EffecTech
Global Leaders in Gas Measurement

UKAS PROFICIENCY TESTING
4719

Global Gas and LNG
Proficiency Testing (PT) Scheme

Presentation of Results

Round 21Q2

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

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Table of Contents

Revisions History

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1	18.08.2021	Dr Gavin Squire	***Final report (for comment)***

Statement of Confidentiality

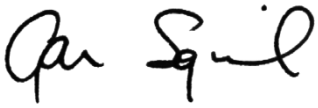
EffecTech keeps all data regarding the performance of individual participants strictly confidential. Results and performance data are protected, stored and backed up on storage network disks and folders to which access is restricted to the scheme coordinator and the technical authority only.

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 21Q2 (April-June 2021).

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 two (2) different mixture types, a typical LNG composition and a sulphur component 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 1
methane	balance

Table 1.2: Composition range - sulphur component mixture

component	range (µmol/mol)
hydrogen sulphide	0.2 to 10
carbonyl sulphide	0.2 to 10
ethyl mercaptan	0.2 to 10
methyl mercaptan	0.2 to 10
dimethyl sulphide	0.2 to 10
methane, ethane & propane	balance

Note: The matrix of the sulphur component mixture is made up of methane, ethane and propane in amount fractions that represent a typical natural gas or LNG matrix. In this way the matrix more accurately represents samples which are measured routinely by your laboratory. Participants are asked to measure and report the sulphur containing components only and are NOT required to report the matrix hydrocarbons in this mixture.

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 thirty-three (33) laboratories signed up to participate in this round. Thirty (30) participants, to whom items were distributed, submitted results for one or more of the mixture types in the scheme.

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 TM002). 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 both 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 fraction in units of %mol/mol (10^{-2} mol/mol) **except** for the sulphur component mixture which is given in µmol/mol (ppm mol/mol).

Table 2.1: Reference values - LNG/natural gas composition

component	x_{ref}	$U(x_{ref})$	u_c / %	u_{char} / %	u_{bb} / %
nitrogen	0.1640	0.0010	0.29	0.26	0.12
carbon dioxide					
methane	95.246	0.015	0.005	0.005	0.001
ethane	2.4029	0.0060	0.12	0.12	0.020
propane	1.9588	0.0060	0.15	0.15	0.013
iso-butane	0.07830	0.00059	0.38	0.22	0.31
n-butane	0.06988	0.00056	0.40	0.25	0.31
iso-pentane	0.03179	0.00029	0.46	0.32	0.33
n-pentane	0.02849	0.00025	0.45	0.30	0.33
n-hexane	0.01983	0.00030	0.53	0.39	0.36

Table 2.2: Reference values - sulphur component mixture

component	x_{ref}	$U(x_{ref})$	u_c / %	u_{char} / %	u_{bb} / %
hydrogen sulphide	2.786	*0.087*	1.6	1.4	0.66
carbonyl sulphide	1.872	*0.067*	1.7	1.7	0.25
methyl mercaptan	2.685	*0.085*	1.6	1.6	0.21
ethyl mercaptan	1.695	*0.068*	2.0	2.0	0.32
dimethyl sulphide	1.651	*0.063*	1.8	1.8	0.19
total sulphur	10.69	0.33			

Note: Following examination of the assigned reference values, it was noted that in some cases the assigned uncertainties were not insignificant compared to the expectation of the participants in terms of the standard deviation for performance assessment (SDPA). These are shown in *italics* in the tables above. In these cases, the reference value uncertainties were considered in the calculation of an adjusted z'-score (see section 3.2 below.)

3. Results

3.1 Reported results

There were thirty (30) laboratories who submitted results in this round of the GGLNG PT scheme. Consignments containing one or both mixture types were shipped to the participating laboratories. The table below shows participation and whether results were submitted.

Table 3.1: Participant laboratories and reported results

participant id	LNG mixture		sulphur component mix	
	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	✓	✓		
P27	✓	✓		
P28	✓	✓		
P29	✓	✓	✓	✓
P30	✓	✓	✓	✓
P31	✓	✓		
P32	✓	✓	✓	×
P33	✓	✓	✓	✓

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. Eighteen (18) sets of results were submitted with estimates of measurement uncertainty. Twelve (12) sets of results were submitted without uncertainty estimates. For those participants who did not submit any uncertainty estimates 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 the LNG mixture except laboratories **P03, P15, P19, P25** and **P32**. Some laboratories reported normalised results which did not sum to exactly 100% mol/mol due to rounding errors from truncation of their results. All sets of results were normalised (or re-normalised) before comparison with reference values were made.

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

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

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

If there is concern that the estimation of the **z**-score may be biased due to the magnitude of the uncertainty of the assigned reference value in the case when $u_{ref} > 0.3\sigma$ then the use of a modified **z'**-score shall be used to evaluation performance for those component failing this condition.

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

$$\boldsymbol{z'} = \frac{x_{meas} - x_{ref}}{\sqrt{\sigma^2 + u_{ref}^2}} \quad (2)$$

For the natural gas mixture, the absolute standard deviation used for performance assessment for *non-methane* components is taken as the reproducibility standard deviation, s_R, defined in ISO 6974-3 [A] - Equation (2) where

$$\ln(s_R) = -4.28 + 0.715.\ln(x_{ref}) \quad (3)$$

This gives

$$\sigma = s_R = e^{-4.28 + 0.715.\ln(x_{ref})} \quad (4)$$

For the *methane* component, the reproducibility standard deviation used for performance assessment is 0.09 % relative also specified in ISO 6974 - Part 3 such that

$$\sigma = s_R = \frac{0.09}{100}.x_{ref} \quad (5)$$

These performance measures defined in this international standard are those based on a statistical evaluation of historical data from this PT scheme and so should represent a reasonable expectation of the proven performance capabilities that should be demonstrated by each laboratory in the measurement of the natural gas mixture.

[A] Natural gas - Determination of composition and associated uncertainty by gas chromatography - Part 3: Precision and bias (ISO 6974-3:2018)

By using equations (4) and (5) and the reference values in table 2.1 we obtain the following

Table 3.2: Standard deviation for performance assessment (LNG mixture)

component	σ (%mol/mol)
nitrogen	0.0038
methane	0.0857
ethane	0.0259
propane	0.0224
iso-butane	0.00224
n-butane	0.00207
iso-pentane	0.00118
n-pentane	0.00109
n-hexane	0.00084

For the sulphur component mixture the absolute standard deviation used for performance assessment, σ, is calculated from the relative standard deviation for performance assessment, S_{PT}, by

$$\sigma = \frac{S_{PT}}{100} . x_{ref} \qquad (6)$$

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

Table 3.3: Standard deviation for performance assessment (sulphur component mixture)

component	S_{PT} (% relative)
hydrogen sulphide	5.0 %
carbonyl sulphide	4.0 %
ethyl mercaptan	4.0 %
methyl mercaptan	4.0 %
dimethyl sulphide	4.0 %
total sulphur	5.0 %

The qualification of the **z**-scores is given in table 3.4 below

Table 3.4: 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

$$E_n = \frac{x_{meas} - x_{ref}}{\sqrt{U_{meas}^2 + U_{ref}^2}} \quad (7)$$

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 3.5 below

Table 3.5: Relationship between E_n-number and quality of result

z-score	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 3.6 below

Table 3.6: Relationship between z-score and quality of result

z-score	score per component
$\|z\| \leq 2$	**1 point**
$2 < \|z\| \leq 2.5$	**0.5 point**
$2.5 < \|z\| \leq 3$	**0.25 point**
$\|z\| > 3$	**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

LNG composition (content)

As per the instructions and published protocols, the LNG mixture **did not** contained carbon dioxide in this round to represent a typical vapourised LNG sample. The summary of z-scores is given below.

Table 3.7 - Summary of *z*-scores

participant id	nitrogen	carbon dioxide	methane	ethane	propane	iso-butane	n-butane	iso-pentane	n-pentane	n-hexane
P01	1.25		-1.42	2.15	2.51	0.91	0.64	0.49	0.71	0.14
P02	2.55		-0.29	0.64	-0.08	0.13	0.55	-0.31	0.01	-0.63
P03	0.94		-0.01	-0.21	0.11	-0.29	-0.14	-0.18	-0.17	1.81
P04										
P05	0.79		-0.25	0.53	0.49	-1.12	-0.81	-0.84	-0.73	-0.51
P06	-0.15		-0.30	-0.09	1.08	0.86	0.91	0.20	0.21	0.43
P07	0.45		-0.32	0.98	-0.05	0.27	0.16	0.16	0.28	0.15
P08	4.97		-0.30	0.58	-0.38	0.43	0.18	-0.58	-0.36	0.28
P09	0.63		-0.07	0.00	0.19	0.00	-0.28	0.01	-0.17	0.08
P10										
P11	-0.39		0.25	-0.51	-0.15	-0.47	-0.57	-0.57	-0.38	-0.45
P12	1.03		0.19	-0.52	-0.14	-0.50	-0.78	-0.40	-0.61	-0.15
P13	11.47		-0.50	0.12	0.23	-1.45	-1.47	-0.58	-1.62	-0.19
P14	0.26		0.47	0.12	-1.60	-1.47	-2.12	-0.25	-0.45	0.20
P15	1.13		0.34	-1.44	0.24	0.14	0.02	-0.64	-0.82	-0.69
P16										
P17										
P18	3.03		-0.25	0.19	0.20	-0.03	0.13	0.01	0.09	0.06
P19	-2.48		0.11	0.14	-0.03	-0.22	0.18	-1.65	-0.62	0.06
P20	0.22		0.13	-0.26	-0.14	-0.04	-0.18	-0.25	-0.50	-0.63
P21										
P22	0.49		-0.40	0.77	0.49	0.51	0.37	0.06	-0.02	-0.25
P23										
P24	0.79		-0.05	-0.09	0.10	-0.09	0.83	-0.54	0.06	0.83
P25	-0.42		-0.28	0.49	0.49	0.40	0.35	0.01	0.19	0.20
P26	4.41		-0.61	0.72	1.19	-1.51	-2.06	-0.15	-0.39	-2.11
P27	-5.32		0.06	0.56	0.20	-0.77	-0.40	-0.65	-0.34	-0.17
P28	1.68		-0.81	2.18	0.38	0.04	0.06	-0.67	-0.82	-0.87
P29	1.32		-0.37	0.97	0.21	-0.58	-0.47	-0.25	-0.45	0.20
P30	1.32		0.10	-0.11	-0.39	-0.58	-0.43	0.18	-0.45	0.20
P31	-0.20		-0.45	0.89	0.60	0.56	0.47	0.11	0.24	0.00
P32	-0.68		-0.15	0.28	0.31	0.22	0.20	0.09	0.01	0.08
P33	4.95		-0.14	-0.22	0.06	-0.46	-0.31	-0.40	-0.36	0.25

Results for the LNG mixture in this round were excellent with sixteen (16) out of twenty-seven (27) reporting participants achieving a perfect score of 100%. The average score was **95.7%**.

Of those not reporting a perfect score, the measurement of nitrogen produced 6 un-satisfactory results. This is once again due to the low amount fraction of nitrogen (0.16 % mol/mol) in the LNG gas mixture this round. There were no other un-satisfactory results in this round.

Table 3.8 - Summary of E_n-numbers

participant id	nitrogen	carbon dioxide	methane	ethane	propane	iso-butane	n-butane	iso-pentane	n-pentane	n-hexane
P01	0.46		-0.27	0.97	0.82	1.21	0.51	0.47	0.64	0.16
P02										
P03										
P04										
P05	1.46		-0.02	0.48	0.47	-2.00	-1.47	-1.49	-1.67	-0.86
P06	-0.30		-1.05	-0.16	2.72	1.17	1.11	0.33	0.34	0.32
P07										
P08	4.98		-0.01	0.31	-0.22	0.58	0.24	-1.00	-0.64	0.47
P09	0.06		-0.06	0.00	0.16	0.00	-0.13	0.00	-0.10	
P10										
P11										
P12										
P13	5.21		-0.05	0.06	0.03	-0.31	-0.38	-0.17	-0.51	
P14	0.06		0.03	0.13	-3.16	-3.46	-3.87	-0.61	-0.34	0.14
P15	3.39		1.72	-3.77	0.89	0.50	0.07	-1.84	-2.11	-1.62
P16										
P17										
P18	1.06		-0.52	0.44	0.33	-0.04	0.16	0.00	0.05	0.12
P19	-4.61		0.50	0.30	-0.11	-0.68	0.62	-3.84	-1.60	0.13
P20	0.13		0.62	-0.23	-0.23	-0.02	-0.14	-0.51	-1.02	-0.69
P21										
P22										
P23										
P24										
P25										
P26										
P27	-2.78		0.00	0.18	0.07	-0.70	-0.33	-0.58	-0.36	-0.06
P28	4.89		-4.60	9.33	1.41	0.13			-1.55	-1.67
P29	0.14		-0.33	0.15	0.12	-0.19	-0.14	-0.11	-0.22	0.12
P30	2.43		0.04	-0.10	-0.09	-0.19	-0.15	0.28	-0.66	0.15
P31										
P32										
P33	4.96		-0.01	-0.12	0.03	-0.63	-0.43	-0.68	-0.63	0.09

Of the sixteen (16) laboratories reporting uncertainties for this mixture, the E_n -numbers are shown above. There were a greater number of unsatisfactory results on the basis of E_n -numbers due to underestimation of uncertainties.

Laboratories **P05, P06, P15, P20** and **P30** scored 100% on the basis of ***z***-scores but failed on one or more components on the basis of E_n-numbers. These laboratories underestimated their uncertainties for failing components due to undetected bias in their measurements.

Laboratories **P09** and **P29** all reported excellent results with perfect scores on the basis of both performance measures. Well done!

LNG 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.

Sulphur component mixture

The sulphur mixture contained components at challengingly low amount fractions in accordance with routine measurements made in their laboratories. The matrix gas included methane, ethane and propane in order to more accurately represent the matrix gas in samples routinely measured by the participants. The results for the sulphur component mixture are shown below.

Table 3.9 - Summary of *z'*-scores

participant id	hydrogen sulphide	carbonyl sulphide	methyl mercaptan	ethyl mercaptan	dimethyl sulphide	total sulphur (from speciated)	total sulphur (unspeciated)
P01	26.71				-4.37		
P02	-2.23	-8.01	-2.73	-2.57	-2.20	-2.96	2.89
P03							
P04	0.03	-0.88	-0.39	-1.65	-0.70	-0.52	
P05	1.07	-0.10	3.20	5.13	-2.97	1.23	
P06	0.14	-2.23	-1.65	1.90	0.04	-0.37	0.23
P07							
P08							
P09							
P10	-1.60	-0.22	-0.94	-0.66	-0.92	-0.86	-1.73
P11							
P12							
P13							
P14							
P15							
P16							
P17	1.97	0.03	-6.35	-4.49	-2.17	-1.69	
P18							
P19							
P20	0.40	1.89	0.20	0.62	0.71	0.60	
P21							
P22							
P23							
P24							
P25							
P26							
P27							
P28							
P29	-0.47	-1.68	-0.04	0.94	-0.21	-0.28	
P30	-0.66	-1.81	-0.65	-0.11	-0.65		
P31							
P32							
P33	-0.82	0.63	-0.29	0.50	0.61	-0.04	

A relatively good set of results were reported for the sulphur component mixture in this round. The overall score was only **75.8%**.

Six (6) laboratories **P04, P10, P20, P29, P30** and **P33** achieved a perfect 100% on the sulphur component mixture out of eleven (11) submitting results. An excellent performance from these laboratories.

Laboratories **P06** and **P10** achieved an acceptable result for the unspeciated total sulphur amount reported.

Laboratory **P02** reported an unspeciated total sulphur amount in units of mass fraction (mgS/kg). For the purpose of comparison with reference values, reported values have been converted to amount of substance fraction in accordance with ISO 14912:2006.

Laboratory **P04** reported values in units of mass concentration (mgS/m^3) at a reference temperature of 0°C. For the purpose of comparison with reference values, reported values have been converted to amount of substance fraction in accordance with ISO 14912:2006.

Table 3.10 - Summary of E_n-numbers

participant id	hydrogen sulphide	carbonyl sulphide	methyl mercaptan	ethyl mercaptan	dimethyl sulphide	total sulphur (from speciated)	total sulphur (unspeciated)
P01	9.25				-2.63		
P02							
P03							
P04	0.02	-0.44	-0.20	-0.85	-0.35	-0.34	
P05	0.94	-0.08	2.52	3.17	-2.64		
P06	0.11	-1.05	-1.05	0.83	0.02	-0.27	0.19
P07							
P08							
P09							
P10							
P11							
P12							
P13							
P14							
P15							
P16							
P17	3.30	0.03	-8.62	-5.01	-2.52	-2.80	
P18							
P19							
P20	0.20	0.65	0.14	0.37	0.40	0.38	
P21							
P22							
P23							
P24							
P25							
P26							
P27							
P28							
P29	-0.10	-0.51	-0.02	0.26	-0.07	-0.09	
P30							
P31							
P32							
P33	-0.37	0.31	-0.11	0.22	0.26	-0.02	

Of the eight (8) laboratories reporting uncertainties for one or more of the components in the sulphur mixture, the E_n -numbers are shown above.

Laboratories **P04, P20, P29** and **P33** reported a perfect score on the basis of E_n -numbers.

Laboratory **P06** achieved an acceptable result for the unspeciated total sulphur amount reported.

Laboratory **P01** only reported results for hydrogen sulphide and dimethyl sulphide.

Laboratories **P04, P20, P29** and **P33** achieved a perfect score on the basis of both performance measures for all speciated sulphur components. This is an excellent performance.

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 3.11 - Summary of overall scores for each mixture type

participant id	LNG mixture	sulphur component
P01	86.1%	0.0%
P02	91.7%	29.2%
P03	100.0%	
P04		100.0%
P05	100.0%	54.2%
P06	100.0%	91.7%
P07	100.0%	
P08	88.9%	
P09	100.0%	
P10		100.0%
P11	100.0%	
P12	100.0%	
P13	88.9%	
P14	94.4%	
P15	100.0%	
P16		
P17		58.3%
P18	88.9%	
P19	94.4%	
P20	100.0%	100.0%
P21		
P22	100.0%	
P23		
P24	100.0%	
P25	100.0%	
P26	77.8%	
P27	88.9%	
P28	94.4%	
P29	100.0%	100.0%
P30	100.0%	100.0%
P31	100.0%	
P32	100.0%	
P33	88.9%	100.0%
Average score	**95.7%**	**75.8%**

On the basis of the average scores, the sulphur component mixture once again proved the most challenging measurement in this round of the scheme. Results for this measurement gave an overall score of only **75.8%**. Six (6) laboratories **P04, P10, P20, P29, P30** and **P33** achieved a perfect 100% score out of eleven (11) submitting results.

The nitrogen component in the LNG mixture proved to be the most challenging in this round once again. Sixteen (16) out of twenty-seven (27) participants achieved a perfect score of 100% for the LNG type mixture in this round. The average score of **95.7%** ranks amongst the best ever recorded in this scheme.

Laboratories **P20, P29** and **P30** are worthy of a particular mention in this round producing excellent sets of results achieving a perfect score of 100% for both the LNG mixture and the sulphur component mixture. An excellent performance.

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.

LNG composition (content)

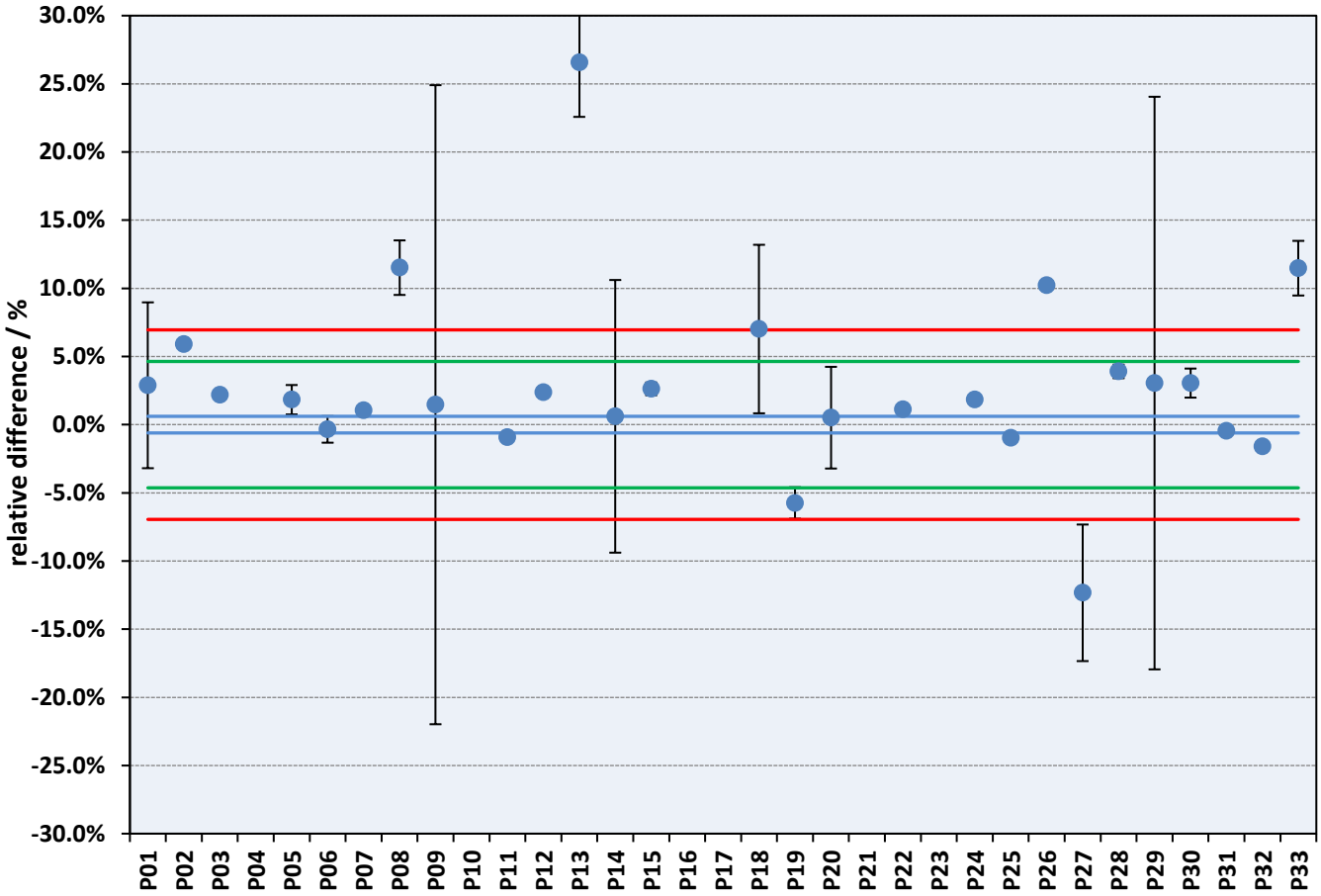
Mixture	LNG
Component	nitrogen

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.1640	0.0010	%mol/mol	0.0038	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.1687	0.0103	2.89%	1.25	0.46
P02	0.1737	0.0000	5.91%	2.55	
P03	0.1676		2.18%	0.94	
P04					
P05	0.1670	0.0018	1.83%	0.79	1.46
P06	0.1634	0.0016	-0.35%	-0.15	-0.30
P07	0.1657		1.04%	0.45	
P08	0.1829	0.0037	11.52%	4.97	4.98
P09	0.1664	0.0390	1.46%	0.63	0.06
P10					
P11	0.1625		-0.91%	-0.39	
P12	0.1679		2.38%	1.03	
P13	0.2076	0.0083	26.57%	11.47	5.21
P14	0.1650	0.0165	0.61%	0.26	0.06
P15	0.1683	0.0008	2.62%	1.13	3.39
P16					
P17					
P18	0.1755	0.0108	7.01%	3.03	1.06
P19	0.1546	0.0018	-5.74%	-2.48	-4.61
P20	0.1648	0.0061	0.51%	0.22	0.13
P21					
P22	0.1659		1.13%	0.49	
P23					
P24	0.1670		1.83%	0.79	
P25	0.1624		-0.98%	-0.42	
P26	0.1808		10.22%	4.41	
P27	0.1438	0.0072	-12.34%	-5.32	-2.78
P28	0.1704	0.0008	3.90%	1.68	4.89
P29	0.1690	0.0355	3.05%	1.32	0.14
P30	0.1690	0.0018	3.05%	1.32	2.43
P31	0.1633		-0.45%	-0.20	
P32	0.1614		-1.59%	-0.68	
P33	0.1828	0.0037	11.48%	4.95	4.96

nitrogen in LNG composition



Reference values	
x_{ref}	0.1640
$U(x_{ref})$ k=2	0.0010

Consensus values (raw data)		
m	0.1675	
s_r	0.0043	2.59%
s_L	0.0108	6.45%
s_R	0.0116	6.95%
p	27	

Consensus values (corrected)		
m	0.1680	
s_r	0.0034	2.00%
s_L	0.0066	3.91%
s_R	0.0074	4.39%
p	25	

Mixture	LNG
Component	methane

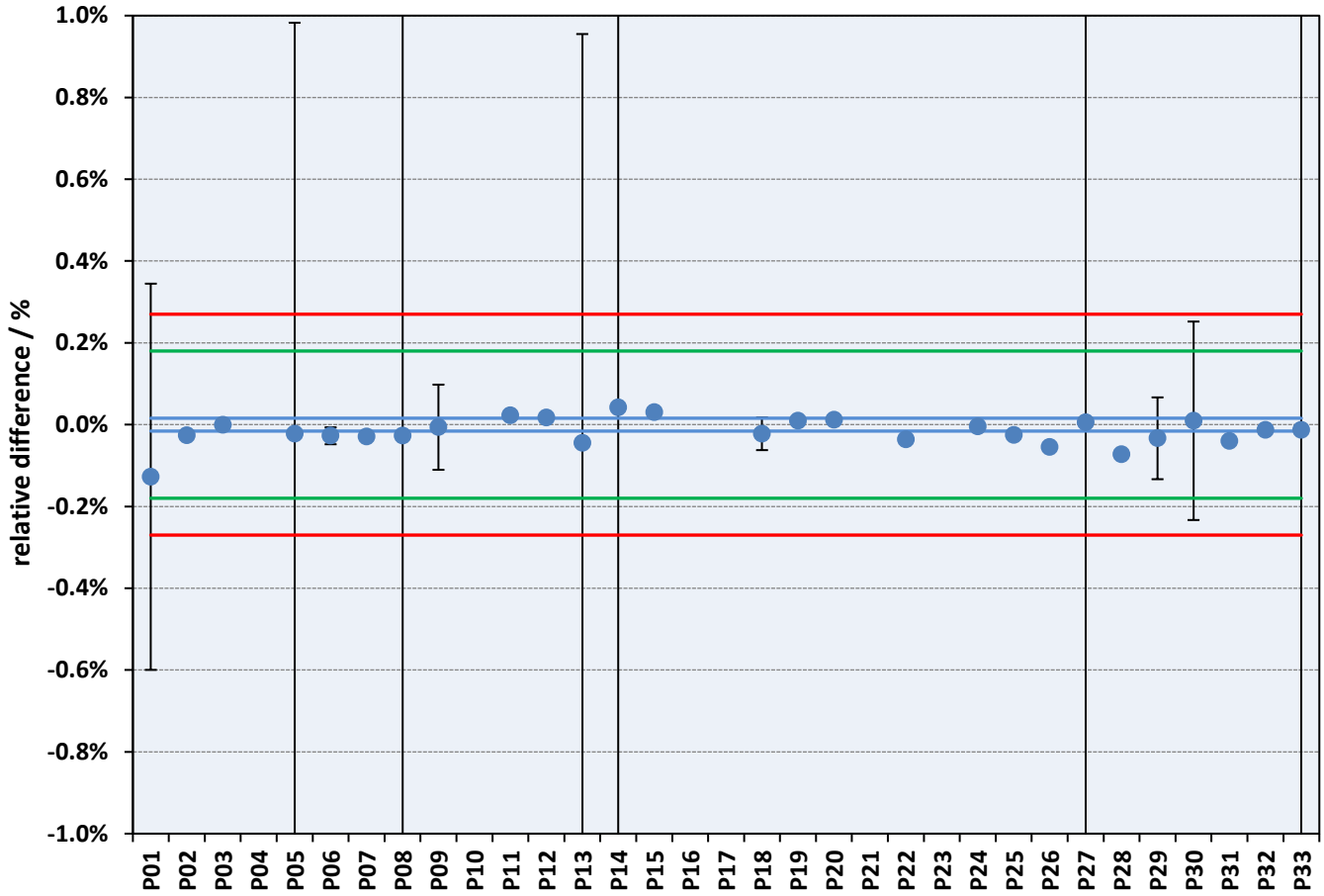
Reference

x_{ref}	$U(x_{ref})$ k=2		σ	
95.246	0.015	%mol/mol	0.086	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	95.125	0.449	-0.13%	**-1.42**	**-0.27**
P02	95.221	0.000	-0.03%	**-0.29**	
P03	95.245		0.00%	**-0.01**	
P04					
P05	95.225	0.957	-0.02%	**-0.25**	**-0.02**
P06	95.220	0.020	-0.03%	**-0.30**	**-1.05**
P07	95.218		-0.03%	**-0.32**	
P08	95.220	1.904	-0.03%	**-0.30**	**-0.01**
P09	95.240	0.099	-0.01%	**-0.07**	**-0.06**
P10					
P11	95.268		0.02%	**0.25**	
P12	95.263		0.02%	**0.19**	
P13	95.203	0.952	-0.05%	**-0.50**	**-0.05**
P14	95.286	1.334	0.04%	**0.47**	**0.03**
P15	95.275	0.008	0.03%	**0.34**	**1.72**
P16					
P17					
P18	95.225	0.038	-0.02%	**-0.25**	**-0.52**
P19	95.255	0.010	0.01%	**0.11**	**0.50**
P20	95.257	0.009	0.01%	**0.13**	**0.62**
P21					
P22	95.212		-0.04%	**-0.40**	
P23					
P24	95.242		0.00%	**-0.05**	
P25	95.222		-0.03%	**-0.28**	
P26	95.194		-0.05%	**-0.61**	
P27	95.251	1.619	0.01%	**0.06**	**0.00**
P28	95.177	0.001	-0.07%	**-0.81**	**-4.60**
P29	95.214	0.095	-0.03%	**-0.37**	**-0.33**
P30	95.255	0.231	0.01%	**0.10**	**0.04**
P31	95.208		-0.04%	**-0.45**	
P32	95.233		-0.01%	**-0.15**	
P33	95.234	1.905	-0.01%	**-0.14**	**-0.01**

methane in LNG composition



Reference values	
x_{ref}	95.246
$U(x_{ref})$ k=2	0.015

Consensus values (raw data)		
m	95.224	
s_r	0.011	0.01%
s_L	0.037	0.04%
s_R	0.039	0.04%
p	27	

Consensus values (corrected)		
m	95.230	
s_r	0.007	0.01%
s_L	0.028	0.03%
s_R	0.029	0.03%
p	26	

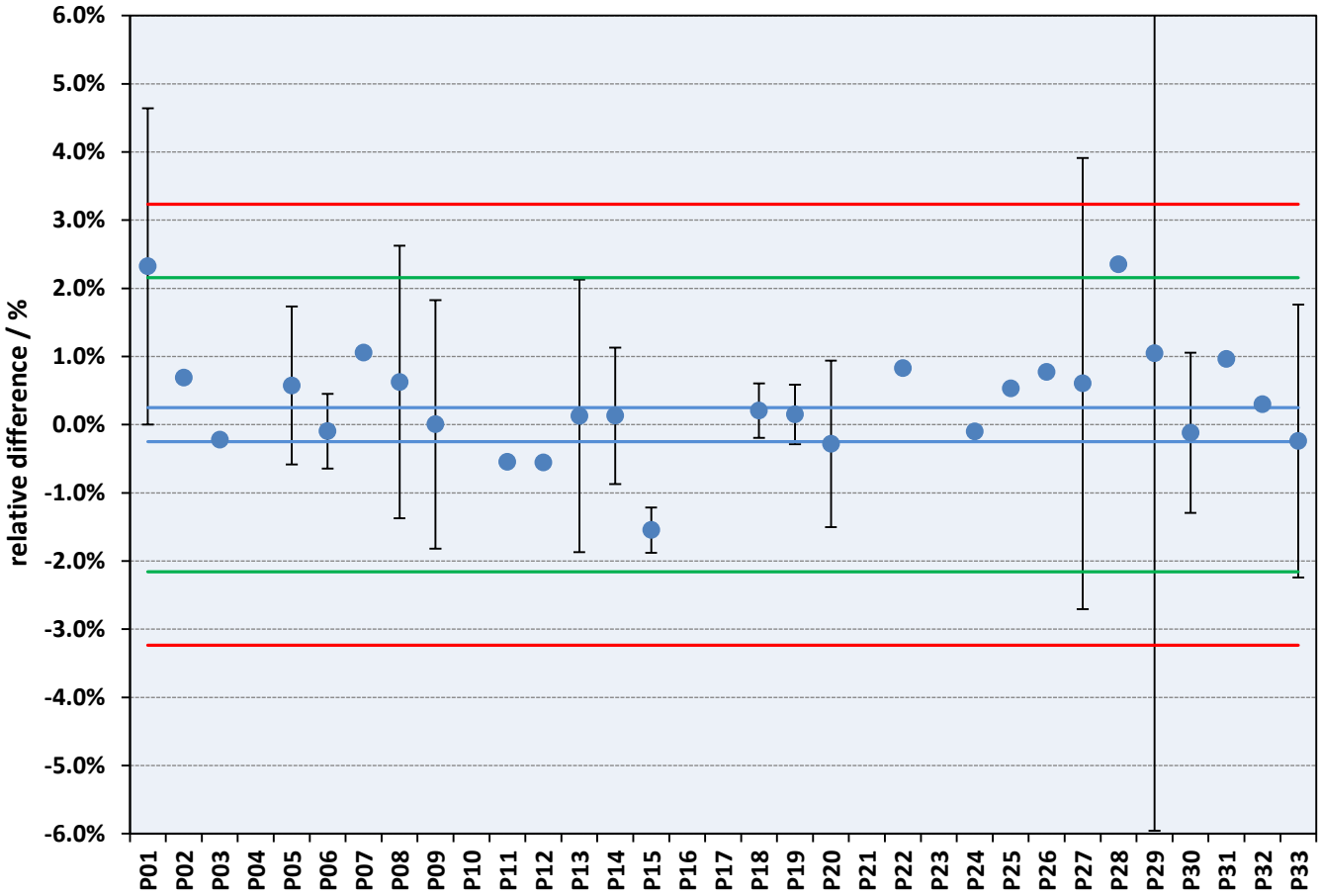
Mixture	LNG
Component	ethane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	2.4029	0.0060	%mol/mol	0.0259	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	2.4587	0.0571	2.32%	2.15	0.97
P02	2.4194	0.0000	0.69%	0.64	
P03	2.3975		-0.22%	-0.21	
P04					
P05	2.4167	0.0280	0.57%	0.53	0.48
P06	2.4006	0.0132	-0.10%	-0.09	-0.16
P07	2.4283		1.06%	0.98	
P08	2.4179	0.0484	0.62%	0.58	0.31
P09	2.4030	0.0438	0.00%	0.00	0.00
P10					
P11	2.3898		-0.55%	-0.51	
P12	2.3896		-0.56%	-0.52	
P13	2.4060	0.0481	0.13%	0.12	0.06
P14	2.4060	0.0241	0.13%	0.12	0.13
P15	2.3657	0.0078	-1.55%	-1.44	-3.77
P16					
P17					
P18	2.4079	0.0096	0.21%	0.19	0.44
P19	2.4065	0.0105	0.15%	0.14	0.30
P20	2.3961	0.0293	-0.28%	-0.26	-0.23
P21					
P22	2.4228		0.83%	0.77	
P23					
P24	2.4005		-0.10%	-0.09	
P25	2.4156		0.53%	0.49	
P26	2.4215		0.77%	0.72	
P27	2.4174	0.0800	0.60%	0.56	0.18
P28	2.4594	0.0008	2.35%	2.18	9.33
P29	2.4280	0.1700	1.04%	0.97	0.15
P30	2.4000	0.0282	-0.12%	-0.11	-0.10
P31	2.4260		0.96%	0.89	
P32	2.4101		0.30%	0.28	
P33	2.3971	0.0480	-0.24%	-0.22	-0.12

ethane in LNG composition



Reference values	
x_{ref}	2.4029
$U(x_{ref})$ k=2	0.0060

Consensus values (raw data)		
m	2.4145	
s_r	0.0050	0.21%
s_L	0.0235	0.97%
s_R	0.0240	0.99%
p	27	

Consensus values (corrected)		
m	2.4114	
s_r	0.0023	0.10%
s_L	0.0128	0.53%
s_R	0.0130	0.54%
p	24	

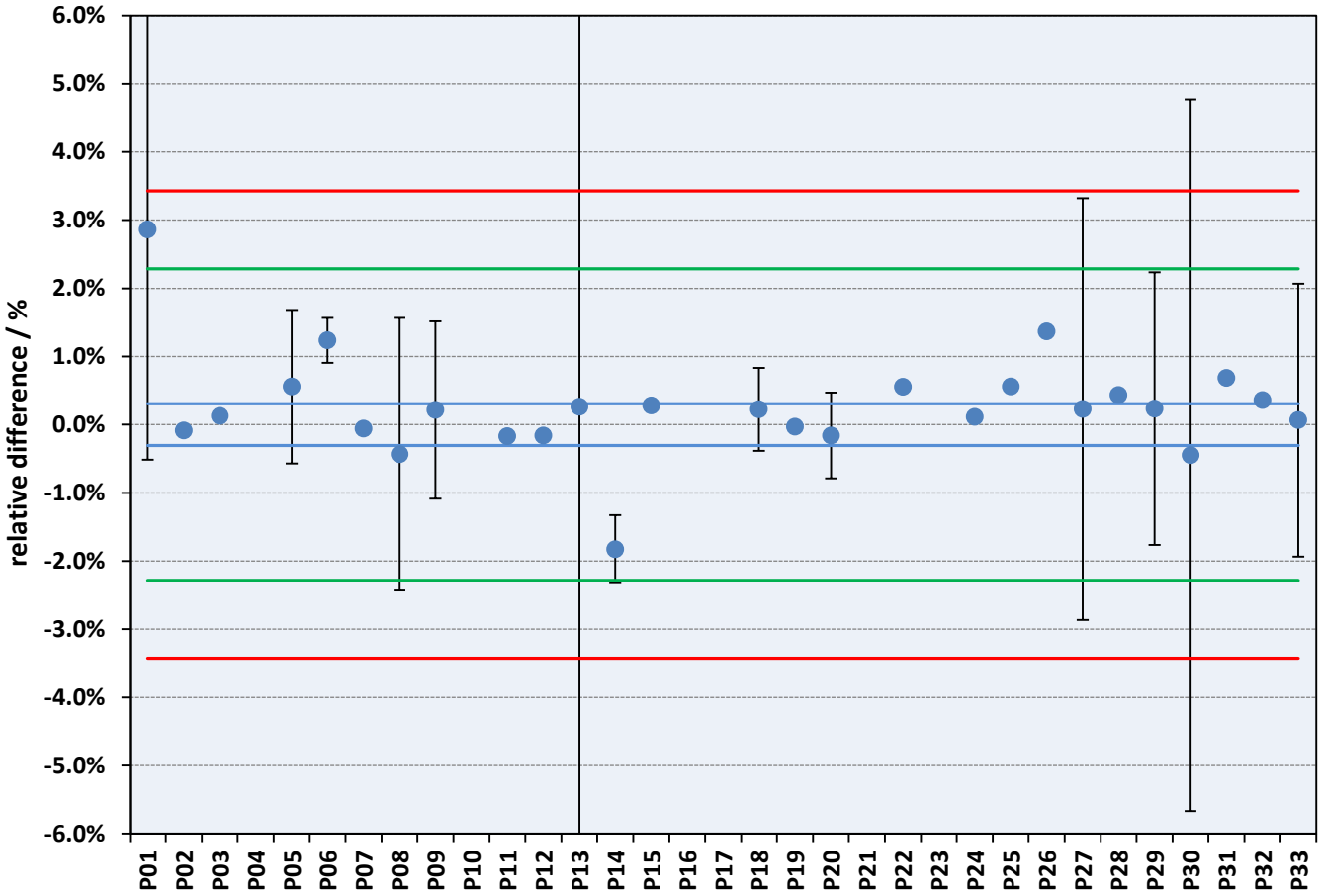
Mixture	LNG
Component	propane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	1.9588	0.0060	%mol/mol	0.0224	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	2.0149	0.0681	2.86%	2.51	0.82
P02	1.9571	0.0000	-0.09%	-0.08	
P03	1.9613		0.13%	0.11	
P04					
P05	1.9697	0.0222	0.56%	0.49	0.47
P06	1.9830	0.0066	1.24%	1.08	2.72
P07	1.9577		-0.06%	-0.05	
P08	1.9503	0.0390	-0.43%	-0.38	-0.22
P09	1.9630	0.0255	0.21%	0.19	0.16
P10					
P11	1.9554		-0.17%	-0.15	
P12	1.9556		-0.16%	-0.14	
P13	1.9639	0.1571	0.26%	0.23	0.03
P14	1.9230	0.0096	-1.83%	-1.60	-3.16
P15	1.9643	0.0014	0.28%	0.24	0.89
P16					
P17					
P18	1.9632	0.0120	0.22%	0.20	0.33
P19	1.9582	0.0009	-0.03%	-0.03	-0.11
P20	1.9557	0.0123	-0.16%	-0.14	-0.23
P21					
P22	1.9697		0.55%	0.49	
P23					
P24	1.9610		0.11%	0.10	
P25	1.9697		0.56%	0.49	
P26	1.9855		1.37%	1.19	
P27	1.9633	0.0607	0.23%	0.20	0.07
P28	1.9673	0.0007	0.43%	0.38	1.41
P29	1.9634	0.0393	0.23%	0.21	0.12
P30	1.9500	0.1018	-0.45%	-0.39	-0.09
P31	1.9722		0.68%	0.60	
P32	1.9658		0.36%	0.31	
P33	1.9601	0.0392	0.07%	0.06	0.03

propane in LNG composition



Reference values	
x_{ref}	1.9588
$U(x_{ref})$ k=2	0.0060

Consensus values (raw data)		
m	1.9671	
s_r	0.0052	0.27%
s_L	0.0158	0.80%
s_R	0.0167	0.85%
p	27	

Consensus values (corrected)		
m	1.9645	
s_r	0.0022	0.11%
s_L	0.0089	0.45%
s_R	0.0092	0.47%
p	25	

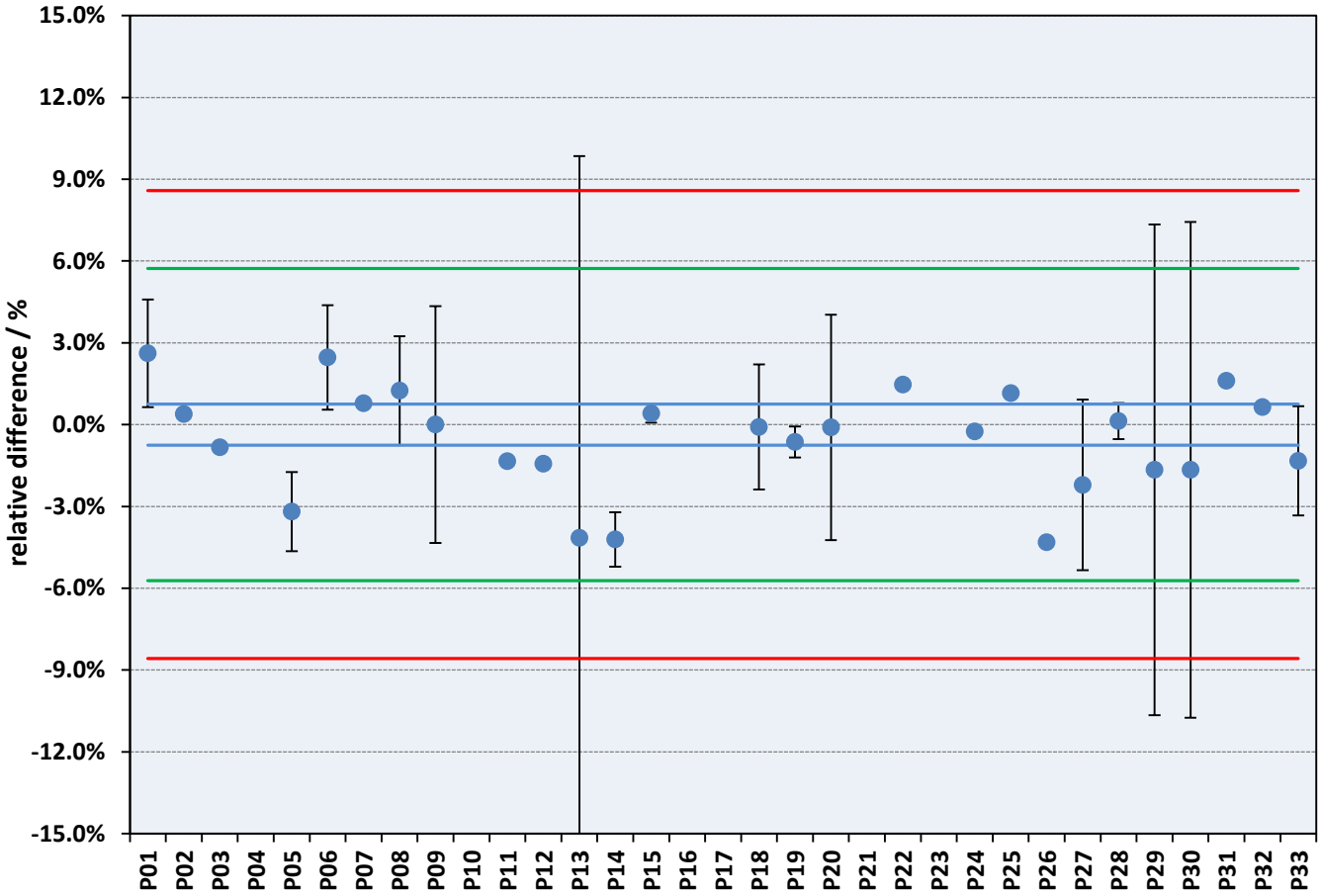
Mixture	LNG
Component	iso-butane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.07830	0.00059	%mol/mol	0.00224	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	***z***-score	E_n-number
P01	0.08035	0.00158	2.61%	**0.91**	**1.21**
P02	0.07860	0.00000	0.38%	**0.13**	
P03	0.07765		-0.83%	**-0.29**	
P04					
P05	0.07580	0.00110	-3.19%	**-1.12**	**-2.00**
P06	0.08023	0.00154	2.46%	**0.86**	**1.17**
P07	0.07891		0.78%	**0.27**	
P08	0.07927	0.00159	1.24%	**0.43**	**0.58**
P09	0.07830	0.00340	0.00%	**0.00**	**0.00**
P10					
P11	0.07725		-1.34%	**-0.47**	
P12	0.07718		-1.44%	**-0.50**	
P13	0.07505	0.01051	-4.16%	**-1.45**	**-0.31**
P14	0.07500	0.00075	-4.21%	**-1.47**	**-3.46**
P15	0.07862	0.00026	0.41%	**0.14**	**0.50**
P16					
P17					
P18	0.07823	0.00179	-0.09%	**-0.03**	**-0.04**
P19	0.07780	0.00044	-0.64%	**-0.22**	**-0.68**
P20	0.07822	0.00323	-0.10%	**-0.04**	**-0.02**
P21					
P22	0.07945		1.47%	**0.51**	
P23					
P24	0.07810		-0.26%	**-0.09**	
P25	0.07920		1.15%	**0.40**	
P26	0.07492		-4.32%	**-1.51**	
P27	0.07657	0.00240	-2.21%	**-0.77**	**-0.70**
P28	0.07840	0.00052	0.13%	**0.04**	**0.13**
P29	0.07700	0.00693	-1.66%	**-0.58**	**-0.19**
P30	0.07700	0.00700	-1.66%	**-0.58**	**-0.19**
P31	0.07956		1.61%	**0.56**	
P32	0.07880		0.64%	**0.22**	
P33	0.07726	0.00155	-1.33%	**-0.46**	**-0.63**

iso-butane in LNG composition



Reference values	
x_{ref}	0.07830
$U(x_{ref})$ k=2	0.00059

Consensus values (raw data)		
m	0.07815	
s_r	0.00033	0.42%
s_L	0.00146	1.87%
s_R	0.00150	1.92%
p	27	

Consensus values (corrected)		
m	0.07843	
s_r	0.00027	0.34%
s_L	0.00115	1.47%
s_R	0.00119	1.51%
p	24	

Mixture	LNG
Component	n-butane

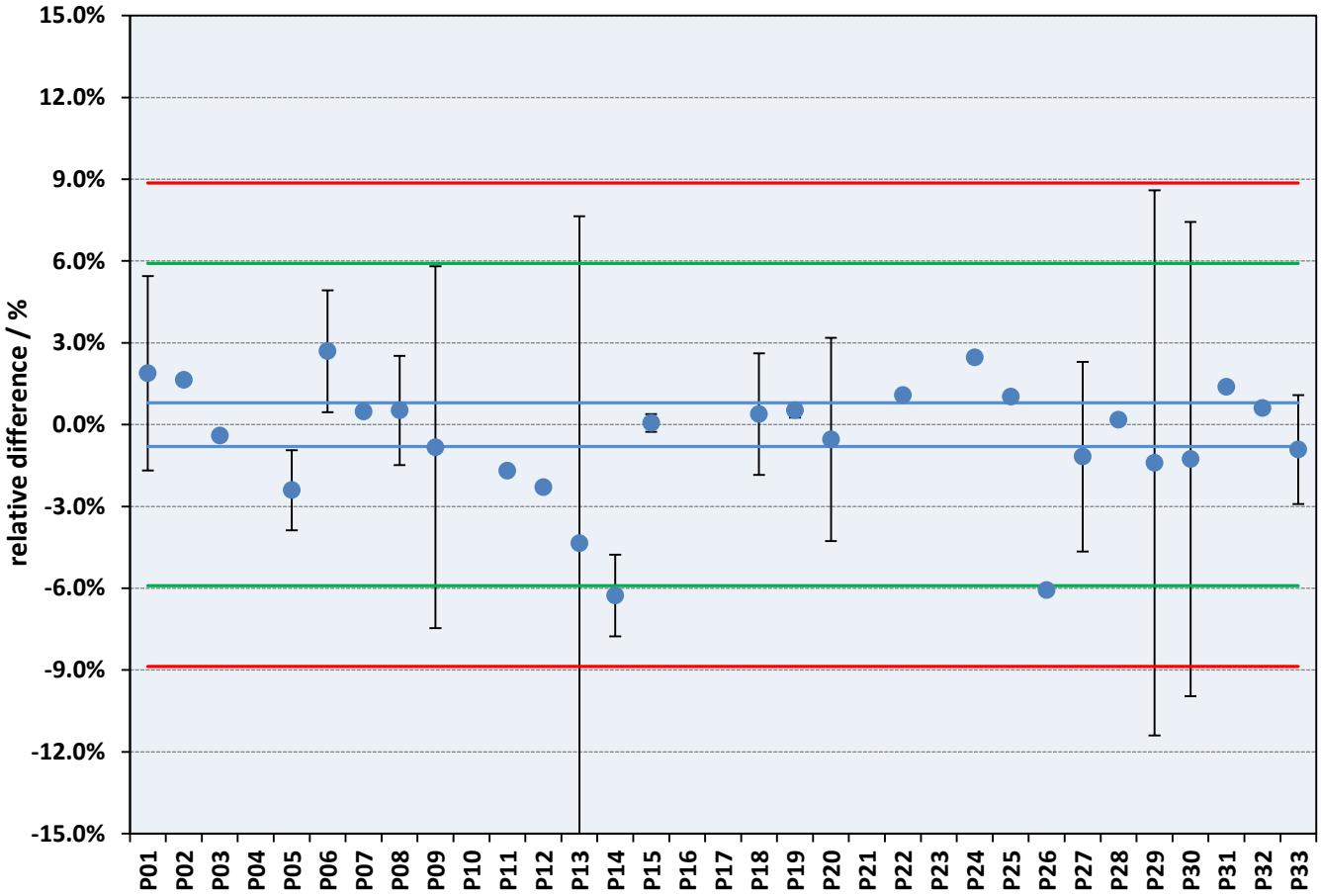
Reference

x_{ref}	$U(x_{ref})$ k=2		σ	
0.06988	0.00056	%mol/mol	0.00207	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.07120	0.00254	1.88%	0.64	0.51
P02	0.07103	0.00000	1.64%	0.55	
P03	0.06960		-0.40%	-0.14	
P04					
P05	0.06820	0.00100	-2.40%	-0.81	-1.47
P06	0.07176	0.00160	2.69%	0.91	1.11
P07	0.07022		0.48%	0.16	
P08	0.07025	0.00141	0.52%	0.18	0.24
P09	0.06930	0.00460	-0.83%	-0.28	-0.13
P10					
P11	0.06870		-1.69%	-0.57	
P12	0.06828		-2.30%	-0.78	
P13	0.06684	0.00802	-4.35%	-1.47	-0.38
P14	0.06550	0.00098	-6.27%	-2.12	-3.87
P15	0.06992	0.00023	0.06%	0.02	0.07
P16					
P17					
P18	0.07015	0.00156	0.39%	0.13	0.16
P19	0.07025	0.00019	0.53%	0.18	0.62
P20	0.06950	0.00259	-0.54%	-0.18	-0.14
P21					
P22	0.07064		1.09%	0.37	
P23					
P24	0.07160		2.46%	0.83	
P25	0.07060		1.03%	0.35	
P26	0.06564		-6.07%	-2.06	
P27	0.06906	0.00240	-1.17%	-0.40	-0.33
P28	0.07000	0.00000	0.17%	0.06	
P29	0.06890	0.00689	-1.40%	-0.47	-0.14
P30	0.06900	0.00600	-1.26%	-0.43	-0.15
P31	0.07085		1.39%	0.47	
P32	0.07030		0.60%	0.20	
P33	0.06924	0.00139	-0.92%	-0.31	-0.43

n-butane in LNG composition



Reference values	
x_{ref}	0.06988
$U(x_{ref})$ k=2	0.00056

Consensus values (raw data)		
m	0.06975	
s_r	0.00036	0.52%
s_L	0.00145	2.08%
s_R	0.00150	2.15%
p	27	

Consensus values (corrected)		
m	0.07000	
s_r	0.00036	0.52%
s_L	0.00105	1.51%
s_R	0.00111	1.59%
p	25	

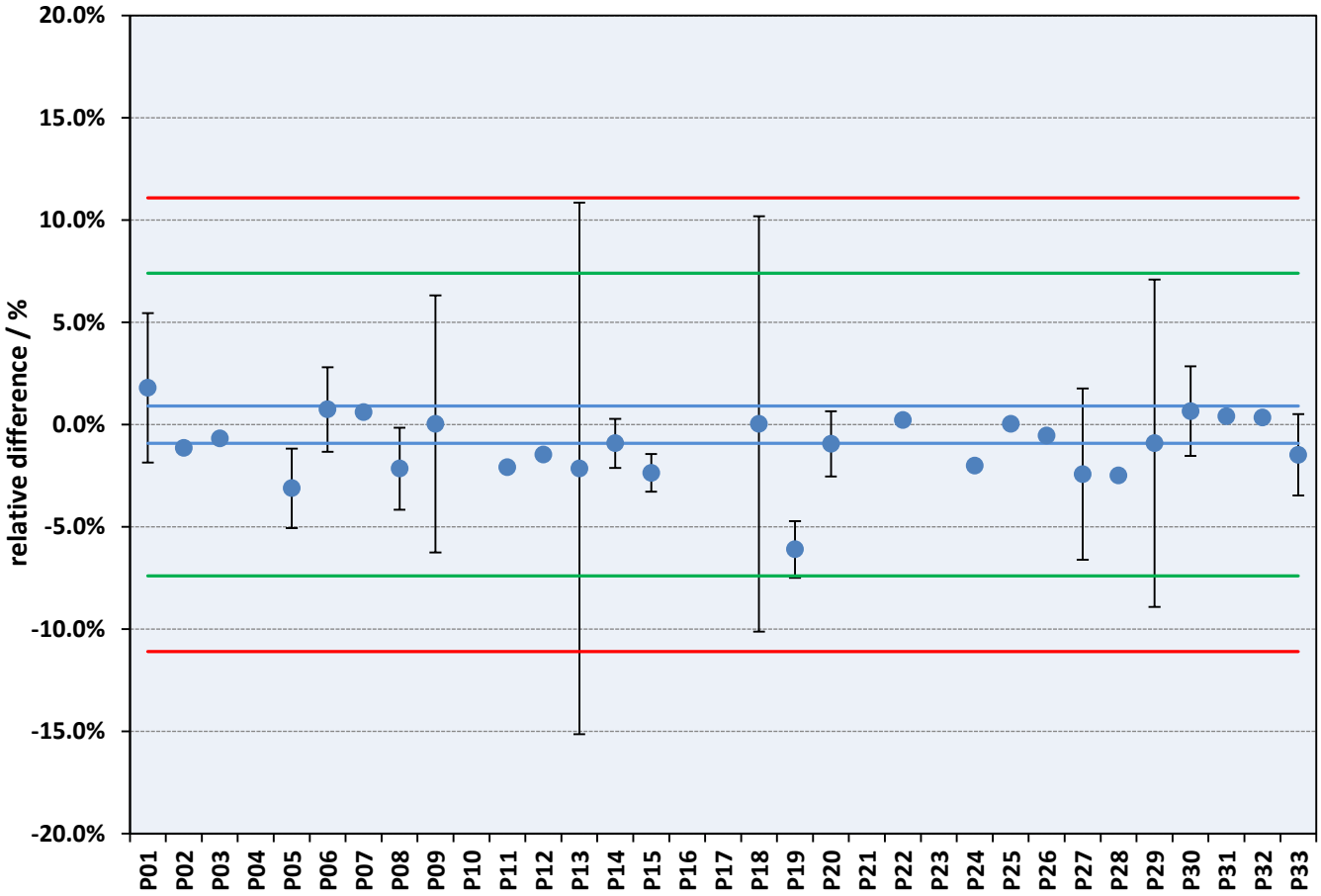
Mixture	LNG
Component	iso-pentane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.03179	0.00029	%mol/mol	0.00118	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.03236	0.00118	1.80%	**0.49**	**0.47**
P02	0.03143	0.00000	-1.15%	**-0.31**	
P03	0.03158		-0.68%	**-0.18**	
P04					
P05	0.03080	0.00060	-3.11%	**-0.84**	**-1.49**
P06	0.03203	0.00066	0.74%	**0.20**	**0.33**
P07	0.03198		0.61%	**0.16**	
P08	0.03111	0.00062	-2.15%	**-0.58**	**-1.00**
P09	0.03180	0.00200	0.03%	**0.01**	**0.00**
P10					
P11	0.03113		-2.09%	**-0.57**	
P12	0.03133		-1.46%	**-0.40**	
P13	0.03111	0.00404	-2.14%	**-0.58**	**-0.17**
P14	0.03150	0.00038	-0.91%	**-0.25**	**-0.61**
P15	0.03104	0.00029	-2.36%	**-0.64**	**-1.84**
P16					
P17					
P18	0.03180	0.00323	0.03%	**0.01**	**0.00**
P19	0.02985	0.00041	-6.10%	**-1.65**	**-3.84**
P20	0.03149	0.00050	-0.94%	**-0.25**	**-0.51**
P21					
P22	0.03186		0.22%	**0.06**	
P23					
P24	0.03115		-2.01%	**-0.54**	
P25	0.03180		0.03%	**0.01**	
P26	0.03162		-0.54%	**-0.15**	
P27	0.03102	0.00130	-2.42%	**-0.65**	**-0.58**
P28	0.03100	0.00000	-2.48%	**-0.67**	
P29	0.03150	0.00252	-0.91%	**-0.25**	**-0.11**
P30	0.03200	0.00070	0.66%	**0.18**	**0.28**
P31	0.03192		0.40%	**0.11**	
P32	0.03190		0.35%	**0.09**	
P33	0.03132	0.00062	-1.48%	**-0.40**	**-0.68**

iso-pentane in LNG composition



Reference values	
x_{ref}	0.03179
$U(x_{ref})$ k=2	0.00029

Consensus values (raw data)		
m	0.03144	
s_r	0.00024	0.77%
s_L	0.00058	1.85%
s_R	0.00063	2.00%
p	27	

Consensus values (corrected)		
m	0.03155	
s_r	0.00024	0.77%
s_L	0.00042	1.32%
s_R	0.00048	1.53%
p	26	

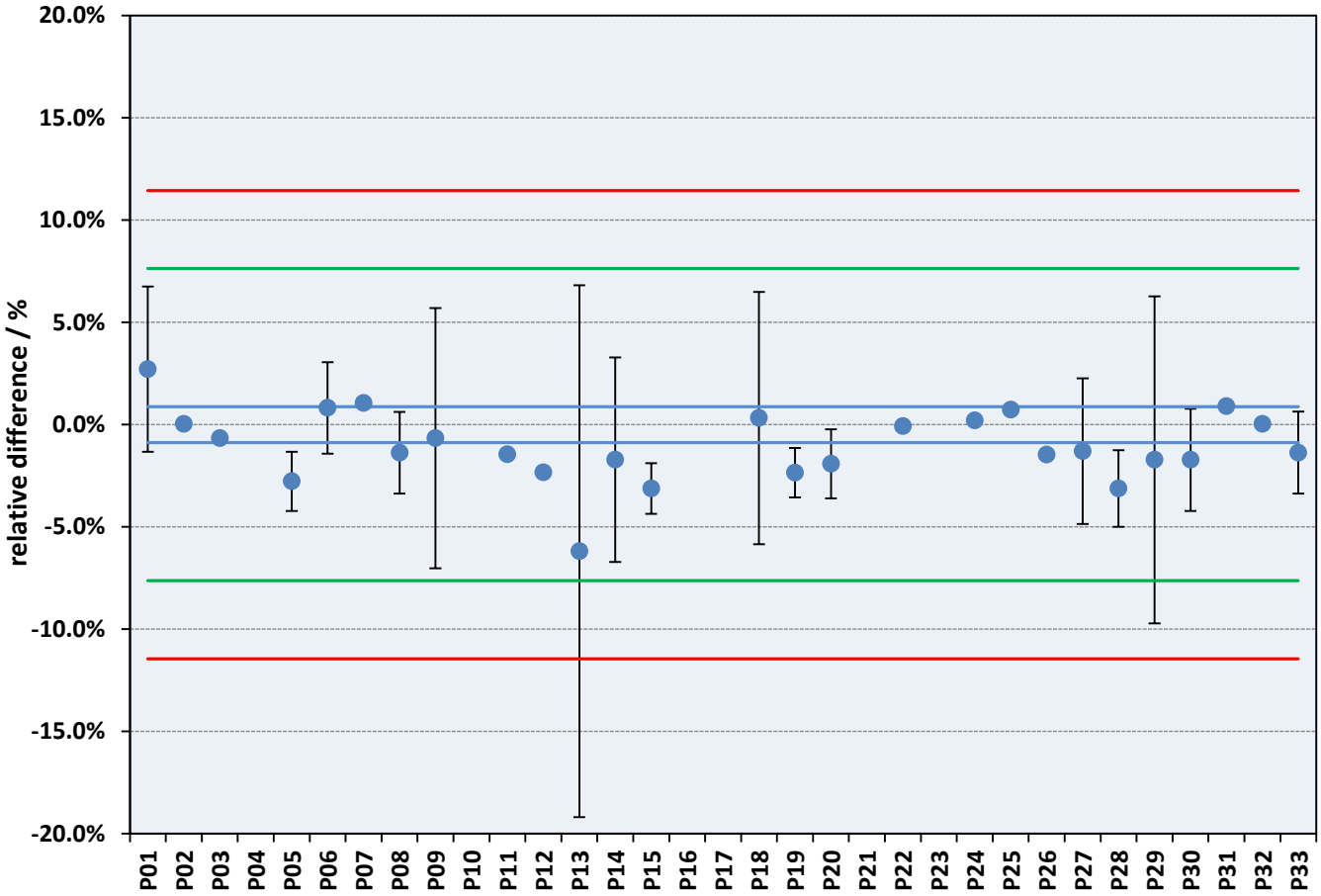
Mixture	LNG
Component	n-pentane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.02849	0.00025	%mol/mol	0.00109	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	***z***-score	E_n-number
P01	0.02926	0.00118	2.71%	**0.71**	**0.64**
P02	0.02850	0.00000	0.04%	**0.01**	
P03	0.02830		-0.67%	**-0.17**	
P04					
P05	0.02770	0.00040	-2.77%	**-0.73**	**-1.67**
P06	0.02872	0.00064	0.82%	**0.21**	**0.34**
P07	0.02879		1.06%	**0.28**	
P08	0.02810	0.00056	-1.38%	**-0.36**	**-0.64**
P09	0.02830	0.00180	-0.67%	**-0.17**	**-0.10**
P10					
P11	0.02808		-1.46%	**-0.38**	
P12	0.02783		-2.33%	**-0.61**	
P13	0.02673	0.00347	-6.19%	**-1.62**	**-0.51**
P14	0.02800	0.00140	-1.72%	**-0.45**	**-0.34**
P15	0.02760	0.00034	-3.12%	**-0.82**	**-2.11**
P16					
P17					
P18	0.02858	0.00176	0.33%	**0.09**	**0.05**
P19	0.02782	0.00034	-2.35%	**-0.62**	**-1.60**
P20	0.02794	0.00047	-1.91%	**-0.50**	**-1.02**
P21					
P22	0.02847		-0.07%	**-0.02**	
P23					
P24	0.02855		0.21%	**0.06**	
P25	0.02870		0.74%	**0.19**	
P26	0.02807		-1.47%	**-0.39**	
P27	0.02812	0.00100	-1.30%	**-0.34**	**-0.36**
P28	0.02760	0.00052	-3.12%	**-0.82**	**-1.55**
P29	0.02800	0.00224	-1.72%	**-0.45**	**-0.22**
P30	0.02800	0.00070	-1.72%	**-0.45**	**-0.66**
P31	0.02875		0.90%	**0.24**	
P32	0.02850		0.04%	**0.01**	
P33	0.02810	0.00056	-1.37%	**-0.36**	**-0.63**

n-pentane in LNG composition



Reference values	
x_{ref}	0.02849
$U(x_{ref})$ k=2	0.00025

Consensus values (raw data)		
m	0.02821	
s_r	0.00023	0.83%
s_L	0.00052	1.83%
s_R	0.00057	2.00%
p	27	

Consensus values (corrected)		
m	0.02818	
s_r	0.00019	0.66%
s_L	0.00039	1.39%
s_R	0.00043	1.54%
p	25	

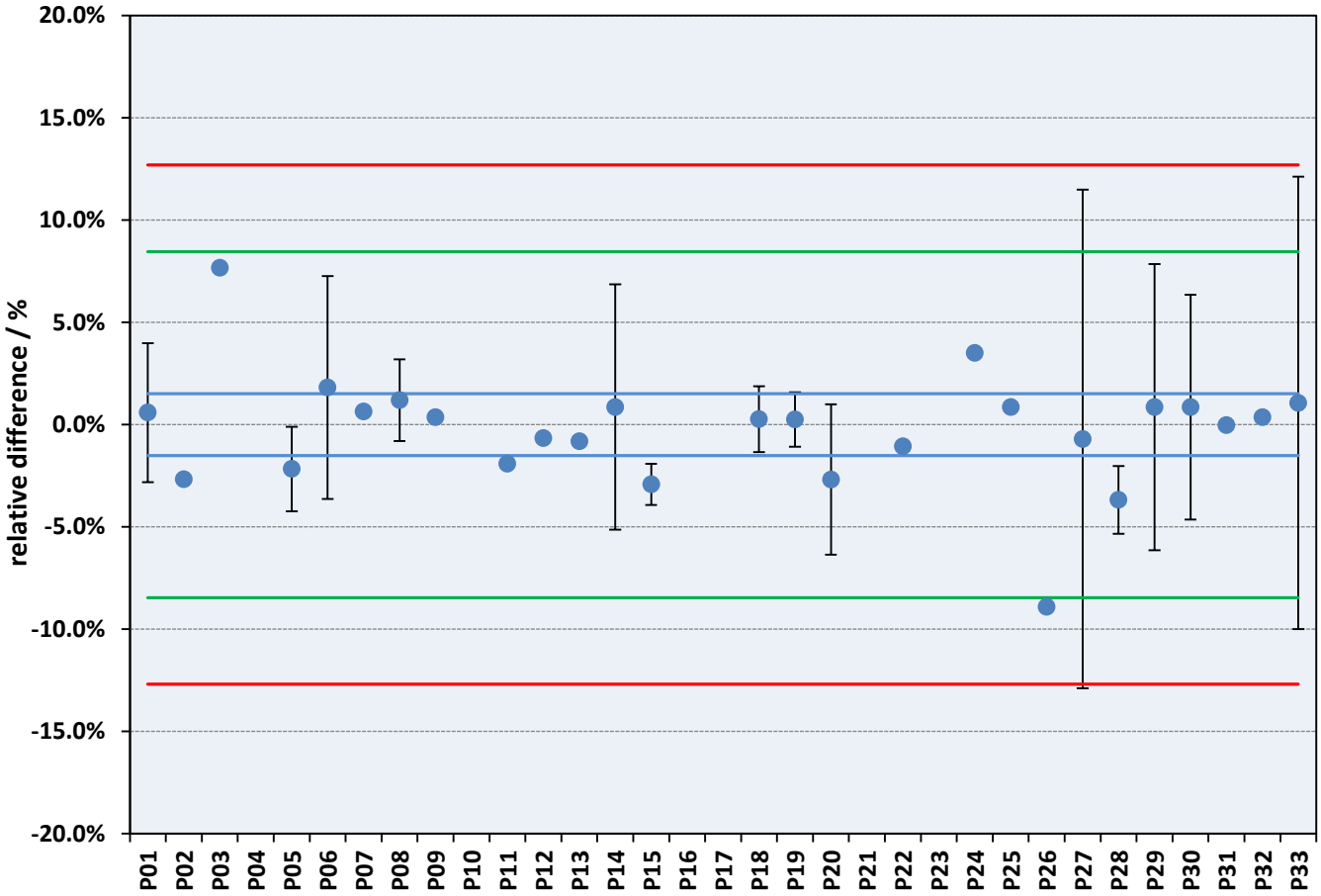
Mixture	LNG
Component	n-hexane

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	0.01983	0.00030	%mol/mol	0.00084	%mol/mol

Reported data

id	value (%mol/mol)	U (k=2) (%mol/mol)	relative difference	*z*-score	E_n-number
P01	0.01995	0.00068	0.59%	0.14	0.16
P02	0.01930	0.00000	-2.67%	-0.63	
P03	0.02135		7.67%	1.81	
P04					
P05	0.01940	0.00040	-2.17%	-0.51	-0.86
P06	0.02019	0.00110	1.81%	0.43	0.32
P07	0.01996		0.64%	0.15	
P08	0.02007	0.00040	1.20%	0.28	0.47
P09	0.01990		0.35%	0.08	
P10					
P11	0.01945		-1.92%	-0.45	
P12	0.01970		-0.66%	-0.15	
P13	0.01967		-0.82%	-0.19	
P14	0.02000	0.00120	0.86%	0.20	0.14
P15	0.01925	0.00019	-2.92%	-0.69	-1.62
P16					
P17					
P18	0.01988	0.00032	0.27%	0.06	0.12
P19	0.01988	0.00026	0.25%	0.06	0.13
P20	0.01930	0.00071	-2.68%	-0.63	-0.69
P21					
P22	0.01962		-1.06%	-0.25	
P23					
P24	0.02053		3.50%	0.83	
P25	0.02000		0.86%	0.20	
P26	0.01806		-8.92%	-2.11	
P27	0.01969	0.00240	-0.71%	-0.17	-0.06
P28	0.01910	0.00032	-3.68%	-0.87	-1.67
P29	0.02000	0.00140	0.86%	0.20	0.12
P30	0.02000	0.00110	0.86%	0.20	0.15
P31	0.01983		-0.02%	0.00	
P32	0.01990		0.35%	0.08	
P33	0.02004	0.00222	1.06%	0.25	0.09

n-hexane in LNG composition



Reference values	
x_{ref}	0.01983
$U(x_{ref})$ k=2	0.00030

Consensus values (raw data)		
m	0.01971	
s_r	0.00023	1.19%
s_L	0.00055	2.78%
s_R	0.00060	3.03%
p	27	

Consensus values (corrected)		
m	0.01974	
s_r	0.00023	1.19%
s_L	0.00034	1.71%
s_R	0.00041	2.08%
p	25	

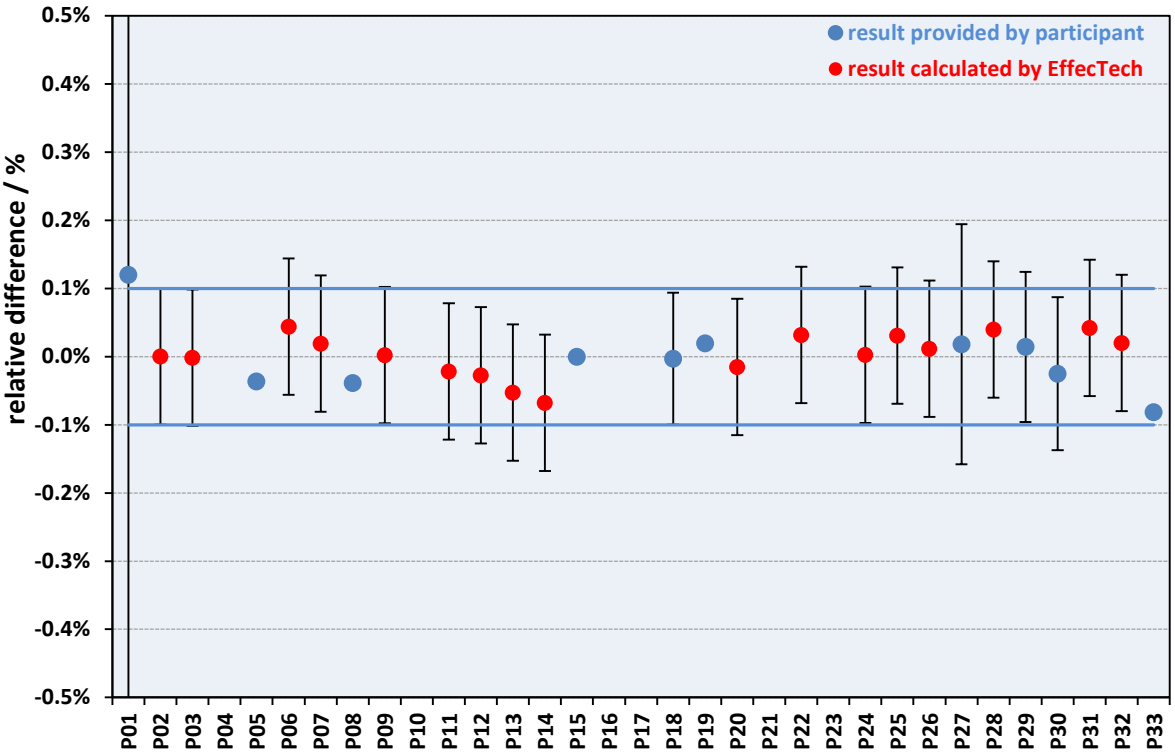
LNG composition (physical properties)

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	39.738	0.040	39.786	0.457	0.12%
P02	39.738	0.040	39.738	0.040	0.00%
P03	39.738	0.040	39.737	0.040	0.00%
P04					
P05	54.952	0.055	54.932		-0.04%
P06	39.738	0.040	39.755	0.040	0.04%
P07	39.738	0.040	39.745	0.040	0.02%
P08	39.035	0.039	39.020		-0.04%
P09	39.738	0.040	39.739	0.040	0.00%
P10					
P11	39.738	0.040	39.729	0.040	-0.02%
P12	39.738	0.040	39.727	0.040	-0.03%
P13	39.738	0.040	39.717	0.040	-0.05%
P14	39.738	0.040	39.711	0.040	-0.07%
P15	54.952	0.055	54.952	0.001	0.00%
P16					
P17					
P18	39.738	0.040	39.737	0.039	0.00%
P19	54.952	0.055	54.963	0.002	0.02%
P20	39.738	0.040	39.732	0.040	-0.02%
P21					
P22	39.738	0.040	39.750	0.040	0.03%
P23					
P24	39.738	0.040	39.739	0.040	0.00%
P25	39.738	0.040	39.750	0.040	0.03%
P26	39.738	0.040	39.742	0.040	0.01%
P27	39.738	0.040	39.745	0.070	0.02%
P28	39.738	0.040	39.754	0.040	0.04%
P29	11.668	0.012	11.670	0.013	0.01%
P30	41.896	0.042	41.886	0.047	-0.02%
P31	39.738	0.040	39.755	0.040	0.04%
P32	39.738	0.040	39.746	0.040	0.02%
P33	39.046	0.039	39.014		-0.08%

superior calorific value

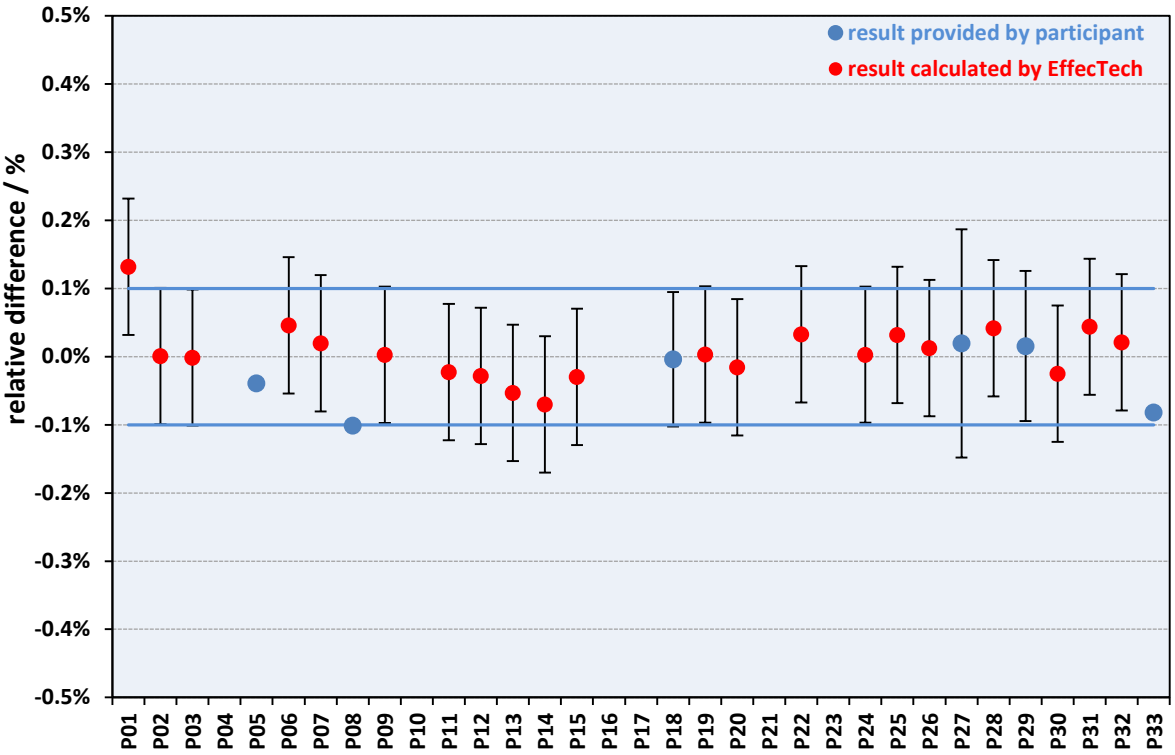


Mixture	LNG
Property	inferior calorific value

Reference and reported data

participant id	calculated reference value	assigned uncertainty	participant reported / calculated	reported / calculated uncertainty	relative difference
P01	35.843	0.036	35.890	0.036	0.13%
P02	35.843	0.036	35.843	0.036	0.00%
P03	35.843	0.036	35.843	0.036	0.00%
P04					
P05	49.566	0.050	49.547		-0.04%
P06	35.843	0.036	35.859	0.036	0.05%
P07	35.843	0.036	35.850	0.036	0.02%
P08	35.226	0.035	35.190		-0.10%
P09	35.843	0.036	35.844	0.036	0.00%
P10					
P11	35.843	0.036	35.835	0.036	-0.02%
P12	35.843	0.036	35.833	0.036	-0.03%
P13	35.843	0.036	35.824	0.036	-0.05%
P14	35.843	0.036	35.818	0.036	-0.07%
P15	35.843	0.036	35.832	0.036	-0.03%
P16					
P17					
P18	35.843	0.036	35.842	0.035	0.00%
P19	35.843	0.036	35.844	0.036	0.00%
P20	35.843	0.036	35.837	0.036	-0.02%
P21					
P22	35.843	0.036	35.855	0.036	0.03%
P23					
P24	35.843	0.036	35.844	0.036	0.00%
P25	35.843	0.036	35.854	0.036	0.03%
P26	35.843	0.036	35.847	0.036	0.01%
P27	35.843	0.036	35.850	0.060	0.02%
P28	35.843	0.036	35.858	0.036	0.04%
P29	10.510	0.011	10.511	0.012	0.02%
P30	37.824	0.038	37.815	0.038	-0.02%
P31	35.843	0.036	35.859	0.036	0.04%
P32	35.843	0.036	35.851	0.036	0.02%
P33	35.219	0.035	35.190		-0.08%

inferior calorific value

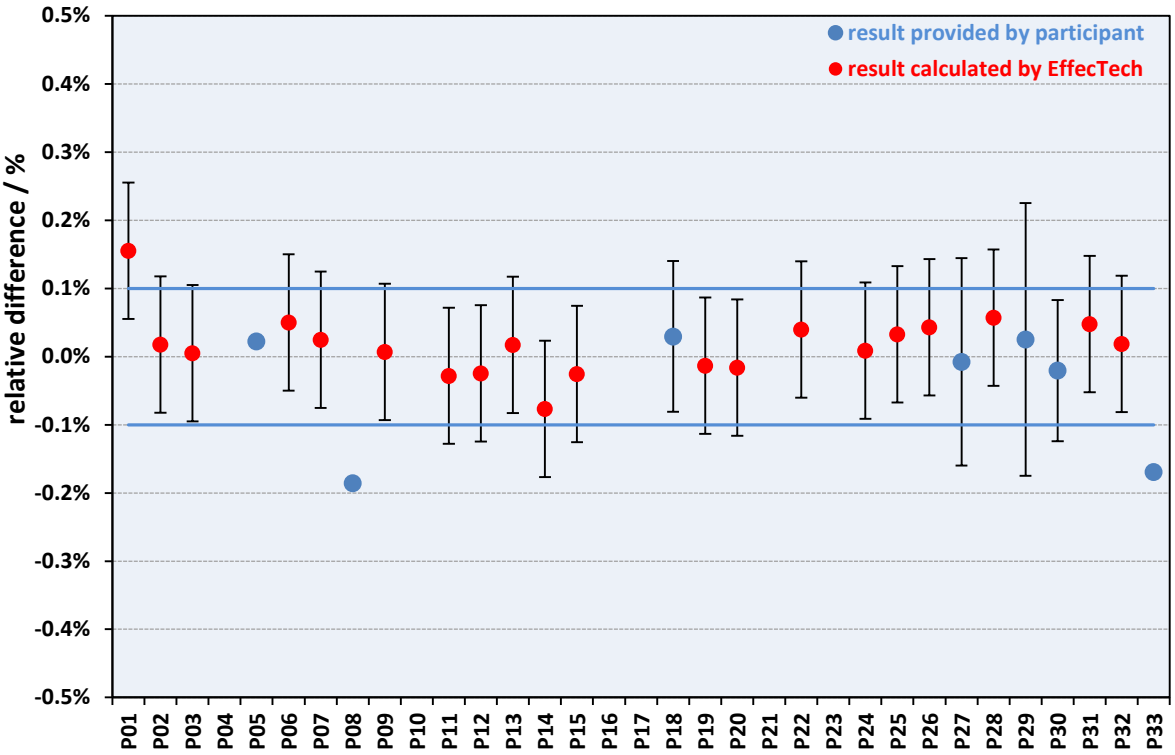


Mixture	LNG
Property	density

Reference and reported data

participant id	calculated reference value	assigned uncertainty	participant reported / calculated	reported / calculated uncertainty	relative difference
P01	0.72314	0.00072	0.72426	0.00072	0.16%
P02	0.72314	0.00072	0.72327	0.00072	0.02%
P03	0.72314	0.00072	0.72317	0.00072	0.00%
P04					
P05	0.72314	0.00072	0.72330		0.02%
P06	0.72314	0.00072	0.72350	0.00072	0.05%
P07	0.72314	0.00072	0.72332	0.00072	0.02%
P08	0.71072	0.00071	0.70940		-0.19%
P09	0.72314	0.00072	0.72319	0.00072	0.01%
P10					
P11	0.72314	0.00072	0.72293	0.00072	-0.03%
P12	0.72314	0.00072	0.72296	0.00072	-0.02%
P13	0.72314	0.00072	0.72326	0.00072	0.02%
P14	0.72314	0.00072	0.72258	0.00072	-0.08%
P15	0.72314	0.00072	0.72295	0.00072	-0.03%
P16					
P17					
P18	0.72314	0.00072	0.72335	0.00080	0.03%
P19	0.72314	0.00072	0.72304	0.00072	-0.01%
P20	0.72314	0.00072	0.72302	0.00072	-0.02%
P21					
P22	0.72314	0.00072	0.72342	0.00072	0.04%
P23					
P24	0.72314	0.00072	0.72320	0.00072	0.01%
P25	0.72314	0.00072	0.72337	0.00072	0.03%
P26	0.72314	0.00072	0.72345	0.00072	0.04%
P27	0.72314	0.00072	0.72308	0.00110	-0.01%
P28	0.72314	0.00072	0.72355	0.00072	0.06%
P29	0.76320	0.00076	0.76339	0.00153	0.03%
P30	0.76320	0.00076	0.76304	0.00079	-0.02%
P31	0.72314	0.00072	0.72348	0.00072	0.05%
P32	0.72314	0.00072	0.72327	0.00072	0.02%
P33	0.71054	0.00071	0.70934		-0.17%

density

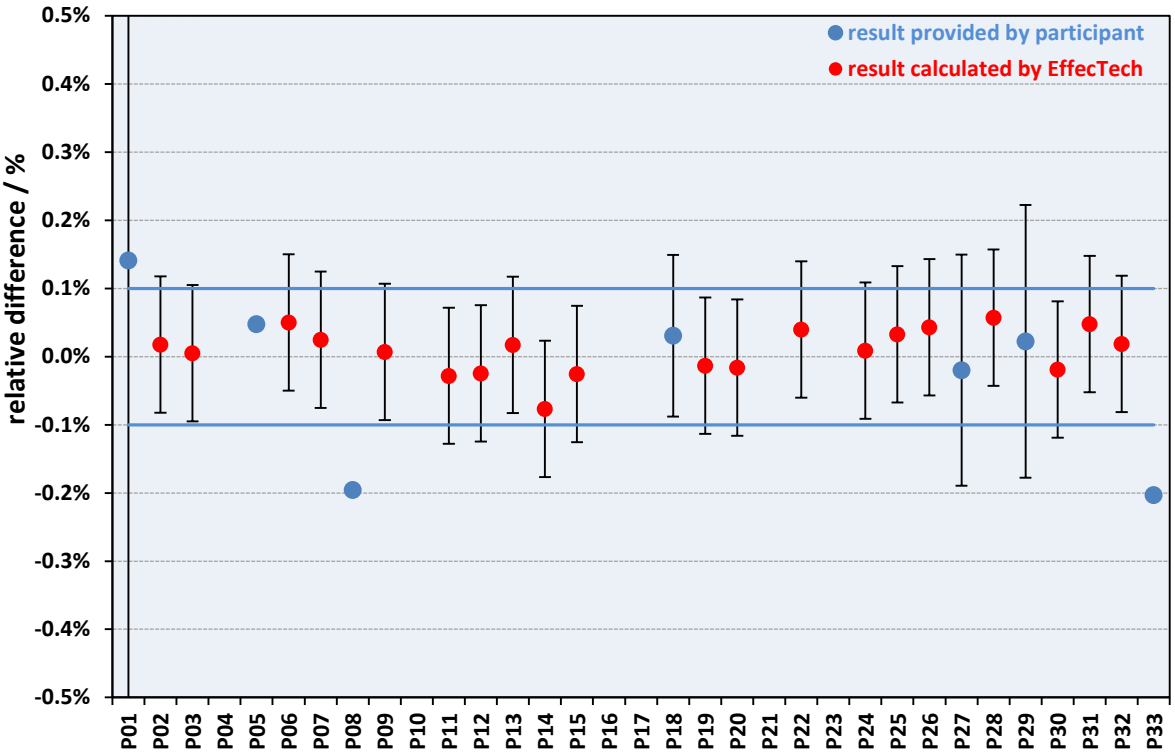

result provided by participant
result calculated by EffecTech
relative difference / %
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
-0.1%
-0.2%
-0.3%
-0.4%
-0.5%
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P20 P21 P22 P23 P24 P25 P26 P27 P28 P29 P30 P31 P32 P33

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	0.59012	0.00059	0.59095	0.00736	0.14%
P02	0.59012	0.00059	0.59022	0.00059	0.02%
P03	0.59012	0.00059	0.59015	0.00059	0.00%
P04					
P05	0.59012	0.00059	0.59040		0.05%
P06	0.59012	0.00059	0.59041	0.00059	0.05%
P07	0.59012	0.00059	0.59027	0.00059	0.02%
P08	0.59008	0.00059	0.58893		-0.20%
P09	0.59012	0.00059	0.59016	0.00059	0.01%
P10					
P11	0.59012	0.00059	0.58995	0.00059	-0.03%
P12	0.59012	0.00059	0.58997	0.00059	-0.02%
P13	0.59012	0.00059	0.59022	0.00059	0.02%
P14	0.59012	0.00059	0.58967	0.00059	-0.08%
P15	0.59012	0.00059	0.58997	0.00059	-0.03%
P16					
P17					
P18	0.59012	0.00059	0.59030	0.00070	0.03%
P19	0.59012	0.00059	0.59004	0.00059	-0.01%
P20	0.59012	0.00059	0.59002	0.00059	-0.02%
P21					
P22	0.59012	0.00059	0.59035	0.00059	0.04%
P23					
P24	0.59012	0.00059	0.59017	0.00059	0.01%
P25	0.59012	0.00059	0.59031	0.00059	0.03%
P26	0.59012	0.00059	0.59037	0.00059	0.04%
P27	0.59012	0.00059	0.59000	0.00100	-0.02%
P28	0.59012	0.00059	0.59046	0.00059	0.06%
P29	0.59029	0.00059	0.59042	0.00118	0.02%
P30	0.59029	0.00059	0.59018	0.00059	-0.02%
P31	0.59012	0.00059	0.59040	0.00059	0.05%
P32	0.59012	0.00059	0.59023	0.00059	0.02%
P33	0.59008	0.00059	0.58888		-0.20%

relative density

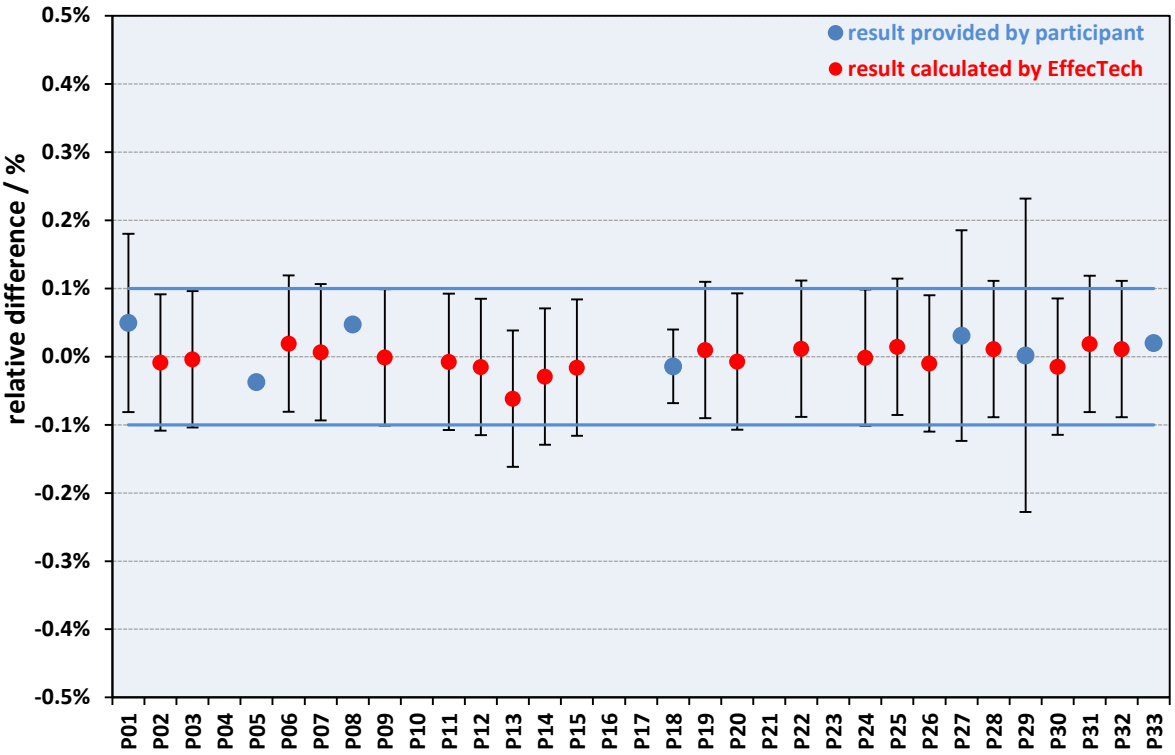


Mixture	LNG
Property	Wobbe index

Reference and reported data

participant id	calculated reference value	assigned uncertainty	participant reported / calculated	reported / calculated uncertainty	relative difference
P01	51.729	0.052	51.755	0.068	0.05%
P02	51.729	0.052	51.725	0.052	-0.01%
P03	51.729	0.052	51.727	0.052	0.00%
P04					
P05	51.729	0.052	51.710		-0.04%
P06	51.729	0.052	51.739	0.052	0.02%
P07	51.729	0.052	51.732	0.052	0.01%
P08	50.816	0.051	50.840		0.05%
P09	51.729	0.052	51.728	0.052	0.00%
P10					
P11	51.729	0.052	51.725	0.052	-0.01%
P12	51.729	0.052	51.721	0.052	-0.02%
P13	51.729	0.052	51.697	0.052	-0.06%
P14	51.729	0.052	51.714	0.052	-0.03%
P15	51.729	0.052	51.721	0.052	-0.02%
P16					
P17					
P18	51.729	0.052	51.722	0.028	-0.01%
P19	51.729	0.052	51.734	0.052	0.01%
P20	51.729	0.052	51.725	0.052	-0.01%
P21					
P22	51.729	0.052	51.735	0.052	0.01%
P23					
P24	51.729	0.052	51.728	0.052	0.00%
P25	51.729	0.052	51.737	0.052	0.01%
P26	51.729	0.052	51.724	0.052	-0.01%
P27	51.729	0.052	51.745	0.080	0.03%
P28	51.729	0.052	51.735	0.052	0.01%
P29	15.187	0.015	15.187	0.035	0.00%
P30	54.531	0.055	54.523	0.055	-0.01%
P31	51.729	0.052	51.739	0.052	0.02%
P32	51.729	0.052	51.735	0.052	0.01%
P33	50.830	0.051	50.840		0.02%

Wobbe index


result provided by participant
result calculated by EffecTech
relative difference / %
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
-0.1%
-0.2%
-0.3%
-0.4%
-0.5%
P01
P02
P03
P04
P05
P06
P07
P08
P09
P10
P11
P12
P13
P14
P15
P16
P17
P18
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P20
P21
P22
P23
P24
P25
P26
P27
P28
P29
P30
P31
P32
P33

Sulphur component mixture

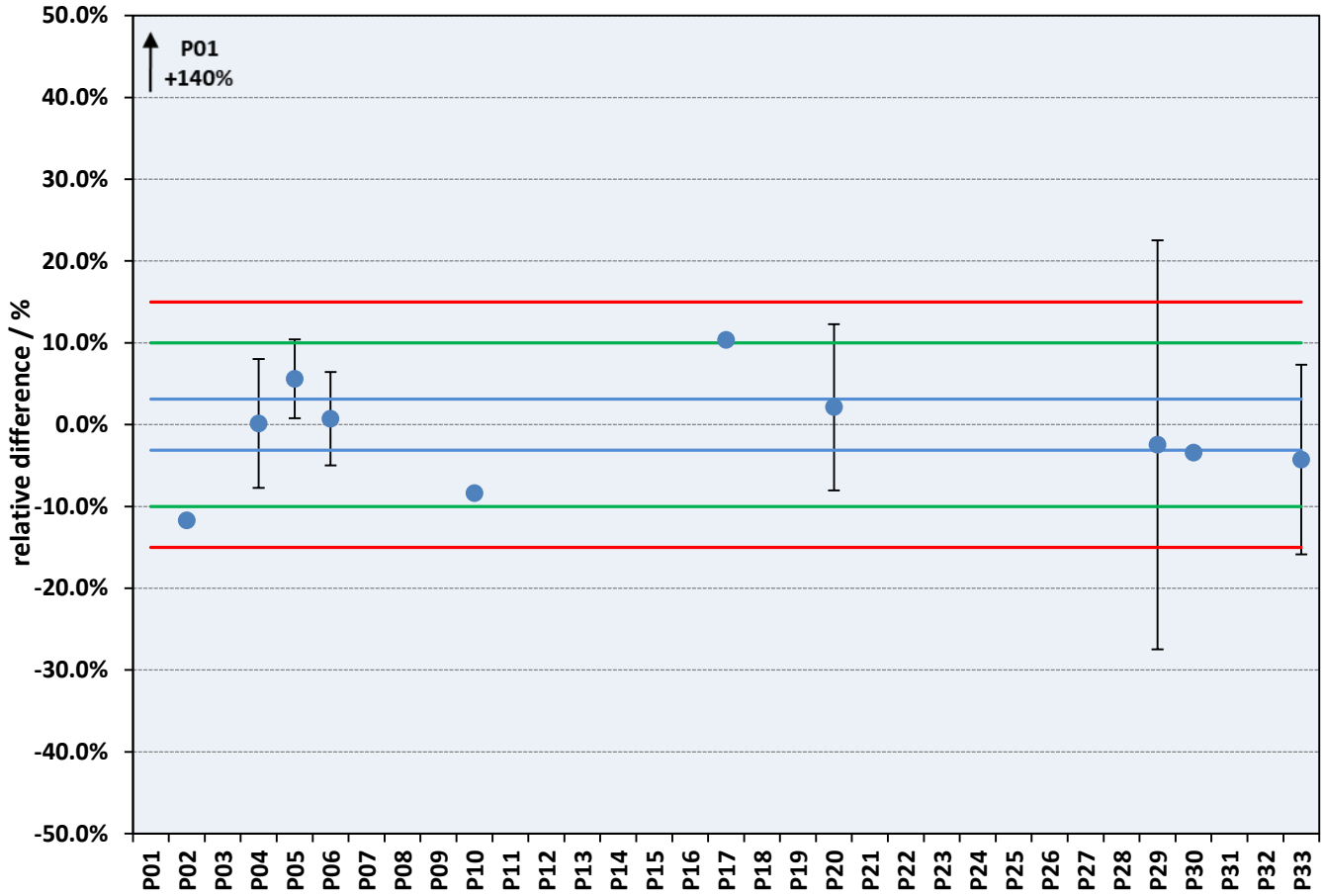
Mixture	sulphur
Component	hydrogen sulphide

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	2.786	0.087	µmol/mol	0.139	µmol/mol

Reported data

id	value (µmol/mol)	U (k=2) (µmol/mol)	relative difference	***z'***-score	E_n-number
P01	6.683	0.412	139.88%	**26.71**	**9.25**
P02	2.460		-11.70%	**-2.23**	
P03					
P04	2.790	0.220	0.14%	**0.03**	**0.02**
P05	2.942	0.142	5.60%	**1.07**	**0.94**
P06	2.806	0.160	0.72%	**0.14**	**0.11**
P07					
P08					
P09					
P10	2.552		-8.40%	**-1.60**	
P11					
P12					
P13					
P14					
P15					
P16					
P17	3.074	0.008	10.34%	**1.97**	**3.30**
P18					
P19					
P20	2.845	0.290	2.12%	**0.40**	**0.20**
P21					
P22					
P23					
P24					
P25					
P26					
P27					
P28					
P29	2.717	0.679	-2.48%	**-0.47**	**-0.10**
P30	2.690		-3.43%	**-0.66**	
P31					
P32					
P33	2.667	0.309	-4.27%	**-0.82**	**-0.37**

hydrogen sulphide in sulphur composition



Reference values	
x_{ref}	2.786
$U(x_{ref})$ k=2	0.087

Consensus values (raw data)		
m	3.329	
s_r	0.108	3.23%
s_L	1.430	42.96%
s_R	1.434	43.08%
p	11	

Consensus values (corrected)		
m	2.797	
s_r	0.074	2.65%
s_L	0.159	5.67%
s_R	0.175	6.26%
p	10	

Mixture	sulphur
Component	carbonyl sulphide

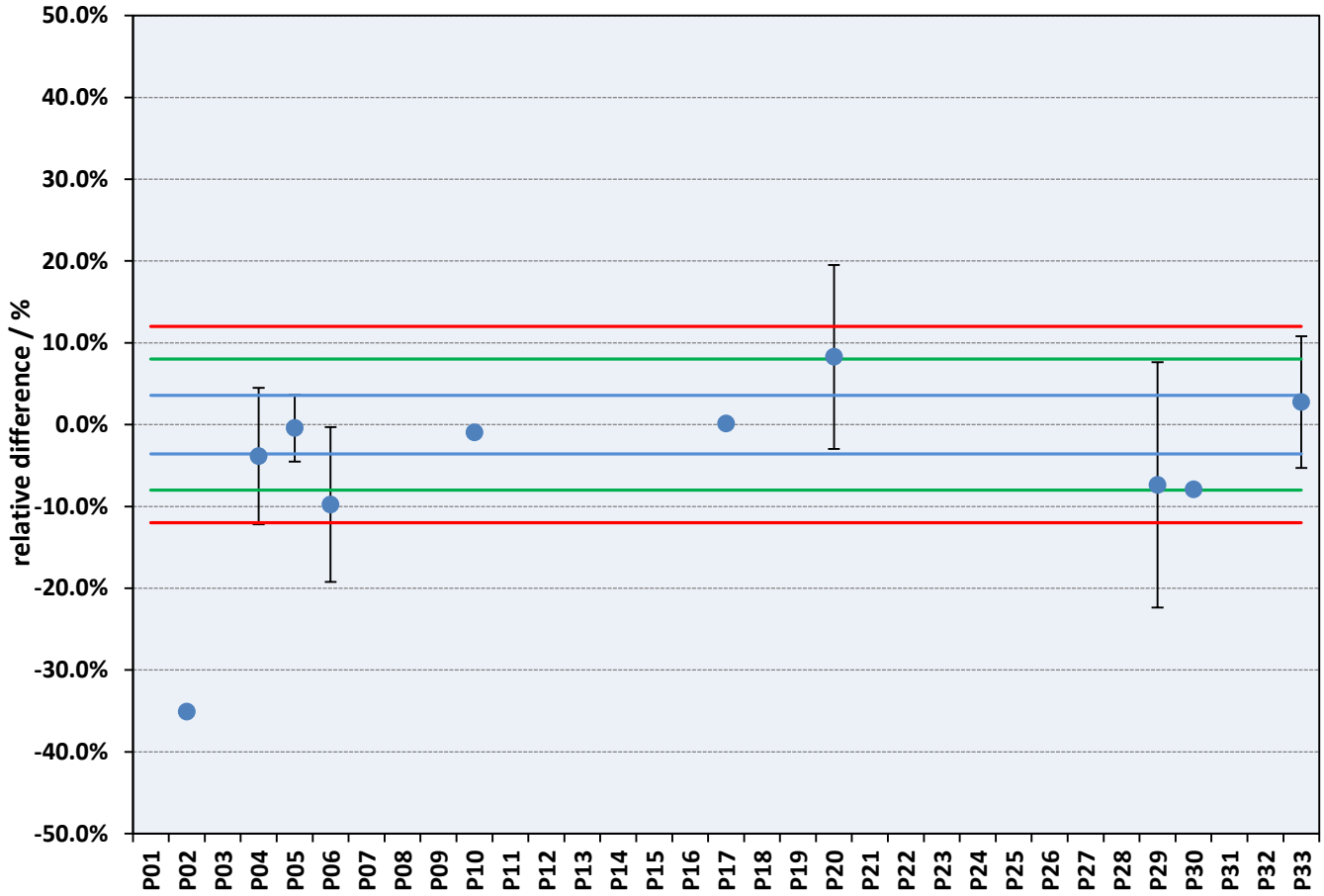
Reference

x_{ref}	$U(x_{ref})$ k=2		σ	
1.872	0.067	µmol/mol	0.075	µmol/mol

Reported data

id	value (µmol/mol)	U (k=2) (µmol/mol)	relative difference	***z'***-score	E_n-number
P01					
P02	1.215		-35.10%	**-8.01**	
P03					
P04	1.800	0.150	-3.85%	**-0.88**	**-0.44**
P05	1.864	0.076	-0.43%	**-0.10**	**-0.08**
P06	1.689	0.160	-9.77%	**-2.23**	**-1.05**
P07					
P08					
P09					
P10	1.854		-0.97%	**-0.22**	
P11					
P12					
P13					
P14					
P15					
P16					
P17	1.874	0.003	0.11%	**0.03**	**0.03**
P18					
P19					
P20	2.027	0.228	8.27%	**1.89**	**0.65**
P21					
P22					
P23					
P24					
P25					
P26					
P27					
P28					
P29	1.734	0.260	-7.37%	**-1.68**	**-0.51**
P30	1.724		-7.92%	**-1.81**	
P31					
P32					
P33	1.924	0.155	2.76%	**0.63**	**0.31**

carbonyl sulphide in sulphur composition



Reference values	
x_{ref}	1.872
$U(x_{ref})$ k=2	0.067

Consensus values (raw data)		
m	1.809	
s_r	0.072	4.00%
s_L	0.160	8.85%
s_R	0.176	9.71%
p	10	

Consensus values (corrected)		
m	1.828	
s_r	0.047	2.57%
s_L	0.115	6.32%
s_R	0.125	6.82%
p	9	

Mixture	sulphur
Component	methyl mercaptan

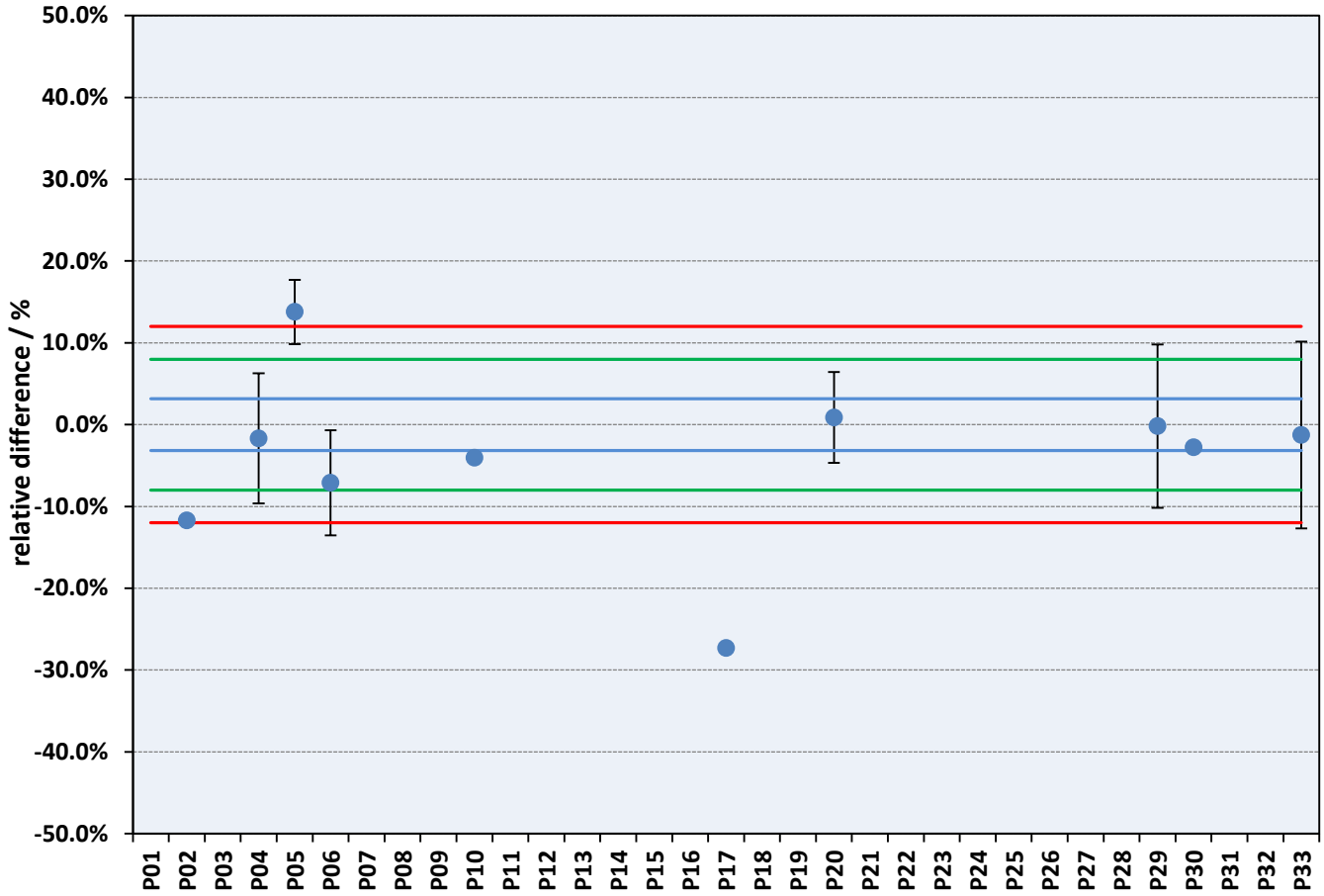
Reference

x_{ref}	$U(x_{ref})$ k=2		σ	
2.685	0.085	µmol/mol	0.107	µmol/mol

Reported data

id	value (µmol/mol)	U (k=2) (µmol/mol)	relative difference	***z'***-score	E_n-number
P01					
P02	2.370		-11.73%	**-2.73**	
P03					
P04	2.640	0.210	-1.68%	**-0.39**	**-0.20**
P05	3.055	0.120	13.78%	**3.20**	**2.52**
P06	2.494	0.160	-7.11%	**-1.65**	**-1.05**
P07					
P08					
P09					
P10	2.576		-4.06%	**-0.94**	
P11					
P12					
P13					
P14					
P15					
P16					
P17	1.952	0.002	-27.30%	**-6.35**	**-8.62**
P18					
P19					
P20	2.709	0.150	0.88%	**0.20**	**0.14**
P21					
P22					
P23					
P24					
P25					
P26					
P27					
P28					
P29	2.680	0.268	-0.19%	**-0.04**	**-0.02**
P30	2.610		-2.80%	**-0.65**	
P31					
P32					
P33	2.651	0.303	-1.25%	**-0.29**	**-0.11**

methyl mercaptan in sulphur composition



Reference values	
x_{ref}	2.685
$U(x_{ref})$ k=2	0.085

Consensus values (raw data)		
m	2.518	
s_r	0.063	2.48%
s_L	0.283	11.22%
s_R	0.289	11.50%
p	10	

Consensus values (corrected)		
m	2.625	
s_r	0.064	2.45%
s_L	0.111	4.24%
s_R	0.128	4.89%
p	9	

Mixture	sulphur
Component	ethyl mercaptan

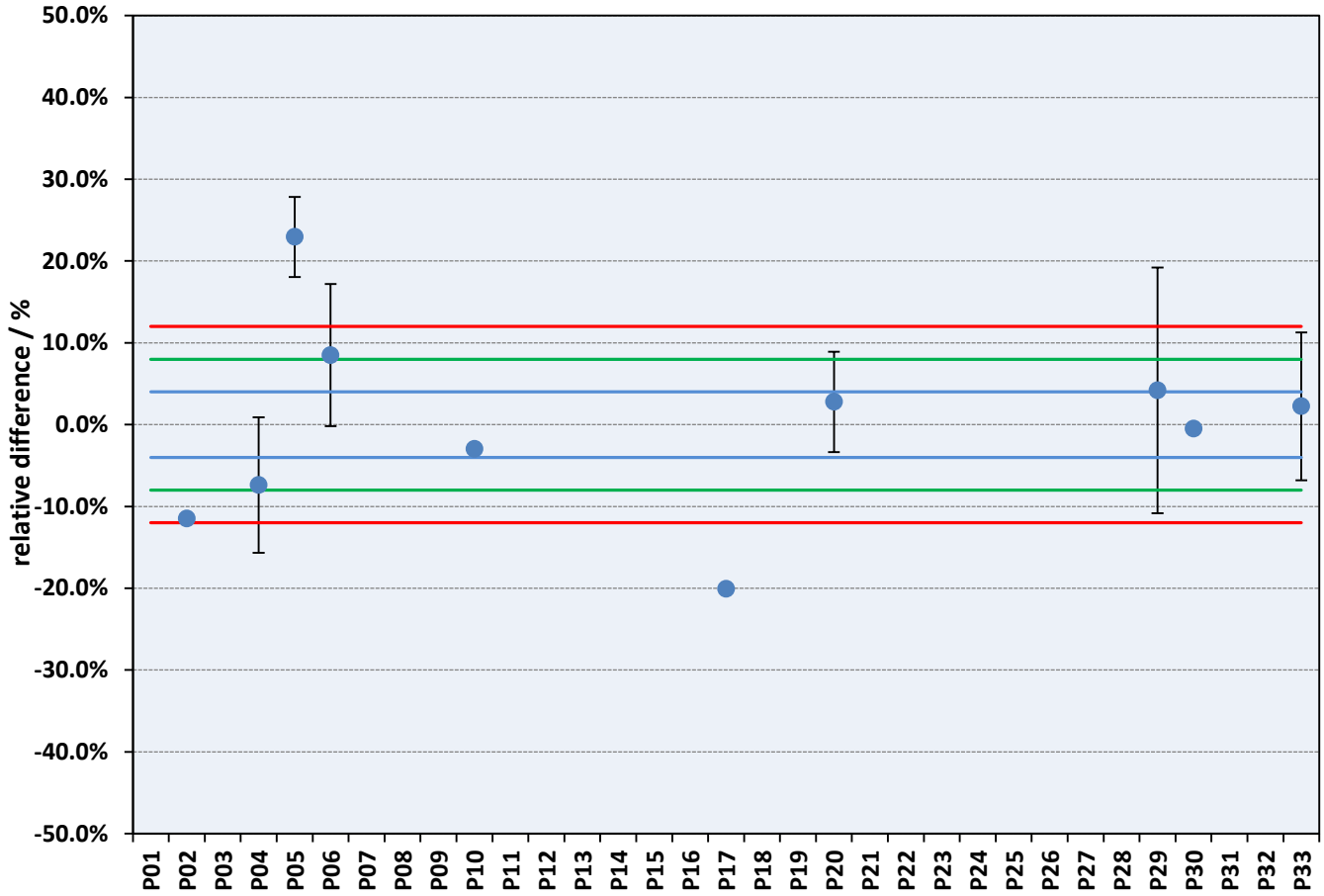
Reference

x_{ref}	$U(x_{ref})$ k=2		σ	
1.695	0.068	µmol/mol	0.068	µmol/mol

Reported data

id	value (µmol/mol)	U (k=2) (µmol/mol)	relative difference	z'-score	E_n-number
P01					
P02	1.500		-11.50%	-2.57	
P03					
P04	1.570	0.130	-7.37%	-1.65	-0.85
P05	2.084	0.102	22.95%	5.13	3.17
P06	1.839	0.160	8.50%	1.90	0.83
P07					
P08					
P09					
P10	1.645		-2.97%	-0.66	
P11					
P12					
P13					
P14					
P15					
P16					
P17	1.355	0.001	-20.08%	-4.49	-5.01
P18					
P19					
P20	1.742	0.107	2.78%	0.62	0.37
P21					
P22					
P23					
P24					
P25					
P26					
P27					
P28					
P29	1.766	0.265	4.19%	0.94	0.26
P30	1.687		-0.48%	-0.11	
P31					
P32					
P33	1.733	0.157	2.24%	0.50	0.22

ethyl mercaptan in sulphur composition



Reference values	
x_{ref}	1.695
$U(x_{ref})$ k=2	0.068

Consensus values (raw data)		
m	1.663	
s_r	0.049	2.93%
s_L	0.179	10.77%
s_R	0.186	11.16%
p	10	

Consensus values (corrected)		
m	1.656	
s_r	0.049	2.94%
s_L	0.171	10.35%
s_R	0.178	10.76%
p	9	

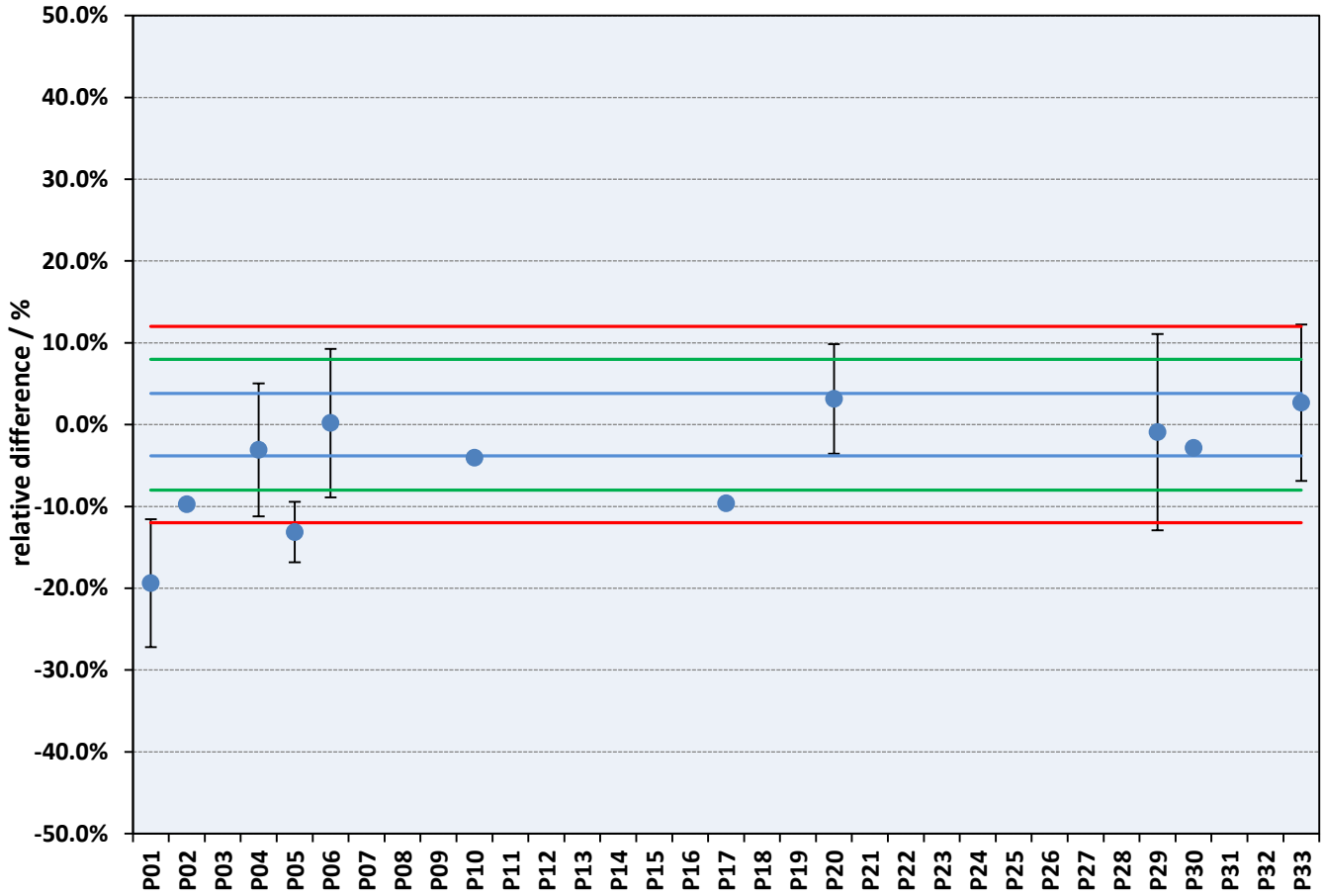
Mixture	sulphur
Component	dimethyl sulphide

Reference	x_{ref}	$U(x_{ref})$ k=2		σ	
	1.651	0.063	µmol/mol	0.066	µmol/mol

Reported data

id	value (µmol/mol)	U (k=2) (µmol/mol)	relative difference	***z'***-score	E_n-number
P01	1.331	0.104	-19.38%	**-4.37**	**-2.63**
P02	1.490		-9.75%	**-2.20**	
P03					
P04	1.600	0.130	-3.09%	**-0.70**	**-0.35**
P05	1.434	0.053	-13.14%	**-2.97**	**-2.64**
P06	1.654	0.150	0.19%	**0.04**	**0.02**
P07					
P08					
P09					
P10	1.584		-4.07%	**-0.92**	
P11					
P12					
P13					
P14					
P15					
P16					
P17	1.492	0.002	-9.62%	**-2.17**	**-2.52**
P18					
P19					
P20	1.703	0.114	3.15%	**0.71**	**0.40**
P21					
P22					
P23					
P24					
P25					
P26					
P27					
P28					
P29	1.636	0.196	-0.91%	**-0.21**	**-0.07**
P30	1.604		-2.87%	**-0.65**	
P31					
P32					
P33	1.695	0.162	2.68%	**0.61**	**0.26**

dimethyl sulphide in sulphur composition



Reference values	
x_{ref}	1.651
$U(x_{ref})$ k=2	0.063

Consensus values (raw data)		
m	1.575	
s_r	0.050	3.20%
s_L	0.125	7.97%
s_R	0.135	8.58%
p	11	

Consensus values (corrected)		
m	1.614	
s_r	0.049	3.05%
s_L	0.077	4.78%
s_R	0.092	5.67%
p	10	

Mixture	sulphur
Component	total sulphur

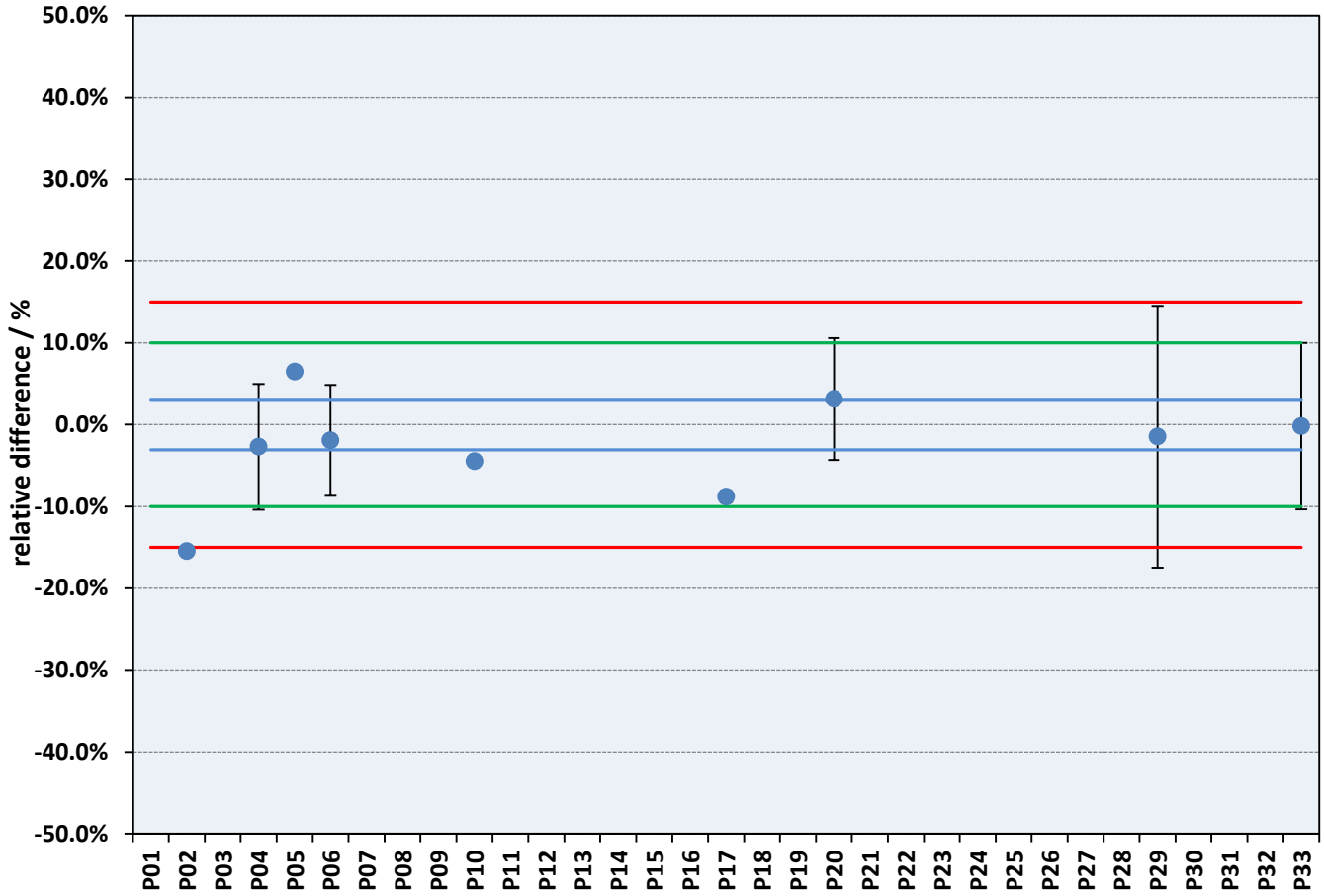
Reference

x_{ref}	$U(x_{ref})$ k=2		σ	
10.69	0.33	µmol/mol	0.53	µmol/mol

Reported data

id	value (µmol/mol)	U (k=2) (µmol/mol)	relative difference	***z'***-score	E_n-number
P01					
P02	9.04		-15.48%	-2.96	
P03					
P04	10.40	0.80	-2.71%	-0.52	-0.34
P05	11.38		6.45%	1.23	
P06	10.48	0.71	-1.94%	-0.37	-0.27
P07					
P08					
P09					
P10	10.21		-4.49%	-0.86	
P11					
P12					
P13					
P14					
P15					
P16					
P17	9.75	0.07	-8.82%	-1.69	-2.80
P18					
P19					
P20	11.03	0.82	3.14%	0.60	0.38
P21					
P22					
P23					
P24					
P25					
P26					
P27					
P28					
P29	10.53	1.69	-1.47%	-0.28	-0.09
P30					
P31					
P32					
P33	10.67	1.09	-0.18%	-0.04	-0.02

total sulphur in sulphur composition



Reference values	
x_{ref}	10.69
$U(x_{ref})$ k=2	0.33

Consensus values (raw data)		
m	10.40	
s_r	0.25	2.39%
s_L	0.49	4.69%
s_R	0.55	5.26%
p	9	

Consensus values (corrected)		
m	10.40	
s_r	0.25	2.39%
s_L	0.49	4.69%
s_R	0.55	5.26%
p	9	