# Energy and Flow Measurement for Hydronic Systems


**Presented By:**

**Joseph Moore**

**AEB Technologies**

Question for the day:

*Which of the below factors is* ***most*** *important when considering metering* ***accuracy:***

a. *The Technology?*
b. *The Accuracy Statement (spec)?*
c. *The Installation?*


# Energy Measurement

ONICON INCORPORATED

# Manufacturer

# Meter Selection

# Energy Measurement

# Why Should We Measure Flow?

Energy Management

- Provides the baseline for Energy Management, Sustainability and Energy Conservation.
- Provides the basis for Billing and Cost Allocation
- Locate energy Hogs

Efficiency

- Required for the implementation of Complex Control Strategies
- Monitor/Verify Equipment Performance
- Reduced Energy Consumption

# Why Should We Measure Flow?

Behavioral

- Displaying a buildings energy usage can cause significant changes in tenant usage.
- Information vital for training and demonstration of quantitative energy savings
- For energy managers, quality data is directly proportional to their performance (TEAM)

# What To Measure?

- Typical Flow Metering Opportunities in todays High-Performance Buildings Include:
  - Chilled Water / Heating Hot Water / Condenser Water
  - Steam / Steam Condensate / Boiler Feed Water
  - Natural Gas
  - Make-Up Water / Blow Down (water treatment)
  - Domestic Water / Domestic Hot Water

# Manufacturer

# ONICON Background

- Founded in Clearwater, FL in 1988
- Shifted focus to HVAC building controls market in early 1990's
- Recognized throughout the HVAC controls industry for innovation and <u>outstanding service</u>

# Marvin Feldman

# Why ONICON?

- Engineered, **calibrated** measurement solutions at a competitive price
- Products **ready to use** out of the box
- Outstanding support from highly capable representatives and in-house support staff
- Industry leading **two-year no-fault** warranty on most products

ONICON INCORPORATED


When all you have is a hammer,
everything looks like a nail.

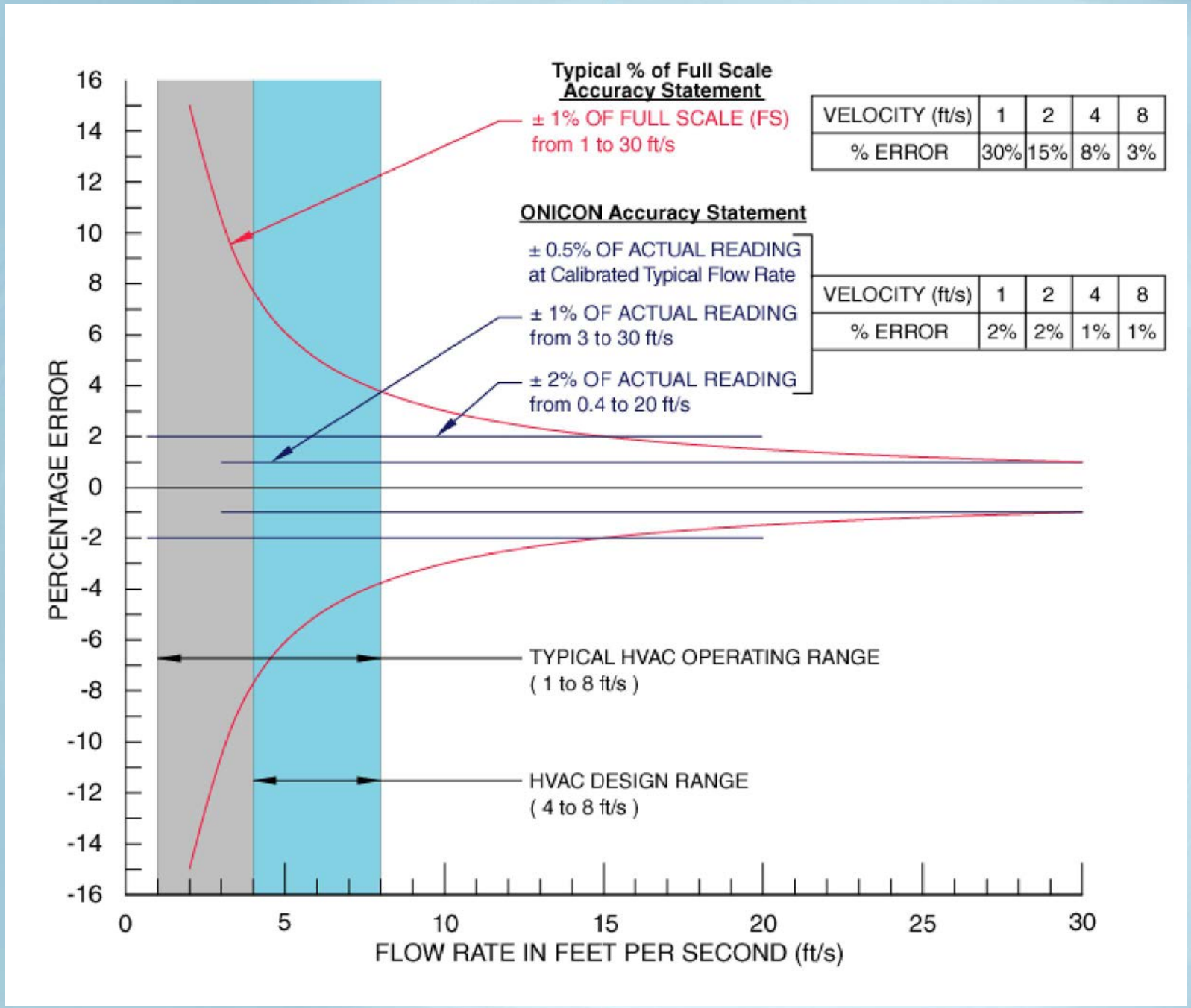

ONICON

# Meter Selection


## Terms – Technologies - Installation

# Terms

- Specifications for Flow Meters
  - Accuracy Statement (% of Rate or % of Span)
  - Range (typical flow rates for the application)
  - Repeatability (calibration certificate, known standard)
- What is a Flow Meter


Typical % of Full Scale
Accuracy Statement
± 1% OF FULL SCALE (FS)
from 1 to 30 ft/s
VELOCITY (ft/s) 1 2 4 8
% ERROR 30% 15% 8% 3%
ONICON Accuracy Statement
± 0.5% OF ACTUAL READING
at Calibrated Typical Flow Rate
± 1% OF ACTUAL READING
from 3 to 30 ft/s
± 2% OF ACTUAL READING
from 0.4 to 20 ft/s
VELOCITY (ft/s) 1 2 4 8
% ERROR 2% 2% 1% 1%
TYPICAL HVAC OPERATING RANGE
( 1 to 8 ft/s )
HVAC DESIGN RANGE
( 4 to 8 ft/s )
PERCENTAGE ERROR
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
5
10
15
20
25
30
FLOW RATE IN FEET PER SECOND (ft/s)

# Rangeability/Turndown

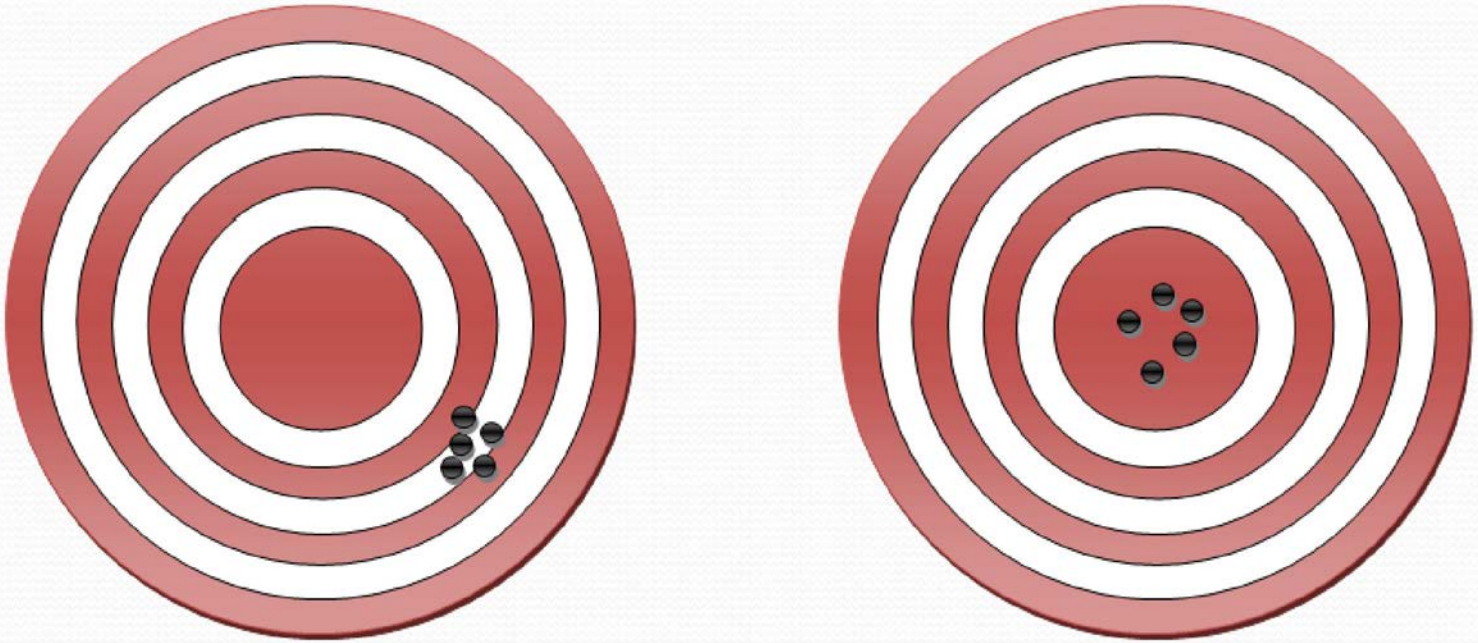
- **Rangeability: The range over which an instrument can measure**

**1-30 fps, 10-1000 gpm**

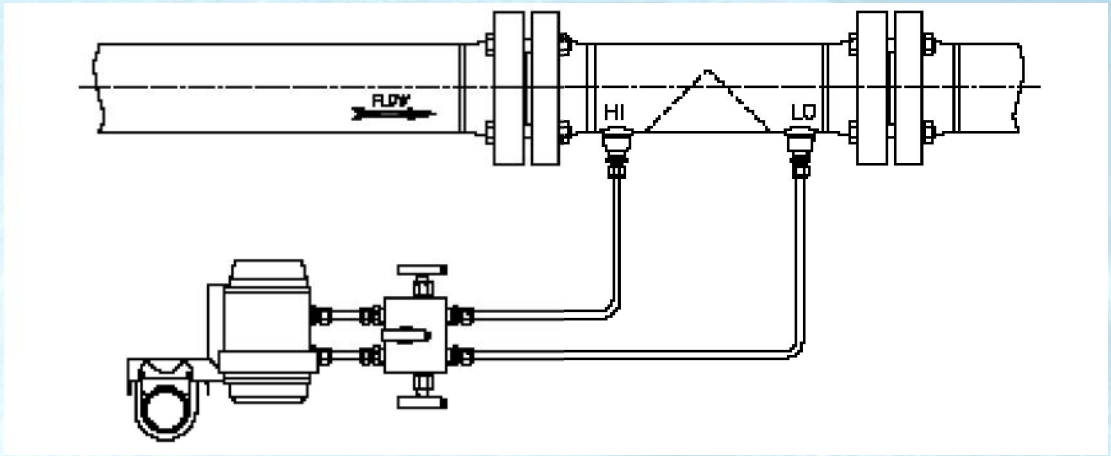
- **Turndown: The range specified as a ratio of the highest measured value over the lowest**

**30:1, 100:1**

# Repeatability vs. Accuracy



# What is a Flow Meter




**Flowmeter:** An Instrument for measuring the rate of motion of a fluid that includes a primary SENSING ELEMENT and a secondary OUTPUT DEVICE.

# Technologies – Flow


## Terms – Technologies - Installation

# Technologies

Available Technologies

- Differential Pressure
- Electromechanical – moving parts
- Electromagnetic
- Thermal Dispersion
- Vortex Shedding
- Ultrasonic
- Positive Displacement
- Others


# Insertion Turbine Meters

- Easy to install, immersion style sensor, direct reading.
- High turndown, linear response over a wide range of flow.
- Hot Tap-able, no system shut down required.
- Wet calibrated versions have high accuracy to cost ratio, good value in clean, closed loop systems.
- Good accuracy over wide turndown, provided straight run requirements are met.

# Insertion Electromagnetic Meters

- Easy to install, immersion style sensor.
- Hot Tap-able, no system shut down.
- Electromagnetic technology, no moving parts.
- High accuracy over wide turndown, provided straight run requirements are met.
- Requires conductive fluid to operate.
- Good value in open loop, conductive fluid systems.

# Clamp On Ultrasonic Meter


- High accuracy & turndown.
- Can measure bi-directional flow.
- Fairly high cost for small pipes, better value on larger pipes.
- Non-invasive design can be installed with no shutdown & no tapping the line.
- Type of transducers and sensing method best suited for application can be dependent on type of pipe and fluid properties.

# Full Bore Electromagnetic Meters

- Highest accuracy & reliability, best short straight pipe run performance.
- Requires conductive fluid to operate.
- Installation, service, or calibration requires shutdown and drain.
- Suitable for use in most open loop and closed loop HVAC systems.
- Best choice for high dollar custody transfer.

# Technologies

# Full Bore Vortex Shedding Meter

- Robust sensing technology, no moving parts, capable of measuring liquids, gases or steam.
- Ideally suited for steam applications.
- Limited turndown due to sensing technology, proper sizing of meter is paramount.
- Installation, service, or calibration requires shutdown and drain.
- Multi-variable technology provides good value in saturated steam applications.

# Thermal Dispersion Meter


- High accuracy & turndown.
- Immersion sensor, hot-tapable versions available.
- Suitable for Gas and Compressed Air Applications.
- Compensated mass flow measurement technology
- Electronic based sensing system, provides outputs compatible with the BAS directly.

# Technologies – Energy

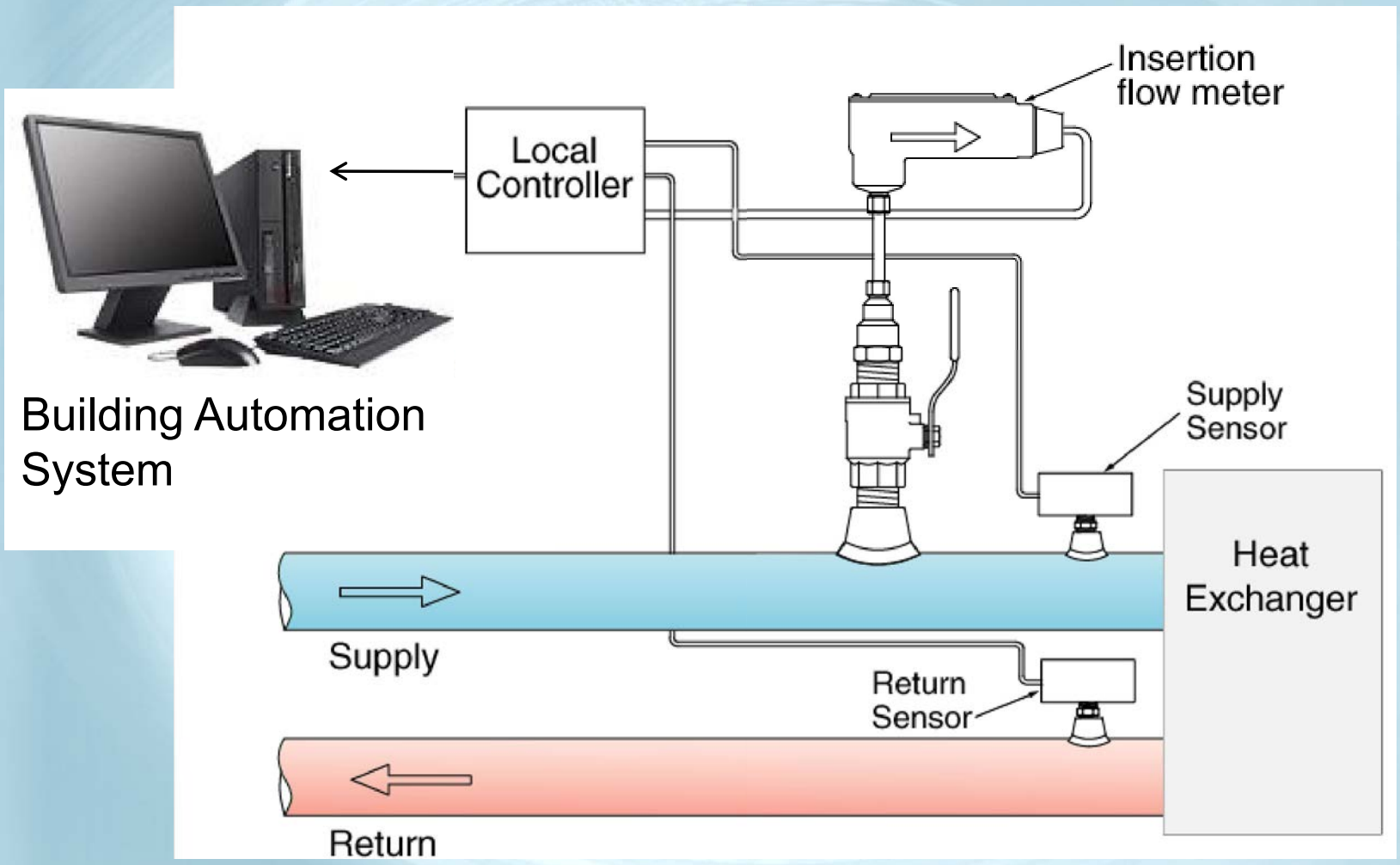

## Terms – Technologies - Installation

# Hydronic Energy Transfer Calculation (BTU Meter)

**BTU Rate = 500* x Flow Rate (GPM) x Delta-T**


* Approximation for Specific Heat x Density for water

# Traditional Approach
## to Energy Measurement in Hydronic Systems



# BTU Measurement Accuracy Evaluation
## Sources of Error Using Traditional Methods

- **Flow**
  - Meter accuracy
  - Signal D/A conversion
  - Control input offset
- **Temperature**
  - Sensor accuracy
  - Transmitter accuracy
  - Sensor matching
  - Signal transmission error
  - Control input offset
- **Resolution**
  - Of inputs
  - Of calculations
- **Specific heat corrections**
- **Density corrections**

# BTU Measurement Accuracy Evaluation

## Potential Cost of Measurement Error

***The negative impacts of using typical HVAC grade flow and temperature sensors into standard analog control system inputs for energy measurement are widely dismissed and underestimated.***

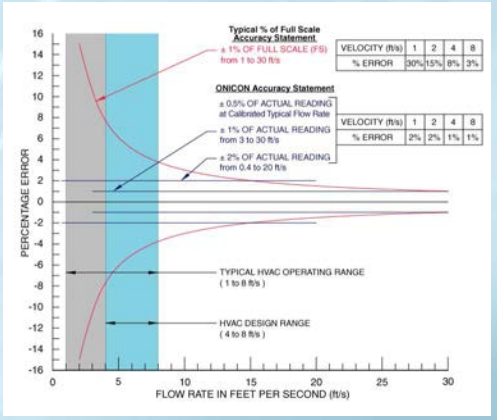
# BTU Measurement Accuracy Evaluation
## Sources of Error Using Traditional Methods

**Example: 6” pipe, 300 gpm, 10 degree F delta-T**

- Flow Measurement Error (Brand X @ 3 fps)
  - Combined Error = 10% of reading
- Temperature Differential (RTDs)
  - Combined Error = 10% to 20% (10 deg delta-T)

**Total Energy Error =**

**10% to 20% of Rate**



# ONICON Electronic Temperature Sensors

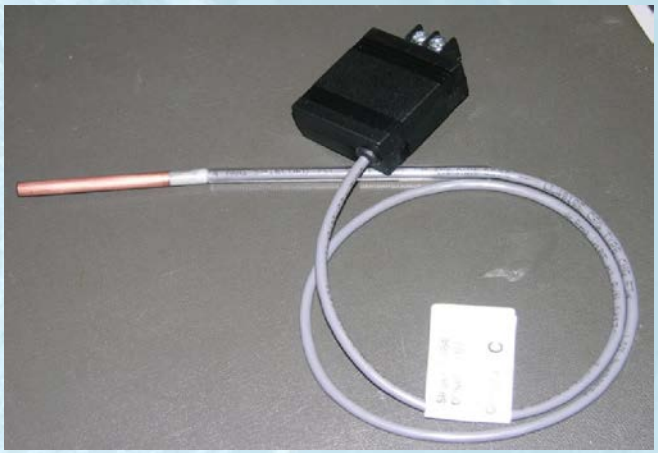
- Manufactured by ONICON
- Semiconductor-based sensors provide excellent stability over time
- NOT Resistance Temperature Detectors (RTDs) or thermistors

**Note:**

- Standard sensors for operating temp. to 200° F
- RTD/transmitters are used for high temp HW, up to 500° F at additional cost.

# ONICON Electronic Temperature Sensors

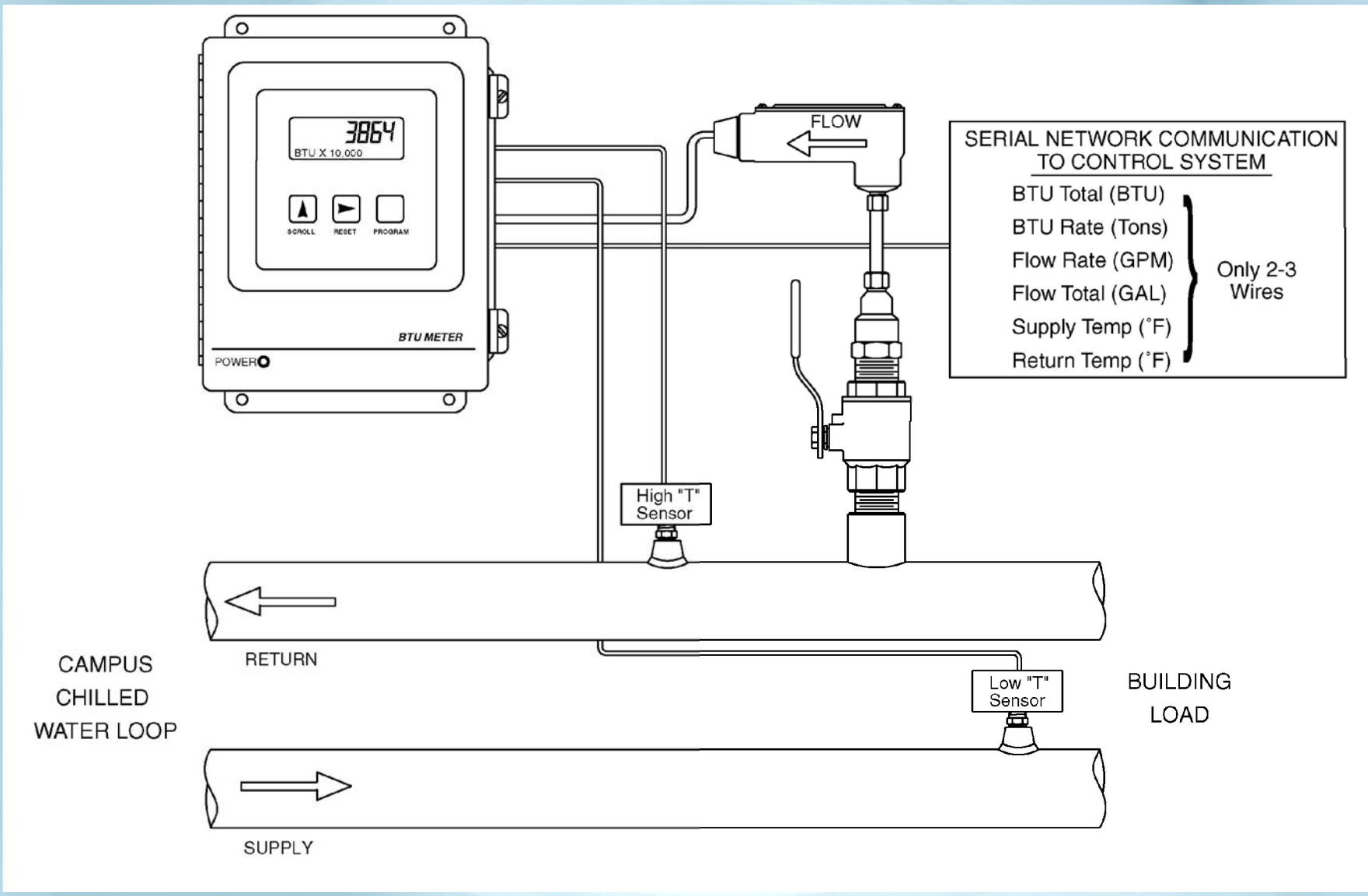
- Proprietary design
- Each sensor is bath-calibrated and characterized over an application specific temperature range.
- Signal conditioner provides current based output signal for stability over long wire runs.
- Data for each sensor is programmed into the Btu meter, providing the basis for 0.15 degree F delta-T accuracy.



# Dedicated BTU Metering System


- Designed specifically for hydronic energy (BTU) measurement
- Provides outstanding accuracy and functionality via:
  - Calibrated/paired temperature sensors
  - High frequency sampling
  - Network communication
  - Local Display
- Strong price for performance value
- 2 Year No Fault Warrantee

# ONICON BTU Measurement System



# BTU Measurement Accuracy Evaluation

## Sources of Error Using System-10 BTU Meter

**Example: 6" pipe, 300 gpm, 10 degree F delta-T**

- Flow Meter (frequency output)
  - Combined Error = 0.5 to 1% of reading
- Bath Calibrated & Matched Temperature Sensors
  - Combined Error = 0.15 deg. F = 1.5% of reading (10°F ΔT)
- Computational Error
  - Combined Error = 0.05 % of reading

**Total Energy Error = 1.58 to 1.8% of Rate**

# Network Communication Options for the System-10 BTU Measurement System:

- BACnet® MS/TP & IP
- Modbus RTU & TCP
- Johnson Controls N2
- LONWORKS®
- Siemens P1 (FLN)

# BTU Measurement System Cost

**What is the typical cost for a complete Btu measurement system?**

**System price can vary greatly based on the type of flow meter and other options.**

**Using Insertion type flow meters: $2500 - $3500**

# Important Considerations for a BTU Measurement System

- Calibrated & **matched temperature sensors** with clearly defined differential error
- Accurate, reliable flow meter
- **Expertly** selected and **installed** flow meter
- Several Building Control Network communication protocols available
- **Single source** for all system components and factory calibration of the entire system

# Meter Selection


## Terms – Technologies - Installation

Question for the day:

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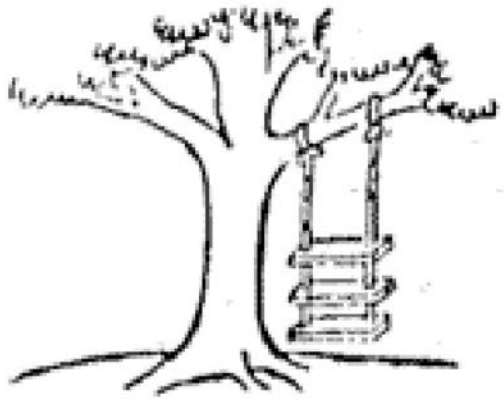
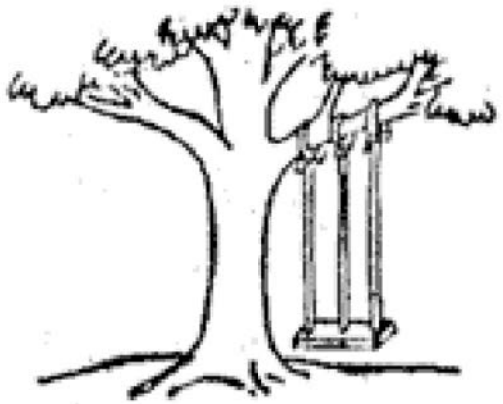
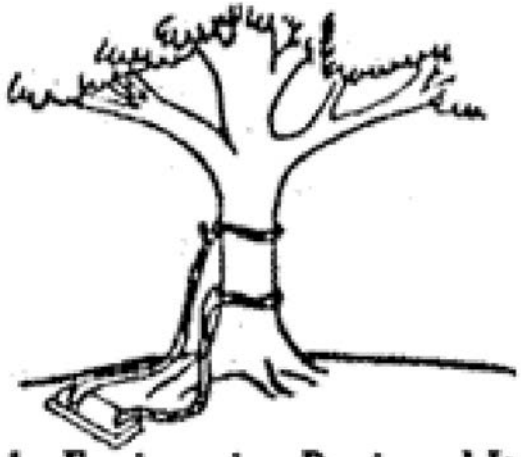
a. *The Technology?*
b. *The Accuracy Statement (spec)?*
c. *The Installation?*



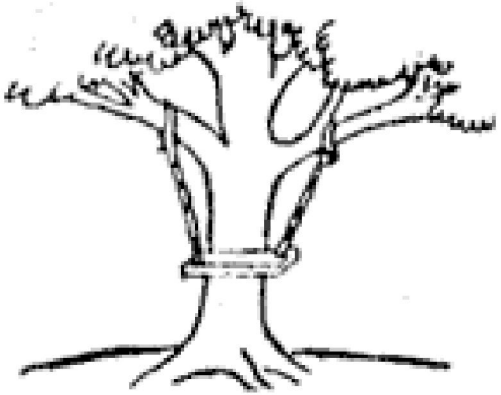
As Marketing Requested It



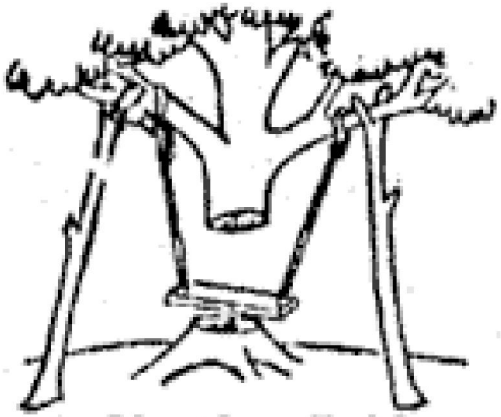
As Sales Ordered It



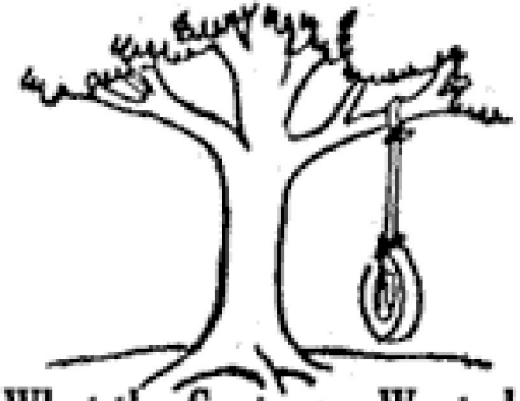
As Engineering Designed It



As Manufactured



As Plant Installed It

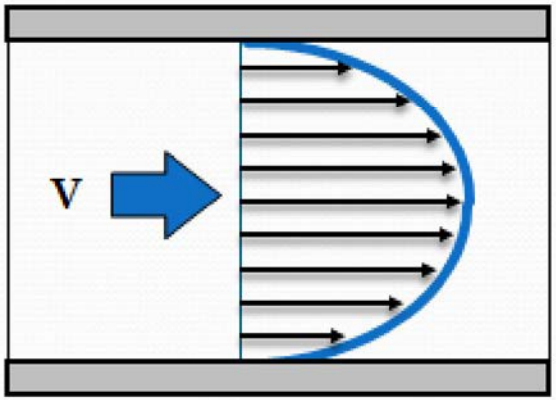


What the Customer Wanted

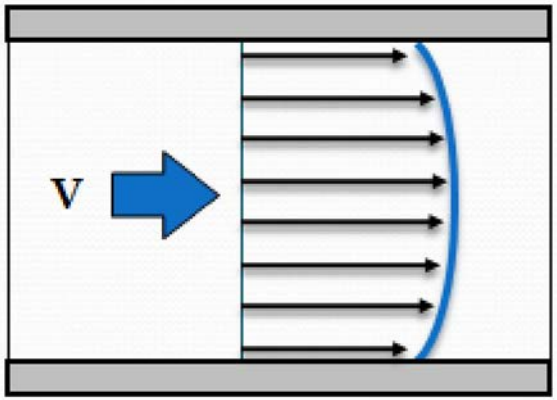
# Installation

# Flow Regimes

**LAMINAR**
flow profile.




**TUBULENT**
flow profile



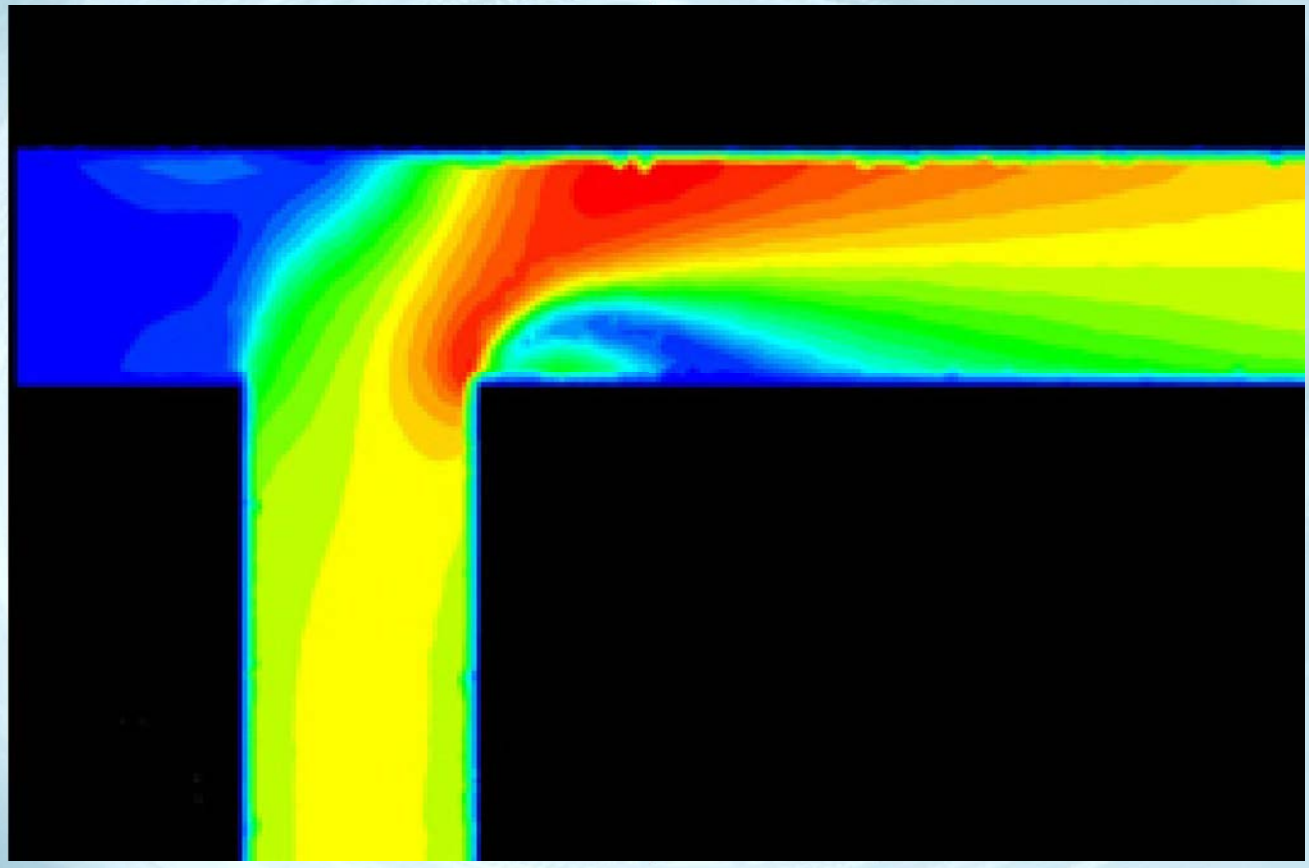
# Reynolds Number

Inertial Forces/Viscous Forces

$$\mathrm{Re} = \frac{\text{inertial forces}}{\text{viscous forces}} = \frac{\rho \mathbf{v} L}{\mu} = \frac{\mathbf{v} L}{\nu}$$ [6]

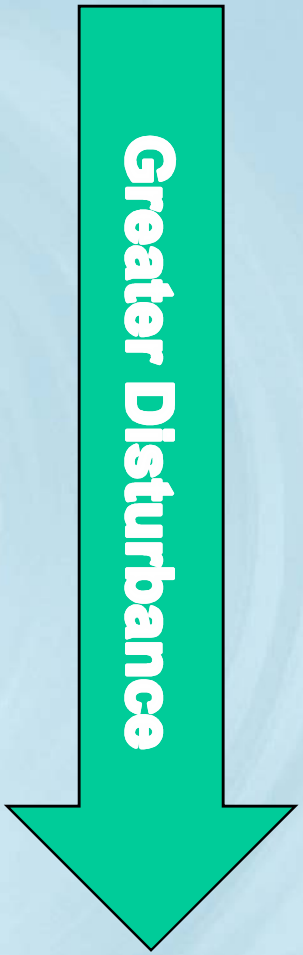
| Laminar | Transitional | Turbulent |
| --- | --- | --- |
| Re < 2300 | 2300 to 4000 | Re > 4000 |

# Fully Developed?



# Obstructions

| | |
|---|---|
| • Single 90° Elbow | 20 Dia |
| • Tee | 20 Dia |
| • Reducer/Expansion | 20 Dia |
| • Two 90's same plane | 30 Dia |
| • Ball/Gate Valve Fully Open | 30 Dia |
| • Two 90° Elbows out of plane | 40 Dia |
| • Control Valve | 50 Dia |
| • P.R.V | 50 Dia |



# Energy Management Review

- TEAM (results)
- Technologies (No Silver Bullet)
- Installation (“A flow meter is only …)

# Thank You!


# For More Information