Thermal Energy - BTU measurement with Clamp-on ultrasonic meters

Izzy Rivera
Market / Product Manager
This webinar is scheduled for one hour, including the presentation and approximately 15 minutes for Q&A. If needed, the webinar will extend past the hour to answer as many audience questions as we can.

Please submit questions via the “Q&A” box during the presentation portion of the webinar. The Q&A icon can be found in the menu bar at the bottom of your screen. Questions will be reviewed by IDEA and posed to the presenters by the host at the conclusion of their presentation.

If you are having audio or video issues, please send a note via the Chat Box to our host, Jason Beal.
Thermal Energy - BTU measurement with Clamp-on ultrasonic meters

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Market / Product Manager
Measurement Principle of Clamp-on Ultrasonic Meters: Transit Time

Signal in the direction of flow travels faster compared to signal against the flow direction. The difference in transit time is a measure for the flow velocity.

A swimmer swims faster with the flow as compared to against the flow. The sonic signal does the same.
Thermal Energy “BTU” Meter?
Meter for high flow range

- The accurate way to meter a high flow range is to have a large and small diameter meter that is controlled by flow rate.
- Because of the additional cost this is rarely done for BTU metering systems.
- The result is that the flow measurement suffers and can not measure the low flow rates.
Brief History of Clamp-on BTU metering

The 1st Clamp on BTU meter was developed for Port Authority JFK airport.
- NY Port Authority realized that off peak flow rates were not being metered
- Back in 1982 the meters being used were orifice meters
- Orifice meters typically have a 4-1 turndown and will not detect low flow velocities below about 0.5 ft/sec
- Clamp-on meters have a very high turndown 1000-1 and can get to very low velocities
Turbine Meter Drop Out
Cost 50,000/yr lost billing
Vortex Metering
Steam and High Temperature Liquids

0.7 ft/sec in a 6” pipe = 63 GPM
0.31 ft/sec in a 6” pipe = 28 GPM

Empellor
BTU Metering

Starts measuring at 0.17 ft/sec,
±2% accuracy begins at 0.4 ft/sec

Low Cutoff for Vortex and Paddle Wheel Meters are NOT Low Enough!

Ultrasonic

| Flow velocity | 0.03 to 82 ft/s |
| Fluid pressure | Without influence |
| Pressure loss | 2% |
| Repeatability | 0.15% of reading ±0.03 ft/s |
Measurement of Liquid Flow in Closed Conduits Using Transit-Time Ultrasonic Flowmeters

ANSI/ASME MFC-5M-1985

The Quotient “SINUS Angle_0 / C-o f(t_o)” is called "Transducer coefficient".

--> This transducer coefficient changes with temperature and has to be temperature compensated
The embedded RTD temperature compensates temperature changes and eliminates “drift”.

Embedded RTD - temp compensation as per ASME MFC 5M
Clamp-on Metering – Drift Test

Meter with temperature compensation eliminates drift
Temperature change is 40°F to 120°F
NO drift, even with changes in temperature!

Brand X Clamp-on Meter
- Drift of 2cm/sec = .07 ft/sec = 6 GPM on a 6” pipe
- 6GPM represents $6,000 CHW season

Brand Y Clamp-on Meter
- Drift of 3cm/sec = .1 ft/sec = 9 GPM on a 6” pipe
- 9 GPM represents $9000 CHW season

Not all ultrasonic meters are the same
• Does your meter drift?
Ultrasonic meter drift test

1. Install flow sensors on a pipe with no flow
2. Apply heat to sensors
3. Observe behavior of flow – note; remove zero cutoff (deadband)
Low Flow Measurement

- Low Velocity measurement is imperative in submetering
- Off peak flow rates are very low
- Example; hot water flow in the summer months – meter at a University that previously was unable to measure these low flow rates
• IS YOUR METER REVENUE GRADE?
• WHAT IS THE STANDARD FOR BTU METERS?

• In the US there is no applied standard for BTU meters (ASHRAE 125-2020 testing)
• In the US BTU specifications used are typically 1% flow, class A or class B RTD’s
• In Europe there is a standard that meters MUST meet – EN1434 Government mandated
• Measurement Canada has begun adopting the EN1434 standard
AGA9 Standard for Gas Measurement with Ultrasonic meters

- UFM’s are used for custody transfer and fiscal measurement of oil and gas
- A UFM on a gas pipeline can account for billions of dollars annually
- Accuracy .1-.2%

STANDARDS FOR METERING

- Are gas pumps regulated?
- Yes - Gas pumps are routinely check by State regulators
WHAT'S MORE EXPENSIVE, WATER OR OIL ????
Cost of Thermal Energy – University Campus

- Rule of thumb – 20BTU/sq/ft
- 1Ton = 12,000 BTU/HR
- 1 Ton cools 600sq/ft
- 1700 Tons needed to cool 1Msq/ft
- University has 12Msq/ft = 20,000Tons cooling capacity
- Billing rate for cooling = $13/TonDay (NE University)
- University has 12Msq/ft = 265,000/day = $8M Month
- A 1% meter delivers a $80,000 uncertainty each Month
Cost of Thermal Energy – Commercial Property

- NYC – Columbus Circle - Deutsche Bank Center
- 2.8 million sq/ft
- $2M monthly cooling
- 150 BTU meters
- 1% uncertainty = $20,000/mo.
JFK Terminal 3

- $1,500,000 / Month - Peak summer Chilled Water
- $350,000 / Month – Peak winter Hot Water
- 1% uncertainty = 18,500 month
BTU Calibrations by Flexim

- Flexim portable meter used to calibrate permanent meter
- Flexim portable is 1% NIST traceable
- Flexim calibrations are ISO 17025 accredited
Error and Costs Associated with some BTU Meters

The cost of meter errors:

- Large errors found with different meter types under calibration
- Customers unaware of errors
- These meters are used for billing

*Based on the error percentages shown, we assume an average error of 15% (highlighted line) to show cost of error on next slide. These are errors from various types of low cost and low quality meters that we have calibrated and fixed.
Error and Costs Associated with some BTU Meters

The cost of meter errors:

Chilled water energy cost = $11.00 Ton/Day

Average temperature difference of 10°F

BTU/HR = GPM (flow) x °F (delta temp) x 500

SCRB1: Flow was off by -148GPM (-15%) 10” pipe

148 x 10 x 500 = 740,000BTU/Hr = 61.66Tons

61.66 x $11.00 = $678Tons/Day = $21,000 / Month

Average Cost of ERROR for ONE Metering Point = $21,000 / Month

$252,000 / Year
# Meter Calibrations

<table>
<thead>
<tr>
<th>Tenant</th>
<th>S/N</th>
<th>% Error as Found</th>
<th>% Error as Left</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>132575</td>
<td>30.1</td>
<td>2.7</td>
<td>Programmed as a 6CS40 is 5CS40</td>
</tr>
<tr>
<td>2</td>
<td>130356</td>
<td>9.7</td>
<td>0</td>
<td>Moved Flow Sensor 1/2 inch inward</td>
</tr>
<tr>
<td>3</td>
<td>239312</td>
<td>-40.1</td>
<td>0</td>
<td>Programmed as 2.5 inch should 3CS40</td>
</tr>
<tr>
<td>4</td>
<td>153115</td>
<td>0</td>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>204472</td>
<td>2</td>
<td>0.7</td>
<td>None</td>
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<tr>
<td>6</td>
<td>132340</td>
<td>14.6</td>
<td>0</td>
<td>Copper pipe size was wrong 2.675 s/b 2.465id</td>
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<tr>
<td>7</td>
<td>132341</td>
<td>37.3</td>
<td>0.6</td>
<td>Pipe size was 10.03 id measured 8CS40</td>
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<tr>
<td>8</td>
<td>208312</td>
<td>0.8</td>
<td>0.8</td>
<td>None</td>
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<tr>
<td>9</td>
<td>141360</td>
<td>49.7</td>
<td>0.06</td>
<td>Pipe was programmed as 6CS40 id but was a 5CS40 inch line</td>
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<tr>
<td>10</td>
<td>141359</td>
<td>15.3</td>
<td>1.5</td>
<td>Adjust Flow sensor inward 1/2 inch</td>
</tr>
<tr>
<td>11</td>
<td>148341</td>
<td>0</td>
<td>0</td>
<td>No Adjustments made</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>1.4</td>
<td>1.04</td>
<td>Being fed by 4-20mA from a Onicon F4000 Ultrasonic meter</td>
</tr>
<tr>
<td>13</td>
<td>131657</td>
<td>0</td>
<td>0</td>
<td>Had to turn on flow there was no delta temperature as found</td>
</tr>
<tr>
<td>14</td>
<td>175166</td>
<td>0</td>
<td>0</td>
<td>No Adjustments made</td>
</tr>
<tr>
<td>15</td>
<td>175167</td>
<td>10</td>
<td>0.3</td>
<td>Changed pipe ID on the onicon from 2.564 to 2.469 id</td>
</tr>
<tr>
<td>16</td>
<td>N/A</td>
<td>12.7</td>
<td>2.1</td>
<td>*Being fed from Ultrasonic Onicon F4300 via 4-20ma</td>
</tr>
</tbody>
</table>

#9 meter 49% error = ~$100,000 / year
Calibration Certificate

Meters are calibrated to NIST standard over range of flow
Temperature Accuracy

- Temperature Standard IEC 751 defines Temperature accuracy

Highest rated “class A RTD’s are specified to .25°F

- Many BTU meters are built with unmatched class A or B rated RTD’s
- The potential error will be 5 – 10% for delta temps of 10°F
- Our RTD’s are matched to 0.03°F – 10x greater than class A
- Highest degree of temperature accuracy available
Thermal Energy – Clamp-on Ultrasonic

REPORT OF CALIBRATION

Thermal Energy – Clamp-on Ultrasonic

Pacific Resistance Thermometers
Model: S302M
Serial Number: XXXX
Purchase Order Number: 616A-XXXX
Submitted by: Flexim Americas Corporation

This ‘calibrated’ thermometer set was connected to our in-house SRT and was compared to an SRT using an AC Bridge at a frequency of 50 Hz and current of 1.0 mA. The calibration procedure followed the S30 Laboratory Procedures Rev 1 and are based on the technical information contained in NIST Technical Note 125, ‘Procedure for Retaining the International Temperature Scale of 1968 (ITS-68) Point’ in secondary SETs and in S3000s’ Technical Data for Approximately the International Temperature Scale of 1990. The following comparison points were used to calibrate the probe. The following temperature values are certified to the nearest tenth of a degree. This calibration is traceable to NIST and in compliance with MIL STD 45662A, AV225449, and EM 134.

<table>
<thead>
<tr>
<th>Measured Temp</th>
<th>Nominal Temp</th>
<th>Delta T</th>
<th>Absolute Difference</th>
<th>Coefficient</th>
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<td>a 8.000</td>
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<tr>
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STANDARDS USED

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Manufacturer</th>
<th>Model Number</th>
<th>Description</th>
<th>Date</th>
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<tr>
<td>3002</td>
<td>Environmental Engineering</td>
<td>1502C</td>
<td>Standard Platinum Resistance Thermometer</td>
<td>05/13/11</td>
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<tr>
<td>4420</td>
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<td>1522C</td>
<td>Standard Platinum Resistance Thermometer</td>
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<tr>
<td>308144</td>
<td>Tinsley</td>
<td>5084A</td>
<td>Standard Resistor (100 Q)</td>
<td>07/20/11</td>
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<tr>
<td>274444</td>
<td>Tinsley</td>
<td>5055E</td>
<td>Standard Resistor (25 Q)</td>
<td>10/02/11</td>
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<tr>
<td>1230-394-296</td>
<td>ASL</td>
<td>61866K</td>
<td>Automatic Resistance Bridge</td>
<td>05/20/11</td>
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<tr>
<td>204088</td>
<td>iXtech</td>
<td>61622K</td>
<td>Automatic Resistance Bridge</td>
<td>05/20/11</td>
</tr>
</tbody>
</table>

Laboratory Environment:
Temperature: 20.0 °C
Humidity: 25%

Calibration by: Chris Albert
Thermal Energy – Clamp-on Ultrasonic

RTD Options
Clamp-on vs Insert

- Clamp-on Ultrasonic Meter surface mount RTDs versus insertion thermowell type
- Clamp-on matches insert
- Accuracy is the same without the added costs of shut down and opening the pipe

**Key**
- ΔT Clamp-on
- ΔT Insert
- Clamp-on Supply Temp
- Insert Supply Temp
- Clamp-on Return Temp
- Insert Return Temp
• The data center has triple redundancy, 3 insertion temperatures sensors
• Clamp-on temperature tested on the same pipe
• The white trend is in the middle of the 3 inserts
• The response time is even with the inserts
Ultrasonic Meters?

- How do I know it’s installed correctly
- How do I know it’s accurate

### Thermal Energy – Clamp-on Ultrasonic

#### Sonic Velocity Relative to Temperature of Pure Water

<table>
<thead>
<tr>
<th>Temperature °F</th>
<th>Velocity M/S</th>
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</thead>
<tbody>
<tr>
<td>32</td>
<td>1402.4</td>
</tr>
<tr>
<td>34</td>
<td>1407.9</td>
</tr>
<tr>
<td>36</td>
<td>1413.3</td>
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<td>38</td>
<td>1418.6</td>
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<td>40</td>
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<td>44</td>
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</tr>
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<td>46</td>
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<td>48</td>
<td>1442.8</td>
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<tr>
<td>50</td>
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<td>52</td>
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<tr>
<td>70</td>
<td>1493.7</td>
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<tr>
<td>72</td>
<td>1498.2</td>
</tr>
</tbody>
</table>

### Flow velocity vs Thermal

<table>
<thead>
<tr>
<th>Flow velocity (fps)</th>
<th>Thermal energy (kBtu/hr)</th>
<th>Flow temp (°F)</th>
<th>Sound speed (m/s)</th>
<th>Gain (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.48</td>
<td>31307.7</td>
<td>11682681</td>
<td>1421.53</td>
<td>96</td>
</tr>
<tr>
<td>9.48</td>
<td>31407.7</td>
<td>11682681</td>
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<td>96</td>
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<td>31407.7</td>
<td>11682681</td>
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<td>9.27</td>
<td>30705.2</td>
<td>11682718</td>
<td>1421.302</td>
<td>95</td>
</tr>
</tbody>
</table>
ARE CLAMP-ON METERS RELIABLE

- What is outside the pipe can not be affected by what is inside the pipe
- With solid mounting clamp-on meter are more reliable than insertion meters

> Permanent coupling compounds

“Coupling Pad” for permanent installation up to 450°F

No Gels or Greases!
Flow Profile Compensation Feature

- Flow Profile correction for elbow, based on extensive CFD & Lab research
- Profile compensation feature can offset error induced by limited straight run
- Eliminates need for flow conditioners as commonly used in traditional installations

- Requires 721 firmware 7.28 or greater and 6.42 or greater for the F601
Case Study: Installation of a BTU meter
Location: University – Chemistry Building
Installation of a Flexim BTU meter

1. Pipe insulation is cut where the transducers and temperature RTD will be installed
2. SS bands are slid around the pipe underneath the insulation.
Installation of a Flexim BTU meter

3. Transducers and RTD are installed.
4. The sensors are covered with the insulation and repaired with insulation tape.
5. The complete installation takes ~4 hours. A feature of Flexim BTU metering is the ultra low flow velocities that the meter accurately picks up. The meter just installed shows velocities down to 0.023 ft/sec.
Steam Condensate – Case Study

Updated Strategic Energy Plan

With Usage for FY 2017-2018

Project - Campus-wide upgrade to ultra-sonic meters

Previously, condensate from steam was captured using turbine meters that couldn’t withstand the caustic environment of the condensate that is returned from the building back to the steam plant. Ultra-sonic meters reside on the exterior of the pipe, don’t require additional flanges or bypass piping, and can be installed without a steam shutdown.

| Initial Cost | $231,400 |
| Annual Savings | $109,046 3 yr avg |
| Savings to Date | $318,966 3 yrs |
| Simple Payback | 2.2 yrs |
| ROI | 46.06% |
| 20 Year Life Cycle | $1,867,882 |

Savings based on billings for residential and dining buildings

- Three year average ($106,046) used to estimate 20 year cash flow
- 10% of initial cost used to estimate Year 10 maintenance/replacement cost
**Winner: FLUXUS ST**

**FLEXIM AMERICAS Corporation**

Nonintrusive steam meter improves accuracy and reliability of steam measurement.

Steam is a commodity and necessity for many industries in the world. Whether it is used for heating a building or as a heating source for an industrial application such as heating a vessel, the measurement of steam is essential. Clamp-on flow measurement for liquids with the transit-time principle has been around for over 40 years. Fifteen years ago, nonintrusive gas flow measurement was introduced, but measuring steam with clamp-on ultrasonics remained elusive. For ultrasonic meters, dry saturated steam is like a gas except the temperatures are much higher.

*1st Clamp-on Ultrasonic Steam Meter*

*1st Meter installed at UMD*
Domestic water metering – smart metering

Motivation: Water management and conservation

Big Box Store

Water Conservation

ASU is committed to reducing its indoor and outdoor water consumption through technology and refined practices.

100 meters getting installed
Domestic water metering

Rotary Meter

Flexim
SERVICES

- Calibration services – any meter type
- Start-up services
- Measurement Services
- Automatic Meter Verification
- Remote Support
Clamp-on Ultrasonics – Feature case study

- Hudson Yards – Manhattan
- 20 Billion mixed use real estate
- 16 skyscrapers
- 28,000,000 sqft of office, residential and retail space
- All BTU, Domestic water metering by Flexim
Review of features of good clamp on meters

1. Transducer temperature compensation
2. No drift – low flow capability
3. Calibration NIST traceable, 1% accuracy
4. Pipe disturbance correction
5. Coupling pad – no more grease failures
6. Matched RTD’s w/ NIST certificate.03deg
7. AMV
8. VTT Support – remote programming capability
9. High volume and quality of references
10. Support
Thermal Energy Conclusions

- Thermal Energy is VERY EXPENSIVE – facilities need an accurate thermal energy meter
- Should come with a calibration certificate, flow and temperature.
- Low flow rates during off peak are normal – facilities need a meter that can reliably pick up low flows.
- Temperature is just as important as flow measurement – facilities need a meter that has excellent temperature accuracy.
- Large facilities will have a high volume of submeters – facilities need a meter that is reliable, robust, and maintenance free.
We are ready to support you in:

• Analyzing the right metering solution and implementation plan
• Measurement Services
• Calibration Services

irivera@Flexim.com
salesus@flexim.com
631-492-2300
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