Steam Metering Basics

Measurement Units
- A pound mass of steam releases approximately 1000 Btu when condensed.
- Condensate at about 200°F contains an additional 170 Btu – about 100 Btu is usable
- Saturated steam is typically measured in units of mass. \(1 \text{ Mlb} = 1000 \text{ lb of steam} = \text{about 1 MmBtu}\)
- Superheated steam may be measured in units of heat – MmBtu.

Metering Options
- Volumetric steam flow at a fixed or assumed density
- Steam mass flow based on volumetric flow and active density compensation (temperature and/or pressure compensated)
- Volumetric condensate flow with fixed or active density compensation
Meter Types

Steam
- Differential pressure – orifice plate, venturi, nozzle, averaging pitot tube, variable aperture
- Oscillatory – Vortex shedder bar, Multi-variable vortex
- Positive Displacement – insertion type turbine wheel
- Others - Ultrasonic, coriolis, target

Condensate
- Positive displacement – turbine, nutating disc water meter
- Magnetic
- Ultrasonic
- Bucket Type – Cadillac, Lincoln
- Oscillatory – Vortex shedder bar
Orifice Plate DP Meter

- Relatively low cost and good accuracy
- Easy to properly size – just change the orifice
- Well established physics and math
- Very wide range of suppliers
- Limited turndown due to square law – 10:1 flow range = 100:1 DP range
- Anything less than perfect impulse line construction can lead to large errors
- Calibration and PM is more difficult and can add to ownership cost
- Typically used on > 8 inch line sizes and in applications with relatively constant flow
- High and low flow (winter/summer) flow stations often required in building applications.
Vortex Meter

- Moderate cost and very good accuracy
- Better turndown than DP – 20:1, *but output drops to zero at low velocities*
- Well established physics and math
- Very wide range of suppliers
- Calibration is very simple and virtually no PM required.
- Typically used on < 8 inch line sizes
- Multi-variable versions available with active density compensation – true mass flow output in saturated steam applications
- Up and downstream straight runs are required
• Local or remote display and totalizer, and 24vdc power supply for meter components
• Calculates steam mass rate and total based on inputs of volumetric flow and/or temperature and pressure. Built in saturated and superheated steam tables.
• Analog 4-20ma, RTD and pulse inputs – MODBUS, serial, modem, pulse and analog 4-20ma outputs.
• Not required with multi-variable meters or in applications where steam density is assumed to be fixed.
• Infinite turndown – 1% accuracy
• Low installed cost, simple totalizer or pulse output
• Not applicable on systems with condensate losses
• Very good back-up or check meter option
Special Application Options - Steam

- **Nozzle** – high velocity with low pressure drop
- **V-Cone** – minimal up and downstream straight run
Ultrasonic tube – very good turndown but expensive and not common.
Special Application Options - Condensate

- **Turbine** – low cost but susceptible to fouling
- **Ultrasonic** – moderate cost but good turndown and low maintenance
Application Considerations

- **Size** – Oversized meters reduce effective turndown leading to poor year round accuracy. Rule of thumb for a commercial office in Boston = 25 BTU/Ft
- **Straight Run Requirements** – Typically 20 diameters up and 10 down, but varies depending upon the meter technology and the obstruction.
- **Velocity** – Most meters will require a reduced bore size piping meter section to increase velocity and maximize accuracy and turndown
- **Impulse line construction** (DP meters) – high and low lines perfectly parallel in the horizontal plane, equal length, and sloping upwards to the pipe to vent gases.
- **Permanent pressure drop** – On distribution lines the pressure drop caused by the meter can be an important energy cost consideration
- Don’t underestimate the possible affect of junk in the steam causing flow element damage – 4000 FPM = 45 MPH
Flow Measurement – Edited by D.W. Spitzer and published by ISA

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
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<tbody>
<tr>
<td>( Q = A \times V )</td>
<td>Volumetric flow rate. ( A ) is the cross-sectional area of flow and ( V ) is the average fluid velocity.</td>
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<tr>
<td>( Q = \sqrt{D\text{P}} \times K )</td>
<td>Volumetric flow rate. ( D\text{P} ) is the differential pressure, ( K ) is the constant unique to the flow meter, and Bernoulli’s theorem applies.</td>
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<tr>
<td>( B = \frac{d}{D} )</td>
<td>Beta ratio. ( d ) is the orifice diameter and ( D ) is the pipe ID. ANSI/API accepted limits are .2 - .6 for custody transfer.</td>
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<td>( h_{\text{loss}} = h \times (1 - B^2) )</td>
<td>Permanent pressure drop in wc. ( h ) is the flowing DP across plate in wc, ( B ) is the beta ratio. Lower beta ratios result in greater static pressure drop.</td>
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<tr>
<td>( M = Q \times \text{Density} )</td>
<td>Mass flow rate. ( M ) is mass flow rate, ( Q ) is volumetric flow rate, and ( D ) is density of fluid.</td>
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