

## **CLAMP-ON, SONAR-BASED VOLUMETRIC FLOW RATE AND ENTRAINED GAS MEASUREMENT FOR INDUSTRIAL APPLICATIONS**

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### **1 ABSTRACT**

A clamp-on, sonar-based flow measurement technology for simultaneously measuring volumetric flow rate and process fluid sound speed is described. The technology utilizes sonar array processing techniques to perform two independent measurements to characterize the process fluid, each well-suited for single and multiphase flows. First, the meter provides volumetric flow by tracking the speed at which naturally occurring, flow-generated pressure fields convect past an array of strain-based sensors clamped-on to existing process pipe. Second, the meter provides compositional information by measuring the speed at which naturally occurring sound waves propagate through the process fluid using the same clamp-on sensors. Measuring the speed of sound of a process fluid utilizing this sonar technique is analogous to measuring process fluid density and has many compositional based applications. A primary example of this is using process sound speed to accurately measure the amount of entrained gas in liquid-continuous mixtures.

The ability to measure volumetric flow and process sound speed reliably and accurately in single and multiphase applications with a non-intrusive, clamp-on device significantly enhances the observability of the many industrial processes.

Data are presented from sonar-based volumetric flow and sound speed compositional measurements for brine and refined hydrocarbon product applications at a natural gas liquid (NGL) storage facility.

**Key words:** Caverns for Gas Storage, Caverns for Liquid Storage, Texas