Panaflow HT
Reliable flow measurement at extreme temperatures
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Transit Time Technique

- Transducer is *both* the **transmitter** and **receiver**
- Ultrasonic Pulses
- \( t \) = Transit Times
  - Upstream direction, \( t_{up} \)
  - Downstream direction, \( t_{dn} \)

\( t_{up} \) = Ultrasound is *decelerated* by flow
\( t_{dn} \) = Ultrasound is *accelerated* by flow

\( t_{up} > t_{dn} \)

\[ V = f(t_{up}, t_{dn}) \]
\[ Q = V \times A \]
Advantages of Ultrasonic Flowmeters

No maintenance
- No periodic calibration required
- No drifting readings
- No moving parts that require maintenance
- Low total cost of ownership

No restrictions in the pipe
- No risk of solid particulates damaging the flowmeter or clogging the line

Fluid Independent
- Measurement of transit time is independent of the flowing fluid
- Transit time technique provides soundspeed as a diagnostic that can be used to identify changes in stream composition

High turndown ratio
- 400:1 (0.1-40 ft/s or 0.03-12.2 m/s) in liquids
- Larger turndown in gas

Advanced Diagnostics
- Soundspeed, Signal to Noise (SNR), and other diagnostics allow detail understanding of flowmeter and process.

Bi-direction flow measurement

Multiple ultrasonic flowmeters available
- Custody transfer to portable clamp-on measurements
PanaFlow HT Overview

PanaFlow HT is a wetted ultrasonic flowmeter for measurement of liquids in either nominal or extremely high or low temperatures.

Complete assembly includes:
(1) XMT900 electronics, (2) BWT transducers, (3) FTPA buffers, (4) Meter body
Advantage #1 of PanaFlow HT
Bundle Waveguide Technology™ (BWT)

Advantages of buffers
- Transducers are outside of the extreme temperatures
- Transducers avoid thermal shock with risks of cracking crystals
- Transducers are removable and can be replaced without shutting down the process
Advantage #1 of PanaFlow HT

Bundle Waveguide Technology™ (BWT)

Advantages of Bundled Waveguide Technology
- Better signal shape and SNR over solid buffers
- Measurements up to 600°C (1112 °F)
- Measurements down to -200°C (-328 °F)
Advantage #1 of PanaFlow HT
Bundle Waveguide Technology™ (BWT)

Transducer is easily re-coupled at this point on the "air" side

- Removable xproof-design transducer
- Length dependent on fluid temperature
- Inner buffer = 150 mm
- Gas or liquid side
- Raised-face coupler
- Gasket
- Lap-joint flange, 1.5" 150# to 2500#

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Advantage #1 of PanaFlow HT

Bundle Waveguide Technology

- Introduced 1998
- A strong history of successfully measuring in difficult applications
- Tolerant to fouling
Advantage #2 of PanaFlow HT

**Time measurement**

- Time of Flight = $T_w$ (time in buffer “dead time”) + $T_f$ (time in fluid)
- To improve measurement, $T_w$ must be eliminated
- Using Pulse-Echo technique allow for active $T_w$ elimination
- Pulse-Echo is the reflection of signal at the end of the buffer
- As a result, $T_f$ is measured very accurately with changing temperatures
Advantage #3 of PanaFlow HT

SIL Certification:
- We are the first company to have a **SIL certified** ultrasonic liquid flowmeter!!!
- Third party certification on design according IEC61508.
- Extensive testing and documentation required to obtain SIL certification

What is SIL
- SIL = Safety Integrity Level
- SIL is discrete level (ranked 1 to 4); SIL4 is the highest level of safety (less chance of failure) and SIL 1 is the lowest
- SIL level is used for specifying the safety integrity requirements of the Safety Instrumented Functions (SIF) to be allocated in a Safety Instrumented Systems (SIS).
- For PanaFlow HT, the probability of failure on demand (PFD) or dangerous failure has been determine through extension testing and documentation.
- PanaFlow HT can be used for your safety system or process control system.
Application Example
Delayed Coking
Delayed Coking

What customers are looking for?

- Get **reliable and accurate flow measurement** on the feed furnace lines as this is a **safety critical process** which can require SIL rating. Failure to achieve these could lead to wrong decisions resulting in a potential furnace blast.

- **Minimize costly process disruptions** due to lack of reliability generating **high OPEX**

- Effectively evaluate Delayed Coker operations

- **Safe working conditions** for staff and environment
Delayed Coking

**What are the current challenges?**

- Traditional technologies like Wedge meters, Venturis, orifice plates and vortex, all have many drawbacks due to the **clogging** nature of the heavy residue feed: High OPEX

- Unclogging process requires **permanent or regular purging** using distillates and/or steam = high cost, impact of unit yield and safety risk for staff

- High safety requirements = redundant measurements (2, 3 or 4). But **large inconsistencies** within the same pass line = unable to efficiently control the process
Delayed Coking

Who cares?
• Process Engineers, Operation Managers, Instrument Technicians with the furnace feed lines

Concerns
• Safety: Furnace tube plugs & ruptures and unit shutdown
• Reliability: (1) Decreased performance between decoking processes or (2) Unnecessary shutdowns due to incorrect flow measurements
Delayed Coking Unit

Where do we fit in? Furnace feed line

• 1 to 2 DCUs per refinery capacity
• 1 to 3 heaters based on DCU capacity
• 4 to 6 heater passes per heater
• 2 to 4 measurement points per heater pass
  – 1 for process control
  – 1 to 3 for safety system

One Customer Example

• 30 passes with 4 points of measurement each
• $68K per pass (four measurements per spool)
• Overall $2.0M win!
• Why? Benefits of ultrasonic flowmeters with proven track record
Delayed Coking

### Delayed Coker Savings using Ultrasonic Meters

#### Facts and Assumptions
- 8 Pass Lines/ Furnace
- 24 Flow measurement points (2 for ESD, 1 for Process Control)
- 48 Impulse lines for orifice plates
- 40,000 bpd capacity
- $14 profit/ bbl

#### Purging
- 1.5 bpd purge rate/ impulse * 48 impulse = 72 bpd
- 72 BPD = 26,000 bbl/ year
- 26,000 bbl/year * $14 lost profit/ barrel = $364 k/ year

#### Routine Maintenance
- Calibrate pressure sensor, replace DP element
- Assume 24 hrs/ year/ measurement point
- 24 hrs * 24 meters * $75/hr = $43 k

#### Unplanned Shutdown
- $14 profit/ bbl * 40,000 bbl = $560 k/ day in lost profit per day
- DCU is shut down

### Total Operating Cost Per Year

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Purging</td>
<td>$364,000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$43,000</td>
</tr>
<tr>
<td>Unplanned Shutdown</td>
<td>$560,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$43K to $967K!</strong></td>
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Customers have options..... But with high maintenance & low reliability

<table>
<thead>
<tr>
<th>Theory</th>
<th>Orifice Plates</th>
<th>Wedge Meters</th>
<th>Vortex Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Differential pressure measurement</td>
<td>• Differential pressure measurement</td>
<td>• Frequency measurement</td>
<td></td>
</tr>
<tr>
<td>• A flat metal plate with an opening restricts the flow</td>
<td>• A flat metal plate with an opening restricts the flow</td>
<td>• A bluff body is placed in the process stream creating alternating shedding vortices</td>
<td></td>
</tr>
<tr>
<td>• Flow rate is calculated based on pressure differential.</td>
<td>• Flow rate is calculated based on pressure differential.</td>
<td>• Flow rate is proportional to the shedding frequency.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Orifice Plates</th>
<th>Wedge Meters</th>
<th>Vortex Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Basic element is robust and entirely mechanical with no moving parts</td>
<td>• Basic element is robust and entirely mechanical with no moving parts</td>
<td>• No moving parts to wear</td>
<td></td>
</tr>
<tr>
<td>• DP-transmitter isolatable for calibration</td>
<td>• Small pressure drop</td>
<td>• No routine maintenance required</td>
<td></td>
</tr>
<tr>
<td>• Cheap installation cost</td>
<td>• Basic element is robust and entirely mechanical with no moving parts</td>
<td>• Stable long term accuracy required</td>
<td></td>
</tr>
<tr>
<td>• SIL certification on transmitter</td>
<td>• Membrane reduces need for heat tracing of impulse line</td>
<td>• Larger rangeability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• SIL certification on transmitter</td>
<td>• SIL certification available</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantages</th>
<th>Orifice Plates</th>
<th>Wedge Meters</th>
<th>Vortex Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Asphaltenes stick to the surface walls as the fluid cools</td>
<td>• Asphaltenes stick to the surface of the membrane reducing sensitivity</td>
<td>• Cannot be used for low velocities</td>
<td></td>
</tr>
<tr>
<td>• Risk of clogging in impulse lines</td>
<td>• Pipe shut down for exchange of primary element</td>
<td>• Pulsating flow vortices adversely affect measurement accuracy</td>
<td></td>
</tr>
<tr>
<td>• Pipe shut down for exchange of primary element</td>
<td>• Limited turndown range</td>
<td>• Not for high viscosity fluids</td>
<td></td>
</tr>
<tr>
<td>• Limited turndown range</td>
<td>• Effected by changes in density, pressure and viscosity</td>
<td>• Coke on bluff body causes heavy drift</td>
<td></td>
</tr>
<tr>
<td>• Effected by changes in density, pressure and viscosity</td>
<td>• Pressure tubing needs trace heating</td>
<td>• Frequent steaming necessary for cleaning (very costly maintenance)</td>
<td></td>
</tr>
<tr>
<td>• Pressure tubing needs trace heating</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PanaFlow HT

Summary

• PanaFlow HT is a wetted ultrasonic flow meter. Designed for measurement of liquids in nominal or extreme process temperatures
• PanaFlow HT is the world’s first ultrasonic flow meter to be SIL certified to IEC61508. **Certification by design** establishes reliability and safety
• 3rd party certification with extensive testing
• SIL2 certification with single design system
• SIL3 achievable with redundant design system

Advantages

• Improves feed reliability with no false furnace “trips” due to poor measurements
• Provides a safer workplace and reduces exposure time in units
• Better overall system control and productivity
• Reduces maintenance costs for feed flow meters
• Field proven since 1998
PanaFlow HT
Panametrics Ultrasonic Liquid Flow Meter

• Questions?
Backup SIL 2 and 3 PanaFlow HT

**Configurations**

- Z1H: 1 Path, Tilted Diameter, One Meter. Standard design for quality measurement Sil 2.
- Z2H: 2 Path, Parallel Mid Radius, One Meter. Additional path for redundant measurement Sil 2.
- R2H: 2 Path, Staggered Tilted Diameter, Two Meters in one body. Completely redundant system for increased security in measurement Sil 3.
## Backup Track Records Heavy Residue Applications

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petronor (Repsol Group)</td>
<td>Bilbao, Spain</td>
</tr>
<tr>
<td>Motiva</td>
<td>Port Arthur, TX – USA</td>
</tr>
<tr>
<td>Dow Chemical</td>
<td>Tarragona, Spain</td>
</tr>
<tr>
<td>Shell Per+</td>
<td>Pernis, The Netherlands</td>
</tr>
<tr>
<td>Saudi Aramco</td>
<td>Rabigh, Saudi Arabia</td>
</tr>
<tr>
<td>ConocoPhillips</td>
<td>Sweeney, TX – USA</td>
</tr>
<tr>
<td>ConocoPhillips</td>
<td>Wood River, IL – USA</td>
</tr>
<tr>
<td>Marathon Petroleum</td>
<td>Garyville, LA – USA</td>
</tr>
<tr>
<td>Chevron</td>
<td>Pascagoula, MS – USA</td>
</tr>
<tr>
<td>Shell</td>
<td>Anacortes, WA – USA</td>
</tr>
<tr>
<td>Repsol</td>
<td>La Coruña, Spain</td>
</tr>
<tr>
<td>Yanbu Export Refinery Project</td>
<td>Yanbu, Saudi Arabia</td>
</tr>
<tr>
<td>Tupras</td>
<td>Izmit, Turkey</td>
</tr>
<tr>
<td>Total</td>
<td>Antwerp (Optara), Belgium</td>
</tr>
<tr>
<td>Socar - STAR project</td>
<td>Izmir, Turkey</td>
</tr>
<tr>
<td>Petromanagas</td>
<td>Venezuela</td>
</tr>
<tr>
<td>BP Whiting</td>
<td>Indiana – USA</td>
</tr>
<tr>
<td>Hunt Refining Company</td>
<td>Alabama – USA</td>
</tr>
<tr>
<td>Total</td>
<td>Feyzin, France</td>
</tr>
<tr>
<td>Total</td>
<td>Port Arthur, TX – USA</td>
</tr>
<tr>
<td>Cepsa</td>
<td>San Roque, Spain</td>
</tr>
<tr>
<td>Total</td>
<td>Feyzin, France</td>
</tr>
<tr>
<td>Orpic</td>
<td>Sohar, Sultanate of Oman</td>
</tr>
<tr>
<td>Preem Refinery</td>
<td>Lysekil, Sweden</td>
</tr>
<tr>
<td>Lotos Refinery</td>
<td>Gdańsk, Poland</td>
</tr>
</tbody>
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Backup Flexible Solutions.... Yes

- Alternative materials, sizes, flanges, and designs are available
- Application and engineering support
- Manufacturing and supply chain expertise
Backup PanaFlow HT Details

- XMT900 Transmitter
  - Enclosure: Epoxy coated aluminum (IP67)
  - Power: 85-260 VAC or 12-28 VDC
  - Display: Local display with built-in magnetic, six-button keypad, for full functionality operation
- Communication
  - Option “A”:
    - One SIL rated analog/HART output
    - Two digital outputs
    - Modbus (RS485) / Service Port
  - Option “B”:
    - One SIL rated analog/HART output
    - Additional analog output (not SIL rated)
    - Two digital outputs
    - Modbus (RS485) / Service Port
- Note: Digital output programmable as:
  - Totalizer Pulse
  - Frequency
  - Alarm Control
  - Control Output
- Transducers/Buffers (0.5 or 1 MHz)
  - High Temperature: -200 to 600°C
  - Normal Temperature: -200 to 315°C
- System Rating (Pending)
  - FM Explosionproof, C1, Div 1, Group B-D
  - ATEX Flameproof, II 2 G EEx d II C T6
  - IECEx Flameproof, II 2 G EEx d II C T6
Backup  PanaFlow HT Details

• Meter Body:
  • Size:
    3” to 16” standard
    Up to 36” available upon request
  • Schedule/Flange Rating:
    ANSI 150# RF (WN) / Std Sch
    ANSI 300# RF (WN) / XS Sch
    ANSI 600# RF (WN) / XS Sch
  • Design:
    ASME B31.3 & NACE MR0103
    PED & NACE MR0103
    ASME B31.3, CRN registered, and NACE MR0103
• Material:
  Carbon steel (ASTM (A106 Gr. B - ASTM A105)
  316/316L Stainless Steel (ASTM (A312 Gr 316/L - A182 Gr. 316/L)
  9Cr-1Mo meter body (ASTM A335 Gr. P9 - ASTM A182 Gr. F9)

• Electronics Mounting:
  – Local ($T_{\text{max}} = 302^\circ\text{F}/150^\circ\text{C}$)
  – Remote
    • 25, 50, or 100 Feet
Backup Performance specifications

• Accuracy
  – ± 0.5% of reading
  – Range: 3 to 40 ft/s (0.9 to 12.2 m/s)
  – Calibration fluid: water (three points)

• Repeatability
  – ±0.2% of reading, 3-40 ft/s (0.9-12.2 m/s)
  – Range: 3 to 40 ft/s (0.91 to 12.19 m/s)

• Range (bidirectional)
  – -40 to 40 ft/s (-12.19 to 12.19 m/s)

• Rangeability (overall)
  – 400:1

• SIL certification
  – IEC61508 certified
  – SIL2 certification with signal design system
  – SIL3 certification achievable with redundant design system