Metrological traceability in LNG custody transfer

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Metrological traceability in natural gas energy measurement

• Quantity
  – Volumetric flow rate measurement
  – Metrological traceability to the harmonised m³

• Quality
  – Composition analysis ISO 6974
  – Calorific value and density calculation ISO 6976
  – Metrological traceability requirements documented in ISO 14111
Long history of LNG

1917  First LNG plant in operation ... for the production of He
1941  First commercial LNG plant
1959  First shipment of LNG from USA to UK
1964  LNG train set up between Algeria and UK

Carl von Linde developed commercial air separation in 1895

Cutting edge research in gas metrology
Large Scale LNG: Reducing Energy Measurement Uncertainties, Transparency, Simpler Processes

Small scale LNG: Regulations (legal metrology), Certified Dispensing Systems, Flow Meter Calibrations
Measurements of LNG

Large scale LNG business
Measurement of energy

Small scale LNG business
Measurement of energy?
Measurement of kilograms?
Measurement of liters?
LNG import in Europe

50 Bcm = 36 Mt(LNG)
LNG import outside Europe

Strong Asian LNG demand growth

Source: BG Group outlook 2013

Asia represents 75% of global trade in 2025

CAGR 2000 – 2010: 6.2% pa
CAGR 2010 – 2025: 6.1% pa
Impact of measurement uncertainty

Large scale LNG

- Typical terminal (10 bm³(N)/year)
  Measurement uncertainty equivalent to
  25 M€/year

One cargo load (Qmax)

- Measurement uncertainty equivalent to
  500 k€

Small scale LNG

- Measurement capabilities not at par
  with other fuel legal metrological
  requirements
Reference values up to 10,000 m³/h uncertainty 0.2% (LNG 5, …)

Reference values up to 1000 m³/h uncertainty 0.2% (LNG 3 & 4)

Reference values up to 200 m³/h uncertainty 0.15% (LNG 2b)

Primary reference values up to 25 m³/h uncertainty ~0.2% (LNG 2a)

Primary reference values up to 25 m³/h uncertainty 0.1% (LNG 2a)

Primary reference values up to 25 m³/h uncertainty ~0.2% (LNG I)

Large scale LNG, main driver: energy security. Targets: reduced measurement uncertainty, transparency, simpler processes

Small and mid scale LNG and LBG, main driver: energy transition. Targets: certified dispensing systems, reduced measurement uncertainty

Feasibility, design, business case

Realization facility
LNG Flow measurement
Primary standard 25 m³/h
Water based calibration?

Overview VSL test results MFM's, Calibrated at LNG, May-June 2013

Deviation MuT [%]

Deviation 'Capetown' [%]

Mass Flow Rate [kg/s]
Example set of test results MFM at LNG, May-July 2013

Deviation MuT [%] vs Mass Flow Rate [kg/s]

Water vs LNG

Water vs LIN

Primary
Water bas
LNG research and calibration facility

Site preparation
Technical drawings

Overview
First and second phase

Phase 1: 5-200 m³/hr

Phase 2: 200-400 m³/hr
Traceability
LNG composition
Two ways …

1. Sampling and gas chromatography
   - Sampling
   - Vaporising
   - Gas chromatographic analysis

2. Online measurement
   - Probe
   - Raman spectroscopy?!
Metrological traceability

• Option 1
  – Issues with sampling
  – Issues with vaporising
  – GC analysis conformant ISO 6974 and traceability as for natural gas

• Option 2
  – Calibration of Raman spectrometer using liquid (!) reference standards
  – Reference standards should be connected to existing PSMs for natural gas
Composition standard

- Special design sampler (subcooled conditions)
- Vaporisation at supercritical conditions
- Gas chromatograph
- Sampling volume flow rate 7.5 ml/min (≈ 5 L/min gas)
Validation of the LNG composition standard

Reference & Vaporizer

Reference Liquefier

Developed within the project

Sampler & Vaporizer

Supercritical vaporizing

Measurement 1 (Reference)

LNG calibration gas

Measurement 2 (Result)

Reference Result

Quantity (unit)

Validation of the LNG composition standard

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Composition measurement system for LNG

Supercritical vaporizing

P > P_c
T > T_c
Release P

Measurement 1
(Reference)

Measurement 2
(Result)

Commercial Sampler Vaporizer

LNG loop

Liquid Sampler

Reference

Vaporizer

calibration gas mixtures

Composition measurement system for LNG

Measurement 2
(Result)
In conclusion …

• LNG is metered using mass flow rate measurement
• Calibration of flow meters requires LNG
• Sampling and vaporising critical for traceable energy measurement
• Raman has still to prove that it is a full-fetched replacement for the GC
• Connection to existing infrastructure for natural gas critical success factor
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