**Metrology for LNG supply chain**

Development of a new cryogenic flow metering technology using Laser Doppler velocimetry.

ATEX Certificate of conformity:

INERIS 16ATEX0202X (Equipment intended for use in potentially explosive atmospheres)

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**Principle of LDV Volume Flowrate Measurement**

Laser wavelength $\lambda$:
- Laser power: up to 300W
- $\lambda$: 520 nm (green light)
- Beam size: 1 mm
- Focal length: $L_2$: 200 mm
- $f_0$: 16 ns
- $T_{peak}$: 40 ns

Measurement volume:

$$U = \frac{\Delta f D}{Q}$$

The volume flow measurement $Q$ based upon the measurement of velocity profiles at a nozzle exit plane is directly traced back to SI units of Length and Time.

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**On-site calibration of cryogenic flow meters**

Site experiments: ELENGY and ENGIE Lab ORIGEN:
- On-site measurements were carried out at Montrouge-du-Bourgogne LNG terminal (France) during routine trunk filling operations.
- The tests were transparent for the operators.
- Natural micron-sized tracers ensure the quality of the measurements.
- The standard has the required safety certifications for explosive atmospheres (ATEX)

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**Metrolgy for LNG & Energy Sales**

Energy transferred from the loading facilities to the LNG carrier or from the carrier to the unloading facilities.

$$E = \frac{V}{U_{LVG} \times D \times G \times U_{MV}}$$

Combined expanded uncertainty of measurement with 95% confidence level (coverage factor $k=2$)

$U_{E_{exp}}=k=2\times0.5-0.7\%$*  
$U_{E_{exp}}=k=2\times0.20-0.55\%$*

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**Level Gauging & Calibration Table**

(see gauges, calibration tables, correction tables, temperature probes distributed in the LNG tanks)

In line flow measurement of LNG:
- Coriolis Flowmeter
- Differential pressure Flowmeter
- Ultrasonic Flowmeter

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**Technical feasibility of LNG Flowrate Measurement using LDV**

**Challenges**
- Handle low cryogenic conditions with the LDV system and no flaring
- Design the optical access for the LDV at low temperature (-160°C) (towering down the stress in the optical window)
- Develop an adapted & clean seeding for LDV measurements (avoid any particulate present in the LNG or selected)
- Accuracy less than 0.3%

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**Air tests**

- Radial velocity profile at the throat
  - Jet profile is flat
  - Camarosa
  - Steep velocity gradient
  - No negative velocities

**LVG as flow measurement technology**

Results in cryogenic condition

- Mechanical behavior of LDV cryogenic measurement system
- Vacuum level required for cryogenic experiments
- Portability behavior with LNG flow
- Optical convergence of the beams in LNG
- Freezing of the porphires after several minutes in cryogenic conditions
- Permeability of the sensors
- 3D velocity measurements with LDV (coincidence) with pressure and cold conditions
- Portability: to measure the flow

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**References**