Micro Motion
Developments in HFO & LNG metering
Per Stenhammar
Business Development Manager
Emerson At-A-Glance 2013

- Manufacturing and/or sales presence in more than 150 countries
- 235 manufacturing locations around the world.
  - Apr 130,000 employed worldwide
- No. 120 on 2011 FORTUNE 500 list of America’s largest corporations
  - Founded in 1890
Past, Single-Phase Fluids only

Offshore

Truck Loading

Pipelines

Refinery Ship loading

Rail Car Loading
2-Phase fluids during bunkering
Energy is **kg/ kwh !!!**

Why care about litres?

1 liter

1 Kg
Why Coriolis mass flow meter?

- Coriolis meters have been the fastest growing flow measurement technologies over the past decade.
- Growth has been driven by a unique ability to measure mass directly.
- Gives the user a window into the process.

![Diagram showing Coriolis effect with temperatures and liquid levels]
Theory of Operations
Mass Flow Measurement

- Process fluid enters the sensor and flow is split with half the flow through each tube
- Drive coil vibrates tubes at natural frequency
- Pick-off coils on inlet and outlet sides
Theory of Operations
Mass Flow Measurement

No Flow

Flow

Inlet side
In-Phase
Outlet side

Pickoff (inlet side)

Pickoff (outlet side)
Density measurement is based on the natural frequency

- As the mass *increases*, the natural frequency of the system *decreases*
- As the mass *decreases*, the natural frequency of the system *increases*
Transparent and Traceable measurement solution

The technology is here today that benefits the complete bunker supply chain

MID based on OIML R117-1
(Measuring systems for the continuous end dynamic measurement of quantities of liquids other than water)
Certified solution on a Vessel
Installation between transfer point and fuel tanks
Characteristics of bunker approval T10265:
- System uncertainty within 0.5%
- HC3 sensor
- Based on water calibration
- Flow rate 120 – 1200 t/h
- Temperature 30 – 70 ºC
Mass flow meter system

promo Exxon Mobil booth at SMM 2012

Time for a clearer view


ExxonMobil
Marine Fuels
A natural progression in measurement

The technology behind the mass flow meter system presents a natural progression in marine fuel measurement processes, offering major value and benefits to customers and suppliers:

- Fuel mass is measured directly, in line with the marine fuel industry’s practice of selling by mass, not volume.
- Direct mass measurement is automatic, using digital data logging for a more efficient and simplified bunkering process.
- The system delivers time savings of up to 3 hours per delivery (versus tank gauging), which can translate into significant financial and resource savings.
- Data is captured continuously during fuel delivery, providing a more transparent measurement process.
- Back-flow can be detected due to the meter’s bi-directional capability with dual-totalizers.

More than just a meter

The integrity of the measurement process relies on ensuring that the whole delivery system, and not just the meter, is completely secure.

- An approved and calibrated meter, sealed by the Weights and Measures Office of Singapore
- Associated pipelines, valves, gauges and barge equipment sealed by an independent third party
- Information systems secured via a sealed transmitter (which stores data) and a measurement ticket printed from a secure, designated printer
- An independent system audit appointed by the MPA
- Procedures for barge operations and dispute resolutions.
Mass flow meter system

promo Exxon Mobil booth at SMM 2012

Security seals reassure of system integrity

Physical seals with unique numbers for all critical elements verify system security and guarantee traceability.

Data Logging System

Ticket Printer ➔ Transmitter ➔ Meter

From: large pump ➔ Meter

Physical seal locations:
1. Transmitter
2. Pressure transmitter
3. Upstream liquid detector

Measurement you can count on

The mass flow meter system, with its added security measures combined with technological improvements, displays the necessary characteristics of a good measurement system.

<table>
<thead>
<tr>
<th>Good measurement practices</th>
<th>Mass Flow Meter System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate</td>
<td>✓</td>
</tr>
<tr>
<td>Approved by the authorities and certified by standards body</td>
<td>✓</td>
</tr>
<tr>
<td>Secure</td>
<td>✓</td>
</tr>
<tr>
<td>Accountable</td>
<td>✓</td>
</tr>
<tr>
<td>Operationally efficient</td>
<td>✓</td>
</tr>
<tr>
<td>Cost effective</td>
<td>✓</td>
</tr>
</tbody>
</table>

Inset: Stainless steel ties and lead seal incorporates unique serial number for traceability.

Photo: Seal on the ExxonMobil measure of system security.
What's Behind the LNG Hype?

Bunker Prices, Monday October 8, 2012

<table>
<thead>
<tr>
<th>Grade</th>
<th>IFO380</th>
<th>IFO180</th>
<th>MDO</th>
<th>MGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fujairah</td>
<td>632.50</td>
<td>657.00</td>
<td>1030.00</td>
<td></td>
</tr>
<tr>
<td>Houston</td>
<td>629.00</td>
<td>670.50</td>
<td>1045.00</td>
<td></td>
</tr>
<tr>
<td>Rotterdam</td>
<td>617.00</td>
<td>638.50</td>
<td>971.00</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>634.50</td>
<td>646.00</td>
<td>949.00</td>
<td>959.00</td>
</tr>
</tbody>
</table>

For more prices, visit: [www.bunkerworld.com/prices](http://www.bunkerworld.com/prices)

Oil prices at approximately 21:40 EST:
- WTI: $89.33 Change: -0.55 (Nov 12 contract)
- Brent: $111.82 Change: -0.20 (Nov 12 contract)

NYMEX Natural Gas Futures
Close (Front Month)

Rising Bunker Prices

Reducing Environmental Impact
Green Shipping
Governmental Interest

- Work to reduce CO2 emissions directed to the IMO through the Kyoto protocol.
- International Maritime Organization:
  - MARPOL annex 6
  - (Sulphur oxide reduction) Emission Control Area

<table>
<thead>
<tr>
<th>Regulation</th>
<th>2012</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARPOL</td>
<td>3.5</td>
<td>3.5</td>
<td>0.5 (0.1)</td>
</tr>
<tr>
<td>ECA</td>
<td>1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Liquefied Natural Gas (LNG)
An Alternative Fuel

- Natural gas is a conventional energy source
- Easy to transport safe to use
- Cryogenic at -163 degC
- 600 times compressed in volume
- Non-explosive in an unconfined environment
- Field data:
  - CO2 reductions by 25%
  - NOx reductions by more than 90%
  - Sox reductions to almost 0%

Safety of LNG to people & environment
http://www.youtube.com/watch?v=hajTi8zFoe4
Market expectation for CY2020 is a lot of New-build vessels which consume Millions Ton LNG/yr
Uncertainties (Accuracy)

- Custody Transfer: Uncertainty = Income / cost

- Quote:
  "The possibility of quantity claims is an unacceptable liability for us that can damage our reputation and can tie us up in legal disputes"
What is OIML and MID?

An overall set of requirements that need to be followed 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 the global standard and MID is the European regulation.
- NMI and Micro Motion worked together to achieve the fulfillment of the MID requirements for the Legal Bunker Transfer Package, we also fulfill the OIML global standard regarding these requirements.
## MID system
### Accuracy classes

<table>
<thead>
<tr>
<th>Accuracy Class</th>
<th>Types of Measuring system</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,3</td>
<td>Measuring systems on pipeline</td>
</tr>
</tbody>
</table>
| 0,5            | All measuring systems if not differently stated elsewhere in this Table, in particular:  
|                | - fuel dispensers (not for liquefied gases),  
|                | - measuring systems on road tankers for liquids of low viscosity (< 20 mPa.s)  
|                | - measuring systems for (un)loading ships and rail and road tankers (1)  
|                | - measuring systems for milk  
|                | - measuring systems for refuelling aircraft |
| 1,0            | Measuring systems for liquefied gases under pressure measured at a temperature equal to or above −10 °C  
|                | Measuring systems normally in class 0,3 or 0,5 but used for liquids  
|                | - whose temperature is less than −10 °C or greater than 50 °C  
|                | - whose dynamic viscosity is higher than 1 000 mPa.s  
|                | - whose maximum volumetric flowrate is not higher than 20 L/h |
| 1,5            | Measuring systems for liquefied carbon dioxide  
|                | Measuring systems for liquefied gases under pressure measured at a temperature below −10 °C (other than cryogenic liquids) |
| 2,5            | measuring systems for cryogenic liquids (temperature below −153 °C) |

(1) However, Member States may require measuring systems of accuracy class 0,3 or 0,5 when used for the levying of duties on mineral oils when (un)loading ships and rail and road tankers.  
Note: However, the manufacturer may specify a better accuracy for a certain type of measuring system.
Globally Recognized
Cryogenic Custody Transfer Approval – NTEP ASIA

Certificate of Approval
No 10/2/11

Issued by the Ch National M

NOTE: This Certificate relates to use for trade only in respect of does not constitute or imply any any other person with any require This approval has been granted Measuring Devices and Systems

EC-type examination certificate

Number T10001 Revision 3
Page 1 of 1

Manufacturer: Emerson
Model: MM/M001

Issued by NMI Cerfin B.V., designated and notified by the Netherlands to perform tasks with respect to conformity modules mentioned in article 9 of Directive 2004/22/EC, after having established that the Measuring instrument meets the applicable requirements of Directive 2004/22/EC.

1. Type: An interruptible or not interruptible measuring instrument for liquids other than water.
2. Manufacturer: Emerson
3. Model: MM/M001
4. Environment class: 0, 0.5, 1.0, 1.5, 2.5
5. Temperature range ambient: Depending on the composition of the measuring instrument.
6. Temperature range liquid: See § 1.2 of the description
7. Gas composition: See § 1.2 of the description
8. Intended for the measurement of: Oil and products, alcohol, chemicals, potable liquids, liquefied gases under pressure and cryogenic liquids with densities between 350 and 2000 kg/m³.

For the National Type Evaluation Program and must be tested with the applicable technical requirements of NBR Handbook 44. 1. Other Technical Requirements for the measuring device apply. The equipment must be properly installed and maintained.

The model number indicated by an “X” represent non-measurable features of the device. However, if the number 3300, 3350, 3500 or 3700 is a number other than zero, the device has measurable scaling and

Standard Features and Options

- LCD
- Measuring System EMISxxxxx
- XXXXXX (ton or psi output)
- XXXXXX (field output)

The model number indicated by an “X” represent non-measurable features of the device. However, if the number 3300, 3350, 3500 or 3700 is a number other than zero, the device has measurable scaling and

Propene, Butane, Freon 11, Freon 12, Freon 22, NH₃, CO₂

Liquefied Oxygen, Liquefied Nitrogen

Up to 1.5 (only mass units)
OR 1.5 (maximum)

Ambient: 0.07 – 1.00 (only mass units)

In this table are covered by this certificate. Only those products filling within the specific limits are covered. Some products may have a specific gravity that falls into more than one product into the product groups, and specific gravity ranges listed in this table are covered by this certificate.

Certificate Number: 9-255A10
Page 1 of 6

NATIONAL TYPE EVALUATION PROGRAM
Certificate of Conformance
for Weighing and Measuring Devices

For: Model Indicating Mass
Digital Electronic
Sensor Model: CMF Series (See Page 2)
Mass Flow Transmitter Module: RTFM395X Series, 2700
Series, 3500 Series and 3700 Series
Flow Rate: (See Page 2)
- Calibration on water, representative for all fluids
- Accredited for in-house water calibration
  - “Approved Supplier AS-001”
- Accredited for initial verification:
  - Gas meter and liquid measuring system
  - Module D” (CE 104 and 105)
Why Micro Motion

- Proven track record, with reference list.
- Traceable, transparent in MID certified solution based on OIML R117-1 for liquids like HFO, MDO, MGO, LNG and gases.
- Operational efficiency increased.
- Water Calibration.
- Electronic Bunker Delivery Notes (BDN).
- Bunker profile.
- Direct mass measure, Density and Volume.
Wide success in LNG

- 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 3rd 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

BOBTAIL & TRUCK DISPENSING

- Best-in-class mass and density flow accuracy
- Meter robustness and expert consultation to ensure correct first time installation
- Experience in land and on ship applications
- Global 3rd 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

SHIP LOADING / UNLOADING
Conversion of Golar Freeze into FSRU for Dubai

Patt 57464

- Golar Freez the world second Floating Regas Terminal
- Golar Freez will be converted into an Floating storage gasification unit and will be moored outside Dubai
- Regasification capacity of 400 MCFD and will store 125,000 m³ at -163 deg.C
- The Vessel is owned by GOLAR and operated by SHELL

Emerson Scope;

- DeltaV and DeltaV SIS
- Rosemount temperature and pressure transmitters
- Metering
- Radar level gauging
- 3000+ I/O
LNG Terminal Flow Handling
With Emerson equipment

Storage capacity:
• 20,000 m³
• 9,260 ton
• 126 GWh

Energy capacity/year: 3 TWh

Emerson measures LNG mass flow at Nynäshamn terminal

Micro Motion® Coriolis flow meters from Emerson Process Management have been chosen by AGA Gas AB for measuring flows of LNG as part of the custody transfer function at its new Nynäshamn receiving terminal on the east coast of Sweden.

Among the equipment supplied by Emerson for Nynäshamn are one of its Micro Motion ELITE® High-Capacity Coriolis (HC3) meters for measuring flows of LNG being discharged from the delivery LNG carrier to the facility’s TANAPOL™ storage tanks and four Micro
# BOG Creation by Design

<table>
<thead>
<tr>
<th>Tank Size</th>
<th>60m³</th>
<th>1000m³</th>
<th>1000m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity in Tank at Start (Heel) (m³)</td>
<td>6</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pressure (Bar)</td>
<td>9</td>
<td>9</td>
<td>Atms</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>-126</td>
<td>-126</td>
<td>-162</td>
</tr>
<tr>
<td>Loading Rate (m³/hr)</td>
<td>2</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Loading Time (hrs)</td>
<td>30</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Boil of Gas Generated (m³)</td>
<td>3.25</td>
<td>2.97</td>
<td>53.8</td>
</tr>
<tr>
<td>Average Boil Of Gas Rate (m³/hr)</td>
<td>0.1</td>
<td>2.97</td>
<td>5.4</td>
</tr>
<tr>
<td>Max BOR (m³/hr)</td>
<td>7</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Min BOR (m³/hr)</td>
<td>1</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Boil of Gas Generated (kg) @-162</td>
<td>2</td>
<td>1.8</td>
<td>33.2</td>
</tr>
<tr>
<td>Boil Off Gas as CO₂ Equivalent (kg)</td>
<td>42</td>
<td>37.8</td>
<td>697</td>
</tr>
</tbody>
</table>
Saga
Fjordbase Ship Bunkering Terminal

- Located in Flora, Norway
- Terminal commissioned July 1st, 2009
- Allows bunkering of ships and trucks
- Terminal connects to local gas grid
- LNG stored in 500 m³ tank
ISO Technical Specification of LNG Bunkering Published


The long awaited ISO Technical Specification of LNG bunkering was published on June 6th on the International Association of Oil & Gas producers’ (OGP) website for review. The document has been developed by an international committee of experts with representatives from classifications societies, LNG suppliers, flag states, equipment suppliers, shipping companies etc.

Johan Algell of White Smoke Consulting represents Sweden in the committee. The importance of the document is yet to be seen but it has been requested by many. If well received it will, together with the forthcoming IGF code, have the ability to fill the regulatory gap identified and become a major contribution to the development of LNG as the future main fuel for shipping.

Participation of Johan Algell from White Smoke Consulting as Swedish representative in the committee has been facilitated through the support from the following Swedish companies, organizations and authorities:

- Swedish Marine Technology Forum
- Mann-Tek AB
- Swedish Transport Agency
- Cryo AB
- Emerson Process Management AB
- Samson AB
- FKAB Marine Design
Viking Line- GRACE with barge Seagas
LNG Off-Loading Application
Emerson’s Coriolis flowmeters provide accurate mass-flow measurement for Cryostar LNG fuel dispensers

Micro Motion® Coriolis flowmeters have European, Asian, Australian and U.S. approvals for cryogenic fluids in custody transfer applications.

BOULDER, COLO (July 7, 2011) -- Micro Motion® Coriolis flowmeters from Emerson Process Management are being used by Cryostar in its fuel dispensers for liquefied natural gas (LNG)-powered vehicles. Cryostar, a leading provider of advanced technologies for LNG applications, chose the Micro Motion flowmeters not only for their inherent accuracy, but also because regulatory organizations in Europe, Asia, Australia and the U.S. have approved the meters for measuring cryogenic fluids in custody transfer applications.

“When we were designing our fuel dispensers, we looked at various measurement technologies and several potential suppliers,” said Philippe Fauvel of Cryostar. “Emerson’s Micro Motion Coriolis flowmeters have all the approvals we need for our growing markets, as well as providing the accurate and reliable data that this fiscal application demands.”

The Cryostar dispenser, which has a 99.5 percent accuracy, has been approved by the relevant Weights and Measures departments in many world areas to the appropriate standard. These include MID (Europe) and Nederlands Meet Instituut (NMI) for Australia and Asia. Cryostar is also seeking National Type Evaluation Program (NTEP) approval for North America.

“This project has been very much a joint development with Emerson,” continued Fauvel. “Emerson helped with obtaining MID approval, and we used their valuable LNG knowledge and experience to achieve the best possible design – making our dispensers among the most accurate and reliable on the market.”
Viking Line Orders LNG-Powered Cruise Ferry

December 25, 2010 – 2:04 am | Finland

STX Finland Oy and Viking Line ABP have signed an agreement for the construction of “the most environmentally friendly big passenger vessel to date”, for Viking Line, with delivery early 2013. The new generation cruise ferry uses LNG as fuel. It has no marine emissions and its aerial emissions are extremely low. The vessel has been specially designed to operate in the delicate and shallow waters of the Finnish and Swedish archipelago. The agreement includes an option for a sister ship. The contract price is about Eur 250 million / USD 300 million.

ConocoPhillips
Skangass
The Linde Group
Linde
INOX
CVA
INOX
cryo Energy
VanZetti
Cryogenic Technology
AIR LIQUIDE
Ballast Nedam
IPM
Emerson
Process Management
Thank You any questions?