

Effects of Non-Axial Cross-Flow on Flowmeter Measurement Accuracy

Susceptibility of flowmetering systems to cross-flow error due to off-axis flow velocity components may be a significant consideration for metering locations downstream from a pipe bend having less than 10-pipe-diameters of straight-pipe approach to the flow metering section. Such locations will exhibit off-axis velocity components (cross flow), such that the flow velocity vectors will be skewed relative to the pipe axis.

This is discussed in ASTM D-5389: *Standard Test Method for Open Channel Flow Measurement by AVM Systems* (Sec. 13.1.3, Ref. 2) which notes:

"This may be the largest potential source of errors for a single-path velocity measurement...each 1° error in assumed (axial) direction of flow...will result in a 1.76% error in velocity measurement. This error increases as the path angle increases. If two crossed 45° paths are used and the outputs averaged, for practical purposes, this error is zero".

Note that Accusonic flowmeters typically utilize a 45° acoustic path (crossing) angle, as called for in the ASTM standard noted above, and Accusonic flowmeter systems always provide the option of utilizing crossed-path configurations, at multiple elevations across the flow, to effectively mitigate cross-flow induced errors such as noted above.

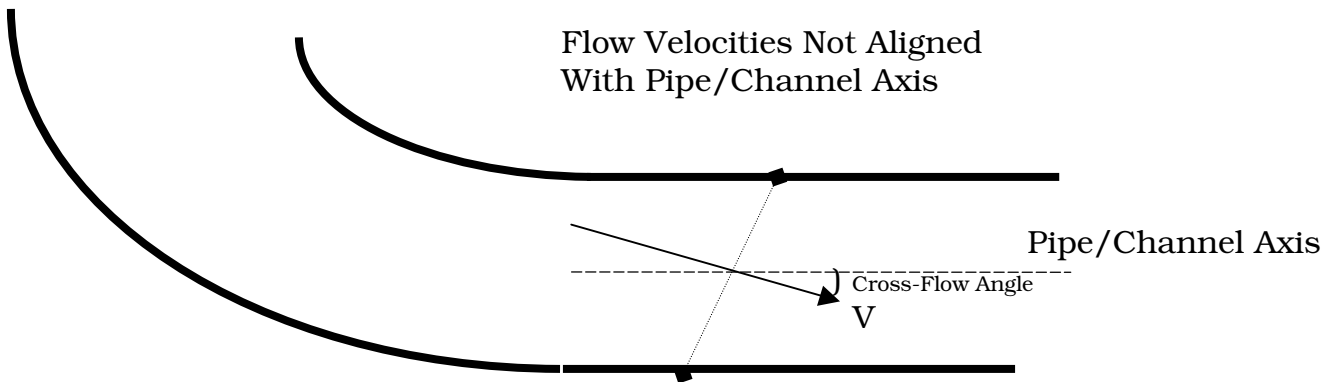
Utilizing crossed-path configurations is not possible with single-path transit-time flowmeters.

In addition, flowmeters utilizing steeper acoustic path angles ($> 45^\circ$) relative to the flow axis are inherently more sensitive to cross-flow error as noted above. Thus, a 65° acoustic path angle results in 2x the cross-flow error noted above for a 45°-path angle.

Accusonic offers crossed-path measurement configurations such as 4-paths symmetrically crossed with 4-paths (i.e., symmetrically crossed paths at each of 4 separate elevations across the pipe) for maintaining flowrate measurement accuracy in the presence of upstream bends in the pipe closer than 10-diameters to the flowmeter measurement section. This is to compensate (correct for) for errors associated with cross-flow velocities (off-axis flow velocities) or "swirling flow" that is created downstream from pipe bends. Accusonic has utilized this 4 x 4 crossed-path configuration at hundreds of critical measurement sites in order to maintain flowrate measurement accuracy. This is the code-specified configuration in IEC-600041 and ASME-PTC-18 flow measurement specifications, used to verify performance of critical turbo-machinery - where maximum flowrate measurement accuracy is required.

ELIMINATING CROSS-FLOW ERROR

The Problem



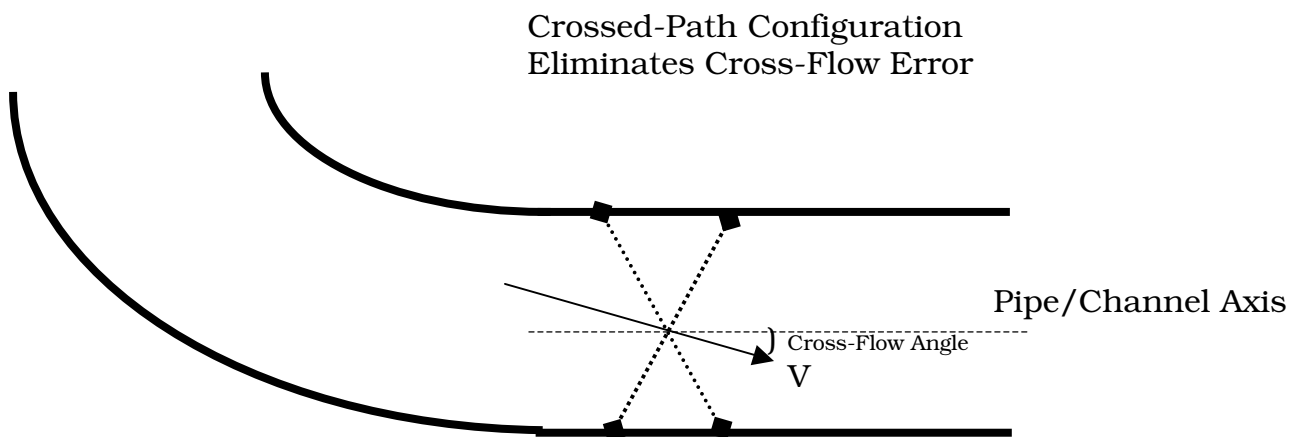
Flow measurements assume that flow velocity vectors are aligned parallel with the pipe/channel longitudinal axis.

Cross-flow velocity components may occur at locations within ten diameters from upstream bends or bifurcations.

The effects of cross-flow can result in significant flowrate measurement errors.

For example, a 2° cross-flow results in a 7.5% velocity measurement error when using a 65° ultrasonic path angle (see diagram). Using a 45° path angle would result in a 3.5% velocity error.

The Solution



Cross-flow error can be eliminated using symmetrical crossed-path transit-time measurements. The average of the velocities measured with the crossed-path configuration represents the true net flow velocity along the pipe/channel axis.