Despite the industrial success of clamp-on ultrasonic flowmeters for liquid measurement, it has long been accepted as if it were a fundamental limit imposed by nature, that this technology could not be used to measure the flow of gases in metal pipes.

The incorrect conclusion, that clamp-on gas flow metering is impossible, developed because the acoustic impedance of gases, even at pressure, is much less than the acoustic impedance of metals. This fact, reinforced with the knowledge that attenuation in most gases is much greater than in common liquids at the same frequency, led to a belief that virtually no useful amount of ultrasonic energy can be transmitted from the pipe into the gas, and then back out of the gas through the metal pipe and into the receiving transducer. Along with this assessment of what was thought to be a negligible amount of sound intensity surviving to the receiver, is the further problem of a relatively strong coherent interfering wave traveling through the pipe wall into the receiver.

Together, these factors led many to conclude that the signal-to-noise ratio would be so low as to be useless, especially if it is
Field Testing

A prototype flowmeter was built and tested in August 2000 at a major petrochemical production facility in the Netherlands. These initial field tests were performed on air flowing in a large number of steel pipes ranging in size from 3-inch to 8-inch at pressure from 6 to 12 bar. The customer needed a measurement survey to determine compressed air usage throughout the facility. Nearly 100 measurements were successfully made in total on different pipes.

This early trial provided results to show the viability of the technology in an uncontrolled field environment. The facility was rather old, and the pipes were in relatively poor condition and at lower than expected pressure. Despite the difficult conditions, the prototype meter worked as desired, and an estimation of the accuracy of the meter was above expectations and well within the customer’s requirements.

Another test was performed in November 2000 on a natural gas transmission pipeline at a customer location in the western United States (see Figure 2). The sour natural gas in this case, containing 12 percent H2S, was corrosive enough to require an Inconel liner inside the 10-inch, Schedule 40 carbon steel pipeline. The Inconel liner posed a problem because it was not mechanically bonded to the carbon steel pipe wall. The interface between the carbon steel pipe and the Inconel liner was too acoustically reflective to pass the ultrasonic signals through.

Located near a well head were an expansion loop and a short section of solid, straight 6-inch Inconel pipe, approximately 12 inches long. The straight pipe section was long enough to mount the transducers and clamp, but the amount of straight pipe run was much less than needed for the flow profile to develop fully for best measurement accuracy. Once installed and adjusted for supercompressibility at a pipeline pressure of 1,300 psi, however, the clamp-on flowmeter closely tracked the field meter reading of approximately 34 MMSCF/D. Later, the clamp-on meter’s stability was monitored for one-and-one-half hours, and then the flow rate was varied to test the clamp-on meter’s response. In all tests, the clamp-on meter closely tracked the field orifice meter (see Figure 3).

Calibrating the Meter

To determine the accuracy of the device compared to that of a reference meter, a calibration of two DigitalFlow GC868 flowmeters was scheduled at the GTI Metering Research Facility at the Southwest Research Institute (SwRI) for the week of May 21, 2001. The two me-
Performance Specifications

Performance specifications have been derived from data obtained during beta testing and calibration runs. The stated accuracy specification of the meter is: above 5.5 feet per second velocity, ±2 percent of volumetric flow reading for single-path installations and ±1.4 percent of volumetric flow reading for two-path installations, with a time averaged accuracy of ±1 percent of reading. The repeatability specification is ±0.2 to ±0.5 percent of reading. Minimum required gas pressure depends on pipe size and fluid density. For example, 90 psig is the minimum pressure requirement for instrument air in a 6-inch carbon steel pipeline. The meter will operate on unlined pipes of all metal and plastic materials, from 3- to 36-inches in diameter. The temperature range for the transducers is –40°F to 300°F. Tests are now underway at up to 450°F.

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About the Author

Michael J. Scelzo received his B.S. ChE from WPI in 1969, and his M.B.A. from the Southern New Hampshire University in 1988. At Panametrics since 1973, he worked in the applications engineering, sales and marketing departments of the PCI Division. He is currently the Vice President of Marketing for the PCI Division.
Until now, clamp-on flow metering was limited to liquids. Many thought it was impossible for gases. Existing methods couldn’t be used, so through extensive research...

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