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CANADA PIPELINE ACCESSORIES

Tech Note: The CPA 50E and Swirl

What is Swirl?

Swirl can be defined as a helical flow pattern within a pipe, whereby there is a component to the gas velocity vector that is perpendicular to the longitudinal axis of the pipe. There are a number of possible causes of swirl in a piping system. Some of these are:

- Multiple elbows or tees
- Mixers
- Compressors

Swirl in natural gas piping can persist for over 200 pipe diameters, due to the typically high Reynolds Number of the flow. Swirl in liquid piping will generally degrade somewhat sooner.

Measurement of Swirl

Swirl can be measured in piping using a pitot tube arrangement which measures both axial and radial velocity. The approximate limit for this measurement apparatus is one degree.

This type of measurement is not practical for industrial installations due to the expense incurred. Therefore it is difficult to estimate the amount of swirl in a given piping configuration.

Swirl and Orifice Meters

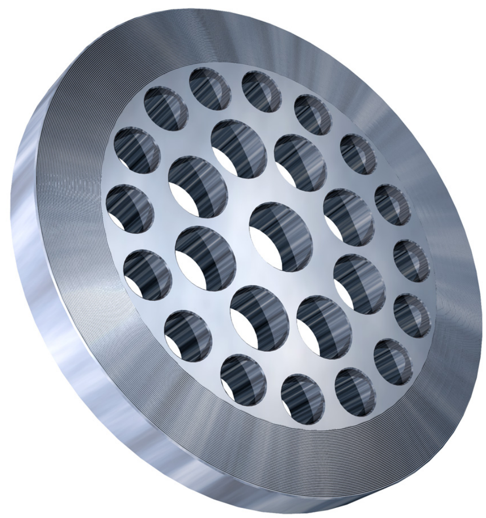
Swirl is known to cause measurement errors in gas and liquid meters. The overall impact depends on the design of the meter and the strength of the swirl. For orifice meters, swirl has the effect of increasing the coefficient of discharge (Cd). In practical terms, the meter will under register the flow.

Swirl will generally have a greater impact on lower beta ratios. At high swirl angles (over 20 degrees) and with Beta ratios up to 0.4, meter error can be in the 10% range (1). This effect of swirl will reduce as swirl angle is reduced.

Two degrees of swirl is the acceptable upper limit specified by ISO 5167. Miller (2) states that tube bundles reduce swirl to 2° or less. This limit of 2° is likely due to both the lack of impact of this amount of swirl has on the meter, as well as the difficulty of measuring smaller amounts.

Can a CPA 50E Eliminate Swirl?

The CPA 50E Flow Conditioner is a perforated plate with 25 holes. The holes are arranged in two concentric rings, with a central hole, as pictured here.



The CPA 50E is 0.12 to 0.15 pipe diameters thick. The holes are sized to the inside diameter of the pipe to produce fully developed flow at high Pipe Reynolds Number (~10^6).

How Can This Single Plate Eliminate Swirl?

There are two effects which combine as the fluid passes through the plate. The first is the acceleration of the gas to over twice the average velocity in the pipe. The flow is also split into 25 streams, each passing through a hole which is approximately 1 diameter long. These 2 effects will tend to straighten the flow.

GRI sponsored research into orifice metering standards which was carried out at Southwest Research Institute (3). The CPA 50E was one of several flow conditioners tested.

Data was gathered on high swirl in bare meter tubes (no flow conditioner). On a 17D meter run, with a swirl generator and tee upstream, the error for a 0.4 beta ratio plate was 5 to 6 percent (in line with Kinghorn).

Then, various flow conditioners were tested at different positions along meter tubes that were 17, 29 and 45 pipe diameters long. Different upstream piping configurations were tested to produce flow conditions similar to those found in the field.

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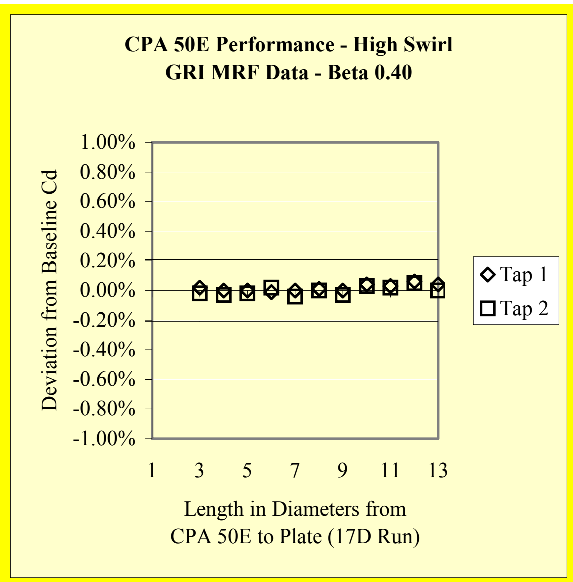
The below graph represents one of the experiments conducted by Southwest research for GRI.



There are some important points to note from this data:

- The deviation from the baseline is very good
- The beta ratio and upstream conditions make this test the most extreme swirl test conducted
- A test with two elbows out of plane (less severe swirl) yielded similar results

There is no evidence that any swirl has passed the flow conditioner.

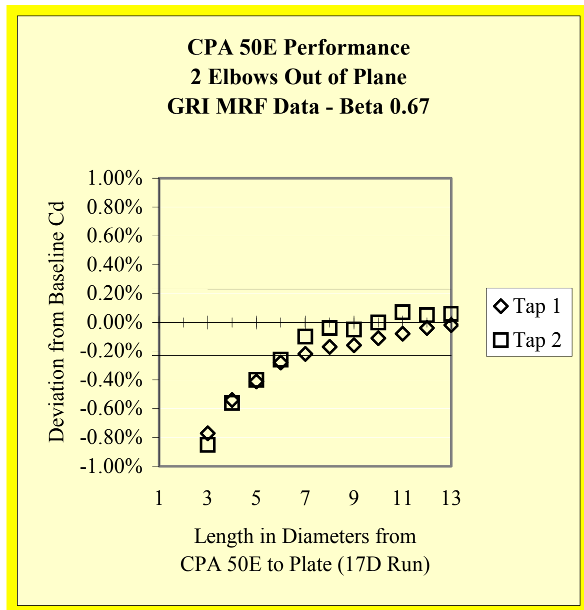
Testing at higher beta ratios yields similar results for the range of upstream piping configurations tested.

For example, the two elbows out of plane results for beta 0.67 on a 17 diameter meter run are shown here.

Points to note from this data include:

- Similar results are achieved, independent of upstream piping
- Seven diameters is sufficient to achieve the criteria of no significant Cd shift under all beta ratios and upstream piping configurations.

At these higher beta ratios, orifice meters are sensitive to velocity profile, and less sensitive to swirl. This data indicates that the swirl upstream of the flow conditioner is transformed to a small velocity profile anomaly downstream. This anomaly is primarily due to the separate jets from the flow conditioner holes, before they recombine to a fully developed velocity profile about 5 diameters downstream.



Conclusions

The evidence available indicates that the CPA 50E flow conditioner isolates the meter run from a wide variety of upstream configurations, and helps produce excellent metering under all conditions.

References:

1. Kinghorn, F. C., Flow Measurement in Swirling or Asymmetric Flow - A Review, *Flowcon 77 Proceedings*, pp 45-71, Institute of Measurement & Control, Gatton & Kent UK, 1977
2. Miller, R. W., *Flow Measurement Engineering Handbook, Third Edition*, McGraw-Hill, 1996
3. Morrow, T.B., *Technical Memorandum - Metering Research Facility Program - Development of a Flow Conditioner Performance Test*, Gas Research Institute, 1997