LNG Dispensing Made Simple Using Micro Motion
Presenters

- Kegan Kavander
- Nicole Rundlett
Introduction

- LNG Market Considerations:
  - Drivers/Need for LNG Mobile Delivery Systems
  - U.S. Terminal locations
  - Advantages of LNG over CNG

- Mobile Delivery Systems by INOXCVA:
  - Description / Highlights
  - Control Summary and Safety
  - Micro Motion and Custody Transfer

- Why Micro Motion for Cryogenic Service Meters:
  - Flow Measurement Challenges
  - Micro Motion Experience in LNG Applications
  - The Elite Solution for LNG!
  - Advantages of Coriolis over Turbine Meters
  - Smart Meter Verification- Superior Diagnostics
  - Additional Diagnostics- Density and Drive Gain
  - Focused on Cryogenic Liquids

- Business Results Achieved
- Summary / Resources
Cryogenic Vessel Alternatives

- Founded in 1999, we are a global cryogenic equipment leader offering storage, transportation, and distribution solutions to the industrial gas, oil field services, and LNG industries.

USA Corporate Headquarters
Mont Belvieu, Texas
CVA – Other Facilities

Red Deer, Alberta, Canada

JAT-CVA Hebel Province, China

Baytown, TX

India (4 Plants)
CVA – Product Overview

ISO/IMO Containers

Skid Mounted Tanks

Horizontal Bulk Storage Tanks

Porta-Cryo Mini Bulk Tanks

Dewar Containers

Vaporizers
CVA – Product Overview

- Mini Bulk Delivery Units
- Mobile Transport Trailers
- Cryogenic Railcars
- Hydraulic Fracture Units
- Truck Mounted Nitrogen Pumpers
- Skid Mounted Nitrogen Pumpers
CVA – LNG Special Products

LNG Mobile Delivery Trailers

Trailer Mounted Mobile Vaporizers

Truck Mounted ISO/IMO Containers
LNG Market Considerations:

- LNG takes up 1/600 of the volume of gaseous state making it ideal for transport
- LNG is transported to regasification terminals for introduction into existing pipeline infrastructure
- LNG sources:
  - predominantly imported from Trinidad, Tobago, and Algeria
  - Indonesia, Malaysia, and Qatar are also the leading exporters of LNG
- U.S. is developing supply chain, but it takes time to set up infrastructure (limited LNG import terminals)
- LNG powered vehicles are growing in number but need secure and dependable supply (trucking industry is primary user)
Location of U.S. LNG Import Terminals

North American LNG Import Terminals

Approved

U.S.
1. Sabine, TX: 1.0 Bcf/d (ExxonMobil - Golden Pass) (Phase II)
2. Elba Island, GA: 0.5 Bcf/d (El Paso - Southern LNG Expansion)*
3. Pascagoula, MS: 1.5 Bcf/d (El Paso/Crest/Sonango - Gulf LNG Energy LLC)

APPROVED - UNDER CONSTRUCTION

Mexico
4. Manzanillo, MX: 0.5 Bcf/d (KMS GNL de Manzanillo)

APPROVED - NOT UNDER CONSTRUCTION

U.S. - FERC
5. Corpus Christi, TX: 1.0 Bcf/d (Occidental Energy Ventures - Ingleside Energy)
6. Corpus Christi, TX: 2.6 Bcf/d (Cheniere - Corpus Christi LNG)
7. Fall River, MA: 0.8 Bcf/d (Hess LNG/Weaver's Cove Energy)
8. Port Arthur, TX: 3.0 Bcf/d (Sempra)
10. Cameron, LA: 3.3 Bcf/d (Cheniere - Creole Trail LNG)
11. Freeport, TX: 2.5 Bcf/d (Cheniere/Freeport LNG Dev. - Expansion)*
12. Hackberry, LA: 0.05 Bcf/d (Sempra - Cameron LNG - Expansion)*
13. Port Lavaca, TX: 1.0 Bcf/d (Gulf Coast LNG Partners - Calhoun LNG)
14. Baltimore, MD: 1.5 Bcf/d (AES Corporation - AES Sparrows Point)
15. Coos Bay, OR: 1.0 Bcf/d (Jordan Cove Energy Project)
16. LI Sound, NY: 1.0 Bcf/d (Broadwater Energy-TransCanada/Shell)

U.S. - MARAD/Coast Guard
17. Gulf of Mexico: 1.0 Bcf/d (Main Pass McMoRan Exp.)
18. Offshore Florida: 1.2 Bcf/d (Hoegh LNG - Port Dolphin Energy)
19. Gulf of Mexico: 1.4 Bcf/d (TOKP Technology-Bienville LNG)

Canada
20. Rivière-du-Loup, QC: 0.5 Bcf/d (Cacouca Energy - TransCanada/PetroCanada)
21. Quebec City, QC: 0.5 Bcf/d (Project Rabaska - Enbridge/Gaz Met/Gaz de France)

Mexico
22. Baja California, MX: 1.5 Bcf/d (Sempra - Energia Costa Azul - Expansion)

Office of Energy Projects
Advantages – LNG Vs. CNG

- LNG allows 1.5 times more range (in hours) than an equivalent CNG vehicle.
  - Example for a 25 M3 side loader:

<table>
<thead>
<tr>
<th></th>
<th>TANK CAPACITY</th>
<th>CONSUMPTION</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIESEL</td>
<td>250 Liter diesel</td>
<td>14 l_{diesel}/h</td>
<td>17.8 h</td>
</tr>
<tr>
<td>LNG</td>
<td>315 Liter LNG</td>
<td>25 l_{LNG}/h</td>
<td>12.6 h</td>
</tr>
<tr>
<td>CNG</td>
<td>640 Liter CNG</td>
<td>75 l_{CNG}/h</td>
<td>8 h</td>
</tr>
</tbody>
</table>

LNG Vehicle Vs. CNG Vehicle

<table>
<thead>
<tr>
<th></th>
<th>DIESEL</th>
<th>LNG</th>
<th>CNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption/year</td>
<td>1,580,085 L</td>
<td>2,844,080 L</td>
<td>6,399,545 L</td>
</tr>
<tr>
<td>Cost/liter</td>
<td>0.541 euro/L</td>
<td>0.109 euro/L</td>
<td>0.0618 euro/L</td>
</tr>
<tr>
<td>Total cost/year</td>
<td>854,826 euro</td>
<td>310,000 euro</td>
<td>395,492 euro</td>
</tr>
</tbody>
</table>

Annual cost for a 40 - vehicles fleet

LNG Station: 390,660 euro
CNG fast - fill station: 751,265 euro

Resource – ROS ROCA Group
LNG Mobile Fueling Station

- 6000 gallon water capacity
- 2200 hour hold time (.5% in 24hrs evap. rate)
- -260 Deg. F
- 175 PSIG MAWP
- 22 HP cryogenic submersible pump
- 30 HP external on-load pump (optional)
- 30kW self contained natural gas generator (460VAC 3 phase) for remote operations
- Transformer (460VAC -110VAC)
- Programmable ladder logic controller (PLC)
- VFD for submersible pump
Other Features

- Pneumatic actuated valves (on deck A/C)
- Rear panel view instructional screens for easy operation
- Pressure build unit (TSCP)
- Saturation vaporizer for product pressure control
- Methane and flame detectors
- 10 minute rule impoundment area
More Features

- Liquid level and pressure transducers
- Working/Warning lights
- Emergency Horn
- Emergency stops (all for corners)
- Card Reader
- Air Link Modem w/ GPS (optional)
- Micro Motion Coriolis flow meter
Operation
Operation

CAUTION

- Always wear safety personnel protection gear.
- Chock wheels
- Connect static ground wire to transfer vessel
- Walk around area and observe that everything is safe
- Check receiving vehicle tank level and pressure. If necessary, vent fuel tank to 50 psi minimum below pump’s discharge pressure. Open diverter valve DV-1 to purge vent hose before venting into mobile re-fueling supply tank.

Press START to ready for DISPENSE.

| TKL: 24 | PDP: 13 | Rate: 0.0 | VOL: 0 |
| TKP: 10  | FMT: 87 | SAT: 10   | TOT: 0 |

CAUTION

Use air hose to thoroughly dry frost and moisture from fill nozzle before connecting to vehicle tank or receptacle HC-6.

At the end of operations each day open the drain valves on all vent stacks to permit moisture to drain, then close. Also pull cables to drain water from air compressor and auxiliary system air supply tanks.

Press START to ready for DISPENSE.

| TKL: 24 | PDP: 13 | Rate: 0.0 | VOL: 0 |
| TKP: 10  | FMT: 87 | SAT: 10   | TOT: 0 |
Operation

Mobile Fueling Trailer
Brought to you by:
INOX-CVA / Cryogenic Vessel Alternatives, Inc., Copyright 2011
Office (281) 385-1204
Built For:
Encana Natural Gas Inc.
(720) 876-5179
Press INFO if needed.
Press START to ready for DISPENSE.

Pump Runtime
0.0
CVA_LNG_V2_1
0
LN2 ACD TC-34
Total Delivered
0

SYSTEM STANDBY - 0.1 MINS.
Fueling system is being prepared for operation. System will prompt for operator response.

Air Pressure Satisfactory

Building Pressure (TSCP)

Press INFO if needed.

TKL: 24
PDP: 13
Rate: 0.0
TKP: 10
FMT: 87
SAT: 10
TSCP: 11
VOL: 0
TOT: 0
Operation

mb.wordpress.com
Operation

**RECIRCULATION MODE**

DO NOT use total on this display for billing. Use totalizer at front.

Press **START** to resume dispensing.

- **Pump Spd**: 3974 RPM
- **TkL**: 70
- **TKP**: 42
- **PDP**: 90
- **FMT**: -212
- **SAT**: 31
- **Pump Load**: 41 %
- **VOL**: 5141
- **TOT**: 23
- **TSCP**: 31

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**RECIRCULATION MODE**

DO NOT use total on this display for billing. Use totalizer at front.

Press **STOP** to shutdown pump and print receipt.

- **Pump Spd**: 3000 RPM
- **TkL**: 69
- **TKP**: 41
- **PDP**: 68
- **FMT**: 208
- **SAT**: 29
- **Pump Load**: 32 %
- **VOL**: 5142
- **TOT**: 23
- **TSCP**: 31
Certified Fuel Delivery

National Type Evaluation Program
Certificate of Conformance
for Weighing and Measuring Devices

For:
Main Flow Meter
Digital Electronic
Sensor Model: CMF Series* (See Page 2)
Manifold Transmission Models: RFT950X Series*,
2700 Series*, 3300 Series*, and 3700 Series*
Flow Rate: (See Page 2)

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Standard Features and Options

- Dual tube design
- Liquid crystal display (LCD)

Options:
- NEMA-4X enclosure
- Handheld programmer: Rosemount Model 2676, Hart Model HC 375, or Hart Model HC 375
- Computer interface
- Printer
- Heater
- Local display on Model 2700 Series transmitter
- Aqueous eliminator or effective means of vapor elimination
- Modbus communications software for PC
- * Digital indicator: Flow Monitoring System Model FMXXXXXXX
  Model 350XXX1111111111 (rack or panel mount)
  Model 350XXX1111111111 (rack mount)

* Numbers or letters in the model number indicated by an “X” represent non-metrical features of the device.
  However, if the eighth digit of the model number 3000, 3300, 3500 or 3700 is a number other than zero, the
device has metrical molding and software.

This device was evaluated under the National Type Evaluation Program (NTEP) and was found to comply with the applicable technical requirements of Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices." Evaluation results and device characteristics necessary for inspection and use in commerce are on the following pages.

G. Weston Dugan
Chairman, NCWM, Inc.

Stanley D. Eggert
Chairman, National Type Evaluation Program Committee

Note: The National Conference on Weights and Measures does not "approve," "recommend," or "endorse" any proprietary product or material, either as a single item or as a class of group. Results shall not be used in advertising or sales promotion to indicate explicit or implicit endorsement of the product or material by the NCWM.
LNG Dispensing Presents Measurement Challenges!

- **Challenges of LNG flow measurement**
  - Cryogenic -163°C
  - Temperature cycling on equipment
  - 2 Phases - vaporizing
  - Temperature & Density control is critical

- **Traditional flow technologies requirements**
  - Insulation jacket needed
  - On line densitometer
  - On line temperature
  - Pressure
  - PTZ compensation must be considered
Micro Motion has experience in LNG!

**Coriolis LNG Measurement Solution**
- Over 15 Years Experience of LNG Measurement & Dispensing
- MVD Diagnostics enable Liquid / Vapour Phase Control
- MVD Multivariable Measurement improves Monitoring & Control
- MID Certification assists OEM and Operators with Regulatory Compliance

<table>
<thead>
<tr>
<th>Meter</th>
<th>Application</th>
<th>Meter Type</th>
<th>Meter Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Truck Loading</td>
<td>CMF 200</td>
<td>87,100 kg/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMF 300</td>
<td>272,000 kg/h</td>
</tr>
<tr>
<td>B</td>
<td>Truck Offloading</td>
<td>CMF 200</td>
<td>87,100 kg/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMF 300</td>
<td>272,000 kg/h</td>
</tr>
<tr>
<td>C</td>
<td>Vapour Return</td>
<td>CMF 025</td>
<td>2,180 kg/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMF 050</td>
<td>6,800 kg/h</td>
</tr>
<tr>
<td>D</td>
<td>Dispenser Filling</td>
<td>CMF 100</td>
<td>27,200 kg/h</td>
</tr>
</tbody>
</table>
Micro Motion’s Solution for LNG Measurement

**Elite Family**
- Highest Mass Accuracy: +/-0.10% of rate (optional +/-0.05%)
- Temperature Ratings: -240°C to +240°C (rated for Cryogenic)
- Approved for Custody Transfer of Cryogenic Liquids
- Three process measurements from one meter:
  - Mass Flow
  - Density
  - Temperature
- Accurate in Empty-Full-Empty Service
- Smart Meter Verification: Safety and Accuracy
- Phase (liquid vs. vapor) of LNG known instantly
- OEM ready: Direct Modbus communications
Advantages of Coriolis Vs. Turbine Meters

- **Direct Mass and Density Measurement**
- **Multi-Variable**
- **No Flow Conditioning**
- **Bi-Directional Capability**
- **Wider Turndown**
- **No moving parts**

**Turbine Limitations**
- Over registering due to coating
- Accuracy is density dependent
- Mechanical wear (maintenance)
- Limited turndown
- Uni-directional measurement
- Different calibration factor for each fluid
- Requires vapor eliminator and straightening vanes
- Volume based measurement
- Poor cleanability

**BI-Directional Capability**
- Micro Motion meters vibrate well under the yield point so there is no deformation or wear!!
Micro Motion’s Smart Meter Verification = Confidence

Meter Verification Process

Operation at Local Display
- Okay
- Not Okay

Factory Calibration

Damage Begins

Customer advised “Not Okay” due to measurement change

Structural Integrity Measure

Measurement Number

K M K M

Tones

Input Tone

Sensor Response

EXCHANGING IDEAS. CREATING SOLUTIONS.
2011 Emerson Global Users Exchange

Erosion
Cracking
Pitting

EMERSON GLOBAL USERS EXCHANGE

Input Tone
Sensor Response
Diagnostics Ensure Accuracy in LNG Dispensing

- MODBUS Direct connection
  - Drive gain
  - Slug Flow
  - Pump Start
- Density
  - Temperature
  - Fluid Status
- Mass Flow
  - Volume flow
  - Measurement

- Traditional technology or other Coriolis manufacturers
  - Analog (4 - 20mA) or Frequency only
  - No fluid phase status available
  - No Smart Meter Verification
Micro Motion- Focused on Cryogenic Applications!

- Has developed more robust sensor internals to address rapid temperature cycling
- Cryogenic Service- Now standard offering on Elite sensors (“C” under Measurement Application Code)
- Cryogenic Best Practices presentations, white papers, and application notes written by Micro Motion
- Elite sensors tested by NIST in cryogenic service and found factory calibration to be transferable

Figure 2. Micro Motion Coriolis meter mounted in a NIST liquid nitrogen test stand
Business Results Achieved

- Environmentally cleaner, cheaper fuel costs, and safer operations provide good selling points for liquid natural gas
- INOXCVA’s automated fuel delivery system saves time at the fuel station
- Micro Motion’s safe, accurate metering features saves time for customers
- Micro Motion’s capability of being approved for custody transfer from state to state and country to country catches the attention of industry suppliers
- 13 mobile fuel stations for 2011 with new customer interest frequently
Summary

- Because of new drilling technology, the LNG market is rapidly growing in the US and worldwide.
- More infrastructure is needed to transition from less abundant fossil fuels to the cleaner energy of natural gas.
- The combination of Micro Motion’s accurate and reliable cryogenic flow meters and INOXCVA’s innovative mobile fuel stations will provide a solution to a transition that will change the energy crisis drastically.
Where To Get More Information

- LNG Import/Export Terminal Information (FERC)  

- www.naturalgas.org

- INOXCVA Website:  www.cvatanks.com

- Micro Motion Website:  www.micromotion.com