	91.7	60.8	92.2	32.1	92.2	52.9	97.5	78.8	95.9	38.9	93.4	47.5	95.2	45.9	98.7	62.8	95.7		

Table 25: Equivalence at 5277 kpa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	11.9	58.4																								
MIKES	-3.2	39.8	-15.2	66.4																						
PTB	-1.6	24.0	-13.5	58.4	1.6	39.8																				
NPL	-16.4	26.1	-28.3	59.2	-13.2	41.1	-14.8	26.0																		
UME	13.5	26.3	1.6	59.3	16.7	41.2	15.1	26.3	*29.9*	28.1																
SMU	-10.7	40.7	-22.7	67.0	-7.5	51.6	-9.1	40.7	5.7	41.9	-24.2	42.1														
NML-EI	*-43.8*	34.5	-55.7	63.4	-40.6	46.9	*-42.2*	34.5	-27.4	36.0	*-57.3*	36.1	-33.1	47.7												
INRIM	5.1	29.6	-6.9	60.9	8.3	43.4	6.7	29.6	21.5	31.3	-8.4	31.5	15.8	44.2	48.9	38.6										
GUM	-1.6	35.0	-13.5	63.7	1.6	47.3	0.0	35.0	14.8	36.4	-15.1	36.6	9.1	48.0	42.2	42.9	-6.7	39.0								
OMH	2.3	43.5	-9.6	68.7	5.5	53.8	3.9	43.5	18.7	44.6	-11.2	44.7	13.0	54.5	46.1	50.0	-2.8	46.8	3.9	50.4						
NML-CSIR	-19.0	36.2	-30.9	64.4	-15.7	48.2	-17.4	36.2	-2.6	37.6	-32.4	37.8	-8.2	48.9	24.9	43.9	-24.0	40.2	-17.3	44.3	-21.2	51.2				
NCM	43.1	91.7	31.2	106.0	46.4	97.1	44.7	91.7	59.5	92.3	29.6	92.4	53.8	97.4	86.9	95.0	38.1	93.4	44.7	95.2	40.8	98.6	62.1	95.7		

Table 26: Equivalence at 6446 kPa

Laboratory(j)	Reference		Force		MIKES		PTB		NPL		UME		SMU		NML-EI		INRIM		GUM		OMH		NML-CSIR		NCM	
Laboratory(i)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)	Diff(i-j)	Unc (i-j)
Reference																										
Force	12.2	58.6																								
MIKES	-1.2	40.0	-13.5	66.5																						
PTB	0.2	24.5	-12.0	58.5	1.5	39.9																				
NPL	-14.6	26.6	-26.8	59.4	-13.4	41.2	-14.9	26.4																		
UME	17.4	26.3	5.2	59.3	18.6	41.0	17.2	26.0	*32.0*	28.1																
SMU	-9.2	40.9	-21.4	67.0	-7.9	51.6	-9.4	40.8	5.4	42.1	-26.6	41.9														
NML-EI	*-37.4*	34.7	-49.6	63.5	-36.1	46.9	*-37.6*	34.6	-22.7	36.1	*-54.8*	35.9	-28.2	47.7												
INRIM	3.6	29.9	-8.6	61.0	4.9	43.4	3.4	29.7	18.3	31.5	-13.8	31.2	12.8	44.3	41.0	38.6										
GUM	2.1	35.2	-10.1	63.7	3.3	47.3	1.9	35.1	16.7	36.6	-15.3	36.4	11.3	48.0	39.5	42.9	-1.5	39.1								
OMH	3.2	43.7	-9.0	68.7	4.5	53.8	3.0	43.5	17.8	44.8	-14.2	44.6	12.4	54.5	40.6	50.0	-0.4	46.8	1.1	50.4						
NML-CSIR	-18.9	36.5	-31.2	64.4	-17.7	48.2	-19.2	36.3	-4.3	37.8	-36.3	37.6	-9.7	48.9	18.4	43.9	-22.6	40.2	-21.0	44.3	-22.2	51.2				
NCM	46.3	92.0	34.1	106.2	47.5	97.2	46.1	91.9	60.9	92.5	28.9	92.4	55.5	97.6	83.6	95.2	42.6	93.5	44.2	95.3	43.1	98.8	65.2	95.8		

Table 27: Equivalence at 6797 kPa

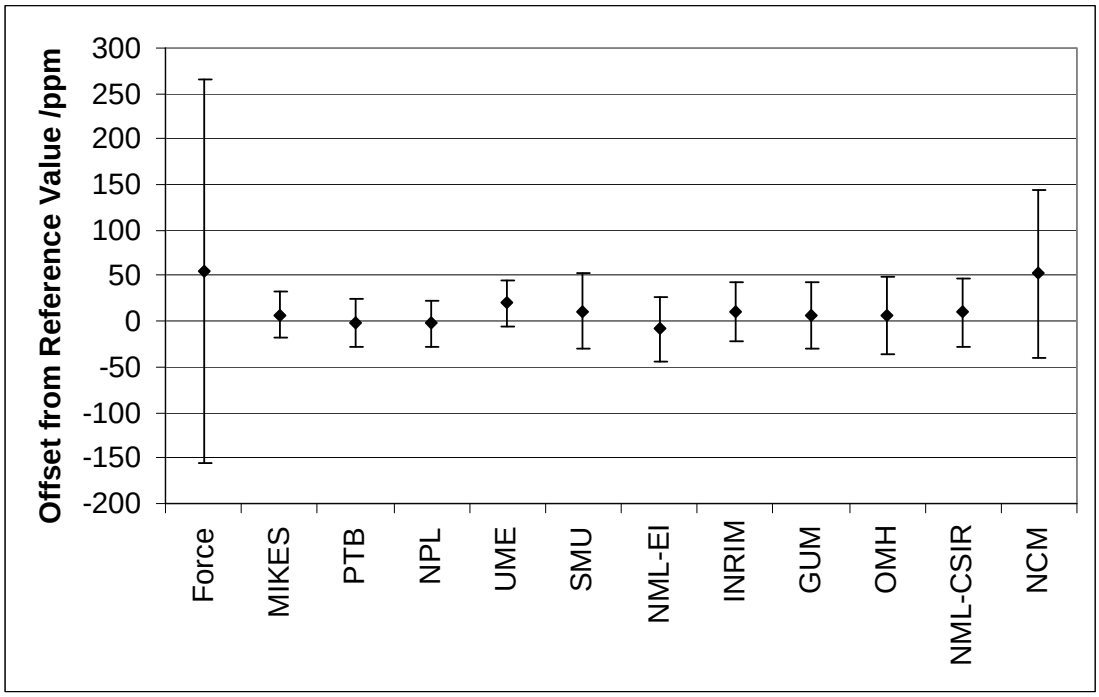

Figure 14: Deviation from Reference Value at 622 kPa

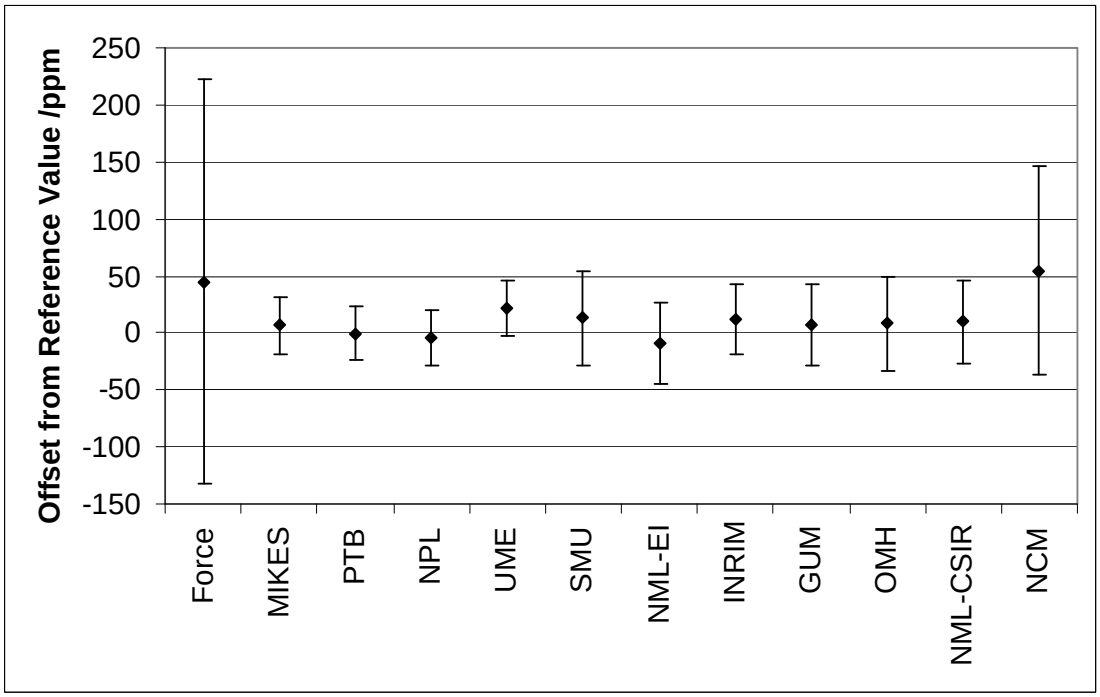

Figure 15: Deviation from Reference Value at 739 kPa

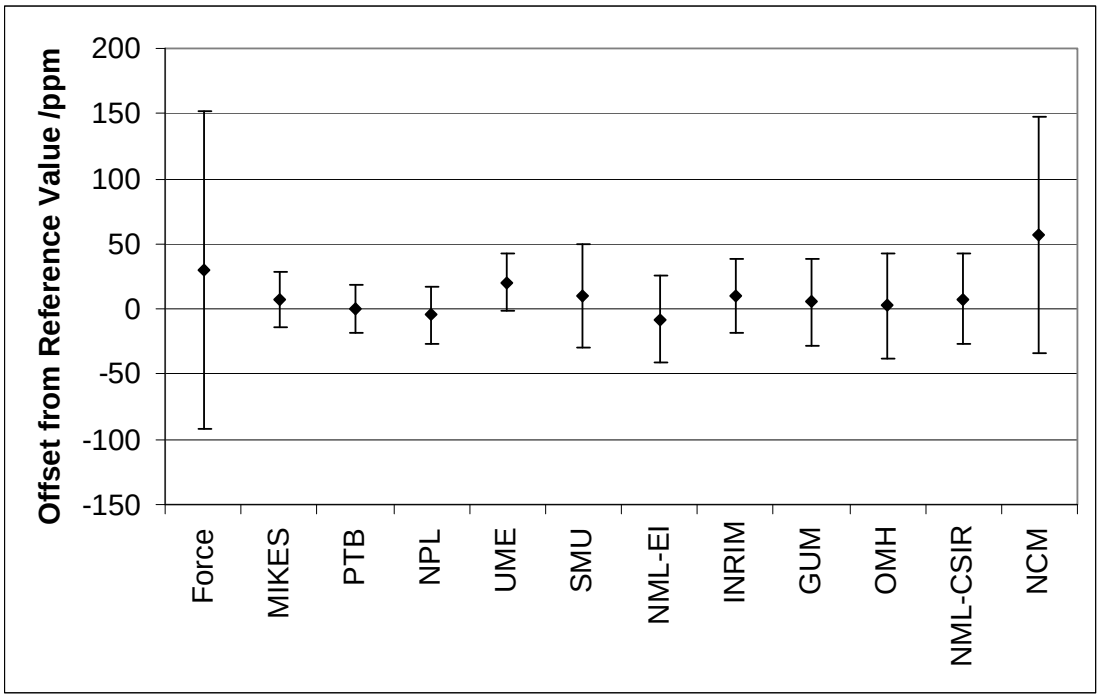

Figure 16: Deviation from Reference Value at 1078 kPa

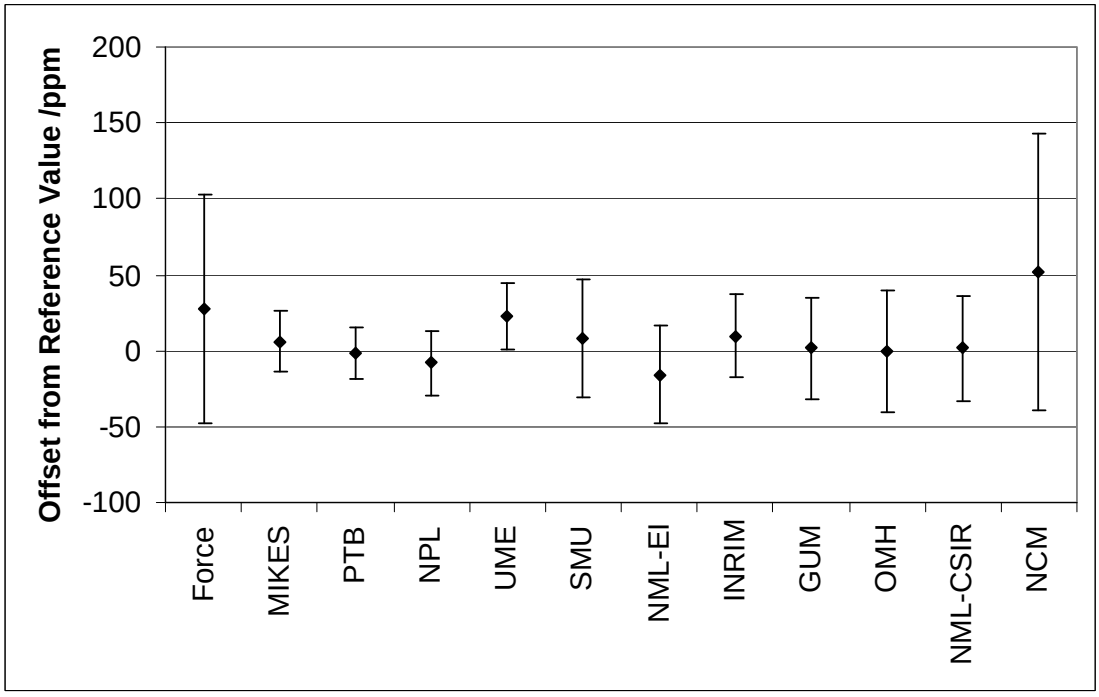

Figure 17: Deviation from Reference Value at 1768 kPa

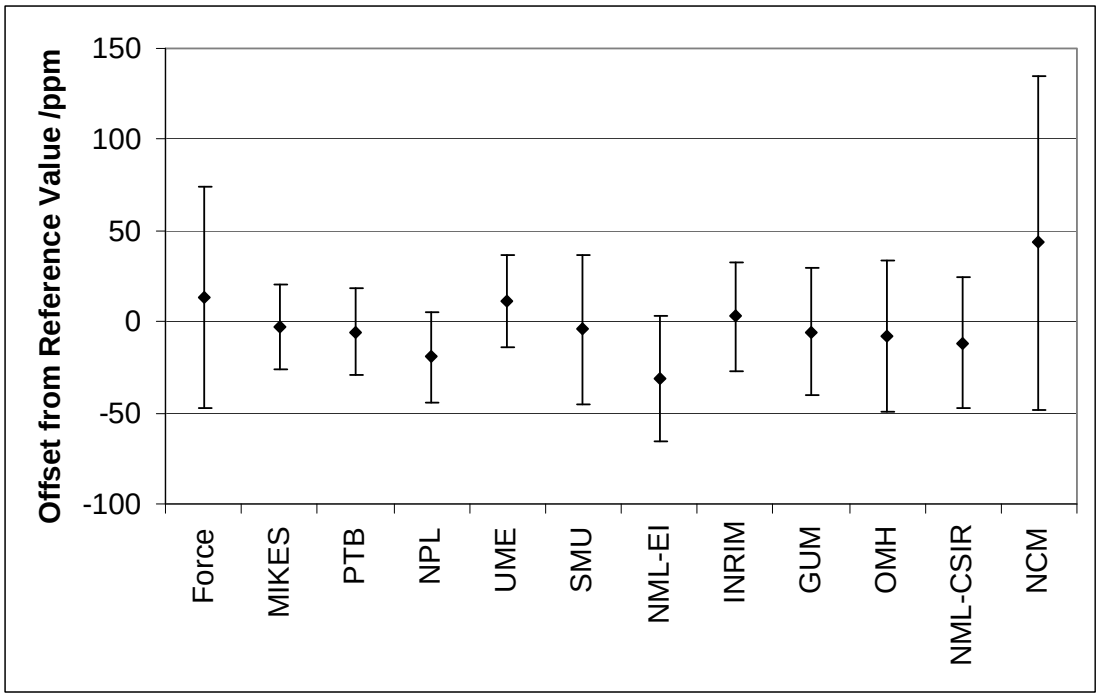

Figure 18: Deviation from Reference Value at 2938 kPa

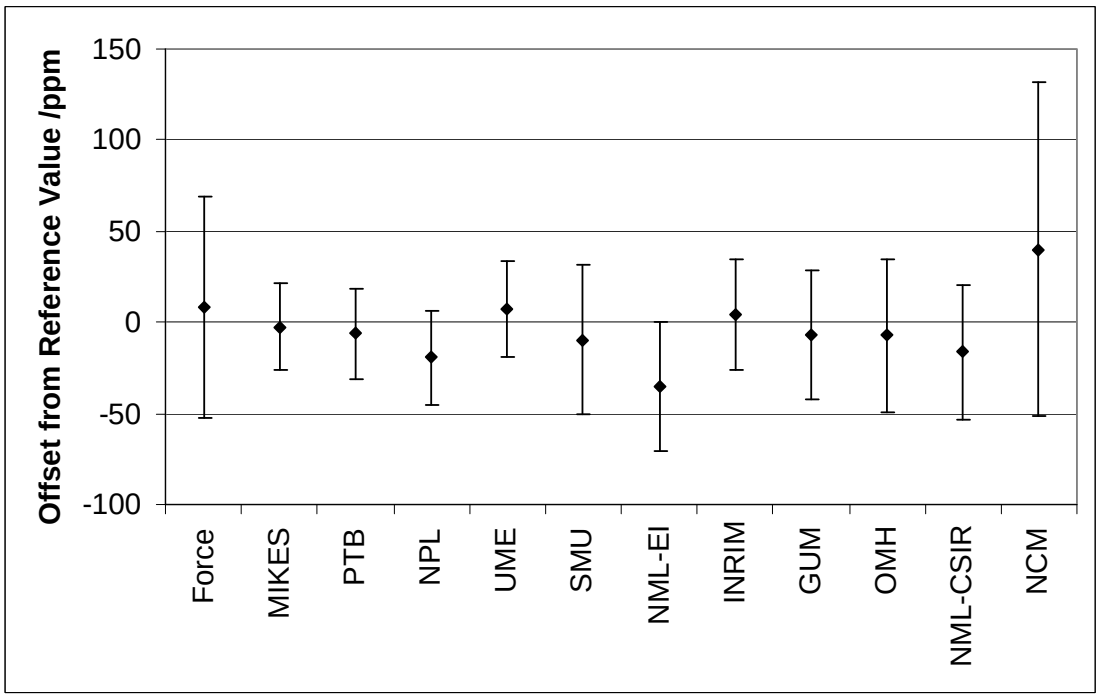

Figure 19: Deviation from Reference Value at 4107 kPa

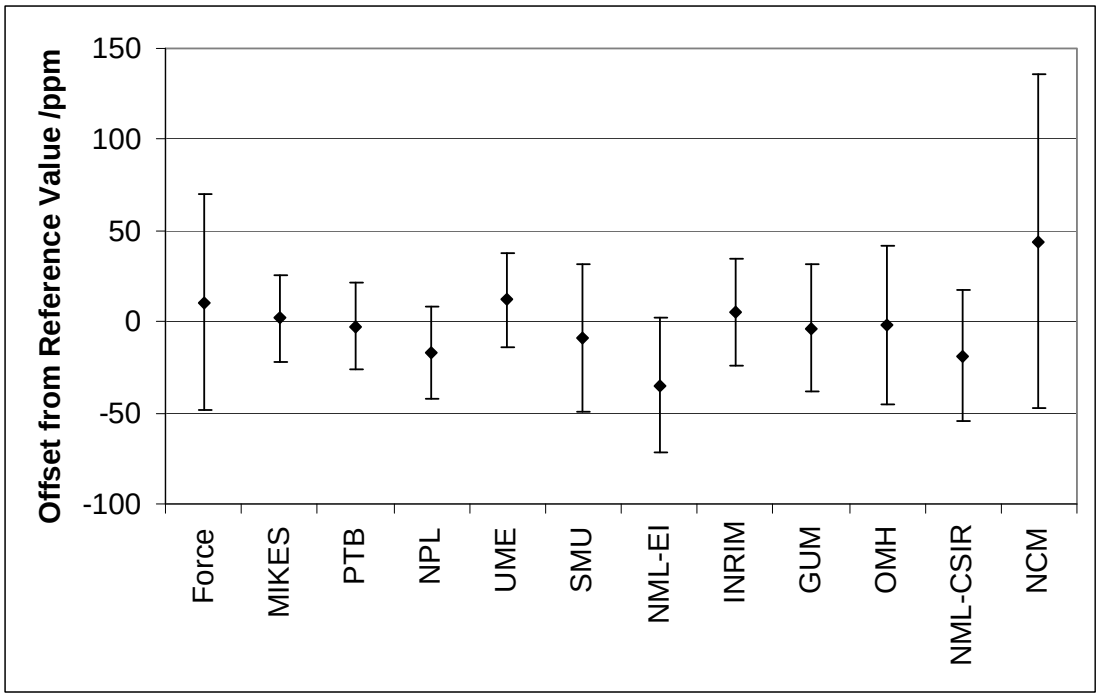

Figure 20: Deviation from Reference Value at 5277 kPa

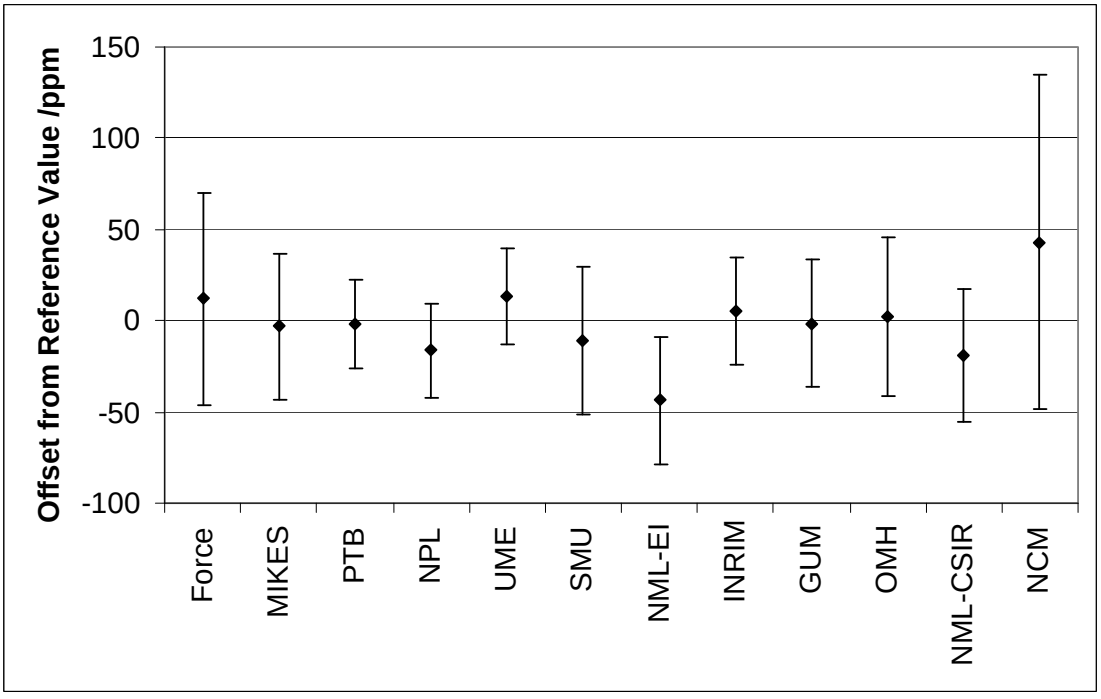

Figure 21: Deviation from Reference Value at 6446 kPa

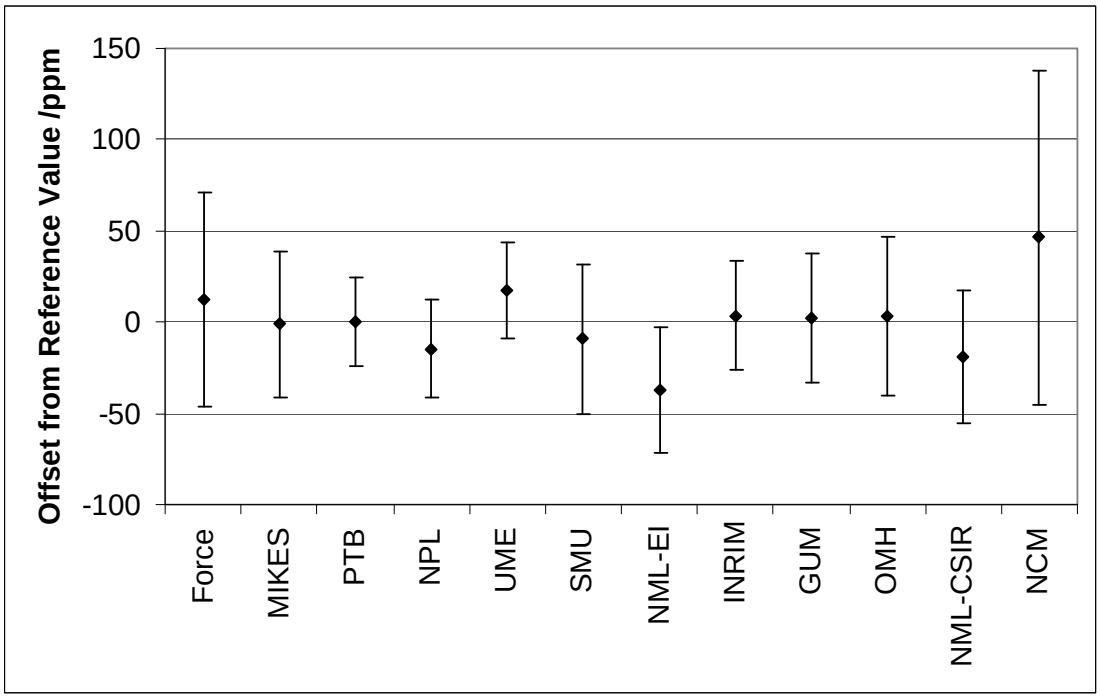

Figure 22: Deviation from Reference Value at 6797 kPa