2008 Big 10 & Friends Utility Conference

Steam Meters – Selection and Installation

Francisco D. Saavedra, P.E.

University of Texas at Austin
May 2008

Steam Meters – Selection & Installation

- Estimate the steam demand
- Select:
  - The location to install the meter
  - The flow sensor – type, turndown and straight-run pipe requirements
  - The secondary elements
  - The flow computer
- Calibrate the steam meter with an independent certified laboratory – i.e. CEESI
- Install, inspect and commission
- Communicate with the flow computer and/or log data

Reasons for Metering Steam

- To accurately evaluate the energy consumption of buildings to establish benchmarks
- To verify the efficiency of both steam production and steam utilization
- To monitor costs and efficiency on a period basis:
  - To give priority in setting targets to those areas of campus where steam consumptions are high
  - To provide guidance for energy management in any decisions entailing changes in steam requirements
  - To contribute to decisions on the future direction of a business in situations where energy is a significant part of operating costs

Buildings Require Steam

- OSU Main Campus
  - 144 buildings served by the central steam plant
  - 36 have steam meters, started with billable customers and large users
  - Future installations planned prioritized on funding resources
- A design standard to select and install steam meters is required

Steam Demand Estimation

- Load per square foot
  - 25 BTUH/GSF to 100 BTUH/GSF
- Control valves of PRV stations
  - Model Cv to determine flow rates
- HVAC software
  - Calculate heating load by modeling the building envelope and conditions
- Archives
  - Life cycle cost analysis, energy costs, consumption history –assuming the building had its own boilers originally

Location of the Steam Meter

- Mechanical Room
  - Upstream or downstream the PRV Station
- Straight-run pipe
  - **9D**, 15D, 30D
- Turndown
  - 10:1, 30:1, **50:1**, 100:1
- Type of Meter
  - Select the best **suitable** one for the application

Different Types of Meters

Differential Pressure Meters	**Orifice Plate**
	Nozzles
	Venturi Tubes
Other Differential Pressure Meters	Pitot Tubes, Annubar, Accelebar
	Bypass Meters
	Pressure Reducing Control Valves
	Spring-loaded Variable Area Meters
	V-Cone
Positive Displacement Meters	Reciprocating Piston
	Helical Rotor Meter
	Oval Gear
	Sliding Vane
Rotary Meters	Turbine Meters
	Propeller Meters
	Pelton Wheel
	Anemometers
Oscillatory Flow Meters	**Vortex Shedding Meters**
	Fluidic Oscillator
Ultrasonic	**Transit-time ultrasonic meters**
	Long Wave Acoustic

2003-08 Installed Steam Meters

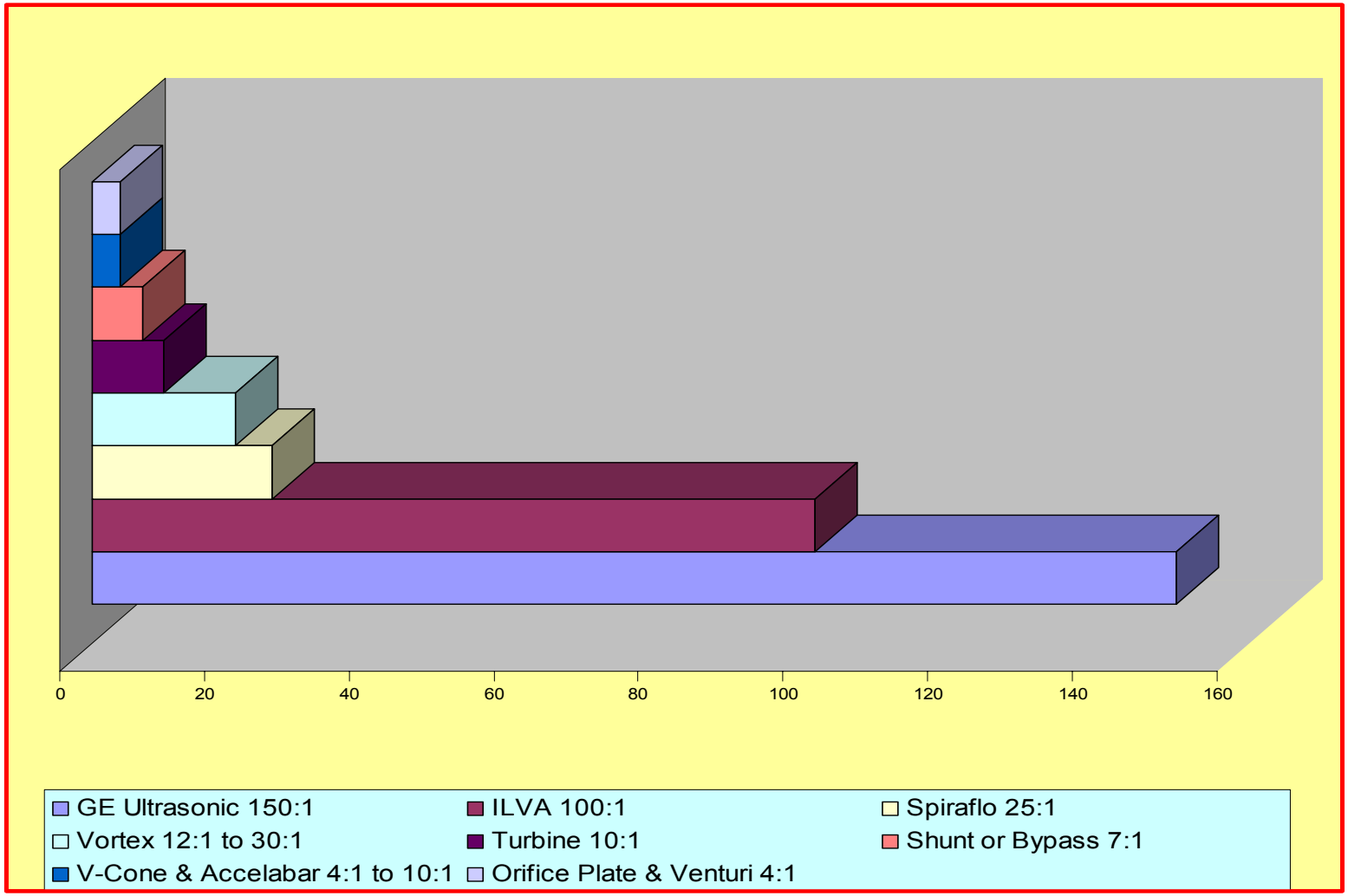
- 11 spring-loaded variable area meters, ILVA [Spirax/Sarco] 2003
- 2 V-Cone [McCrometer] 2005
- 3 GE transit-time ultrasonic meters [GE Sensing] 2007
- 6 Vortex meters in the power plant [Rosemount] 2007

Bases of Selection

The steam meter station has to be custody transfer

- Accuracy of the steam station is expected to be 3%. Includes all uncertainties of the components
- The meter selected must be repeatable
- A turndown ratio of 50:1 is preferred
- The straight-run pipe depends on the selection of the location. Most of the time short straight-run pipes found.

Turndown


0
20
40
60
80
100
120
140
160
GE Ultrasonic 150:1
ILVA 100:1
Spiraflo 25:1
Vortex 12:1 to 30:1
Turbine 10:1
Shunt or Bypass 7:1
V-Cone & Accelabar 4:1 to 10:1
Orifice Plate & Venturi 4:1

Flowmeter Selection

- Maximum Flow Rate in lb/hr
- Pressure in psig
- Temperature in deg F

Flowmeter Selection

Performance:

- Accuracy
- Repeatability
- Turndown
- Straight-run length
- Pressure Drop

Maintenance:

- Reliability
- Calibration
- Spare Parts
- Ease of Maintenance

Flowmeter Selection

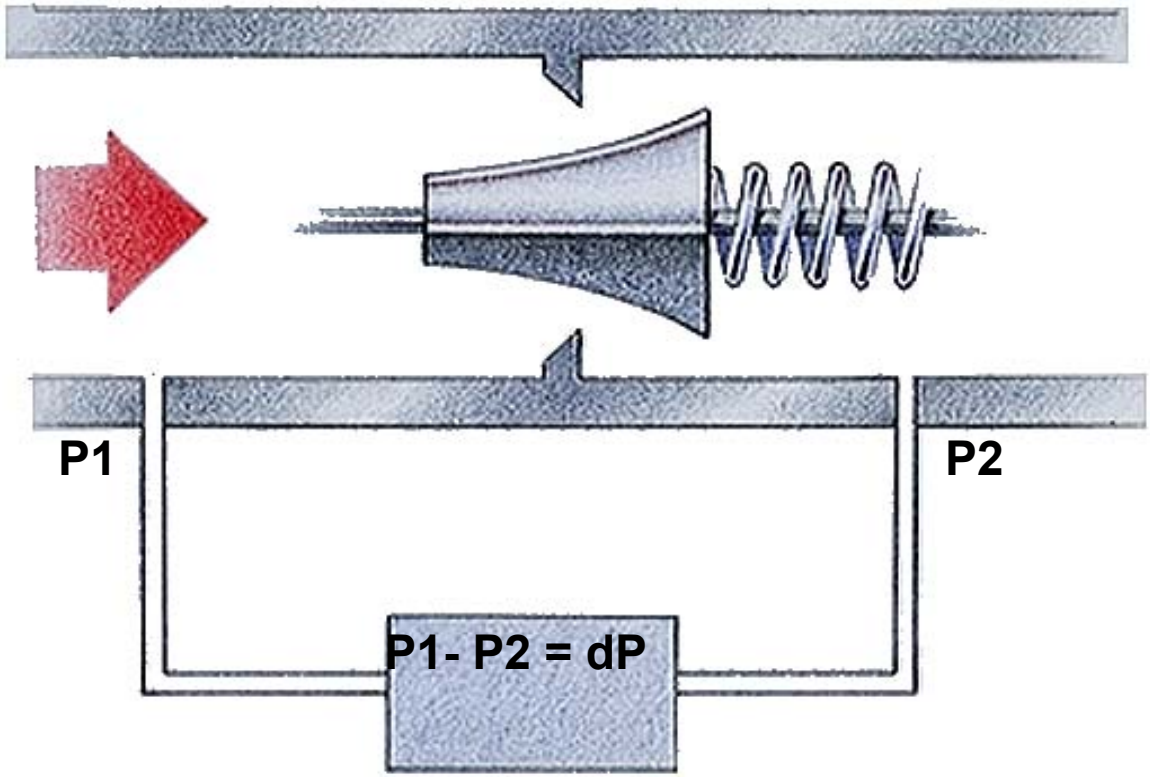
Cost:

- Steam meter station
- Installation –Mech. and Elec.
- Initial calibration

As well as:

- Pressure and temperature compensation
- Ability to Interface with other Equipment
- Data logger
- Literature Availability

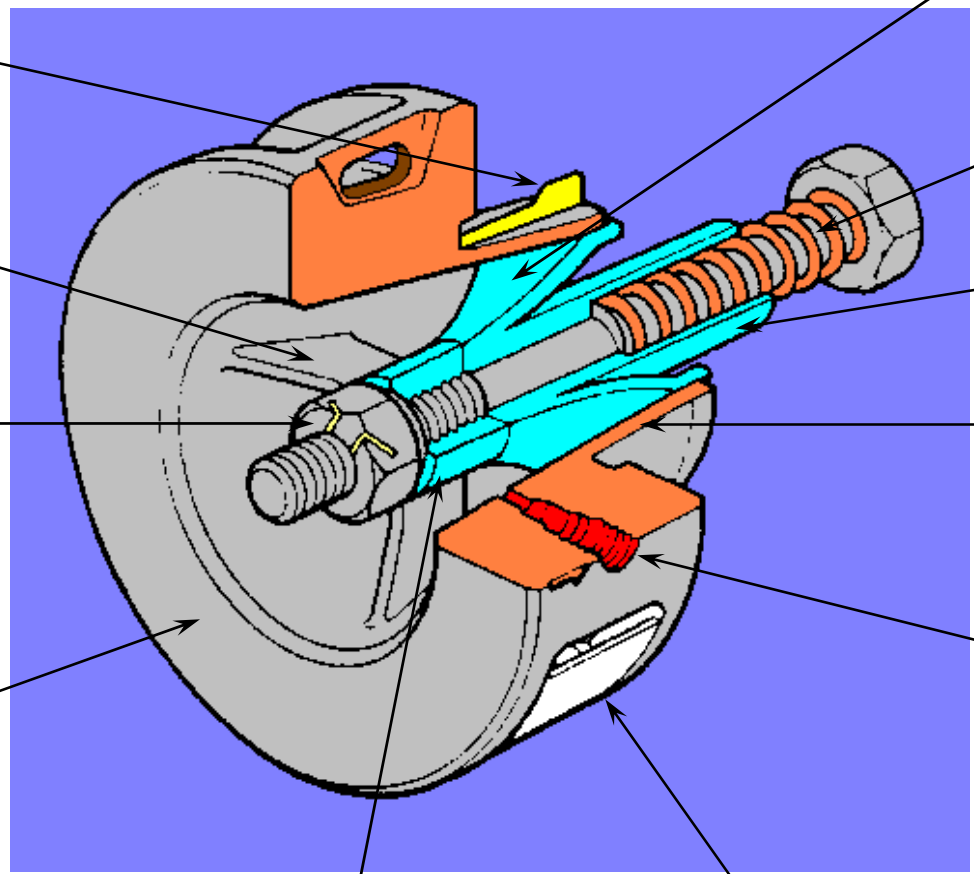
Spring-loaded Variable Area Meter



Area of annular orifice is varied by movement of profiled cone against spring

Differential pressure is measured by the dP transmitter

Spring-loaded Variable Area Meter



Alignment webs for easy installation

Integral steady

Adjuster used to set cone during calibration

Wafer design fits between flanges

Cone for high turndown

Nickel cobalt alloy spring

Over range stop

Conical entry orifice

Pressure tappings built into meter body

Stop prevents damage from reverse flow

Calibration details engraved on nameplate

Spring-loaded Variable Area Meter

- Accuracy of +/- 1% of volume flow rate
- Large flow turn-down 100:1 type
- Straight-run length 9D, 15D
- Linear flow output
- Some maintenance costs

Spring-loaded Variable Area Meter

- All Stainless Steel Grade 316
- Wafer Style
- Suitable for installation between 150, 300 & 600 Class ANSI flanges
- Produces 200 inches w.c. differential pressure at maximum flow
- Available in sizes: 2”, 3”, 4”, 6”, 8”

Transit-time Ultrasonic Meter

Transit-time Ultrasonic Flowmeter

- Accuracy of +/- 1% of volume flow rate
- Large flow turn-down 150:1 type
- Straight-run length 15D, 30D
- Linear flow output
- Low maintenance costs
- Bidirectional operation

A two-path PanaFlow meter system

Transit-time Ultrasonic Meter

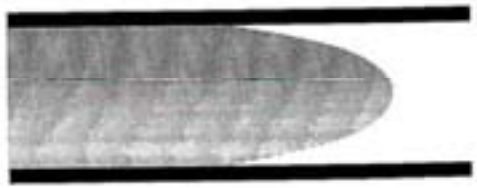
Flow Profile Regions

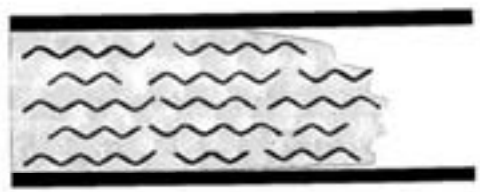
- Laminar
  - » Stratified, parabolic profile

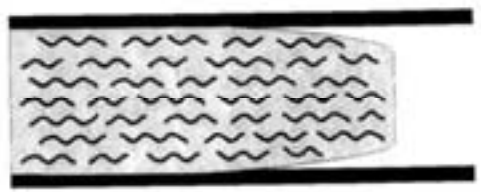
    Re = 0 to 2000
- Transitional
  - » Undefined profile

    Re = 2000 to 4000
- Turbulent
  - » Flattened profile

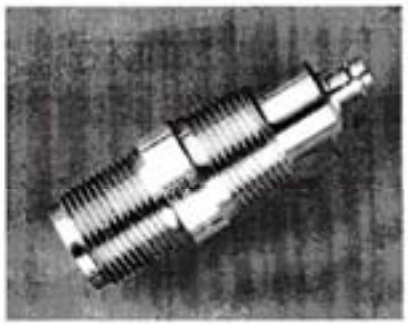
    Re = >4000

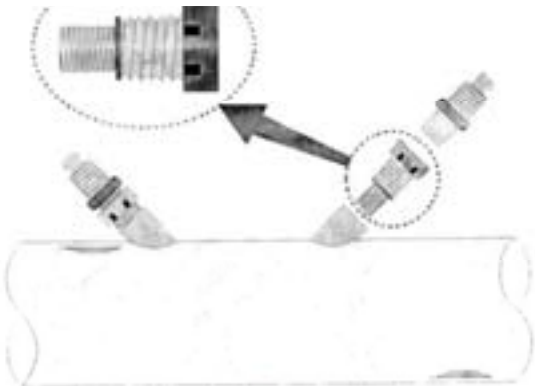




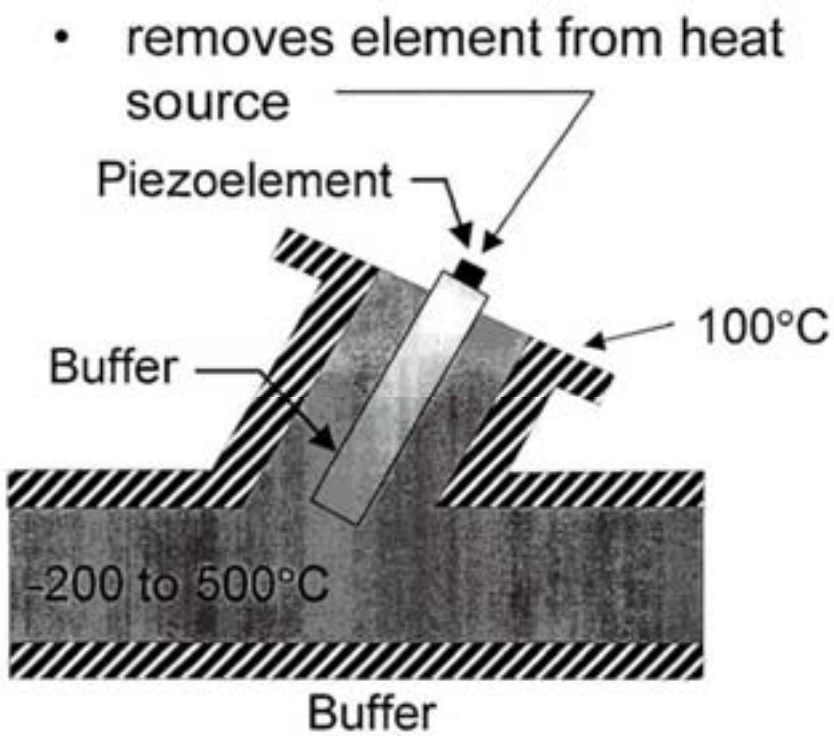


Transit-time Flow Meter



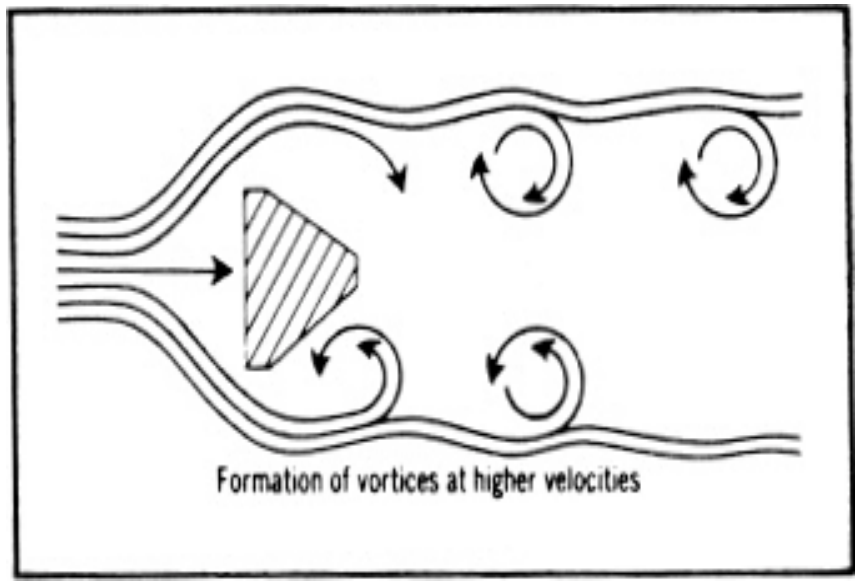


- removes element from heat source



Vortex Meter – Shedder Bar

- Accuracy of +/- 1% of volume flow rate
- 30:1 flow turn-down
- Linear flow output - Pulse and analog
- Straight-run length 15D
- Flow rate cutoff
- 12-inch max line size



V-Cone Meter

- Accuracy of +/- 1%
- 3D inlet/outlet pipe runs required
- Low flow turndown, 10:1
- Low first cost
- Square law flow output

Standard design concepts

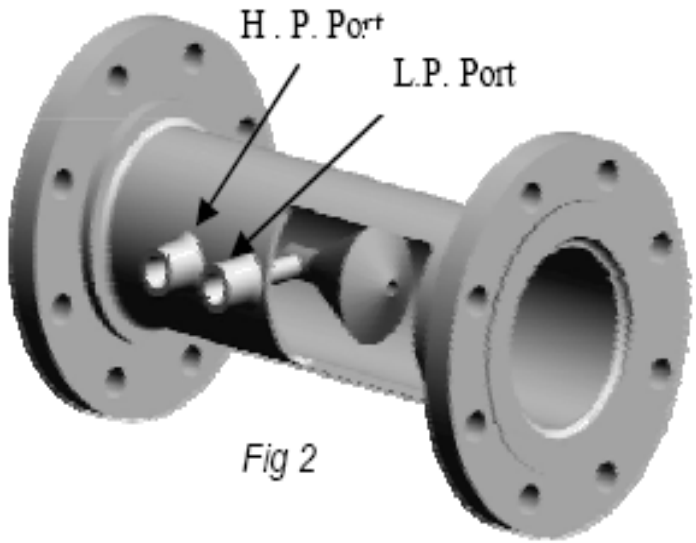


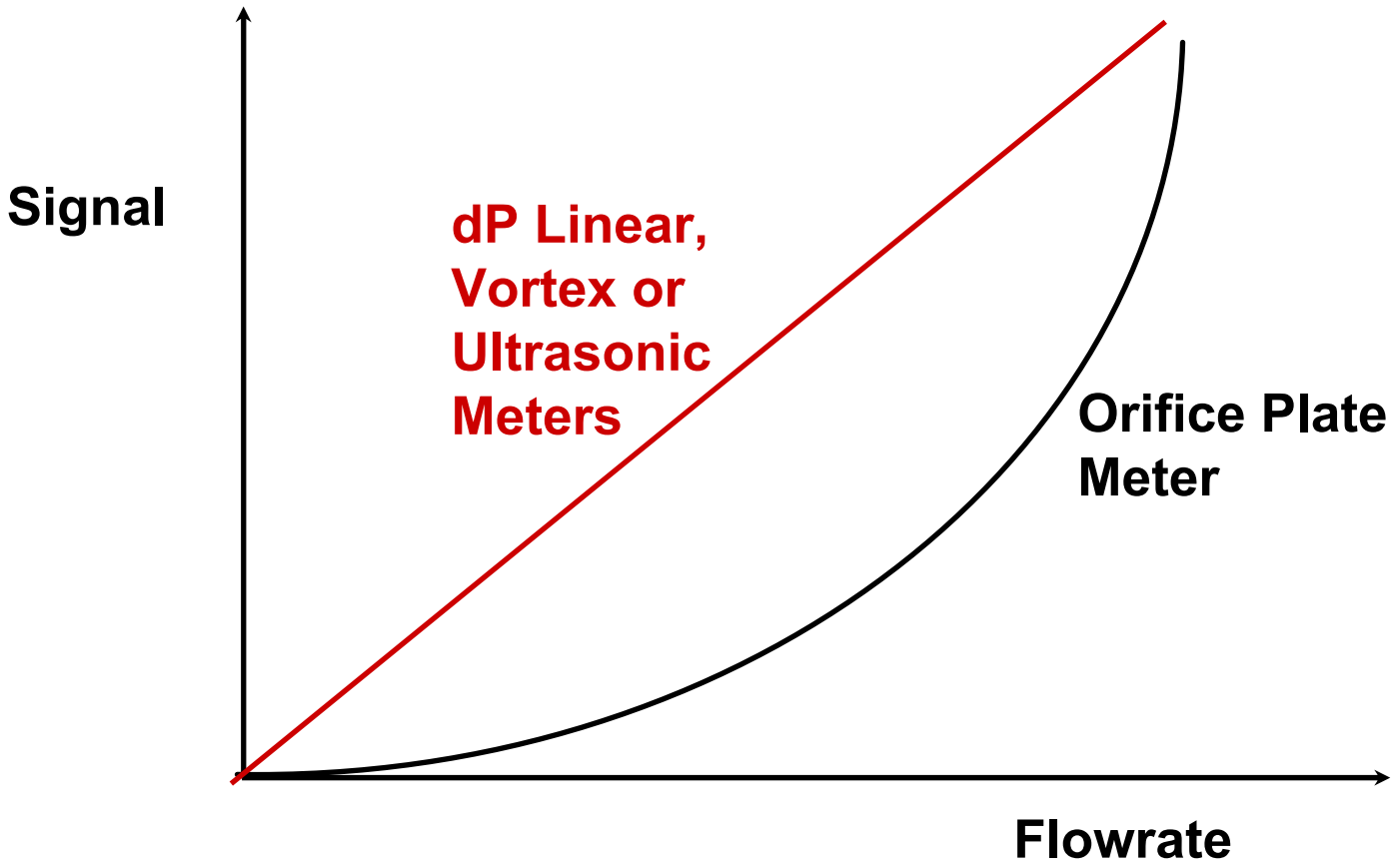
Fig 2

V-Cone with Welded Construction :

Pressure Reducer Valve Meters

- Accuracy of +/- 2%
- No inlet/outlet pipe runs required
- Flow turndown equal to the control valve turndown
- High investment and maintenance costs
- Flow computer and secondary elements incorporated with the valve package

Output of a Linear-Response Meter



Secondary Elements

- Pressure Transmitter - 0 to 300 psig
- Spring-loaded RTD with temperature transmitter – 20 to 800 deg F with a ¾-inch thermo-well
- Differential pressure transmitter - 0 to 200 inches w.c.

Specifications of the Secondary Elements

- NIST certified
- Class 1, Div 2 or better
- 4 – 20 mA signal processing
- +/- 0.1% accuracy or better
- Drift less than +/- 0.1% of URL over 8,000 hrs
- Digital energized with a 24 VDC source
- HART protocol communication
  - Ease of setup and calibration
  - Loop verification from anywhere in the loop

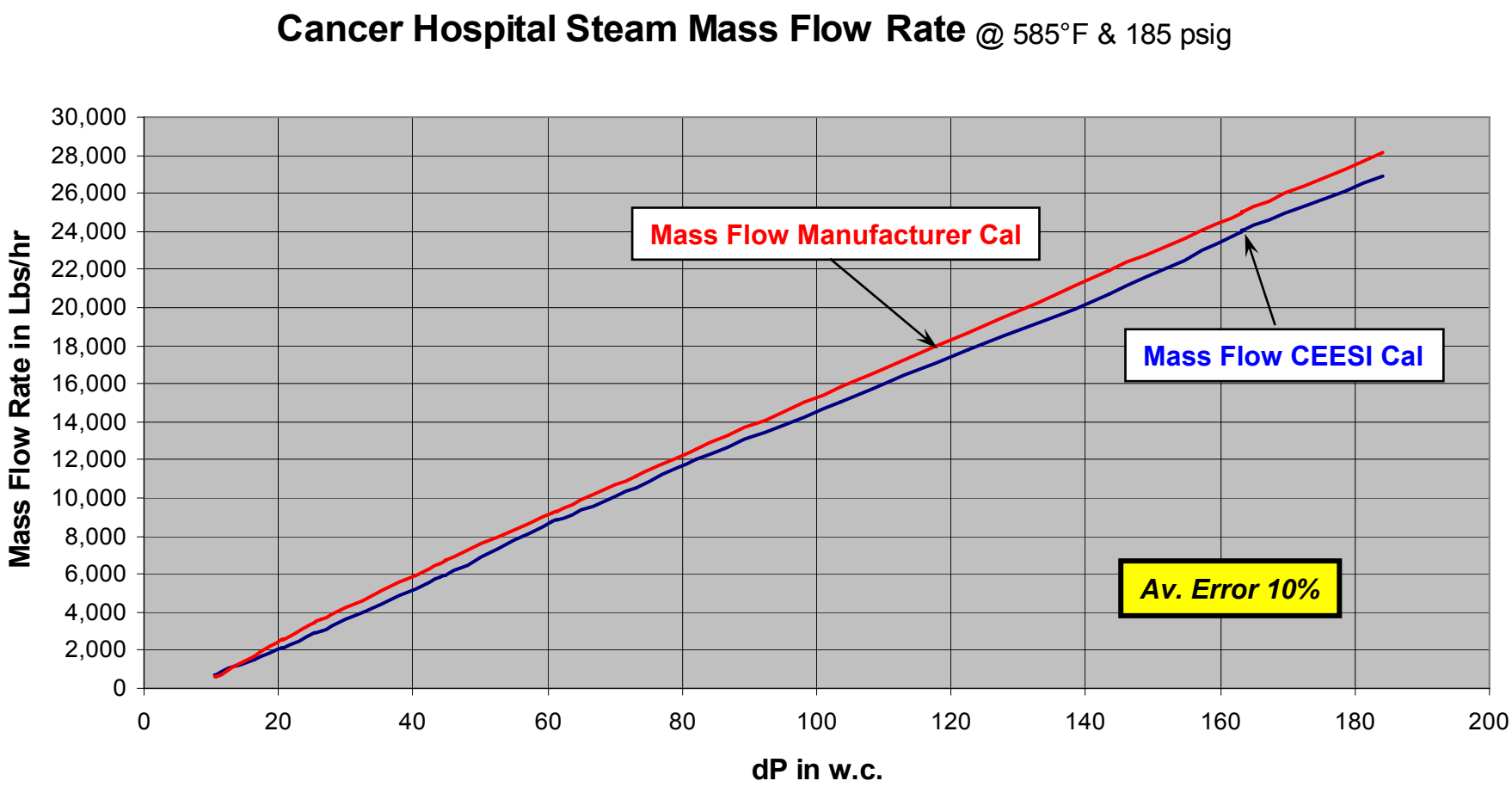
Flow Computer - KEP

- Total mass and instantaneous mass flow rate computations for Steam
- Support for all flow meter types and output signals – V-cone, ILVA, Vortex, among others
- User selectable units of measure
- ASME 1997 Steam Tables
- Internal data-logging for later retrieval
- Conventional outputs
    - Scaled pulse, analog output, relay alarms
- Communication options
    - Modbus RTU RS485, RS 232, Modem, Modbus TCP/IP Ethernet
- Built-in test and documentation aids

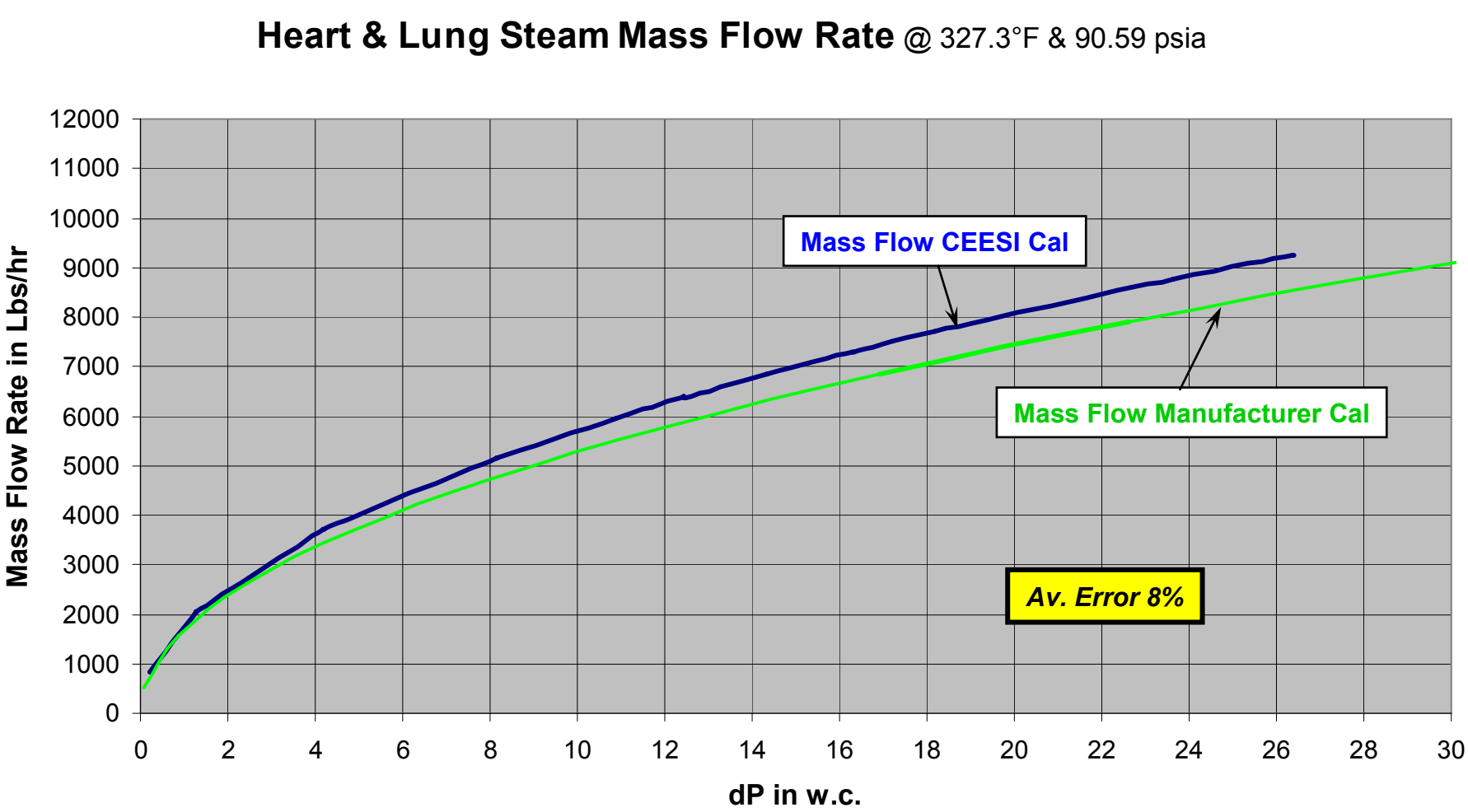
Calibration

- Third-party calibration – Certified Laboratory CEESI
- Compressed air is used for the calibration with a density the same as the density of the steam
- Certification of the calibration must be submitted
- For differential pressure meters
  - »Air mass flow rate x SQT (steam density/air density)
- For linear-output meter
  - »Air mass flow rate x (steam density/air density)

ILVA Meter Calibration

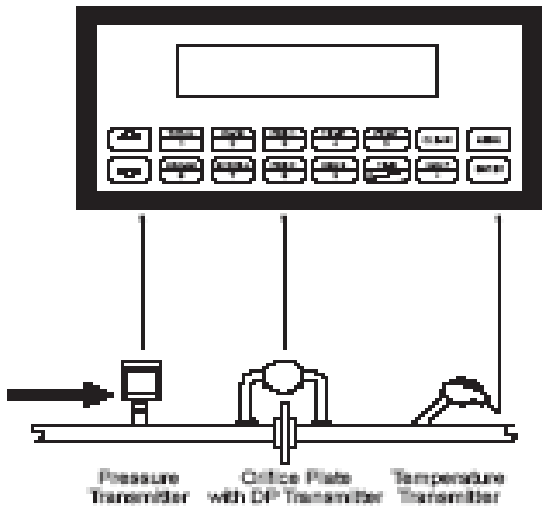


V-Cone Meter Calibration



Steam Meter Station

Steam Mass & Steam Heat Illustration



Calculations

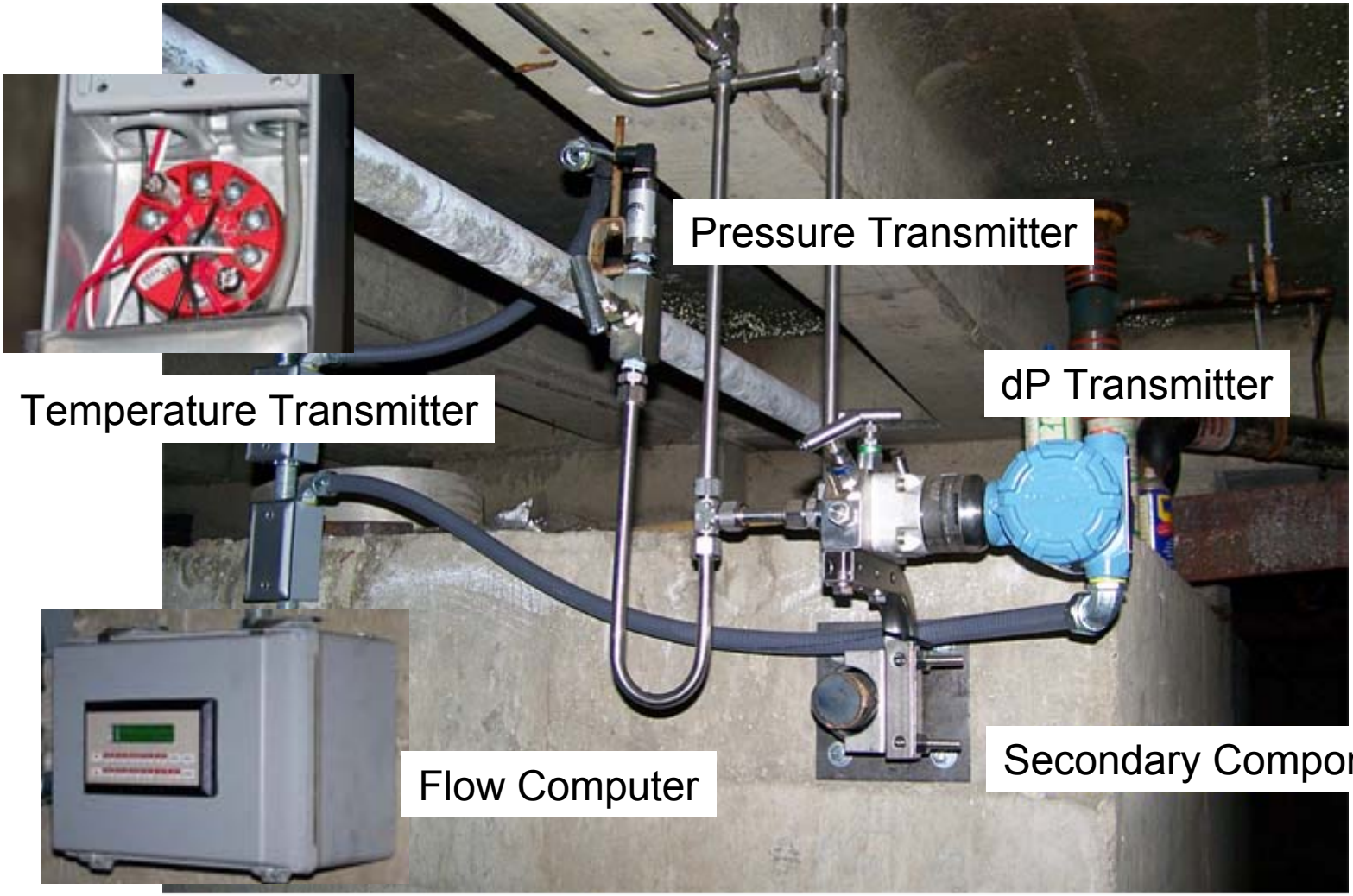
Mass Flow

Mass Flow = volume flow • density (T, p)

Heat Flow

Heat Flow = Volume flow • density (T, p) • Sp. Enthalpy of steam (T, p)

Steam Meter Secondary Components



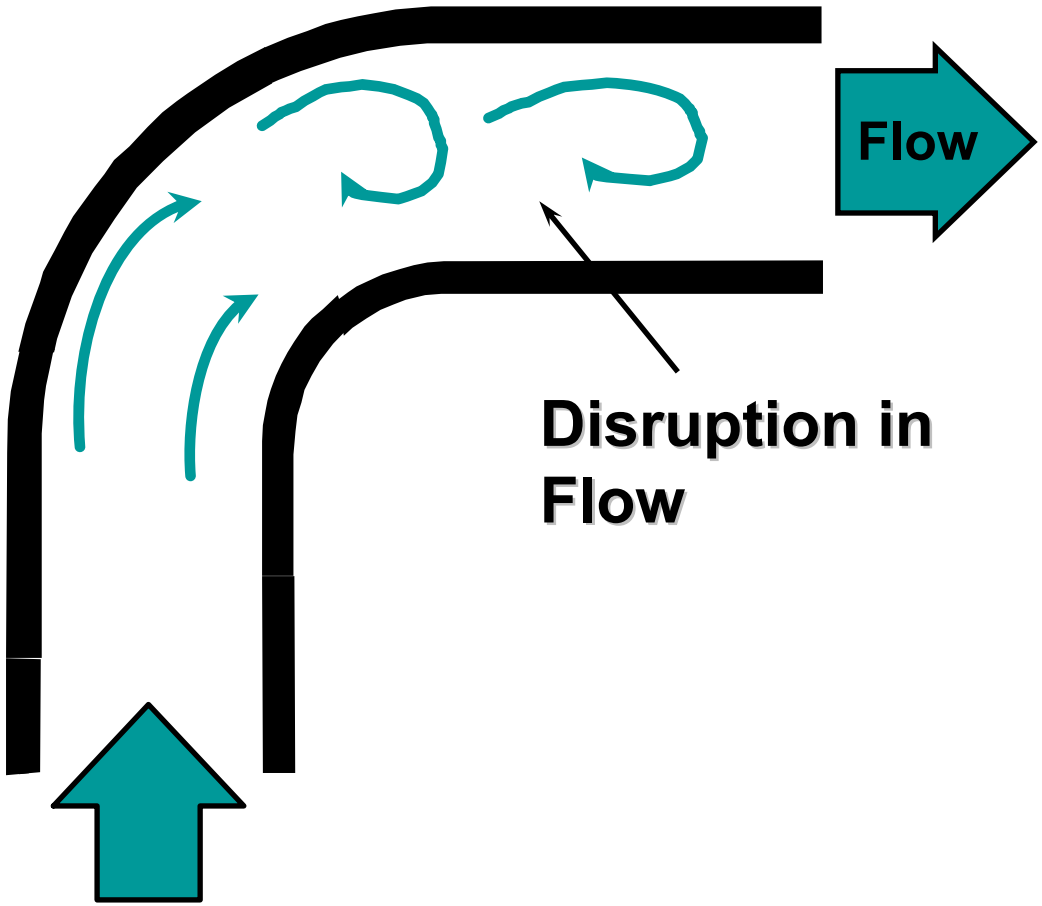
Steam Meter Installation

Steam Meter Installation

- Flange connections
- Signal and electrical wires
- Impulse lines
- Transmission cables
- Isolation valves
- Flow computer cabinet
- Conduits
- Power source

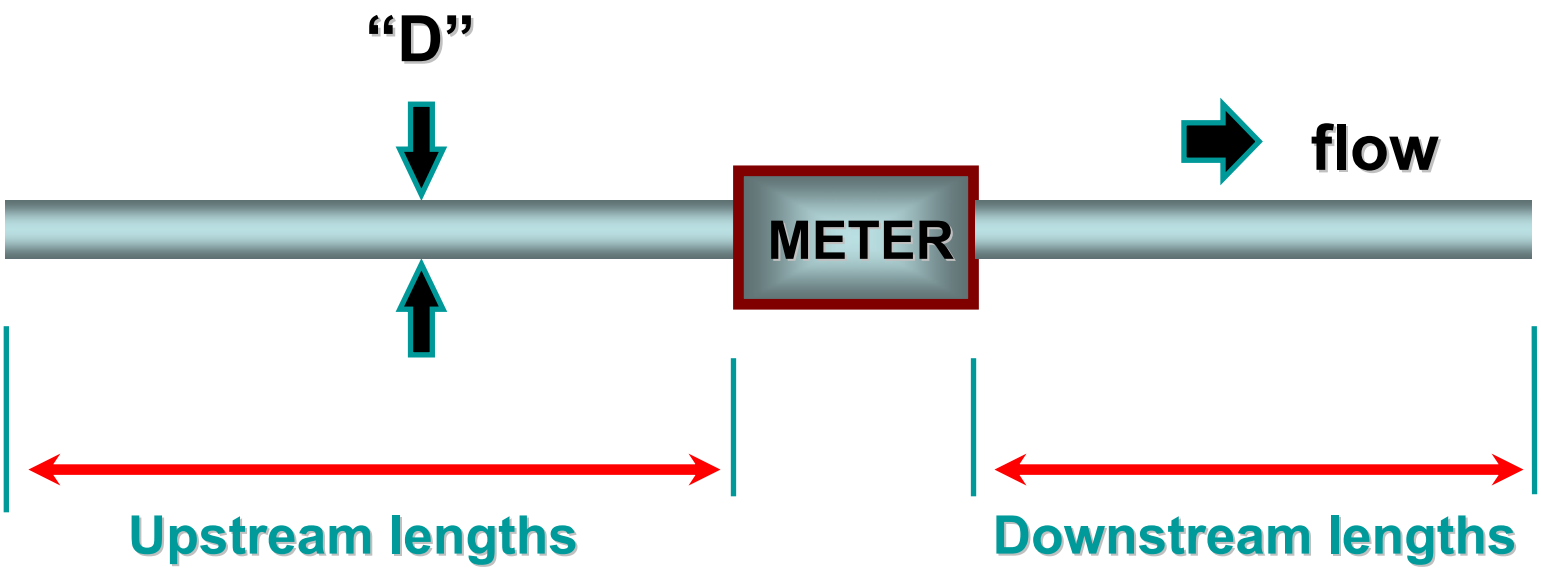
Pipe Bends

Swirl Due to Pipe Bends



Straight-run Pipe Diameters

All flowmeters must be correctly installed. In particular, adequate lengths of clear straight pipe must be provided upstream and downstream of the meter. This requirement can often dictate which type of meter can be fitted.



Flange Connections

- 300# Class A-105 Flanges for medium steam pressure MPS – 75 psig
- 600# Class A105 Flanges for high steam pressure HPS – 200 psig

Impulse Lines

- Stainless Steel Tubing 316 Grade
- Compressed fittings
- ½-inch diameter tubing
- Over the flow sensor and pitched back to its taps

Electrical and Control Requirements

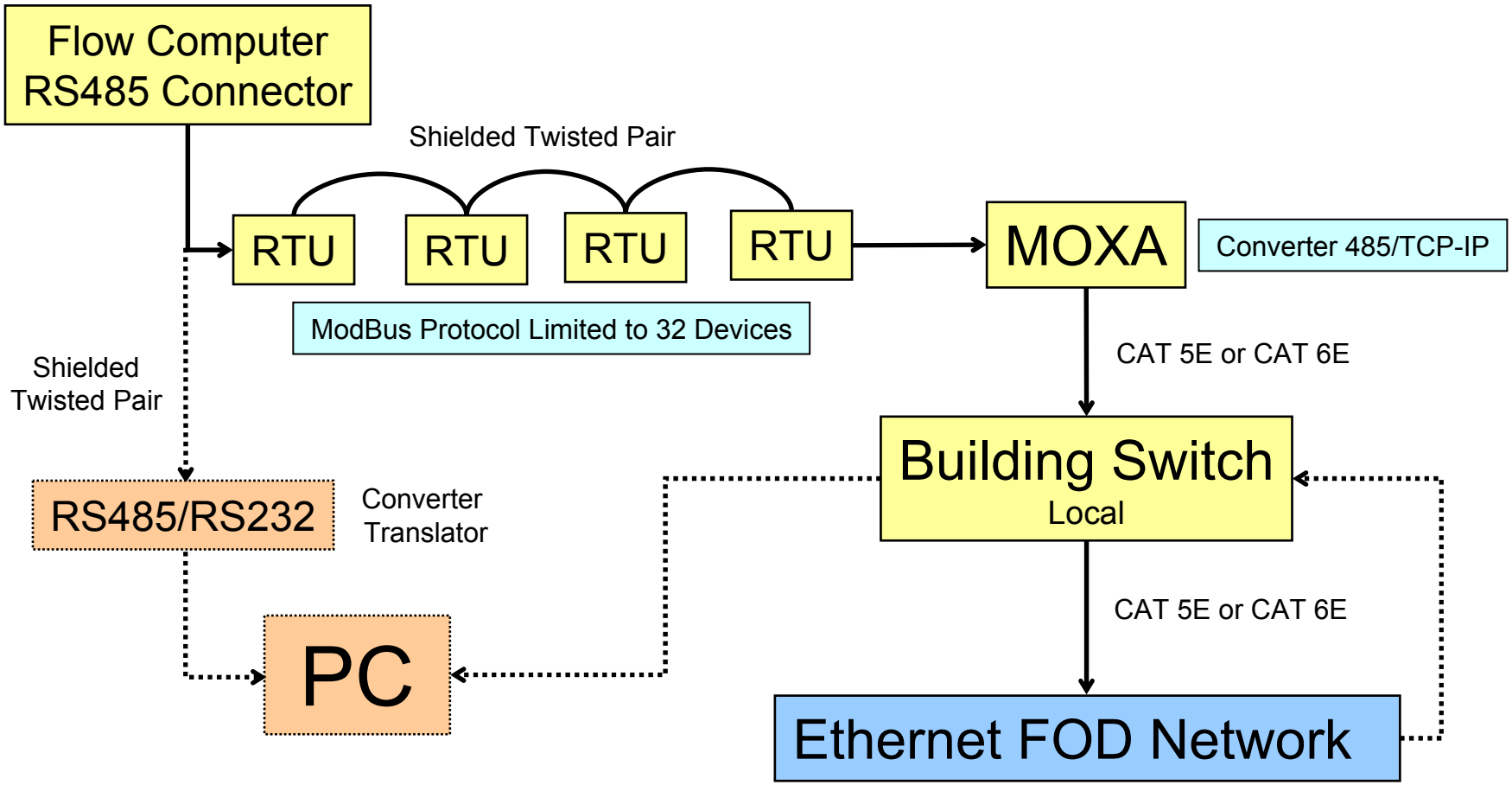
- Cabinet NEMA 4
- Rigid conduit
- Seal-tight connections
- Shielded twisted pair AWG 18 or larger
- 120 V power source connected to a UPS upon availability
- Electric conductor #12 or bigger

GS868 Flow Computer
Transit-time ultrasonic meter

Installation Cost (2008) – ILVA & GE

- **Flow sensor and electronic devices**
  - **» $13,000 to 20,000**
- **Calibration at CEESI**
  - **» $3,200 to 4,200**
- **Mechanical Installation**
  - **» $8,000 to 14,000**
- **Electrical Installation and Control Connections**
  - **» $2,700 to 10,000**
- **Overall: $27,000 to 50,000**

Communication



Summary

- The estimation of the steam demand eases the size of the flow sensor
- The location of the flow sensor is important to determine its type and straight-run pipe
- The calibration with a third-party laboratory warranties an overall accuracy of 3% or less of the steam meter station
- There is no steam meter that adjusts to all applications. An engineering judgment is required for each steam meter installation.

Acknowledgments

- FOD – Ross Parkman, Henry Dammeyer, Ron Forrest, Tracy Willcoxon, Patrick Smith, Terry Little
- V-F Controls – Jim Weinstein
- Rosemount, Spirax/Sarco, GE Sensing, Alpha Controls, Kessler-Ellis Products

Thank You

Questions?