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Panametrics Flow Solutions

Measurement & Sensing

Lesman
INSTRUMENTS • VALVES • CONTROLS

Gerard Bottino

February 25th 2020

Ultrasonic Transit Time Fundamentals

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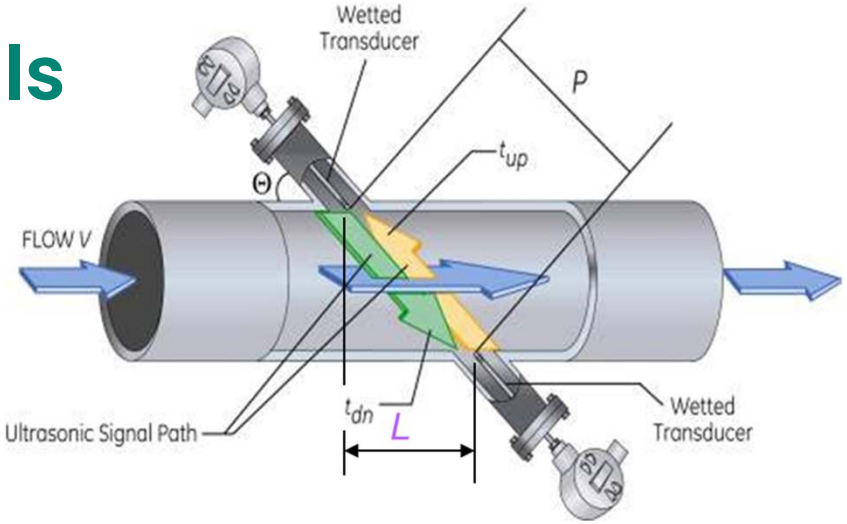
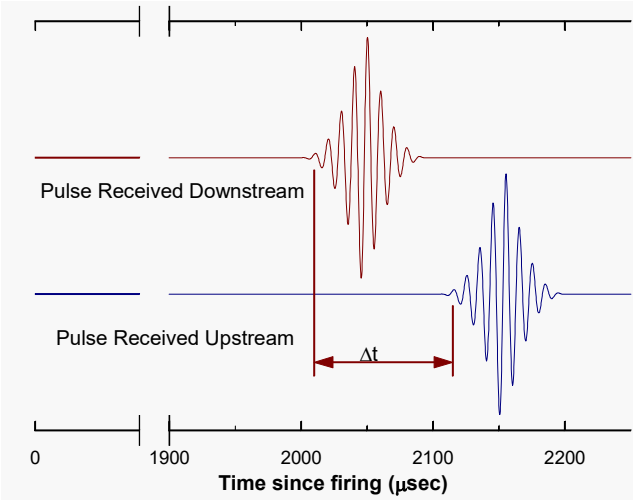
Fundamentals





$$T_{UP\to DOWN} = \frac{P}{C + V * \sin\theta}$$

$$T_{DOWN\to UP} = \frac{P}{C - V * \sin\theta}$$

$$V = \frac{P}{2\sin\theta} * \frac{T_{DOWN\to UP} - T_{UP\to DOWN}}{T_{DOWN\to UP} * T_{UP\to DOWN}}$$

No pressure drop = No wasted energy
No pipe restriction = Not prone to contamination
No drifting = No need for recalibration
No filters or strainers = No maintenance cost
Bi-directional = No complex piping
No moving parts = Nothing to wear and tear
Not influenced by P, T = No complexity

$$Q = V * A$$

Panametrics Ultrasonic flowmeter 1st patent: 1971

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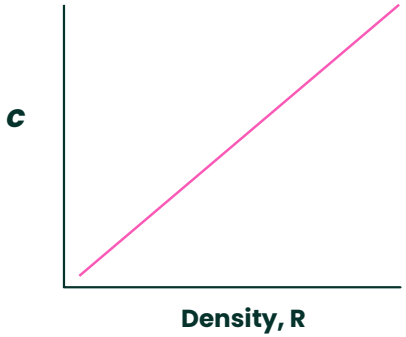
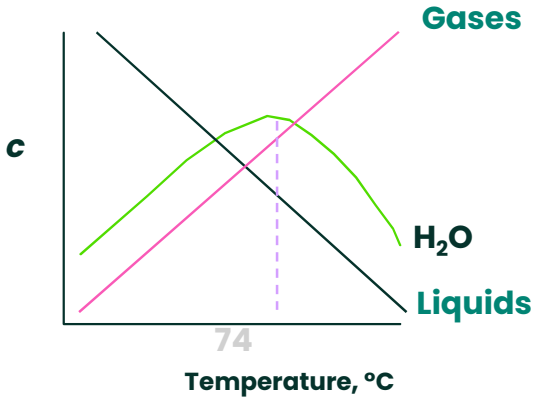
Challenges of making good ultrasonic measurements

Speed of Sound (Velocity of Sound), C: The time it takes for the ultrasonic signal to travel in the medium. It is **NOT** the fluid velocity

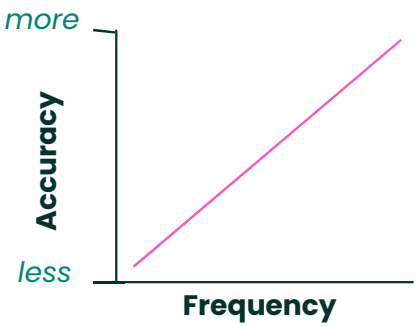


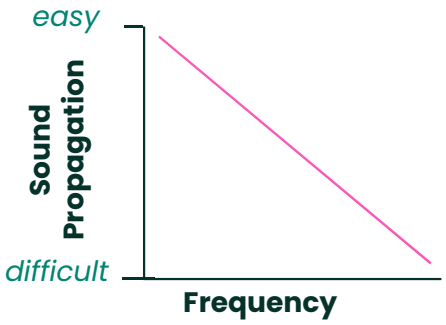
$$t_{avg} = \frac{t_{dn} + t_{up}}{2}$$

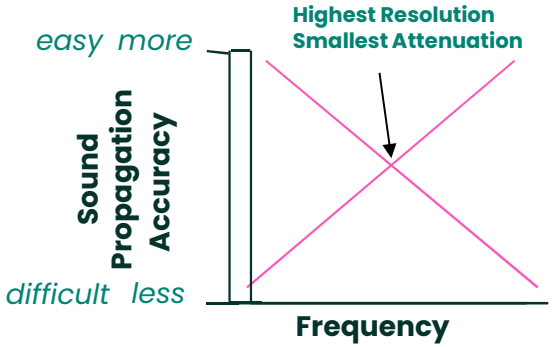
$$c = \frac{P}{t_{avg}}$$



Transducer Resolution: The higher the frequency is the better is the resolution. But there are some trade offs to consider.







Balance: Frequency/Accuracy vs. Attenuation/Propagation

Transducer frequency:

Liquid: 4MHz down to 500kHz Gas: 1MHz down to 100kHz (50kHz as a special)

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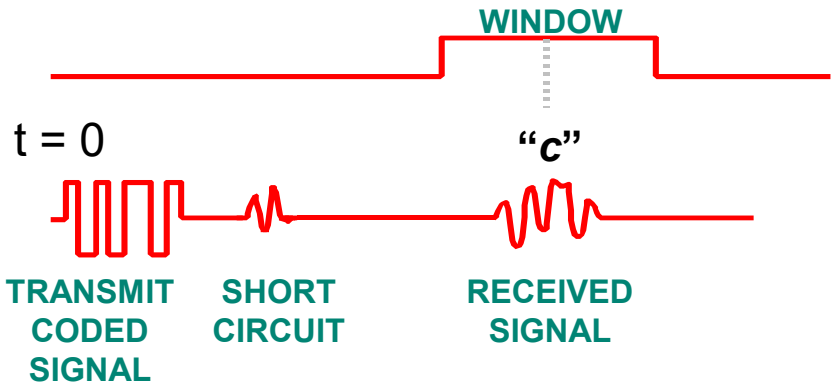
Challenges of making good ultrasonic measurements

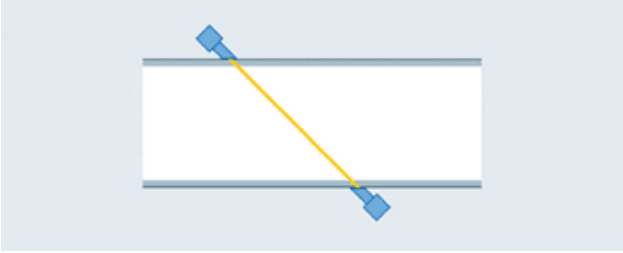
Automatic Tracking Window in changing conditions: Capture the signal when VoS changes

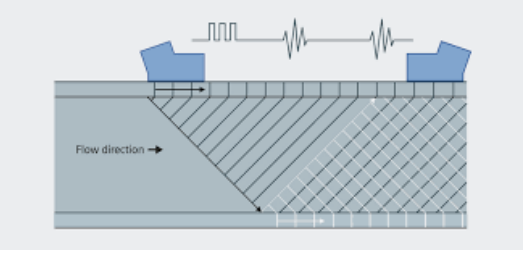


Shear Wave vs. Lamb Wave (Wide beam) transducers: Both are used in clamp on gas applications.

- Shear wave = Focused signal
- Broadly utilized and pretty universal on liquid and gas
- Need more P in gas application than Lamb wave
- Use CTF878 for LP gas (Correlation Tag technique)

- Lamb Wave = Wide signal, pipe wall used as a wave guide
- Used in gas application especially at low P. Need wise freq. selection f(pipe material and thickness). Not for heavy walls





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Challenges of making good ultrasonic measurements

Signal treatment: Coded and cross-correlated signals

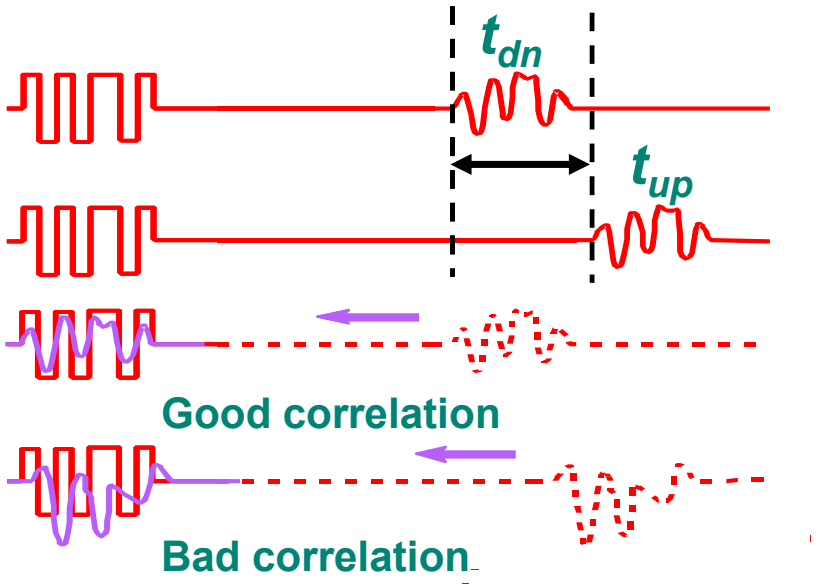
Correlation = signal quality

Coded signals:

- Fingerprint
- Find signal in noisy applications

Cross-correlation:

- Reduces noise
- Improves Δt measurement



Extensive Diagnostics available: Measurement reliability with dozens of diagnostics

Velocity of sound, Signal strength, Signal quality, Amplitude, Gain, etc.

High voltage transducers and various array of transducer designs: Capable of handling difficult applications like flare, steam, heavy residue, etc.

Buffers to tackle extreme temperatures: Cope with temperature down to -325°F up to 1,100°F

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Panametrics solutions width and breadth

Liquid


Sentinel LNG

Sentinel LCT4/8


Sentinel


PanaFlow HT


PanaFlow LZ


PanaFlow Z3

PanaFlow



Panaflow LC


DF868


PT900


AT600

Clamp-on

Performance & Features

Pipe sizes from ½" up to 300" (liquid)

Temperature: cope with temperature down to -325°F up to 1,100°F

From 1 up to 8 path

Gas


XGM868i


GM868


PanaFlow ZxG

PanaFlow


XGS868i


GS868

Steam


XGF868i


GF868

Flare


GC868


CTF878


PT878GC

Clamp-on

Performance & Features

Various Transducer types to tackle all applications

Pressure from atm up to 6,000+ psi

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Benefits of ultrasonic flow measurement

Large turndown ratio	One meter covers the entire range, even on large line sizes, from low P to high P
No drifting, no periodic calibration required	No loss of process control, optimization of assets and efficiency, no downtime or expense from calibration
No pressure drop	No wasted energy from running a pump/compressor or no need to purchase a larger size pump or compressor
No restriction in the pipe	Contamination will not affect meter's measurement (drifting) or cause any damage to meter
No filters or strainers	No maintenance cost
Bi-directional measurement	No additional meters required
No moving parts	No loss of process control, optimization of assets and efficiency, no downtime or expense from calibration
Advanced diagnostics	Better data for decision-making
Low cost of ownership	No additional costs for maintenance and operation, field replaceable transducers

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Best practice for successful performance

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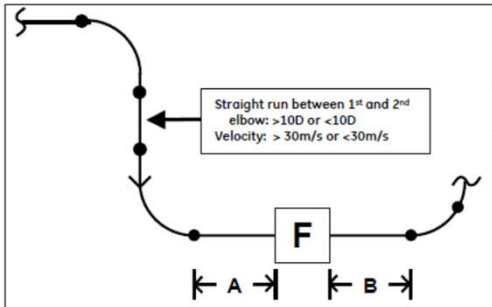
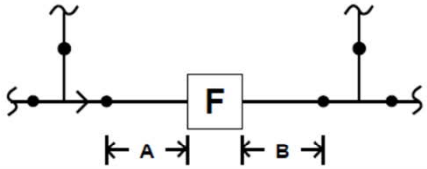
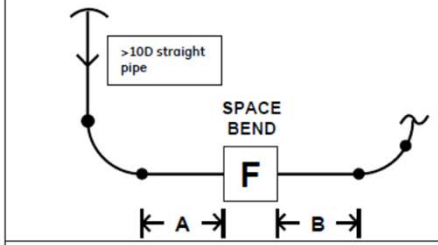
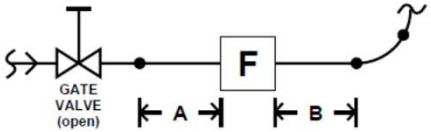
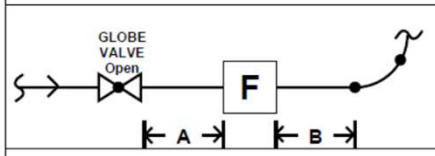
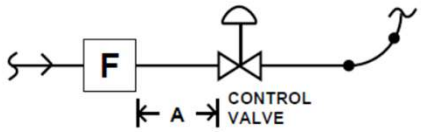
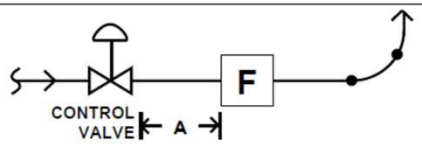
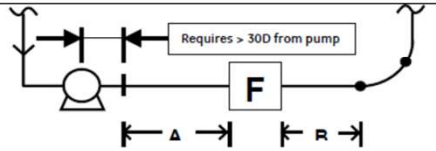
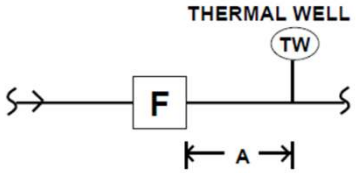
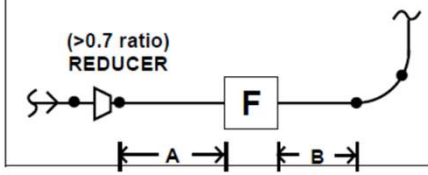
Velocity meter needs a fully developed flow profile

	Straight Run requirements of pipe			
	Liquid Service		Gas Service	
	A	B	A	B
	10D	5D	20D > 10D 40D < 10D, < 30m/s 40D < 10D, > 30m/s	10D 10D 20D
	A 10D	B 5D	A 20D	B 10D
	A 10D	B 5D	A 20D	B 10D
	A 10D	B 5D	A 20D	B 10D

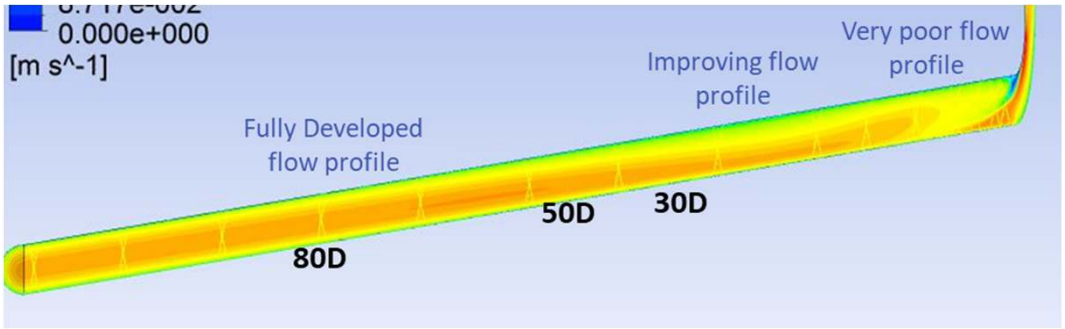
	Straight Run requirements of pipe			
	Liquid Service		Gas Service	
	A	B	A	B
	20D	5D	20D	10D
	A 7D		A 15D	
	A 25D		A 50D	
	A 15D	B 5D	A 50D	B 10D
	(Downstream of Pump/compressor/fan)			
	A 2-5D		A 2-5D	
	A 5D	B 5D	A 10D	B 10D

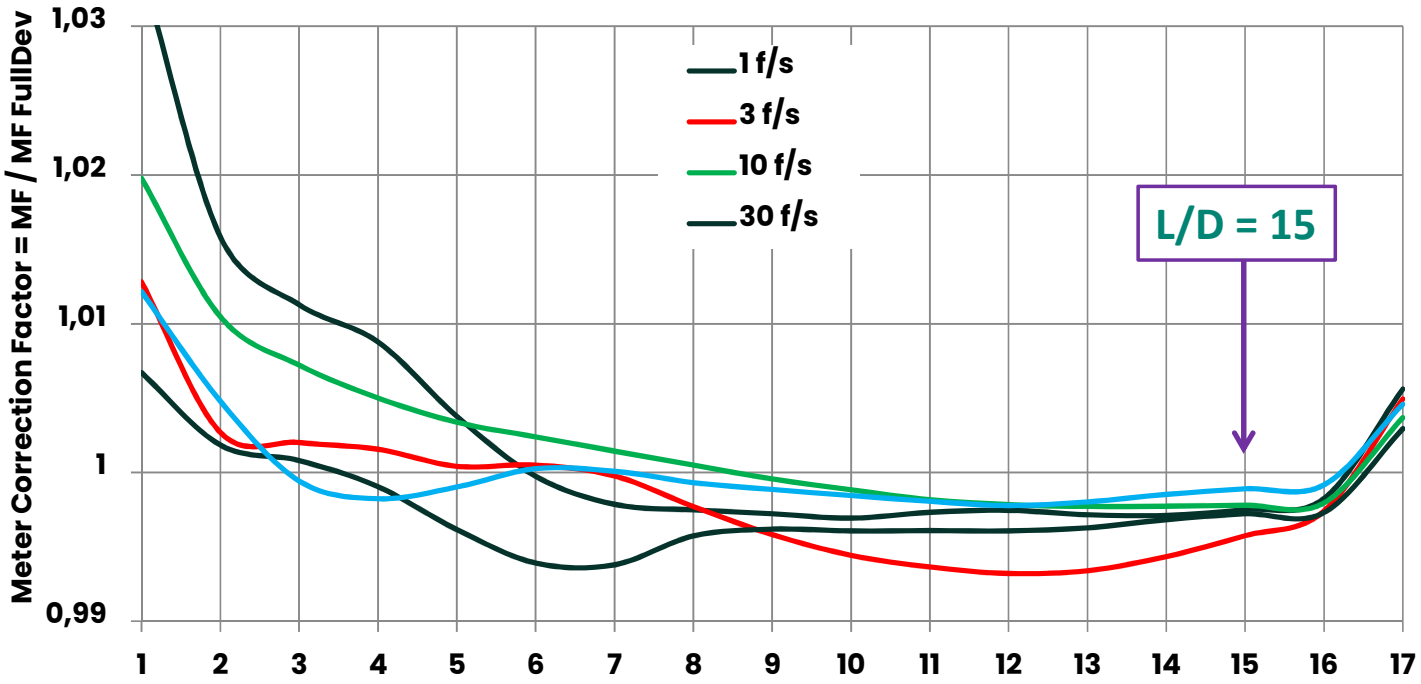
*Note: Straight run recommendations are estimates only, based on industry practice and experience, and NOT on specific testing performed by GE Sensing.

What if insufficient straight runs? CFD models

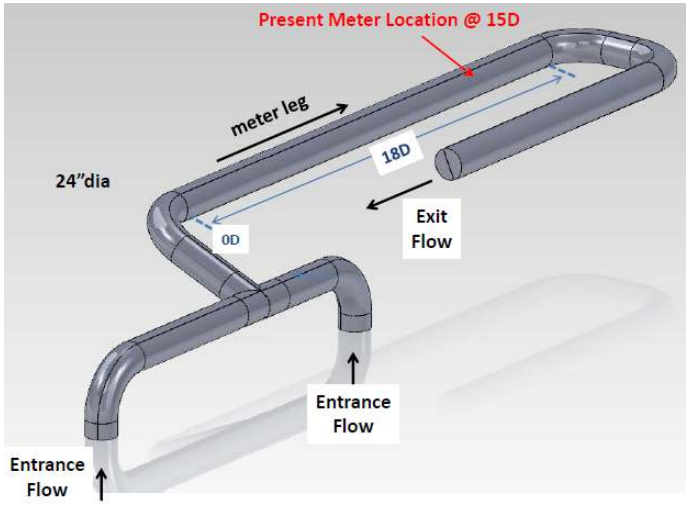
CFD models can be used to:

- Define optimized meter location AND path configuration
- Increase tolerance to non-perfect flow
- Determine correction factors for known disturbances
- Enable accuracy to stay within specifications





CFD Analysis using a Horizontal Mid-Radius dual path on a 24" flare line



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Are there potential limitations to use ultrasonics?

- Limited straight runs
- Other phase content in excess of 5% in volume
- Small pipe sizes at very low velocity (i.e. 1” and Qmax 0.1 ft/s)
- Custody Transfer application with a compact prover (need a master meter in between)
- Non-Newtonian fluids (yogurt, honey, ketchup, etc.)

Application Examples

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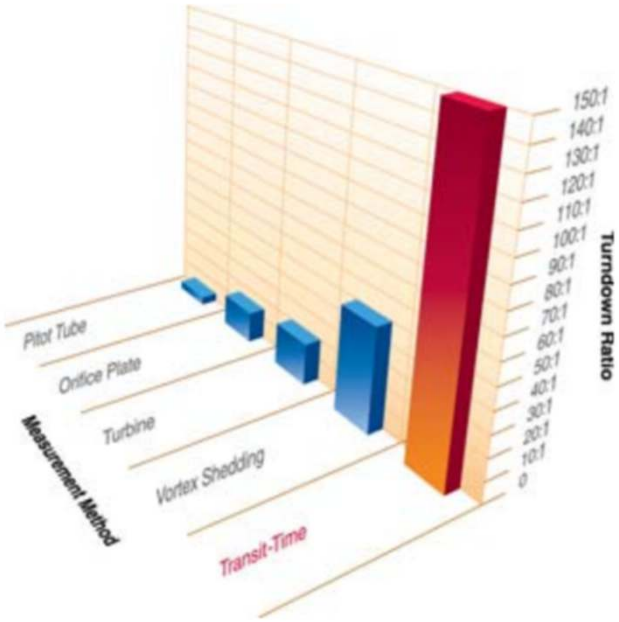
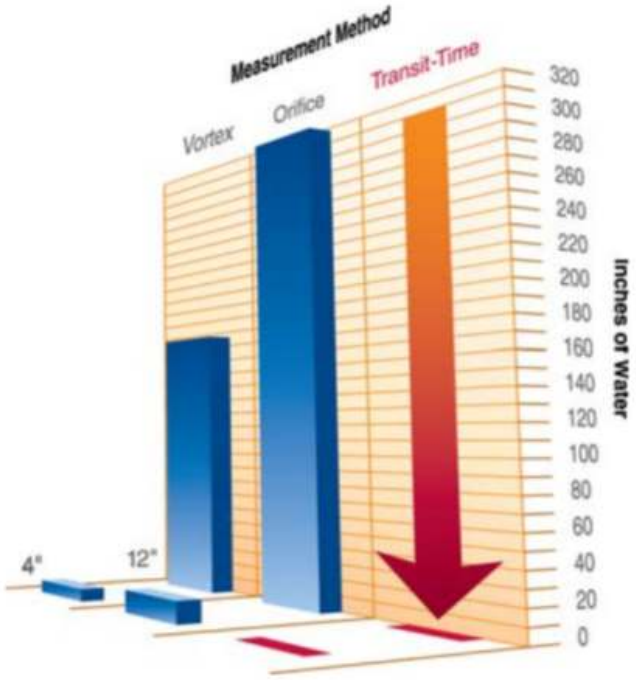
Difficulties in Measuring Steam

Measurement Range



Pressure Drop



Accuracy within entire range

Maintenance & reliability

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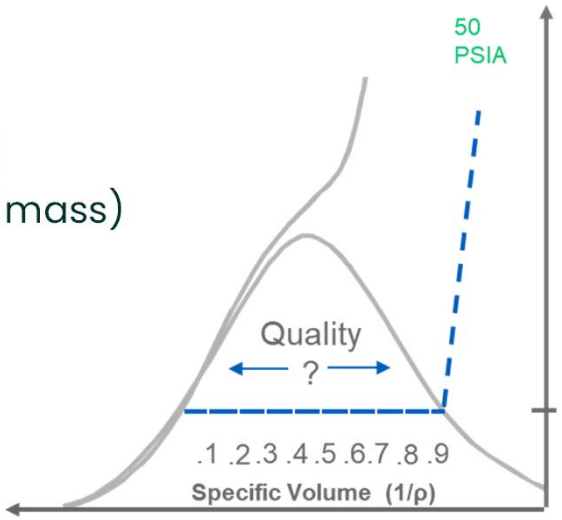
Steam

- Saturated
  - Low flow to high flow up to 150:1
  - Steam quality (mass gas/total mass)
  - Can have some free water
- Superheated
  - T° > saturated T° at process P
  - P < saturation P at process T°
  - Hot dry gas
- Energy is required to produce steam



US Meter Capabilities

- The turndown ratio and low-end sensitivity exceeds conventional flow technologies
- Temperature up to 1000°F (verify gasket!)
- Wide transducer options and set up
- No pressure drop
- No maintenance
- P **&** T compensation for mass flow for superheated steam; P **or** T compensation for saturated steam
- Need steam quality > 0.92
- On-site verification

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DigitalFlow Steam Measurement

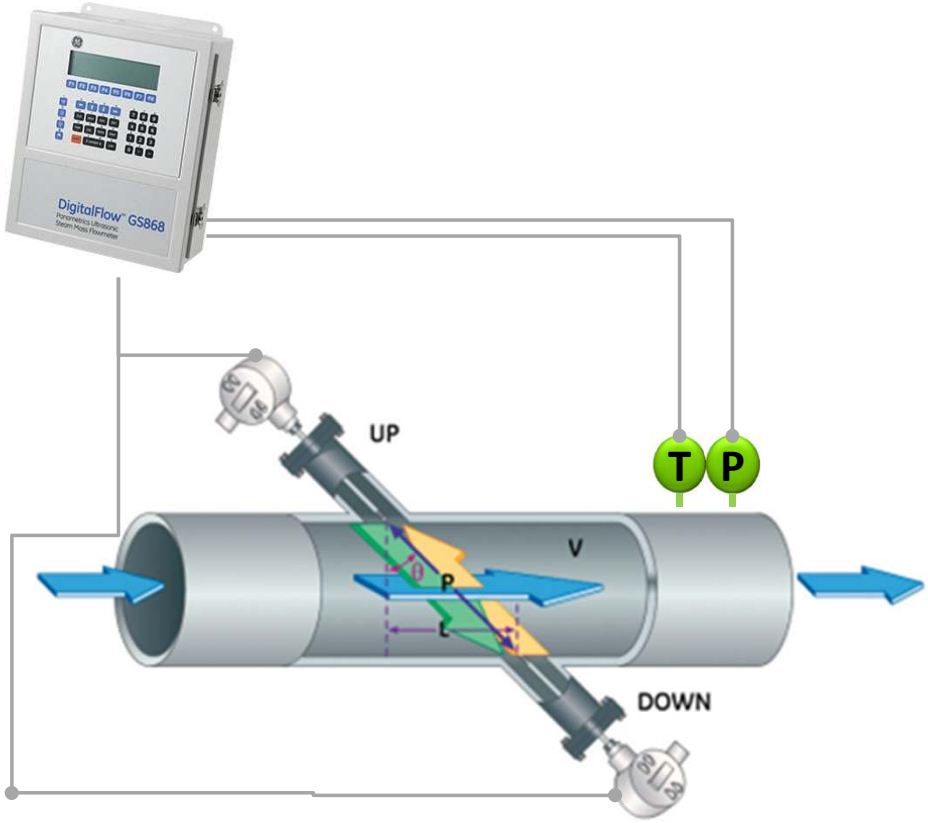
GS868 or XGS868i Ultrasonic Flow Meter

Permanent wetted ultrasonic flow meter for nominal or high temperature steam

The flowmeter computes flow, measures temperature and pressure to calculates mass flow (example: LB/HR or KG/HR)

Flowmeter system consists of:

1. GS868 / XGS868i Electronics
2. Transducers: T5, T9, BWT
3. Holder: FH, FTPA, FIPA
4. Cable
5. Flowcell



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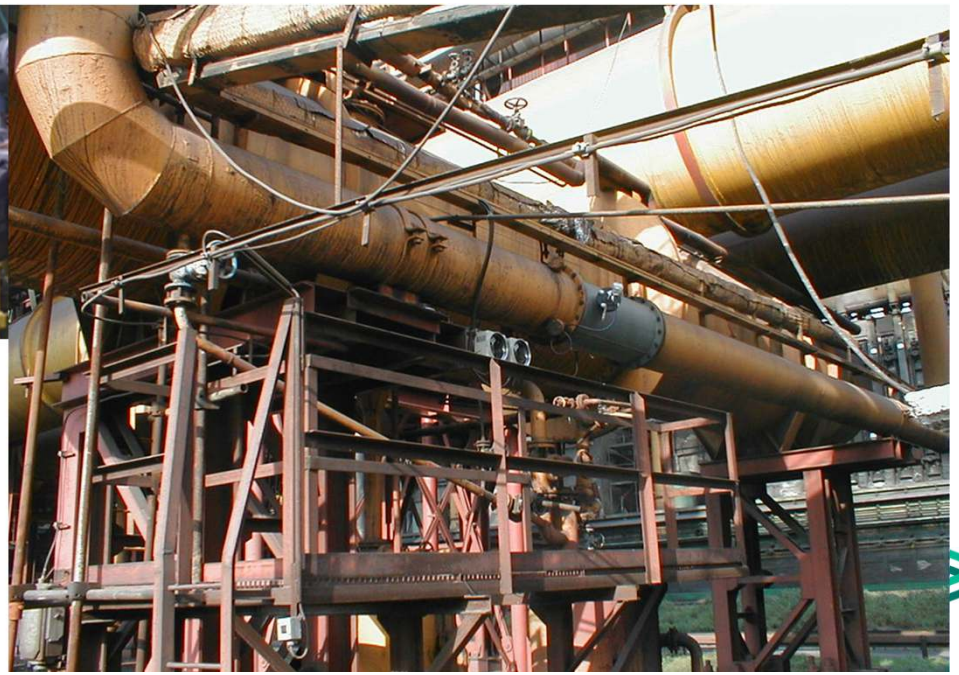
Gas

- Utility gases: Air, N_2
- Feed gas, make-up gas, fuel gas, NG
- Biogas
- Acid gas, sour gas, blast furnace gas, coke oven gas
- Wet gas

US Meter Capabilities

- Wide turndown ratio
- No pressure drop
- No low flow cut off
- Limited to no maintenance
- Optional online retraction



Clamp On

- Utility gases: Air, N_2, O_2, argon
- Natural Gas, gas lift, etc.
- Water, waste water, irrigation, etc.
- Cooling water
- Penstock

US Meter Capabilities

- Wide turndown ratio
- No process interruption
- No HSE risk
- No contamination
- No pressure drop
- No low flow cut off
- Limited maintenance

Clamp On Toolbox

- Check inline meters
- Validate pump performance
- Validate fire network flow rate

US Meter Capabilities

- Wide turndown ratio
- No process interruption
- No HSE risk
- No contamination
- No pressure drop
- No low flow cut off
- Limited maintenance

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Flare and Gas with variable composition

- Variable Flow Rates (4000:1 turndown ratio)
  - Low flow = normal flare (0.1 ft/s)
  - Moderate flow = inadvertent flare
  - High flow = emergency flare (400 ft/s)
- Variable Composition
  - Range of hydrocarbons
  - H_2 to C6 + (typical)
- Corrosive Environment
  - H_2S, HF etc.
  - Liquid dropout
- Low Pressure
  - From atm up to HP
- Wide Temperature Range
  - From –325°F to 500°F and more

US Meter Capabilities

- The turndown ratio and low-end sensitivity exceeds conventional flow technologies
  - Very wide range of flow rates
- Volume flow independent of composition
- Transducers materials compatibility (Ti, Monel, Hastelloy)
- Wide transducer options and set up
- No pressure drop
- No maintenance
- Wide process T° range
- Patented algorithm for MW and mass flow On-site verification

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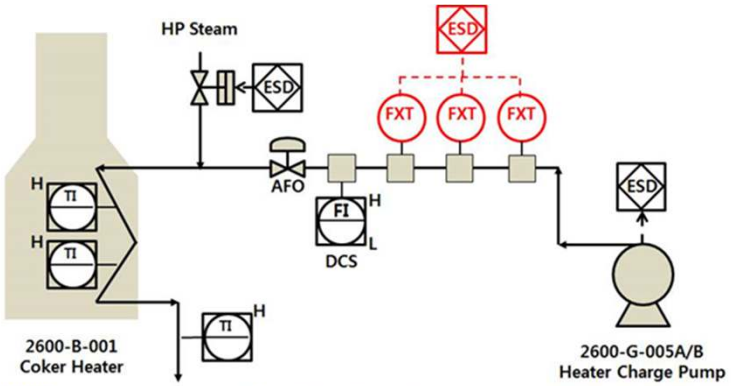
Extreme Temperature and Pressure

- LNG
- BOG
- Heavy Residue (Coker feed, asphaltene, etc.)
- Boiler Feed Water
- Gas or water injection



US Meter Capabilities

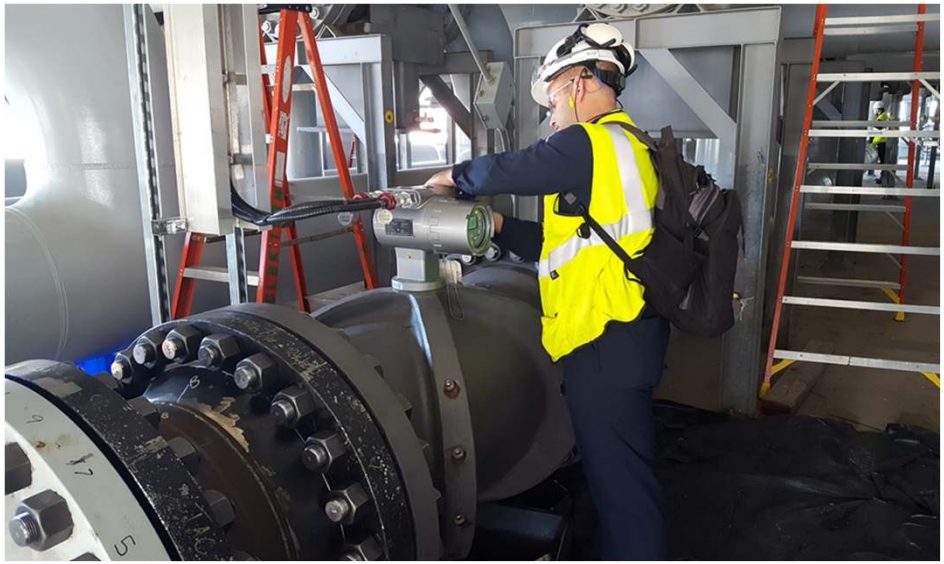
- Wide temperature range
- Signal treatment with feed thru buffers
- Transducers positioned away from extreme temperature
- Online replacement possible
- No pressure drop
- No to limited maintenance
- SIL

High Accuracy

- Leak Detection
- Fiscal and Custody
- Allocation

US Meter Capabilities

- Multi path meters (up to 8)
- Viscosity independence
- Accuracy down to ±0.1% of reading



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Thanks

Time for Q&A

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