KUWAIT 3RD FLOW MEASUREMENT TECHNOLOGY CONFERENCE

19 - 21 NOVEMBER 2017

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شركة نفط الكويت
Kuwait Oil Company

إحدى شركات مؤسسة البترول الكويتية
A Subsidiary of Kuwait Petroleum Corporation

PHIL JANOSI – MSC.

International Product Manager, Coriolis Flowmeter – KROHNE Ltd, UK.

ADVANCES IN HIGH CAPACITY CORIOLIS FLOWMETERS

INTRODUCTION

- Rising Oil prices between 2005 to 2015 resulted in many requests for accurate high capacity mass flowmeters.

- Coriolis manufactures invested heavily in the development of large line size (LLS) Coriolis meters – from 6'' to 16''.

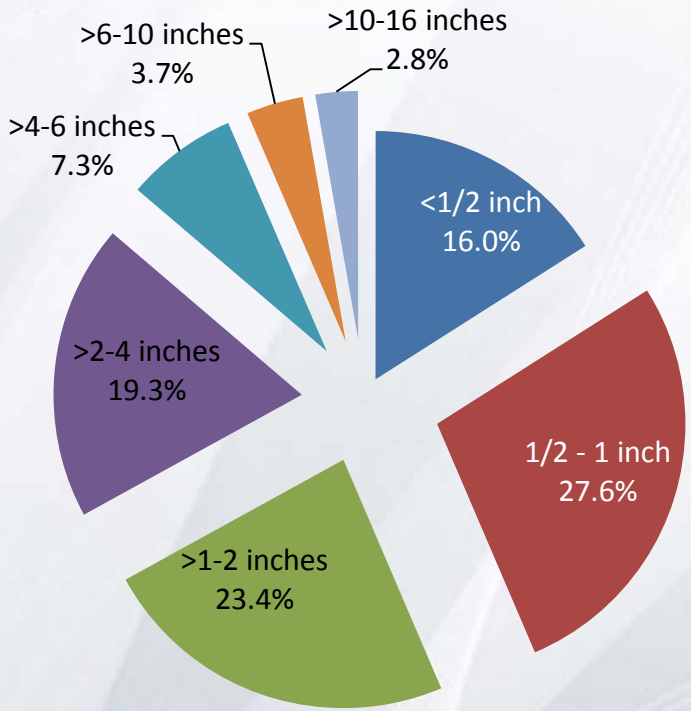
- Coriolis meters technology provides superior diagnostic solution, 2 phase flow with Entrained Gas Measurement (EGM™).

- LLS designed for CT applications in the O&G.

Coriolis Market by line size

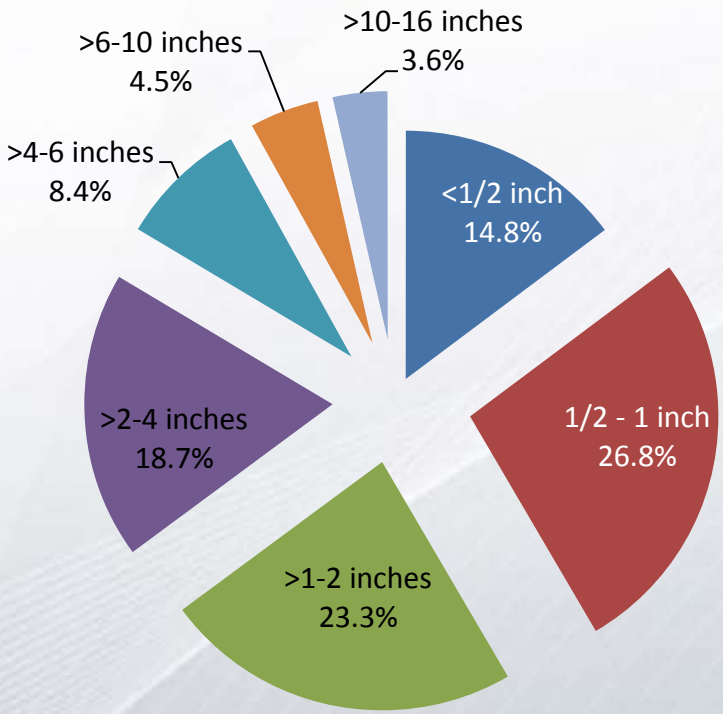
Millions of Dollars 2015-2020

Market 2015



Total WW: 1.280.000.000 $

Market 2018



Total WW: 1.739.600.000 $

1). **COST vs. ACCURACY** - Producers are pumping more and looking to lower production costs to guarantee the best Return on Investment (ROI).

2). **CALIBRATION** - Coriolis manufacturers have responded to the long-standing need of calibrating meters to full scale with uncertainty of 0.05%.

3). **INSTALLATION** - Users are changing from turbine meters and orifice plates due to maintainability, installation costs and accuracy concerns.

4). **SOLUTIONS** – Application solution for the Oil & Gas Industry.

1). COST of Ownership.

- Engineering, installation and maintenance costs saving versus conventional mechanical meters.

- Best possible accuracy – True Mass flow & Density reading, no need to compensate pressure and temperature – Eliminate the need for a flow computer.

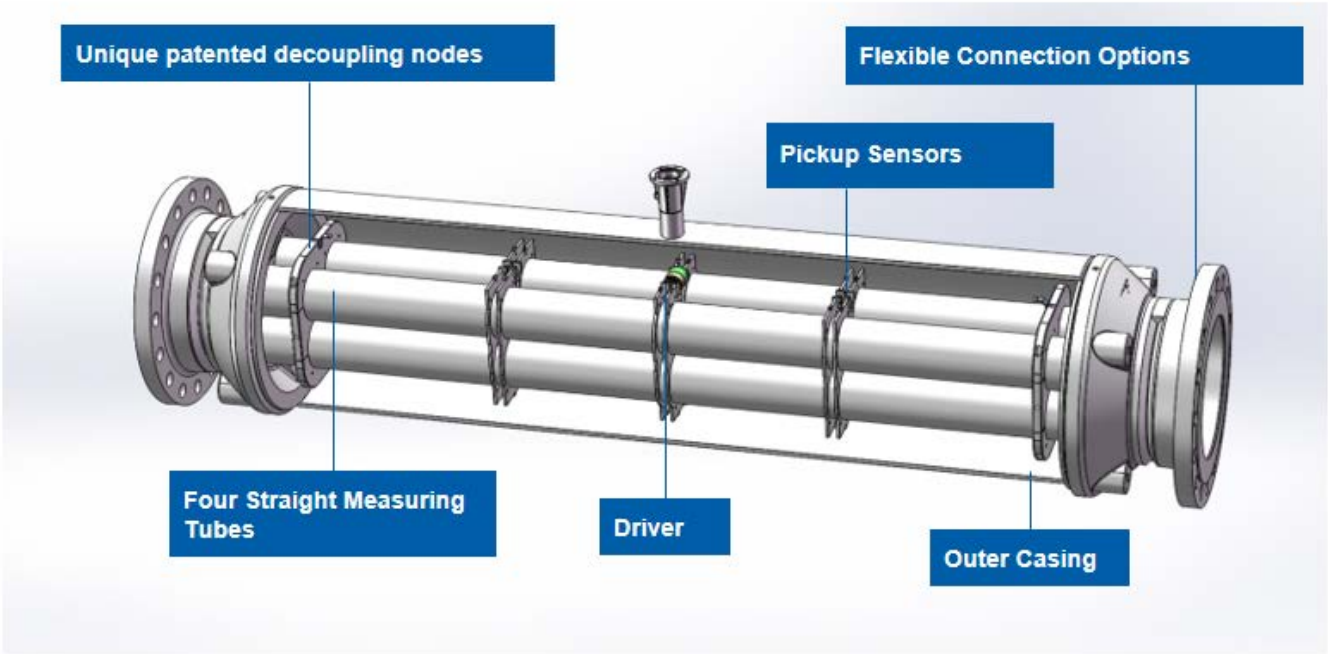
- Not affected by normal process changes such as different fluids, temperature, pressure or flowrates - Coriolis meters are regarded as Reliable.

- No moving parts - do not suffer from wear & tear - more stable – therefore not required to be re-calibrated every year – cost saving on replacement parts.

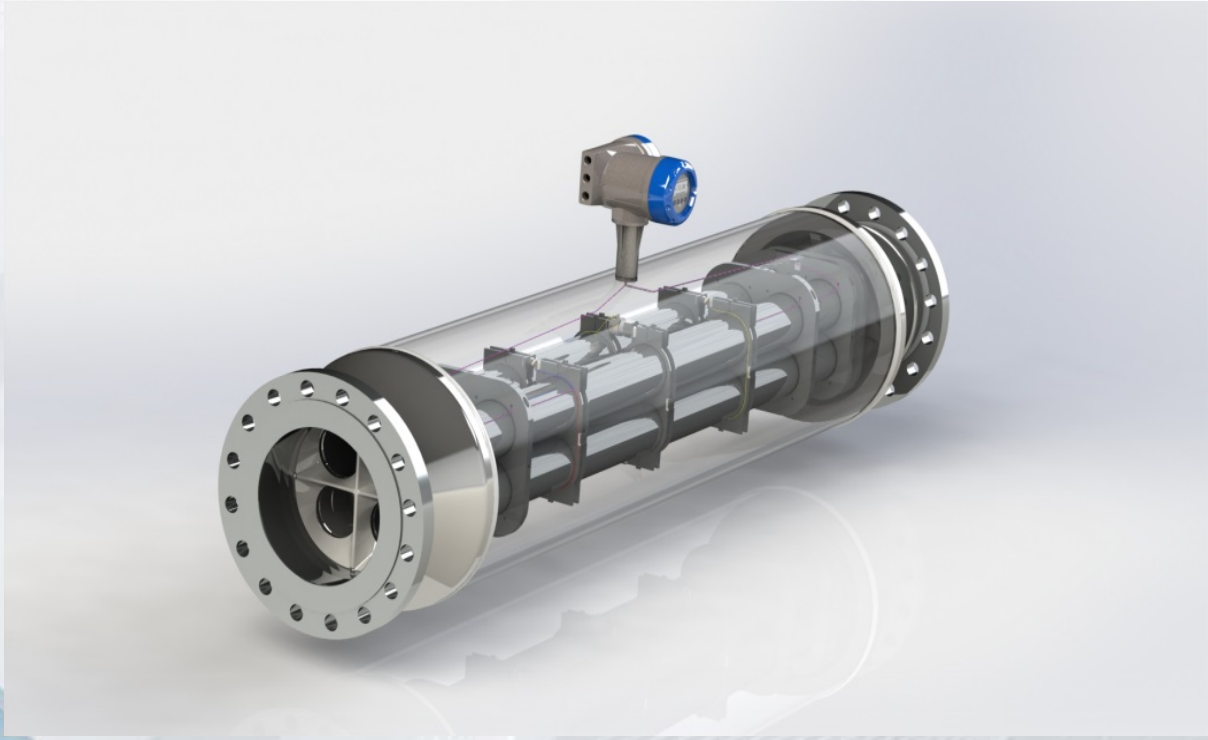
- Straight tube Coriolis meters offer a lower pressure drop with optimised flow splitter, large turndown, and reduces cavitation risks.

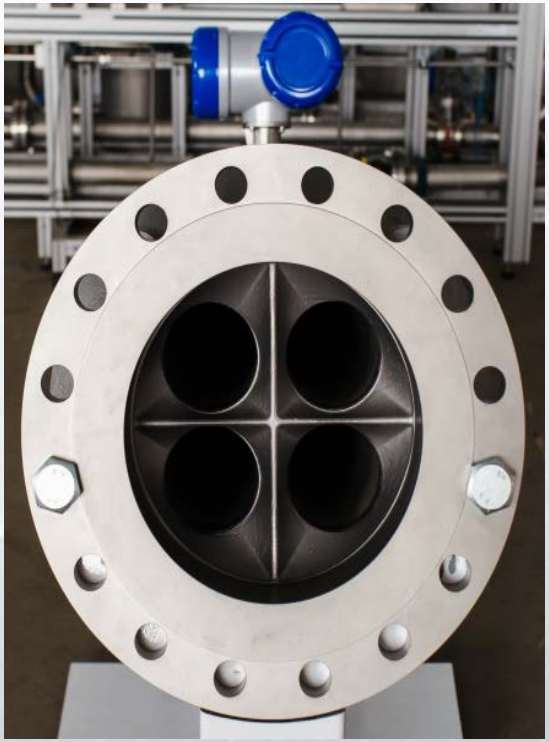
- Innovative design with Four Straight Measuring Tubes – 16’’ meter.
- High capacity meter with flowrates up to 4600 t/hr – for CT 2000 t/hr.
- Compact Cost Saving installation envelope.
- Duplex and Super Duplex with secondary containment (150 bar).
- Measuring tube design pressure: -1 to 180 bar (PED).

OPTIMASS 2400 S400 3D Internal View



- Benefits include reduce build-up, easy to clean, lower pressure drop.
- Accuracy 0.1% - 20:1 turndown and option of 0.05% with 10:1 turndown
- Temperature Range -45C to +130C.
- OIML & MID CT approved, API & AGA compliant + ATEX, IECEX, cFMus, NEPSI
- With proven Entrained Gas Management (EGM™) technology.





2). CALIBRATION

- It takes a large calibration rig to calibrate the Highest Capacity Coriolis flowmeters on the market.

- It is important to understand the flow rates to which these meters can be calibrated to.

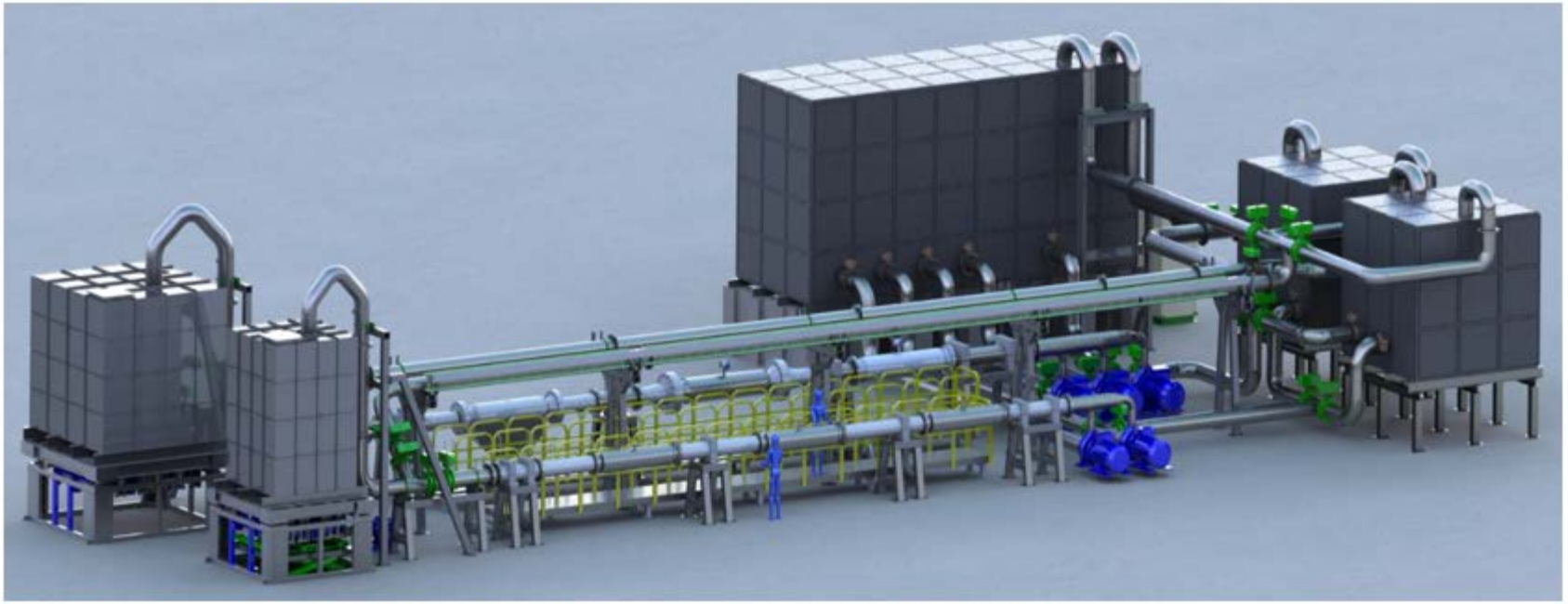
- In some cases if the flow is above 1200 T/hr, then some meters can only be calibrated to a fraction of the required maximum process flow.

- KROHNE Ltd, UK, has invested heavily in the in-house design of the GIGA and MEGA calibration rig to ensure our LLS meters can be calibrated to full scale.

- The Optimass 2400 S400 / DN400 / 16'' CT meters can be calibrated to 2000 T/hr with 0.05% accredited measurement uncertainty, the calibration rig is UKAS accredited with extended uncertainty of 0.017%.

2). CALIBRATION – MEGA & GIGA Calibration Rig – KLTD UK

- Two rigs
  - "Giga Rig", flow rate up to 2,300 t/h, 20t weighing reference, 14" line



  - "Mega Rig", flow rate up to 1,000 t/h, 10t weighing reference, 12" line

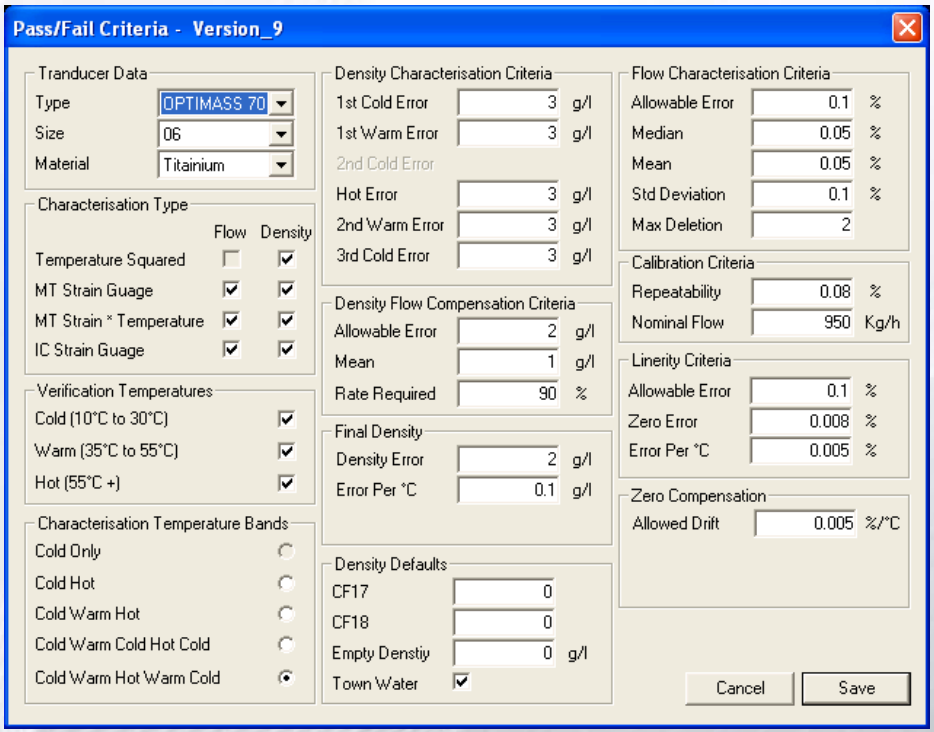
2). CALIBRATION – MEGA & GIGA Calibration Rig – KLTD UK

Weigh system based on load cells

- Mega rig: 4x 5t C6, Mettler 0970 Compression Load Cell
- Giga rig: 4x 10t C6, Vishay 220 Compression Load Cell

2). CALIBRATION

- Each flow meter leaves the factory with a set of data which is saved as a “finger print” of the performance and health of the meter.
- This can be used to evaluate the condition of the meter at a later date when the calibration is verified.
- A range of diagnostic information can also be accessed with the appropriate software tools.

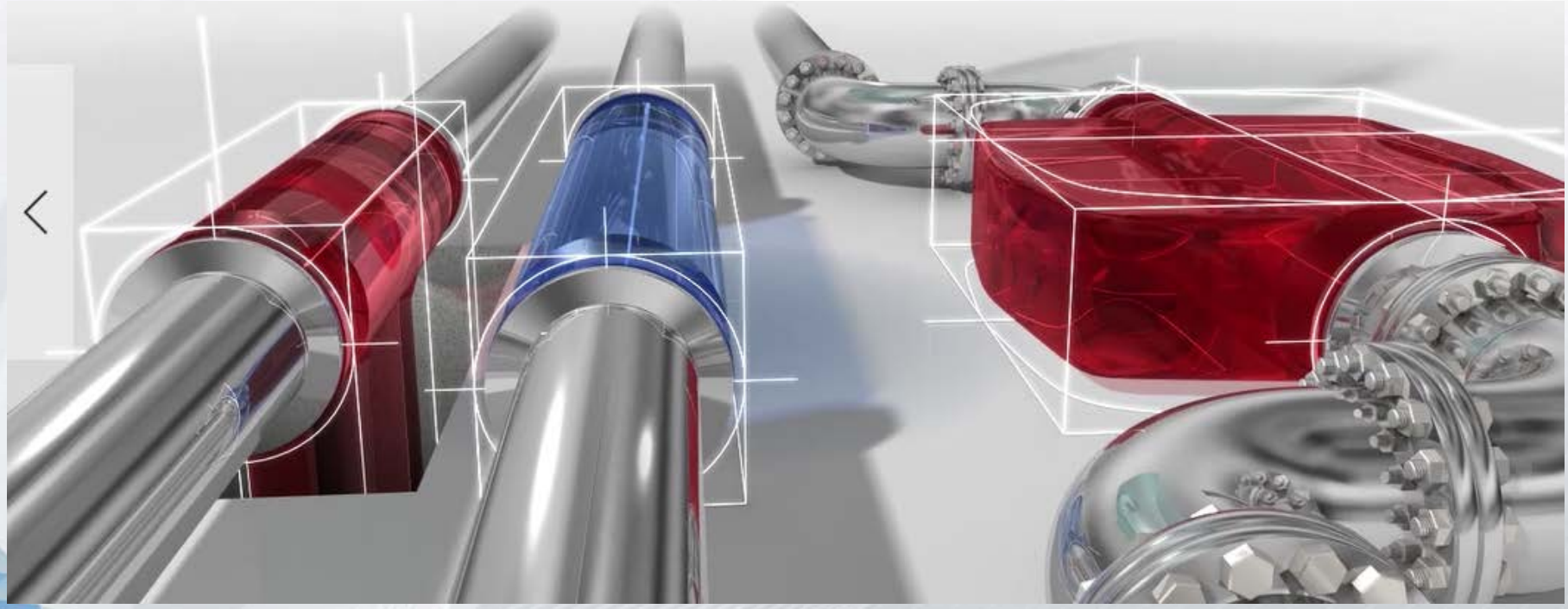


3). INSTALLATION

➢The design of the leading High Capacity Coriolis meters available on the market today, vary in shape & envelope size.

➢The U-bend or OVNI are traditional shapes for large Coriolis meters.

➢ Straight tube meters are proving to provide considerable saving in installation cost and provide flexibility with compact installation envelope.



OPTIMASS 2400 Size 400

Target Application

End-User	Sinopec
Location	Nanjing City, Jiangsu, China
Year of supply	2016
Application	Vessel loading, CT measurement
Medium	Diesel
Scope of supply	OPTIMASS 2400 S400
Project details	CT measurement application for ship loading with flow rates up to 1500 t/h / 55116 lb/min. The site accuracy must be within 0.2% accuracy. We supplied the OPTIMASS 2400 S400 which is the biggest capacity mass flowmeter worldwide with four straight tube design. The straight tube design saves installation space and reduces cavitation risks. The customer is very satisfied with the excellent performance and accuracy of the meter.

OPTIMASS 2400 S400 installed at Sinopec

OPTIMASS 2400 S250

Target application

Location	Cape Canaveral, Brevard County, Florida
End-user	Port Canaveral
Medium	Heavy fuel oil RMG 380
Requirements	• Flow rates: 900 t/h / 33069 lb./min • Density: 0.9 kg/l / 56 lb/ft³ • Temperature: 30°C / 86°F
Scope of supply	Flow measurement of HFO on a ship (bunkering) • Two 10-inch OPTIMASS 2000 meters are used • Proving of the meters was done using a large volume prover
Customer benefits	Installation space is always a challenge in bunkering applications and hence the customer was very happy to find a CT meter with the most compact envelope
Application document	KROHNE America

Optimass 2000 S250 in Cape Canaveral, Florida

Proving of the Optimass 2000 S250

OPTIMASS 2400C S250

Target application

Location	Belarus
End-User	JSC Mozyr Oil Refinery
Medium	Crude oil and black oils
Requirements	• Flow rates: 1600 t/h / 58790 lb/min • Density: 0.78 kg/l / 48.71 lb/ft³ • Temperature: 35°C / 94°F
Customer benefits	The customer did not have much space for installation because of low hanging pipelines in process but at the same time they needed a 10-inch meter. No wonder the OPTIMASS 2000 was their only choice
Application document	Application Report 277

OPTIMASS 2000 C S250 in use

OPTIMASS 2400C S250

Target application

Location	North Sea Export Allocation
End Users	Platform Service 2 x OPTIMASS 2000 S250 1500# Super Duplex Flanges
Medium	Oil metering skid
Requirements	Material Super Duplex European sourced
Customer benefits	Converters with SS housing Elbow directly at the meter inlet Modbus electronics Flow up to 438 t/h
Application document	N/A

OPTIMASS 2000C S250

OPTIMASS 2400 S150

Target application

Location	Crude Oil Metering Skids in Turkey
End Users	Customer is one of the biggest names in Oil and Gas
Medium	Oil metering skid
Requirements	40 x OPTIMASS 2000 Large Line Size Meters were used to build these skids
Customer benefits	The skids will be spread all across Eastern Turkey oil network
Application document	N/A

OPTIMASS 2000C S150

4). SOLUTION

- Two-Phase flow has always been a challenge for Coriolis Mass Flowmeters due to dampening of driver frequency.
- Typical applications are oil drilled from the reservoir and oil separated from gas after HP Separator.

- Entrained Gas Management (EGM™) feature measure from 0 to 100 % gas entrainment without any loss of signal.

- OPTIMASS Meters bring a new era of sophisticated synthesised drive control with dynamically matched sensor system.

- Measurement process continues even under “noisiest” conditions.
- EGM TM functionality verified by several independent flow labs.

EGM™
Entrained Gas Management

Location	Denver-Julesburg Basin
Year of supply	2013 - 2016
Application	Post separator wellhead allocation
Medium	Crude Oil / Produced Water

BONANZA CREEK

Denver-based Bonanza Creek Energy, Inc. is an:

- **Exploration and production company**
- Focused on **extracting oil** and associated liquids-rich **natural gas**
- Based in Colorado's Denver-Julesburg Basin,
- A major oil and gas field that is being actively developed
- Through the use of **horizontal drilling and multi-stage fracture** stimulation.

Scope of supply	>450 OPTIMASS 6400, OPTIMASS 1400
Year of supply	2013 - 2016
Application	Post separator wellhead allocation
Medium	Crude Oil / Produced Water

- Competitors recommended to collapse the bubbles in the liquid stream by using a smaller flowmeter and install an orifice plate downstream of the meter to increase the back pressure
- That can also require replacing the snap acting dump valve with a much more expensive throttling valve to prevent flashing

.

End-User	Production Company
Location	Permian Basin
Year of supply	2016
Application	Post separator wellhead allocation
Medium	Crude Oil / Produced Water
Scope of supply	OPTIMASS 1400, OPTIFLUX 4100
Project details	The customer is able to get accurate allocation of crude oil and produced water from a production well using KROHNE's OPTIMASS 1400C and OPTIFLUX 4100C. Meters have been successfully installed and used for 6 months. The customer is very happy with the performance and will continue to purchase these meters.

End-User	Petrobank
Location	Alberta, Ca
Year of supply	2014
Application	Wellhead a
Medium	Oil / Water
Scope of supply	OPTIMASS
Project details	The custon because th entrained g process wa inaccurate with all co KROHNE's outperforn competito

PETROBANK
STRENGTH IN OUR RESOURCES

March 19, 2014

Nick Powell
Technical Sales Representative
GS Hitech Controls Inc.
6173 – 6th Street S.E.
Calgary, AB T2H 1L9

Dear Nick,

RE: Petrobank, Kerrobert THAI project Optimass 6400 performance

We are very pleased with the performance of Krohne "Optimass 6400" coriolis mass flow meter we purchased from you recently. In a very difficult application of heavy oil flow with up to 90% of entrained/free gas (by volume) Krohne meter outperformed all competitors we tried before. The much more accurate rates provided by your meter truly helped us to improve overall well control which is very important in THAI process we use.

Sincerely yours,

Konstantin Starkov
Production Engineer
Petrobank Energy and Resources Ltd.

CONCLUSION

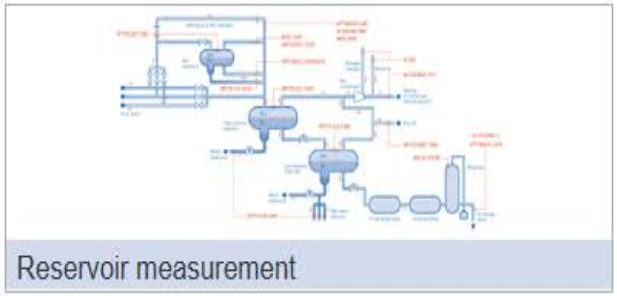
- Provides the-best-in class error margins
- Ensures repeatable measurements

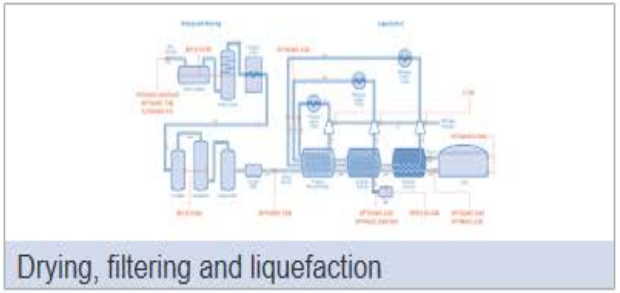
- Oscillation can be maintained under challenging conditions for a whole range of possible gas volume fractions (GVF).

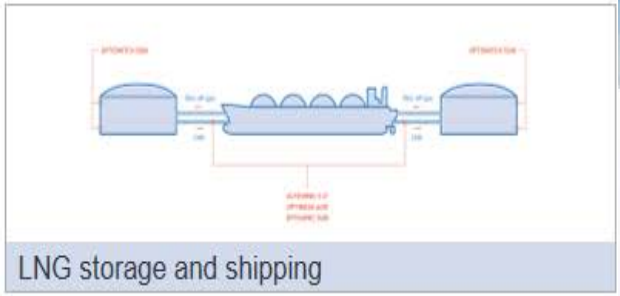
- Real-world applications demonstrate tangible business benefits due to EGM™
- Enables density and flow measurements at any flow regime
  - Improves process control and efficiency
- EGM™ provides continuous and repeatable measurements from 0% to 100% entrained gas

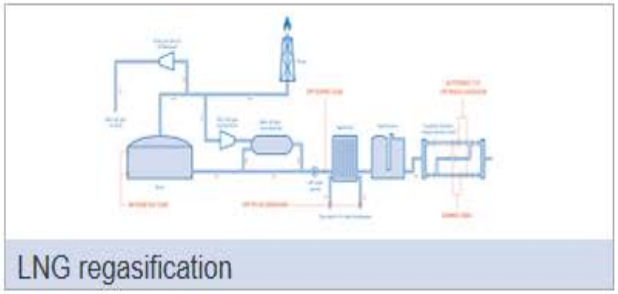
KROHNE has a wide experience in the O&G industry and we are able to deliver knowledge & support for all applications.

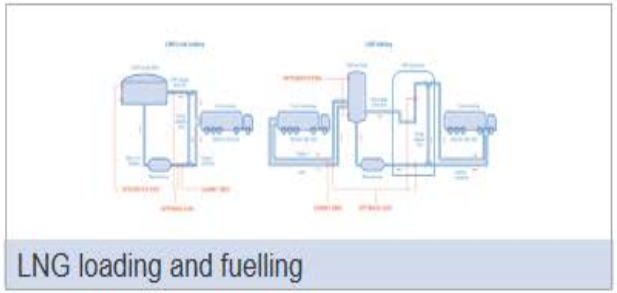
We welcome discussing & providing a solution to your applications…

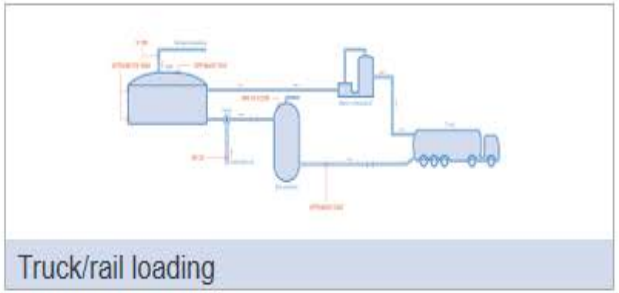

Reservoir measurement

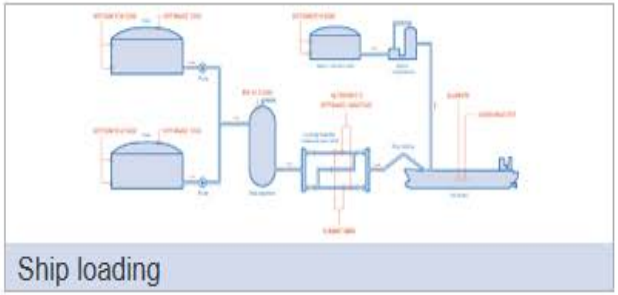

Drying, filtering and liquefaction

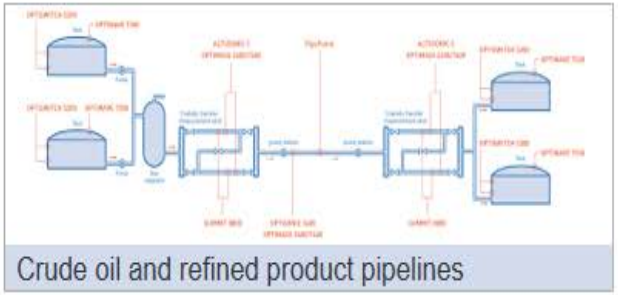

LNG storage and shipping

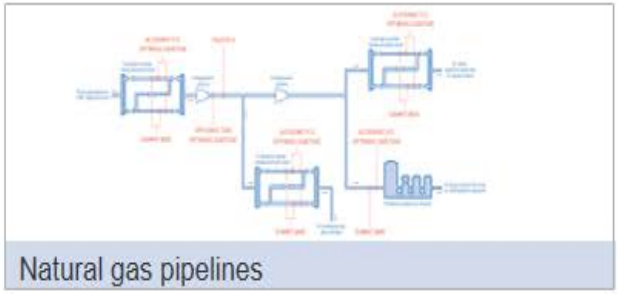

LNG regasification


LNG loading and fuelling


Truck/rail loading


Ship loading


Crude oil and refined product pipelines


Natural gas pipelines

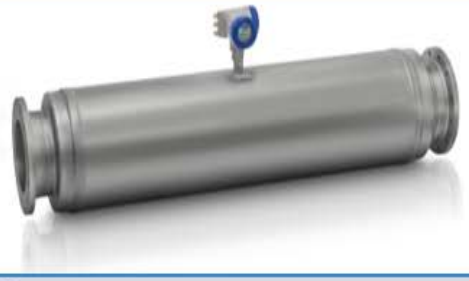
Thanks for Attention

KROHNE
measure the facts

OPTIMASS Highest Capacity Coriolis Flowmeters

Overview

OPTIMASS 2400 S400



4,600 t/h / 169021 lb/min

OPTIMASS 6400 S150

480 t/h / 17637 lb/min

OPTIMASS 6400 S200

825 t/h / 30314 lb/min

OPTIMASS 6400 S250

1,500 t/h / 55115 lb/min **Launch Q3 / 2018**