The effect of temperature changes on the uncertainty of the LNG density

Uncertainty budget for the LNG density using temperature sensitivity method

Rank	Source	Units	Value	Uncertainty U	U*%	Distribution	Divisor k	Stand. Unc u	Sensitivity (∂f/∂x_i) c	Product u.c	Square $(u.c)^2$
5	Composition	kg/m^3	458.479	0.215	0.047	Rectangular	1.732	0.124	1	0.124	1.54E-02
1	Klosek-McKinley Method	kg/m^3	458.479	0.458	0.100	Rectangular	1.732	0.265	1	0.265	7.01E-02
4	Exp data to derive K-M Model	kg/m^3	458.479	0.275	0.060	Normal	2.000	0.138	1	0.138	1.89E-02
3	Temperature	°C	-160.000	0.2	-0.125	Rectangular	1.732	0.115	-1.3709	-0.158	2.51E-02
2	Temp - field experience	°C	-160.000	0.3	-0.188	Rectangular	1.732	0.173	-1.3709	-0.237	5.64E-02
	Combined uncertainty	kg/m^3	458.479	0.862	0.188	Normal	2	0.431	1	0.431	1.86E-01

Uncertainty budget for the LNG density

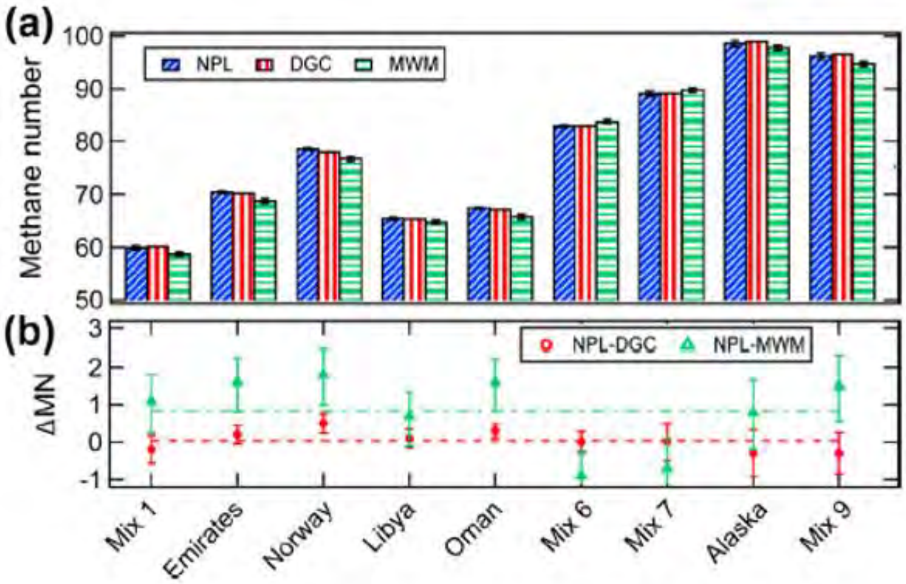
Rank	Source	Units	Value	Uncert. U	U*%	Distribution	Divisor k	Stand. Unc u	Sens. (∂f/∂x_i) c	Product u.c	Square $(u.c)^2$
5	Composition	kg/m^3	458.479	0.215	0.047	Rectangular	1.732	0.124	1	0.124	1.54E-02
2	Revised Klosek-McKinley Method	kg/m^3	458.479	0.458	0.100	Rectangular	1.732	0.265	1	0.265	7.01E-02
4	Exp data to derive K-M Model	kg/m^3	458.479	0.275	0.060	Normal	2.000	0.138	1	0.138	1.89E-02
3	Temperature (±0.2 °C)	kg/m^3	458.479	0.320	0.070	Rectangular	1.732	0.185	1	0.185	3.41E-02
1	Temp - Field experience (additional ±0.3 °C)	kg/m^3	458.479	0.480	0.105	Rectangular	1.732	0.277	1	0.277	7.68E-02
	Combined uncertainty	kg/m^3	458.479	0.928	0.202	Normal	2	0.464	1	0.464	2.15E-01

- Comparing the different methods gives an insignificant difference in the density uncertainty of ±0.014%.

SENSITIVITY STUDY OF LNG ENERGY TRANSFER UNCERTAINTY FROM COMPOSITION AND TEMPERATURE CHANGES,
https://lngmetrology.info/publications /reports

Methane number

- A new algorithm, based on existing algorithms such as the AVL and MWM, has been developed
- The new algorithm pays special attention to the influence of heavier hydrocarbons as the concentration of these components in stored LNG incresses over time.
- None of the other algorithms provide information about the uncertainties in their results
- Resulting uncertainty strongly depends on LNG composition
- Uncertainty values vary between 0.2 and 0.7 MN or 0.3 and 0.8% (k=2)



- Novel algorithm shows a good agreement with other popular methods for the set of exemplar LNG mixtures

Achivements towards uncertainty reduction

- Development of a primary LNG mass flow standard (25 m^3/h) with a CMC of 0.12 - 0.15%
- Establishment of the real uncertainty for (state of the art) ship-based tank-gauging methods by performing a comprehensive metrological study
- Standard based LDV device and associated uncertainty to support the validation of the mid-scal flow calibration facility
- Development and validated an advanced primary LNG densimeter system (single-sinker) to produce new reference data with a target uncertainty of 0.02%. The achieved reported uncertainty in 2016, 0.02%.
- Development and validation of new fundumental EOS (ERKM) for LNG density prediction for a boader range of temperature ($115K \leq T \leq 135\ K$) and the associated uncertainty. A prototype speed of sound sensor has been developed for on-line density and speed of sound measurements to transfer the metrological traceability to field operation.
- A new algorithm for methane number, based on existing algorithms such as the AVL and MWM, has been developed, associated uncertainty between 0.3 to 0.8% (K=2).

Thank you for your attention

Justervesenet