High Pressure Vapor Liquid Equilibrium Measurements of Gas and Water Mixtures using Nuclear Magnetic Resonance Spectroscopy

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Gas composition, which can vary from location to location in natural gas pipelines, constrains the allowable operating conditions and compressor package design. Systems are designed such that they provide the optimal balance between efficiency and gas throughput with safety margins to maintain component lifetime. The presence of liquid in the compressor can lead to excessive wear of intake and discharge valves and impact performance. To prevent ingestion of liquid slugs, operating conditions and separation equipment must be selected appropriately using mixture dew point calculations from commercially available software such as NIST-Refprop. Improved understanding of the VLE (Vapor Liquid Equilibrium) for high pressure gas mixtures, especially those containing H2O, would lead to more accurate dew point calculations and allow designers to maximize system performance without compromising component wear and tear. For a mixture comprised completely of hydrocarbon species, VLE calculations at high pressures can be accurately determined. However, when H2O is present in natural gas significant intermolecular interactions cause the mixture VLE to deviate from ideal. In order to accurately model the VLE of these mixtures, the energy associated with these interactions must be known and accounted for in the calculations. As such, high quality experimental VLE data are needed to improve and validate the thermodynamic models. Nuclear Magnetic Resonance (NMR) spectroscopy allows for such high-quality data collection to add to these models. NMR spectroscopy was used to quantify each constituent of the binary mixture of methane and water, for both liquid and vapor phases. Data collection occurred across a variety of thermodynamic conditions from 30°C to 70°C and from 0 to 1000 PSIA and compared to NIST-Refprop predictions.