Energy Sub-metering Presentation for AEE Seminar at BC

Presented by : Brad Selmon

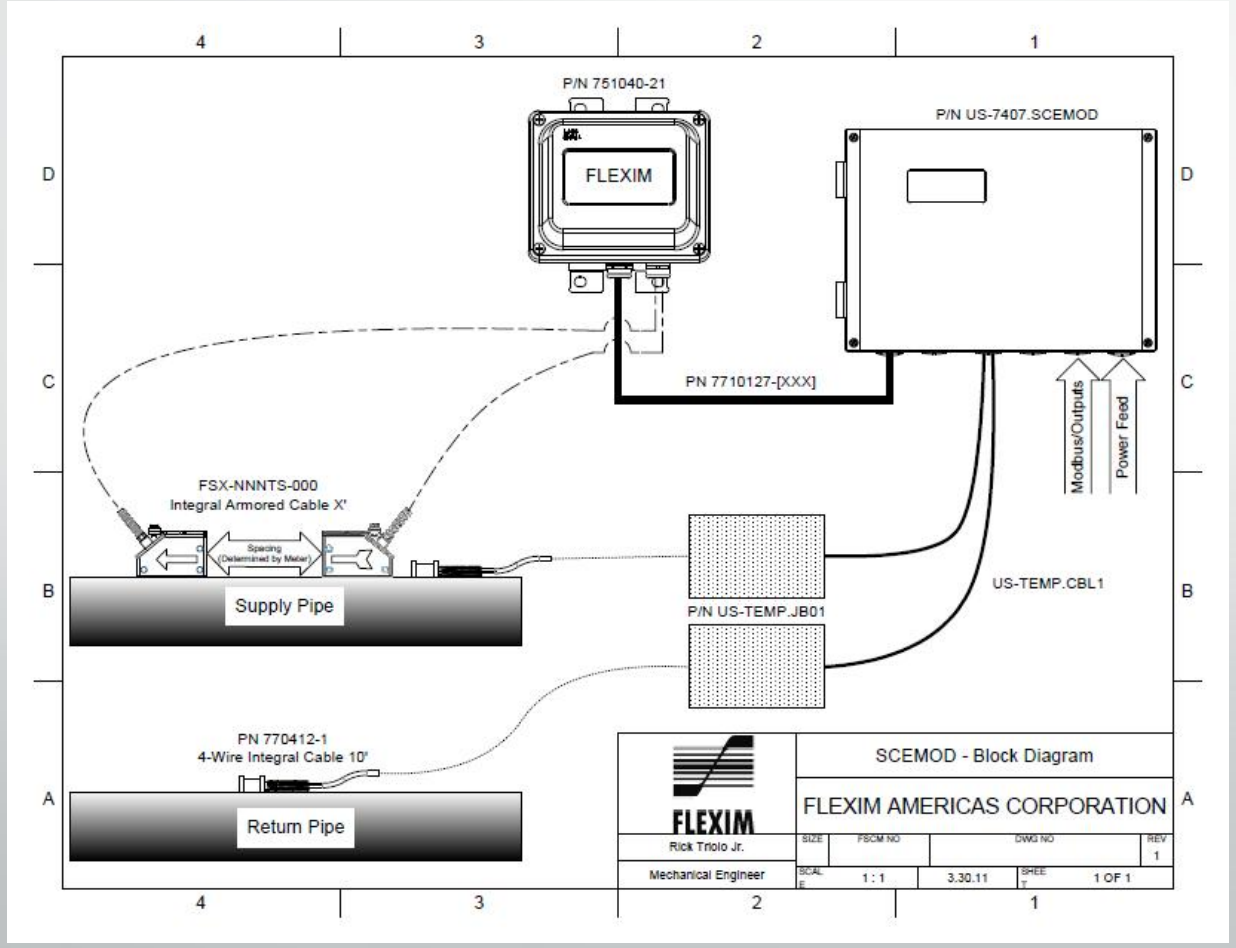
selmon Co.
Unique Instruments

What is a Thermal Energy "BTU" Meter?

- A metering device that measures the volume or mass of flow, temperature differential, and computes BTU thermal energy consumption or production

- 3 Measurement Points:
- Flow
- Supply temp
- Return Temp

Block Diagram



Challenges to Accurate Metering

- Straight Run
- Partial Full Pipes
- Wrong Meter Location
- Meter installed improperly
- Poor Temperature Measurement
- Poor BTU Calculation
- Air Entrained in Liquid
- Mechanical Failure of meter
- Post Installation Accuracy Verification
- Wet Flow Calibrated Sensors
- Client Expertise and System Knowledge
- All Flowmeter Brands are not created Equal

Brief Flow Energy Equation

Q (Energy) = 500 x f x DeltaT (in F)

500 = the “fluid factor” this is based on water as the heat transfer fluid.

The fluid factor is obtained by using the weight of a gallon of water (8.33 lbs.) multiplied by the specific heat of the water (1.0) multiplied by 60 (minutes). This comes out to 499.8 when using water.

0.5 % error on Chilled Water

2% error on Condensate

2.5 % error on Hot Water

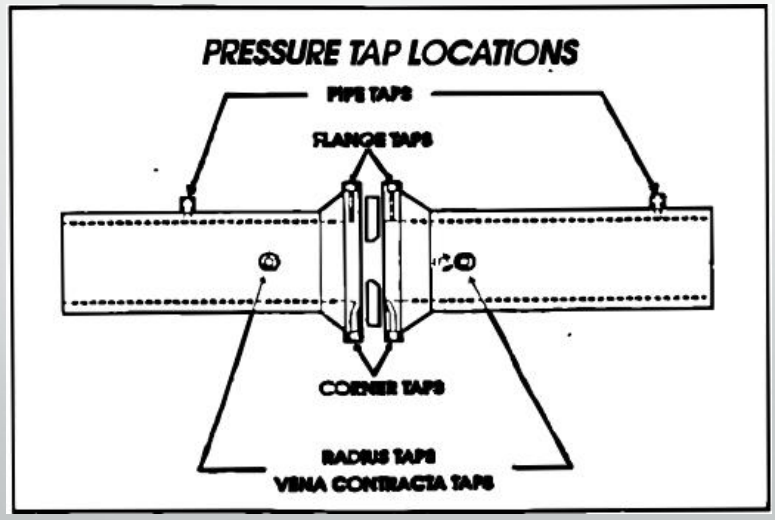
5.0 % error on High Temp Hot Water

ASHRAE Guideline 14P

Type	Configuration	Typical Accuracy/ Minimum Flow	Advantages	Disadvantages
Turbine (single for small pipes, dual for pipes 2.5" and larger)	Insertion	±2% 0.5 fps	• Usually least expensive Insertion style allows easy retrofit (via hot tap) and removal for cleaning, replacement	• Can be fouled by contaminants in water; not recommended for open circuit systems Moving parts result in lower operating life, possibly degrading accuracy • Requires correct installation depth to be accurate Sensitive to installation details – long straight inlet and outlet runs required
Full-bore magnetic	Flow tube	±0.5% 0.05 fps	• Most accurate meter Lowest minimum flow rate Least sensitive to installation problems and requires least amount of straight piping runs at inlet and discharge Very little maintenance required; no moving parts Long life with little calibration required	• Most expensive meter, and especially expensive for large pipes (>12") Cannot be removed without shutting off system or providing an expensive bypass
Single point magnetic	Insertion	±1% 0.2 fps	• Insertion style allows easy retrofit (via hot tap) and removal for cleaning, replacement Very little maintenance required; no moving parts Long life with little calibration required	• Relatively expensive for small pipe sizes Requires correct installation depth to be accurate Sensitive to installation details – long straight inlet and outlet runs required
Vortex shedding	Insertion	±2% 1 fps	• Insertion style allows easy retrofit (via hot tap) and removal for cleaning, replacement	• Not accurate at low flows Can be fouled by contaminants in water; • Requires correct installation depth to be accurate Sensitive to installation details – long straight inlet and outlet runs required
Transit time ultrasonic	External	±1.0% 0.05 fps	• External mount allows easy retrofit and replacement High turndown and good low flow capability. With Proper installation, high accuracy. Less straight pipe runs required with multi-bounce configurations. No moving parts and no parts exposed to fluid so maintenance costs are low. Relatively low cost for large diameter pipes.	• Relatively expensive for small pipe sizes Requires correct configuration to be accurate – sensitive to configuration details such as pipe dimensions and wall thickness Sensitive to installation details

The early days of Flow / BTU metering

- 30 years ago Orifice Dp metering was the prevalent metering technology.
- The issue with Dp is low turndown (4-1) and no low flow detection (<0.5ft/sec)

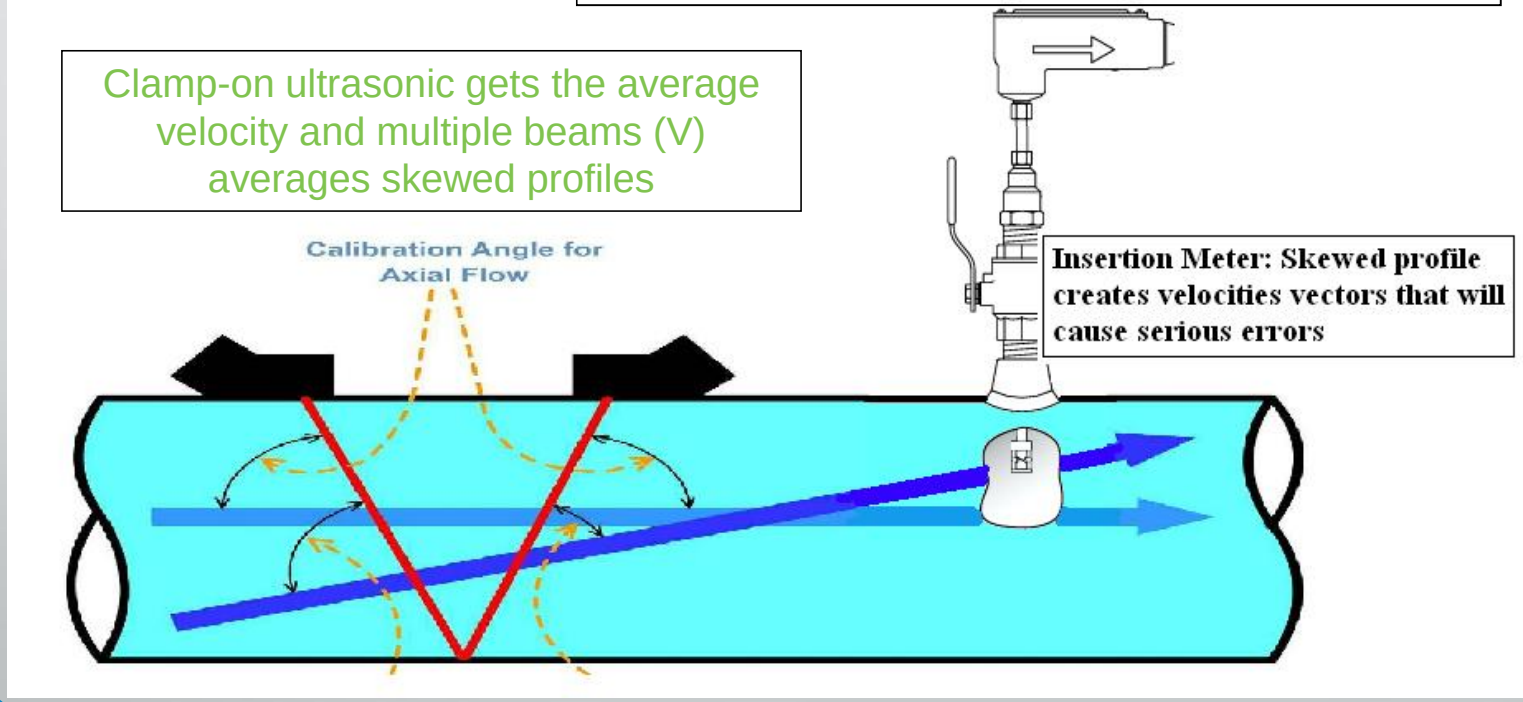


- NY Port Authority realized that off peak metering was not being metered
- Back in 1982 the meters being used were orifice meters
- Orifice meters typically have a 4-1 turndown and will not detect low flow velocities below about 0.5 ft/sec
- Clamp-on meters have a very high turndown 1000-1 and can get to very low velocities

Challenge: Short Straight Run

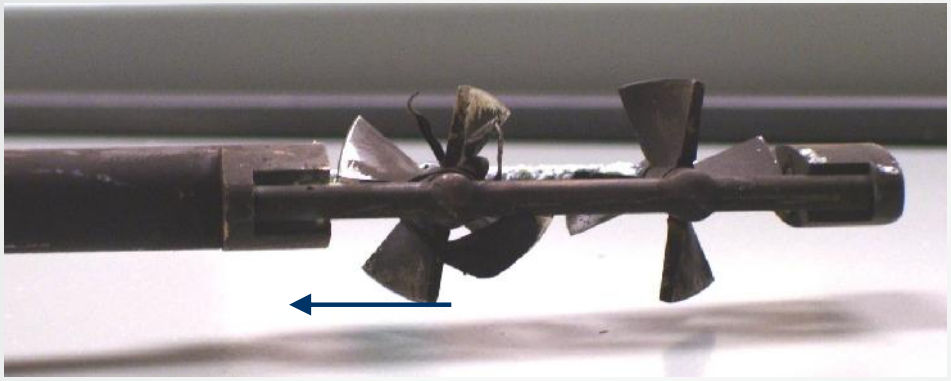
Insertion Meters are highly susceptible to errors from flow profile skew and swirl

Clamp-on ultrasonic gets the average velocity and multiple beams (V) averages skewed profiles



… external measurement of internal flow

Insertion BTU meters - Is it worth?



Debris on Paddle Wheels

Lost (Head) Paddle Wheels

Meter Requirements

- High Turndown
- Low flow sensitivity
  - Peak Demand is only 8 hrs! (Optimum Flow)
  - Off-Peak Demand is 16 hrs! (Low Flow)
- Pre-zeroed – never have to shut down to zero meter
- No Drift!!!
- Highest temperature accuracy – Laboratory Certified
- Integrated BTU System
- Permanent couplant – no more maintenance
- Higher Temperature Capability
- Every Meter Wet Flow Calibrated – Certified Traceability
- Technical Service and Know-how

Typical Calibration Certificate

Calibration Certificate

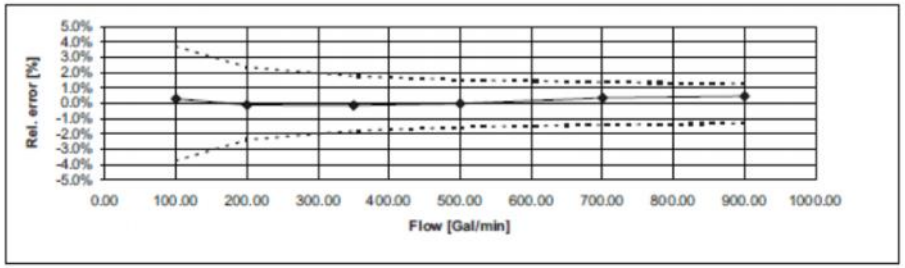
FLEXIM

Device under test (DUT)

Certificate No.:	20091202-003				
Work Order No.:	WO-09-0342				
Purchase Order No.:	O 09-0761				
Type:					
Transmitter:	F601	Ser. No.:	0667		
Transducer:	CDK1NZ7	Ser. No.:	14076		
Pipe ID [inch]:	6.11	Fluid:	Water	Temperature:	68.0 °F
	155.1				20.0 °C
Range [Gal/min]:	900	Spec. Accuracy:	1.0% of rate	Offset Allowance:	±0.03 ft/s

Test results

Meas. Point	Meas. Time sec.	Standard Flowrate Qn Gal/min	DUT Flowrate Qp Gal/min	Error	Limit	Velocity v ft/s	Pass/ Fail
1	120	-0.01	0.20	0.2Gpm	2.7Gpm	0.0	p
2	120	99.99	100.29	0.3%	3.7%	1.1	p
3	120	199.95	199.77	-0.1%	2.4%	2.2	p
4	120	350.00	349.57	-0.1%	1.8%	3.8	p
5	120	499.98	499.98	0.0%	1.5%	5.5	p
6	120	700.07	702.65	0.4%	1.4%	7.7	p
7	120	899.93	904.16	0.5%	1.3%	9.9	p



Environmental conditions:

Temperature[°F]:	68 ± 3	Atmosph. press.:	1013 ± 25 mBar	Humidity:	50 ± 15 %RH

The indicated instrument meets the accuracy data published in the specification (passed / failed). **p**

The calibration of the instrument specified above was carried out against standards which accuracies are traceable to the National Institue of Standards and Technologies (NIST), in accordance with ISO9000.

Standard	YOKOGAWA AXF100C	Ser. No.	AAXFBC503	Rig	PS101
Calibration due	07.17.2010	Certificate No.	N66475		

Calibration Facility

Accuracy of the Temperature Measurement According to IEC 751 and DIN 1434

- Matched RTD's with certified accuracy of better than 0.03°F
- 4 wire RTD's which eliminates the effect of wire resistance
- Clamp-on or wetted 100 ohm & 1000 ohm RTD's

BTU Measurement Accuracy

- Accuracy of the Flow Measurement
- Accuracy of the Temperature Measurement
- Accuracy of the Thermal Energy Calculation
- Accuracy of input devices

Accuracy of outputs

Error From Inaccurate Temperature Measurement

- In BTU metering inadequate attention is often given to temperature accuracy.
- Typical delta T's for CW systems are 5-10°F

Highest rated "class A RTD's" are specified to .25°F

Temperature Tolerance IEC 751-95

Deg (C)	Class B (±C)	Class B (±F)	Class A (±C)	Class A (±F)
0	0.30	0.54	0.15	0.25
100	0.80	1.44	0.35	0.63

- Many BTU meters are built with unmatched class A or B rated RTD's
- The potential error resulting from unmatched RTD's will be 5 – 10% for delta temps of 5-10°F
- Matched and certified RTD's 0.03°F @ 32 and 50°F – roughly 10x greater than class A

ANY QUESTIONS?!