FUNDAMENTALS OF NATURAL GAS FLOW MEASUREMENT USING CLAMP-ON ULTRASONIC FLOW METERS

PRESENTED BY MARTIN DINGMAN

SIEMENS INDUSTRY, INC.

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DEFINITIONS

Clamp-on – Refers to “Field Installed” meters

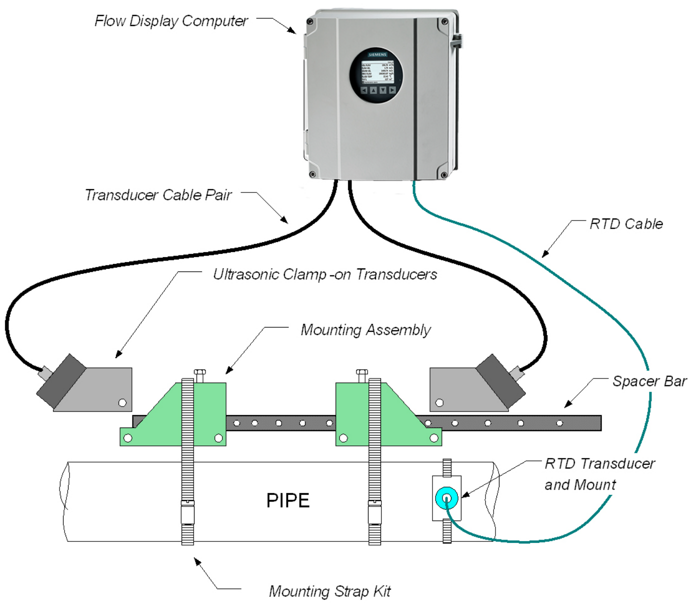
- External mounting of transducers designed for flexibility and convenience on existing piping
- Accuracy 0.5 – 1.0% of rate or better (Working with some unknowns)
- No flow calibration certificate

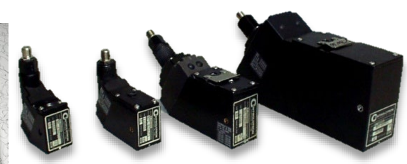
Custody Transfer (CT) – Refers to Custody Spool based meters

- Spool meter run with flow conditioning in accordance with AGA9
- Transducers can be external (Clamp-on) or insert (Chordal)
- Eliminates ‘Field Installed’ uncertainties
- Rigid, secure transducer mounting (Welded)
- Calibrated to Custody Transfer requirements (Calibration Certificate)

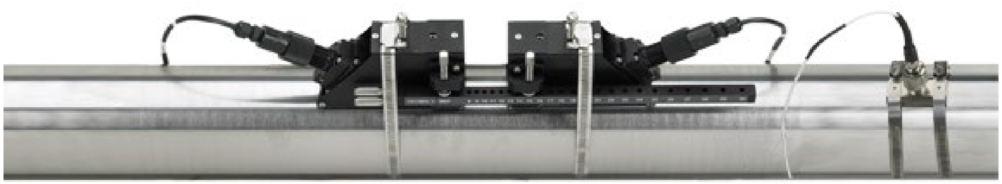
CLAMP-ON ULTRASONIC SYSTEM

ULTRASONIC CLAMP-ON SYSTEM COMPONENTS

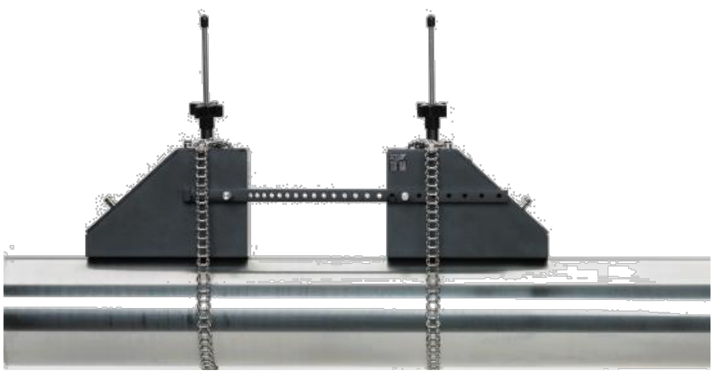




ULTRASONIC CLAMP-ON SYSTEM COMPONENTS – TRANSDUCER MOUNTING



Mounting Frames



Ladder chain Mounting Straps

ULTRASONIC CLAMP-ON SYSTEM COMPONENTS – TRANSDUCER MOUNTING

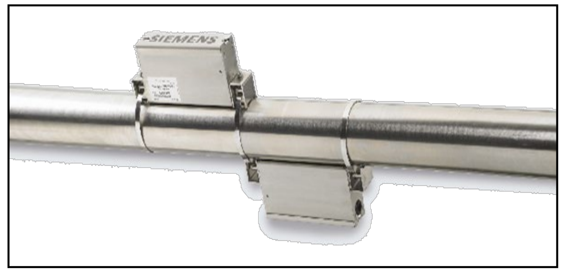
High Precision sensor mount features

316 Stainless

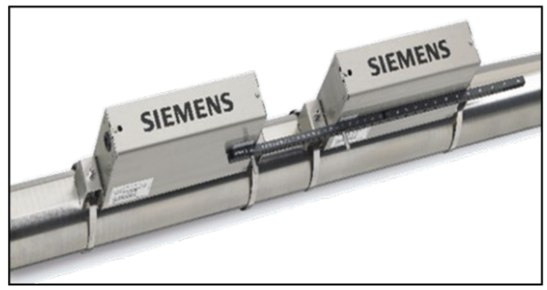
Compatible with sensor size:

- C & D High Precision
- E Universal

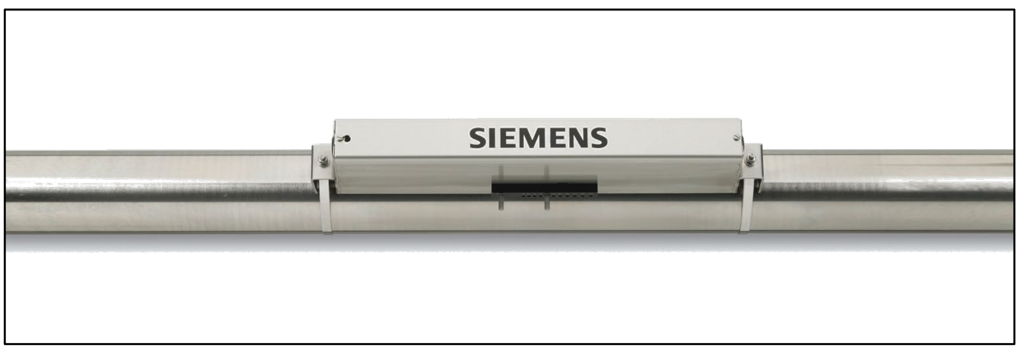
Single and Dual enclosure



Dual Enclosure (Direct)

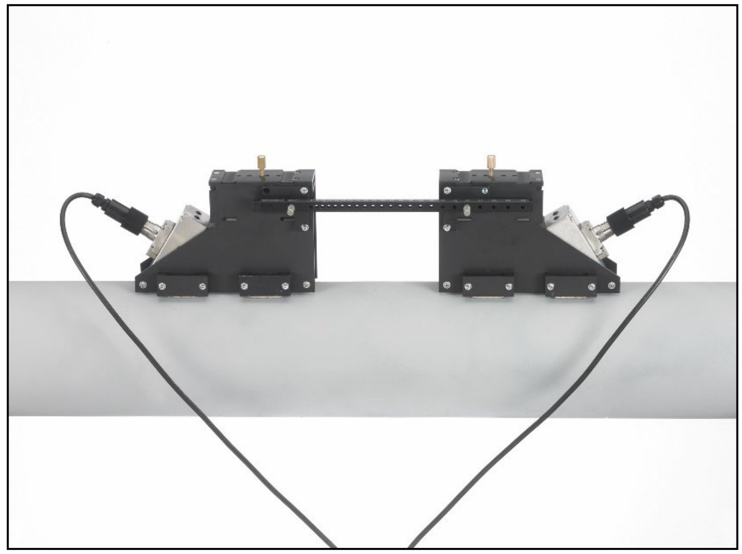


Dual Enclosure (Reflect Mount)



Single Enclosure (Reflect Mount)

ULTRASONIC CLAMP-ON SYSTEM COMPONENTS – TRANSDUCER MOUNTING



Magnetic Mounting features and applications:

Features:

(Rare Earth) Nickel-plated Neodymium Iron Boron (NdFeB)

Resists a load of 20lbs min

HP & Universal size C, D, and E

Capable of accepting straps

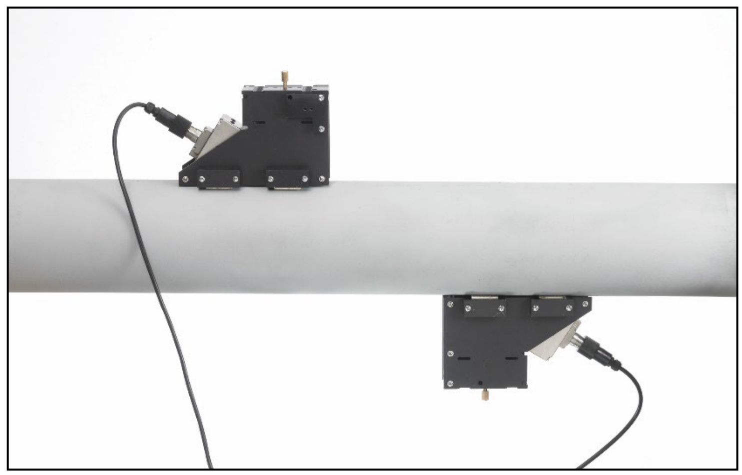
Available in Stainless (special)

One size fits all - 7ME39600MD02

Applications:

Temporary measurement

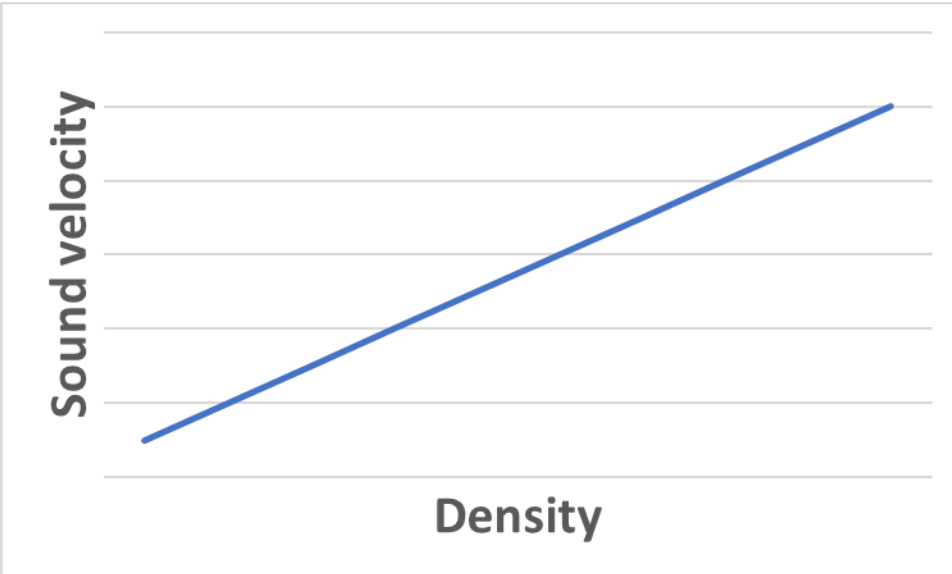
Large diameter pipes

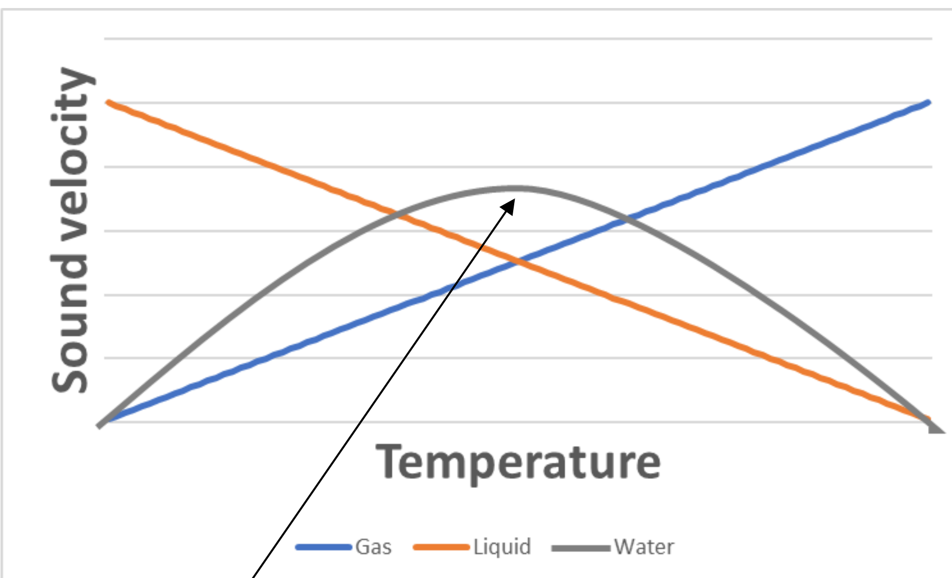


WHAT IS ULTRASOUND / ULTRASONIC?

- Sound whose frequency is above the upper limit of the range of human hearing (approximately 20 kilohertz)
- The speed at which sound waves (or ultrasound waves) propagate through a specific material or medium.
- Depends on density and medium temperature

DEPENDNECE ON THE SPEED OF SOUND ON TEMPERATURE AND DENSITY

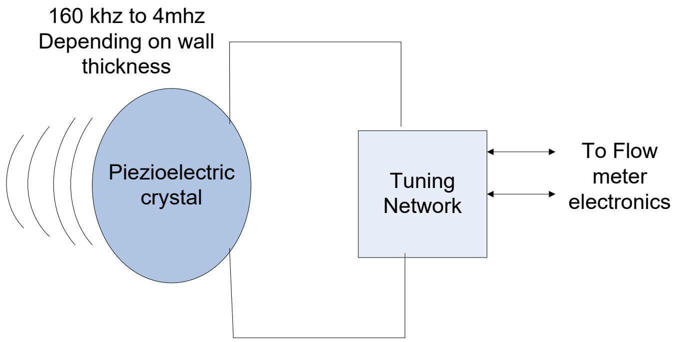




74°C / 165°F

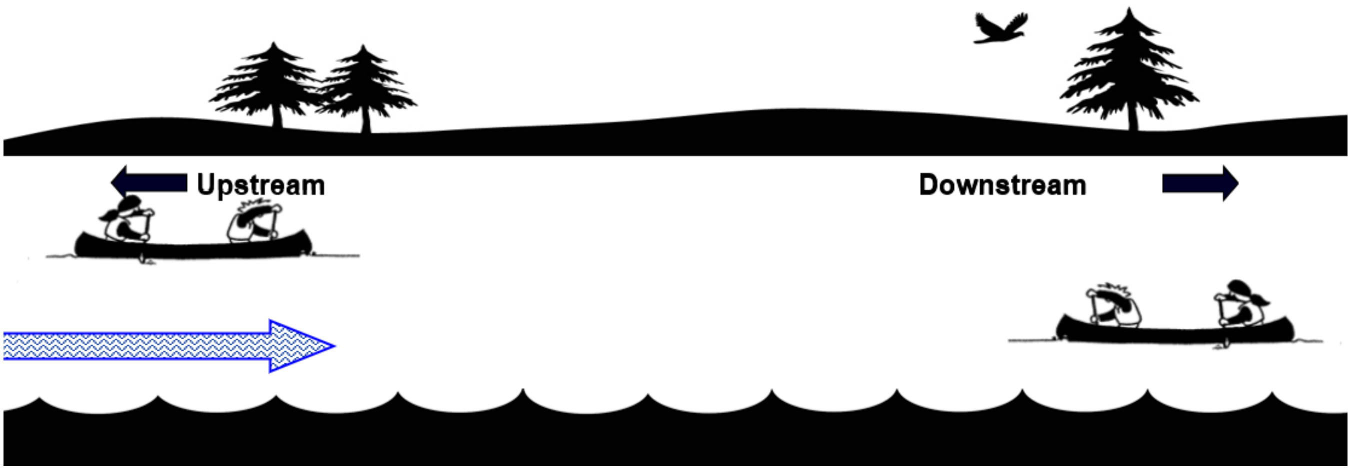
HOW WE GENERATE SOUND

- A sensor converts electrical energy into mechanical energy
- A sensor also converts mechanical energy into electrical energy
  - Piezoelectric Effect
- A sensor is both a transmitter and receiver

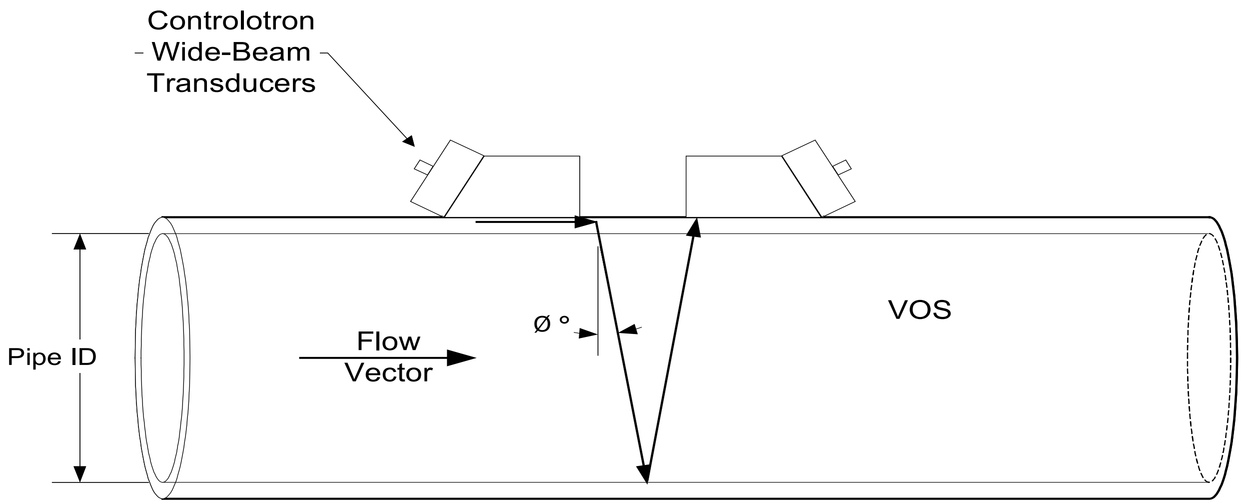


PRINCIPLES OF OPERATION – TRANSIT TIME

There is a time difference. Why?



PRINCIPLES OF OPERATION



$Ø° = \sin^{-1}(VOS / V_{phase})$

$T_L = 2 * ID / (VOS * \cos(Ø))$

$V_F = V_{phase} * DT / (2 * T_L)$

Where:

VOS = Velocity of Sound in Gas

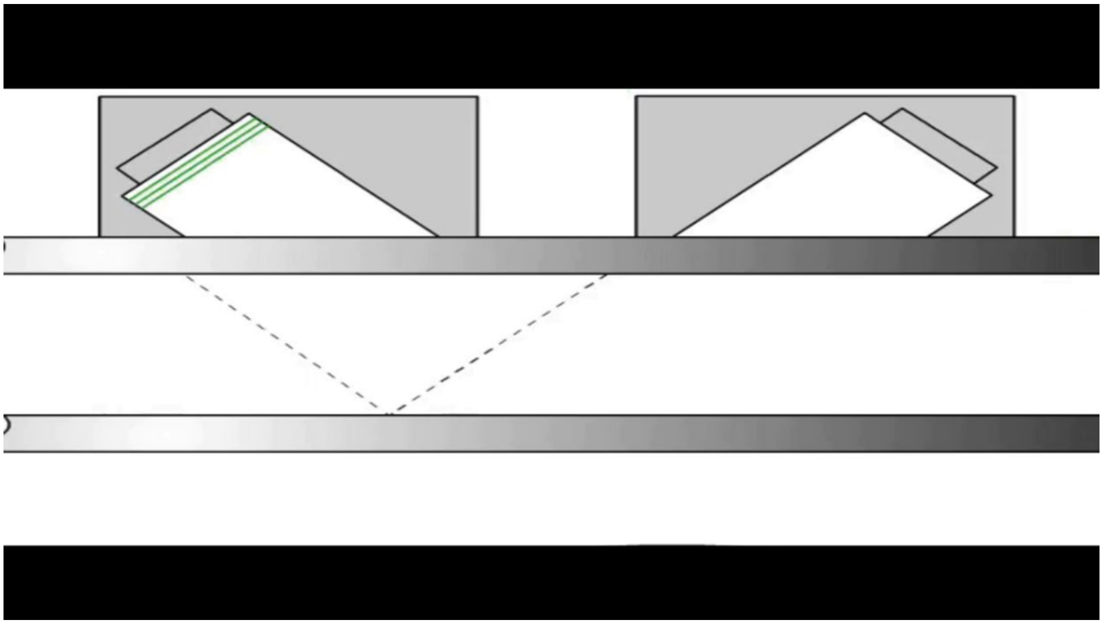
V_{phase} = Phase Velocity of Transducer

ID = Pipe Inside Diameter

T_L = Transit time in Gas

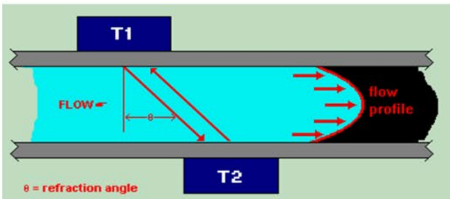
DT = Measured Transit-Time difference

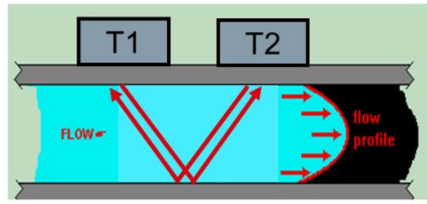
PRINCIPLES OF OPERATION – WIDE BEAM



THE MOST COMMON INSTALLATION MODES – DIRECT AND REFLECT

Direct mount	Reflect mount
Transducers on each side of the pipe	Transducers on the same side of the pipe





WHEN TO CHOOSE DIRECT MODE VS. REFLECT MODE?

Choose direct mode:

For old pipes (with deposits inside since it disturbs reflection)

Installations with limited space along the pipe

The pipe materials does not reflect the ultrasonic signals, therefore, use direct mode:

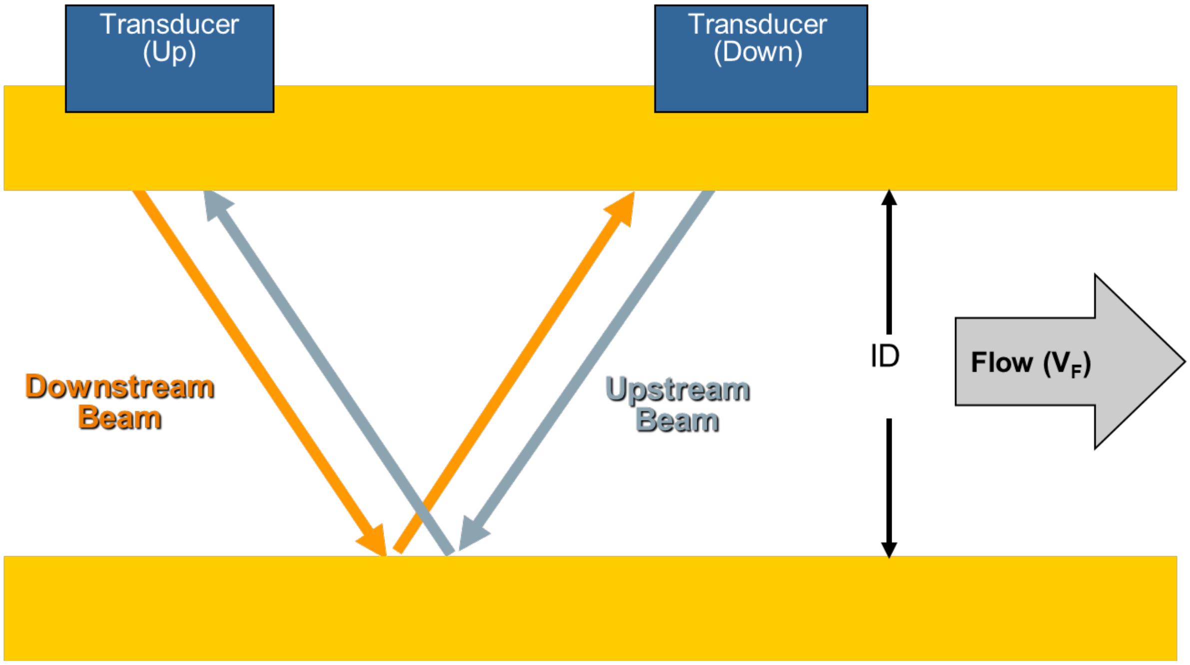
- Fiber-reinforced plastic (FRP)
- PVC
- Glass
- Polyethylene (PE)

Choose reflect mode: Whenever possible!

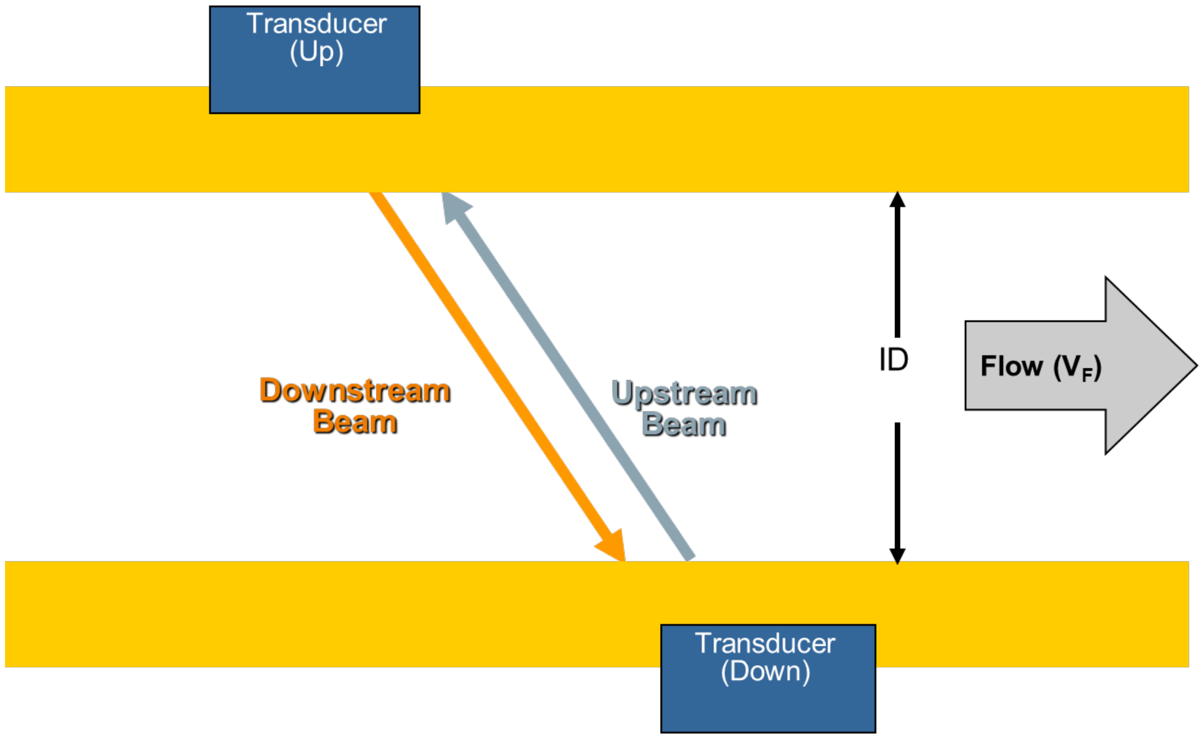
Metallic pipes (e.g. like steel, nickel, brass, copper, titanium etc.)

The software FS200 Utility or the transmitter tells you what mode (direct/reflect) you have to use.

PRINCIPLES OF OPERATION (REFLECT MODE)

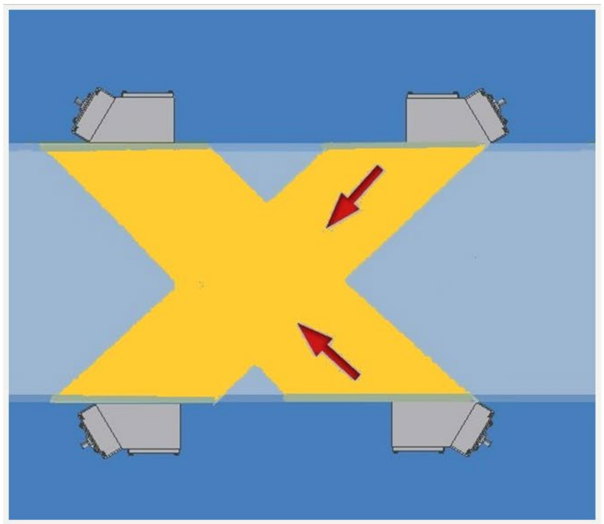


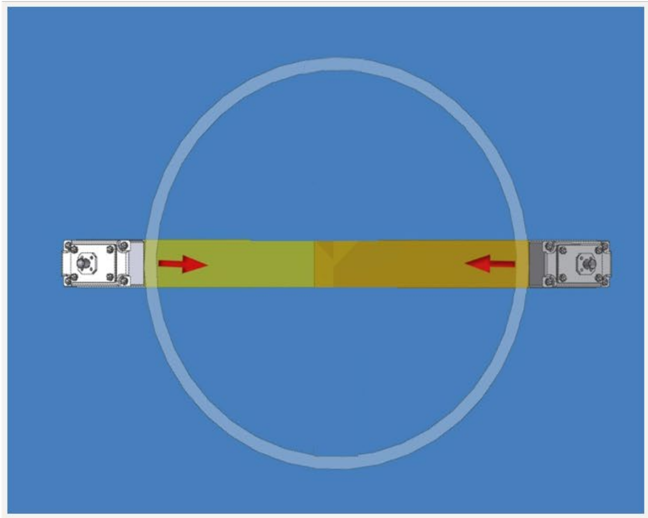
PRINCIPLES OF OPERATION (DIRECT MOUNT)



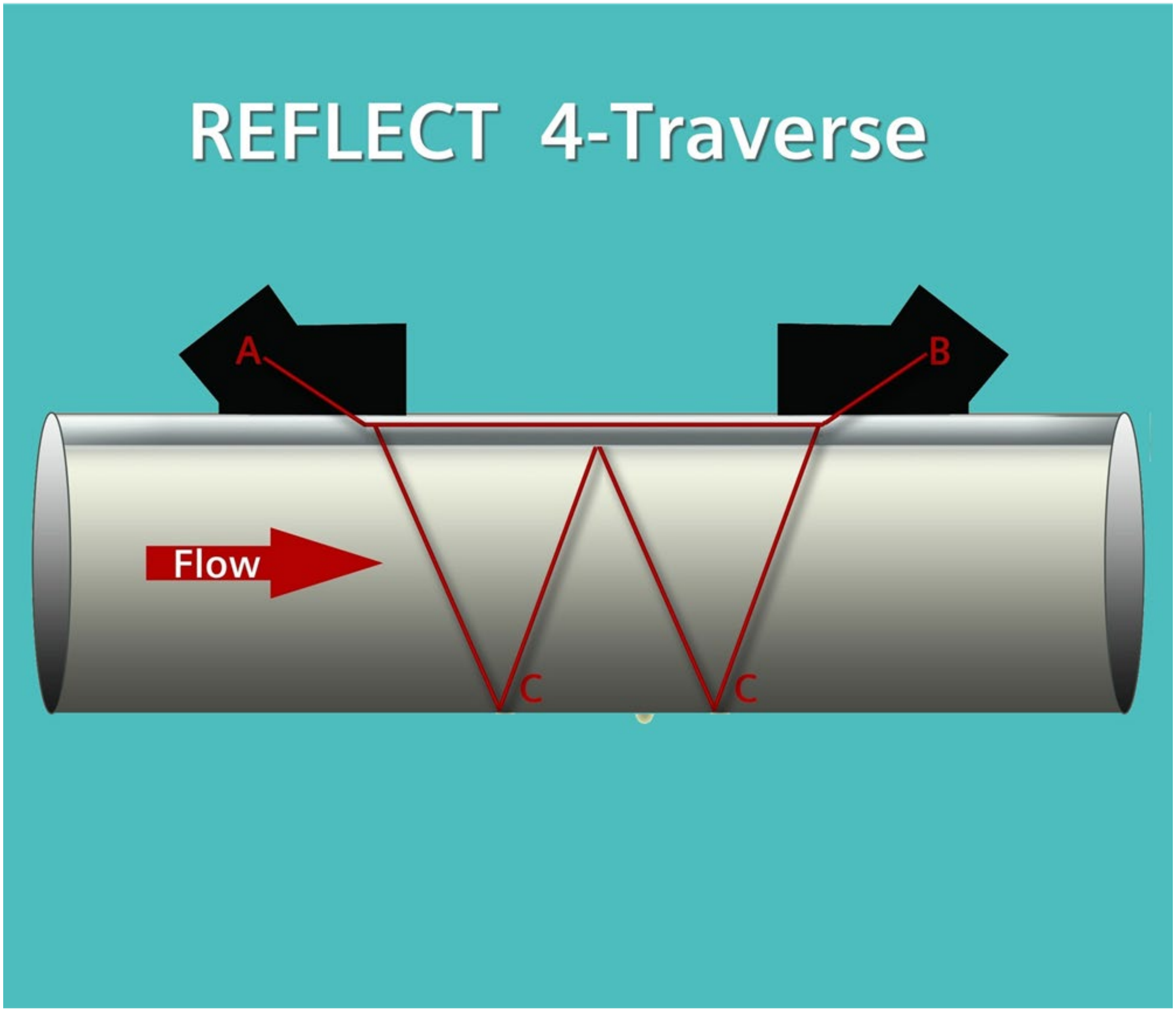
PRINCIPLES OF OPERATION (DIRECT MOUNT – X-MOUNT)

X-Mount produces Sonic transmissions at opposing angles, thus providing the benefits of Reflect Mount <u>crossflow immunity</u> when Direct Mount must be utilized.





PRINCIPLES OF OPERATION (REFLECT MOUNT) – 4 TRAVERSE – GAS MEASURMEMENT ON SMALLER LINE SIZES



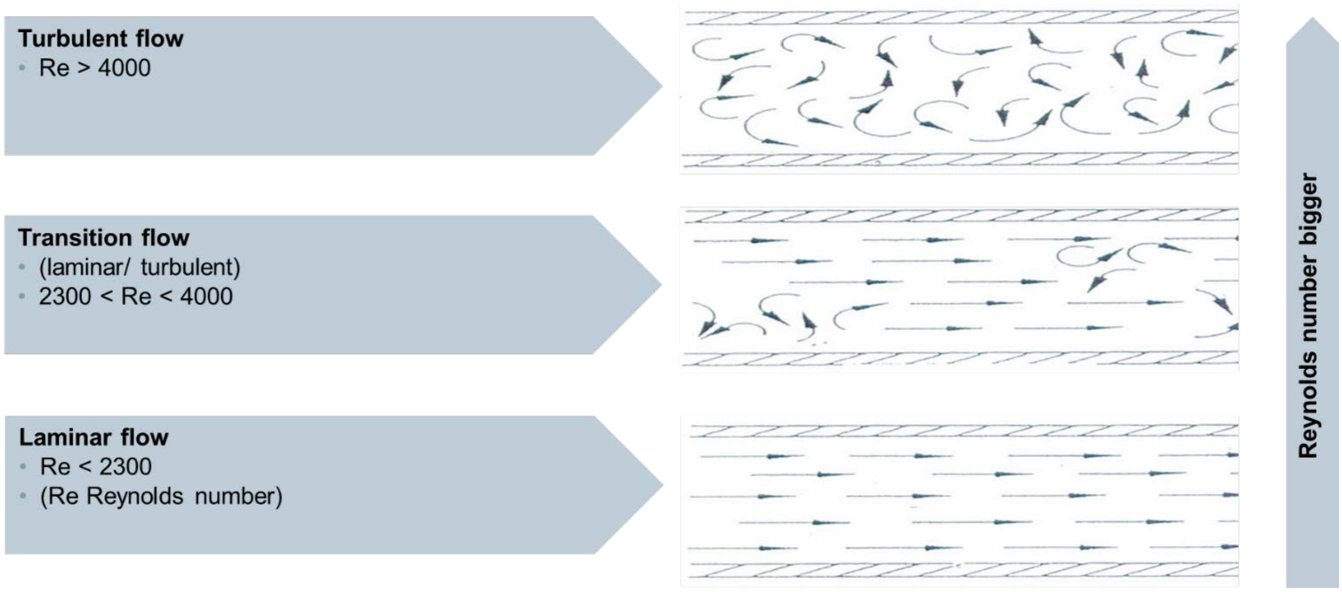
VOLUME CALCULATION

Volume calculation

$$V = K(Re) \times \left(\frac{\pi}{4 \times Di^{2}}\right) \times \mathrm{v}$$

V =	Volumetric Flow
v =	Flow velocity
K(Re) =	K factor from Reynolds number
Di =	Pipe inside diameter

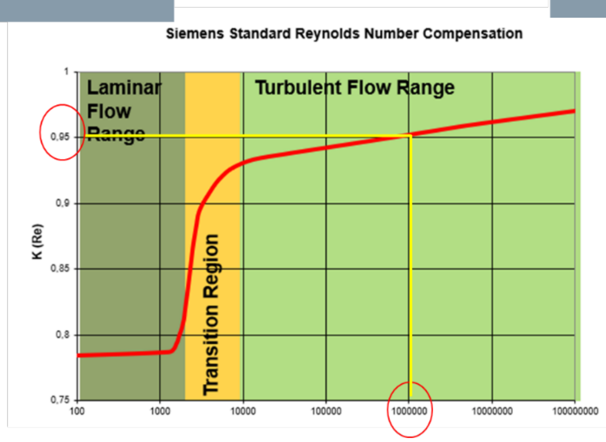
REYNOLDS NUMBER



REYNOLDS NUMBER

Reynolds number calculation

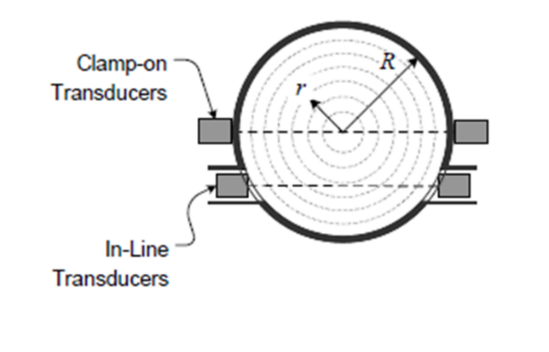
$$Re = Di \times \frac{v}{vis}$$

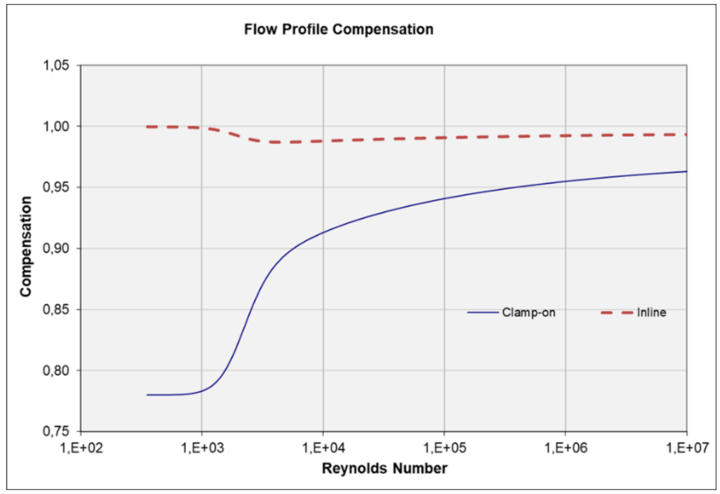


Volume calculation

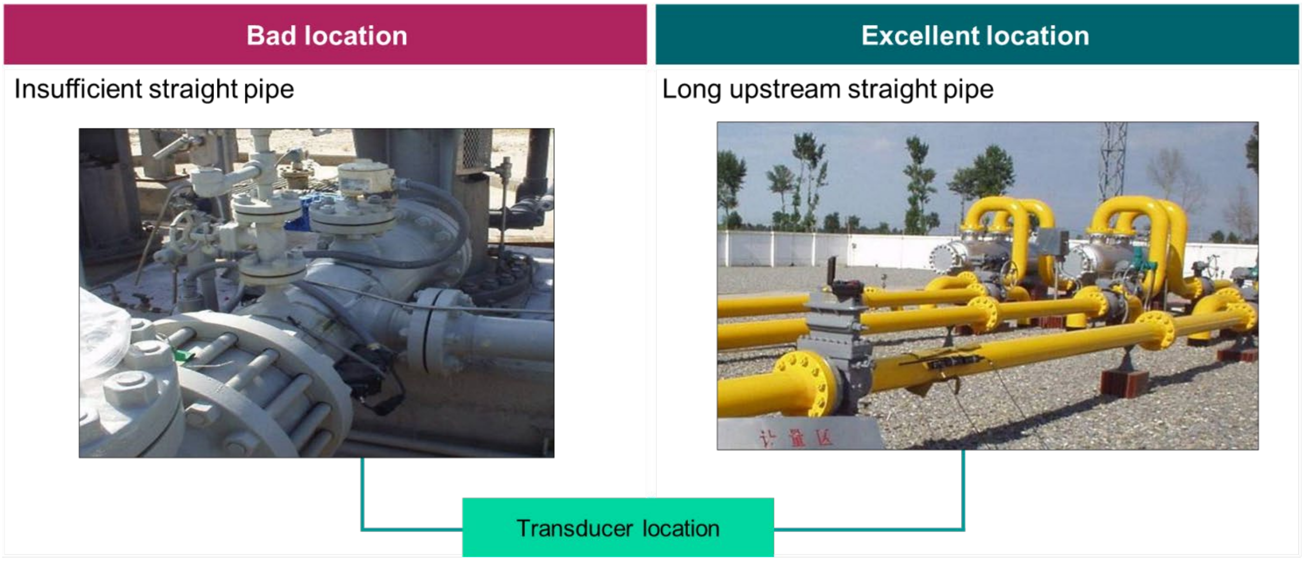
$$V = 0.95 \times Volume\ Flow$$

INLINE VS. CLAMP-ON

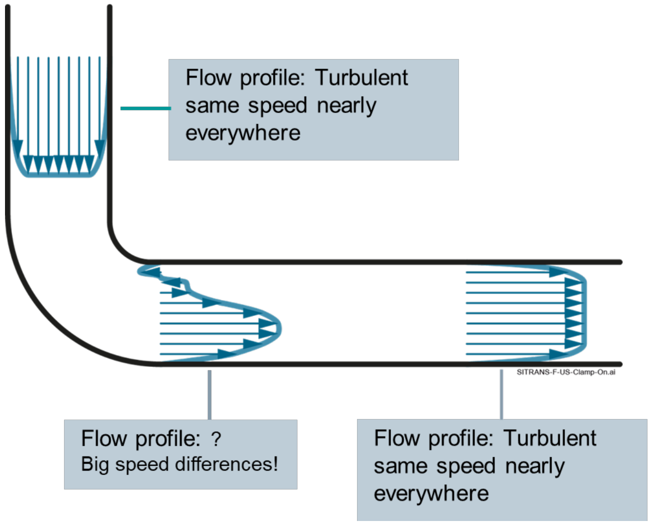




SENSOR INSTALLATION – CHOOSING A LOCATION



PRINCIPLES OF OPERATION – FLOW PROFILE

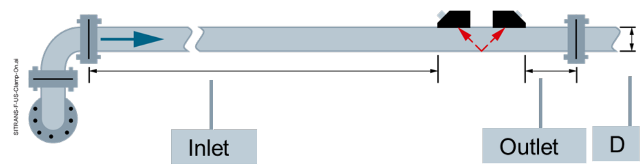


Result:

Mounting position is very important on Flow devices!

The area before the flow device: Inlet is more important than the outlet!

The necessary straight pipe is calculated in multiples of the pipe diameter D.
It depends on:
•Measurement technology,
•accuracy
•pipe structure. (Bends, double, triple bends and valves)



PRINCIPLES OF OPERATION – FLOW PROFILE

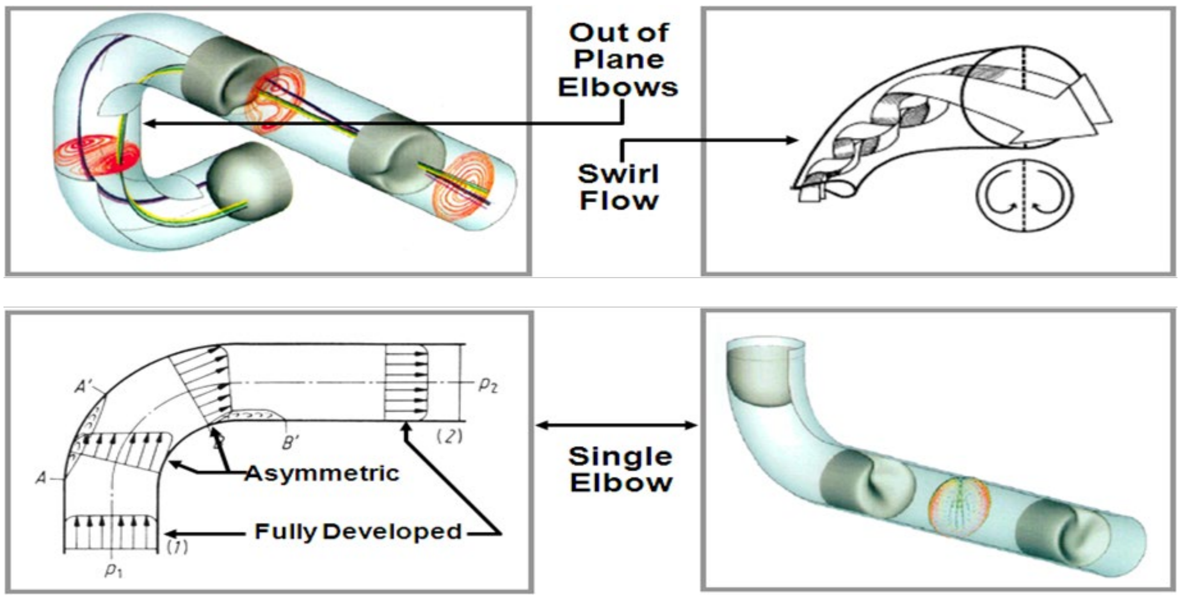
Most flow meter types require sufficient straight piping run upstream to produce a fully developed flow condition

Out of Plane Elbows

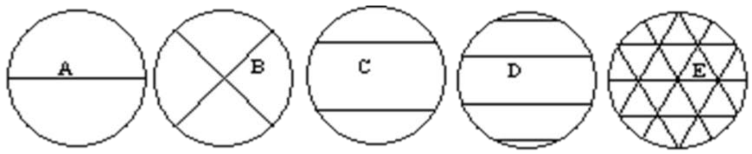
- **Produces a full counter-propagating swirl that can persist for >40 diameters**

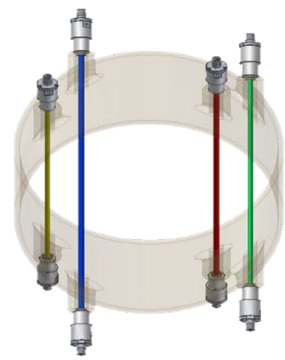
Single Elbow

- **Distorts the flow profile for a short distance before resuming to fully developed**



PRINCIPLES OF OPERATION – PATH CONFIGURATIONS FOR IN-LINE TRANSDUCERS (CHORDAL)





In-line Transducers

PRINCIPLES OF OPERATION – DUAL / FOUR PATH

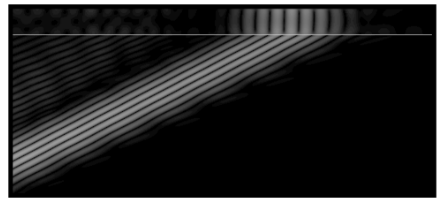
Dual / Four Paths

Increase flow sample averaging for greater precision

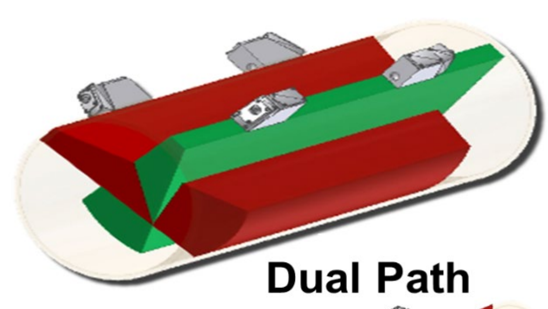
Benefits

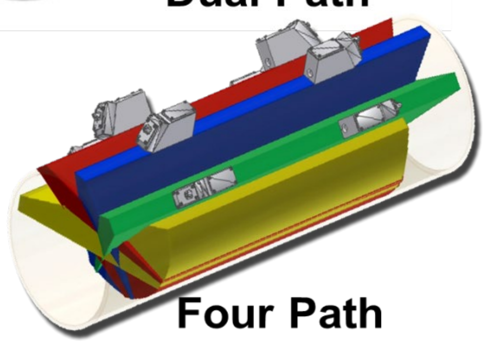
- Greater cross-sectional averaging
- Improved accuracy
- Improved repeatability
- Adds redundancy
- More time in the flow stream

Wide Beam

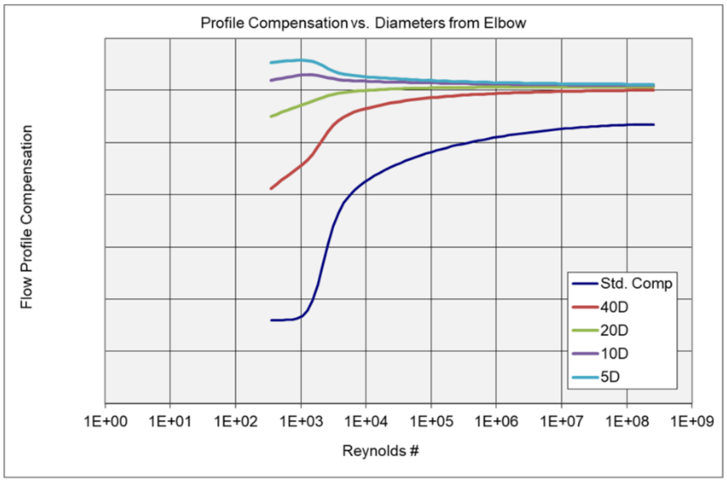


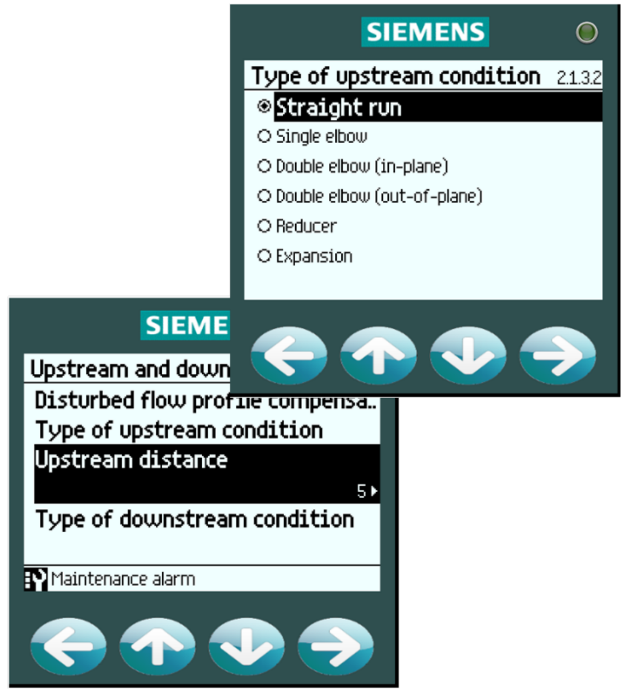
Wide Beam samples approx. 20x the volume of a typical insert system with each transmission.



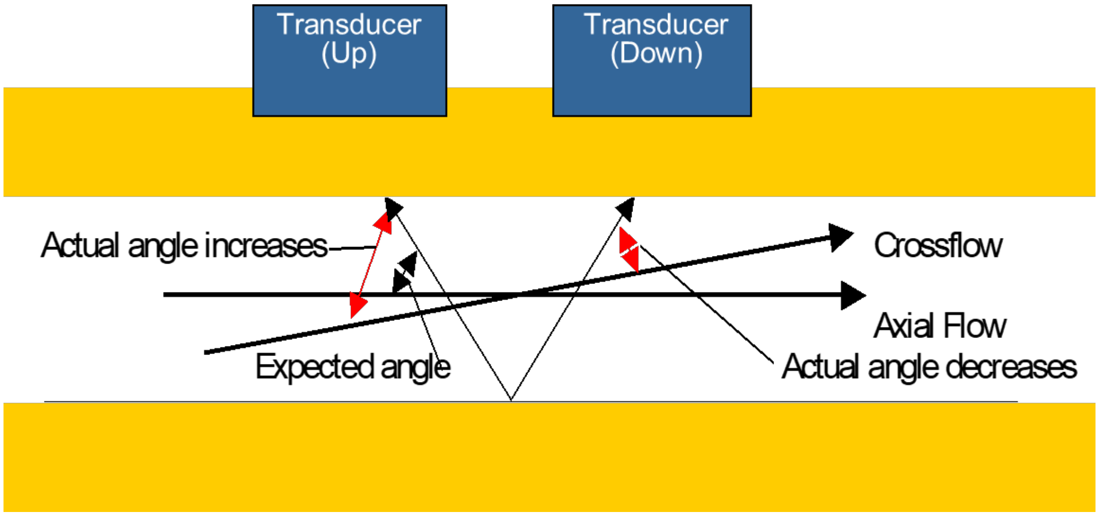


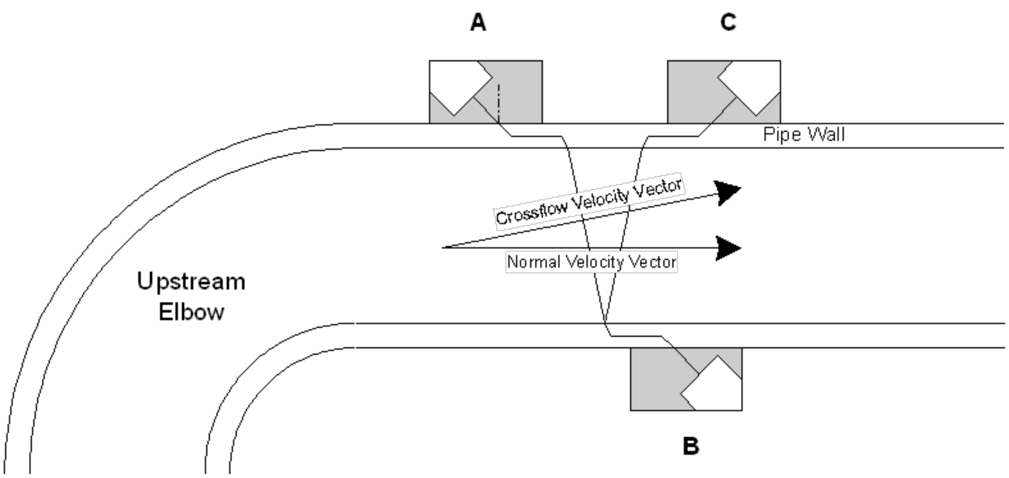
PRINCIPLES OF OPERATION – DISTURBED FLOW PROFILE COMPENSATION





PRINCIPLES OF OPERATION (REFLECT MODE) – 2 TRAVERSE – CROSSFLOW

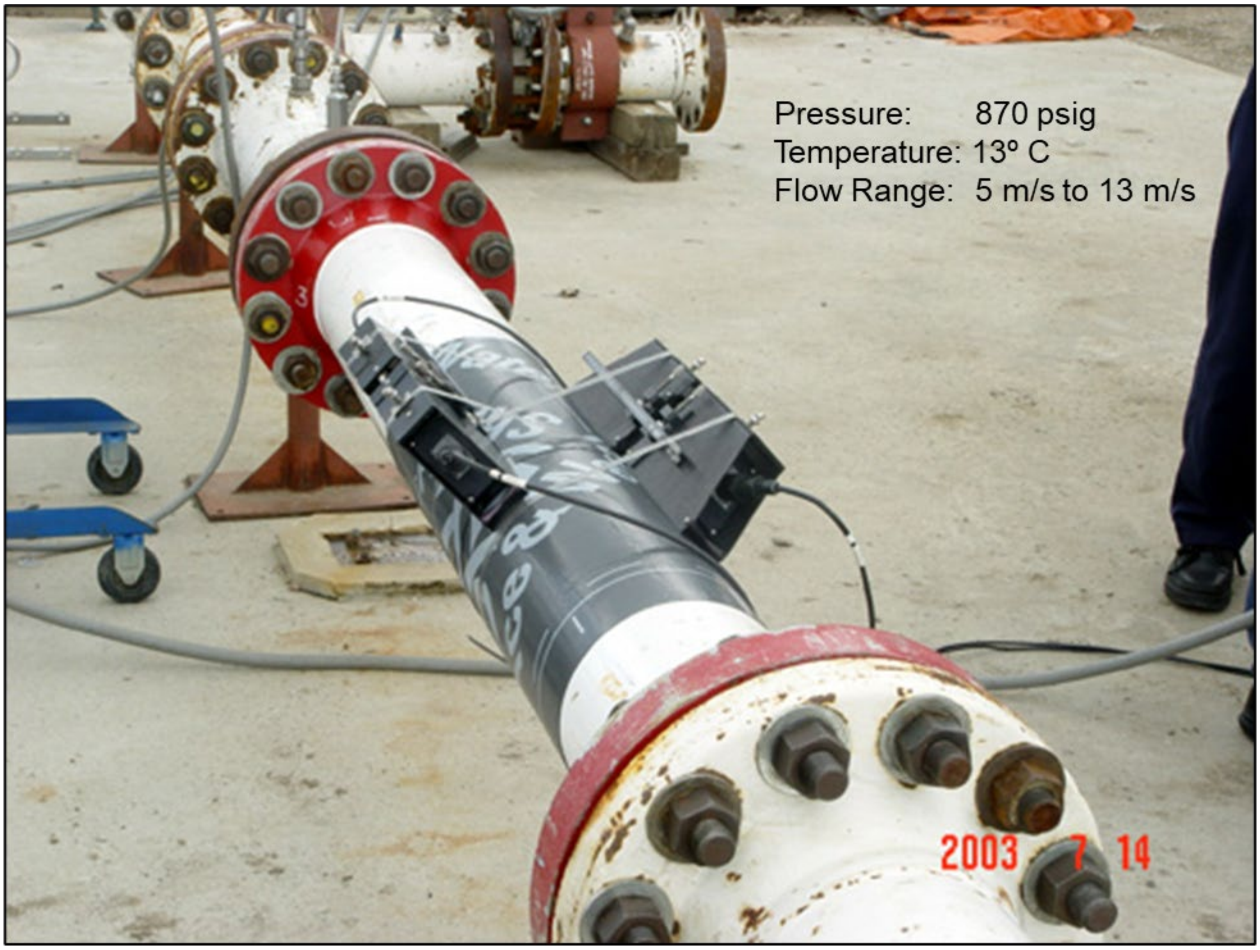




SENSOR INSTALLATION – CHOOSING A LOCATION

- Choose a location that provides at least 10 diameters of straight pipe upstream, and 5 downstream. More if possible
- Do not mount sensors immediately downstream of a pressure drop such as; expander, orifice plate, valves, intrusions, etc.
- Use the "Disturbed Flow" tool (in Pipe Settings) to program for actual pipe geometry when available straight pipe is limited
- Be sure pipe dimensions at selected location match meter programming!
- Remove flaky paint, rust, scale. Well bonded paint is OK and may be left alone
- On horizontal pipes; avoid mounting sensors at the 12 or 6 o'clock positions
- On vertical pipes, upward flow is preferred
- Do not mount sensors on (or opposite) pipe seams
- For pipes with internal liners; the liner material MUST be intimately bonded to the inner pipe wall to enable ultrasonic signal to conduct through the interface

TESTING CONDITIONS AT NOVA (NATURAL GAS)



8” carbon steel schedule 40 stock pipe

TESTING CONDITIONS AT NOVA (SINGLE 90 DEGREE ELBOW)

Out of the box
Performance at:

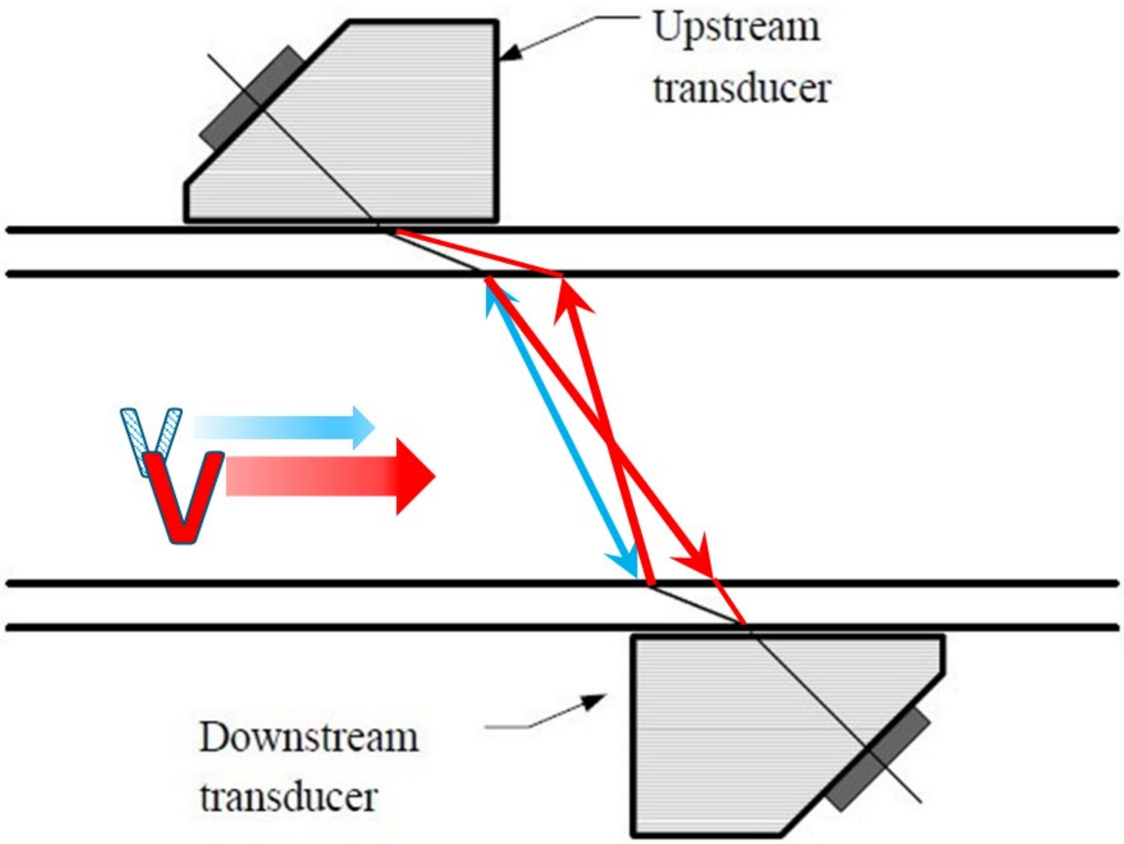
- 4D = -3.3%
- 9D = -1.7%
- 23D = -0.1%

TESTING CONDITIONS AT NOVA (DUAL 90 DEGREE ELBOW OUT OF PLANE)

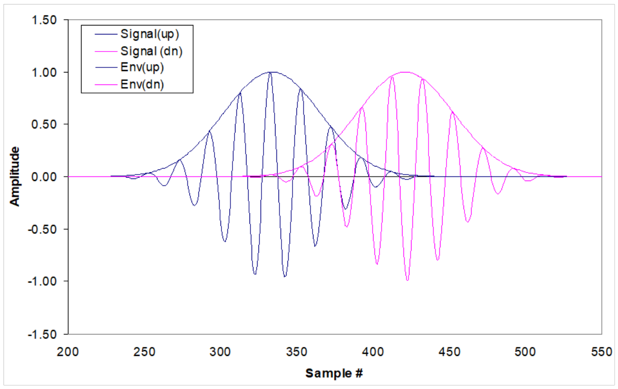
Out of the box
Performance at:

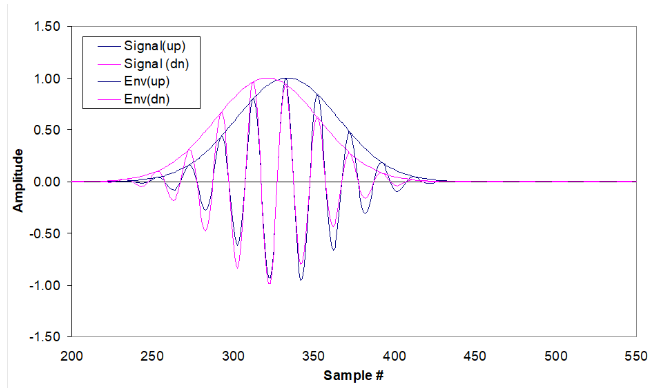
- 4D = -2.6%
- 9D = -1.7%
- 23D = -1.2%
- 44D = -0.1%

PRINCIPLES OF OPERATION – BEAM BLOWING EFFECT

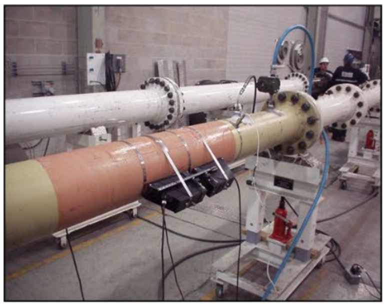


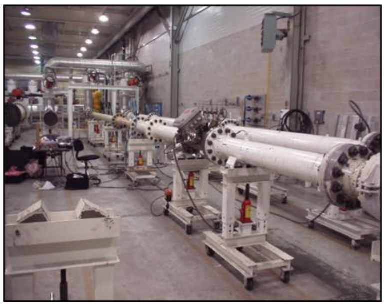
PRINCIPLES OF OPERATION – BEAM BLOWING EFFECT



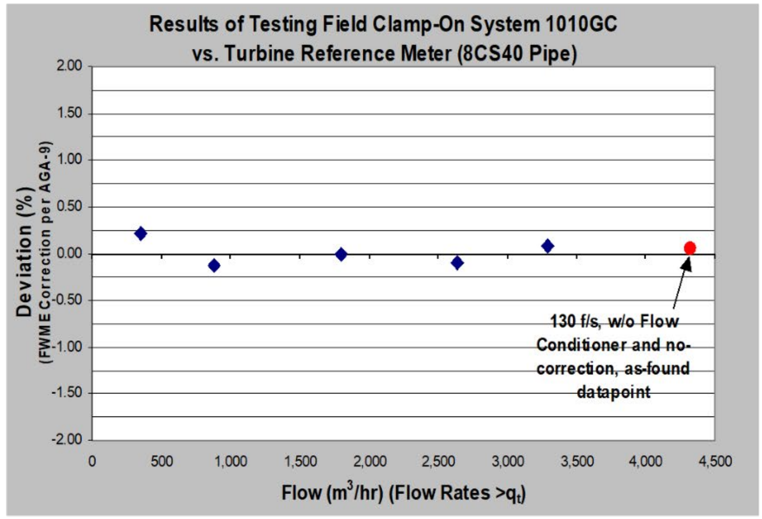


PRINCIPLES OF OPERATION – BEAM BLOWING EFFECT





Testing at TCC with flow conditioner (◆); except for the data point at 130 ft/sec (●), which was with flow conditioner removed.



PRINCIPLES OF OPERATION – TYPICAL PERFORMANCE AND INSTALLATION CONSIDERATIONS

Out-Of-Box accuracy:	0.5% - 1% for velocities above 0.3 m/s and >10 diameters straight run
Accurate pipe dimensions:	Sensors matched to wall thickness
Minimum Line Pressure:	Approx 100 PSIG on steel, atmospheric on plastic
Pipe Size:	2 inches to 52 inches

Pipe Condition: Pipe should generally be in good condition

- No scaling
- Uniform wall thickness
- Smooth outer surface (can mount over paint)

Temperature (Transducers):	-40 F to 250 F
Flow Velocity:	< 1 f/sec to >130 f/sec
Repeatability:	0.25 % (based on ISO 11631)
Gas Properties:	Most gases, but less than 15% CO_2
Pipe Damping Material:	Improves Signal to Noise Ratio

PRINCIPLES OF OPERATION – MINIMUM PRESSURE GUIDELINES

Pipe Size		Minimum Pressure BARG (PSIG): See *Transducer Size selection table)*						
mm	inches	B1H	B2H	C1H	C2H	D1H	D2H	D4H
50	2	7 (100)	10 (150)	14 (200)	31 (450)			
75	3	7 (100)	7 (100)	14 (200)	17 (250)		Not Recommended	
100	4	7 (100)	7 (100)	7 (100)	14 (200)	28 (400)		
150	6		7 (100)	7 (100)	7 (100)	24 (350)	35 (500)	
200	8			7 (100)	7 (100)	21 (300)	28 (400)	35 (500)
250	10			7 (100)	7 (100)	14 (200)	24 (350)	28 (400)
300	12				7 (100)	10 (150)	21 (300)	24 (350)
350	14				7 (100)	7 (100)	14 (200)	21 (300)
400	16				7 (100)	7 (100)	10 (150)	17 (250)
450	18					7 (100)	10 (150)	17 (250)
500	20		Not Recommended			7 (100)	10 (150)	17 (250)
550	22					7 (100)	10 (150)	17 (250)
600	24					7 (100)	10 (150)	17 (250)
650	26						10 (150)	17 (250)
700	28						10 (150)	17 (250)

Transducer Size Selection

Transducer Size Code	Pipe Wall (mm)		Pipe Wall (inches)	
	Wall Min	Wall Max	Wall Min	Wall Max
B1H	2.0	3.0	0.08	0.12
B2H	3.0	4.1	0.12	0.16
C1H	4.1	5.8	0.16	0.23
C2H	5.8	8.1	0.23	0.32
D1H	8.1	11.2	0.32	0.44
D2H	11.2	15.7	0.44	0.62
D4H	15.7	31.8	0.62	1.25
B3H	2.7	3.3	0.106	0.128
D3H	7.4	9.0	0.293	0.354

DIFFERENCE BETWEEN IDEAL GAS AND REAL GAS

- In the real world ideal gas does not exists
- Real gas have attractions between particles and the particles have volume
- Real gas has ideal properties when:

  - Temperature is high (particle have enough energy to overcome any acctration)

  - Pressure is low (particles are so far apart their individual volume is insignificant)

DIFFERENCE BETWEEN IDEAL GAS AND REAL GAS

Ideal gas

- Ideal gas has no definite volume
- particles of the ideal gas have elastic collision
- intermolecular attraction forces do not present between molecules
- It is hypothetical gas that do not really exist in the environment
- Independent of factors like temperature, pressure and gas composition

Real gas

- Real gas has definite volume
- particles of real have non-elastic collisions between molecules
- intermolecular attraction forces present between molecules
- Not a hypothetical gas that really exist in our environment
- Interacts with other gas and highly dependent

GAS PROPERTIES – GAS MEASUREMENT CAPABILITY

Actual (Gross) Volume Flow: $\mathrm{Q_{ACT}} = K(Re)\ x \left(\frac{\pi}{4 \times Di^2}\right) x\ \mathrm{v}$ $\qquad Re = \frac{Di\ \mathrm{v}\ \rho_{ACT}}{\eta}$

Standard Volume Flow: $Q_{Standard/Norm} = Q_{ACT}\, x \frac{P_{ACT}}{P_{BASE}}\, x \frac{T_{BASE}}{T_{ACT}}\, x \frac{Z_{BASE}}{Z_{ACT}}$

Mass Flow: $\mathrm{Q_M} = Qact\ x\ \rho_{ACT}$ $\qquad \rho_{ACT} = \rho_{BASE}\, x \frac{P_{ACT}}{P_{BASE}}\, x \frac{T_{BASE}}{T_{ACT}}\, x \frac{Z_{BASE}}{Z_{ACT}}$

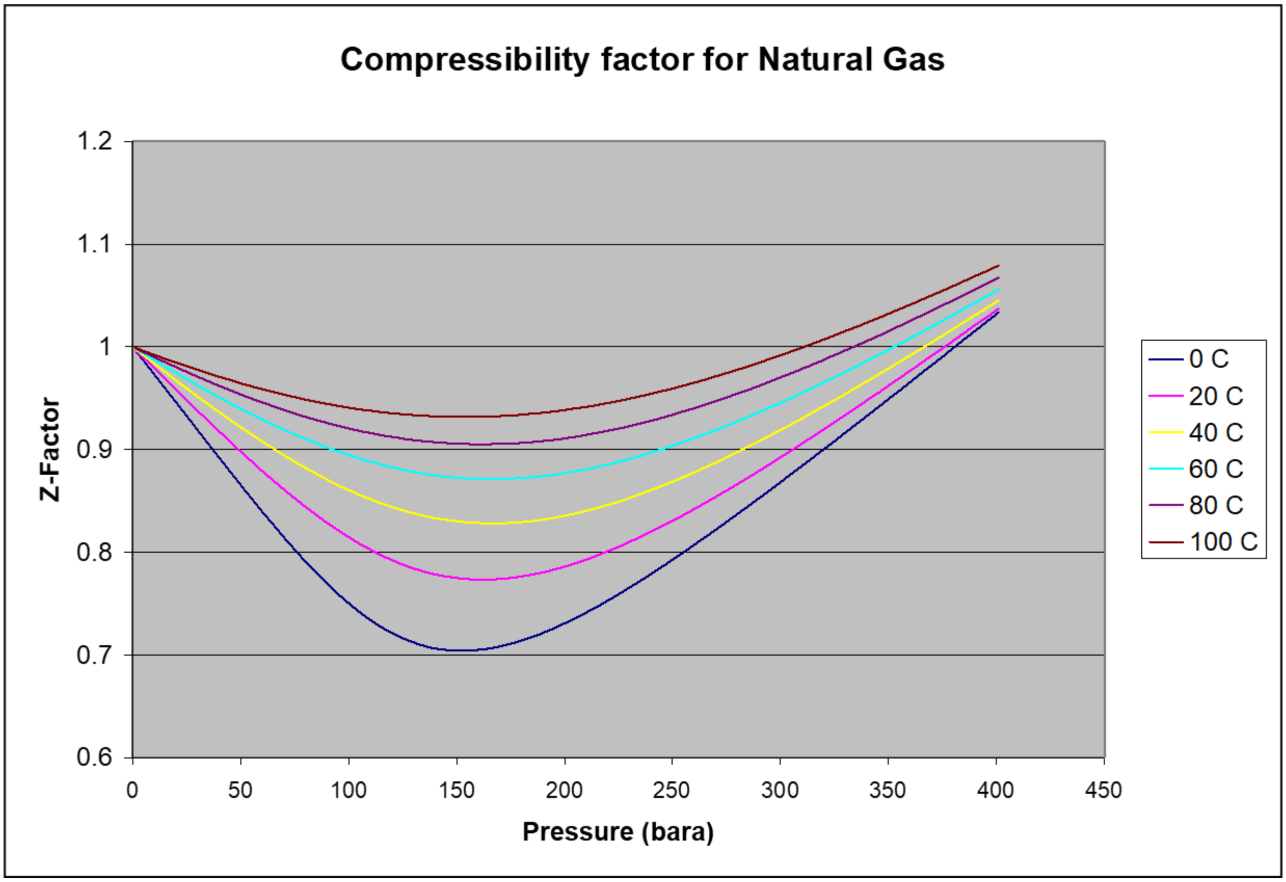
GAS PROPERTIES – AGA8 TABLE

Typical Natural Gas Composition

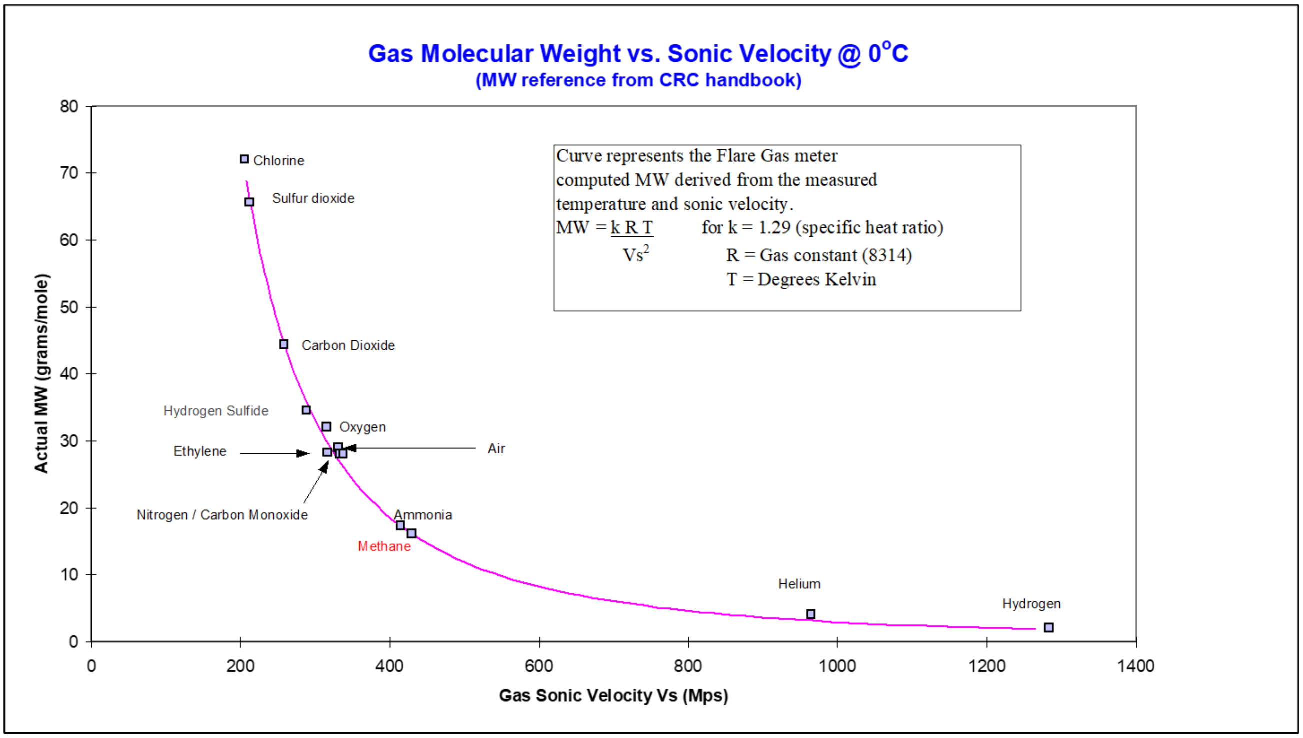
Component	(mole %)	Range (mole %)
Methane	94.9	87.0 - 96.0
Ethane	2.5	1.8 - 5.1
Propane	0.2	0.1 - 1.5
iso – Butane	0.03	0.01 - 0.3
normal – Butane	0.03	0.01 - 0.3
iso – Pentane	0.01	trace - 0.14
normal – Pentane	0.01	trace - 0.04
Hexanes plus	0.01	trace - 0.06
Nitrogen	1.6	1.3 - 5.6
Carbon Dioxide	0.7	0.1 - 1.0
Oxygen	0.02	0.01 - 0.1
Hydrogen	trace	trace - 0.02

- Note: Gas Found outside of the range provided is usually referred to as “out of spec gas”

GAS PROPERTIES



GAS PROPERTIES



GAS PROPERTIES – AGA8 / AGA10 COMPRESSIBILITY FACTOR AND SPEED OF SOUND (SOS)

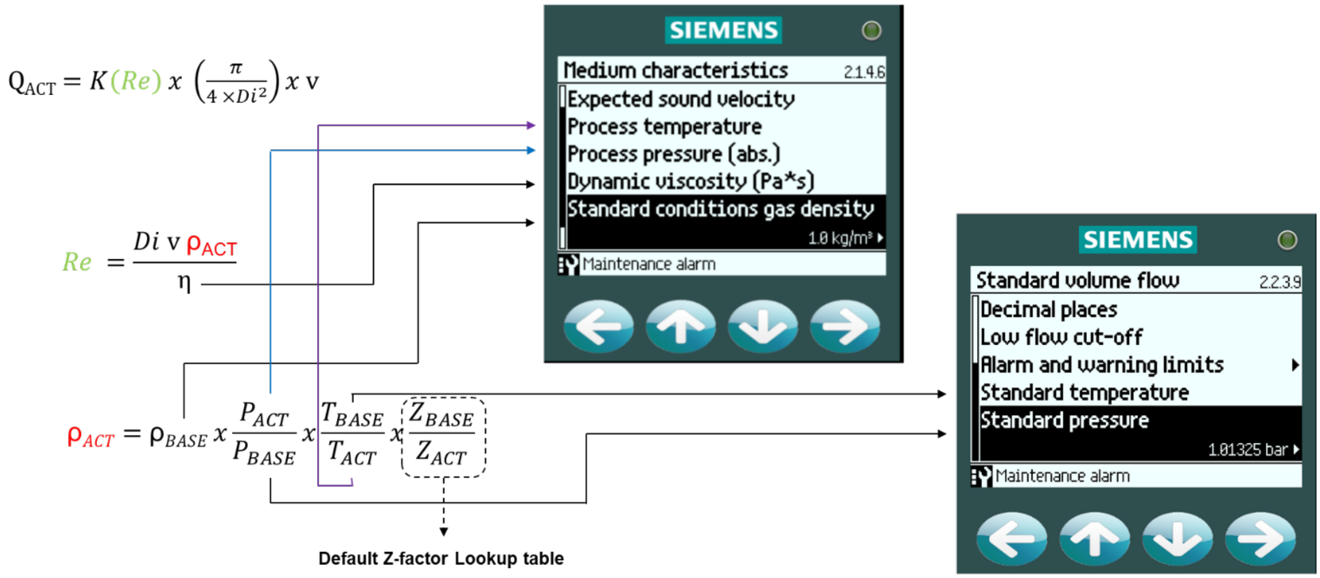
Compressibility factor (Z)

		Pressure									
		100000,0	1033333,3	1966666,6	2900000,0	3833333,3	4766666,5	5700000,0	6633333,5	7566666,5	8500000,0
Temperature	-20,0000	0,9968	0,9666	0,9359	0,9048	0,8733	0,8416	0,8101	0,7790	0,7491	0,7212
	-8,8889	0,9972	0,9712	0,9449	0,9184	0,8920	0,8657	0,8398	0,8146	0,7904	0,7677
	2,2222	0,9976	0,9750	0,9524	0,9298	0,9074	0,8854	0,8638	0,8430	0,8231	0,8044
	13,3333	0,9979	0,9783	0,9587	0,9394	0,9204	0,9017	0,8836	0,8662	0,8496	0,8342
	24,4444	0,9982	0,9811	0,9642	0,9476	0,9313	0,9154	0,9001	0,8855	0,8716	0,8587
	35,5556	0,9984	0,9835	0,9689	0,9545	0,9406	0,9271	0,9141	0,9017	0,8901	0,8793
	46,6667	0,9986	0,9856	0,9729	0,9606	0,9486	0,9370	0,9260	0,9155	0,9057	0,8967
	57,7778	0,9988	0,9875	0,9764	0,9658	0,9555	0,9456	0,9362	0,9274	0,9191	0,9115
	68,8889	0,9989	0,9891	0,9795	0,9703	0,9615	0,9531	0,9451	0,9376	0,9307	0,9243
	80,0000	0,9991	0,9905	0,9822	0,9743	0,9667	0,9595	0,9528	0,9465	0,9407	0,9354

Diagnostic sound speed

		Pressure									
		100000,0	1033333,3	1966666,6	2900000,0	3833333,3	4766666,5	5700000,0	6633333,5	7566666,5	8500000,0
Temperature	-20,0000	404,3500	398,3500	392,5800	387,1600	382,2400	378,0200	374,7600	372,7900	372,5100	374,3700
	-8,8889	412,6600	407,5400	402,7000	398,2300	394,2700	390,9500	388,4600	387,0100	386,8500	388,2400
	2,2222	420,7100	416,3400	412,2800	408,6000	405,4100	402,8100	400,9400	399,9400	399,9700	401,1900
	13,3333	428,4900	424,7800	421,3800	418,3700	415,8100	413,8100	412,4400	411,8200	412,0500	413,2400
	24,4444	436,0300	432,8800	430,0600	427,6100	425,5900	424,0800	423,1300	422,8300	423,2600	424,4800
	35,5556	443,3400	440,7000	438,3700	436,4000	434,8400	433,7400	433,1500	433,1200	433,7200	435,0000
	46,6667	450,4400	448,2400	446,3400	444,7900	443,6200	442,8700	442,5800	442,8000	443,5600	444,9100
	57,7778	457,4500	455,5400	454,0200	452,8300	452,0000	451,5500	451,5300	451,9500	452,8600	454,2800
	68,8889	464,0800	462,6100	461,4300	460,5600	460,0200	459,8400	460,0400	460,6500	461,6900	463,1700
	80,0000	470,6400	469,4800	468,6000	468,0100	467,7300	467,7800	468,1800	468,9500	470,1000	471,6600

ACTUAL VOLUME FLOW



STANDARD VOLUME FLOW

$$Q_{Standard/Norm} = Q_{ACT}\, x\, \frac{P_{ACT}}{P_{BASE}}\, x\, \frac{T_{BASE}}{T_{ACT}}\, x\, \frac{Z_{BASE}}{Z_{ACT}}$$

Z-factor Lookup table

MASS FLOW

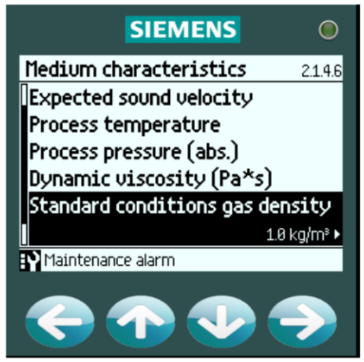
$$\boxed{Q_M = Qact\ x\ \rho_{ACT}}$$

Pressure sensor

$$\rho_{ACT} = \rho_{BASE}\ x\ \frac{P_{ACT}}{P_{BASE}}\ x\ \frac{T_{BASE}}{T_{ACT}}\ x\ \frac{Z_{BASE}}{Z_{ACT}}$$

Temp. sensor

Z-factor Lookup table



AGA8 TABLE

AGA8 Calculations

Status: Calculation Completed Successfully ☑ Create AGA8 Table

Units

Pressure:	Temperature:	Velocity:	Density:	Enthalpy:
BARA	Celsius	meters/second	kg/M3	kJ/kg

Gas Composition and Mole Fraction %

Helium: 0.0	CO2: 0.0	Ethane: 20.0	n-Butane: 0.0	n-Hexane: 0.0	n-Nonane: 0.0	Water: 0.0
Hydrogen: 0.0	H2S: 0.0	Propane: 0.0	i-Pentane: 0.0	n-Heptane: 0.0	n-Decane: 0.0	C0: 0.0
Nitrogen: 0.0	Methane: 80.0	i-Butane: 0.0	n-Pentane: 0.0	n-Octane: 0.0	Argon: 0.0	O2: 0.0

Normalize Clear Open Save Save As Total: 100.0

Gas Pressure and Temperature

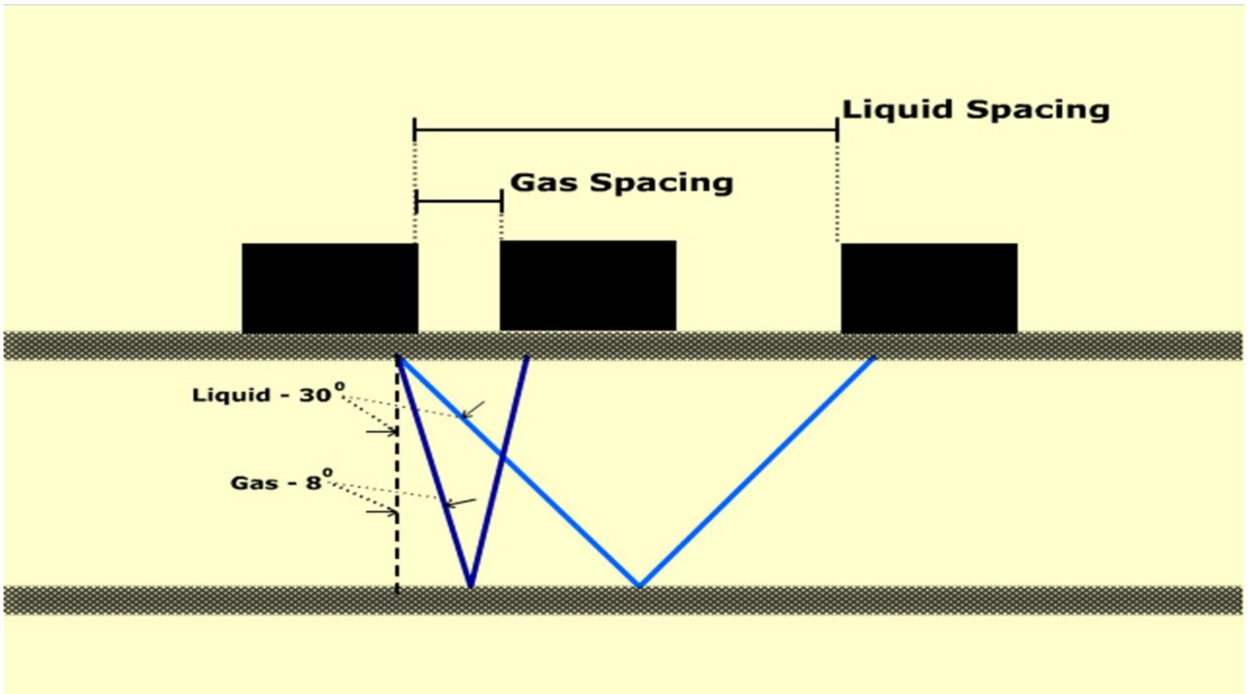
Base Pressure:	Minimum Pressure:	Maximum Pressure:	Base Temperature:	Minimum Temperature:	Maximum Temperature:
1.013	5.0	40.0	15.5	20.0	40.0

Z-Factor					Pressure (BARA)					
Temperature (deg C)	5.0000	8.8889	12.7778	16.6667	20.5556	24.4444	28.3333	32.2222	36.1111	40.0000
20.0000	0.9863	0.9756	0.9649	0.9541	0.9434	0.9326	0.9218	0.9109	0.9001	0.8894
22.2222	0.9867	0.9763	0.9658	0.9554	0.9449	0.9344	0.9239	0.9134	0.9029	0.8925
24.4444	0.9870	0.9769	0.9667	0.9565	0.9463	0.9361	0.9260	0.9158	0.9056	0.8955
26.6667	0.9873	0.9775	0.9676	0.9577	0.9478	0.9378	0.9280	0.9181	0.9082	0.8984
28.8889	0.9877	0.9780	0.9684	0.9588	0.9491	0.9395	0.9299	0.9203	0.9107	0.9012
31.1111	0.9880	0.9786	0.9692	0.9598	0.9505	0.9411	0.9318	0.9224	0.9132	0.9039
33.3333	0.9883	0.9791	0.9700	0.9609	0.9518	0.9427	0.9336	0.9245	0.9155	0.9066
35.5556	0.9886	0.9797	0.9708	0.9619	0.9530	0.9442	0.9353	0.9266	0.9178	0.9091
37.7778	0.9888	0.9802	0.9715	0.9629	0.9542	0.9456	0.9370	0.9285	0.9200	0.9116
40.0000	0.9891	0.9807	0.9722	0.9638	0.9554	0.9470	0.9387	0.9304	0.9222	0.9140
Speed of Sound (M/SEC)					Pressure (BARA)					
Temperature (deg C)	5.0000	8.8889	12.7778	16.6667	20.5556	24.4444	28.3333	32.2222	36.1111	40.0000
20.0000	402.7836	400.5581	398.3738	396.2367	394.1535	392.1312	390.1777	388.3017	386.5123	384.8198
22.2222	404.2261	402.0606	399.9375	397.8626	395.8422	393.8833	391.9934	390.1808	388.4543	386.8236
24.4444	405.6590	403.5520	401.4883	399.4737	397.5142	395.6167	393.7883	392.0370	390.3711	388.7999
26.6667	407.0824	405.0324	403.0265	401.0705	399.1702	397.3321	395.5632	393.8710	392.2637	390.7498
28.8889	408.4967	406.5020	404.5525	402.6533	400.8104	399.0299	397.3186	395.6836	394.1327	392.6742
31.1111	409.9018	407.9612	406.0664	404.2226	402.4353	400.7107	399.0551	397.4754	395.9791	394.5740
33.3333	411.2981	409.4101	407.5686	405.7785	404.0454	402.3749	400.7733	399.2471	397.8036	396.4500
35.5556	412.6856	410.8490	409.0593	407.3216	405.6409	404.0230	402.4737	400.9994	399.6068	398.3031
37.7778	414.0646	412.2780	410.5389	408.8520	407.2224	405.6554	404.1568	402.7327	401.3895	400.1340
40.0000	415.4352	413.6974	412.0075	410.3701	408.7901	407.2726	405.8233	404.4478	403.1524	401.9434

Calculate Send Table Erase Flash Stop Print View Manual Exit

GAS PROPERTIES – GAS AND LIQUID COMPARISON

Gas and liquid installation comparison (beam angle)



GAS PROPERTIES – GAS AND LIQUID COMPARISON

Parameter	***Clamp-On Water***	***Insert Gas @ 15 barg***	***Clamp-On Gas @ 15 barg***	***Units***
Fluid Sound Velocity	1500	400	400	m/sec
Signal Amplitude	100	20	1	mV
Beam Angle	30	45	7	degrees
Transit-Time	234.6	1077.6	767.7	usecs
Delta-Time @ 10m/s velocity	1.63	38.1	5.34	usecs
# cycles delta	0.70	4.57	2.30	cycles

BENEFITS

- Wide range of pipe sizes, 10 mm to 10m (0.5" to 394")
- Large turn-down ratio (can be +/- 400:1)
- No pressure drop
- Bi-directional flow
- No cutting into the pipe or stopping the process required
- Clamp-on independent of pipe size (cost)
- Conductive and non-conductive liquids & gases
- No potential for leak point
- Low installation costs
- Retrofits easily
- Ideal as a replacement for other meters or for existing pipelines with no meters in place
- Maintains measurement over a wide range of liquids
- As accurate as conventional meter technologies
- Actual and Standard Volume flow measurement
- Dynamic Viscosity compensation, Pressure, & Temperature
- Pig Detector capability

BENEFITS

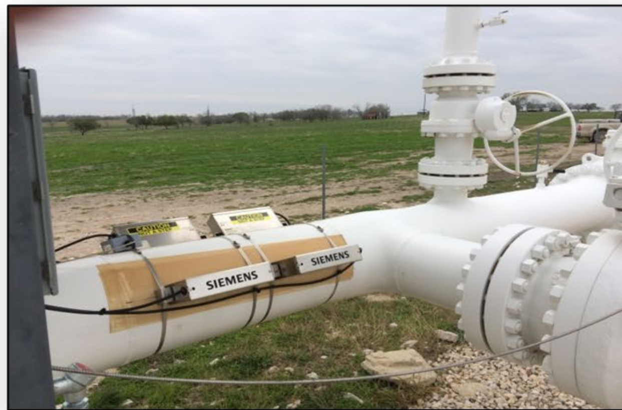
- **Valve leak check – It is easy to temporally install a pair of transducers for leak checking a suspect valve. If velocity is indicated, a complete installation can be performed to obtain further data. Low velocity, even a fraction of a foot per second, accumulates to significant value over time.**
- **Evaluating the performance of pigging or cleaning – The clamp-on meter is useful to identify change effects for special field actions like cleaning. Base data can be obtained at four or more flow rates before cleaning and then the related tube can be cleaned, and another set of data will show the effect of cleaning.**

FIELD INSTALLATIONS

Pipeline Measurement

Storage Field Check Measurement (LAUF)

FIELD INSTALLATIONS



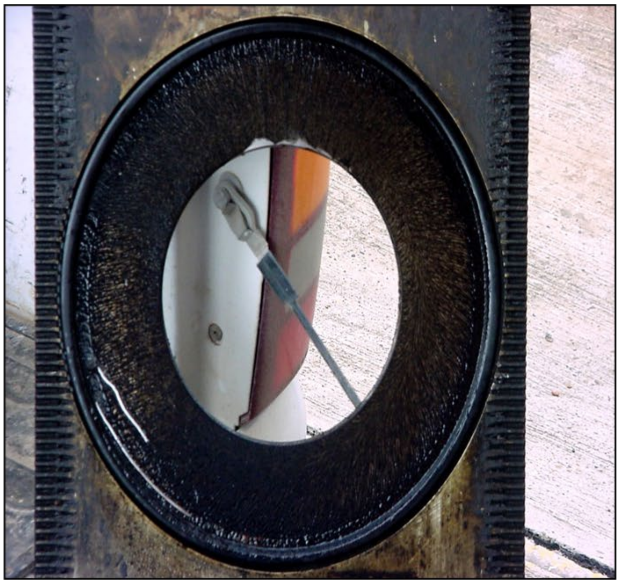
This installation had about 1-D Up & 1-D Down from the meter.

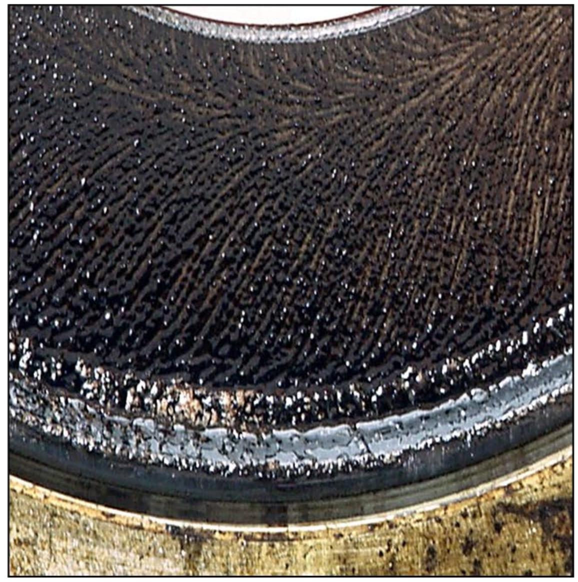
After four months of running a wide variety of flow rates it was determined the meter had a constant +2.5% bias from the system balance.

The meter was using the pipe anomaly table, but we still needed to do an adjustment.

Result: The user is very happy with the measurement.

FIELD INSTALLATIONS – WHAT CAN GO WRONG? WHY YOU NEED "CHECK METERS"





Dirty Gas = Bad Measurement

12" pipe 0.1" build up Cross sectional change 113.09 to 111.22 =1.65%

FIELD INSTALLATIONS

42” Field Clamp-On

APPLICATION – GAS UNDERGROUND STORAGE

Challenge:

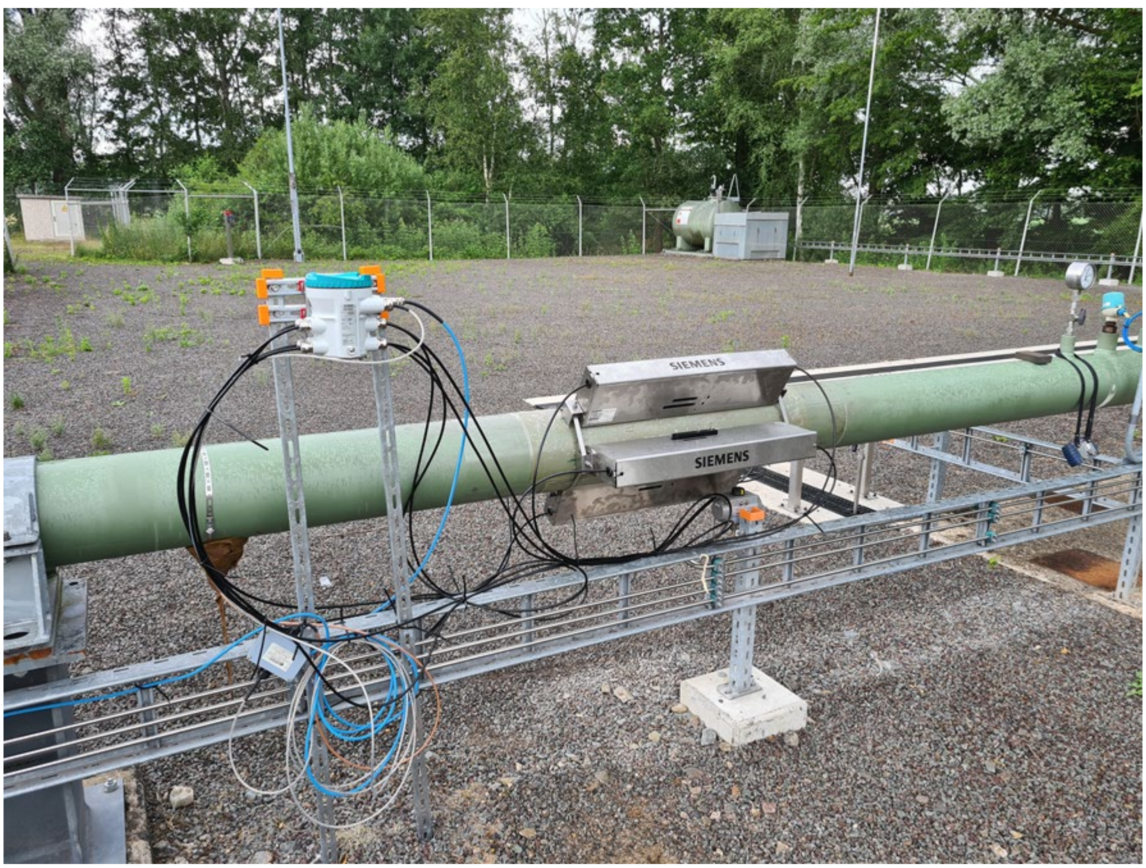
- Unable to stop flow and depressurize line
- Limited straight run.
- Poor outer diameter to wall thickness ratio
- OD = 221 mm (8 inch), WT = 22mm (0.86 inch)

Product:

SITRANS FS230 4-path with gas software (option B50)

Main benefits:

- Non-intrusive
- Much lower installation cost than inline meters due to external sensors, which do not require cutting of pipes or interruption of flow
- High-quality diagnostic data
- Anomaly compensation



APPLICATION – TRANSPORTATION GAS PIPELINE

Challenge:

- Very large pipe size. OD = 1120 mm (44 inch)
- Hydrogen is injected near the installed sensors.
- The sensors are buried after installation

Product:

SITRANS FS230 4-path with gas software (option B50)

Main benefits:

- Much lower installation cost than inline meters due to pipe size.
- FS230 4-path system
- Hydrogen has no contact with the sensors
- The stainless-steel mounts provide a firm grip and are therefore perfect for buried installation.

APPLICATIONS – FLARE GAS APPLICATION

Challenge:

- Pressure below atmospheric (vacuum)
- 14 PSI absolute / 0.96 bar absolute
- Very high flow velocities

Product:

SITRANS FUG1010 2-Path

Main benefits:

- No potential for leak point
- Low installation costs
- No cutting into the pipe or stopping the process required

FIELD INSTALLATION REQUIRED ACCESSORIES

Thickness Gauge

Level

Pi Tape

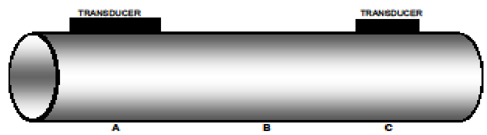
FIELD INSTALLATION MEASUREMENT FORM

SIEMENS

Field Installation measurement form for Clamp on ultrasonic meters

Meter Location/Identifier	ABC Pipeline, South TX gathering station #1 12" Schedual 80	
Units of Measurement	SI	(Type US for inches or SI for mm)
Nominal Diameter of Pipe	12	
Tape Measure Type	S	(Type P for "PI" tape/S for Standard tape) 1/8 OR 1/4 WIDE

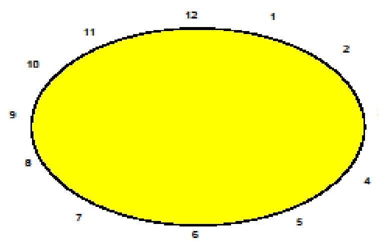
clean the pipe before measuring
remove loose paint



	A	B	C
Meas. 1	12.75	12.83	12.81
Meas. 2	12.79	12.91	12.88

Calc. Pipe O.D. = 12.828

Point#	A	B	C
1	0.500	0.511	0.509
2	0.511	0.522	0.502
3	0.522	0.521	0.505
4	0.521	0.502	0.503
5	0.502	0.505	0.500
6	0.505	0.503	0.511
7	0.503	0.505	0.522
8	0.505	0.507	0.507
9	0.507	0.509	0.509
10	0.509	0.505	0.512
11	0.512	0.507	0.507
12	0.510	0.503	0.509



do not put zero in boxes leave box empty

Average wall thickness = 0.508

Calculated Pipe I.D. = 11.812

AVOID MOUNTING TRANSDUCERS ON SEAMS
CLEAN ALL LOOSE PAINT FROM PIPE

FIELD INSTALLATION – APPLICATION DATA SHEET (ADS)

SIEMENS Industry

SITRANS FS230 Gas Field Clamp-On Flowmeter Application Data Sheet

Email To: piabusales.industry@siemens.com or FAX TO: 972-522-4503

Instructions: Navigate through the form using the TAB key or mouse. To select a checkbox, click with mouse or press the SPACEBAR. To select units, click and choose from drop-down menu.

Requestor Information		Customer Information		End-User Information	
Company Name:		Company Name:		Company Name:	
Requestor Name:		City:		City:	
Phone:		State*:		State*:	
E-mail		Country*:		Country*:	

Selected Part Numbers:

Process Information

Gas Data:

Gas Type: ☐ Natural Gas ☐ Process Gas ☐ Other Gas ___ Amount of CO2: ___%

Gas Condition: ☐ Dry ☐ Wet % Moisture: ___

If Known, include Mole fraction list:

Methane:	%	Ethane:	%	Propane:	%	Isobutane:	%	n-Butane:	%
Isopentane:	%	n-Pentane:	%	n-Hexane:	%	Carbon Dioxide:	%	Nitrogen:	%
Hydrogen:	%	Water:	%	Oxygen:	%	Hydrogen Sulfide:	%	Carbon Monoxide:	%
Other:	%								

Process Data:

Flow Range: Min: ___ Typical: ___ Max : ___ Units: ___

Operating Pressure: Min: ___ Typical: ___ Max: ___ Units: ___

Operating Temperature: Min: ___ Typical: ___ Max: ___ Units: ___

Installation

Pipe Data:

Actual Outside Diameter: ___ ☐ Inches ☐ mm <OR> Nominal Pipe Size: ___ ☐ Inches ☐ mm

Pipe Material Choose if Other: ___ | Schedule Choose if Other: ___

Pipe Wall Thickness: ___ | Class Choose if Other: ___

Liner Material: Not Applicable if Other: ___ | Liner Thickness: ___ ☐ Inches ☐ mm

Unrestricted
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Flow Sensor Location:

Straight run in pipe diameters: Up stream: ___ Down stream: ___

Length of unobstructed pipe: ___ ☐ Feet ☐ Meters | Both sides of pipe accessible? ☐ Yes ☐ No

Number of beams (single measuring point) ☐ 1 ☐ 2 ☐ 3 ☐ 4 (Number of beams will be recommended based on accuracy requested)

Flow Sensor Data:

Type: (Choose all applicable) ☐ Submersible ☐ Dedicated ☐ Portable Other: ___

Sensor Type: ☐ Standard Sensor (Aluminum head) ☐ Corrosion Resistant (S.S. head)

Sensor Mounting: ☐ Standard mounting frames ☐ Stainless Steel enclosures

Will sensors be located: ☐ Indoors ☐ Outdoors | Will sensors be installed in a hazardous area? ☐ Yes ☐ No

If yes, Agency and Area Rating ☐ FM/CSA Choose ☐ CENELEC Zone: Choose Protection type: Choose Other: ___

Temperate / Pressure Data: (if required)

Check all that apply:

Available 4-20 mA temperature signal?	☐ Yes ☐ No
If No, Siemens Industry supplied Temperature?	☐ Yes ☐ No
Available 4-20 mA Pressure signal?	☐ Ye s ☐ No
If No, Siemens Industry supplied Pressure Transmitter?	☐ Yes ☐ No

Temperature Element ☐ Clamp-On ☐ Insert ☐ 4-20mA input

Pressure Transmitter (if required) : Pressure Range Min: ___ Typ: ___ Max: ___

Cables:

Length from transducer to flowmeter: ___ ☐ Feet ☐ Meters | Type: Choose if Other: ___

Transmitter

Enclosure desired: ☐ Splash proof IP65, Nema 4x ☐ Flame/Explosion proof (Nema 7)

Input Power Choose

Temperature at Flow Transmitter: Min: ___ Typ: ___ Max: ___ ☐ ºF ☐ ºC

If yes, Agency and Area Rating: ☐ FM/CSA Choose ☐ CENELEC Zone: Choose Protection type: Choose

Other:___

Unrestricted
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Outputs required:		Communications:
☐ 4-20 mA Qty: ___	☐ Pulse Qty: ___	☐ Modbus
☐ 0-10V Qty: ___	☐ Frequency Qty: ___	☐ RS-232
☐ Relay Qty: ___		

Output type (Pick One): Actual flow (uncorrected) ☐
OR Standard volume or mass (Corrected) ☐
Compensation type (only if corrected) ☐ AGA 8 Detailed Other: ___

Performance:

Desired Accuracy: ___% of rate, Repeatability: ___%

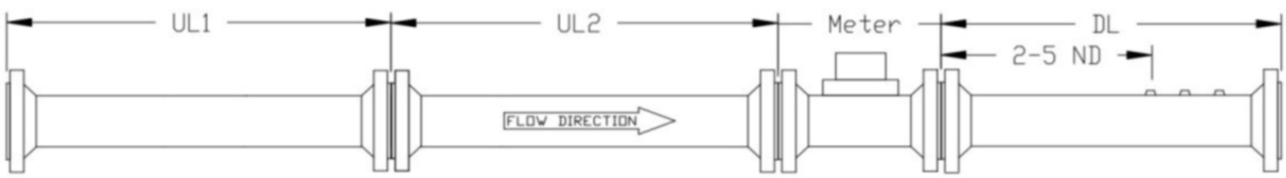
Flow Direction: ☐ Uni-directional ☐ Bi-Directional

CUSTODY TRANSFER – LETS GET OUR HEADS INTO THE PIPE

FIELD INSTALLATION COMPARED TO CUSTODY TRANSFER INSTALLATION

CUSTODY TRANSFER METER RUN IN ACCORDANCE WITH AGA NO.9 GUIDELINES

- **3rd party measurement and fabrication specialist built an engineered 16" meter run**
  - **The meter run was:**
    - **A precision honed pipe**
    - **Precise concentricity**
    - **Precise cross-sectional area**
  - **Spool was installed with:**
    - **Up stream flow conditioners (CPA Plate)**
    - **Dual path, Clamp-on ultrasonic gas meter**
  - **The assembly was then calibrated and linearized at CEESI on their natural gas pipeline.**



CALIBRATION ADJUSTMENT FACTORS / CALIBRATION TEST REPORT (AGA REPORT NO. 9)

AGA Report No. 9 sec. 6.5 Calibration Adjustment Factors

Calibration factors are applied to minimize any meter-bias offset:

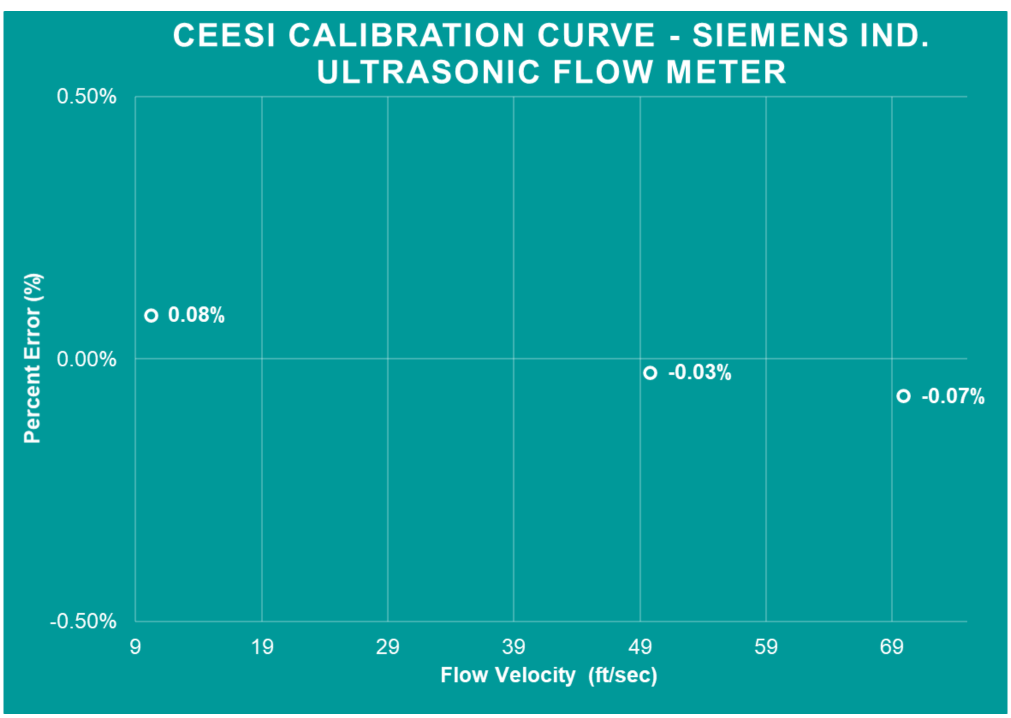
- **To meet AGA 9 accuracy, meters 12" and larger shall have a maximum error of +/- 0.70% as found**
- **Piece-wise / Multi-point linear or (PWL) interpolation – used to linearize the meter**

Flow data after calibration and linearization

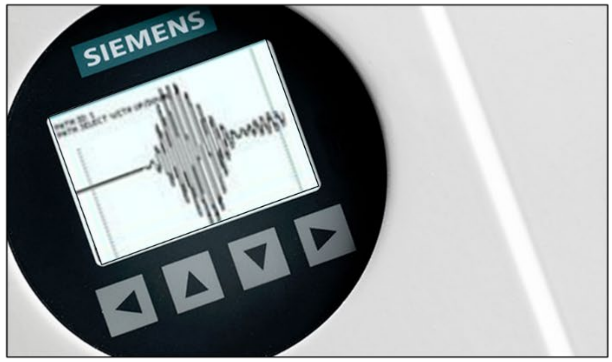
Ceesi Flowrate [ACFH]	Meter Flowrate [ACFH]	Velocity [ft/sec]	Percent Error [%]
308530.3	308313.3	69.9	-0.070
219754.6	219700.3	49.8	-0.025
44849.57	44887.22	10.2	0.084

CEESI SPOOL AND METER ACCURACY DATA

Taking the unknown and making it known!



Enhanced Diagnostics



Signal wave shapes
Signal-to-noise ratio
Signal strength

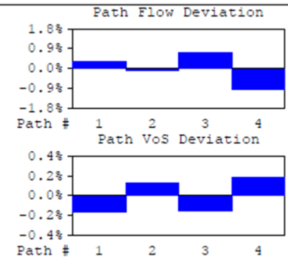
BENEFITS

- Assessment of flowmeter status
- Detailed information about the measured medium

CRITICAL DIAGNOSTICS – FS200 UTILITY

Process values		Units
Flow Rate:	6085.564	m3/h
Standard Volume Flow Rate:	6022.429	Nm3/h

Path diagnostics	Path 1	Path 2	Path 3	Path 4	Path 5	Pass/Fail	Units
RX Gain(up)	13.750	15.000	15.000	21.250		Pass	
RX Gain(dn)	13.750	15.000	15.000	21.250		Pass	
SNR(up)	61	65	59	55		Pass	
SNR(dn)	56	62	58	55		Pass	
Status:	Measurement	Measurement	Measurement	Measurement		Pass	
Correlation Q:	0.99	1.00	0.99	0.97		Pass	
%Accepted:	100	100	100	100		Pass	
Delta-Time nsec:	2689.112	2671.622	2699.071	2652.008			
Flow & VoS							
Flow Velocity:	2.296	2.286	2.304	2.267		Pass	m/s
VoS:	1337.82	1341.68	1337.97	1342.47		Pass	m/s



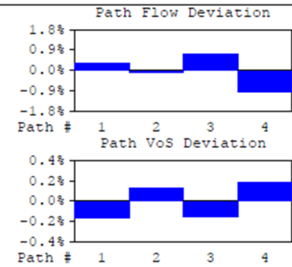
	Description	Typical values
GAIN	Receive amplifier gain value for the receive signal. Lower gain values indicate a stronger receive signal.	0 to 50 dB
SNR	Signal to Noise Ratio of the signal. A high SNR indicates less baseline noise on the receive signal.	20 to 80 dB
Correlation factor	A dimensionless indication of how strongly correlated the upstream and downstream signal are to each other. A value of 1 represents the best correlation, 0 the worst.	0.9 to 1.0
Accepted	% of bursts accepted Based on various diagnostic input (i.e. correlation strength, gain level, SNR, etc.) the meter may reject specific up/down receive sets or bursts. The percentage of accepted bursts is one measure of the application's health. Less than 100% generally indicates a disruption in the fluid, such as from suspended solids or bubbles in the liquid.	99 to 100 %

CRITICAL DIAGNOSTICS – AGA10 SPEED OF SOUND (SOS)

Process values		Units
Flow Rate:	6085.564	m3/h
Standard Volume Flow Rate:	6022.429	Nm3/h

Path diagnostics	Path 1	Path 2	Path 3	Path 4	Path 5	Pass/Fail
RX Gain(up)	13.750	15.000	15.000	21.250		Pass
RX Gain(dn)	13.750	15.000	15.000	21.250		Pass
SNR(up)	61	65	59	55		Pass
SNR(dn)	56	62	58	55		Pass
Status:	Measurement	Measurement	Measurement	Measurement		Pass
Correlation Q:	0.99	1.00	0.99	0.97		Pass
%Accepted:	100	100	100	100		Pass
Delta-Time nsec:	2689.112	2671.622	2699.071	2652.008		

Flow & VoS							Units
Flow Velocity:	2.296	2.286	2.304	2.267		Pass	m/s
VoS:	1337.82	1341.68	1337.97	1342.47		Pass	m/s



	Description	Typical values
GAIN	Receive amplifier gain value for the receive signal. Lower gain values indicate a stronger receive signal.	0 to 50 dB
SNR	Signal to Noise Ratio of the signal. A high SNR indicates less baseline noise on the receive signal.	20 to 80 dB
Correlation factor	A dimensionless indication of how strongly correlated the upstream and downstream signal are to each other. A value of 1 represents the best correlation, 0 the worst.	0.9 to 1.0
Accepted	% of bursts accepted Based on various diagnostic input (i.e. correlation strength, gain level, SNR, etc.) the meter may reject specific up/down receive sets or bursts. The percentage of accepted bursts is one measure of the application's health. Less than 100% generally indicates a disruption in the fluid, such as from suspended solids or bubbles in the liquid.	99 to 100 %

SUMMARY

- **Clamp-on – “Field Installed” - Proper evaluation and tools can yield high accuracy (0.5% - 1.0% or better)**
- **Clamp-on Ultrasonic flow meters can measure:**
  - **Actual Gross Volume Flow**
  - **Standard Volume Flow – Compensated for Pressure and Temperature**
  - **Mass Flow – Compensated for Pressure, Temperature, and Density**
  - **The Siemens Clamp-on Gas meter can correct for the theoretical flow profile based on actual piping**
- **Critical Diagnostics – Vs, Signal Wave Shape, Gain, SNR, Correlation Factor, and Accepted**
- **Clamp-on Gas meters can meet AGA9 Custody Transfer (CT) meter package performance requirements**