LNG Bunkering Solutions

Arjan van Ginkel

Business Development Manager Europe

Micro Motion®

EMERSON™
Process Management

Agenda

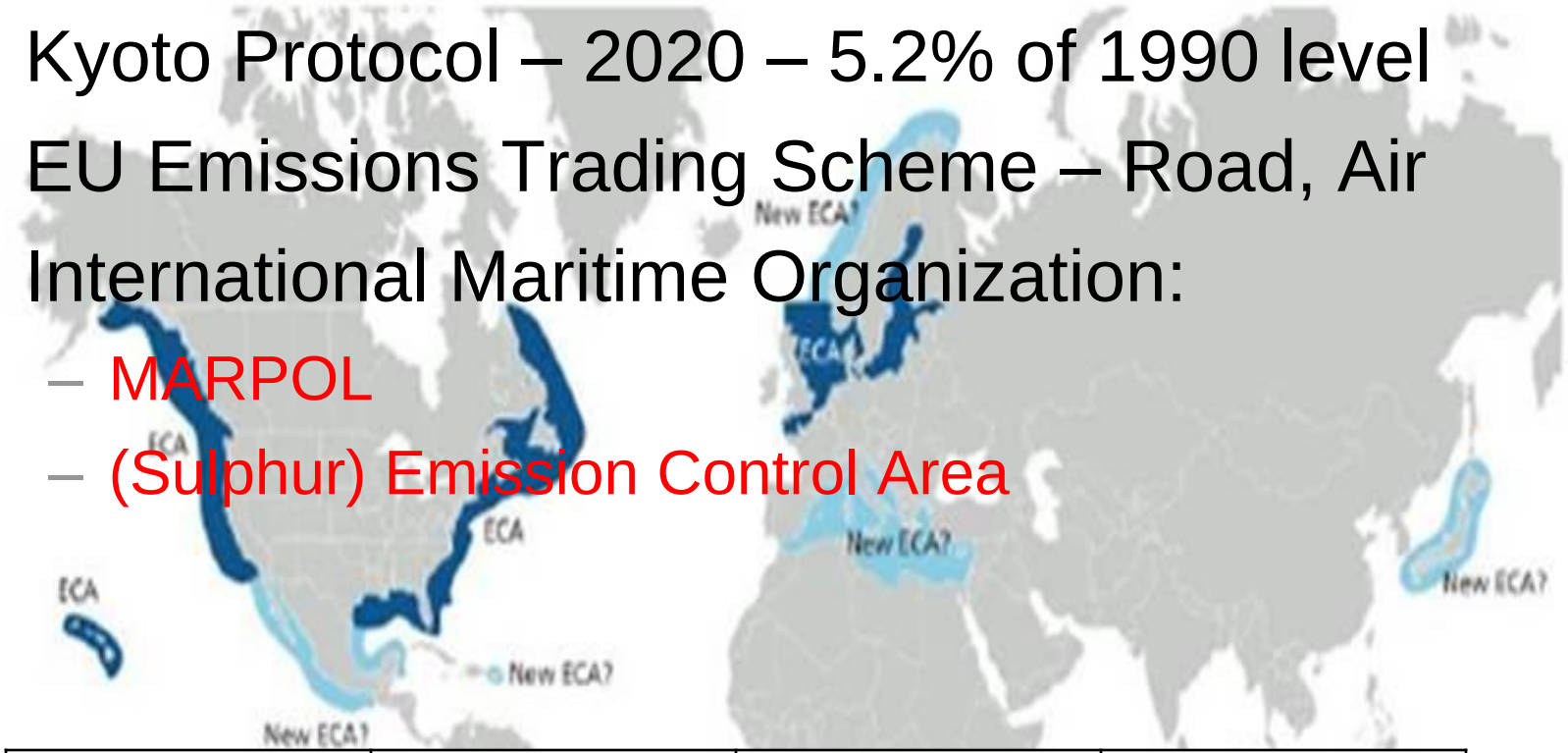
- ***LNG is HOT & 2015 is closing in..***
- Bunkering LNG – Custody Transfer
- Bunkering LNG – what to measure & how
- Bunklering LNG – Installation

Micro Motion®

EMERSON™
Process Management

Green Shipping – Governmental Interest

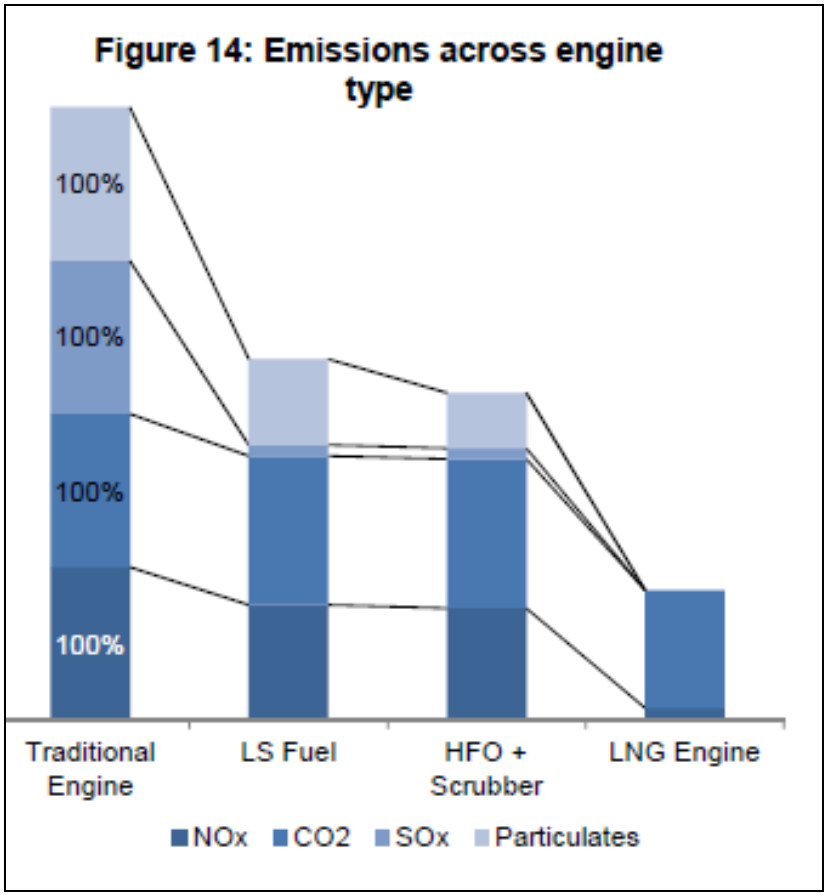
- Kyoto Protocol – 2020 – 5.2% of 1990 level
- EU Emissions Trading Scheme – Road, Air
- International Maritime Organization:
  - MARPOL
  - (Sulphur) Emission Control Area



Regulation	2012	2015	2020
MARPOL	3,5	3.5	0.5 (0.1)
ECA	1	0.1	0.1

Liquefied Natural Gas(LNG) – An Alternative Marine Fuel

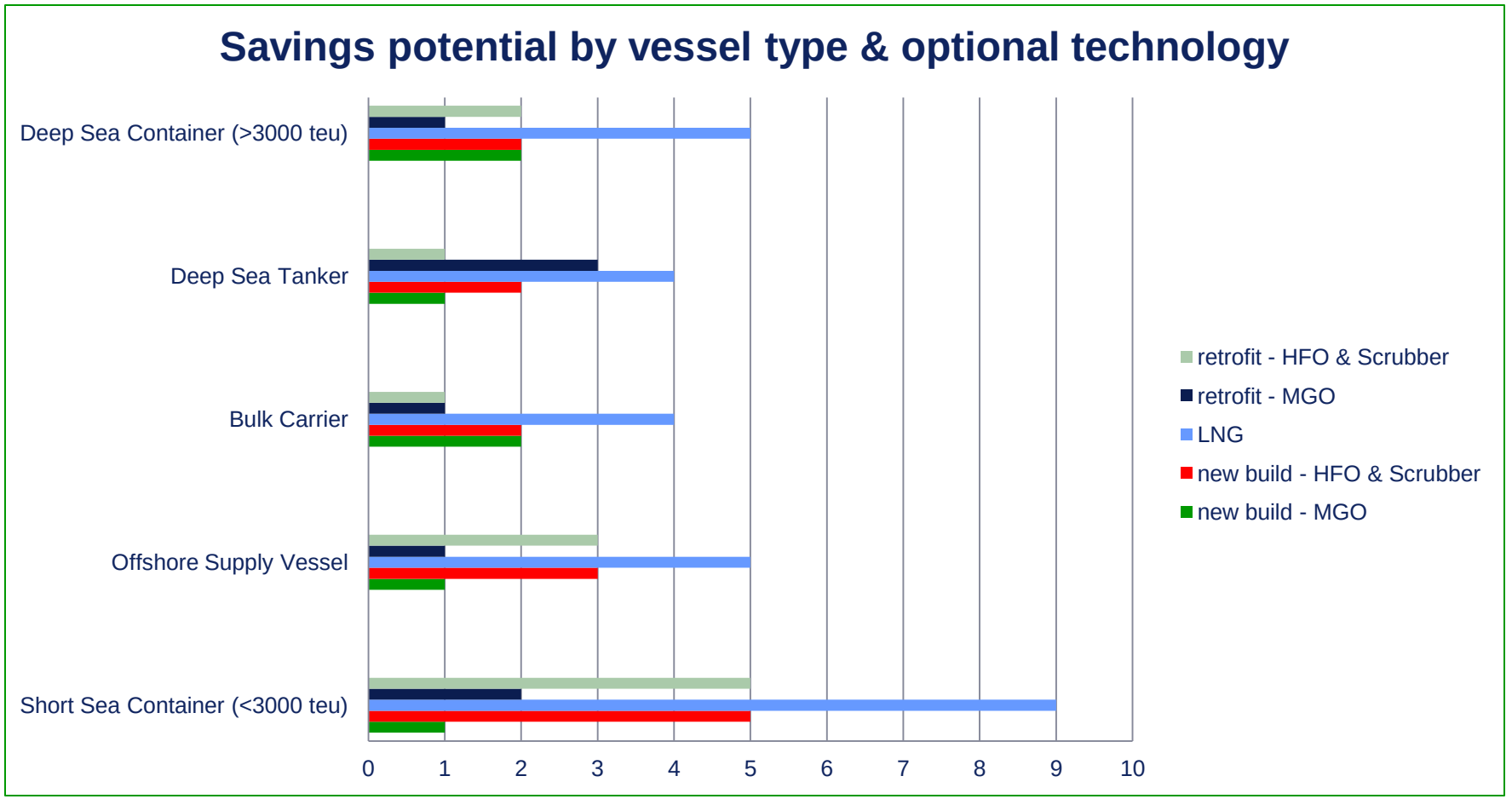
- Natural gas is a conventional energy source
- Cheaper than HFO or low sulphur fuels
- Available & reaching regulations
- Easy to transport
- 600x compressed in volume
- Natural gas made clean of freezable gases, like CO_2.
- Non-explosive in an unconfined environment & Non-polluting when spilled



Micro Motion

EMERSON
Process Management

Ship Types & technology options



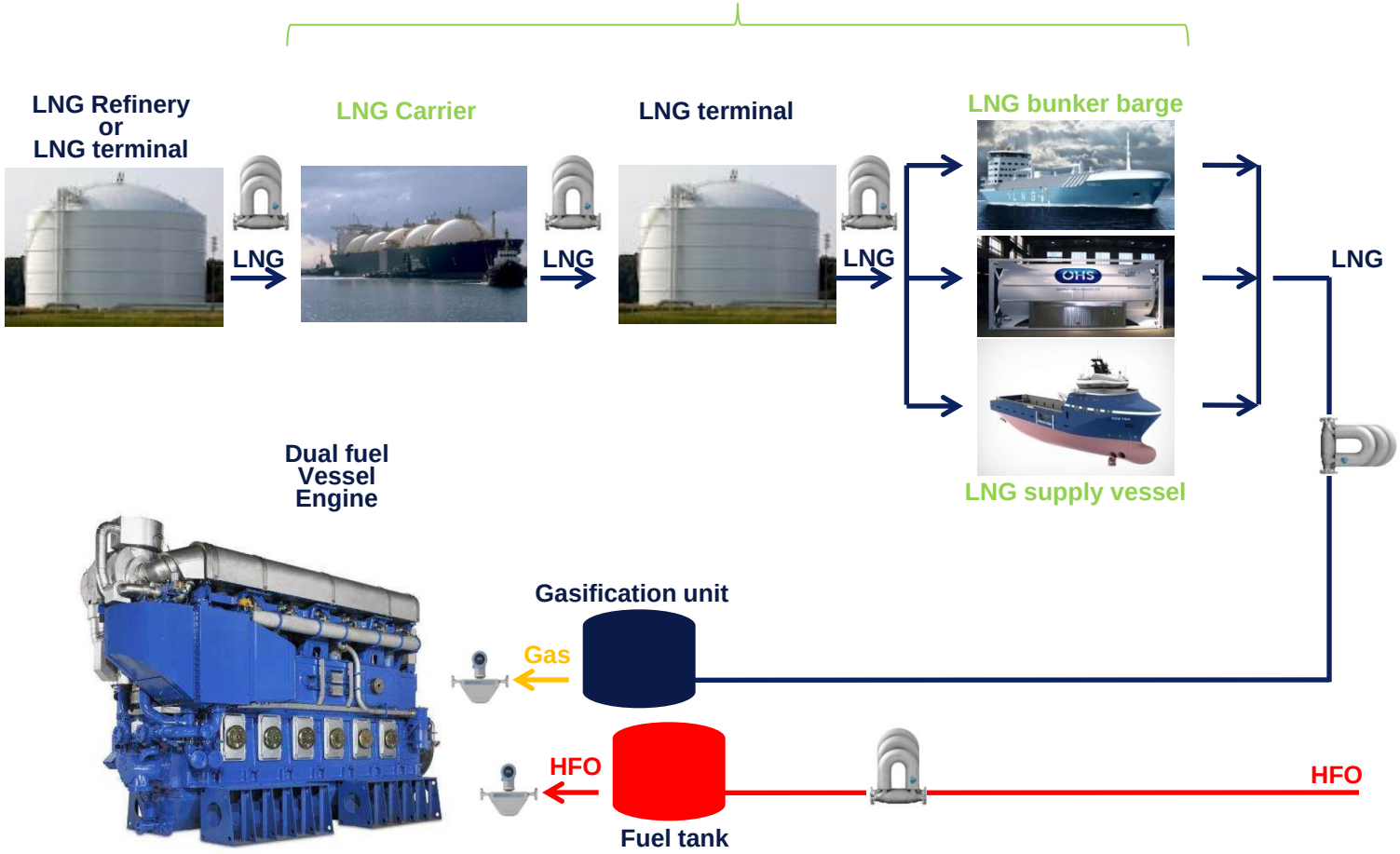
MEC Intelligence Report, October 2011

Micro Motion®

EMERSON™
Process Management

LNG Supply Chain

Market expectation for CY2020 is 4500 New-build vessels which consume 4.8 Million Ton LNG/yr



Agenda

- LNG is HOT
- ***Bunkering LNG – Custody Transfer***
- Bunkering LNG – what to measure & how
- Bunklering LNG – Installation

Micro Motion®

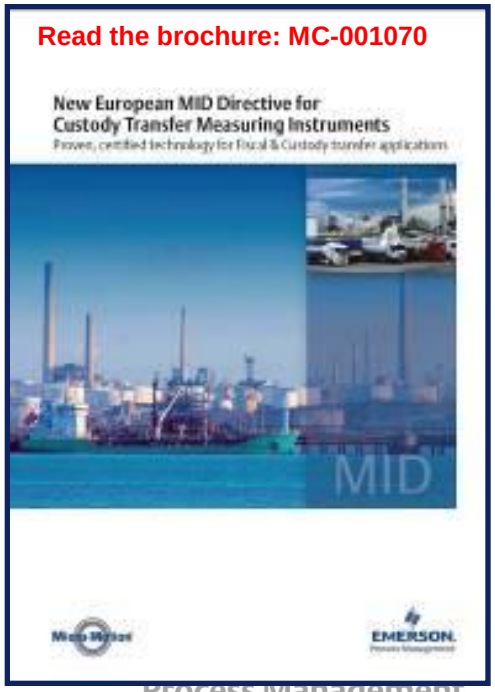
EMERSON™
Process Management

Custody Transfer – MID

- 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 – 27 EU countries + CH, NO & TR
  - Introduction– transfer time – Obligation by October 31, 2016
  - Local regulations may continue to apply to pay taxes over fuels and liquors.
- Liquids (other than water) and Gases
- Type approval
- System certificate
- Accuracy classes

Applications:

- Loading / unloading, pipeline
- % alcohol measurement
- Cryogenics



Micro Motion

Process Management

What is OIML and MID?

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.

Micro Motion

EMERSON
Process Management

MID, in-use installations

- What does it mean for existing installations
  - In–use & unmodified, no problem
  - Modification means upgrade
- What does it mean for new installations
  - Pre-MID National legislation, or
  - MID

MID Responsibility

- Two steps process, responsibility of the “MID manufacturer”
  - 1st Obtain an EC Type Examination Certificate for each model code
  - 2nd Initiate the initial verification for each serial number

- New installation only; maintenance outside MID scope

(National regulated)

- Measuring System for liquids, other than water
  - End user / Contractor / Emerson / Skid Builder to obtain System certificate
  - Incl. Flow meters & computers, temperature & pressure sensors, valves, etc.

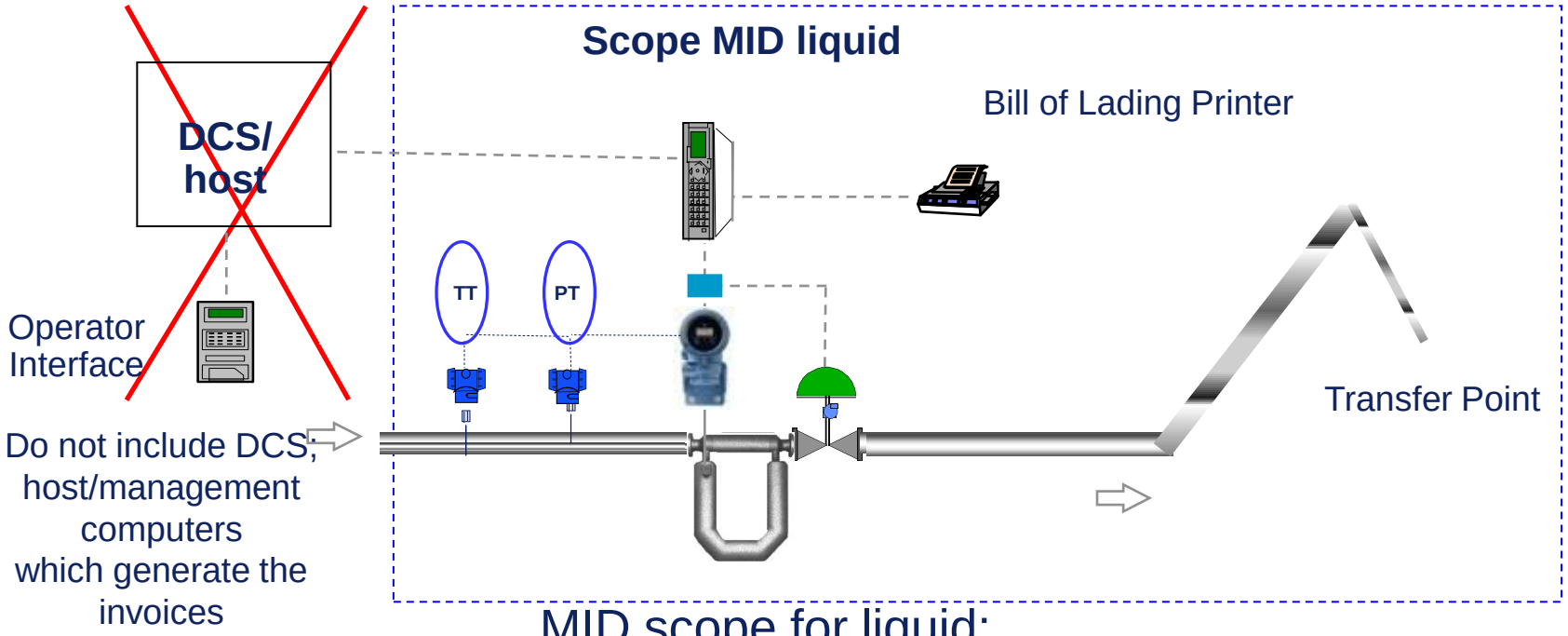
- LNG is liquid; BOG = gas (manufacturer step 1 only)
- Boil Off Gas – outside OIML / MID scope

Micro Motion

EMERSON
Process Management

Scope of instruments under MID for liquid

Typical measurement set up:

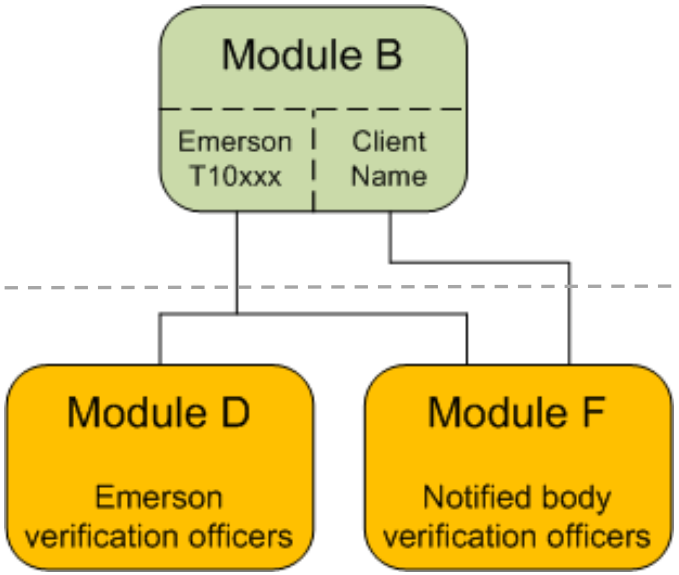


MID scope for liquid:
CT display; local printer; memory etc. AND installation between meter and transfer point

Micro Motion

EMERSON Process Management

MID Verification in Practice



- ***System Certificate***
  (EC Type Examination Certificate)
  Description of:
  - *Installation*
  - *Application*
  - *Functionality*

- ***System Verification***
  (Initial Verification)
  Field verification for:
  - *Installation integrity*
  - *Components integrity*
  - *Functional integrity*

Practice according Certificate?

Micro Motion

EMERSON Process Management

MID covered applications

	Accuracy Class	Types of Measuring system
Meter: 0,2;	0,3	Measuring systems on pipeline
Meter: 0,3;	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
Meter: 0,6;	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
Meter: 1,0;	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)
Meter: 1,5;	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.

Micro Mo

ERSON
Process Management

Agenda

- LNG is HOT
- Bunkering LNG – Custody Transfer
- ***Bunkering LNG – what to measure & how***
  - Mass vs Volume
  - Energy content – Gross Caloric Value
  - LNG Quality – methane number
- Bunkering LNG – Installation

Micro Motion®

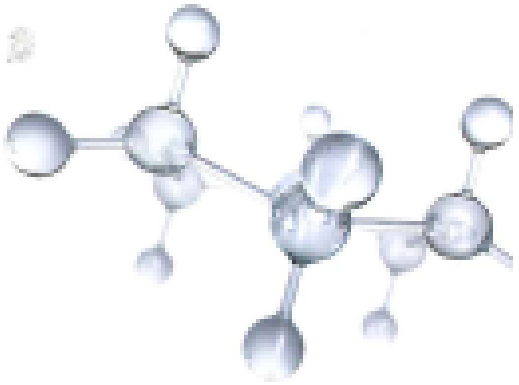
EMERSON™
Process Management

Volume or Mass

Question: What do you get if you put 0,5l water together with 0,5l alcohol?

Answer: 0,9L

Why: Alcohol is hydroforbic



Consequence: 0,5 + 0,5 ≠ 1,0L

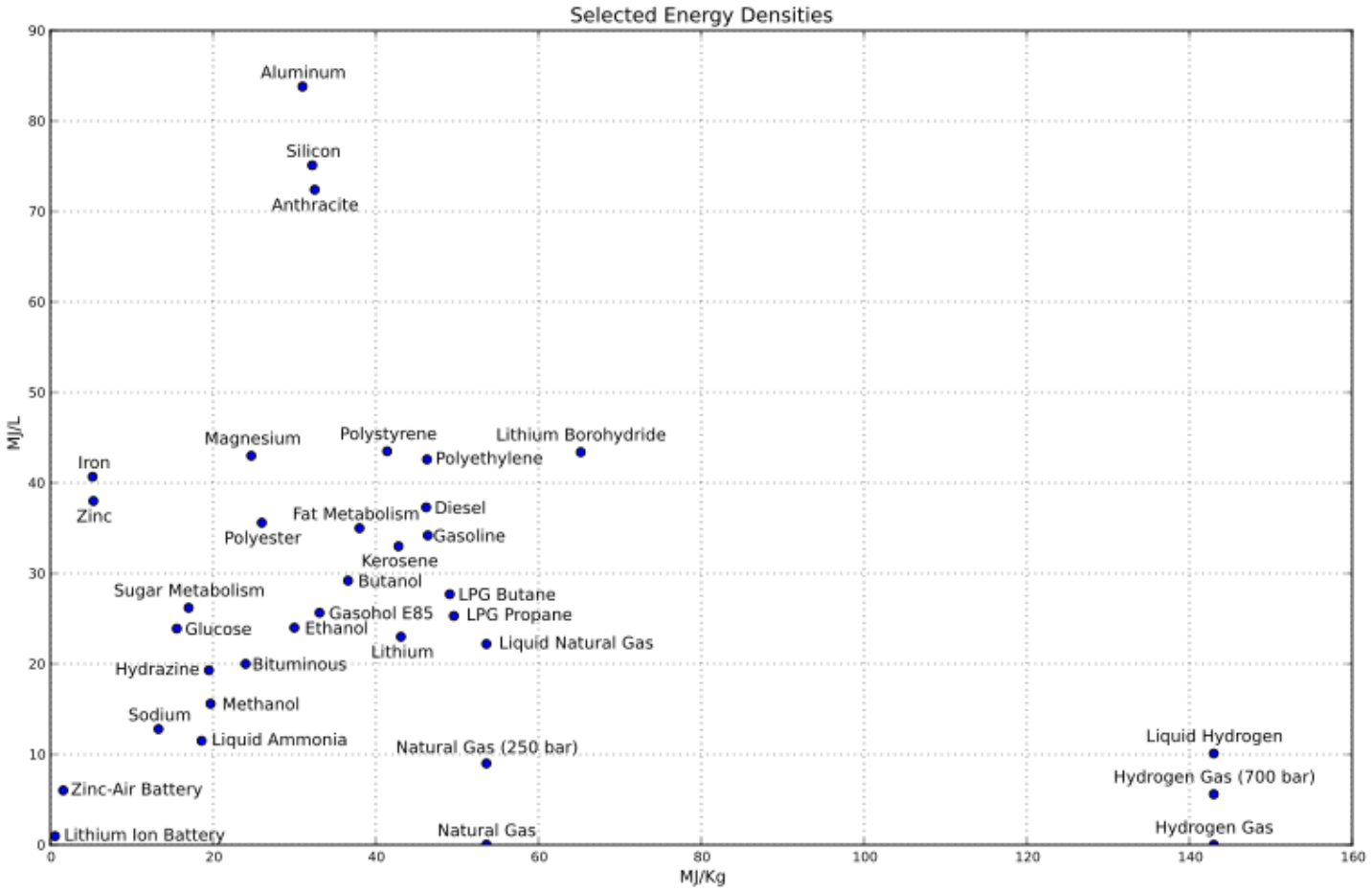
Why important to you: 1L LNG ≠ 1kg. Temperature & Pressure has the same effect.

Conclusion: Measure in mass!

Micro Motion

EMERSON
Process Management

Energy densities – L vs kg



Micro Motion®

EMERSON™
Process Management

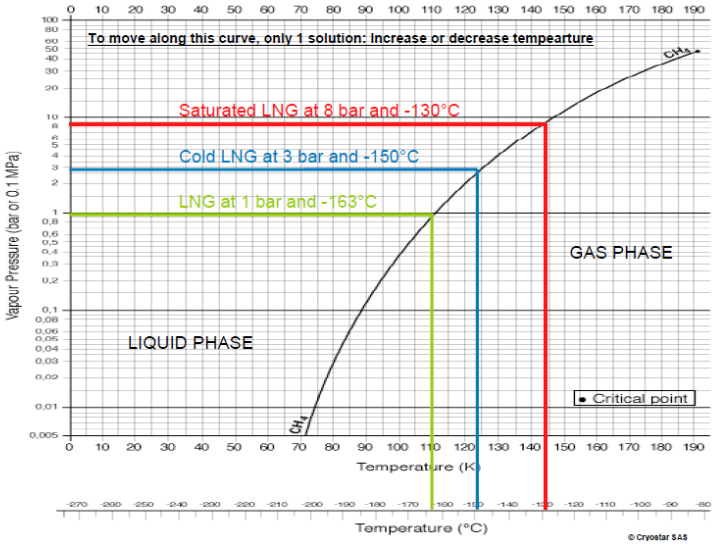
Gross Caloric Value (GCV)

- MJ/kg – trading value
- How to know it:
  - On the contract / delivery note
  - Gas chromatograph
  - Coriolis + SG meter = SG
- Storage Energy content 1m3 @ -163C > 1m3 @ -126C

Micro Motion

EMERSON
Process Management

LNG – Behavior – density shift



Vessel	Bunker Capacity	Range @ full power (-162oC)	Range @ full power (-126oC)	Difference
Small Ferry	50m3	39 hours	34 hours	- 5
Offshore Vessel	1500m3	236 hours	203 hours	-33
Cont Vessel	10,000m3	793 hours	681 hours	- 112 (4.5 days)

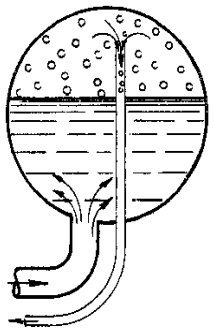
Micro Motion®

EMERSON™
Process Management

LNG Composition – Methane Number

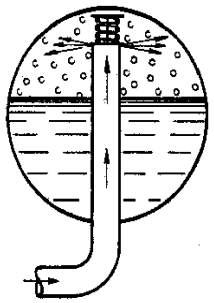
- Two ways to fill tanks

1)



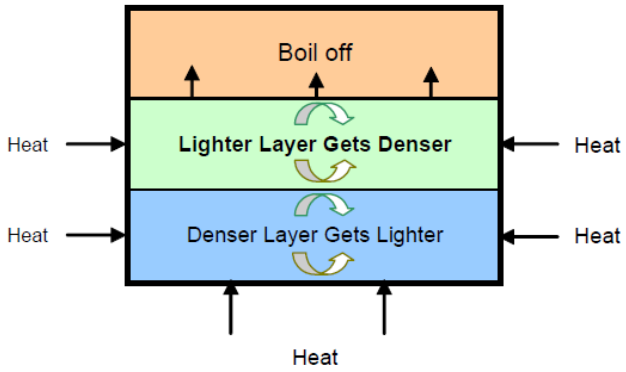
Vapour Return

2)



Spray Nozzle

- Filling time 1 is slower than filling time 2
- @ 1 – MN drops, @ 2 hardly any BOG return
- Future: method 2 & loading full tanks.



Micro Motion

EMERSON Process Management

BOG Creation by Design

Tank Size	60m³		1000m³		1000m³	
Quantity in Tank at Start (Heel) (m³)	6		100		100	
Pressure (Bar)	9		9		Atms	
Temperature (°C)	-126		-126		-162	
Loading Rate (m³/hr)	2	60	100	500	100	500
Loading Time (hrs)	30	1	10	2	10	2
Boil of Gas Generated (m³)	3.25	2.97	53.8	51.69	1.4	1.46
Average Boil Of Gas Rate (m³/hr)	0.1	2.97	5.4	25.8	0.14	0.73
Max BOR (m³/hr)	7	20	20	79	0.6	2.47
Min BOR (m³/hr)	1	2.5	2.5	11	0.06	0.4
Boil of Gas Generated (kg) @-162	2	1.8	33.2	31.9	0.865	0.9
Boil Off Gas as CO_2 Equivalent (kg)	42	37.8	697	667	18	18.9

Micro Motion

HART, FENTON & COMPANY LIMITED

EMERSON Process Management

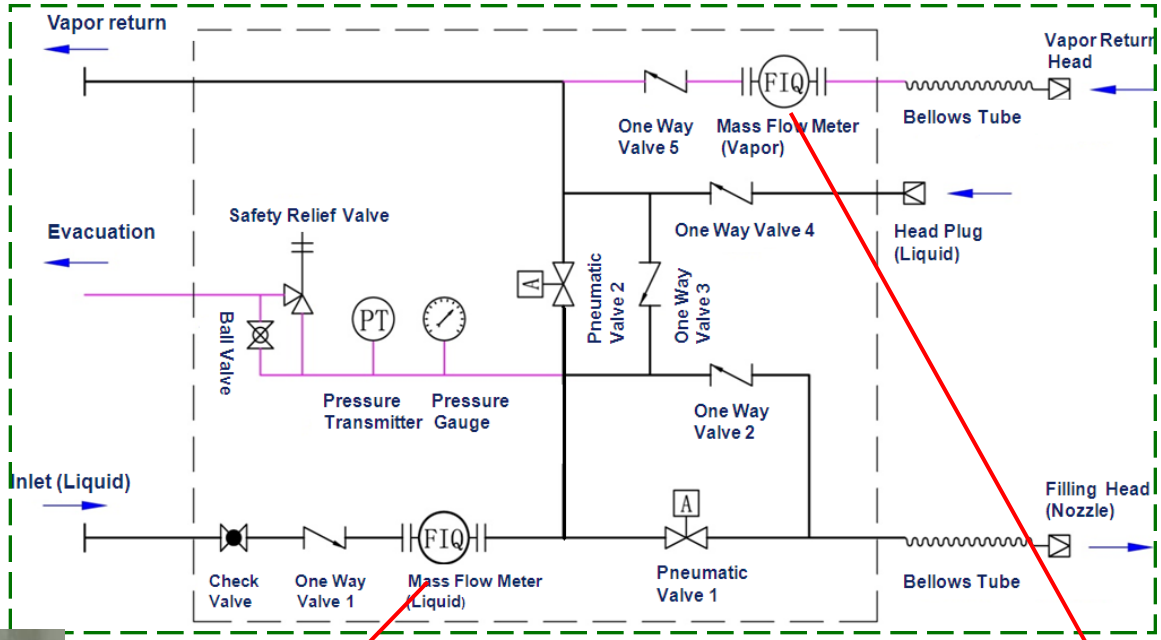
Agenda

- LNG is HOT
- Bunkering LNG – Custody Transfer
- Bunkering LNG – what to measure & how
- ***Bunkering LNG – Installation***

Micro Motion®

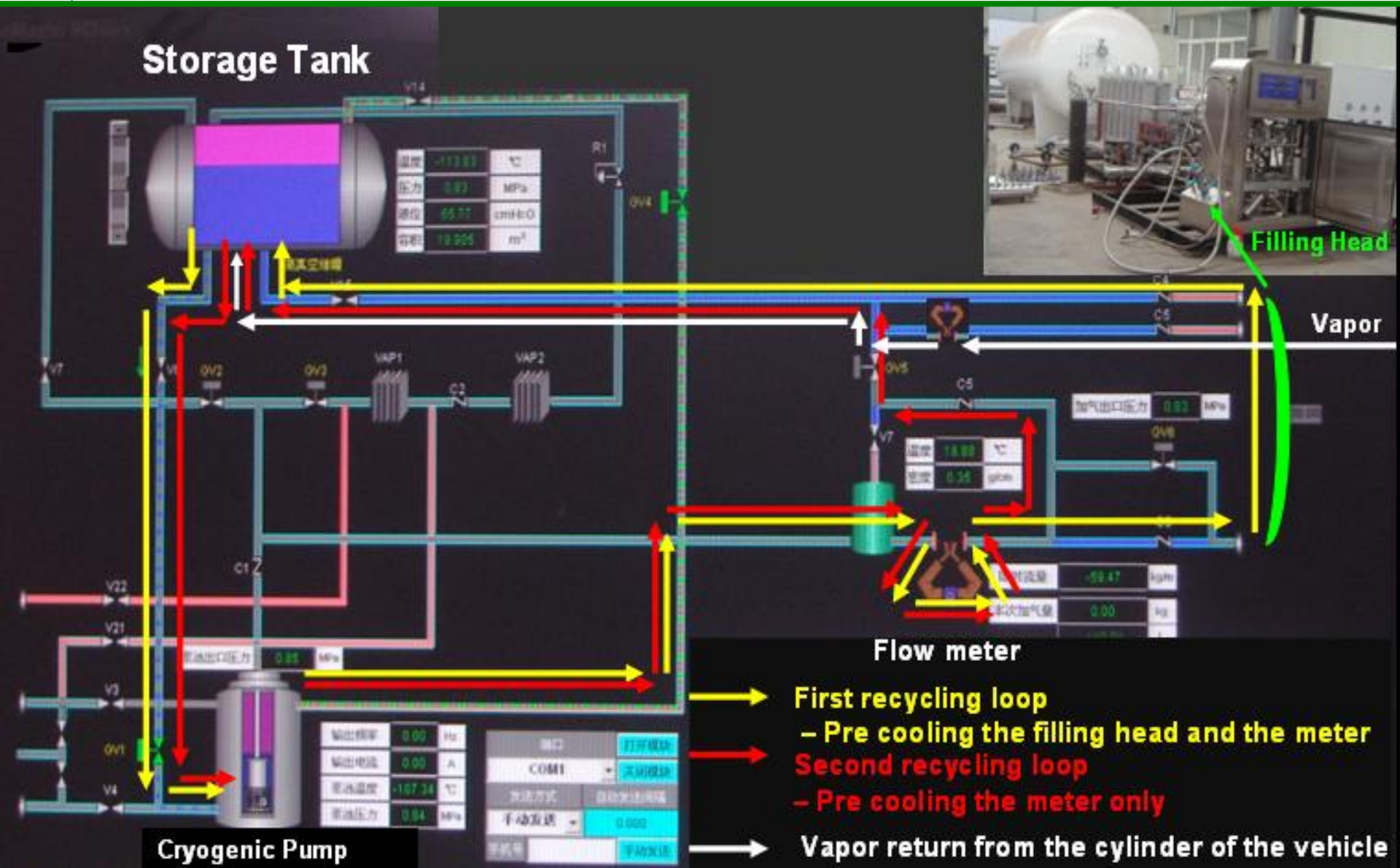
EMERSON™
Process Management

LNG Dispensing – Control Process



Whole Dispenser Control system

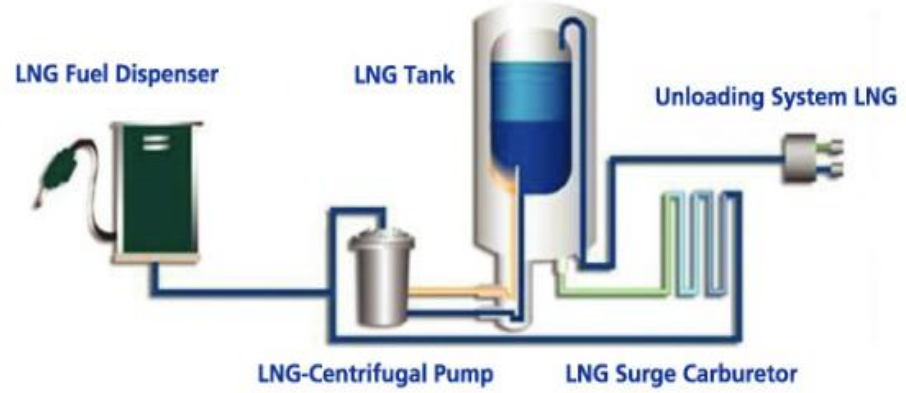
Recycling Process-
Standard Filling Station Asia

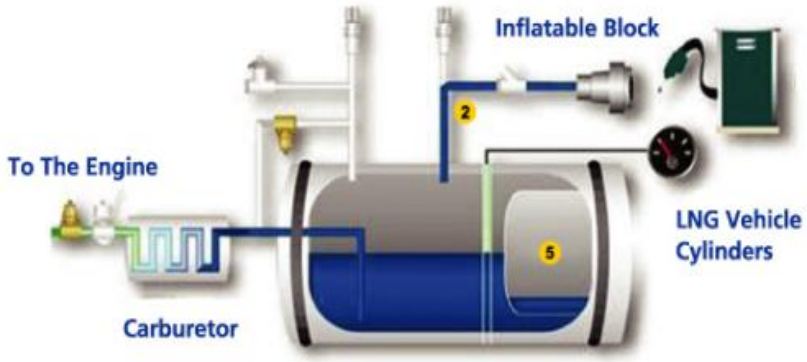


Advantages of Elite meter

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

- Traditional technology or other Coriolis
  - Analog Hz or 4—20mA
  - No fluid status can be described
  - MODBUS to be more time developed





Flow Sensor choice

- Flow requirements:
  - Payment – Mass – Euro/kg
  - Flow condition – Temperature, Pressure, Density reading
  - Flow rate indication – Volume - m3/h
  - Energy content – GCV - MJ/kg
  - LNG Quality – MN - Gas Chromatograph
- To consider:
  - Custody Transfer – MID / OIML
  - Accuracy & allowable uncertainty
  - Line Size, Flow Rate & Flow Conditions, installation
  - Energy Content Calculation & density

Micro Motion®

EMERSON™
Process Management

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

Micro Motion®

Some LNG related business partners

Viking Line Orders LNG-Powered Cruise Ferry

December 23, 2010 – 2:04 am | Finland

The new generation cruise ferry will be LNG-powered for clean operation.

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

WÄRTSILÄ

CRYO STAR

Ballast Nedam IPM

GASNOR
A Shell Subsidiary

THE LINDE GROUP
Linde

Hamworthy
a Wärtsilä company

iPRAGAZ
"emin ellerdesiniz"

INOXCVA

LIQUILINE

CNOOC LIMITED
中国海洋石油有限公司

cryonorm

Skangass

AIR LIQUIDE

ConocoPhillips

A Member of The Linde Group | AGA

Micro Motion

INDOX
cryoEnergy

VANZETTI
CRYOGENIC TECHNOLOGY

EMERSON
Process Management

THANK YOU !

Arjan van Ginkel
Arjan-van.Ginkel@Emerson.com
+31 (0)615 159 806

Micro Motion

EMERSON
Process Management