Ultrasonic Solution
For High Pressure Gas Service

By Mike Hopkins, Manager of Engineering, Williams International, Tulsa, OK

Twenty ultrasonic meters today are successfully operating in high-pressure, demanding gas service for Williams International in Venezuela as the result of a development project that started about seven years ago.

In 1996, much of the natural gas industry was just beginning to consider accepting ultrasonic meters for custody transfer measurement. At that time, the American Gas Association, Transmission Measurement Committee was writing what would eventually become AGA Report No. 9 (AGA-9), titled Measurement of Gas by Multipath Ultrasonic Meters, and published in June 1998.

Technical information relating to the use of ultrasonic meter performance in 1996 consisted primarily of a limited number of magazine articles and published papers, some of which would later become part of AGA-9, primarily in Appendix C. Therefore, at that time, orifice meters or turbine meters appeared to be the only industry-accepted options since both meter types were covered by well-accepted, and well-documented, gas industry measurement standards.

Because of safety concerns about repeated depressurizing of orifice and turbine meters in this application, Williams International, a wholly owned subsidiary of The Williams Companies of Tulsa, OK, working with their WilPro Venezuela Joint Venture, chose to pursue ultrasonic meter technology and began searching for natural gas meters that would measure gas flow to an operating pressures up to 7,705 psig for its El Furrial Project in Venezuela. This search led to a partnership with Daniel, to work together for a solution.

Ultrasonic meters are inferential meters that derive the gas flow rate by measuring the transit times of ultrasonic sound waves passing through the flowing gas. Transit times are measured for sound pulses traveling at an angle with respect to the pipe axis. Each path has two transducers, which act alternately as a transmitter and a receiver; one downstream with the gas flow and one upstream against the gas flow, permitting the upstream and downstream gas flow transit times to be measured. The difference in these transit times is a measurement of an average angular gas flow velocity along the transducer acoustic path. Mathematical equations are then used to compute the average axial gas flow velocity and the gas volume flow rate through the meter.

Daniel agreed to manufacture the 10,000 # API ultrasonic meters and provide ongoing technical support for the meters and their development. This work was beyond existing applications and required going “outside the box” but reliable results seemed achievable.

Success of the work is now evident by the 20 meters in high-pressure, demanding service today.

El Furrial Project
Commissioned in 1998, El Furrial is a high-pressure gas compression facility (113,000 site horsepower) that receives gas via two pipelines (30-inch and 24-inch) at about 1,100 to 1,000 psig. Centrifugal and reciprocating compressors then compress the gas up to an MAOP of 7,705 psig before discharge seven miles down a 14-inch pipeline delivering gas to five injection wells along the route. Gas is then injected into the oil zone, enhancing the oil recovery rate. By keeping the reservoir pressurized, operators maximize reservoir management efficiencies.

PIGAP II Project
Commissioned in 2001, PIGAP II is a high-pressure gas compression facility (233,600 site horsepower) that receives gas via two 36-inch pipelines at around 1,100 psig. Twenty-four centrifugal compressors then compress the gas up to a MAOP of 9,750 psig. Gas is then discharged to a central manifold in the station. Out of the manifold, it goes in two 12-inch and two 10-inch pipelines for about two miles each to four individual manifolds (a “ma-coy-ya” is a pod of well surface facility equipment for horizontally drilled wells) surrounding the plant. It is then further distributed via manifold to as many as four injection wells per macolla.

Since Williams International, via WilPro Energy Services, provides this compression and distribution service on a per MMscf/d fee, it is imperative that high-quality gas measurement be achieved. Typical daily station flow rates for El Furrial range from 450 MMscf/d to a maximum of 650 MMscf/d. Flow rates per injection meter range from 30 to 80 MMscf/d.

At PIGAP II typical daily station flow rates are in the range of 1,100 MMscf/d with a maximum of 1,500 MMscf/d. Flow rates per injection meter range from 50 to 120 MMscf/d. Gas is individually measured as it is injected into each well for both projects to maximize reservoir management efficiencies.

El Furrial Problems
At El Furrial, the key questions in 1996 related to whether ultrasonic gas measurement could be achieved at the high pressures involved, and could it be done safely. Investigations of high-pressure metering found that there was a non-custody transfer ultrasonic meter installed in the North Sea operating in the 6,000-psig range and several orifice flange units in service at these higher pressures. It was recognized that maintenance of the orifice meters for orifice plate inspections and plate sealing for routine inspections would be an issue. No differential pressure transmitter was available on the market that would provide acceptable accuracies required at static pressures up to 7,705 psig. Turbine meters would be cumbersome to work with due to safety concerns over the weight of the materials and yearly inspections. Meter-factor stabilities of turbines at these high pressures were also a concern. All of these factors contributed to progressing with ultrasonic metering development.

In early 1997, five 6-inch, 10,000 # API Daniel JuniorSonic Meters were ordered. Meter skids were constructed and shipped to Venezuela for installation and initial operation in 1998.

Startup went off as planned, but when...
of the transducers with the new design, the composition, and mechanical stress.

The samples were then analyzed for the effects of pressure, temperature, gas mixtures where the speeds of sound are up to 3,000 feet/second.

The results were encouraging. The Daniel thick-wall metal meter construction was not growing, twisting or changing transducer separation distance with pressure changes. Measured speeds of sound were within the known uncertainties of calculated values. However, several individual transducers quit working at lower pressures after having been cycled to the highest pressure. They became operational again when high pressures were reinstated.

Results were encouraging. The Daniel thick-wall metal meter construction was not growing, twisting or changing transducer separation distance with pressure changes. Measured speeds of sound were within the known uncertainties of calculated values. However, several individual transducers quit working at lower pressures after having been cycled to the highest pressure. They became operational again when high pressures were reinstated.

Daniel found the problem was caused by methods used in transducer assembly prior to encapsulation. The fabrication procedure was modified accordingly.

Results were encouraging. The Daniel thick-wall metal meter construction was not growing, twisting or changing transducer separation distance with pressure changes. Measured speeds of sound were within the known uncertainties of calculated values. However, several individual transducers quit working at lower pressures after having been cycled to the highest pressure. They became operational again when high pressures were reinstated.

Results were encouraging. The Daniel thick-wall metal meter construction was not growing, twisting or changing transducer separation distance with pressure changes. Measured speeds of sound were within the known uncertainties of calculated values. However, several individual transducers quit working at lower pressures after having been cycled to the highest pressure. They became operational again when high pressures were reinstated.

After testing, the meters were skidded and shipped to Venezuela for installation and initial operation in 2001. The meters are now in service and meeting the required contract performance levels. They were installed with the four blind tee configuration, separating each meter from its control valve.

**Conclusions**

- These ultrasonic meters perform within their contracted tolerances in this high-pressure application.
- Ultrasonic transducers may be susceptible to decomposition affects if exposed to pressure cycling.
- Static tests indicate that ultrasonic meters should be able to perform in gas mixtures where the speeds of sound are up to 3,000 feet/second.
- Static tests indicated that meters should perform better at 9,000 psig if correction factors from a flow test at 1,100 psig are applied.