Steam Flow Measurement

- **Measuring Steam Energy**
- **Evaluating Important Design and Installation Considerations**
- **Overview of Current Technologies**

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Measuring Steam Energy

Basic steps for the steam energy calculation

Velocity (ft/s)

↓ Internal area (ft^2)

Volumetric Flow Rate (ft^3/m)

↓ Density (lb/ft^3)

Mass Flow Rate (lb/hr)

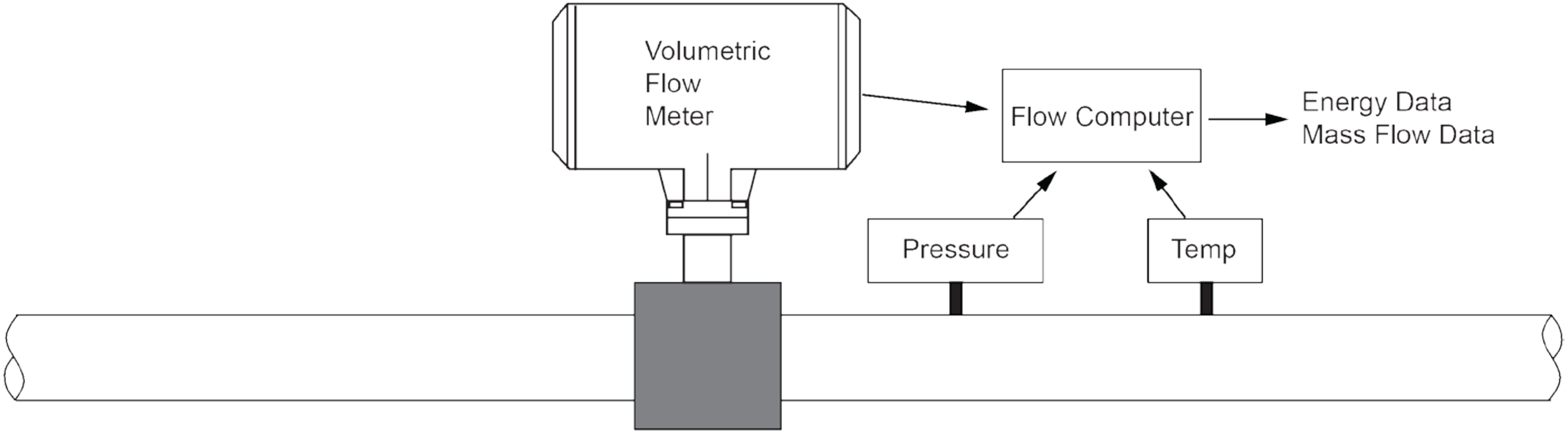
↓ Enthalpy (Btu/lb)

Energy Rate (Btu/hr)

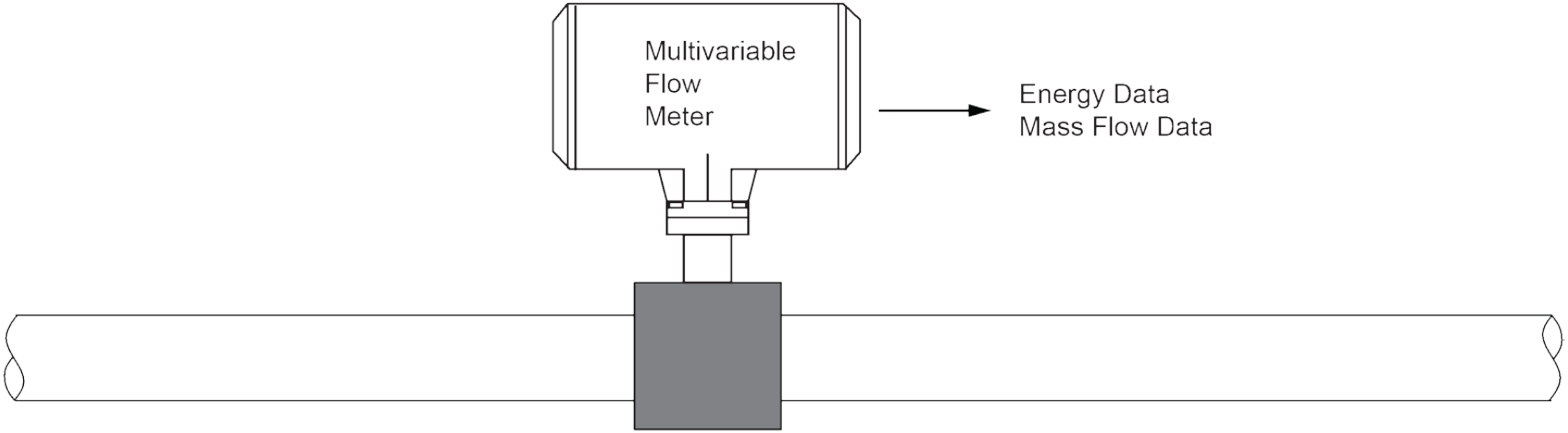
Density

- Steam is a compressible fluid
- Density is a function of both temperature and pressure
- Saturated steam: Temperature and pressure are dependent variables. Density can be calculated by measuring one variable.
- Superheated steam: Temperature and pressure are independent variables. You must measure both to calculate density to measure mass flow and energy.

Steam Measurement Using Discreet Components



Steam Measurement
Using Multivariable Technology



Evaluating Important Design and Installation Considerations

* Reliability
* Accuracy
* Rangeability/Turndown/Sizing
* Multivariable vs. Discreet Components
* Installation Requirements
* System shutdown required to install?
* Pressure drop

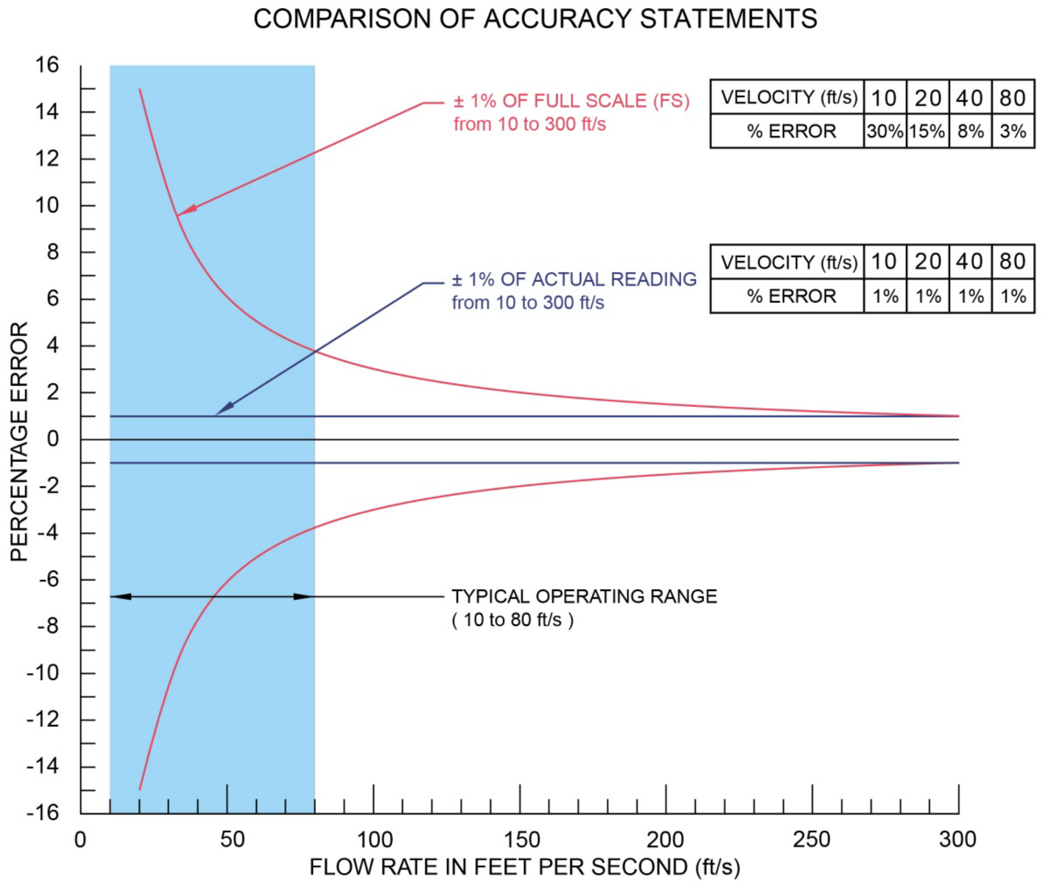
Reliability Considerations

* Does the sensing element of the meter contain moving parts that require periodic maintenance?
* Are there analog transducers that can drift over time?
* Are the pressure and temperature limitations of the equipment acceptable for the application?

Evaluating Accuracy

* Overall steam energy accuracy is determined by combining the uncertainty of the flow, temperature, and pressure sensors and calculation uncertainty.
* Calibration
* How is the accuracy expressed:
  * Percentage of scale?
  * Percentage of reading?

Evaluating Accuracy



Rangeability / Turndown

* Rangeability: The range over which an instrument can measure. (e.g. typical 3” vortex meter measuring 100psig saturated steam; 420-12,700 lb/hr or 10-300 ft/s)
* Turndown: The range specified as a ratio of highest measured value to lowest measured value. (i.e. in above example: 30:1)

Effective Turndown / Sizing

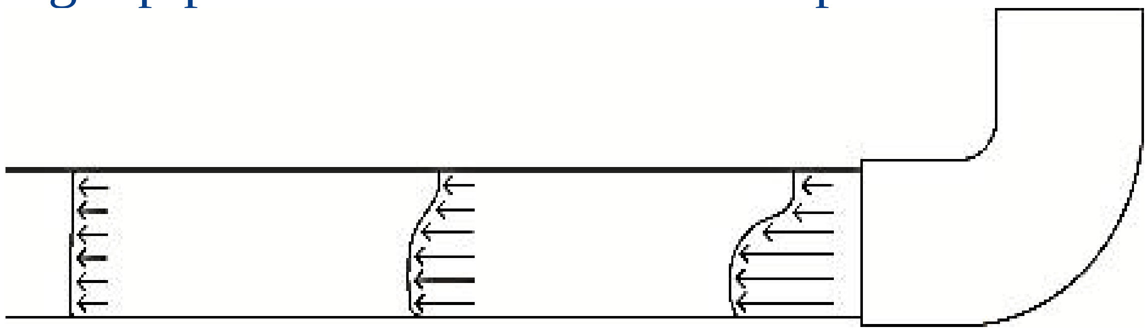
- Effective Turndown: The instrument range as related to the maximum flow for a specific application.

  (e.g. Meter has a 30:1 turndown from 10-300 ft/s;
  Application design max = 80 ft/s;
  Effective turndown = 8:1 for this application)

- Sizing: In many applications it is advantageous to size the meter based on flow to improve the effective turndown.
  - (e.g. reducing the 3” meter above to a 2” meter increases the effective turndown to 18:1)

Installation Requirements

* Straight pipe run conditions the flow profile



* Flow conditioners can minimize straight run requirements.
* Straight run requirements are determined by the nature of the obstruction.

Straight Pipe Run Requirements

Minimum upstream dimensions depend on the type of pipe obstruction.

These are the most disruptive to the flow profile:

- Control (PRV) Valve
- Inflowing Tees
- Multiple Bends Out of Plane
- Multiple Bends In Plane

These are less disruptive, but still affect accuracy:

- Outflowing Tees
- Pipe Reduction or Enlargement
- Single Bend

This is what all good installations have in common:

- Enough straight pipe to properly condition flow

Installation Options

* **Retrofit installations**
  * It is necessary to shut down the system to install a full bore flanged meter.
  * Insertion meters can be hot tapped into existing systems without interruption of service.

Pressure Drop

- **Some systems are sensitive to the introduction of additional pressure drop. In these cases, consider the following:**
  - Does the flow meter technology introduce a significant pressure drop?
  - Will downsizing a meter to improve turndown create too much pressure drop?

Overview of Current Technologies

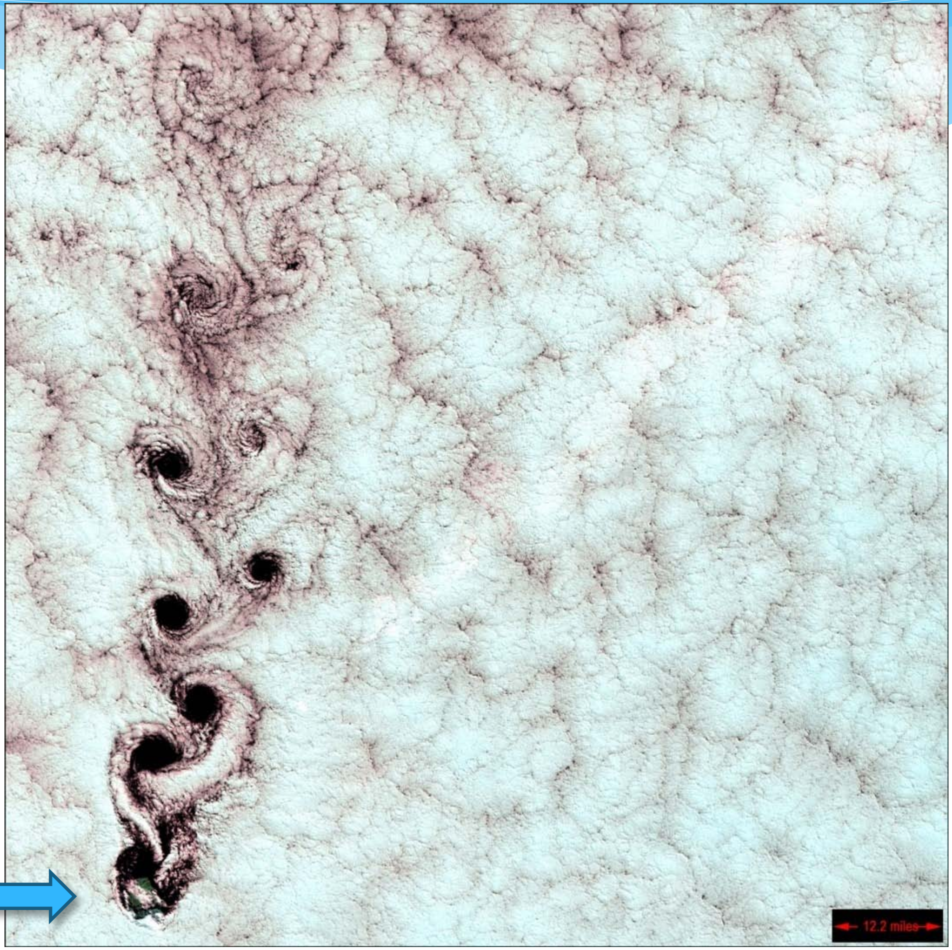
Common flow measurement technologies include:

* Vortex meters
* Differential Pressure (DP) meters
* Turbine meters

Vortex Meters

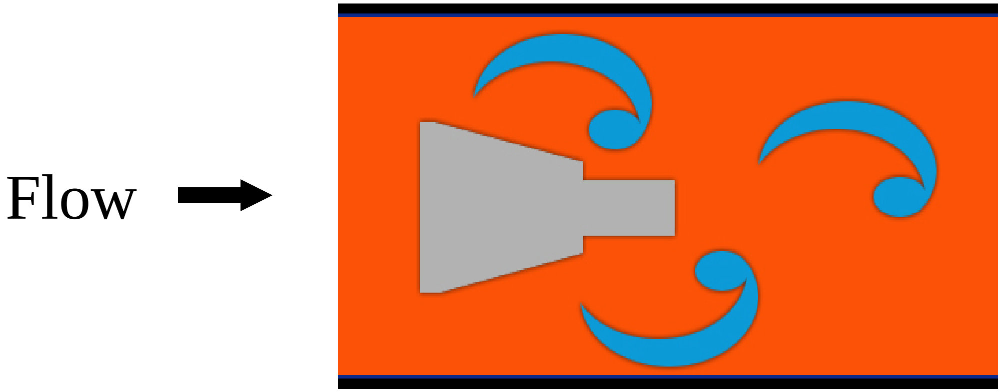
Vortex Shedding is
a Natural Phenomenon

Volcano



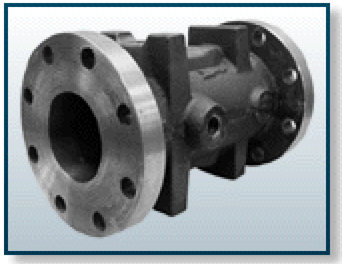
Vortex Shedding Principle

When any liquid, gas or vapor in motion hits a solid body in its path, it flows around it shedding vortices alternately on either side of the body.

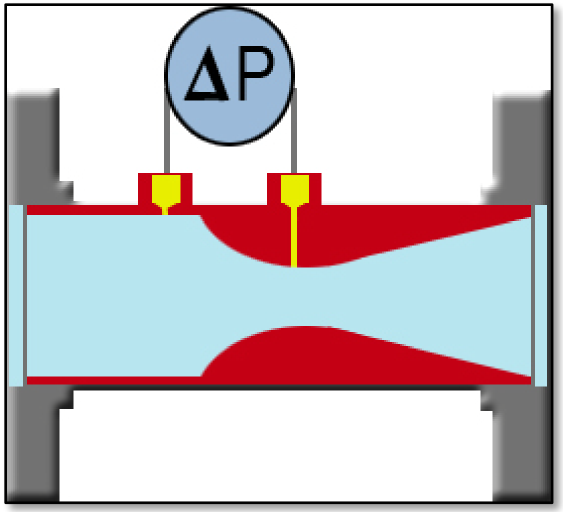


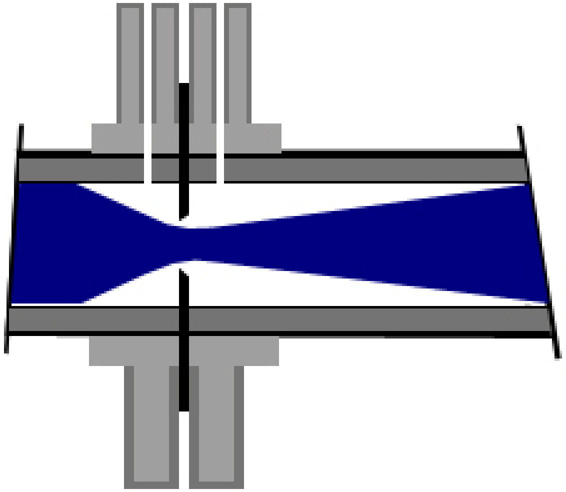
The frequency of the vortices is directly proportional to the velocity of the fluid.

Differential Pressure Meters

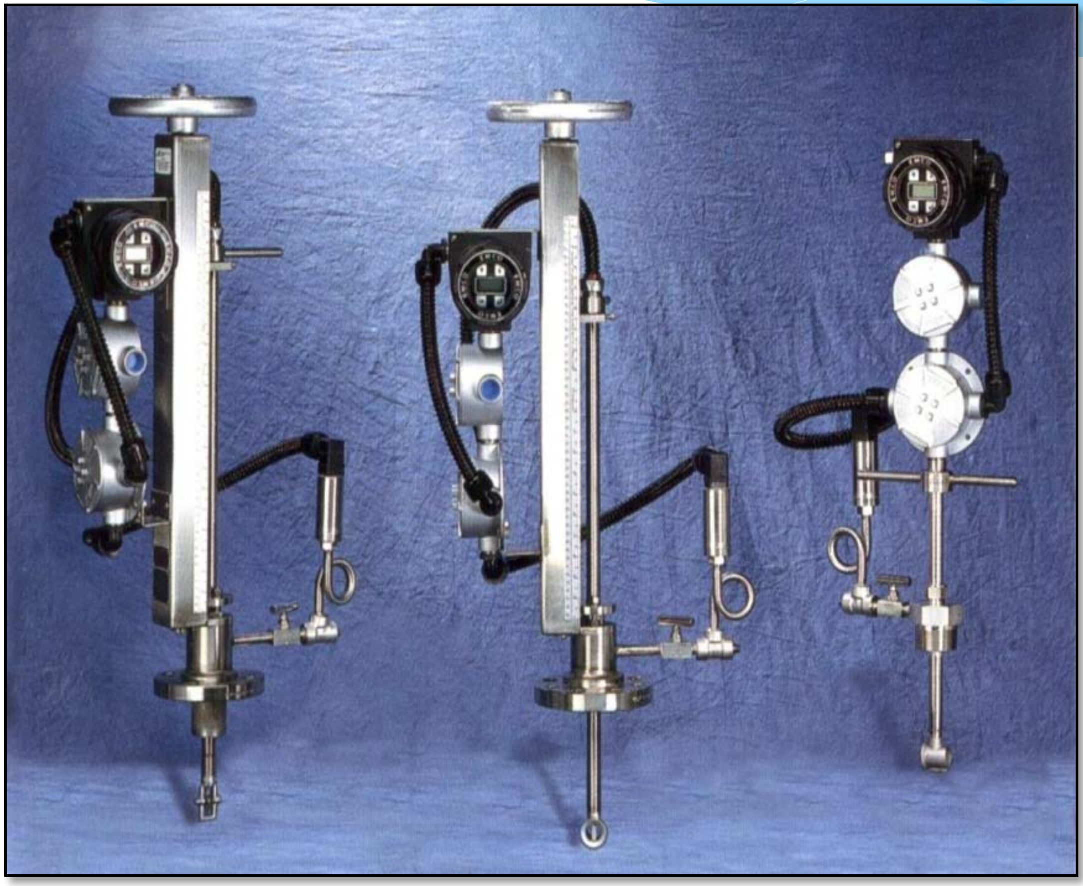


Differential Pressure Principle





Turbine Meters



Conclusions