High Pressure Density Measurements

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The petrochemical industry requires highly accurate equations of state (EoS) to calculate accurately thermodynamic properties such as densities and calorific properties. However, the accuracy of an EoS depends strongly upon the accuracy of the data used to construct the EoS. Thus, a great need exists for high accuracy *p*-*V*-*T* measurements. Multiple apparatus can produce highly accurate *p*-*V*-*T* measurements, but most cannot do so over broad ranges of pressure and temperature. With deep gas reservoirs now exhibiting pressures in excess of 140 MPa at temperatures reaching 475 K, a need exists for measurements at these extreme conditions. Two such apparatus, which can handle these harsh conditions, are a magnetic suspension densitometer (MSD) and a vibrating tube densimeter (VTD). The operating limits for the VTD and the MSD are 140 MPa and 475 K and 200 MPa and 525 K. This work presents a method to increase the rate of accurate data acquisition by using the MSD and the VTD in an optimum combination. The fluids of interest are pure fluids and natural gas-like mixtures at high pressures and temperatures. The VTD can measure densities rapidly, but the accuracy of the measurements depends upon one or more calibration fluids having accurately known densities. The MSD measurements are much slower, but accuracy of the results does not depend upon a calibration fluid. Clearly, these two apparatus used together can use measurements from the MSD to validate reference equations for calibration fluids within the VTD temperature and pressure ranges and to measure densities at higher temperatures and pressures. The VTD then adds measurements at the temperatures and pressures within its operating range. Pure fluids such as methane, carbon dioxide, nitrogen, and argon are good calibration fluids. The fluids of ultimate interest are simple mixtures of natural gas components.