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Capacitance-based mass flow rate measurement of 2-phase hydrogen in a ½ inch tube.

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Mass flow rate is a critical measurement parameter when designing cryogenic hydrogen fluid systems. It is vitally important not only in custody transfer applications for calculating financial obligations but also in fundamental heat transfer research and fluid system design applications to optimize chill down performance, maintain thermal equilibriums, and provide feedback control for pumps and valves. However, due to the large temperature differential between cryogenic fluids and the environment, there is often unavoidable multiphase flow during system chilldown or even in steady state operation. Current available measurement techniques are not equipped to deal with the complex multiphase flow inherent in cryogenic fluid systems. Mass flow measurement inaccuracy due to multiphase flow can cause financial loss, system instability, and even component failure, resulting in a strong market demand for a multiphase cryogenic mass flow meter to optimize and control sophisticated and costly cryogenic systems. This paper presents a solution in the form of a novel capacitance-based technique for measuring the multiphase mass flow rate of cryogenic hydrogen in a terrestrial environment. The device was calibrated and tested on a ½"tube multiphase hydrogen flow loop at a cryogenic hydrogen test facility. An error of ±2% full scale was achieved across a range of flow conditions, including transient and steady states.

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