EffecTech
global leaders in gas measurement

4719

Global Gas and LNG
Proficiency Testing (PT) Scheme

Presentation of Results

Round 16Q3

EffecTech is accredited by the United Kingdom Accreditation Service (UKAS) to provide this Proficiency Testing Scheme in accordance with the requirements of ISO/IEC 17043 : 2010

Document Ref.: 16/0664-0666/R
Revision: 1
Document Date: 10 October 2016
Author(s): Dr Gavin Squire

Dove House
Dove Fields
Uttoxeter
Staffordshire ST14 8HU
United Kingdom
T +44 (0)1889 569229
F +44 (0)1889 569220
www.effectech.co.uk

Table of Contents

Revisions History

Issue	Date	Author(s)	Comments
1	10.10.2016	Dr Gavin Squire	***Final report (for comment)***

Statement of Confidentiality

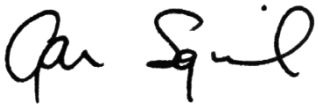
EffecTech keeps all data regarding the performance of individual participants strictly confidential. Results and performance data are protected, stored and backed up on storage network disks and folders to which access is restricted to the scheme coordinator and the technical authority only.

The relationship between results and the laboratories that submitted them will never be disclosed. The laboratory alone is granted access to its performance through the assigned participant code and through issue of a confidential Certificate of Participation.

Checked by

Steve Price
Scheme Coordinator

Approved by



Dr Gavin Squire
Technical Authority

1. Introduction

EffecTech provides and organises the Global Gas and LNG Proficiency Testing Scheme (GGLNG). This report presents data on the reference mixtures and the results of the participants for round 16Q3 (July - September 2016).

The GGLNG scheme provides an objective way of assessing the performance of each participant by a series of quarterly (four rounds per year) inter-laboratory comparisons. The scheme is aimed at laboratories working in the field of liquefied natural gas (LNG) and natural gas processing and transportation.

In this round participants were given the opportunity of measuring up to three (3) different mixture types, a typical LNG / natural gas composition, propane composition and a mixed refrigerant mixture. The composition range of each component in each mixture is shown in the tables below.

Table 1.1: Composition range - LNG composition

component	range (% mol/mol)
ethane	0.1 to 14
propane	0.05 to 5
iso-butane	0.01 to 1
n-butane	0.01 to 1
iso-pentane	0.005 to 0.35
n-pentane	0.005 to 0.35
n-hexane	0.001 to 0.35
nitrogen	0.1 to 8
carbon dioxide	0.1 to 8
methane	balance

Table 1.2: Composition range - propane composition

component	range (% mol/mol)
ethane	0.25 to 3
iso-butane	0.03 to 0.7
n-butane	0.03 to 0.7
iso-pentane	0.02 to 0.08
n-pentane	0.02 to 0.08
nitrogen	0.1 to 2
propane	balance

Table 1.3: Composition range - mixed refrigerant (MR)

component	range (% mol/mol)
ethane	20 to 35
propane	5 to 15
nitrogen	8 to 16
methane	balance

Gas mixture preparation, reference value assignment and the assessment of participants' results are all carried out by designated operators and approved signatories within EffecTech. In addition, all logistics management and preparation of shipping documentation is also carried out by designated approved personnel within EffecTech. All shipping, freight forwarding and proficiency testing item distribution is supplied by specialist transport providers.

A total of twenty-six (26) laboratories signed up to participate in this round. Twenty-four (24) participants, to whom items were distributed, submitted results for one or more of the mixture types in the scheme. Two (2) participants failed to submit results in time for the deadline set by EffecTech.

2. Mixture preparation and reference value assignment

2.1 Procedure

Preparation of mixture batches

For each mixture type, a single large volume parent mixture was prepared by a gravimetric method in accordance with ISO 6142. A batch of mixtures of each type was then produced by decanting the parent mixture into a batch of lower volume pre-prepared and evacuated daughter cylinders. The parent mixture and daughter mixtures were then calibrated.

Mixture calibration

All parent mixtures were calibrated by a multipoint calibration technique by comparison with a suite of reference mixtures in accordance with the requirements of ISO 6143:2001. Where this was not possible, a bracketing technique was used where one or more reference gases of similar composition and matrix were used.

Every single decant mixture was calibrated by an exact matching technique through comparison with its nominally identical parent mixture. A selective batch calibration technique was not used. All mixtures despatched to participants were calibrated individually to provide ultimate assurance in the assigned reference values.

The uncertainty on amount fraction of each measurand in the mixtures resulting from this calibration is termed the characterisation uncertainty, u_{char} (ISO Guide 35 : 2006).

All calibrations are performed in accordance with EffecTech's ISO 17025 accredited calibration methods (in-house methods TM001 and TM020). These can be found in our scope of accreditation published on the United Kingdom Accreditation Service (UKAS) website (www.ukas.org).

Reference mixture traceability

Gas chromatography was used as the analytical technique for the calibration of all mixtures in this scheme. Each gas chromatograph was calibrated with one or more reference mixtures traceable to either the National Physical Laboratory (NPL, UK) or the Van Swinden Laboratory (VSL, NL). This process ensured that the values assigned to the mixtures in this scheme are metrologically traceable to international standards, through an unbroken chain of comparisons, and ultimately to the amount of substance (mole) defined in the SI (International System of Units).

Homogeneity assessment

Statistical analysis of the spread of reference values obtained for each batch of mixtures (derived through calibration above) is used to assess the homogeneity between the set of decant mixtures to be distributed to each participant. The dispersion of the amount fraction of each component due to batch inhomogeneity is known as the between-bottle standard deviation (s_{bb}). The uncertainty arising from this is the between-bottle uncertainty, u_{bb}. The statistical procedure used for the determination of $u_{bb}=s_{bb}$ can be found in ISO Guide 35 : 2006. This uncertainty should be less than or equal to the characterisation uncertainty, u_{char}, in order to accept the batch. This condition was met for all components in all mixtures produced for all participants in this round.

Reference value assignment

For all three (3) mixture types, each component was assigned a reference value, x_{ref}, calculated from the average (simple arithmetic mean) of those determined in the calibration stage (see section above).

The initial combined uncertainty determined for each reference value was calculated from the equation below (ISO Guide 35 : 2006 - section 6.2).

$$u^2_c = u^2_{char} + u^2_{bb}$$

This combined uncertainty, u_c, is dominated in all cases by the calibration uncertainty, u_{char}

Following this calculation, the expanded uncertainty, $k \cdot u_c$, (k=2), was compared to the Calibration and Measurement Capability (CMC) for which EffecTech is accredited to ISO 17025. If U_{CMC} (k=2) was greater than $k \cdot u_c$ (k=2) then the uncertainty on the reference value was assigned to that stated in our published CMC in accordance with accepted practice such that

$$U_{ref} = \max (U_{CMC} , 2u_c)$$

The use of a coverage factor of k=2 in the assignment of U_{ref} provides a level of confidence of approximately 95%.

The individual calibration data for each suite of decant mixtures is not shown in this report. However, this data is available to all participants on request from EffecTech.

Stability statement

Over several years EffecTech has built up a history of intercomparisons of mixture types featured in this PT scheme. Data from these intercomparisons show clearly that all mixtures remain stable within their stated uncertainty for a minimum of 12 months.

The stability of each mixture is guaranteed for a period of 12 months. Within this time period there is no additional uncertainty ascribed to the reference values resulting from the long or short term stability of the mixtures. This is valid providing the mixtures are not used beyond this stability period.

The majority of mixtures will be stable (within their stated uncertainty) for considerably longer but this period has not been determined.

2.2 Assigned reference values

In the tables that follow, all reference values and their uncertainties are given as amount of substance in units of %mol/mol (10^{-2} mol/mol).

Table 2.1: Reference values - natural gas composition

component	x_{ref}	$U(x_{ref})$	u_c / %	u_{char} / %	u_{bb} / %
nitrogen	3.645	0.012	0.17	0.17	0.02
carbon dioxide	2.590	0.008	0.15	0.14	0.04
methane	82.351	0.028	0.015	0.014	0.003
ethane	6.346	0.016	0.12	0.12	0.02
propane	3.705	0.011	0.14	0.14	0.03
iso-butane	0.4978	0.0018	0.18	0.18	0.04
n-butane	0.4625	0.0024	0.26	0.25	0.05
iso-pentane	0.1660	0.0016	0.49	0.48	0.06
n-pentane	0.1381	0.0016	0.59	0.57	0.13
n-hexane	0.0989	0.0011	0.57	0.53	0.21

Table 2.2: Reference values - propane composition

component	x_{ref}	$U(x_{ref})$	u_c / %	u_{char} / %	u_{bb} / %
nitrogen	1.851	0.011	0.29	0.25	0.13
ethane	0.818	0.004	0.25	0.25	0.03
propane	96.534	0.013	0.006	0.006	0.002
iso-butane	0.3693	0.0022	0.29	0.28	0.09
n-butane	0.3161	0.0016	0.26	0.25	0.05
iso-pentane	0.0619	0.0008	0.62	0.59	0.18
n-pentane	0.0492	0.0007	0.70	0.66	0.22

Table 2.3: Reference values - mixed refrigerant (MR)

component	x_{ref}	$U(x_{ref})$	u_c / %	u_{char} / %	u_{bb} / %
nitrogen	15.434	0.047	0.15	0.15	0.023
methane	37.547	0.072	0.08	0.08	0.021
ethane	32.847	0.082	0.09	0.09	0.013
propane	14.172	0.046	0.16	0.16	0.037

3. Results

3.1 Reported results

There were twenty-six (26) laboratories signed up for participation in this round of the GGLNG PT scheme. Consignments containing up to three different mixture types were shipped to the participating laboratories.

The table below shows participation and whether results were submitted for the mixtures shipped.

Table 3.1: Participant laboratories and reported results

Participant id	LNG mixture		propane composition		mixed refrigerant	
	participation	results	participation	results	participation	results
P01			✓	✓		
P02	✓	✓				
P03	✓	✓				
P04	✓	✓	✓	✓	✓	✓
P05			✓	✓		
P06	✓	✓				
P07	✓	✓				
P08	✓	✓				
P09	✓	×				
P10	✓	✓	✓	✓	✓	✓
P11	✓	✓	✓	✓	✓	✓
P12	✓	✓	✓	✓	✓	✓
P13	✓	✓				
P14	✓	✓				
P15	✓	✓				
P16	✓	✓				
P17	✓	✓				
P18	✓	✓				
P19	✓	✓				
P20	✓	✓				
P21	✓	✓				
P22	✓	×			✓	×
P23	✓	✓	✓	✓	✓	✓
P24	✓	✓				
P25	✓	✓	✓	✓		
P26	✓	✓				

To enable the calculation of E_n numbers, the laboratory is required to submit an estimate of the uncertainty placed on their measured amount fractions. The majority of participants submitted estimates of measurement uncertainty. Those who did not submit any uncertainty estimates were participants **P01**, **P05**, **P07**, **P13**, **P18**, **P19, P21, P24, P25** and **P26**. In these instances E_n numbers could not be calculated and have not been presented in this report.

All laboratories responded that they had reported normalised results for complete mixture compositions except laboratory **P13**. Results for **P13** were normalised before performance measures were calculated. Some laboratories reported normalised results which did not sum to exactly 100% mol/mol due to rounding errors from truncation of their results. These results were also normalised before comparison with reference values.

3.2 Measures of performance

z-score

The evaluation of performance was carried out by means of a **z**-score, which gives the relative deviation of the participant's result from the reference value.

The **z**-score is calculated with the following general formula

$$z = \frac{x_{meas} - x_{ref}}{\sigma} \quad (1)$$

where x_{meas} is the measured result reported by the laboratory
x_{ref} is the assigned reference value and
σ is the absolute standard deviation used for performance assessment which can be calculated from the relative standard deviation for performance assessment S_{PT} by

$$\sigma = \frac{S_{PT}}{100} . x_{ref} \quad (2)$$

The relative standard deviation for performance assessment used for calculating the **z**-scores has been fixed for all components by EffecTech and based upon a reasonable expectation of the performance capabilities that should be demonstrated by each laboratory. These are given in the tables below

Table 3.2: Standard deviation for performance assessment (natural gas composition)

component	S_{PT} (% relative)
nitrogen	1.1 %
carbon dioxide	
(0.1 to 1 %mol/mol)	2.2 %
(1 to 8 % mol/mol)	1.1 %
methane	0.1 %
ethane	1.1 %
propane	1.1 %
iso-butane	2.2 %
n-butane	2.2 %
iso-pentane	2.2 %
n-pentane	2.2 %
n-hexane[†]	0.0022 %mol/mol

[†] The standard deviation for performance assessment for n-hexane is given in absolute terms (%mol/mol). Hence $\sigma = S_{PT}$ for this component.

Table 3.3: Standard deviation for performance assessment (propane composition)

component	S_{PT} (% relative)
nitrogen	3.0 %
ethane	2.0 %
propane	0.1 %
iso-butane	2.5 %
n-butane	2.5 %
iso-pentane	3.0 %
n-pentane	3.0 %

Table 3.4: Standard deviation for performance assessment (mixed refrigerant)

component	S_{PT} (% relative)
nitrogen	1.5 %
methane	1.0 %
ethane	1.0 %
propane	1.5 %

The qualification of the **z**-scores is given in table 3.5 below

Table 3.5: Relationship between z-score and quality of result

z-score	quality of result
$\|z\| \leq 2$	**satisfactory result**
$2 < \|z\| < 3$	**questionable result**
$\|z\| \geq 3$	**unsatisfactory result**

E_n number

In addition, an E_n number is calculated which assesses the difference in the reference and measured (reported) values relative to their respective uncertainties.

The calculation of E_n numbers is dependent upon the laboratory reporting estimates of uncertainties associated with their measurement results.

The E_n number is calculated with the following general formula

$$E_n = \frac{x_{meas} - x_{ref}}{\sqrt{U_{meas}^2 + U_{ref}^2}} \quad (3)$$

where x_{meas} is the measured result reported by the laboratory
x_{ref} the assigned reference value and
U_{meas} and U_{ref} their respective uncertainties (using a coverage factor k=2)

The qualification of the E_n number is given in table 3.6 below

Table 3.6: Relationship between E_n-number and quality of result

E_n- number	quality of result
$\|E_n\| \leq 1$	**satisfactory result**
$\|E_n\| > 1$	**unsatisfactory result**

Evaluation of the performance of a laboratory based on E_n numbers requires them to report an estimate of their measurement uncertainty, U_{meas}. In addition, it is important that the reported uncertainties are in the same order of magnitude as the uncertainties on the reference values. Due to the nature of the formula used to calculate the E_n number, high reported uncertainties are much more likely to result in very low E_n numbers.

Overall score

In addition, a score has been calculated which expresses the participants score as percentage of the maximum possible score for each mixture type. The scoring scheme is as follows.

For each parameter in each round points can be earned in accordance with the scheme in table 3.7 below

Table 3.7: Relationship between z-score and quality of result

z-score	score per component
$\|z\| \leq 2$	**1 point**
$2 < \|z\| 2.5$	**0.5 point**
$2.5 < \|z\| 3$	**0.25 point**
$\|z\| \geq 3$	**no points**

A participant's score for each mixture is then expressed as percentage of the maximum score possible. The maximum score possible is attained when a participant obtains a *z*-score of less than 2 for all components that the laboratory measures in the mixture.

3.3 Evaluation of results

Natural gas composition (content)

As per the instructions and published protocols, the "LNG" mixture contained carbon dioxide in this round to represent a typical vapourised natural gas / feed gas sample. The summary of z-scores is given below.

Table 3.8 - Summary of *z*-scores

participant id	nitrogen	carbon dioxide	methane	ethane	propane	iso-butane	n-butane	iso-pentane	n-pentane	n-hexane
P01										
P02	-0.92	0.47	0.03	0.61	-0.50	-0.31	0.00	0.11	0.28	0.32
P03	1.48	-0.58	0.14	0.00	0.45	-3.15	-2.94	-2.20	-1.71	2.00
P04	1.13	2.47	-0.93	0.24	-1.12	-0.53	-0.10	-0.27	-0.69	-0.41
P05										
P06	-0.19	-0.13	-0.05	0.20	0.06	-0.05	-0.20	0.11	0.53	-0.18
P07	0.32	-0.11	-0.61	0.71	-0.15	0.06	-0.12	0.00	-0.26	-1.05
P08	-0.21	0.10	-0.01	0.14	0.01	0.11	-0.57	0.12	0.19	-0.36
P09										
P10	0.88	0.55	-1.36	0.43	0.29	0.34	0.38	0.78	0.92	2.50
P11	-0.33	0.12	0.03	0.13	-0.03	-0.04	-0.08	0.10	0.05	0.17
P12	0.03	-0.05	0.26	1.01	0.28	0.41	0.44	0.18	-37.15	-0.32
P13	-0.28	0.84	0.45	0.75	0.38	-0.08	-0.23	-0.74	-36.23	-0.78
P14	0.04	0.15	1.25	-1.11	-0.66	-0.15	-0.10	-0.05	-0.03	-1.09
P15							0.09	-0.08	0.05	
P16	-4.11	0.35	1.81	0.54	-0.03	0.16	-0.20	-5.68	-2.72	-0.53
P17	-4.06	-0.78	2.22	0.56	-0.53	-0.15	-0.03	-2.14	-1.82	-0.22
P18	0.09	0.91	0.10	-0.11	-0.34	-0.41	-0.49	-1.03	-0.44	-1.05
P19	-0.13	-0.76	-1.12	0.27	2.47	0.30	0.30	-1.74	0.04	-0.43
P20	-0.66	0.73	1.51	-1.10	-0.98	-0.59	-0.25	2.17	-2.02	2.40
P21	-0.31	1.27	0.15	-0.16	-0.36	-0.31	-0.36	-0.23	-0.34	-0.95
P22										
P23	0.27	-0.13	0.00	0.01	-0.21	0.01	0.04	0.13	-0.01	-0.13
P24	-0.16	0.03	-0.15	0.23	-0.20	-0.02	0.24	0.04	1.09	1.52
P25	0.44	-0.12	0.16	0.17	-0.57	-0.38	-0.70	-0.12	-0.53	-1.04
P26	-14.49	0.97	3.90	0.12	3.79	2.36	2.24	2.25	2.32	2.18

Results for the LNG mixture in this round were good with twelve (12) out of twenty-two (22) reporting participants achieving a perfect score of 100%. The average score was 91.7%.

Of the laboratories not achieving a perfect score, accurate measurement of the several components in the mixture resulted in outliers. However, questionable and unsatisfactory results were few and far between.

Unusually, laboratories **P12** and **P13** reported large errors in n-pentane but would have scored 100% otherwise.

Laboratory **P26** struggled with the majority of components and under-measured nitrogen significantly.

Laboratory **P15** reported only n-butane and pentanes as the other components were "outside of the limits of the calibration curve".

Table 3.9 - Summary of E_n-numbers

participant id	nitrogen	carbon dioxide	methane	ethane	propane	iso-butane	n-butane	iso-pentane	n-pentane	n-hexane
P01										
P02	-0.42	0.15	0.01	0.50	-0.29	-0.30	0.00	0.11	0.25	0.14
P03	2.10	-1.19	0.05	0.01	1.41	-3.20	-1.94	-1.19	-0.66	0.29
P04	0.61	1.31	-0.05	0.13	-0.62	-0.58	-0.11	-0.27	-0.67	-0.37
P05										
P06	-0.11	-0.12	-0.04	0.34	0.08	-0.11	-0.21	0.14	0.55	-0.02
P07										
P08	-0.14	0.07	0.00	0.27	0.02	0.19	-0.93	0.09	0.16	-0.18
P09										
P10	0.62	0.30	-0.45	0.64	0.41	0.69	0.40	0.76	0.86	2.33
P11	-0.34	0.11	0.02	0.12	-0.03	-0.08	-0.17	0.19	0.08	0.24
P12	0.07	-0.12	0.10	1.98	0.57	1.54	1.64	0.36	-42.74	-0.47
P13										
P14	0.09	0.45	2.03	-2.69	-1.55	-0.55	-0.29	-0.07	-0.04	-0.33
P15							0.04	-0.04	0.03	
P16	-1.63	0.24	0.19	0.52	-0.03	0.17	-0.22	-8.10	-0.28	-0.36
P17	-7.01	-1.18	3.49	2.31	-1.56	-0.73	-0.12	-3.74	-2.95	-0.33
P18										
P19										
P20	-1.95	2.50	4.14	-4.76	-3.50	-3.18	-0.99	3.83	-2.92	3.48
P21										
P22										
P23	0.66	-0.29	-0.01	0.05	-0.55	0.02	0.05	0.09	-0.01	-0.06
P24										
P25										
P26										

For the fourteen (14) laboratories reporting uncertainties for this mixture, the E_n -numbers are shown above.

Laboratories **P14** scored 100% on the basis of ***z***-scores but failed on one or more components on the basis of E_n-numbers. This laboratory underestimated their uncertainties for failing components.

Laboratories **P02**, **P06**, **P08**, **P11** and **P23** all reported excellent results with perfect scores on the basis of both performance measures.

Natural gas composition (physical properties)

Participants were asked to report physical properties (calculated from their measured composition) in order to assess any measurement errors in these properties. This was not a mandatory requirement. However, EffecTech encourages laboratories to submit these calculations if it is a local requirement of their laboratory.

As physical properties can be submitted using a variety of reference methods and conditions, laboratories were allowed to submit their results alongside the methods and references used. For comparison purposes, EffecTech also calculated properties using the same methods submitted by each participant.

The tables in Annex A show the relative difference between reference values (calculated from reference composition) and those submitted by the laboratory (or calculated by EffecTech from reported composition). Data reported by the laboratory is shown with **Blue** markers whereas those calculated by EffecTech are shown in **Red**.

Where results were calculated by EffecTech, these were done using ISO 6976 [ISO6976:1995 *Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition*] for a real gas at reference temperatures of 15°C (combustion) and 15°C (metering) and a pressure of 101.325 kPa.

As a basis for the performance of these measures has yet to be established, **z**-scores and $\boldsymbol{E_n}$-numbers for these parameters have not been calculated in this round.

Propane composition

The results for the propane composition are shown in the tables below.

Table 3.10 - Summary of *z*-scores

participant id	nitrogen	ethane	propane	iso-butane	n-butane	iso-pentane	n-pentane
P01	0.17	0.44	-0.34	0.06	1.88	0.32	0.23
P02							
P03							
P04	0.07	0.69	-0.29	-0.55	2.42	-0.10	-0.34
P05	-2.60	-0.09	1.54	-0.70	0.03	-0.08	2.90
P06							
P07							
P08							
P09							
P10	-0.12	0.40	-0.05	-0.01	0.55	0.35	0.54
P11	-0.22	-0.20	0.11	0.27	0.24	0.32	0.13
P12	-0.16	0.15	0.08	-0.22	0.00	0.31	0.43
P13							
P14							
P15							
P16							
P17							
P18							
P19							
P20							
P21							
P22							
P23	-0.23	0.01	0.11	-0.13	0.52	0.06	-0.43
P24							
P25	-0.26	-0.27	0.24	-0.31	-0.17	0.03	0.08
P26							

Eight (8) laboratories took part in the measurement of the propane composition. All laboratories reported a perfect score of 100% with the exception of **P04** and **P05**. These laboratories reported questionable results only. This is an excellent overall performance in this round.

Table 3.11 - Summary of E_n-numbers

participant id	nitrogen	ethane	propane	iso-butane	n-butane	iso-pentane	n-pentane
P01							
P02							
P03							
P04	0.09	0.66	-0.01	-0.66	2.78	-0.13	-0.42
P05							
P06							
P07							
P08							
P09							
P10	-0.18	0.71	-0.01	-0.01	0.66	0.44	0.48
P11	-0.51	-0.14	0.31	0.29	0.52	0.63	0.17
P12	-0.63	0.30	0.05	-0.69	0.01	0.47	0.56
P13							
P14							
P15							
P16							
P17							
P18							
P19							
P20							
P21							
P22							
P23	-0.99	0.02	0.72	-0.25	1.48	0.13	-0.38
P24							
P25							
P26							

On the basis of E_n-numbers the results show an additional outlier for laboratory **P23** due to the under-estimation of the uncertainties for n-butane.

Laboratories **P10, P11** and **P12** achieved perfect scores on the basis of both assessments.

Mixed refrigerant (MR)

The results for the mixed refrigerant are shown in the tables below

Table 3.12 - Summary of *z*-scores

participant id	nitrogen	methane	ethane	propane
P01				
P02				
P03				
P04	1.32	0.53	-1.02	-0.79
P05				
P06				
P07				
P08				
P09				
P10	0.25	-0.17	0.07	-0.08
P11	0.29	0.02	-0.05	-0.26
P12	0.11	1.47	-1.57	-0.28
P13				
P14				
P15				
P16				
P17				
P18				
P19				
P20				
P21				
P22				
P23	-0.20	0.51	-0.32	-0.18
P24				
P25				
P26				

All five (5) laboratories submitting results for the mixed refrigerant scored a perfect 100%.

This is an excellent set of results.

Table 3.13 - Summary of E_n-numbers

participant id	nitrogen	methane	ethane	propane
P01				
P02				
P03				
P04	0.96	0.26	-0.51	-0.59
P05				
P06				
P07				
P08				
P09				
P10	0.35	-0.32	0.13	-0.20
P11	0.35	0.01	-0.04	-0.33
P12	0.36	5.30	-4.49	-0.89
P13				
P14				
P15				
P16				
P17				
P18				
P19				
P20				
P21				
P22				
P23	-0.64	1.61	-1.00	-0.40
P24				
P25				
P26				

Laboratories **P04**, **P10** and **P11** scored perfectly by both measures of assessment.

Laboratories **P12** and **P23** reported results for this mixture with significant errors on the basis of E_n-numbers; it seems they were a little too ambitious with their uncertainty estimates for these components.

Overall scores

The table below shows the ratings calculated for each laboratory expressed as a percentage of the maximum possible score for each mixture.

Table 3.14 - Summary of overall scores for each mixture type

Participant id	natural gas mixture	propane composition	mixed refrigerant
P01		100.0%	
P02	100.0%		
P03	77.5%		
P04	95.0%	92.9%	100.0%
P05		78.6%	
P06	100.0%		
P07	100.0%		
P08	100.0%		
P09			
P10	92.5%	100.0%	100.0%
P11	100.0%	100.0%	100.0%
P12	90.0%	100.0%	100.0%
P13	90.0%		
P14	100.0%		
P15	100.0%		
P16	72.5%		
P17	80.0%		
P18	100.0%		
P19	95.0%		
P20	85.0%		
P21	100.0%		
P22			
P23	100.0%	100.0%	100.0%
P24	100.0%		
P25	100.0%	100.0%	
P26	45.0%		
Average score	**91.9%**	**96.4%**	**100.0%**

On the basis of average scores participants performed extremely well in this round with few unsatisfactory or gross errors reported for any mixture type.

Laboratories **P11** and **P23** are worthy of particular mention in this round achieving a perfect score of 100% for all three (3) mixtures. This is an excellent performance from an excellent pool of laboratories.

Annex A - Detailed results by component (and property)

Detailed results for all components (and properties) in all mixtures are shown in subsequent charts.

In each chart, the reported results are shown with the dots in terms of a relative difference (in percent) from the assigned reference value. The reported uncertainties (where supplied) are shown as "error bars" on the reported values.

In each chart the bound limit lines surrounding the zero relative difference signify

- the percentage relative uncertainty on the reference value, %U(x_{ref}) k=2 (in **blue**)
- the |z|=2 satisfactory limit (in **green**)
- the |z|=3 unsatisfactory limit (in **red**)

This annex also include some additional statistics in this round presenting consensus values from the pool of laboratories on the basis of raw data and correct data (following the removal of outlying reported values). Additional tables also show repeatability standard deviation (s_r), between laboratory standard deviation (s_L) and reproducibility standard deviation (s_R) on the basis of raw and corrected data. The data has been calculated in accordance with the robust statistical methods in ISO 5725 Parts 1 and 2. The detailed calculations made to derive these results are outside the scope of this report but will be provided to participants on request from the scheme coordinator.

Natural gas composition (content)

Mixture	LNG
Component	nitrogen

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	3.645	0.012	%mol/mol	0.040	%mol/mol

Reported data

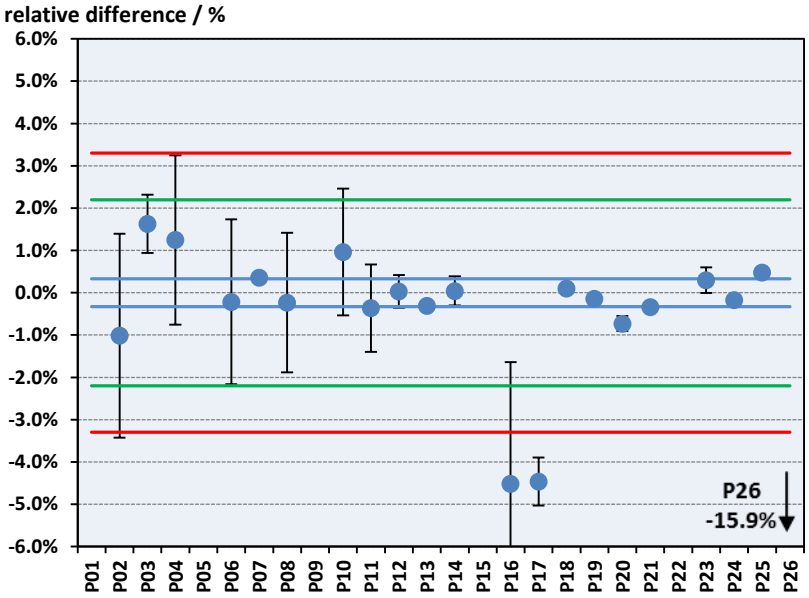
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	3.608	0.087	-1.01%	-0.92	-0.42
P03	3.704	0.026	1.63%	1.48	2.10
P04	3.691	0.074	1.25%	1.13	0.61
P05					
P06	3.637	0.071	-0.21%	-0.19	-0.11
P07	3.658		0.35%	0.32	
P08	3.636	0.060	-0.23%	-0.21	-0.14
P09					
P10	3.680	0.055	0.96%	0.88	0.62
P11	3.632	0.038	-0.37%	-0.33	-0.34
P12	3.646	0.014	0.03%	0.03	0.07
P13	3.634		-0.31%	-0.28	
P14	3.647	0.013	0.04%	0.04	0.09
P15					
P16	3.480	0.100	-4.52%	-4.11	-1.63
P17	3.482	0.020	-4.46%	-4.06	-7.01
P18	3.649		0.10%	0.09	
P19	3.640		-0.14%	-0.13	
P20	3.618	0.006	-0.73%	-0.66	-1.95
P21	3.633		-0.34%	-0.31	
P22					
P23	3.656	0.011	0.29%	0.27	0.66
P24	3.639		-0.17%	-0.16	
P25	3.663		0.48%	0.44	
P26	3.064		-15.94%	-14.49	

Consensus values (raw data)

m	3.607	
s_r	0.008	0.21%
s_L	0.095	2.64%
s_R	0.096	2.65%
p	21	

Consensus values (corrected)

m	3.616	
s_r	0.008	0.21%
s_L	0.064	1.77%
s_R	0.064	1.78%
p	20	



Mixture	LNG
Component	carbon dioxide

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	2.590	0.008	%mol/mol	0.028	%mol/mol

Reported data

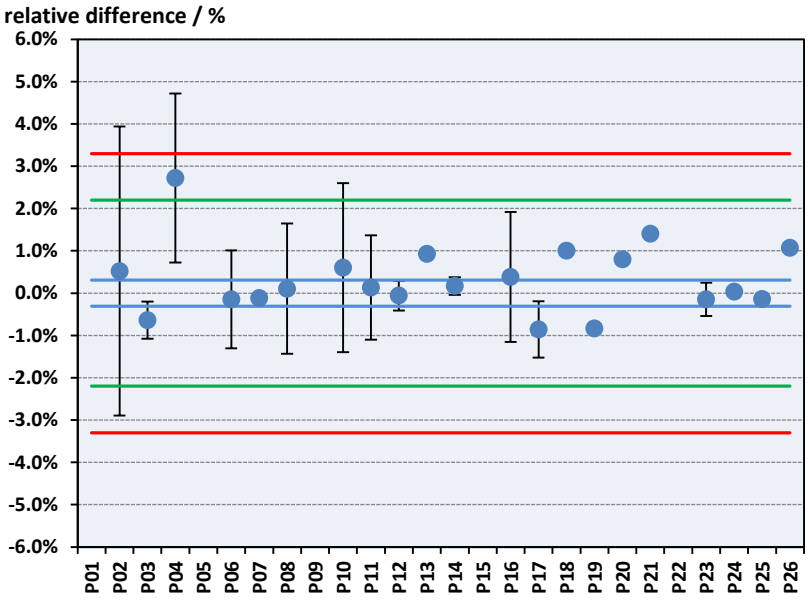
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	2.604	0.089	0.52%	0.47	0.15
P03	2.574	0.011	-0.64%	-0.58	-1.19
P04	2.660	0.053	2.72%	2.47	1.31
P05					
P06	2.586	0.030	-0.15%	-0.13	-0.12
P07	2.587		-0.12%	-0.11	
P08	2.593	0.040	0.11%	0.10	0.07
P09					
P10	2.606	0.052	0.60%	0.55	0.30
P11	2.593	0.032	0.13%	0.12	0.11
P12	2.589	0.009	-0.06%	-0.05	-0.12
P13	2.614		0.93%	0.84	
P14	2.594	0.005	0.17%	0.15	0.45
P15					
P16	2.600	0.040	0.38%	0.35	0.24
P17	2.568	0.017	-0.86%	-0.78	-1.18
P18	2.616		1.00%	0.91	
P19	2.568		-0.83%	-0.76	
P20	2.611	0.002	0.80%	0.73	2.50
P21	2.626		1.40%	1.27	
P22					
P23	2.586	0.010	-0.15%	-0.13	-0.29
P24	2.591		0.04%	0.03	
P25	2.587		-0.14%	-0.12	
P26	2.618		1.07%	0.97	

Consensus values (raw data)

m	2.594	
s_r	0.004	0.15%
s_L	0.018	0.68%
s_R	0.018	0.70%
p	21	

Consensus values (corrected)

m	2.593	
s_r	0.004	0.15%
s_L	0.016	0.60%
s_R	0.016	0.62%
p	20	



Mixture	LNG
Component	methane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	82.351	0.028	%mol/mol	0.082	%mol/mol

Reported data

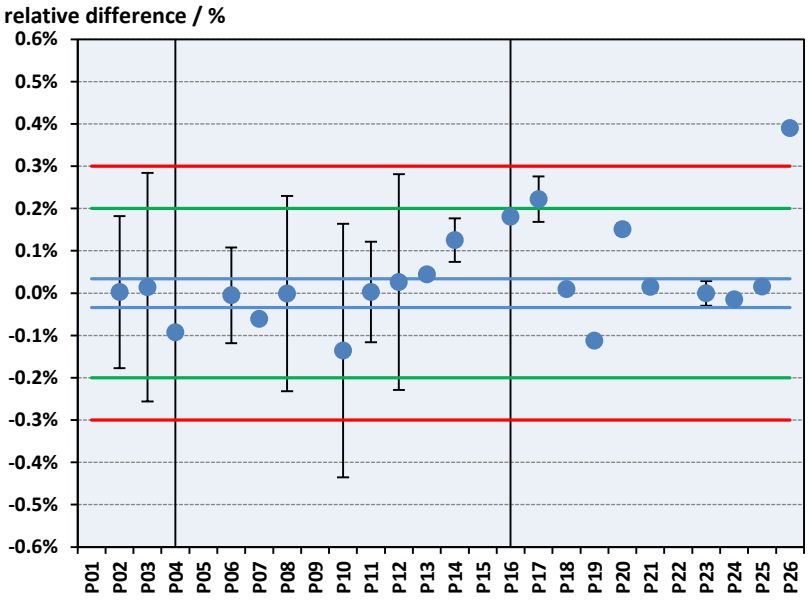
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	82.353	0.148	0.00%	0.03	0.01
P03	82.363	0.222	0.01%	0.14	0.05
P04	82.274	1.645	-0.09%	-0.93	-0.05
P05					
P06	82.347	0.093	-0.01%	-0.05	-0.04
P07	82.301		-0.06%	-0.61	
P08	82.350	0.190	0.00%	-0.01	0.00
P09					
P10	82.239	0.247	-0.14%	-1.36	-0.45
P11	82.353	0.098	0.00%	0.03	0.02
P12	82.373	0.210	0.03%	0.26	0.10
P13	82.388		0.04%	0.45	
P14	82.454	0.042	0.13%	1.25	2.03
P15					
P16	82.500	0.800	0.18%	1.81	0.19
P17	82.534	0.044	0.22%	2.22	3.49
P18	82.359		0.01%	0.10	
P19	82.259		-0.11%	-1.12	
P20	82.476	0.011	0.15%	1.51	4.14
P21	82.363		0.02%	0.15	
P22					
P23	82.351	0.024	0.00%	0.00	-0.01
P24	82.339		-0.01%	-0.15	
P25	82.364		0.02%	0.16	
P26	82.673		0.39%	3.90	

Consensus values (raw data)

m	82.386	
s_r	0.013	0.02%
s_L	0.091	0.11%
s_R	0.092	0.11%
p	21	

Consensus values (corrected)

m	82.381	
s_r	0.013	0.02%
s_L	0.084	0.10%
s_R	0.085	0.10%
p	20	



Mixture	LNG
Component	ethane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	6.346	0.016	%mol/mol	0.070	%mol/mol

Reported data

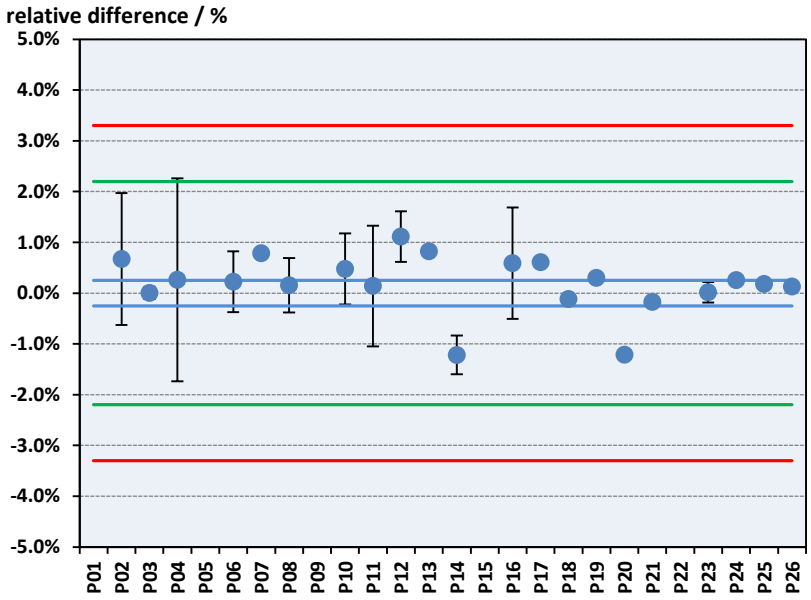
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	6.389	0.083	0.67%	0.61	0.50
P03	6.346	0.008	0.00%	0.00	0.01
P04	6.362	0.127	0.26%	0.24	0.13
P05					
P06	6.360	0.038	0.22%	0.20	0.34
P07	6.396		0.79%	0.71	
P08	6.356	0.034	0.16%	0.14	0.27
P09					
P10	6.376	0.045	0.48%	0.43	0.64
P11	6.355	0.075	0.14%	0.13	0.12
P12	6.417	0.032	1.12%	1.01	1.98
P13	6.398		0.83%	0.75	
P14	6.269	0.024	-1.22%	-1.11	-2.69
P15					
P16	6.383	0.070	0.59%	0.54	0.52
P17	6.385	0.005	0.61%	0.56	2.31
P18	6.339		-0.12%	-0.11	
P19	6.365		0.30%	0.27	
P20	6.269	0.003	-1.22%	-1.10	-4.76
P21	6.335		-0.17%	-0.16	
P22					
P23	6.347	0.013	0.02%	0.01	0.05
P24	6.362		0.25%	0.23	
P25	6.358		0.18%	0.17	
P26	6.354		0.13%	0.12	

Consensus values (raw data)

m	6.357	
s_r	0.005	0.07%
s_L	0.040	0.62%
s_R	0.040	0.63%
p	21	

Consensus values (corrected)

m	6.370	
s_r	0.004	0.06%
s_L	0.021	0.32%
s_R	0.021	0.33%
p	19	



Mixture	LNG
Component	propane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	3.705	0.011	%mol/mol	0.041	%mol/mol

Reported data

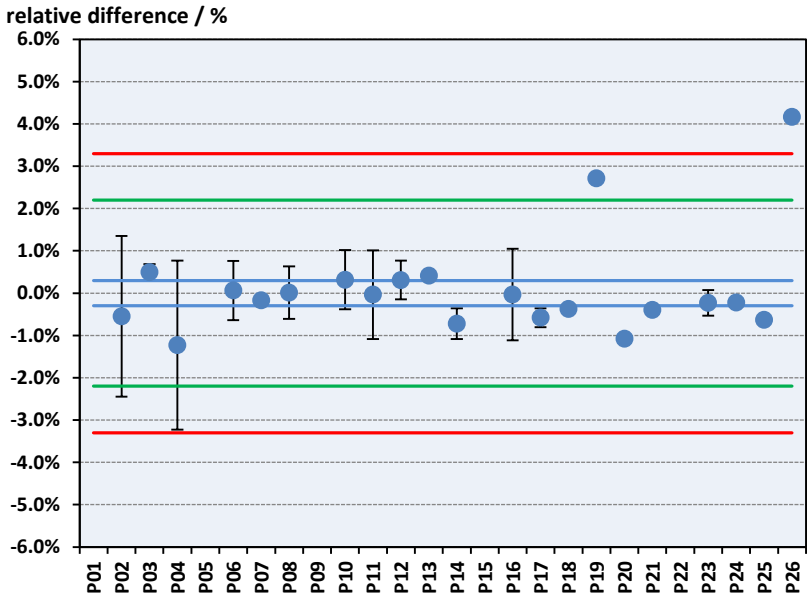
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	3.685	0.070	-0.55%	-0.50	-0.29
P03	3.724	0.007	0.50%	0.45	1.41
P04	3.659	0.073	-1.23%	-1.12	-0.62
P05					
P06	3.707	0.026	0.06%	0.06	0.08
P07	3.699		-0.17%	-0.15	
P08	3.706	0.023	0.02%	0.01	0.02
P09					
P10	3.717	0.026	0.32%	0.29	0.41
P11	3.704	0.039	-0.04%	-0.03	-0.03
P12	3.717	0.017	0.31%	0.28	0.57
P13	3.720		0.41%	0.38	
P14	3.678	0.013	-0.72%	-0.66	-1.55
P15					
P16	3.704	0.040	-0.03%	-0.03	-0.03
P17	3.684	0.008	-0.58%	-0.53	-1.56
P18	3.691		-0.37%	-0.34	
P19	3.806		2.72%	2.47	
P20	3.665	0.003	-1.08%	-0.98	-3.50
P21	3.690		-0.40%	-0.36	
P22					
P23	3.696	0.011	-0.23%	-0.21	-0.55
P24	3.697		-0.22%	-0.20	
P25	3.682		-0.63%	-0.57	
P26	3.859		4.17%	3.79	

Consensus values (raw data)

m	3.704	
s_r	0.004	0.11%
s_L	0.040	1.09%
s_R	0.040	1.09%
p	21	

Consensus values (corrected)

m	3.693	
s_r	0.004	0.11%
s_L	0.015	0.42%
s_R	0.016	0.43%
p	19	



Mixture	LNG
Component	iso-butane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.4978	0.0018	%mol/mol	0.0110	%mol/mol

Reported data

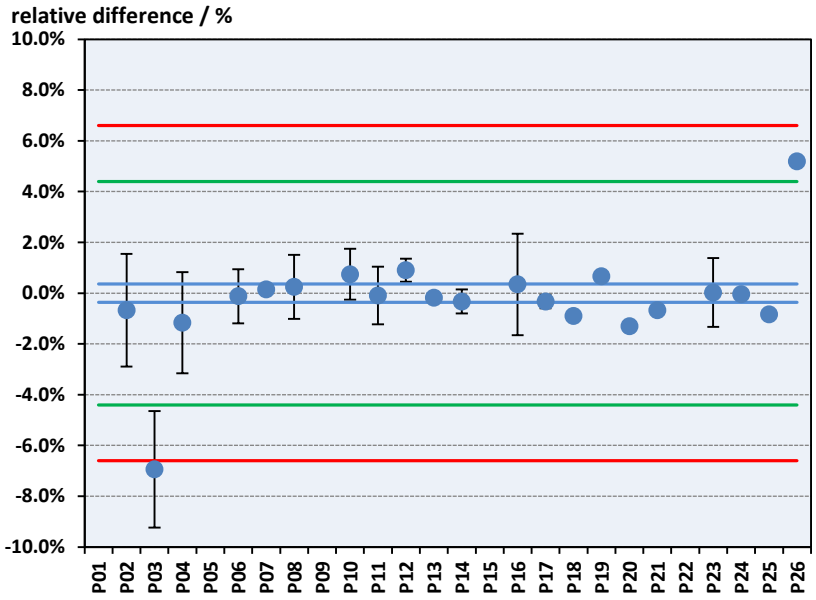
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	0.4945	0.0110	-0.67%	-0.31	-0.30
P03	0.4633	0.0107	-6.94%	-3.15	-3.20
P04	0.4920	0.0098	-1.17%	-0.53	-0.58
P05					
P06	0.4972	0.0053	-0.12%	-0.05	-0.11
P07	0.4985		0.14%	0.06	
P08	0.4991	0.0063	0.25%	0.11	0.19
P09					
P10	0.5015	0.0050	0.74%	0.34	0.69
P11	0.4973	0.0056	-0.09%	-0.04	-0.08
P12	0.5023	0.0023	0.90%	0.41	1.54
P13	0.4969		-0.18%	-0.08	
P14	0.4962	0.0023	-0.33%	-0.15	-0.55
P15					
P16	0.4995	0.0100	0.35%	0.16	0.17
P17	0.4962	0.0013	-0.33%	-0.15	-0.73
P18	0.4933		-0.90%	-0.41	
P19	0.5011		0.66%	0.30	
P20	0.4913	0.0010	-1.30%	-0.59	-3.18
P21	0.4944		-0.68%	-0.31	
P22					
P23	0.4979	0.0067	0.03%	0.01	0.02
P24	0.4976		-0.04%	-0.02	
P25	0.4936		-0.84%	-0.38	
P26	0.5236		5.19%	2.36	

Consensus values (raw data)

m	0.4967	
s_r	0.0019	0.38%
s_L	0.0063	1.27%
s_R	0.0066	1.32%
p	21	

Consensus values (corrected)

m	0.4968	
s_r	0.0019	0.38%
s_L	0.0029	0.59%
s_R	0.0035	0.70%
p	19	



Mixture	LNG
Component	n-butane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.4625	0.0024	%mol/mol	0.0102	%mol/mol

Reported data

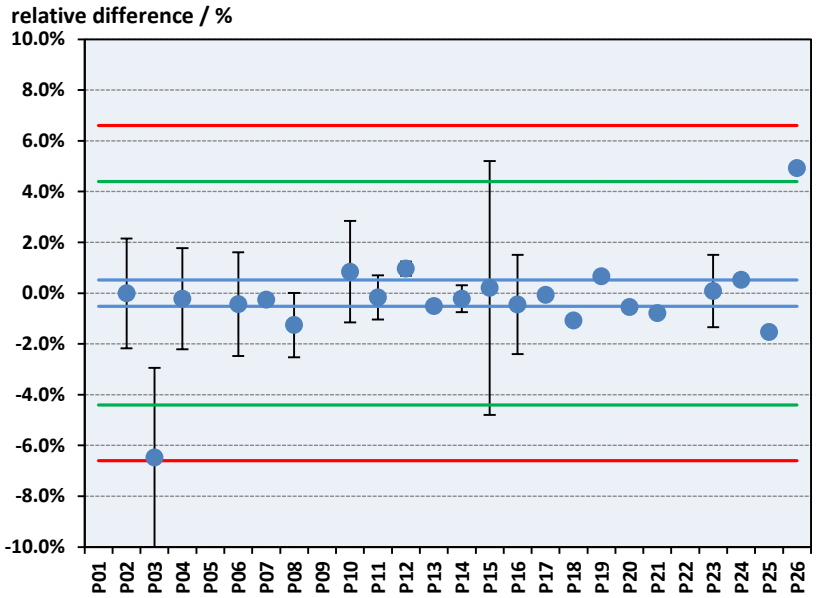
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	0.4625	0.0100	-0.01%	0.00	0.00
P03	0.4326	0.0153	-6.48%	-2.94	-1.94
P04	0.4615	0.0092	-0.22%	-0.10	-0.11
P05					
P06	0.4605	0.0094	-0.43%	-0.20	-0.21
P07	0.4613		-0.26%	-0.12	
P08	0.4567	0.0058	-1.26%	-0.57	-0.93
P09					
P10	0.4664	0.0093	0.84%	0.38	0.40
P11	0.4617	0.0040	-0.17%	-0.08	-0.17
P12	0.4670	0.0013	0.97%	0.44	1.64
P13	0.4602		-0.51%	-0.23	
P14	0.4615	0.0024	-0.22%	-0.10	-0.29
P15	0.4635	0.0232	0.21%	0.09	0.04
P16	0.4604	0.0090	-0.45%	-0.20	-0.22
P17	0.4622	0.0009	-0.07%	-0.03	-0.12
P18	0.4575		-1.08%	-0.49	
P19	0.4656		0.66%	0.30	
P20	0.4600	0.0008	-0.54%	-0.25	-0.99
P21	0.4589		-0.78%	-0.36	
P22					
P23	0.4629	0.0066	0.08%	0.04	0.05
P24	0.4649		0.52%	0.24	
P25	0.4554		-1.53%	-0.70	
P26	0.4853		4.93%	2.24	

Consensus values (raw data)

m	0.4610	
s_r	0.0018	0.39%
s_L	0.0056	1.21%
s_R	0.0059	1.27%
p	22	

Consensus values (corrected)

m	0.4611	
s_r	0.0018	0.39%
s_L	0.0029	0.62%
s_R	0.0034	0.73%
p	20	



Mixture	LNG
Component	iso-pentane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.1660	0.0016	%mol/mol	0.0037	%mol/mol

Reported data

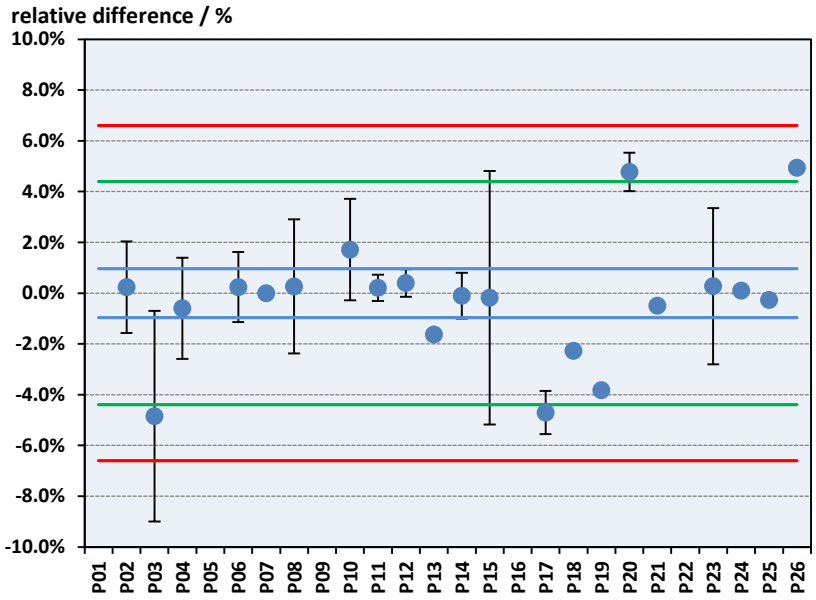
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	0.1664	0.0030	0.23%	0.11	0.11
P03	0.1580	0.0066	-4.85%	-2.20	-1.19
P04	0.1650	0.0033	-0.60%	-0.27	-0.27
P05					
P06	0.1664	0.0023	0.24%	0.11	0.14
P07	0.1660		0.00%	0.00	
P08	0.1664	0.0044	0.27%	0.12	0.09
P09					
P10	0.1689	0.0034	1.72%	0.78	0.76
P11	0.1664	0.0009	0.21%	0.10	0.19
P12	0.1667	0.0009	0.40%	0.18	0.36
P13	0.1633		-1.63%	-0.74	
P14	0.1658	0.0015	-0.10%	-0.05	-0.07
P15	0.1657	0.0083	-0.18%	-0.08	-0.04
P16	0.1452	0.0020	-12.50%	-5.68	-8.10
P17	0.1582	0.0013	-4.70%	-2.14	-3.74
P18	0.1622		-2.27%	-1.03	
P19	0.1597		-3.83%	-1.74	
P20	0.1739	0.0013	4.78%	2.17	3.83
P21	0.1652		-0.50%	-0.23	
P22					
P23	0.1665	0.0051	0.28%	0.13	0.09
P24	0.1662		0.09%	0.04	
P25	0.1656		-0.27%	-0.12	
P26	0.1742		4.94%	2.25	

Consensus values (raw data)

m	0.1638	
s_r	0.0008	0.47%
s_L	0.0069	4.21%
s_R	0.0069	4.23%
p	22	

Consensus values (corrected)

m	0.1654	
s_r	0.0008	0.49%
s_L	0.0042	2.55%
s_R	0.0043	2.60%
p	21	



Mixture	LNG
Component	n-pentane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.1381	0.0016	%mol/mol	0.0030	%mol/mol

Reported data

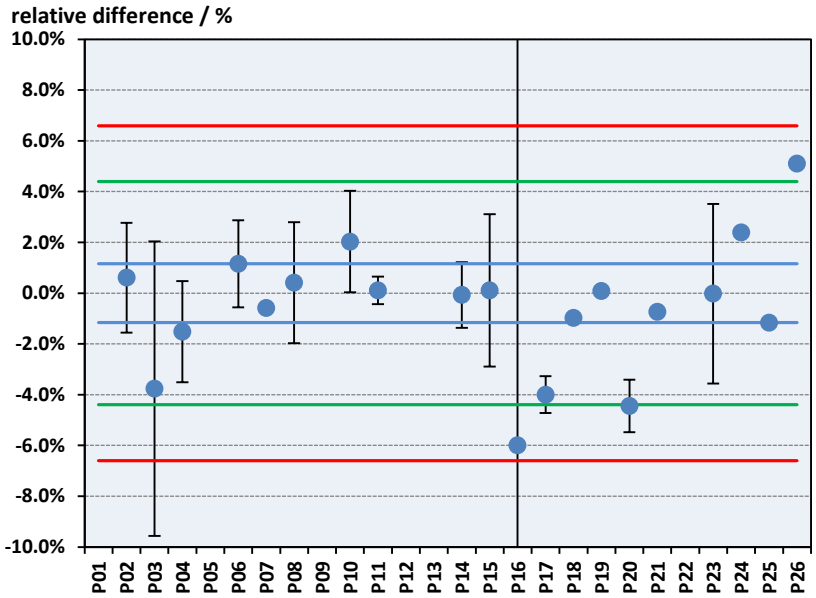
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	0.1389	0.0030	0.61%	0.28	0.25
P03	0.1329	0.0077	-3.77%	-1.71	-0.66
P04	0.1360	0.0027	-1.52%	-0.69	-0.67
P05					
P06	0.1397	0.0024	1.16%	0.53	0.55
P07	0.1373		-0.58%	-0.26	
P08	0.1387	0.0033	0.41%	0.19	0.16
P09					
P10	0.1409	0.0028	2.03%	0.92	0.86
P11	0.1382	0.0007	0.11%	0.05	0.08
P12	0.0253	0.0021	-81.70%	-37.15	-42.74
P13	0.0281		-79.69%	-36.23	
P14	0.1380	0.0018	-0.07%	-0.03	-0.04
P15	0.1383	0.0041	0.11%	0.05	0.03
P16	0.1298	0.0300	-5.99%	-2.72	-0.28
P17	0.1326	0.0010	-4.00%	-1.82	-2.95
P18	0.1367		-0.98%	-0.44	
P19	0.1382		0.08%	0.04	
P20	0.1320	0.0014	-4.45%	-2.02	-2.92
P21	0.1371		-0.74%	-0.34	
P22					
P23	0.1381	0.0049	-0.02%	-0.01	-0.01
P24	0.1414		2.39%	1.09	
P25	0.1365		-1.16%	-0.53	
P26	0.1451		5.10%	2.32	

Consensus values (raw data)

m	0.1313	
s_r	0.0007	0.52%
s_L	0.0242	18.42%
s_R	0.0242	18.43%
p	22	

Consensus values (corrected)

m	0.1365	
s_r	0.0007	0.51%
s_L	0.0034	2.46%
s_R	0.0034	2.51%
p	20	



Mixture	LNG
Component	n-hexane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.0989	0.0011	%mol/mol	0.0022	%mol/mol

Reported data

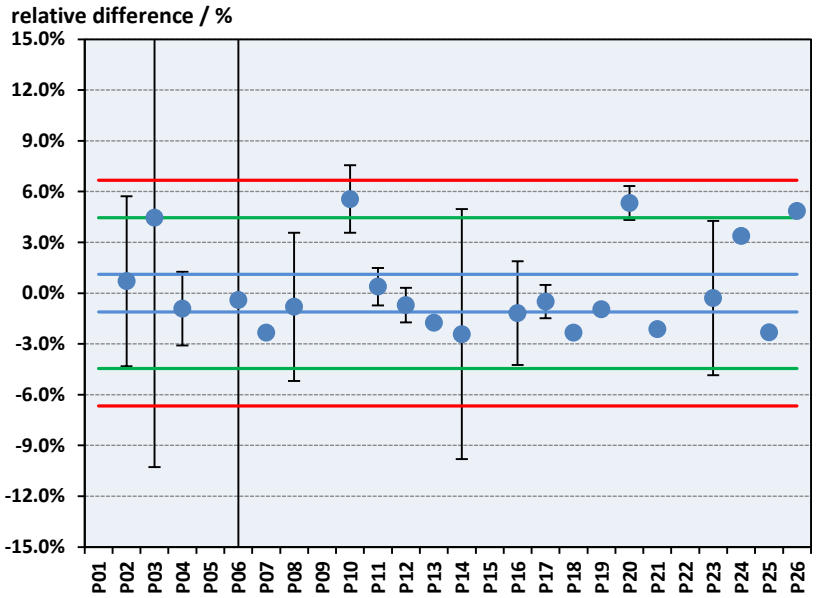
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02	0.0996	0.0050	0.71%	0.32	0.14
P03	0.1033	0.0152	4.45%	2.00	0.29
P04	0.0980	0.0021	-0.91%	-0.41	-0.37
P05					
P06	0.0985	0.0200	-0.40%	-0.18	-0.02
P07	0.0966		-2.33%	-1.05	
P08	0.0981	0.0043	-0.81%	-0.36	-0.18
P09					
P10	0.1044	0.0021	5.56%	2.50	2.33
P11	0.0993	0.0011	0.38%	0.17	0.24
P12	0.0982	0.0010	-0.71%	-0.32	-0.47
P13	0.0972		-1.75%	-0.78	
P14	0.0965	0.0071	-2.43%	-1.09	-0.33
P15					
P16	0.0977	0.0030	-1.18%	-0.53	-0.36
P17	0.0984	0.0010	-0.50%	-0.22	-0.33
P18	0.0966		-2.33%	-1.05	
P19	0.0980		-0.95%	-0.43	
P20	0.1042	0.0010	5.33%	2.40	3.48
P21	0.0968		-2.12%	-0.95	
P22					
P23	0.0986	0.0045	-0.29%	-0.13	-0.06
P24	0.1023		3.39%	1.52	
P25	0.0966		-2.31%	-1.04	
P26	0.1037		4.85%	2.18	

Consensus values (raw data)

m	0.0987	
s_r	0.0010	1.02%
s_L	0.0023	2.36%
s_R	0.0025	2.57%
p	21	

Consensus values (corrected)

m	0.0982	
s_r	0.0010	1.07%
s_L	0.0015	1.55%
s_R	0.0018	1.88%
p	19	

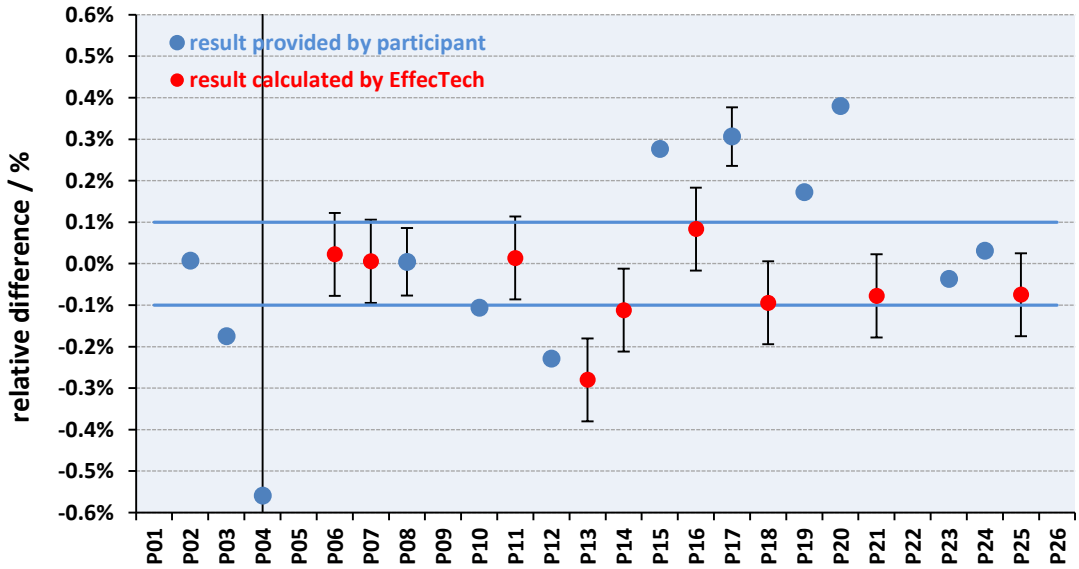


Natural gas composition (physical properties)

Mixture	LNG
Property	superior calorific value

Reference and reported data

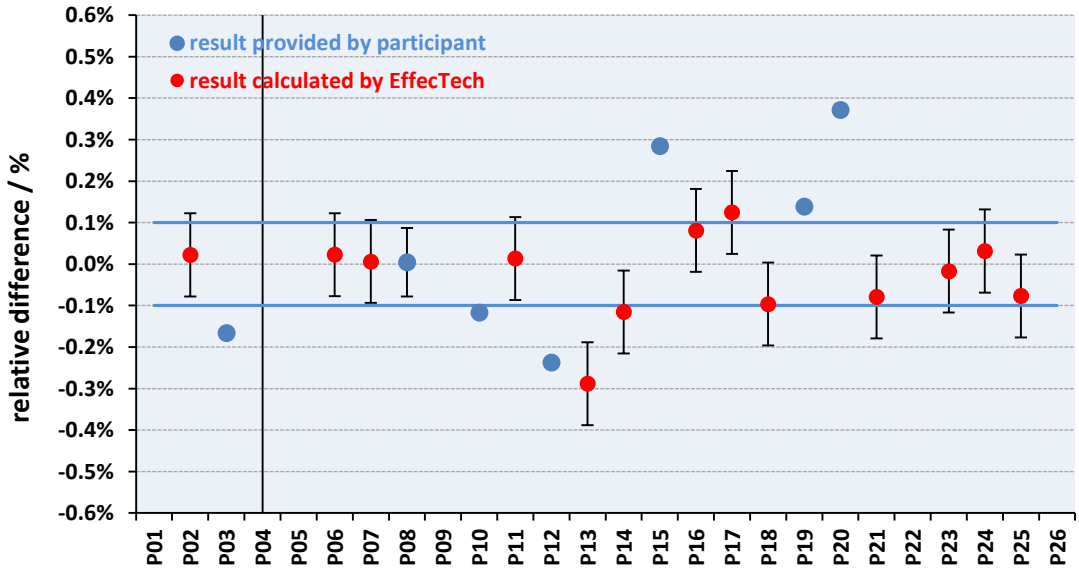
participant id	calculated reference value	assigned uncertainty	participant reported / calculated	reported / calculated uncertainty	relative difference
P01					
P02	40.64	0.04	40.64		0.01%
P03	40.64	0.04	40.57		-0.17%
P04	39.92	0.04	39.69	0.79	-0.56%
P05					
P06	40.64	0.04	40.65	0.04	0.02%
P07	40.64	0.04	40.64	0.04	0.01%
P08	42.96	0.04	42.96	0.04	0.00%
P09					
P10	48.45	0.05	48.40		-0.11%
P11	40.64	0.04	40.64	0.04	0.01%
P12	40.64	0.04	40.54		-0.23%
P13	40.64	0.04	40.52	0.04	-0.28%
P14	40.64	0.04	40.59	0.04	-0.11%
P15	958.14	0.96	960.80		0.28%
P16	40.64	0.04	40.67	0.04	0.08%
P17	48.45	0.05	48.59	0.03	0.31%
P18	40.64	0.04	40.60	0.04	-0.09%
P19	1085.43	1.09	1087.30		0.17%
P20	1085.43	1.09	1089.55	0.14	0.38%
P21	40.64	0.04	40.60	0.04	-0.08%
P22					
P23	48.45	0.05	48.43		-0.04%
P24	42.85	0.04	42.86		0.03%
P25	40.64	0.04	40.61	0.04	-0.07%
P26	40.63	0.04	40.99	0.04	0.90%



Mixture	LNG
Property	inferior calorific value

Reference and reported data

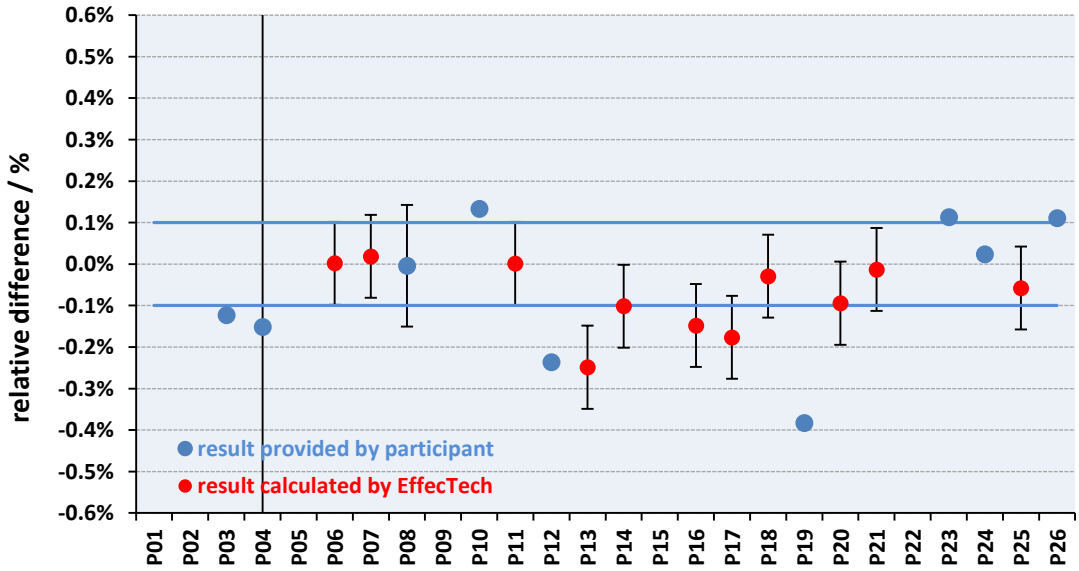
participant id	calculated reference value	assigned uncertainty	participant reported / calculated	reported / calculated uncertainty	relative difference
P01					
P02	36.76	0.04	36.76	0.04	0.02%
P03	36.76	0.04	36.70		-0.17%
P04	36.12	0.04	35.89	0.72	-0.63%
P05					
P06	36.76	0.04	36.76	0.04	0.02%
P07	36.76	0.04	36.76	0.04	0.01%
P08	38.80	0.04	38.80	0.03	0.00%
P09					
P10	43.82	0.04	43.77		-0.12%
P11	36.76	0.04	36.76	0.04	0.01%
P12	36.76	0.04	36.67		-0.24%
P13	36.76	0.04	36.65	0.04	-0.29%
P14	36.76	0.04	36.71	0.04	-0.12%
P15	866.66	0.87	869.13		0.28%
P16	36.76	0.04	36.79	0.04	0.08%
P17	36.76	0.04	36.80	0.04	0.12%
P18	36.76	0.04	36.72	0.04	-0.10%
P19	981.85	0.98	983.21		0.14%
P20	981.85	0.98	985.50	0.13	0.37%
P21	36.76	0.04	36.73	0.04	-0.08%
P22					
P23	36.72	0.04	36.72	0.04	-0.02%
P24	38.79	0.04	38.80	0.04	0.03%
P25	36.76	0.04	36.73	0.04	-0.08%
P26	36.75	0.04	37.09		0.93%



Mixture	LNG
Property	density

Reference and reported data

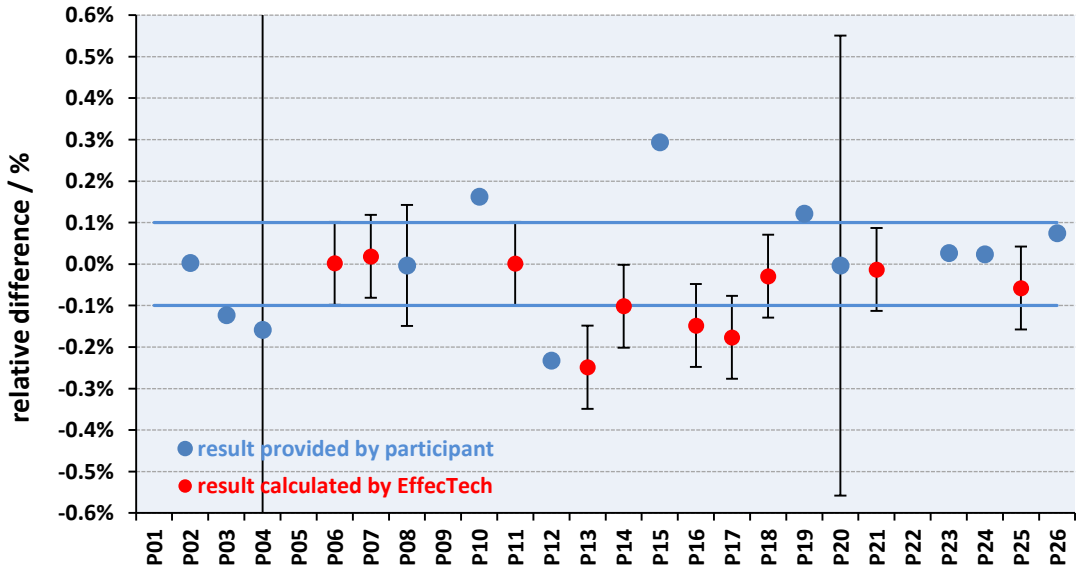
participant id	calculated reference value	assigned uncertainty	participant reported / calculated	reported / calculated uncertainty	relative difference
P01					
P02	0.8388	0.0008	0.8629		2.87%
P03	0.8388	0.0008	0.8378		-0.12%
P04	0.8243	0.0008	0.8231	0.0165	-0.15%
P05					
P06	0.8388	0.0008	0.8388	0.0008	0.00%
P07	0.8388	0.0008	0.8389	0.0008	0.02%
P08	0.8853	0.0009	0.8853	0.0013	0.00%
P09					
P10	0.8388	0.0008	0.8399		0.13%
P11	0.8388	0.0008	0.8388	0.0008	0.00%
P12	0.8388	0.0008	0.8368		-0.24%
P13	0.8388	0.0008	0.8367	0.0008	-0.25%
P14	0.8388	0.0008	0.8379	0.0008	-0.10%
P15	0.8388	0.0008			
P16	0.8388	0.0008	0.8375	0.0008	-0.15%
P17	0.8388	0.0008	0.8373	0.0008	-0.18%
P18	0.8388	0.0008	0.8385	0.0008	-0.03%
P19	0.8388	0.0008	0.8356		-0.38%
P20	0.8388	0.0008	0.8380	0.0008	-0.09%
P21	0.8388	0.0008	0.8387	0.0008	-0.01%
P22					
P23	0.8380	0.0008	0.8390		0.11%
P24	0.8853	0.0009	0.8856		0.02%
P25	0.8388	0.0008	0.8383	0.0008	-0.06%
P26	0.8386	0.0008	0.8395		0.11%



Mixture	LNG
Property	relative density

Reference and reported data

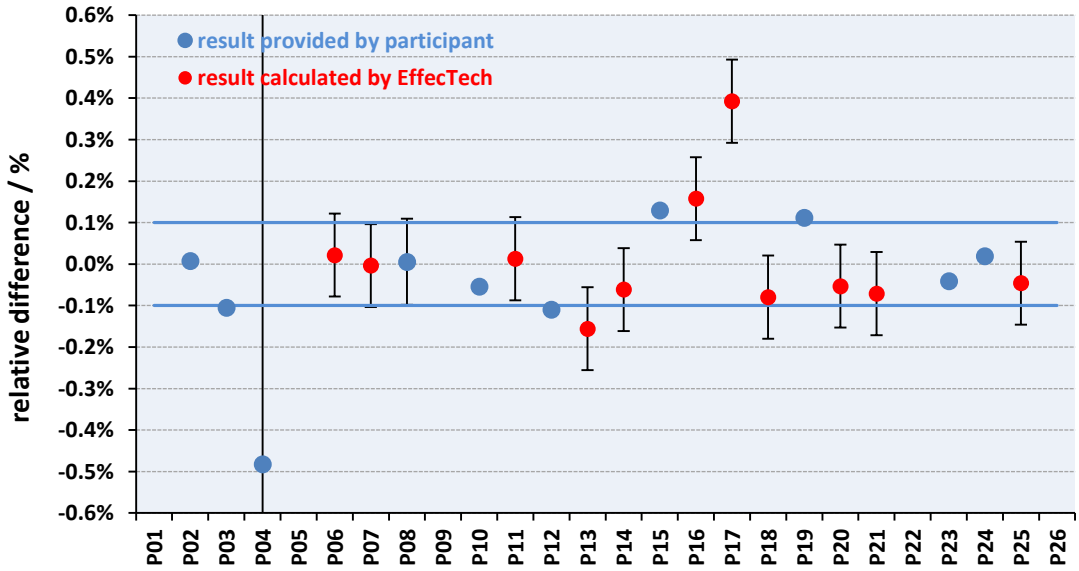
participant id	calculated reference value	assigned uncertainty	participant reported / calculated	reported / calculated uncertainty	relative difference
P01					
P02	0.6845	0.0007	0.6845		0.00%
P03	0.6845	0.0007	0.6837		-0.12%
P04	0.6844	0.0007	0.6833	0.0137	-0.16%
P05					
P06	0.6845	0.0007	0.6845	0.0007	0.00%
P07	0.6845	0.0007	0.6846	0.0007	0.02%
P08	0.6848	0.0007	0.6847	0.0010	0.00%
P09					
P10	0.6845	0.0007	0.6856		0.16%
P11	0.6845	0.0007	0.6845	0.0007	0.00%
P12	0.6845	0.0007	0.6829		-0.23%
P13	0.6845	0.0007	0.6828	0.0007	-0.25%
P14	0.6845	0.0007	0.6838	0.0007	-0.10%
P15	0.6845	0.0007	0.6865		0.29%
P16	0.6845	0.0007	0.6835	0.0007	-0.15%
P17	0.6845	0.0007	0.6833	0.0007	-0.18%
P18	0.6845	0.0007	0.6843	0.0007	-0.03%
P19	0.6828	0.0007	0.6837		0.12%
P20	0.6828	0.0007	0.6828	0.0038	0.00%
P21	0.6845	0.0007	0.6844	0.0007	-0.01%
P22					
P23	0.6845	0.0007	0.6847		0.03%
P24	0.6848	0.0007	0.6849		0.02%
P25	0.6845	0.0007	0.6841	0.0007	-0.06%
P26	0.6845	0.0007	0.6850		0.07%



Mixture	LNG
Property	Wobbe index

Reference and reported data

participant id	calculated reference value	assigned uncertainty	participant reported / calculated	reported / calculated uncertainty	relative difference
P01					
P02	49.12	0.05	49.12		0.01%
P03	49.12	0.05	49.07		-0.10%
P04	48.25	0.05	48.02	0.96	-0.48%
P05					
P06	49.12	0.05	49.13	0.05	0.02%
P07	49.12	0.05	49.11	0.05	0.00%
P08	51.91	0.05	51.91	0.05	0.01%
P09					
P10	49.12	0.05	49.09		-0.05%
P11	49.12	0.05	49.12	0.05	0.01%
P12	49.12	0.05	49.06		-0.11%
P13	49.12	0.05	49.04	0.05	-0.16%
P14	49.12	0.05	49.09	0.05	-0.06%
P15	49.12	0.05	49.18		0.13%
P16	49.12	0.05	49.19	0.05	0.16%
P17	58.56	0.06	58.79	0.06	0.39%
P18	49.12	0.05	49.08	0.05	-0.08%
P19	1313.54	1.31	1315.00		0.11%
P20	49.12	0.05	49.09	0.05	-0.05%
P21	49.12	0.05	49.08	0.05	-0.07%
P22					
P23	49.12	0.05	49.10		-0.04%
P24	51.78	0.05	51.79		0.02%
P25	49.12	0.05	49.09	0.05	-0.05%
P26	49.10	0.05	49.54		0.89%



Propane composition

Mixture	propane
Component	nitrogen

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	1.851	0.011	%mol/mol	0.056	%mol/mol

Reported data

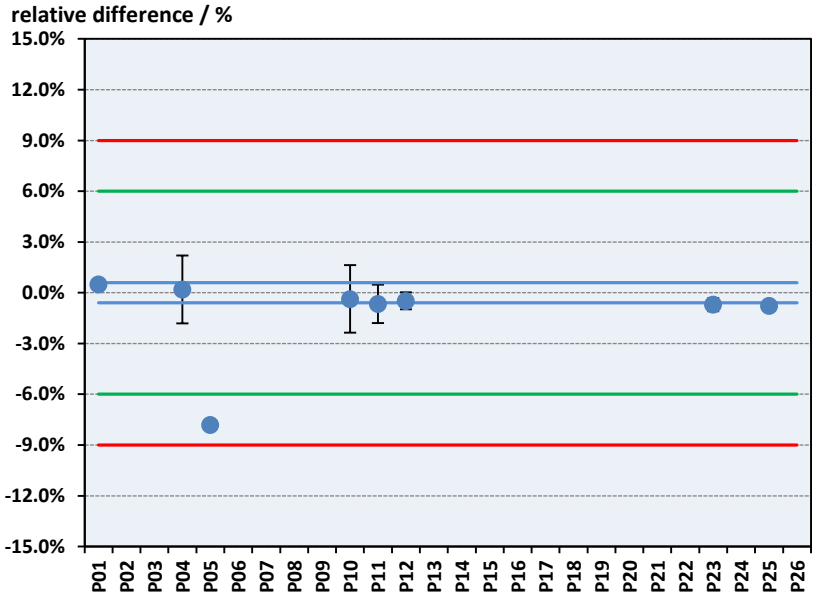
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	1.860		0.50%	0.17	
P02					
P03					
P04	1.855	0.037	0.20%	0.07	0.09
P05	1.706		-7.81%	-2.60	
P06					
P07					
P08					
P09					
P10	1.844	0.037	-0.37%	-0.12	-0.18
P11	1.839	0.021	-0.65%	-0.22	-0.51
P12	1.842	0.009	-0.48%	-0.16	-0.63
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	1.838	0.007	-0.70%	-0.23	-0.99
P24					
P25	1.837		-0.78%	-0.26	
P26					

Consensus values (raw data)

m	1.813	
s_r	0.019	1.02%
s_L	0.060	3.31%
s_R	0.063	3.46%
p	8	

Consensus values (corrected)

m	1.842	
s_r	0.018	0.98%
s_L	0.001	0.07%
s_R	0.018	0.98%
p	7	



Mixture	propane
Component	ethane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.818	0.004	%mol/mol	0.016	%mol/mol

Reported data

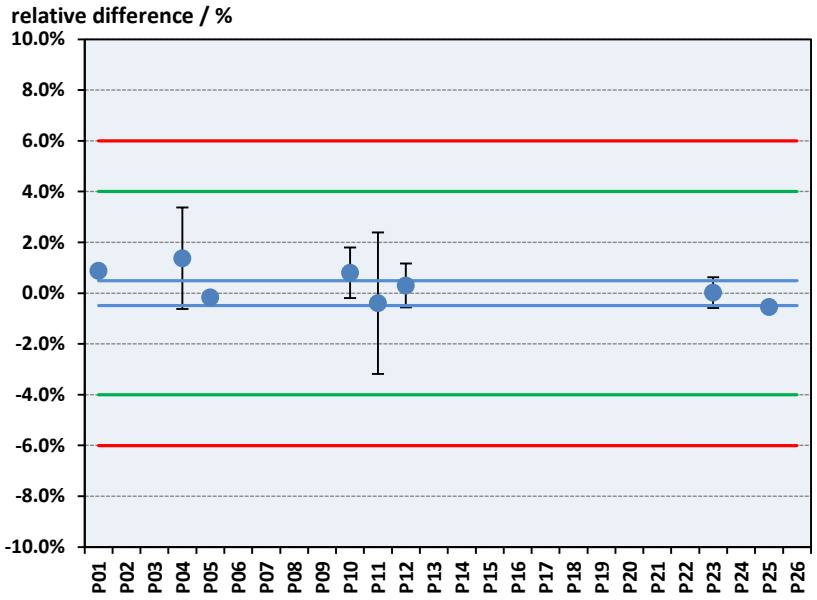
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.825		0.88%	0.44	
P02					
P03					
P04	0.829	0.017	1.38%	0.69	0.66
P05	0.817		-0.17%	-0.09	
P06					
P07					
P08					
P09					
P10	0.825	0.008	0.80%	0.40	0.71
P11	0.815	0.023	-0.40%	-0.20	-0.14
P12	0.820	0.007	0.30%	0.15	0.30
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	0.818	0.005	0.02%	0.01	0.02
P24					
P25	0.814		-0.55%	-0.27	
P26					

Consensus values (raw data)

m	0.818	
s_r	0.003	0.36%
s_L	0.005	0.58%
s_R	0.006	0.68%
p	8	

Consensus values (corrected)

m	0.817	
s_r	0.002	0.29%
s_L	0.004	0.45%
s_R	0.004	0.53%
p	7	



Mixture	propane
Component	propane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	96.534	0.013	%mol/mol	0.097	%mol/mol

Reported data

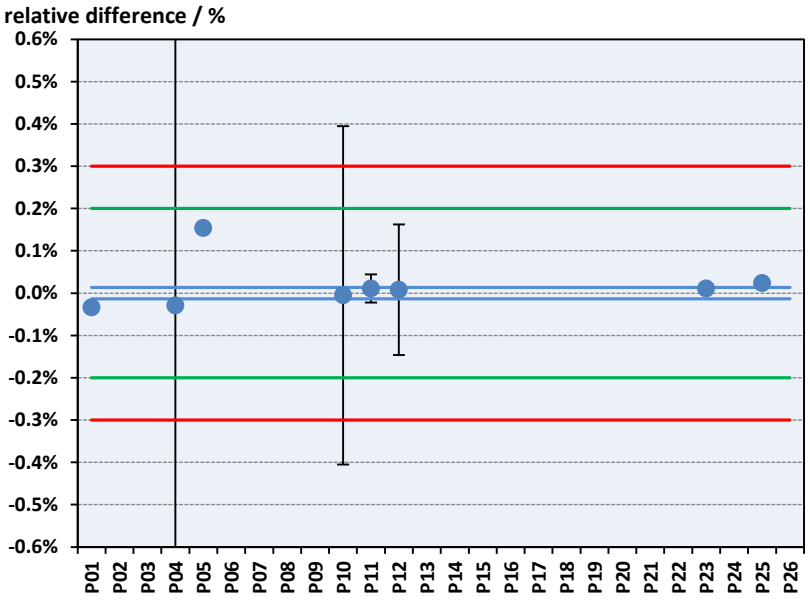
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	96.502		-0.03%	**-0.34**	
P02					
P03					
P04	96.506	1.930	-0.03%	**-0.29**	**-0.01**
P05	96.683		0.15%	**1.54**	
P06					
P07					
P08					
P09					
P10	96.529	0.386	-0.01%	**-0.05**	**-0.01**
P11	96.545	0.032	0.01%	**0.11**	**0.31**
P12	96.542	0.149	0.01%	**0.08**	**0.05**
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	96.545	0.008	0.01%	**0.11**	**0.72**
P24					
P25	96.557		0.02%	**0.24**	
P26					

Consensus values (raw data)

m	96.570	
s_r	0.020	0.02%
s_L	0.065	0.07%
s_R	0.068	0.07%
p	8	

Consensus values (corrected)

m	96.570	
s_r	0.020	0.02%
s_L	0.065	0.07%
s_R	0.068	0.07%
p	8	



Mixture	propane
Component	iso-butane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.3693	0.0022	%mol/mol	0.0092	%mol/mol

Reported data

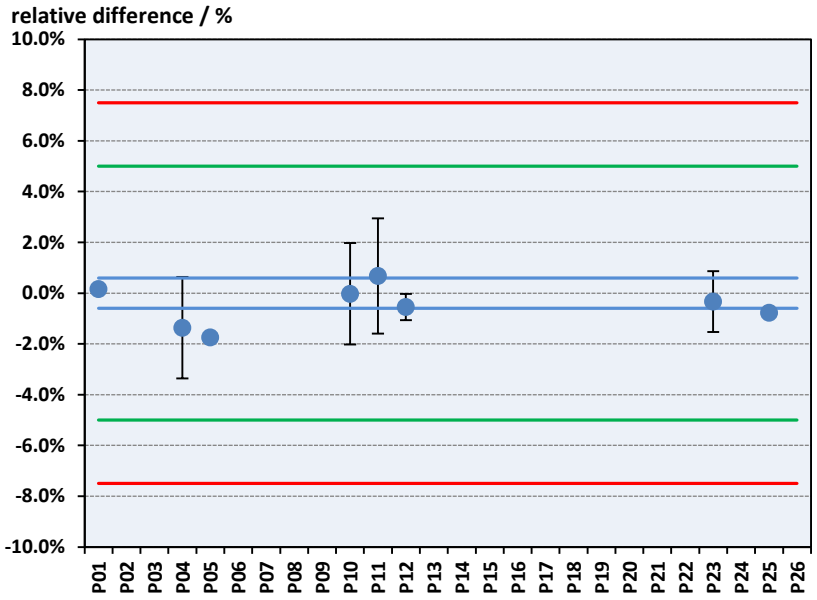
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.3699		0.16%	**0.06**	
P02					
P03					
P04	0.3643	0.0073	-1.37%	**-0.55**	**-0.66**
P05	0.3629		-1.74%	**-0.70**	
P06					
P07					
P08					
P09					
P10	0.3692	0.0074	-0.03%	**-0.01**	**-0.01**
P11	0.3718	0.0084	0.68%	**0.27**	**0.29**
P12	0.3673	0.0019	-0.54%	**-0.22**	**-0.69**
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	0.3681	0.0044	-0.34%	**-0.13**	**-0.25**
P24					
P25	0.3665		-0.77%	**-0.31**	
P26					

Consensus values (raw data)

m	0.3673	
s_r	0.0012	0.32%
s_L	0.0034	0.92%
s_R	0.0036	0.97%
p	8	

Consensus values (corrected)

m	0.3673	
s_r	0.0012	0.32%
s_L	0.0034	0.92%
s_R	0.0036	0.97%
p	8	



Mixture	propane
Component	n-butane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.3161	0.0016	%mol/mol	0.0079	%mol/mol

Reported data

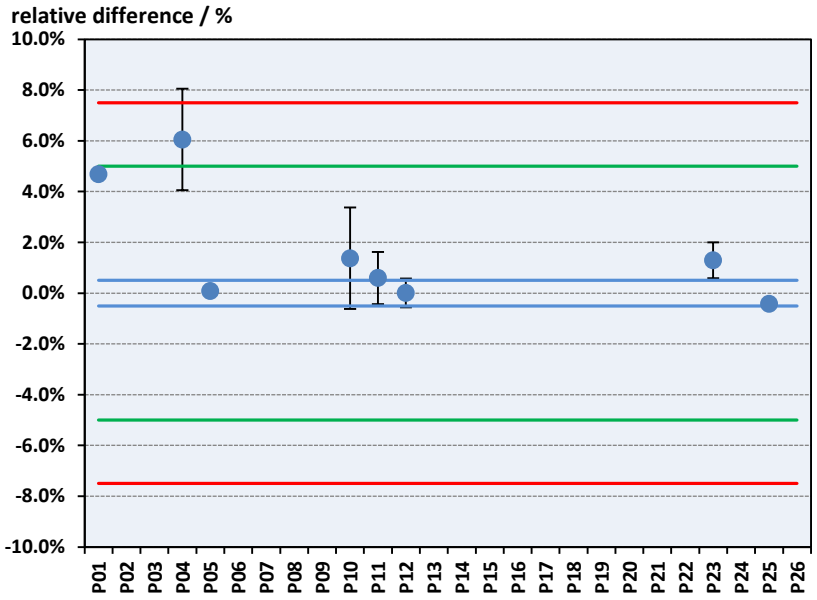
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.3309		4.69%	1.88	
P02					
P03					
P04	0.3352	0.0067	6.05%	2.42	2.78
P05	0.3164		0.08%	0.03	
P06					
P07					
P08					
P09					
P10	0.3205	0.0064	1.38%	0.55	0.66
P11	0.3180	0.0033	0.60%	0.24	0.52
P12	0.3161	0.0018	0.01%	0.00	0.01
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	0.3202	0.0023	1.30%	0.52	1.48
P24					
P25	0.3148		-0.42%	-0.17	
P26					

Consensus values (raw data)

m	0.3192	
s_r	0.0012	0.37%
s_L	0.0061	1.92%
s_R	0.0062	1.95%
p	8	

Consensus values (corrected)

m	0.3181	
s_r	0.0012	0.37%
s_L	0.0043	1.35%
s_R	0.0045	1.40%
p	7	



Mixture	propane
Component	iso-pentane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.0619	0.0008	%mol/mol	0.0019	%mol/mol

Reported data

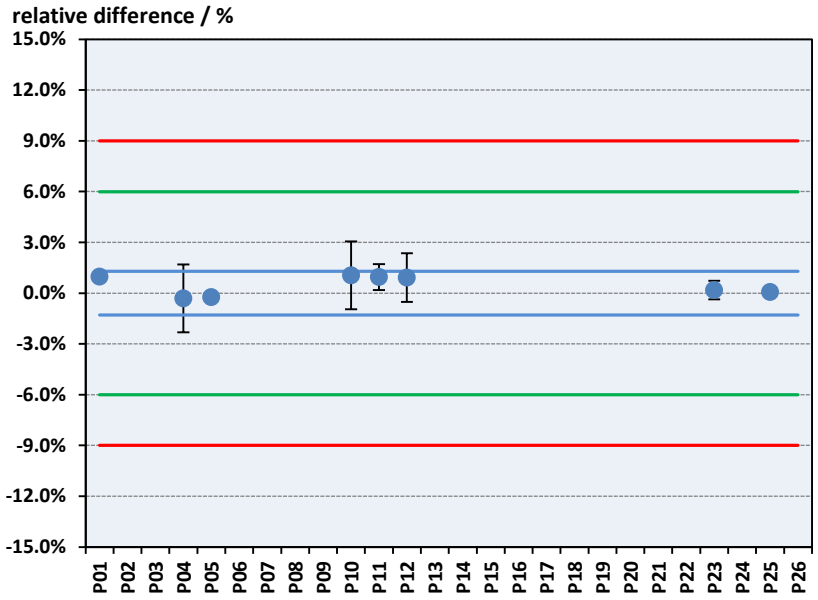
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.0625		0.97%	**0.32**	
P02					
P03					
P04	0.0617	0.0012	-0.31%	**-0.10**	**-0.13**
P05	0.0618		-0.24%	**-0.08**	
P06					
P07					
P08					
P09					
P10	0.0626	0.0013	1.05%	**0.35**	**0.44**
P11	0.0625	0.0005	0.95%	**0.32**	**0.63**
P12	0.0625	0.0009	0.92%	**0.31**	**0.47**
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	0.0620	0.0003	0.18%	**0.06**	**0.13**
P24					
P25	0.0619		0.08%	**0.03**	
P26					

Consensus values (raw data)

m	0.0621	
s_r	0.0006	0.90%
s_L	0.0003	0.41%
s_R	0.0006	0.99%
p	8	

Consensus values (corrected)

m	0.0621	
s_r	0.0006	0.90%
s_L	0.0003	0.41%
s_R	0.0006	0.99%
p	8	



Mixture	propane
Component	n-pentane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.0492	0.0007	%mol/mol	0.0015	%mol/mol

Reported data

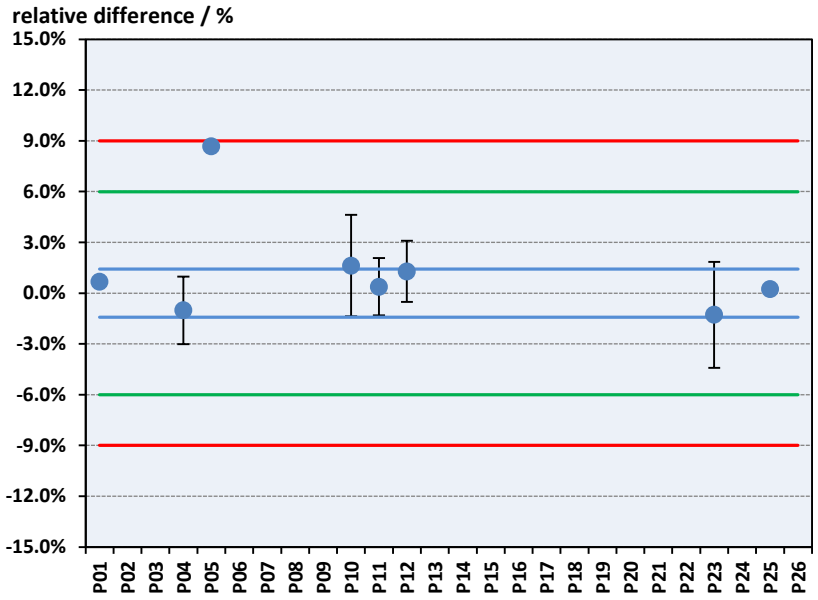
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.0495		0.68%	**0.23**	
P02					
P03					
P04	0.0487	0.0010	-1.02%	**-0.34**	**-0.42**
P05	0.0535		8.68%	**2.90**	
P06					
P07					
P08					
P09					
P10	0.0500	0.0015	1.63%	**0.54**	**0.48**
P11	0.0494	0.0008	0.38%	**0.13**	**0.17**
P12	0.0498	0.0009	1.29%	**0.43**	**0.56**
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	0.0486	0.0015	-1.28%	**-0.43**	**-0.38**
P24					
P25	0.0493		0.23%	**0.08**	
P26					

Consensus values (raw data)

m	0.0501	
s_r	0.0008	1.64%
s_L	0.0019	3.78%
s_R	0.0021	4.12%
p	8	

Consensus values (corrected)

m	0.0492	
s_r	0.0004	0.82%
s_L	0.0004	0.88%
s_R	0.0006	1.20%
p	7	



Mixed refrigerant (MR)

Mixture	MR
Component	nitrogen

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	15.434	0.047	%mol/mol	0.232	%mol/mol

Reported data

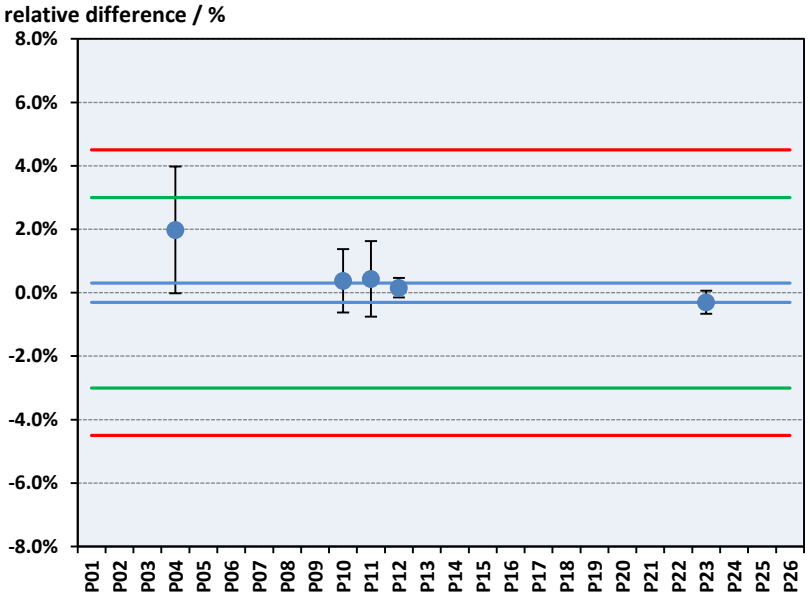
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02					
P03					
P04	15.739	0.315	1.98%	**1.32**	**0.96**
P05					
P06					
P07					
P08					
P09					
P10	15.491	0.155	0.37%	**0.25**	**0.35**
P11	15.501	0.184	0.44%	**0.29**	**0.35**
P12	15.458	0.048	0.16%	**0.11**	**0.36**
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	15.387	0.055	-0.30%	**-0.20**	**-0.64**
P24					
P25					
P26					

Consensus values (raw data)

m	15.492	
s_r	0.015	0.10%
s_L	0.120	0.78%
s_R	0.121	0.78%
p	5	

Consensus values (corrected)

m	15.492	
s_r	0.015	0.10%
s_L	0.120	0.78%
s_R	0.121	0.78%
p	5	



Mixture	MR
Component	methane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	37.547	0.072	%mol/mol	0.375	%mol/mol

Reported data

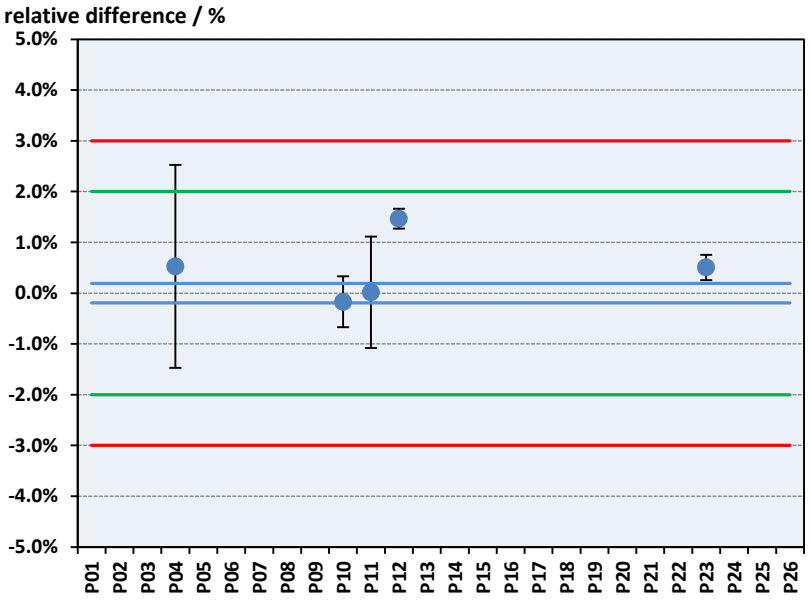
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02					
P03					
P04	37.745	0.755	0.53%	**0.53**	**0.26**
P05					
P06					
P07					
P08					
P09					
P10	37.483	0.187	-0.17%	**-0.17**	**-0.32**
P11	37.553	0.412	0.02%	**0.02**	**0.01**
P12	38.098	0.075	1.47%	**1.47**	**5.30**
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	37.737	0.094	0.51%	**0.51**	**1.61**
P24					
P25					
P26					

Consensus values (raw data)

m	37.687	
s_r	0.019	0.05%
s_L	0.209	0.56%
s_R	0.210	0.56%
p	5	

Consensus values (corrected)

m	37.687	
s_r	0.019	0.05%
s_L	0.209	0.56%
s_R	0.210	0.56%
p	5	



Mixture	MR
Component	ethane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	32.847	0.082	%mol/mol	0.328	%mol/mol

Reported data

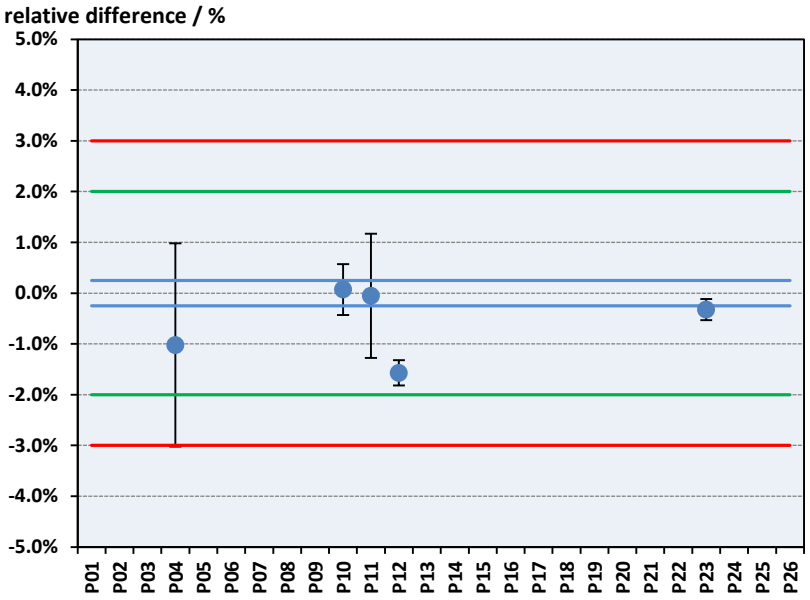
id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02					
P03					
P04	32.512	0.650	-1.02%	-1.02	-0.51
P05					
P06					
P07					
P08					
P09					
P10	32.870	0.164	0.07%	0.07	0.13
P11	32.830	0.402	-0.05%	-0.05	-0.04
P12	32.331	0.081	-1.57%	-1.57	-4.49
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	32.741	0.068	-0.32%	-0.32	-1.00
P24					
P25					
P26					

Consensus values (raw data)

m	32.710	
s_r	0.013	0.04%
s_L	0.203	0.62%
s_R	0.204	0.62%
p	5	

Consensus values (corrected)

m	32.710	
s_r	0.013	0.04%
s_L	0.203	0.62%
s_R	0.204	0.62%
p	5	



Mixture	MR
Component	propane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	14.172	0.046	%mol/mol	0.213	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01					
P02					
P03					
P04	14.005	0.280	-1.18%	-0.79	-0.59
P05					
P06					
P07					
P08					
P09					
P10	14.155	0.071	-0.12%	-0.08	-0.20
P11	14.117	0.162	-0.39%	-0.26	-0.33
P12	14.113	0.047	-0.41%	-0.28	-0.89
P13					
P14					
P15					
P16					
P17					
P18					
P19					
P20					
P21					
P22					
P23	14.134	0.081	-0.26%	-0.18	-0.40
P24					
P25					
P26					

Consensus values (raw data)

m	14.111	
s_r	0.015	0.11%
s_L	0.048	0.34%
s_R	0.050	0.35%
p	5	

Consensus values (corrected)

m	14.111	
s_r	0.015	0.11%
s_L	0.048	0.34%
s_R	0.050	0.35%
p	5