

The Effects of Flow Conditioners When Using Liquid Ultrasonic Flow Meters

APRIL 8, 2015 by CURTIS GULAGA

Questions have been raised as to how effective flow conditioning is when using multipath liquid ultrasonic flow meters. Is it possible to diagnose a partially blocked flow conditioner when flowing crude oil, and are the pressure drops associated with using these devices worth the performance gain?

This article includes test data that addresses the above concerns from volumetric proving methods and mathematical perspectives. We will make reference specifically to the Caldon 4 and 8 path meter design.

Flow Weighted Mean Error Shift			8-path meter	Planar 4-path (Westinghouse)		Non-planar 4-path (British Gas)	
Disturbance	Upstream	Path orientation		A	B	1	2
Single Bend	5D	Horizontal	0.06%	-0.08%	0.21%	1.02%	-0.90%
		Vertical	0.03%	0.00%	0.07%	-0.86%	0.93%
Double Bends		Horizontal	0.02%	-0.10%	0.15%	1.17%	-1.12%
Vertical		-0.06%	-0.26%	0.14%	0.45%	-0.57%	
Single Bend	15D	Horizontal	-0.08%	-0.04%	-0.13%	0.30%	-0.46%
		Vertical	-0.05%	-0.02%	-0.08%	-0.61%	0.51%
Double Bends		Horizontal	-0.05%	-0.24%	0.13%	0.09%	-0.20%
		Vertical	-0.08%	-0.06%	-0.11%	-0.12%	-0.05%
Single Bend	5D - CPA - 10D	Horizontal	-0.02%	-0.06%	0.02%	-0.12%	0.07%
		Vertical	-0.04%	-0.01%	-0.07%	-0.14%	0.06%
Double Bends		Horizontal	0.03%	-0.05%	0.11%	-0.11%	0.17%
		Vertical	0.06%	-0.08%	0.20%	0.12%	0.00%

Table 1: Flow Weighted Mean Error Shift-Full Flow Range

Liquid Ultrasonic Meter Designs

Table 1 references British Gas and Westinghouse ultrasonic meter designs. Some meter designs technically fall into both categories depending on how they are set up to process the transducer signals. Similar to other manufacturers, the Caldon meter has two 4 path USM's in the same body. Due to the transducer placement, they can run in Westinghouse mode (all transducers in the same plane), or in BG mode (transducers crossed. The eight -path meter is the average of both 4 path meters.

FMC also offer a 4 path Westinghouse design meter as well as an 8-path dual Westinghouse/BG design. At the time this paper was written, it is unclear which configuration the 6-path set up resembles. The top transducer pairs are in the same planes, and the bottom transducers are offset. Similar to an 8 path, but they disable one of the middle paths, and one of the bottom paths.

The results shown in Table 1 are for an 8 path, BG, and Westinghouse design using the same meter, just switching from BG to WH mode, and then combining all of the results for 8-path mode. One can have a philosophical discussion over the value of

the accuracy and repeatability improvement versus the value of having dual meters that are checking each other. When in 8 path mode, the effectiveness of the flow conditioner was less significant than when the meters were operating in 4-path mode.

Table 2 below shows the effect of asymmetry (swirl) and profile factor on an 8 path meter with and without a flow conditioner for various upstream pipe configuration. The tested grouping of data within the grey dotted box was a 4 path with a CPA 50E. The results demonstrate increased repeatability for various upstream piping configurations.

8-path LEFM 380Ci – ALL DATA

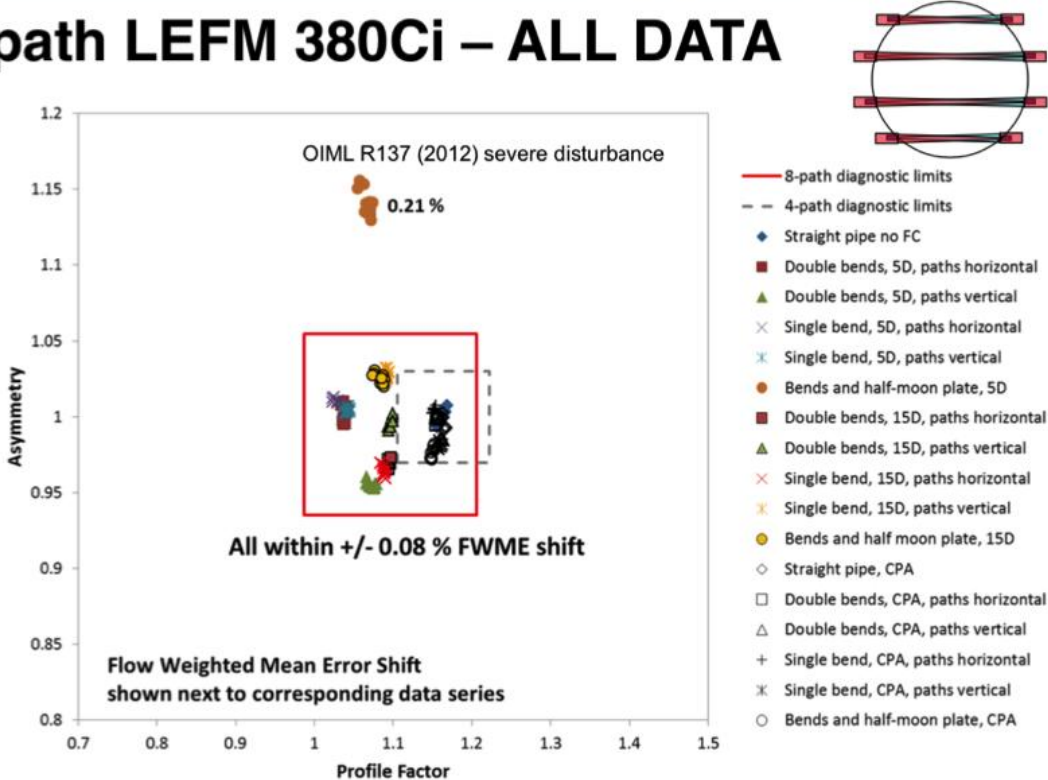


Table 2: 8 path LEFM Asymmetry / Profile Factor

Flow Conditioners and Identifying Blockage

Measuring heavy oil has its challenges. Unlike natural gas applications, where borescope technology is used to visually assess the inner pipe diameter, and potential flow conditioner blockage. In Oil applications, differential pressure is the easiest and most commonly used method by pipeline companies. A common solution is using a flow conditioner, which has an extremely repeatable pressure drop, and blockages show up quickly. Or you can merely tap the pipe and make reference to an in situ calibration baseline flow.

From a mathematical/fluid standpoint, table 3 shows how a flow conditioner significantly increases accuracy with multiple path layouts for different upstream piping configurations. From the author’s perspective, the upstream piping scenarios provided are not necessarily practical, and do not meet the existing API MPMS 5.8 minimum recommendations of 10D upstream and 5D downstream. It is the author’s

understanding that API 5.8 may be revised and referenced as Chapter 6 to include shorter meter run lengths. What the table does demonstrate is how effective the flow conditioner is at eliminating swirl created from extreme piping configurations, and the overall impact that had on the meter’s performance.

			SawchukSonic Meter Performance					
			1 Path, USM Final	1 Path, 1/4 Path, USM Final	2 Path, USM Final	3 Path, USM Final	4 Path, USM Final	7 Path, USM Final
Dual Elbows In Plane	1D	No FC	6.879%	4.359%	3.357%	4.534%	3.365%	0.226%
Dual Elbows In Plane	1D	CPA SSE	4.365%	0.183%	0.313%	1.211%	1.312%	0.202%
Error Change			-36.54%	-95.80%	-90.67%	-73.29%	-61.01%	-10.72%
Dual Elbows In Plane	5D	No FC	5.231%	2.870%	0.492%	1.629%	1.131%	0.082%
Dual Elbows In Plane	5D	CPA SSE	1.535%	1.519%	0.098%	0.382%	0.266%	0.009%
Error Change			-70.65%	-47.09%	-80.19%	-76.55%	-76.48%	-89.68%
Dual Elbows Out Of Plane	1D	No FC	4.808%	1.968%	0.619%	1.743%	1.399%	0.235%
Dual Elbows Out Of Plane	1D	CPA SSE	3.686%	0.466%	0.405%	0.960%	1.064%	0.150%
Error Change			-23.34%	-76.34%	-34.55%	-44.90%	-23.99%	-36.14%
Dual Elbows Out Of Plane	5D	No FC	2.914%	3.140%	0.310%	0.969%	0.522%	0.186%
Dual Elbows Out Of Plane	5D	CPA SSE	1.150%	1.825%	0.334%	0.181%	0.123%	0.016%
Error Change			-60.55%	-41.88%	7.80%	-81.35%	-76.42%	-91.25%
Dual Tees In Plane	1D	No FC	4.639%	3.199%	0.015%	1.620%	1.527%	0.143%
Dual Tees In Plane	1D	CPA SSE	2.659%	3.139%	0.005%	0.866%	0.880%	0.094%
Error Change			-42.68%	-1.88%	-69.45%	-46.56%	-42.33%	-34.15%
Dual Tees Out Of Plane	1D	No FC	4.580%	2.421%	0.772%	2.094%	1.388%	0.153%
Dual Tees Out Of Plane	1D	CPA SSE	3.553%	1.128%	0.066%	1.147%	1.119%	0.050%
Error Change			-22.41%	-53.41%	-91.43%	-45.20%	-19.43%	-67.33%
Dual Tees Out Of Plane	5D	No FC	8.184%	1.705%	0.317%	2.755%	2.306%	0.180%
Dual Tees Out Of Plane	5D	CPA SSE	3.196%	5.013%	0.115%	1.184%	0.712%	0.055%
Error Change			-60.95%	194.08%	-63.67%	-57.00%	-69.11%	-69.23%
Dual 45's In Plane	1D	No FC	4.046%	0.907%	0.795%	0.885%	1.373%	0.380%
Dual 45's In Plane	1D	CPA SSE	1.530%	0.259%	0.437%	0.150%	0.375%	0.099%
Error Change			-62.18%	-71.39%	-44.95%	-83.11%	-72.66%	-73.87%

Table 3: SawchukSonic Meter Performance

Conclusion

There are diagnostic benefits to using the 4 path + 4 path meter design. Using strainers upstream may help eliminate flow conditioner blockage, but they have also caused unnecessary loading on the same flow conditioner. There are differential pressure techniques that can be implemented to detect that occurrence. Some of the more current flow conditioner designs provide reduced pressure drop, and their effectiveness in improving meter performance has been demonstrated by one of the manufacturers. For custody transfer applications, flow conditioners cause less pressure drop than conventional tube bundles at high viscosity, low Re oil flow, and should be used if better measurement is desired.