Coriolis in the Marine Industry

made in Germany

Advantages Coriolis Meters

- Direct Measurement of Mass, Temp, Density
- Indirect measurement of Volume and Concentration (e.g. BRIX)
- Accuracy - high precision…Swiss Watch
- Rate, Total, Density, and Temperature outputs standard
- No moving parts
- No straight piping requirements
- Low maintenance
- No need for recalibration
- Overall cost of ownership
- Variety of materials

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Coriolis Mass Flow Meter

- Accurate Mass Flow measurement
- Accurate Density Measurement
- Accurate Temperature Measurement

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What makes the difference between suppliers ?

- Mechanical Design
- Signal Processing

- **MASS FLOW SENSITIVITY DEFINITION**:
- K = flowrate (gm/sec) / per unit Δt time-delay (µsec)
- The better the Phase Shift (Δt time-delay (µsec)) the better the mechanical design

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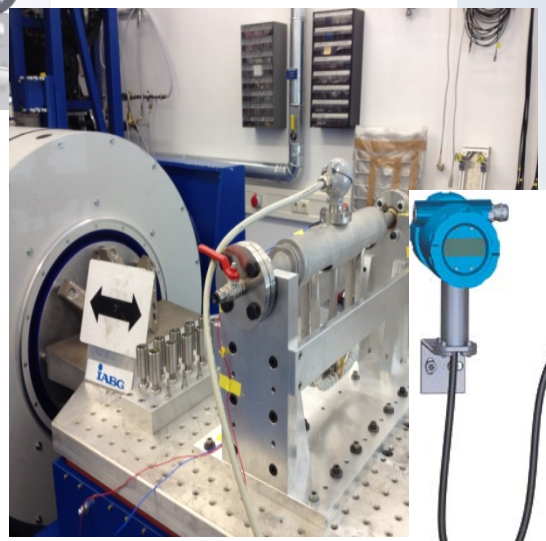
DN10-DN80 (1/2”-3”)

0 – 230.000 kg/h

made in Germany

Mech. Design



U-Tube

Diamond shape

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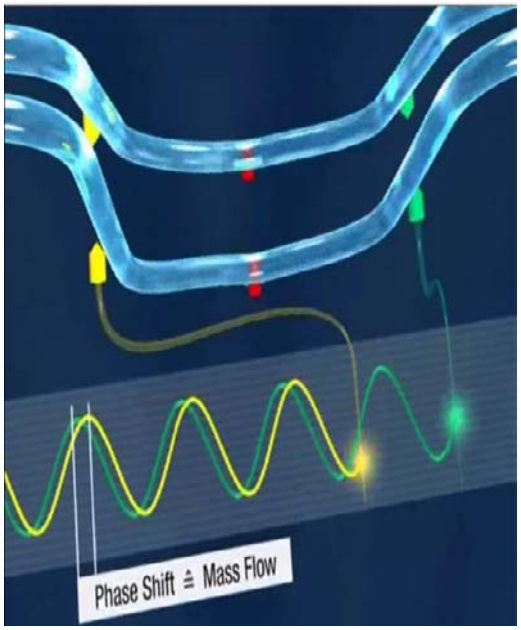
Coriolis or Inertia force

Gaspard Gustave de Coriolis

20th Century



Sur les équations du mouvement relatif des systèmes de corps, 1835

$$\vec{F}_C = -2\,m\,(\vec{\omega} \times \vec{v})$$

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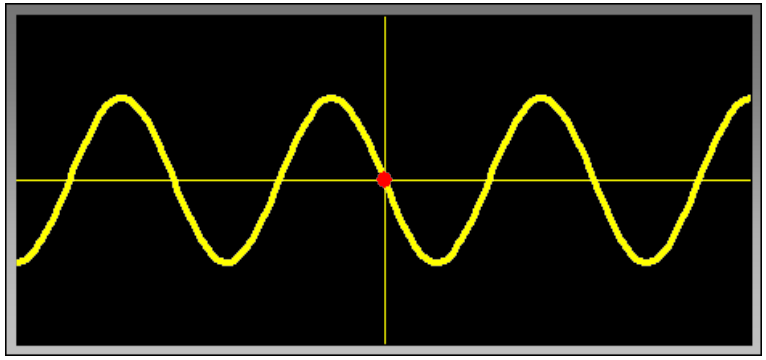
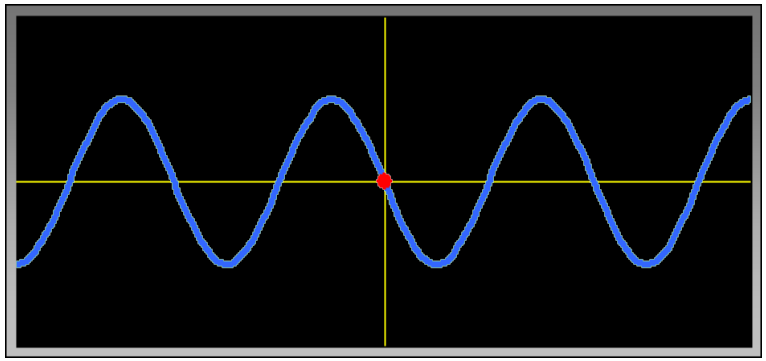
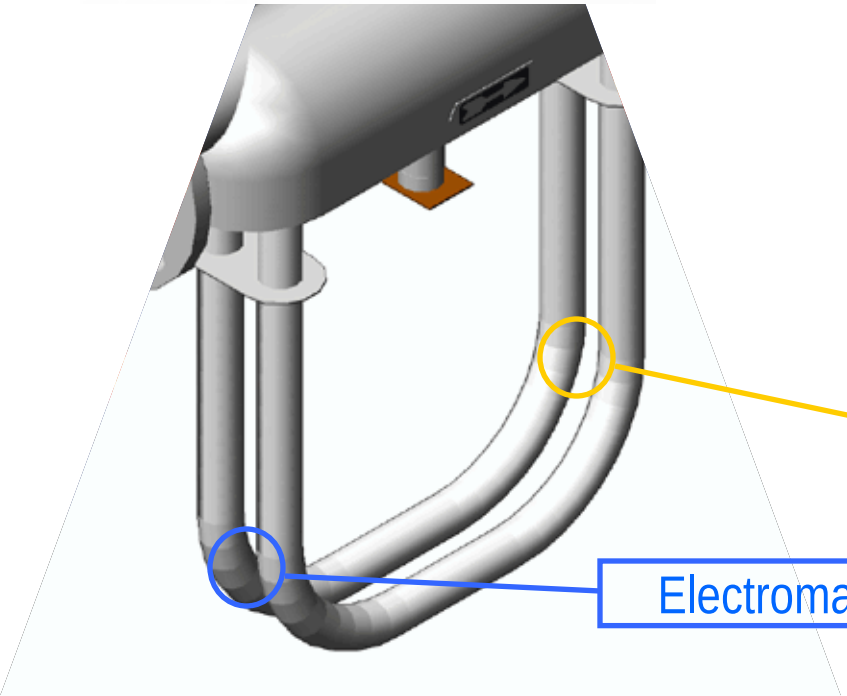
Principle of Measurement

Mass Flow







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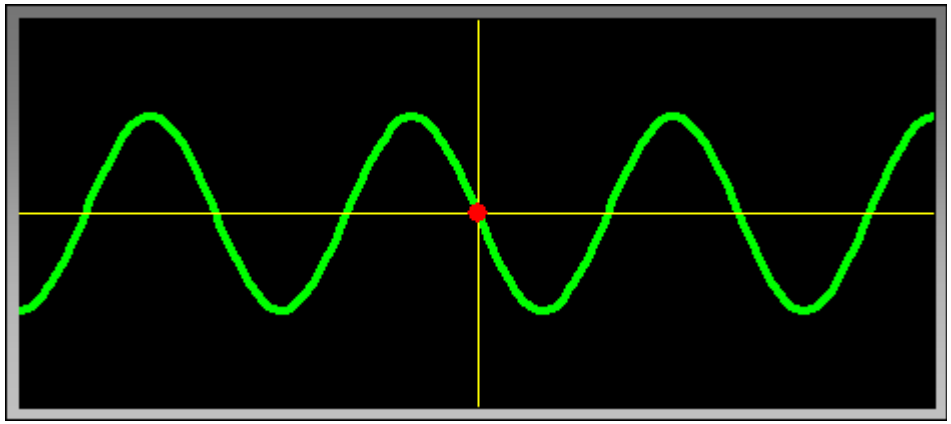
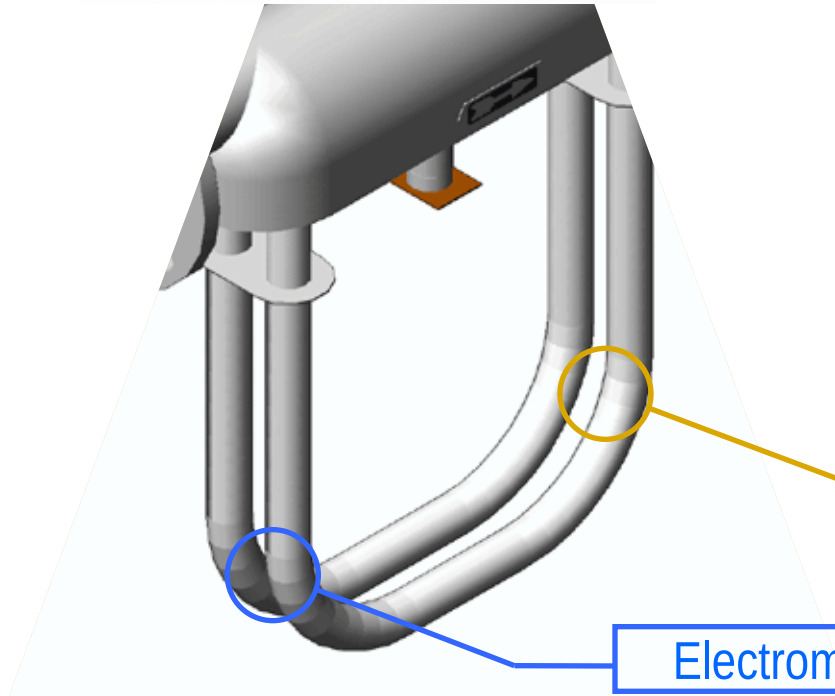
Principle of Measurement

Zero flow

ΔT : No time difference





Electromagnetic Pick-off (Downstream)

Electromagnetic Pick-off (Upstream)

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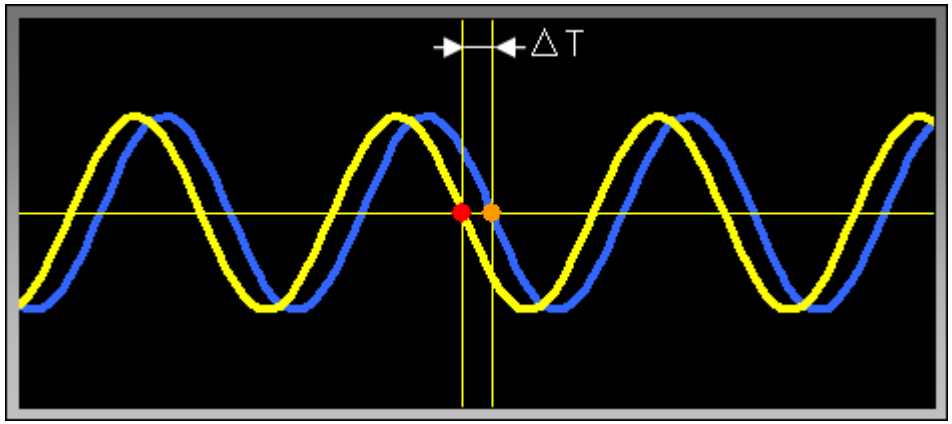
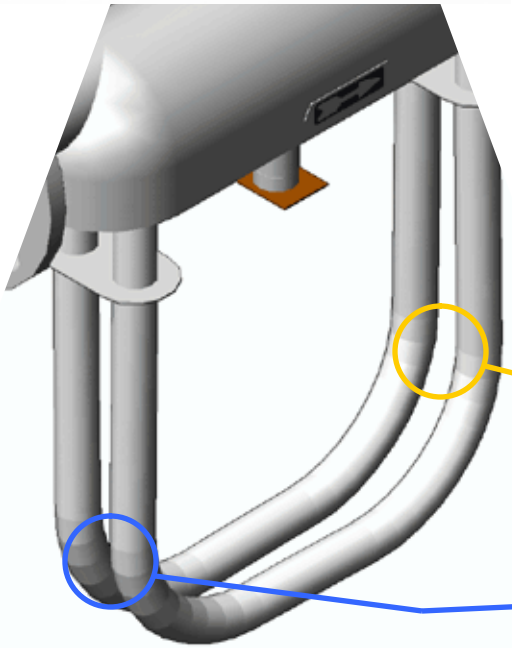
Principle of Measurement

Low flow

ΔT : Small





Electromagnetic Pick-off (Downstream)

Electromagnetic Pick-off (Upstream)

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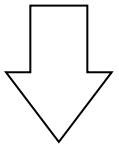
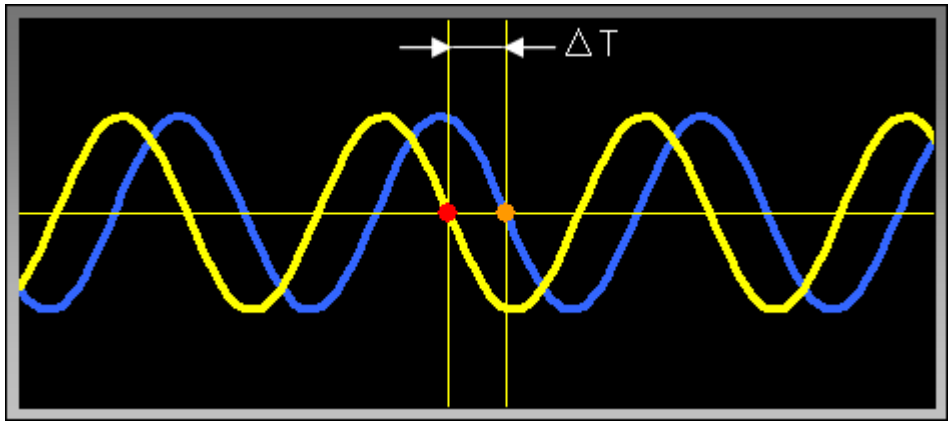
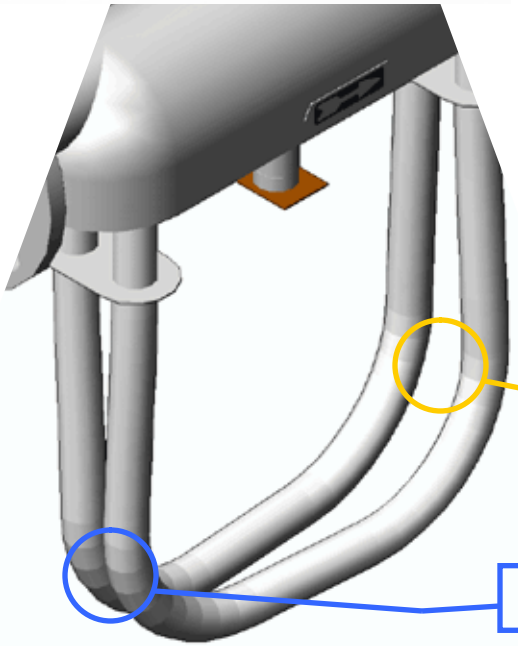
Principle of Measurement

High flow



ΔT : High





Electromagnetic Pick-off (Downstream)

Electromagnetic Pick-off (Upstream)

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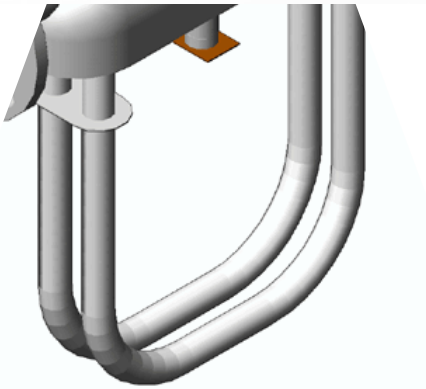
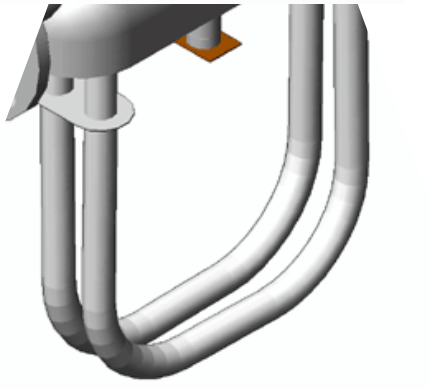
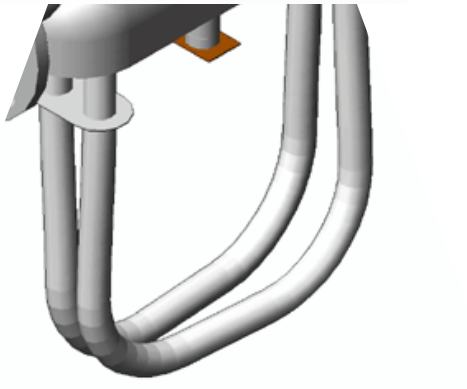
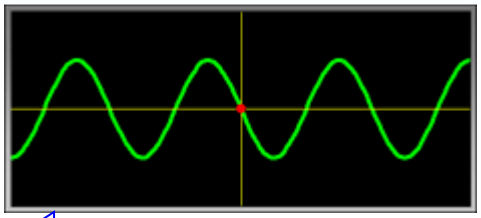
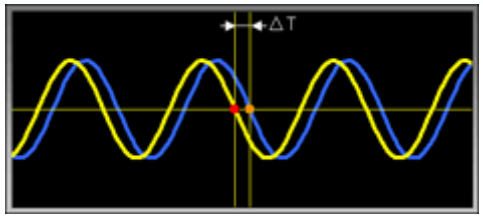
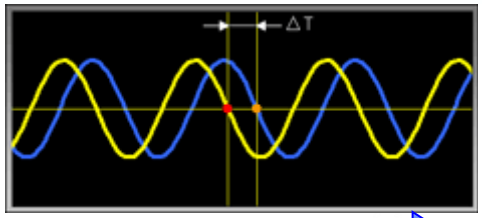
Principle of Measurement





No flow, no ΔT

Small flow, small ΔT

High flow, high ΔT

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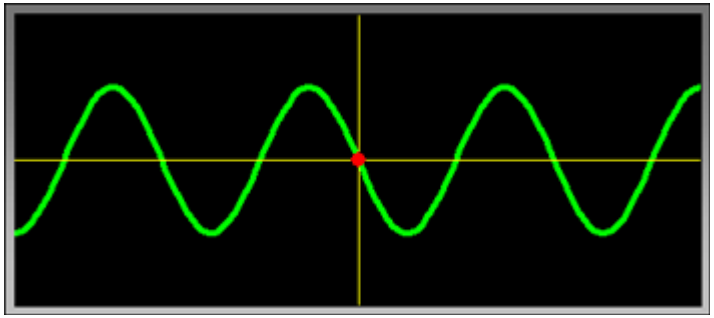
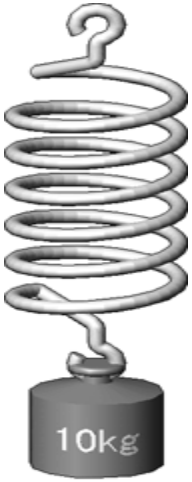
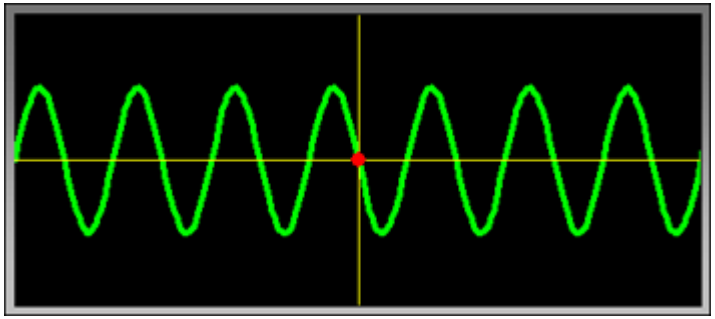
Principle of Measurement

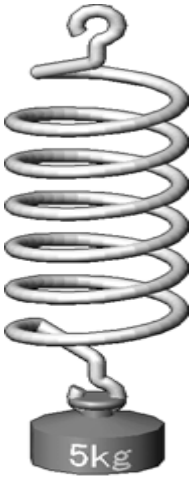
Density





Density





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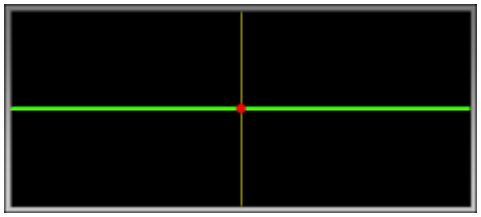
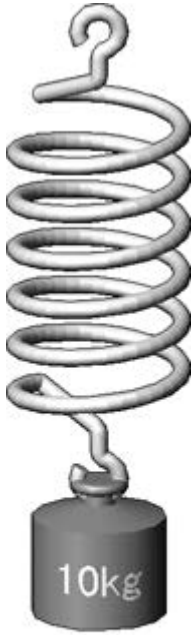
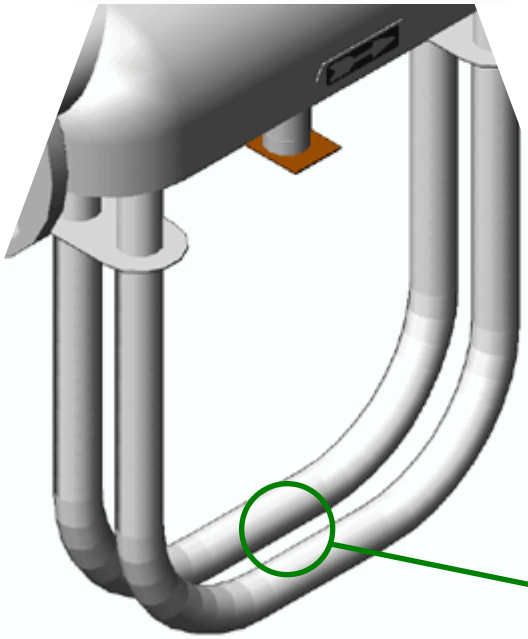
Principle of Measurement







Electromagnetic Oscillator

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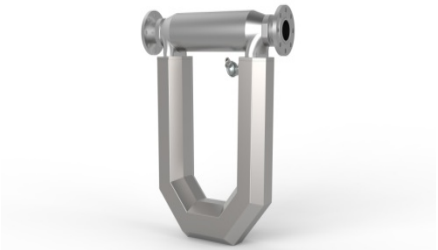
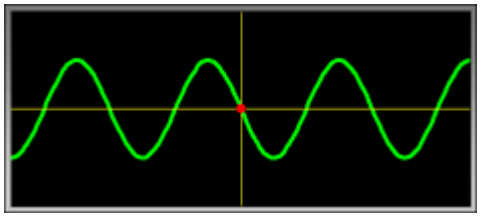
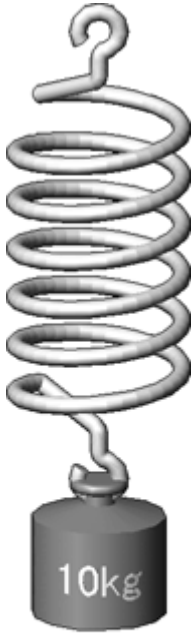
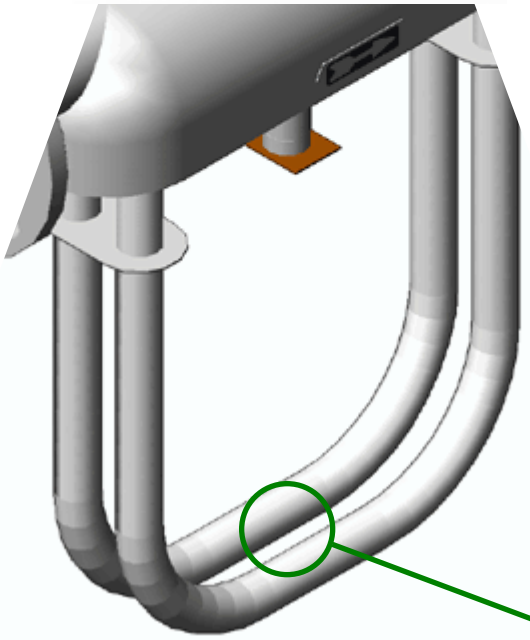
Principle of Measurement





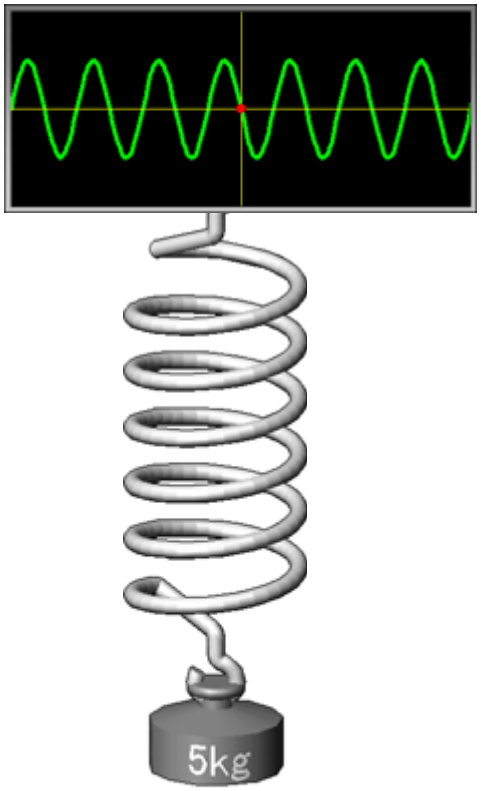


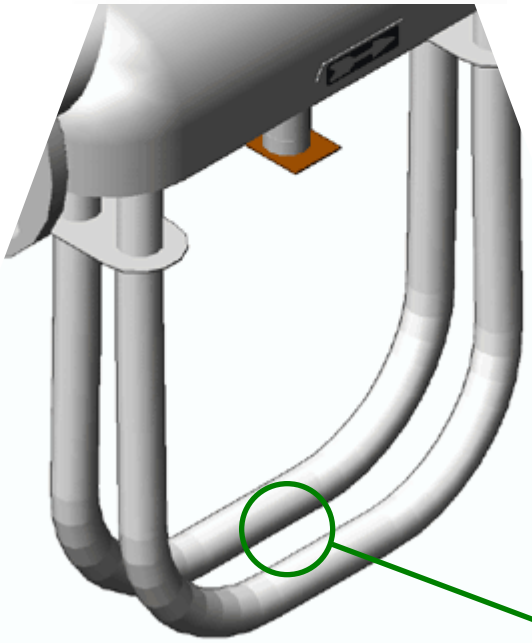


Electromagnetic Oscillator

made in Germany

Principle of Measurement





Electromagnetic Oscillator

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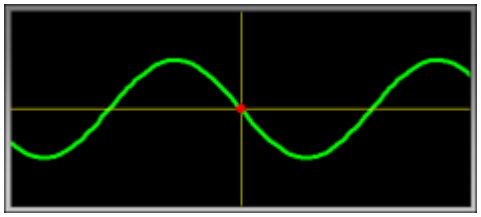
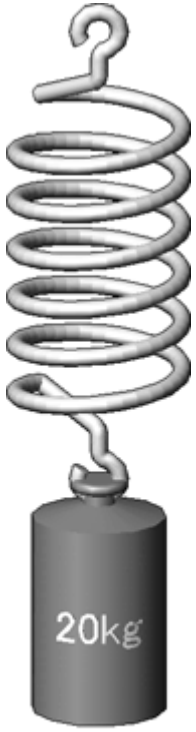
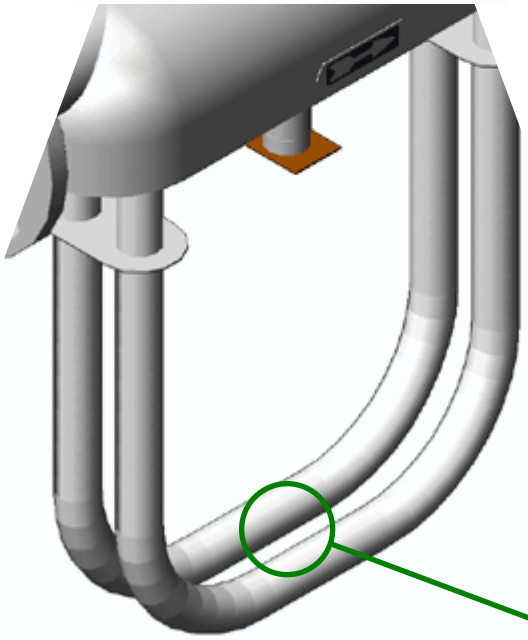
Principle of Measurement







Electromagnetic Oscillator

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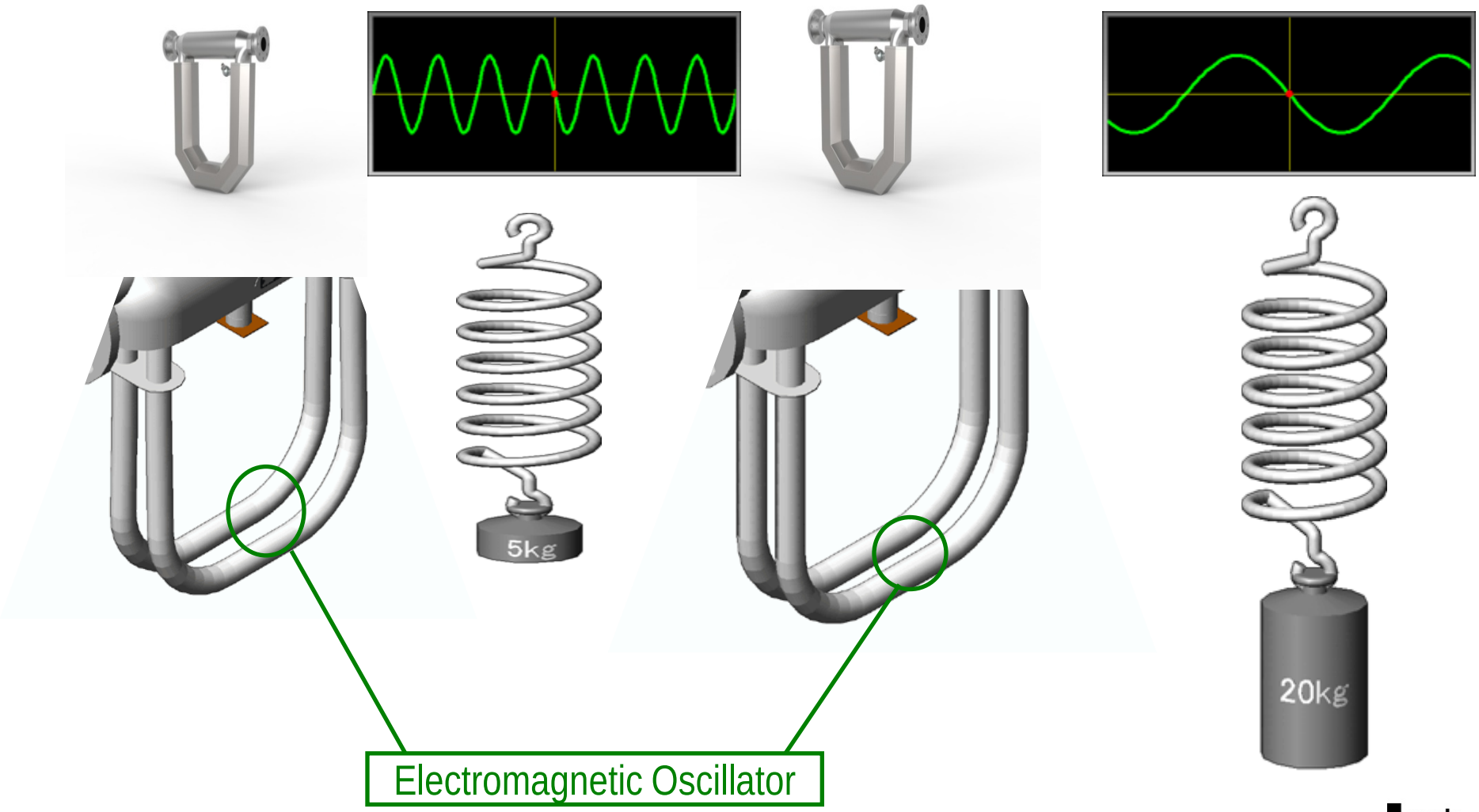
Principle of Measurement



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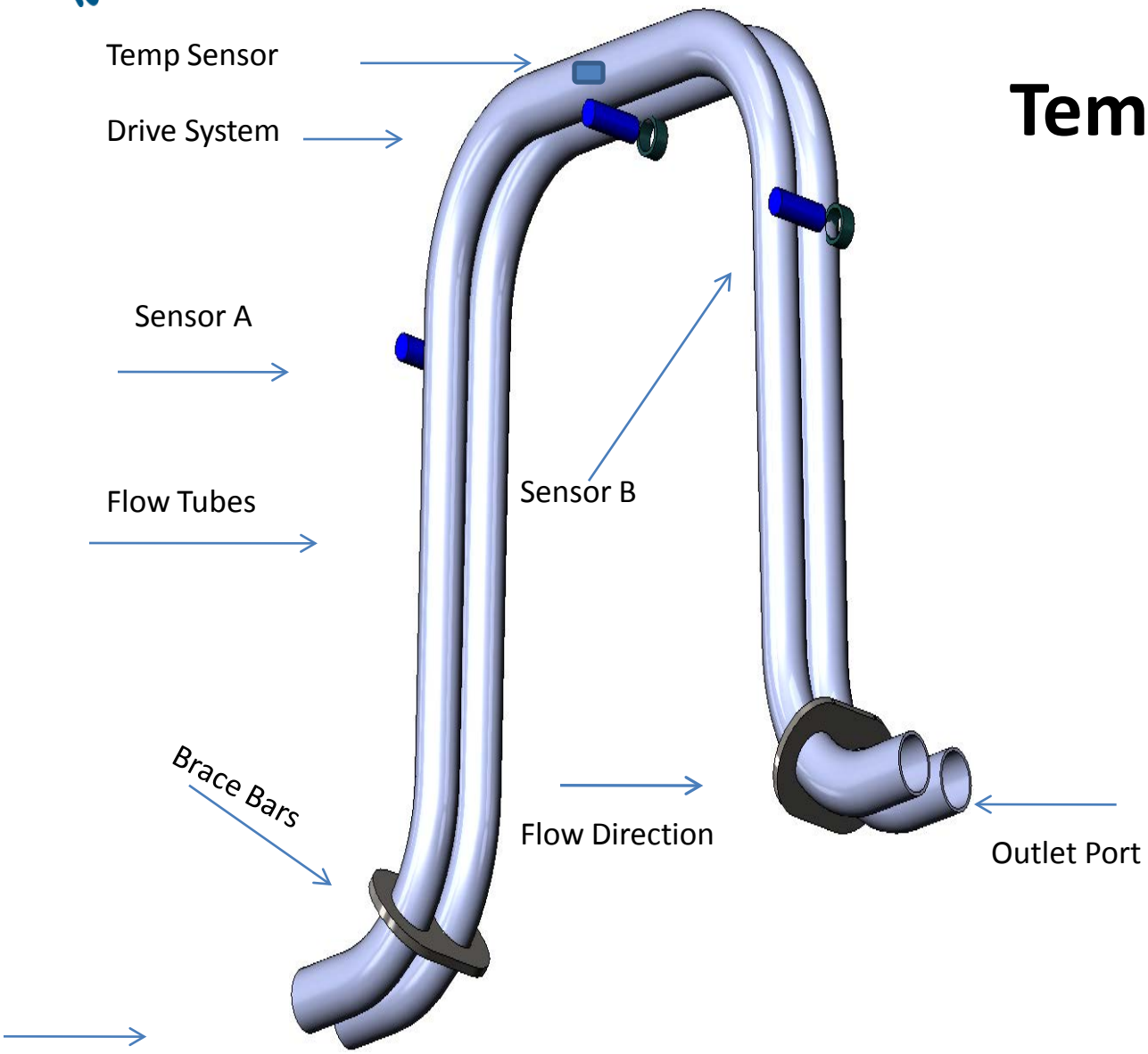
Principle of Measurement



Temperature

ACCURACY CLAIMS:
Claimed Mass Flow Accuracy = 0,1%
METER DESIGN:
316L Temperature Coefficient = 4,26% per 100°C (.0426 % /°C)
Mass Flow Temperature Accuracy Required = 0.1 / 0,0426 = **2.3°C**

MAXIMUM TEMPERATURE ERROR AT 90°C
Class A Sensors : Δt=±(0,15°C + 0,002 Itl) = 0.15 + .002*90 = **0.33°C**
Class B Sensors: Δt=±(0.3°C + 0,005 Itl) = 0,3+.005*90 = **0,75°C**

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What makes the difference between suppliers ?

- **Mechanical Design**
- Our Phase Shift is @ 40 µS
- 40 µS reflects and excellent mechanical design

- **MASS FLOW SENSITIVITY DEFINITION**:
- K = flowrate (gm/sec) / per unit Δt time-delay (µsec)
- The better the Phase Shift (Δt time-delay (µsec)) the better the mechanical design

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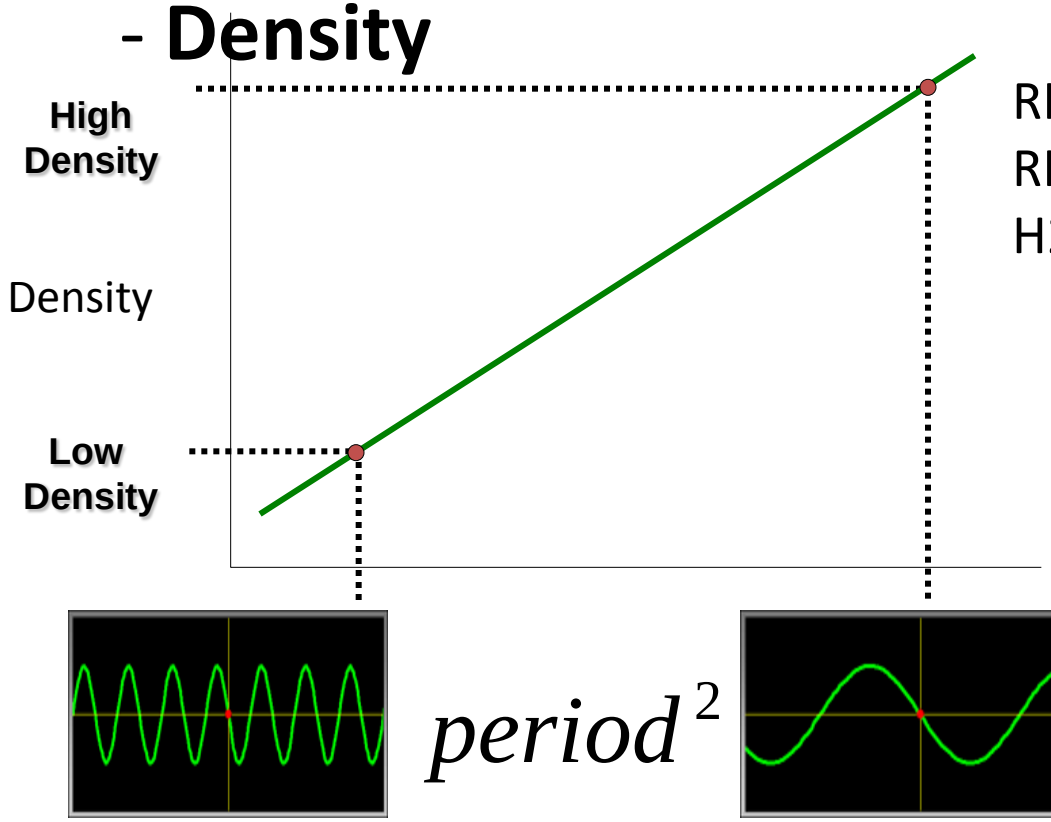
- Density



RHO air	0,0012g/cc	163Hz
RHO H2O	0,998g/cc	141Hz

Periode^2
Air
3,76378E-05
Water
5,02993E-05
Slope Air/Water = 25,17%
25% reflects an excellent Density slope

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- **Temperature**
- **Class A Sensor :** $\Delta t = \pm(0{,}15°C + 0{,}002\ Itl)$
- We are fully matching the required specification

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What makes the difference between suppliers ?

- **Signal Processing**
- Analog Front End makes the electronics very robust for harsh conditions
- Digital Signal Processing with a µP timer resolution of 100MHz (10 ns)

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What makes a good Coriolis meter?

- Accurate Mass Flow measurement ++
- Accurate Density Measurement ++
- Accurate Temperature Measurement +

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Consequence

An excellent meter to replace Volume flow meters in the Marine Industry as Density accuracy is also key also for an excellent Volume Measurement of a Mass Flow Meter

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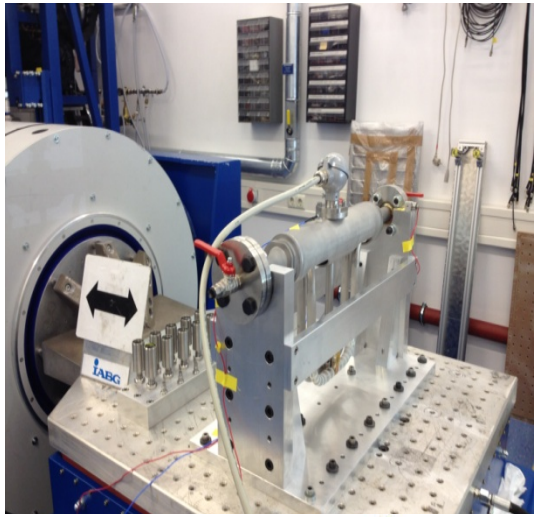
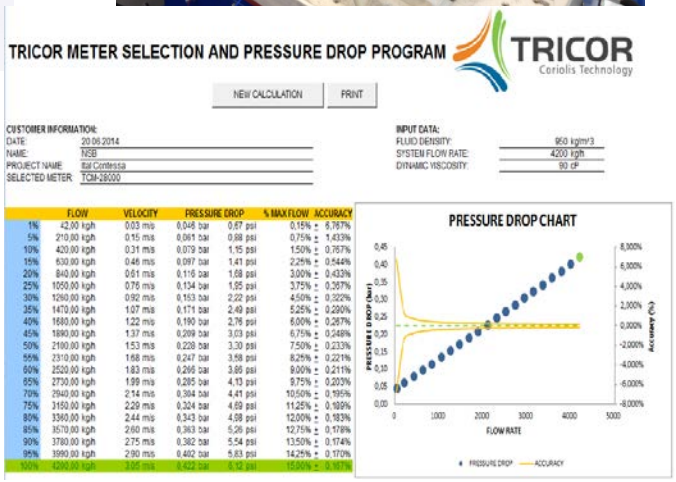
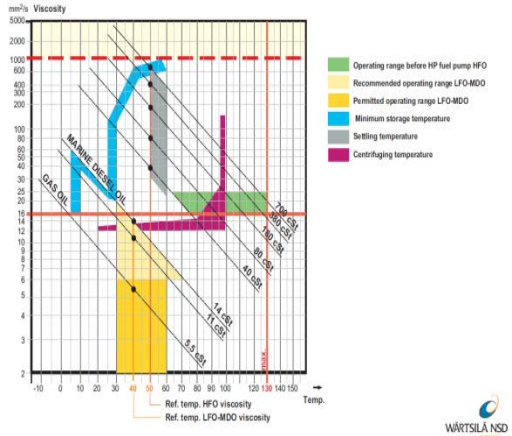
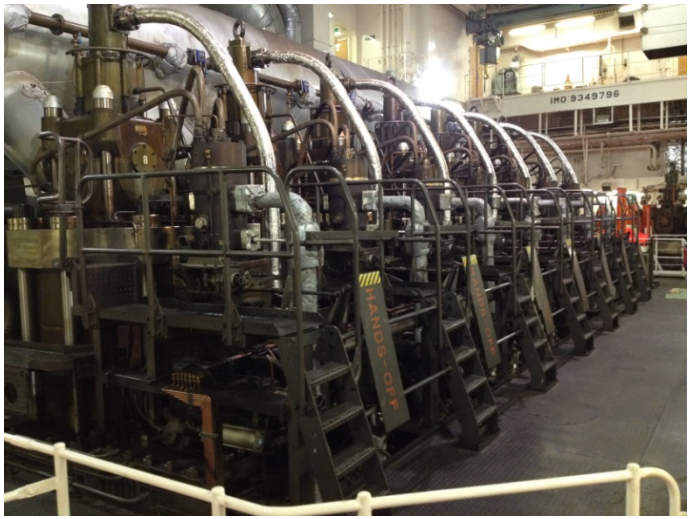
NSB Design



Quoted for:
Hanjin Gothenburg
Ever-Chivalry
Ital Contessa







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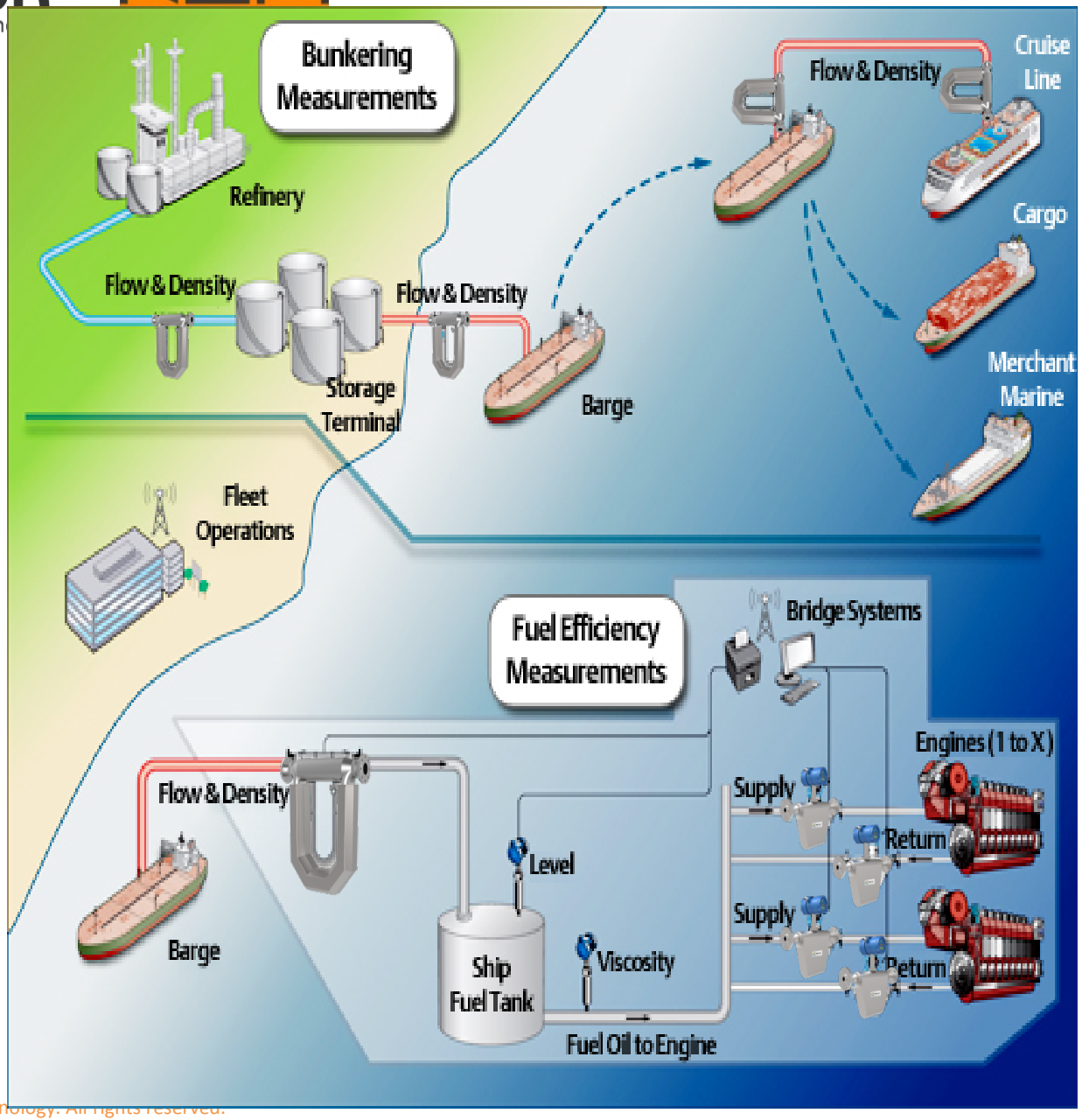
Marine



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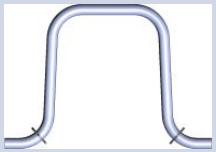
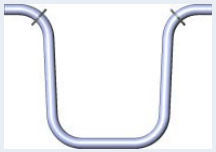
Key Mounting considerations

Tube Design	Orientation		Required Flow Direction	Self Draining	Risk of Air Entrapment	Use with Slurries	Use with Fluids with Solids
U-Tube	Horizontal Flow Line Tubes Up		None	Yes	Yes	Yes	Yes
	Horizontal Flow Line Tubes Down		None	No	No	No	No
	Vertical Flow Line		Yes, Flow Up	Yes	No	Yes	Yes
D-tube	Horizontal Flow Line Tubes Up		None	Yes	Yes	Yes	Yes
	Horizontal Flow Line Tubes Down		None	No	No	No	No
	Vertical Flow Line		Yes, Flow Up	No	Yes	No	No

Key Selection Criteria

Tube Shape	Model	Flow Accuracy & Sensitivity	Density Accuracy	Pressure Drop	Vibration Immunity	Signal-to-Noise Ratio	Self Draining	Manufacturing Cost	Price versus Performance
U-Tube		Good	Excellent	Good	Good	Good	Yes	Average/High	Good/Excellent
D-Tube		Excellent	Excellent	Poor	Excellent	Excellent	No	High	Average
LP-Tube		Poor	Poor	Excellent	Good	Average	Yes	Low/Average	Poor

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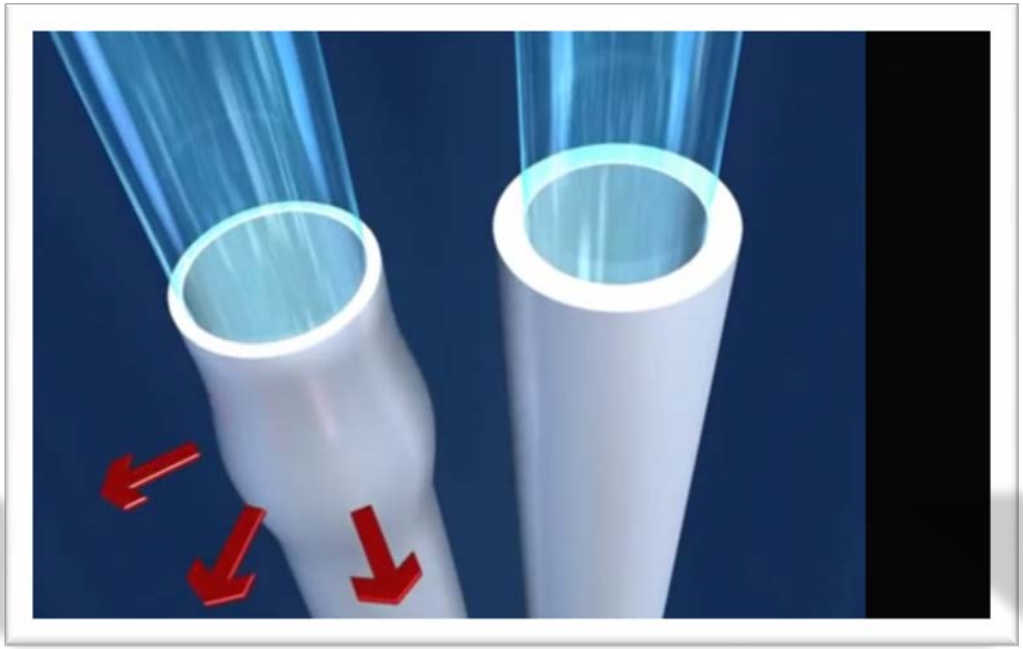
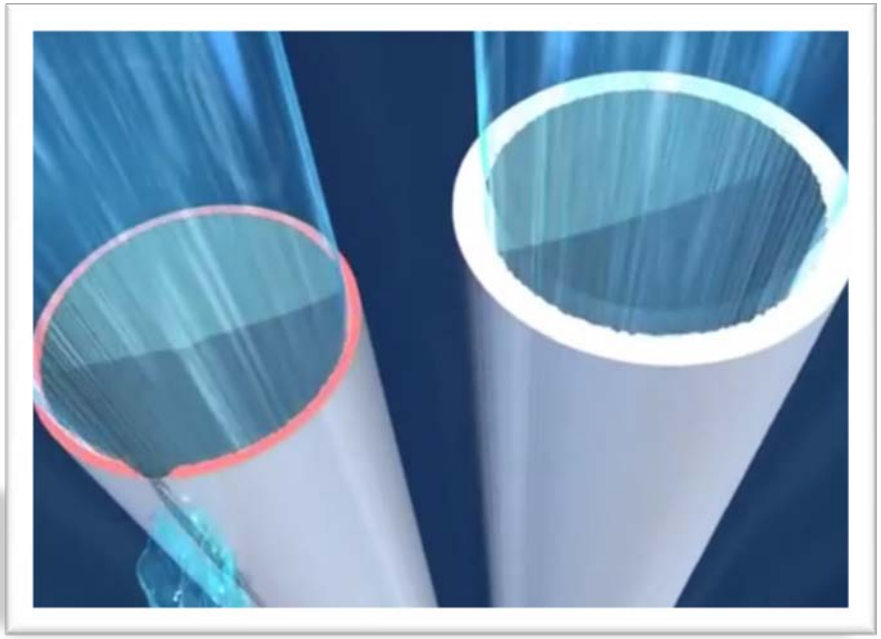
Additional value

Less exposed or prone to pressure expensions or pressure shocks/surge
Less prone to erosion, corrosion
Less sensitive for density measurement under changing pressure conditions





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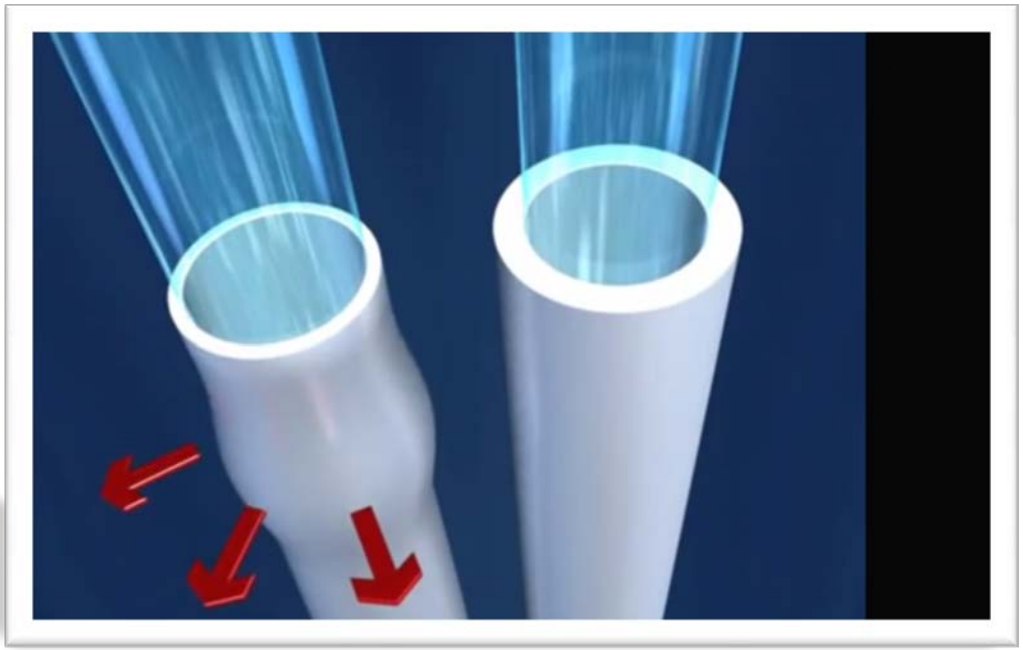
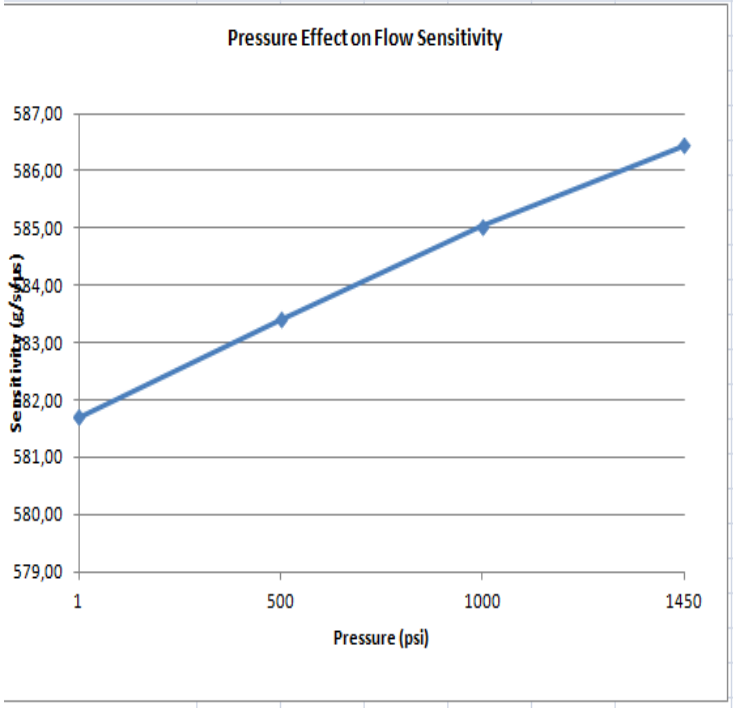
Additional value

Integrated pressure compensation



TCM 065K

Pressure in bar	Pressure(psi)	Sensitivity(g/s/µs)	Sens. Deviation in %
0,06895	1	581,70	0
34,475	500	583,40	0,292281345
68,95	1000	585,03	0,571677986
99,9775	1450	586,44	0,812691267



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Additional Advantages TRICOR

- Integrated pressure compensation
- Less prone to pressure changes
- One of the last independent Coriolis manufacturers
- Customized Solutions
- Customized flange sizes
- Customized installation length
- Mechanical design outperforms most competitors
- Increased Safety

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Value of our assets

Our assets = Our benefits

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Thank you

Questions ?

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