Emerson in the LNG market chain

Emerson Flow Portfolio & Solutions in the LNG supply chain

Skangas MID solution to comply with GIIGNL

Energy measurement: Emerson’s response to full compliance of the Int’l Std’s for the customer’s applications

- Consultancy & Services
Emerson in the LNG market chain

Emerson Flow Portfolio & Solutions in the LNG supply chain

Skangas MID solution to comply with GIIGNL

Energy measurement: Emerson’s response to full compliance of the Int’l Std’s for the customer’s applications

- Consultancy & Services
Major LNG Operations from Earth to Client

- Gas Production
- Compression & Pipeline
- Onshore Liquefaction
- FPSO/GBS
- Ship Loading
- LNG Shipping
- Offshore & Onshore LNG
- Receiving & Regasification
- Terminals
- Pipeline Delivery
Emerson is committed to the LNG Market

- Gas Production 100%
- Liquefaction plant 95-100%
- Shipping 90-100%
- Regasification Terminal 95-100%
- Distribution 100%: Pipeline, Truck Loading and Dispenser

Fisher Control Valves & Regulators, DeltaV, PlantWeb & AMS, Rosemount Measurement, Valve Automation, SAAB Ship Gauging & Ultrasonic
LNG Emerson Dynamic Flow Applications (Bunkering: on-shore or vessel/barge – truck loading)
LNG Emerson Dynamic Flow Applications (Bunkering: on-shore or vessel/barge)

Bunkering: Seagas (1st LNG bunkering vessel in the world) uses Emerson Mass Flowmeter since more than 1000 deliveries

Boil Off Gas: direct mass flow measurement to establish correct mass balance on LNG carriers
LNG Emerson Dynamic Flow Applications

- Inventory
- Tank management
- Blending
- Movement
- Pipelines
- Unit Feed
- Vessels
- Trucks
- Railroad

Tank management

Inventory

Blending

Movement

Pipelines

Unit Feed

Vessels

Trucks

Railroad
Emerson in the LNG market chain

**Emerson Flow Portfolio & Solutions in the LNG supply chain**

Skangas MID solution to comply with GIIGNL

Energy measurement: Emerson’s response to full compliance of the Int’l Std’s for the customer’s applications

- Consultancy & Services
## Daniel Gas and Liquid Ultrasonic Meters

### Daniel Gas Ultrasonic Meters

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daniel 3411/3412</td>
<td>Single and Dual Reflective Path Allocation Meters</td>
<td>3(\text{”} to 12(\text{”})</td>
</tr>
<tr>
<td>Daniel 3414</td>
<td>4-Path Daniel Chordal Custody Transfer</td>
<td>6(\text{”} to 42(\text{”})</td>
</tr>
<tr>
<td>Daniel 3415/3416/3417</td>
<td>Dual Configuration Meters Custody Transfer</td>
<td>8(\text{”} to 36(\text{”})</td>
</tr>
</tbody>
</table>

### Daniel Liquid Ultrasonic Meters

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daniel 3812</td>
<td>Dual Chordal Path Allocation and Check Meters</td>
<td>3(\text{”} to 12(\text{”})</td>
</tr>
<tr>
<td>Daniel 3814</td>
<td>4-Path Daniel Chordal Custody Transfer</td>
<td>6(\text{”} to 42(\text{”})</td>
</tr>
<tr>
<td>Daniel 3818 LNG</td>
<td>8-Path Daniel Chordal LNG Custody Transfer</td>
<td>6(\text{”} to 42(\text{”})</td>
</tr>
</tbody>
</table>
Technical Data Daniel 3818 LNG

**LNG Application**

**Perfomance**
- Linearity 0.15% of measured value over a 1.2 to 12.2 m/s

**Temperature**
- -196° to 60°C

**Pressure**
- 0 to 250 bars

**Line Size**
- DN200 (8") to DN900 (36")

**Rangeability**
- 0.6 to 12.2 m/s

**Installation**
- Typically 20D-USCO-5D

**Approvals**
- ATEX / PED / OIML R117-1 & MID

**Key Advantages**
- Highly accurate, stable, and redundant measurement in custody transfer applications
- Full-bore design, no obstruction, low pressure drop
- Inherently bi-directional
- High range-ability

**Some Constraints**
- Not designed for multi-phase fluids
- Highly corrosive fluids are not appropriate
- Extremely high velocity may be problematic
- Viscosity limitations in liquid applications restricted to Reynolds number above 4000
Typical LNG Flow Product Profile

Vortex

Volumetric Flow Temperature
Typical LNG Flow Product Profile

Venturi

Volumetric Flow
Typical LNG Flow Product Profile

Coriolis

Mass / Volumetric Flow Density / Temperature
Micro Motion for LNG

- Emerson Solution for Micro Motion meters
  - Transferability of Ede water calibration to field
  - No need for field calibration
  - Dedicated cryogenic procedure FL-NI-359

Emerson Cryo Zeroing Procedure

The observed errors with liquefied nitrogen did not exceed 0.3 %, including the uncertainty of the Cryogenic test installation (0.17%) and the uncertainty of the water calibration (0.05%), the expected errors will be within ±0.5% for cryogenic applications when only calibrated with water at ambient temperature.

NMi Declaration from project 14200852, applicable for CMF025; CMF050; CMF100; CMF200; CMF300; CMF350; CMF400; HC2; HC3 and HC4
EC Type Examination Certificate
Elite Series
LNG supply chains supported by Emerson; many include custody transfer applications

Bunkering loading / unloading on-shore / marine
LNG Bunkering

FEATURED PROJECT: Saga Fjordbase Ship Bunkering Terminal

The Saga Fjordbase ship bunkering terminal project in Flora, Norway has been formally completed.

Lepidean’s position in the project was the overall project management and the design of the concrete system. Lepidean worked closely with the terminal contractors, was responsible for the design of the concrete system and for ensuring that all contractors worked in close collaboration to achieve the overall project schedule.

The terminal is designed to accommodate 100 vessels as possible and allows bunkering of LNG to both ships and trucks. In addition, LNG can be delivered to the terminal from bulk carriers and ships, and it will also be possible to connect the terminal to a local gas grid at a later stage.

The terminal was successfully commissioned on 1st of July 2023 and became the project followed nearly the agreed time schedule. One of the main reasons for the success of this project was the very good collaboration and coordination among the project team and all the stakeholders. The project team, including the terminal owner, Saga Fjordbase, was very pleased with the result.

For questions concerning this project, please contact
Storage capacity:
- 20,000 m³
- 9,260 ton
- 126 GWh

Energy capacity/year: 3 TWh
Gorgon LNG Plant

End User: Chevron
Partners: Exxon Mobil
Destination: Australia
Project: Gorgon LNG
Scope:

- 2 x 30" Model 3818 (LNG loading)
- 6 x 30" Model 3812 (Amine Treater)
- 9 x 20" Model 3414 (Raw Gas Inlet)

Overview:
LNG plant, condensate handling facilities, carbon dioxide injection facilities and associated utilities
Daniel Gas USMs installed in 2004 for raw gas inlet to 7 LNG Trains in Trinidad & Tobago
Gas Production & Regasification

Daniel Gas USMs installed in all UK LNG receipt facilities
Gas Production & Regasification

Daniel Gas USMs installed in 1999, In place when LNG receipts restart in 2003

Dominion Cove Point LNG, LP
Gas Production & Regasification

Daniel Gas USMs on first LNG receipt facility in China 2003
LNG truck Loading at
Enagas Barcelona
Enagas Barcelona

- CMF 300 test meter on LNG
- Truck loading at Barcelona port
- Start up conducted June 15th, 2016
- Check the meter performance + - 0.35%
- Comparing with loading cells over 60 days test.
- Positive results!

LNG measurement for Small Scale applications: static vs. dynamic systems

**ABSTRACT**

Susana Sanz, Concepción Rabinal, Francisco Javier Lezau
Technology & Innovation Direction, Enagas S.A. (Spain)

**Background**

Enagas is involved in a strategic project, with EU funding, to promote the LNG utilization in SSLNG applications in Spain (bunkering, trucks fueling, etc).

Large Scale LNG Cargo is measured by a reliable/mature procedure of volumetric gauging for Custody Transfer. However, currently in SSLNG applications the fiscal measurement of the LNG transferred quantities is carried out with dynamic metering systems. The "state of the art" involves mass flowrate meters (Coriolis) and volumetric flowrate meters (Ultrasonic), but a suitable and traceable standard based on LNG is still not available.

Enagas made the decision of testing a Coriolis meter in order to get knowledge and evaluate new procedures for LNG Small Scale applications. The best way to check a new technology is by comparison against other mature and widely accepted technique, in this case the mass measured with a Coriolis meter calibrated with water, has been checked against a calibrated (and certified) weighbridge used to determine the mass of LNG loaded in trucks.

**Results and Conclusions**

175 truck loadings have been monitored, and operational data base of process parameters has been acquired from truck loading facility and from Coriolis meter with the proprietary software.

After selection of the suitable tests and mathematical treatment of data, totalized mass differences in a range of 0.7 % have been obtained (0.4% average and 0.1% standard deviation).

The best performance of the Coriolis meter is attained with LNG free of BOG bubbles, so recirculation of LNG and cooling of the meter is recommended before starting the fiscal measurement procedure.

As a result of the comparison between static and dynamic LNG metering systems (LNG truck weighbridge vs. Coriolis Mass Flowmeter) we can say that the differences between the two systems are acceptable. The mass metering in that kind of applications can be metrologically certified, following international recommendations and standards (i.e. MID), to be used with Custody Transfer purposes.

In fact, Enagas has already decided the implementation of LNG dynamic mass measurement with Coriolis meters for the new bunkering and loading facilities in its LNG terminals in Spain.
Zero calibration at Enagas – Without any in-situ proving calibration

A set of Measuring System requirements to guarantee:

• You get what you are paying for and you can prove it
• You deliver what you are being paid for and you can prove it
• OIML is a global standard and MID is a European Directive.
• NMi and Emerson (if applicable, cooperative with system owners) to achieve fulfillment of MID (and OIML) for Legal applications.
Also other LNG Emerson Dynamic Flow Applications

Dispensers

Tank truck loading/unloading

- Best-in-class mass and density flow accuracy
- Meter robustness and expert consultation to ensure correct first time installation
- Proven track record world wide
- Density measure to avoid flashing during transfer
- Global third party Custody Transfer measuring system approval for line sizes from 0.25” to 14”
- Smart Meter Verification for in-line check of your instruments health, integrity and performance
EC Type Examination Certificate
F Series

F100/F200 cryogenic application
Gasnor LNG Bobtail Application Solution Schematic

- Interlock Release (grounding / dead mans button / etc)
- DC Power
- Pump Control (optional)
- Single / Dual Stage Valve Control (optional via external solid state relays)
- 5700C MID/ATEX approved
- 9-wire connection
- Epson TM-T88V RS232 (MID approved)
- Truck Cabin
- F200 J-box MID approved
Multiple Metering Applications

- Gas USM
- Gas Chromatograph
- Cryogenic Liquid USM
- Cryogenic LNG Prover
HYDRAULIC STRESS ANALYSIS MODEL
Emerson prepare Hydraulic Stress Analyses taking account of all possible conditions including the full temperature reversal
Daniel Systems LNG Metrology Solution
Few of the **LNG related** customers

Emerson was chosen as Main Automation Contractor for:
- Shell Prelude FLNG
- Petronas FLNG1
Emerson in the LNG market chain

Emerson Flow Portfolio & Solutions in the LNG supply chain

Skangas MID solution to comply with GIIGNL

Energy measurement: Emerson’s response to full compliance of the Int’l Std’s for the customer’s applications

- Consultancy & Services
Cost of Uncertainty – Why Measurement Matters

Quick exercise for a transaction with $ value of 25.15 million
- Measurement uncertainty ties directly to $ throughput
- Financial risk quickly builds with poor measurement

### Financial Risk Associated With Measurement Accuracy

<table>
<thead>
<tr>
<th>Measurement Uncertainty</th>
<th>0.20%</th>
<th>0.40%</th>
<th>0.80%</th>
<th>1.00%</th>
<th>1.50%</th>
<th>2.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Risk (+/- $)</td>
<td>$50300</td>
<td>$100600</td>
<td>$201200</td>
<td>$251500</td>
<td>$377250</td>
<td>$503000</td>
</tr>
</tbody>
</table>

Minimizing measurement uncertainty is extremely important
Coriolis Dynamic Flow Measurement
(measures mass and density)

- LNG accuracy: 0.35%
- Based on water calibration
- Validated by independent parties such as NMI, Dutch Notified Body, on liquefied nitrogen
- Maintenance free (no moving parts; proven to be very stable)
- Re-calibration
- Many advantages over static technology
- Last, but not least, proving issue is solved

Acc. GIIGNL:
Uncertainty in mass: 0.61% - 0.71%
LNG BUNKERING
at Risavika Havn Stavanger - Norway

Obtained experiences with a MID Approved mass based measuring system
A set of Measuring System requirements to guarantee:

- You get what you are paying for and you can prove it
- You deliver what you are being paid for and you can prove it
- OIML is global standard and MID is European Directive.
- NMi and Emerson cooperated (with system-owners) to achieve fulfillment of MID (and OIML) for Legal applications.
MID-General

- MID stands for Measuring Instruments Directive
- EU harmonization & standardization around the transfer of ownerships of liquids and gases and the method of tax paying around it:
  - 1 European union, 1 set of rules for custody transfer
  - 28 EU countries + CH, NO & TR
  - Introduction—transition time—Obligation by October 31, 2016
- Liquids (MI-005) (other than water) and Gases (MI-002)
- Accuracy classes
  - Applications:
    - Loading / unloading, pipeline
    - % alcohol measurement

Cryogenics- LNG accuracy class changed to 1.5 (meter 1.0)
EC Type Examination Certificate

System Certificate

Measures required to meet MID integrity
EC Type Examination Certificate

System Certificate
• Can be seen as a theoretical plan of the measuring solution. - Think of it as an approved blue print or P&ID which is required when you design an installation.
• Before building the measuring solution, the owner must contact a Notified Body to approve this plan on paper. - Then the owner is approved to built the measurement solution according to the approved Type Examination.
Responsibilities

MID Certification Process

Emerson / NMi

MID Approval

Subsequent Verification

Local Notified Body
Volume between meter and transfer point is approx. 20.5 m³ (approx. 9 ton)
Process flow diagram
Minimum Measured Quantity (MMQ)

Solution
- Fixed compensation for loading arm capacitance

- Relieved quantity is measured by a dedicated gas meter and compensated for in next bunkering by flow computer
Initial Verification as originally planned

- Emerson Solution for Micro Motion meters
  - Transferability of Ede water calibration to field
  - No need for field calibration
  - Dedicated cryogenic procedure FL-NI-359 Emerson Cryo Zeroing Procedure

The observed errors with liquified nitrogen did not exceed 0.3%. Including the uncertainty of the Cryogenic test installation (0.17%) and the uncertainty of the water calibration (0.05%), the expected errors will be within +/- 0.5% for cryogenic applications when only calibrated with water at ambient temperature.

NMi Declaration from project 14200852, applicable for CMF025; CMF050; CMF100; CMF200; CMF300; CMF350; CMF400; HC2; HC3 and HC4
Subsequent verification as agreed
Minimum costs and impact on operations

A 4” Coriolis master meter to verify per year each of the two installed 4” duty meters; Master meter to be re-calibrated on water per 3 years.
Verifications as agreed with user and local Weights and Measure authority
Minimum costs and impact on operations

A 4” Coriolis master meter to verify per year each of the two installed 4” duty meters;
Master meter calibrated at NIST on LN2 and to be re-calibrated on water per 3 years

Initial verification April 2015:
Flowrate: 150 t/h    70 t/h
Stream 1: + 0.016 % + 0.084
Stream 2: - 0.016 % + 0.043

Subsequent verification April 2016:
Flowrate: 150 t/h
Stream 1: - 0.018%
Stream 2: - 0.025 %

Stability over first year
Stream 1: - 0.034 %
Stream 2: - 0.009 %
Common causes eliminated by considering absolute density from composition

Approved by local Norwegian Weights and Measures, Justersevenet
Zero calibration in situ – Without any in-situ proving calibration

A set of Measuring System requirements to guarantee:

- You get what you are paying for and you can prove it
- You deliver what you are being paid for and you can prove it
- OIML is global standard and MID is European Directive.

NMi and Emerson (if applicable, cooperative with system owners) to achieve fulfillment of MID (and OIML) for Legal applications.
Emerson in the LNG market chain

Emerson Flow Portfolio & Solutions in the LNG supply chain

Skangas MID solution to comply with GIIGNL

Energy measurement: Emerson’s response to full compliance of the Int’l Std’s for the customer’s applications

Consultancy & Services
LNG metrology initiative

- Big question remains: **What is now the real value of the master meter?**
- Need proper LNG cal facilities with low uncertainty (mid and large scale)
- LNG Metrology initiative by VSL and other W&M authorities very welcome
- Justersevenet calibrated a 2" Micro Motion CMF200 during tank truck filling with weighing scale >

Result: -0.11% +/- 0.05%, based on water calibration settings
A 4” Coriolis master meter to verify per year each of the two installed 4” duty meters; Master meter to be re-calibrated on water per 3 years.
Traceability of LNG (not LN2) coming soon

European initiative, lead by VSL, the Dutch measurement standard holder, to establish a measurement traceability for LNG:

- Primary, scale based calibration facility (2-12 t/h)
- Mid scale calibration facility (2 – 96 t/h)

Emerson chosen as supplier for 6 master meters
LNG standardization activities

OIML R117 (measuring systems for liquid other than water); is under revision to include LNG:

• Class 1.5 for system; meter 1%

• Measuring the vapor in vapor return line (BOG) and correct for it
  • Corrective measures for empty/partly filled delivery hoses
  • Measure to relief the pressure in receiving tanks prior to the start of the transaction
  • Installation of pressure relief valves
  • No bypass over the meter with pressure relief valve

Also a new ISO standard within ISO TC28 (petroleum) is currently edited: ISO 21903: Refrigerated Hydrocarbon Fluids - Dynamic Measurement - Guidance for the calibration, installation and use of flow meters for LNG and other refrigerated hydrocarbon fluids
LNG energy measurement according MID/OIML

Emerson Gas Chromatograph 370XA is certified for:

- composition (Z compressibility) acc MID annex-02
- caloric value acc. OIML R140 (measuring systems for gaseous fuels)
- including sampling

Emerson flow computer to calculate energy is certified for MID liquid; MID gas and OIML R140

Emerson uses NMi as certification body
Typical LNG Energy Measurement set-up for Custody Transfer

- LNG sample probe
- Operator Interface
- Gas chromatograph
- DCS / host
- Bill of Lading Printer
- Flow computer
- Temp
- Press
- LNG liquid direct mass measurement
- BOG direct mass measurement
- BOG (vapor return line)
- Not within scope of W&M legislation
Typical LNG Energy Measurement set-up for Custody Transfer

- LNG sample probe
- Operator Interface
- DCS / host
- Not within scope of W&M legislation
- Sample probe and GC for BOG (optional)
- Flow computer
- Gas chromatograph
- Temp
- Press
- BOG (vapor return line)
- BOG direct mass measurement
- Bill of Lading Printer
- LNG liquid direct mass measurement
- Transfer Point
Typical LNG Energy Measurement set-up for Custody Transfer

OIML R117 subtract the mass; customer want to subtract the energy.

Net energy, based on GC certified under OIML R140 by NMI.
Sampling effect to evaporate LNG liquid to gas phase is probably not known to NMI.

**Custody transfer in net energy of transferred LNG**

\[
\text{Net energy} = \text{mass}_{\text{LNG-liquid}} \times CV_{\text{LNG-liquid}} - \text{mass}_{\text{BOG}} \times CV_{\text{BOG}}
\]
Emerson as Solution Provider for LNG Energy Calculation

- Quantity measurement by Micro Motion Coriolis meters measuring direct mass (and density)

- Composition and Caloric measurement by Rosemount gas chromatograph

- Flow computer

- Custody transfer certification acc. OIML and MID via NMi, Dutch Notified body
Emerson delivers also services to comply with custody transfer regulations

- European legislation MID allows that the manufacturer performs the conformity assessment

- Based on accuracy, integrity and transparency

- Important for the not-owner of the installation (receiving party in most cases; think of a fuel dispenser)

- Emerson has 12 certified “MID verification officers” to serve the customer

- Also appreciated by customers outside Europe

- Review for integrity of Process and Instrumentation diagram (P&ID)

- Calibration of meter on water and assessment in field under own responsibility

- Deliver all MID documentation to maintain accuracy; integrity and transparency
LNG energy measurement according MID/OIML

Emerson accepts full responsibility for the custody transfer certification of whole measuring system and energy calculation (less burden for end-user)
Take away

• Emerson’s products comply with Global Standards

• Emerson delivers also the services to comply with national Custody Transfer Legislation

• Emerson accepts full responsibility for the certification of any LNG application

• Emerson complies with the recommendations of GIIGL concerning proving of installed flow meters

Emerson is the ultimate solution provider for LNG applications concerning products and custody transfer services

Emerson reduces your CAPEX and OPEX
Let’s connect

Giuseppe Bernardelli
Guiseppe.Bernardelli@emerson.com
+39 348 0195 604