GovEnergy
www.govenergy.gov

Charting a Course to Energy Independence

Providence, RI
August 9-12, 2009

Metering All Things Not Electric

By John B Thompson

Why meter?

- Business Need
  - Mitigate rising energy costs
  - Manage energy consumption efficiently
  - Apportion energy costs by usage and not square footage, creating behavior change
  - Government requirements

Monitoring is the first step to energy and material savings.

Presentation objectives

- Utility flows being measured
- Selecting a flow meter
  - Accuracy & Repeatability
  - Fluid Conditions – straight run, pressures, temperatures
  - Flow range – min and max flows
- Flow meter selection criteria

Utilities being measured

- Water
- Air
- Gas
- Steam

Selecting a flowmeter

- Performance
  - Accuracy (or Uncertainty)
  - Repeatability
  - Turndown
  - Density compensated (Multivariable)
  - Display options
  - Ability to interface (comms)
  - Response time
  - Pressure drop

Selecting a flowmeter

- Material
  - Pressure, temperature, corrosion compatibility
- Installation issues
  - Inline or insertion (hot tap?)
  - Up and downstream piping requirements
  - Horizontal or vertical
  - Environmental: inside/outside, NEMA, I.S. etc.
  - Power requirements

Selecting a flowmeter

- Reliability
  - Moving parts
  - Ruggedness (vibration, shock, humidity, temp.)
  - Calibration needs
- Cost
  - Meter
  - Associated equipment
  - Installation
  - Ownership

Selecting a flowmeter

- Maintenance
  - Ease of maintenance & spare parts availability
- Reputation and support of manufacturer
  - Technical support
  - After sales service
  - Warranty
  - Quality of literature and information provided

Selecting a flowmeter

Accuracy

- A measure of a meter's performance or uncertainty in indicating a correct flowrate value against a 'true' value obtained by extensive calibration procedures.

Two methods used to express accuracy:

- As a percentage of reading
- As a percentage of full scale deflection (FSD)

Accuracy....+/- 3%

% of Rate or Reading

Error = % of rate ∗ measurement

% of Full Scale

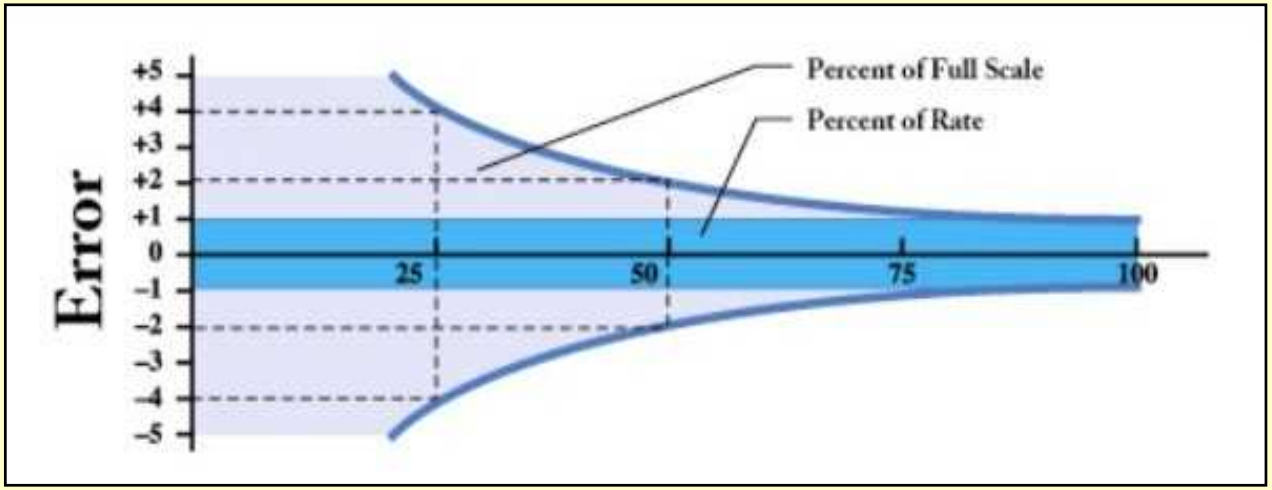
Error = % of full scale ∗ full scale flow

ACCURACY +/-3%

% of Rate
Max flow 1,000lb/h = 1,030 to 970 lb/h
Min flow 100 lb/h = 103 to 97 lb/h

% Full scale (FS)
Max flow 1,000 lb/h = 1,030 to 970 lb/h
Min flow 100 lb/h = 130 (100 + 30) lb/h to 70 (100 - 30) lb/h

i.e. +/- 30% error at minimum flow

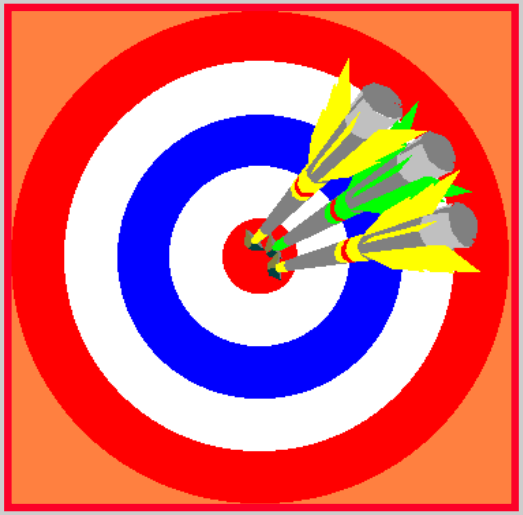


Selecting a flowmeter

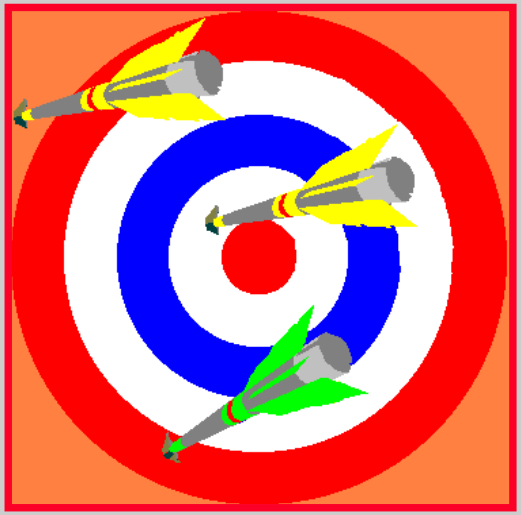
Repeatability

- A flowmeter's ability to indicate the same value for an identical flow conditions on more than one occasion.
- Repeatability should not be confused with accuracy.
- Good repeatability is important because many flowmeter users are more interested in observing trends than absolute and minute accuracy.

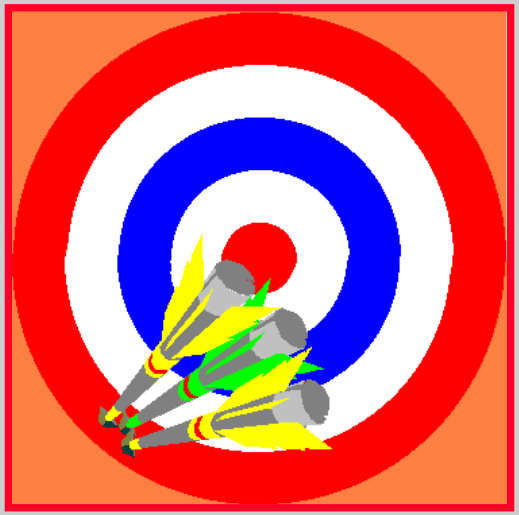
Repeatability



Accurate and therefore repeatable



Not repeatable and therefore not accurate

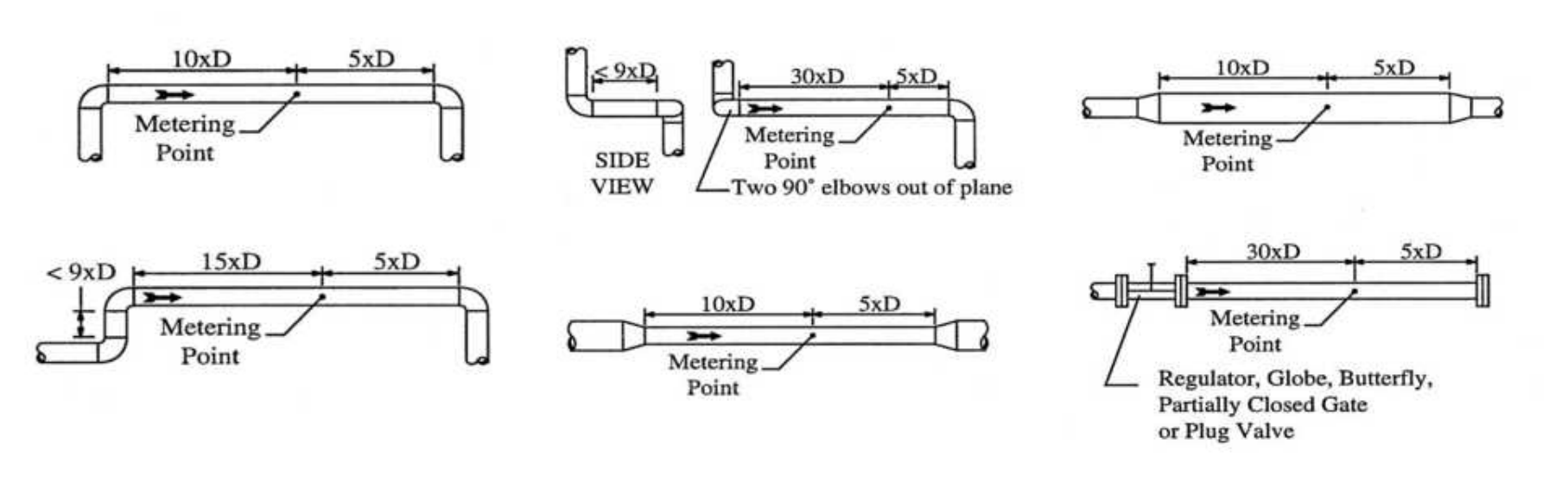


Repeatable <u>but</u> not accurate

Selecting a flowmeter

Straight run

- Typical **10 pipe diameters upstream and 5 pipe diameters downstream** required to get proper flow profile
- Less straight run affects meter accuracy



Selecting a flowmeter

Turndown

- The Turndown of a flowmeter is the ratio of the maximum to minimum flowrate over which it will operate within it's specified <u>accuracy and repeatability tolerances</u>

Maximum Flowrate = 1,000 lb/h

Minimum Flowrate = 100 lb/h

Turndown = 1,000 ÷ 100 = 10:1

Selecting a flowmeter

Density Compensation

The pressure in steam systems is rarely constant i.e. its density varies and must be accounted for...

Example: A vortex meter in a saturated steam application specified to operate at 75 psig but actually operating at only 50 psig. Without density compensation the error can be calculated as follows:

Flow error = ((75 psi density ÷ 50 psi density) -1) x 100

= ((0.2043 ÷ 0.1503) -1) x 100

= 35.928

The meter over reads by almost 36%!

Meter Technologies

Technology	Operating Principle	Advantages	Disadvantages	Fluids Measured
DP (Differential Pressure) *Orifice plate* *Pitot tube* *Variable area* *Venturi* *V-Cone* *Accelabar*	**An obstruction in the flow, measure pressure differential before and after the obstruction**	**Low initial cost** **No moving parts** **Handle dirty media** **Easy to use** **Well understood technology** **Supported by AGA and API**	**Not highly accurate, particularly in gas flow** **Orifice plate and pitot tube can become clogged** **High maintenance to maintain accuracy** **Typically low turndown** **Pressure drop**	**Liquids** **Gases** **Steam**
Vortex *Inline* *Insertion*	**Bluff body creates alternating vortices, vortex shedding frequency equal to fluid velocity**	**High accuracy** **No moving parts** **No maintenance** **Measures dirty fluids**	**Can be affected by pipe vibration** **Cannot measure low flows**	**Liquids** **Gases** **Steam**
Turbine *Inline* *Insertion* *Dual turbine*	**Turbine rotates as fluid passes by, fluid velocity equal to blade rotational frequency**	**High accuracy** **Low flow rates** **Good for steam** **Wide turndown**	**Moving parts require higher maintenance** **Clean fluids only**	**Liquids** **Gases** **Steam**
Magnetic *Mag* *Electromagnetic*	**Measures voltage generated by electrically conductive liquid as it moves through a magnetic field, induced voltage is equal to fluid velocity**	**High Accuracy** **Wide turndown** **Bi-directional** **No moving parts** **No pressure loss to system**	**Conductive fluids only** **Expensive to use on large pipes**	**Conductive liquids (condensate)**

Meter Technologies Cont'd

Technology	Operating Principle	Advantages	Disadvantages	Fluids Measured
Transit-time Ultrasonic	**Fluid velocity measured by time arrival difference of sound waves from upstream and downstream transducers**	**Low cost clamp-on installation Non-intrusive No maintenance Bi-directional Best for larger pipes**	**Typically not used on pipes < 2" Less accurate than inline or insertion meters Used primarily for liquids Susceptible to changes in fluid sonic properties**	**Most liquids (condensate) Gas (when spool-piece)**
Doppler Ultrasonic	**Fluid velocity measured by sensing signals from reflective materials within the liquid and measuring the frequency shift due to the motion of these reflective materials**	**Low-cost, clamp-on installation Non-intrusive Measures liquids containing particulates or bubbles Low maintenance Best for larger pipes**	**Can't be used in clean liquids Less accurate than in-line or transit-time ultrasonic**	**Most liquids containing reflective materials**
Thermal Mass	**Measure heat loss of heated wire thermistor in fluid flow**	**Measure flow at low pressure Relative low cost Measure fluids not dense enough for mechanical technologies Easier to maintain than DP meter**	**Susceptible to sensor wear and failure Not very accurate Limited to fluids with known heat capacities**	**Gases**

Meter Selection Guide

Flow Meter Type /Fluid	Water	Gas	Steam	Product Features
Orifice Plate	▪	▪	▪	Temperature: up to 806°F (430°C) Line Size: 1-24" Process Shutdown: Required Accuracy: ±3.0% of rate Pressure: 5,990 psig (413 bar) Turndown: up to 4:1
Variable Area	•	•	•	Temperature: up to 842°F (450°C) Line Size: 2-8" Process Shutdown: Required Accuracy: ±1.0% of rate Pressure: 600 psig (41 bar) Turndown: up to 100:1
Direct Variable Area			▪ Saturated Steam ONLY	Temperature: up to 347°F (175°C) Line Size: 2-4" Process Shutdown: Required Accuracy: ±2.0% of rate Pressure: 218 psig (15 bar) Turndown: up to 50:1
Insertion Vortex	▪	▪	▪	Temperature: up to 500°F (260°C) Line Size: 3-80" Process Shutdown: Not required; Hot-Tappable Option Accuracy: ±1.0% of rate Pressure: 2000 psig (138 bar) Flow Range: Liquid 1.5 ft/sec to 32 ft/sec Gas and Steam: ?(50/p) ft/sec to 300 ft/sec
Insertion Turbine	•	•	•	Temperature: up to 750°F (400°C) Line Size: 3-80" Process Shutdown: Not required; Hot-Tappable Option Accuracy: ±1.0% of rate Pressure: 2160 psig (149 bar) Flow Range: Liquid 0.5 ft/sec to 30 ft/sec Gas and Steam: 3.19/?p ft/sec to 300 ft/sec (rotor dependant)
In-Line Vortex	▪	▪	▪	Temperature: up to 750°F (400°C) Line Size: 1-12" Process Shutdown: Required Accuracy: ±1.0% of rate Pressure: 825 psig (57 bar) saturated steam Flow Range: Liquid 1.5 ft/sec to 32 ft/sec Gas and Steam ?50/p to 260 ft/sec (p=density in lb/ft³)
Electromagnetic	•			Temperature: up to 240°F (116°C) Line Size: 2-80" Process Shutdown: Required Accuracy: ±0.5% of rate Conductivity: >0.80 µS/cm
Commercial Vortex	▪			Temperature: up to 160°F (71°C) Line Size: 2-20" Process Shutdown: Not required; Hot-Tappable Accuracy: ±1.0% of full scale
Transit Time Ultrasonic	•			Temperature: up to 400°F (205°C) Line Size: 2-80" Process Shutdown: Not required; Clamp-On Accuracy: ±2.0% of rate

GovEnergy
www.govenergy.gov

Meter Selection Guide Cont'd

Fluid	Water	Gas	Steam	Product Features
Selection Criteria				Line Size Fluid Temperature Fluid Pressure Process Shutdown Accuracy Flow Range

Customer requirements will dictate proper meter for a specific application

Reference Terms

- Flow Measurement Accuracy

  Average = 1 to 2% of flow rate
- Turndown (Max. flow/Min. flow)

  Typical = 10 to 1
- Straight run Requirements

  Typical = 10 diameters upstream and 5 diameters downstream from the flow meter

Installed meters

In-Line Variable Area (ILVA) meter on saturated steam line

Output:
Pounds/hour

Installed meters

Insertion meter on saturated steam installed under flow using hot tap (no line shutdown)

Hot tapping

Installed meter

Output:

Pounds/hour

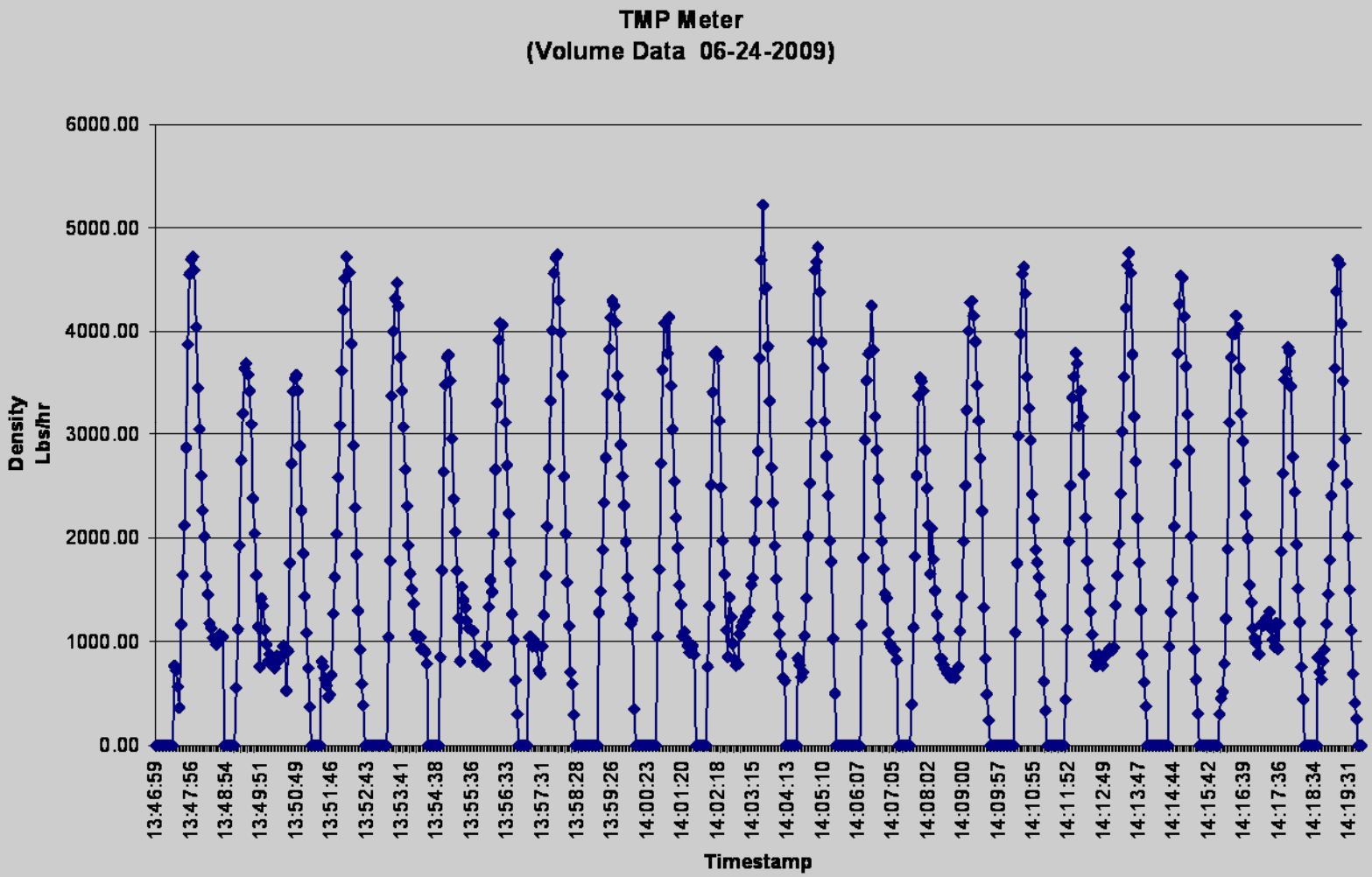
Installed meters

Mag meter on water line

Output:

gallons/hour

Meter Data


TMP Meter
(Volume Data 06-24-2009)
Density
Lbs/hr
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
13:46:59
13:47:56
13:48:54
13:49:51
13:50:49
13:51:46
13:52:43
13:53:41
13:54:38
13:55:36
13:56:33
13:57:31
13:58:28
13:59:26
14:00:23
14:01:20
14:02:18
14:03:15
14:04:13
14:05:10
14:06:07
14:07:05
14:08:02
14:09:00
14:09:57
14:10:55
14:11:52
14:12:49
14:13:47
14:14:44
14:15:42
14:16:39
14:17:36
14:18:34
14:19:31
Timestamp

For More Information

- Contact: John B Thompson
- Spirax Sarco, Inc.
- 2150 Miller Drive, Longmont, CO 80501
- jthompson@spirax.com

Don’t forget to fill out and drop off your session evaluations!