Kuwait 4th Flow Measurement Technology Conference

3-5 December 2019

Hilton Kuwait Resort

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EIKE SCHWEDE

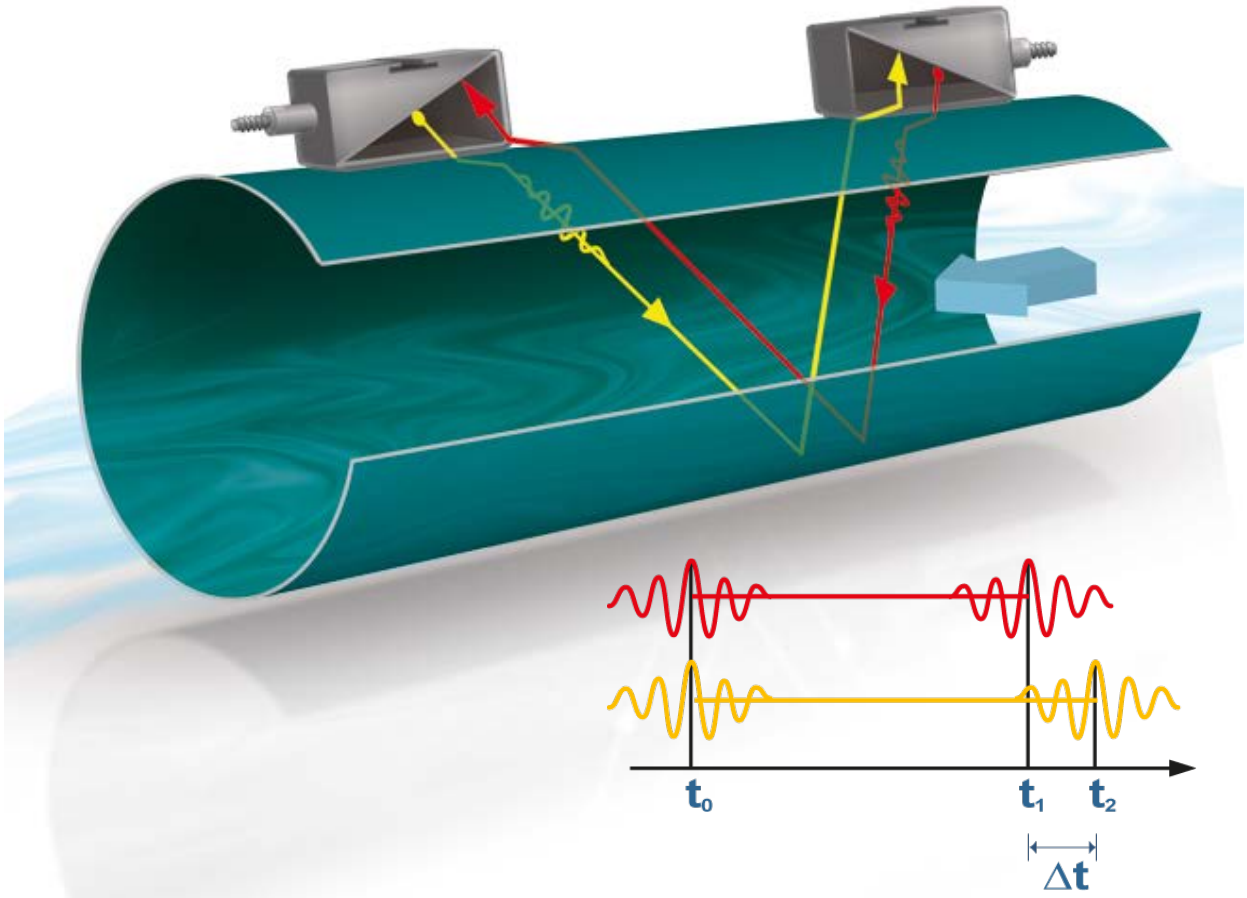
Business Unit Leader - FLEXIM

Clamp-on Mass Flow Measurement

FLEXIM

- FLEXIM: a specialist in Clamp-On Ultrasonic Flow Measurement
- Metering solutions for Liquids and Gases as well as Process Concentration Analytics
- Headquartered in Berlin, Germany, with more than 400 employees worldwide
- International presence with offices in Europe, United States, Middle East, and Asia, etc.
- Strong investment in R&D and in-house production facilities
- Huge installed instrumentation base (>100,000 units worldwide) + over 8,000 new meters per year

Clamp–on Transit Time Ultrasonic Flow Measurement



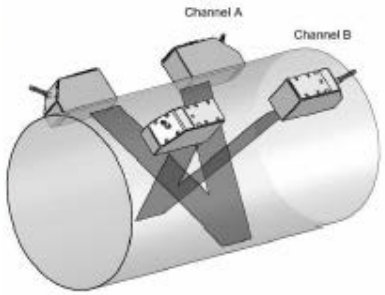
Calculation of Volume Flow [Q]

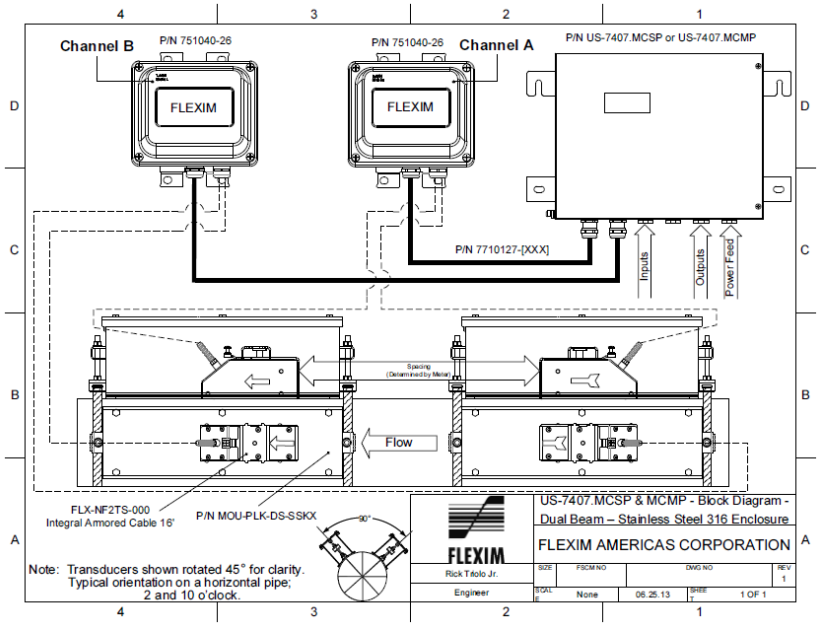
$$Q = K_{RE} \times A \times k_{\propto} \times \frac{\Delta t}{2 \times t_t}$$

Q	Volume Flow
K_{RE}	Fluid Mechanical Correlation Factor
A	Cross-Sectional Area of Pipe
k_a	Transmitter-Constant
D t	Transit Time Difference
t_t	Transit Time in Medium

Components of the mass flow measurement

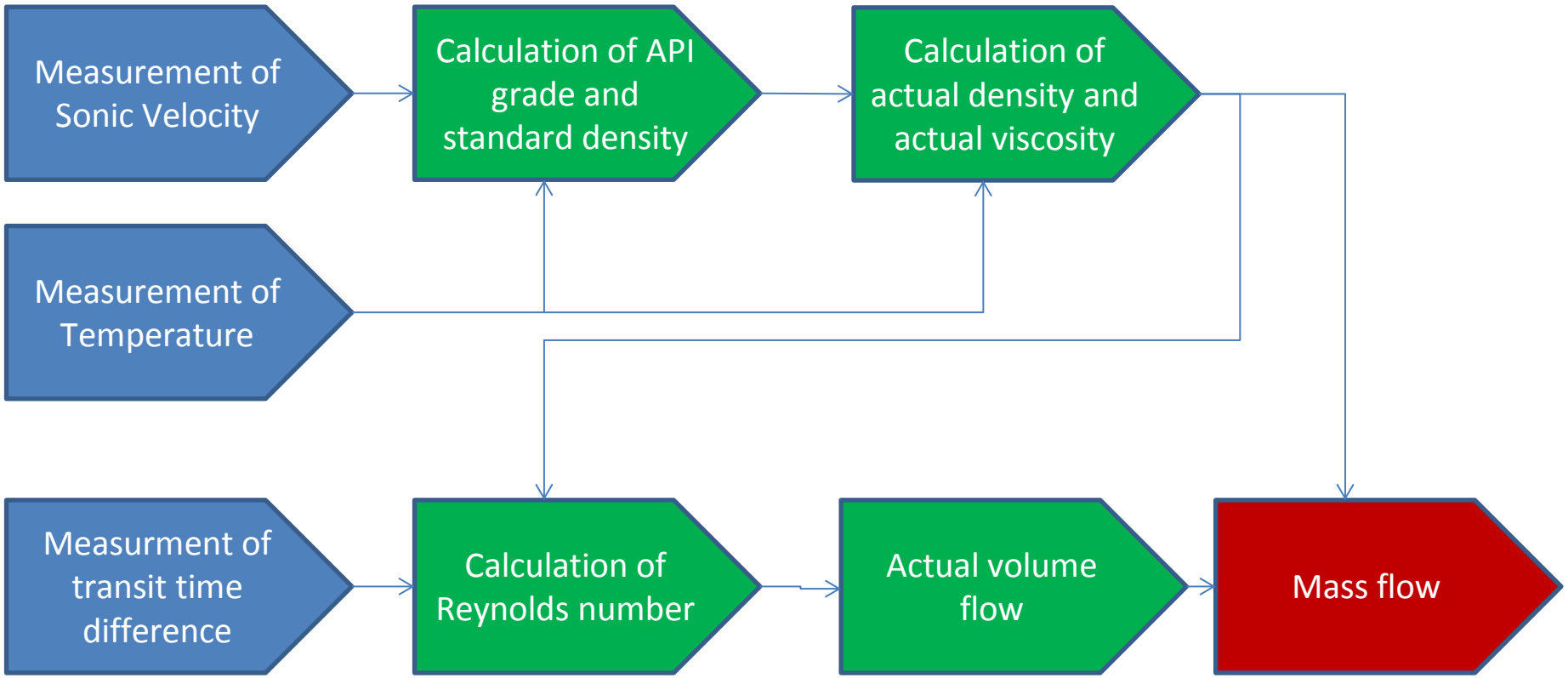
- FLEXIM FLOW METER
  - Always Dual Beam (min)
    - Quad Beam Option
  - Always has a Temp input (min)
    - Could have Pressure as well
- TRANSDUCERS
  - Lamb Wave for some Multi-Products
  - Lamb Wave for most Crudes
  - Shear Wave for most Refined Products





ADM 7407 meter in Stainless Steel Enclosure

How to get the mass flow

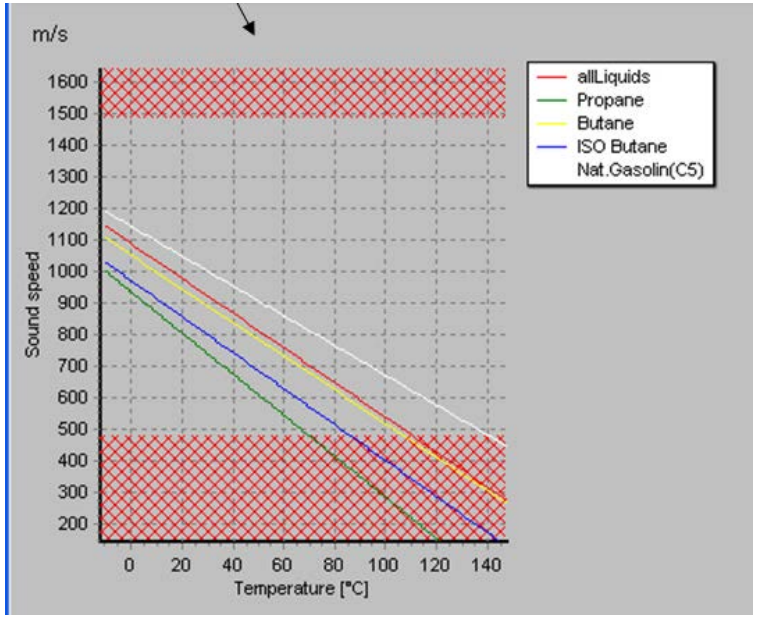


Background

Multiple Product Standard Volume + Mass Compensation and Interface Detection Algorithm

– Providing Temperature Compensated Volume Algorithm as per ASTM 1250, TP25, D4311 standard volume correction different liquids

Multi Product HPI meters must apply correct liquid characteristics (Algorithm, Viscosity, & Density) to ensure an accurate flow measurement.



Product Identifier	Total Sulphur (% by wt.)	Pour Point (C)	Reid Vapour Pressure (kPa)	Density (kg/m3)	Viscosity (cSt) at Specified Temperature (degree Celsius) 10.00	20.00	30.00	40.00	45.00
AHS	2.39	<-30*	43	935.9	257.00	131.00	72.00	43.60	34.90
AWB	3.65	n/a	n/a	918.2	263.00	139.00	79.40	50.00	41.90
BR	2.86	<-30*	32	925.9	197.00	106.00	62.50	39.20	31.80
CL	3.74	<-30*	52	926.4	284.00	148.00	85.10	54.20	43.90
CSB	3.67	<-30***	34	925.3	317.00	163.00	92.30	56.60	45.30
F	3.2	<-30***	8	931.2	261.00	145.00	80.90	49.00	39.20
HSB	0.1	<-30*	40	861.6	12.10	8.45	6.20	4.73	4.18
LLB	3.47	<-30*	50	925.4	297.00	155.00	89.20	55.10	54.20
LLK	3.27	<-30*	54	927.3	291.00	153.00	87.20	53.20	45.00
LSB	1.02	-20*	69.5	846.6	8.00	5.82	4.54	3.63	3.36
M	2.36	-8*	54.2	882.8	23.60	14.10	9.73	7.23	6.40
MKH	2.93	<-30***	25	936.4	247.00	128.00	72.70	44.80	36.00
NSA	0.11	<-30*	38	856.4	8.97	6.58	5.02	3.96	3.55
OSA	0.18	<-30*	38	857.7	7.19	5.34	4.12	3.28	2.94
OSH	2.99	<-30*	14	931.9	95.80	50.70	29.80	19.00	15.50
PAS	0.05	<-30*	1	855.7	6.93	5.15	3.99	3.18	2.78
PSH	2.81	n/a	n/a	932.5	n/a	n/a	n/a	n/a	n/a
SC	2.98	<-30*	46	932.3	270.00	142.00	81.80	50.70	41.20
SH	4.64	<-30*	55	929.1	249.00	249.00	77.90	49.40	40.20
SHB	2.63	n/a	17	933.4	320.00	320.00	88.50	53.20	42.40
SHE	1.67	-26*	50.8	856.6	12.80	12.80	6.71	5.20	4.70
SO	1.62	-29*	76	867.9	24.30	24.30	11.60	8.67	7.59
SSX	0.15	<-30*	3	868.7	20.40	20.40	9.46	6.96	6.06
SW	0.46	-20*	63.2	825.9	7.11	7.11	4.23	3.43	3.19
SYN	0.17	<-30*	28	864.7	10.90	10.90	5.75	4.44	3.94
UHC	0.37	-29*	58.4	830.6	6.84	6.84	4.24	3.48	3.24
WCB	3.13	<-30*	34	928.5	275.00	275.00	83.20	51.50	41.50
WCS	3.41	<-30*	34	928.1	280.00	280.00	84.60	52.20	43.20
WH	4.06	<-30*	46	931.1	305.00	305.00	91.10	56.20	45.60
P	0.43	-21*	55.0*	822	6.16	4.52	3.53	2.80	2.58
SES	1.26	-21*	52	840.6	7.43	5.63	4.23	3.41	3.08

Background

Product Standard Volume Compensation – Providing Temperature Compensated Volume Algorithm as per ASTM 1250, TP25, D4311 standard volume correction.

Implemented Standards :

ASTM D1250	Crude oils, Gasolines and Naphthalenes, Jet fuels and Kerosenes, Diesels, heating oils and fuel oils Lubricating oils
TP25	Light Hydrocarbons (Ethen, Butane, Propane, etc.)
ASTM D4311-04	Asphalt

WHERE DO WE USE THESE METERS

Refinery Applications:

- Check Metering – Typically checking stability/accuracy of a different technology/CTM
- Leak Detection – Usually short segments with meter to meter balance

APPLICATIONS

Check Metering Applications:

FLEXIM HPI Meters can be used to verify other types of Custody Transfer Meters or vital metering locations.

Application – Third Party Verification for Ethylene; Pipeline Terminal near Orange, TX

APPLICATIONS

Leak Detection Applications:

FLEXIM HPI Meters can be used as a stand-alone leak detection system or used in conjunction with a Leak Detection System.

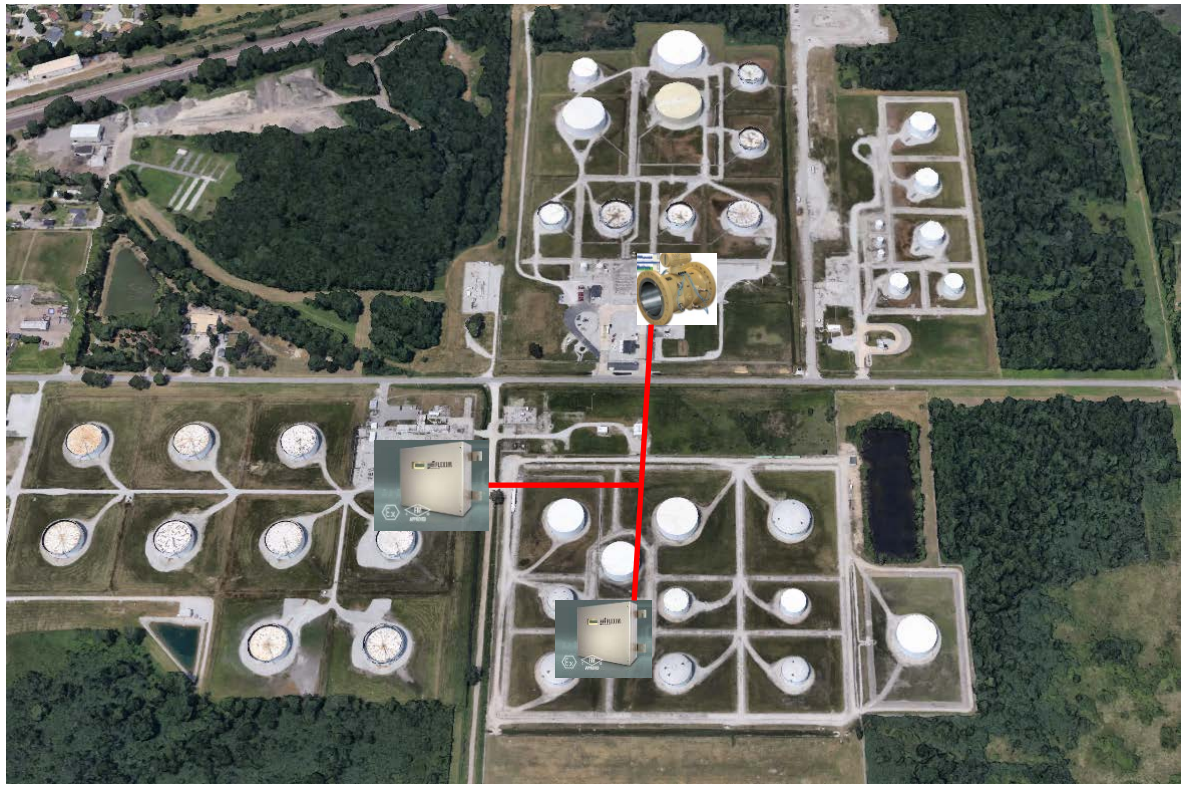
Point to Point Stand Alone System:

- FLEXIM to FLEXIM
- FLEXIM to CTM

FLEXIM to FLEXIM Leak Detection
2.5 miles from Tank to Tank at a Refinery

APPLICATIONS

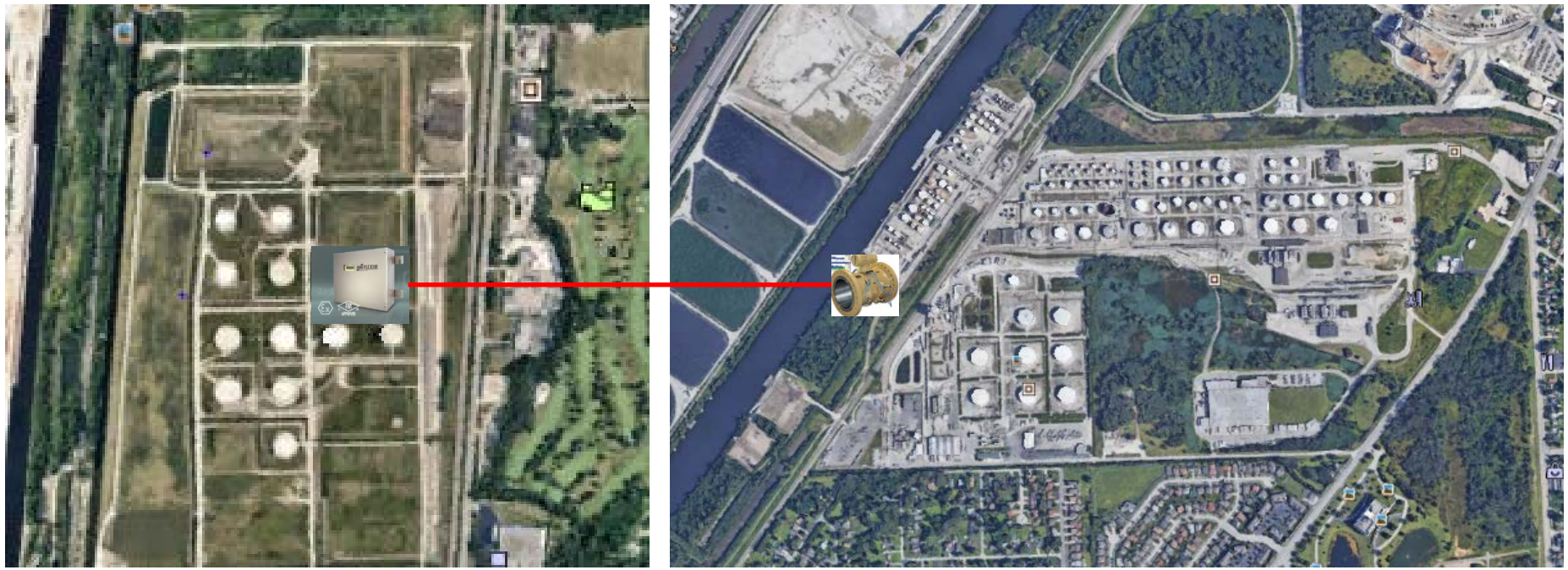
FLEXIM to Custody Transfer Leak Detection
0.5 miles from Tank Farm to Tank Farm



APPLICATIONS

Point to Point with Leak Detection System

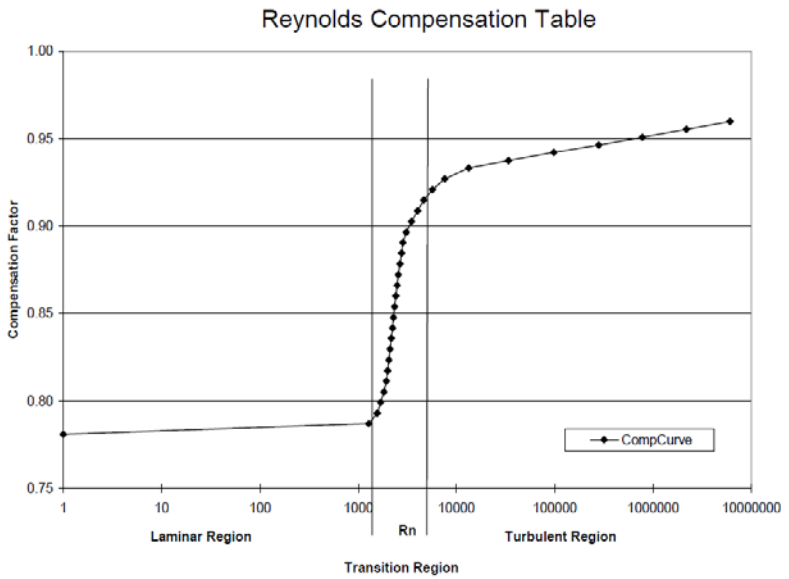
FLEXIM to Custody Transfer Leak Detection
12.5 miles from Tank Farm to Tank Farm
used in conjunction with a proprietary LDS
that uses Flow, Pressure and Temperature inputs



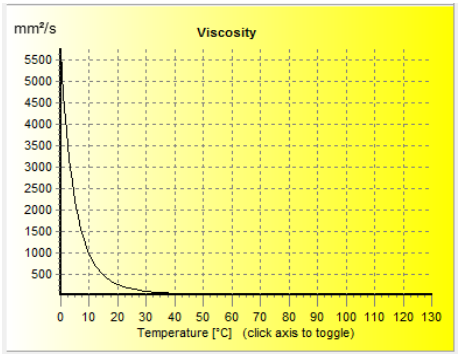
INFLUENCE FACTORS

FACTORS FOR ACCURATE MEASUREMENT:

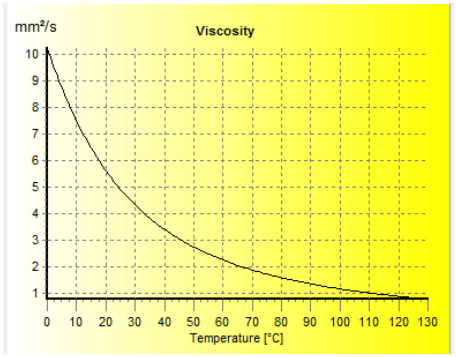
- Uncertainties – Pipe and liquid
  - Pipe Geometry
  - Accurate information for liquid
- Reynolds Correction for Viscosity
  - For Crude Oils, extremely important
- Correct Liquid Identification
  - Customer input necessary
  - Optimization of Meters



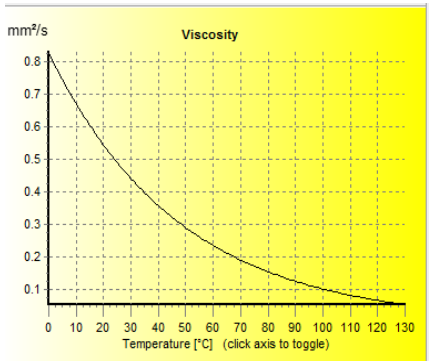
Heavy Crude



Light Crude



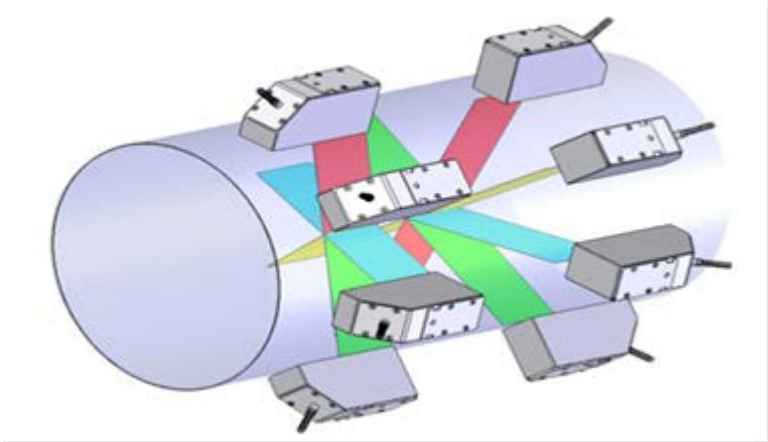
Gasoline

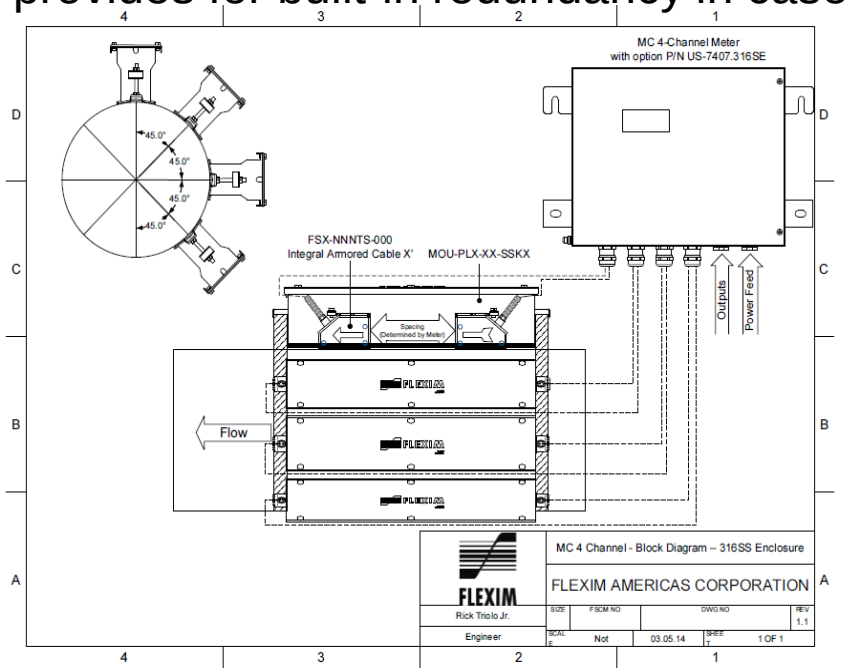


TEST AT CEESI 2016

4 Channel Meter Up to 8 Paths

This mounting arrangement is ideal for large pipes / limited straight run installations. This metering solution not only mitigates the affect of poor upstream piping conditions and large pipe profile influences but also provides for built-in redundancy in case of a signal path interruption.

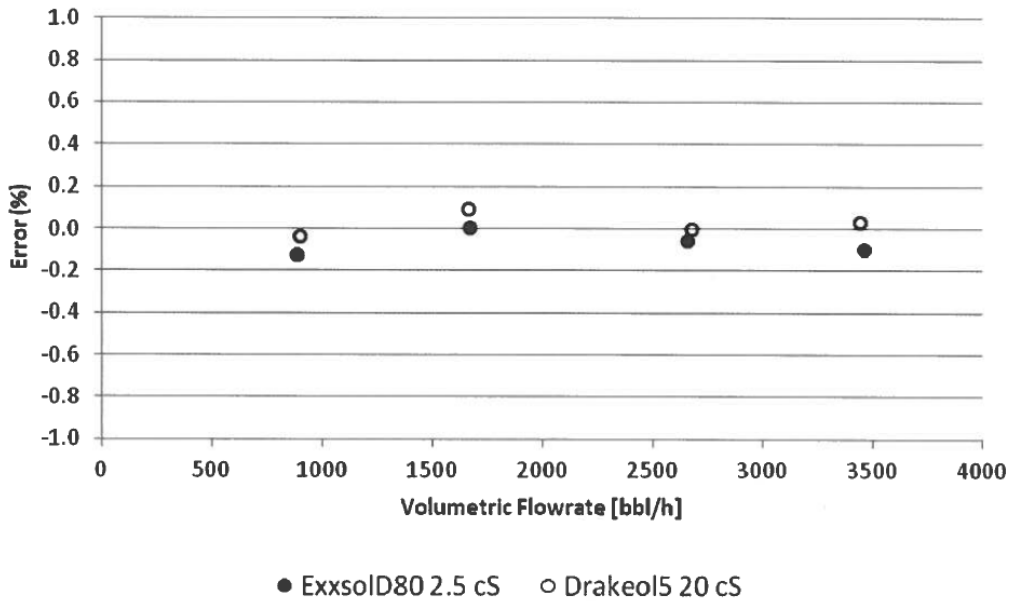




TEST AT CEESI 2016

Pt.	Fluid	Avg VolFlow [bbl/h]	Avg Error [-]	Spread [%]	Runs [-]
1	ExxsolD80	3467.3	-0.101	0.028	3
2	ExxsolD80	2661.8	-0.055	0.073	3
3	ExxsolD80	1672.8	0.005	0.131	3
4	ExxsolD80	889.77	-0.122	0.183	3
5	Drakeol5	3448.2	0.034	0.133	3
6	Drakeol5	2679.4	0.000	0.094	3
7	Drakeol5	1663.9	0.096	0.104	3
8	Drakeol5	901.31	-0.039	0.273	3

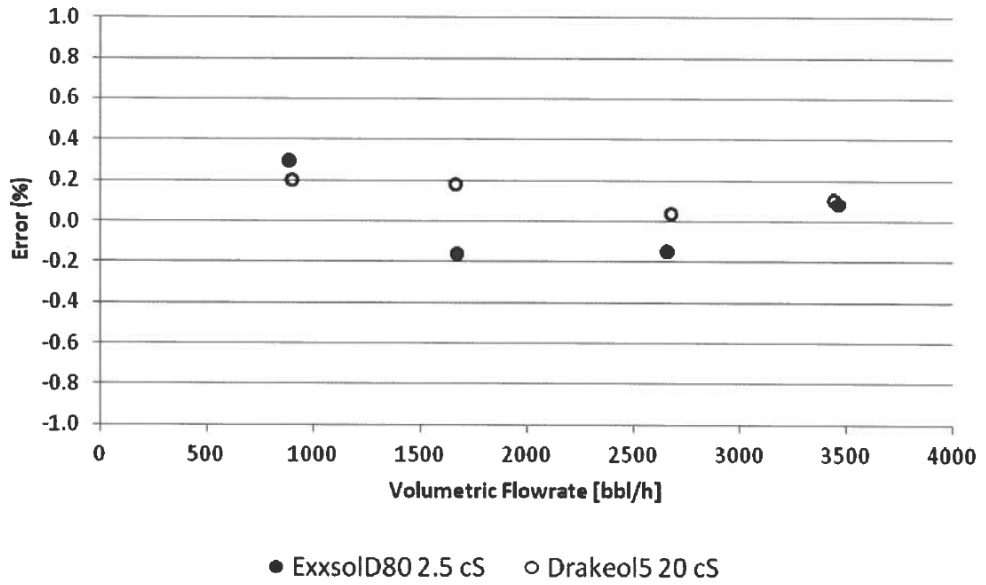
Table 3: Average Calibration Data



4-Channel Results had average errors below +/- 0.125% and a maximum error of 0.192% on both test fluids. The FLEXIM Meters were compared to custody type flow meters that were proved.

TEST AT CEESI 2016

Pt.	Fluid	Avg VolFlow [bbl/h]	Avg Error [-]	Spread [%]	Runs [-]
1	ExxsolD80	3467.3	0.088	0.177	3
2	ExxsolD80	2661.8	-0.143	0.234	3
3	ExxsolD80	1672.8	-0.157	0.403	3
4	ExxsolD80	889.77	0.296	0.346	3
5	Drakeol5	3448.2	0.105	0.083	3
6	Drakeol5	2679.4	0.041	0.292	3
7	Drakeol5	1663.9	0.181	0.025	3
8	Drakeol5	901.31	0.199	0.150	3

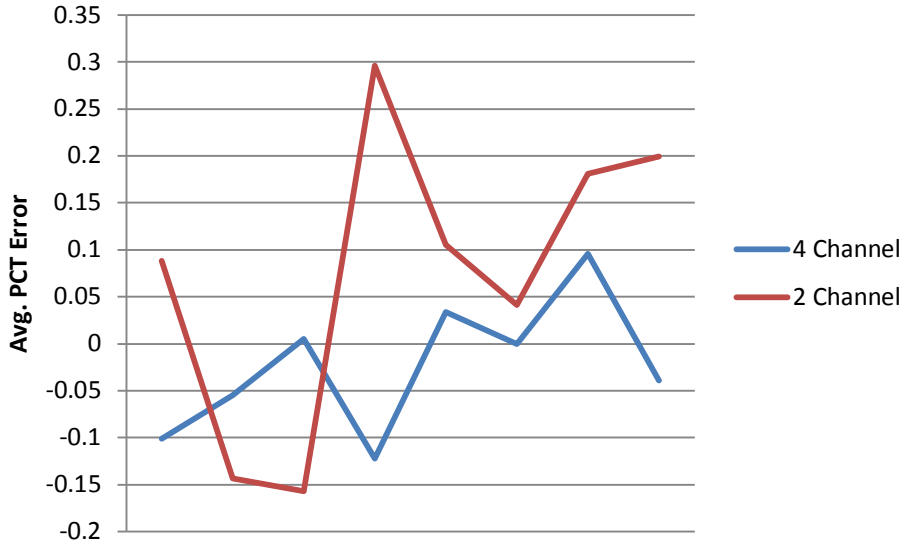


2-Channel Results had average errors below +/- 0.30% and a maximum error of 0.4% on both test fluids. The FLEXIM Meters were compared to custody type flow meters that were proved.

TEST AT CEESI 2016

Conclusion:

For added accuracy and repeatability, the 4 Channel, Quad Beam meter delivers an average error that is over 2 times better than a 2 Channel, Dual Beam meter. For accuracy, the Quad Beam FLEXIM HPI Meter can do the job (FROM OUTSIDE THE PIPE!).



Conclusion

- Standard volume flow measurement is achievable, and field proven with clamp-on devices

- Possible additional calculated outputs from clamp-on Mass Flow meter :
  - Density
  - API Grade or density @base conditions for the medium
  - Viscosity

- Main Component to total uncertainty is the volume flow measurement with the clamp-on device. 1% is typical achievable with multi channel installation and fully developed turbulent flow regime.

- Uncertainty from ASTM 1250, TP25 or D4311 calculation for density is significant lower.

- During the set up of the meter the density of the medium must be known for field adjustment of Sound Speed Measurement and for a reliable reference point for calculation. The accuracy of this information determines the accuracy of the calculation.

Questions ?

FLEXIM

when measuring matters