Thermophysical Properties and Uncertainty of Liquid Fluoride Salts as a Nuclear Coolant

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The Fluoride Salt-cooled High Temperature Reactor (FHR) design employs fluoride salts to operate at high temperature and low pressure, which consequently leads to improved power conversion efficiency and safety of the nuclear reactor. This work is a critical review of the thermophysical properties of the fluoride salts of interest as FHR primary coolants. Discussed are the two coolants considered for a test reactor primary coolant—LiF-BeF_2 (flibe) with a 66-33 mol% composition and NaF-ZrF_4 with a 59.5-40.5 mol% composition. The thermophysical properties of these coolants are important for reactor design considerations, and when it comes to safety and licensing, quantifying the uncertainty of these properties is necessary. Unfortunately, experimental data is very limited, and most published properties do not report uncertainty. Additionally, almost every reported uncertainty is merely listed, which requires estimating its cause and how many standard deviations it covers. Recommended values or correlations and their corresponding uncertainty for the thermophysical properties of density (kg/m^3), viscosity (Pa-s), thermal conductivity, and heat capacity are presented. For the primary coolants over the liquid temperature range, the coolants exhibit temperature independent heat capacity and thermal conductivity values of 2386 J/kg-K and 1.1 W/m-K respectively for flibe and 1172 J/kg-K and 0.49 W/m-K respectively for NaF-ZrF_4. Density temperature dependence is linear, and viscosity follows the Arrhenius equation. For flibe, the density correlation is 3413-0.4884*T[K] and viscosity is 1.16E-4*exp(3755/T[K]). For NaF-ZrF_4, density is 3829.7-0.889*T[K] and viscosity is 7.667E-5*exp(3977/T[K]). The uncertainties range from 2% for density to 20% for viscosity.