

## High-Pressure and Temperature Viscosity Standards in the Range Required for Heavy Oils

Hernán Quiroz-Villareal<sup>S</sup>, Jairo Duarte-Rodelo, Christian Castillo-Gómez and Sergio E. Quiñones-Cisneros<sup>C</sup>  
*Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México, Mexico, D.F., México*  
*seqc@unam.mx*

The main purpose of this work is the design, validation and implementation of an experimental system operating in a range of temperature that goes from ambient to reservoir conditions ( $\sim 120^{\circ}\text{C}$ ) and up to 1000 bar of pressure to measure the viscosity of reference/calibration fluids with good accuracy – aimed to better than 2% at high-pressure (HP) conditions. For this purpose, the design of a hydraulic system is proposed and implemented; this system was designed to allow simultaneous measurements of viscosity and density of a sample. The viscosity measurement system includes different laboratory equipment: a HP syringe pump, a transfer fluid piston cylinder, a high-pressure falling body viscometer equipped with a variety of geometries that allow for the determination of viscosities covering five orders of magnitude, a thermal bath, an oscillating U-tube densitometer and a high-accuracy Stabinger viscometer. The experimental setting is validated against pure reference fluids, including water, obtaining average deviations better than 0.5% at high pressure. Further HP estimations of other relevant fluids, such as hexadecane, are also determined. Once the experimental system has been validated, three Newtonian viscosity reference blends of 1000 mPa's, 10000 mPa's and 50000 mPa's have been studied and their reference tables extended from atmospheric pressure to 1000 bar in a temperature range of 20-120 °C. This has resulted in the development of calibration tables covering a viscosity range of  $10^2$ - $10^6$  mPa's with accuracy better than 4% at high viscosity conditions in normal scale. In a logarithmic scale the uncertainty is better than 0.5% for the full viscosity range. Afterwards, representative, light to heavy, Mexican crude oils have been measured and several comparative results are presented.