

Thermal Conductivity of Refrigerant Fluids: a New Correlation for the Compounds of the Methane and Ethane Series in the Liquid Phase Along the Saturation Line

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Reliable experimental thermal conductivity data for organic compounds in the liquid phase are available usually in narrow temperature ranges, sometimes at only one value of temperature and often they are lacking. Theoretical studies of the liquid state so far are unable to be used extensively, exception for simple chemical structures. Although some remarkable prediction methods, based on general assumptions and on experimental measurements, were proposed for the estimation of the liquid thermal conductivity as a function of temperature and density, the need for a simple and general method is strongly perceived for engineering purposes in large temperature ranges. This is the case of the refrigerant fluids used in industrial plants. Several empirical equations are present in the literature, but often they cover narrow temperature ranges, or contain complicated factors. The aim of this work is to propose a simple and general formula to calculate the thermal conductivity, containing only the reduced temperature T_r and some specific parameters for the refrigerant fluids in the liquid phase along the saturation line. This choice leads to an empirical equation, very simple and attractive in mathematical and geometrical terms. The equation contains T_r and three parameters: a factor A with the dimensions of the thermal conductivity and characteristic of each compound, an exponent a depending on each organic family, and the “golden ratio” $((1+5^{1/2})/2 = 1.618033\dots)$ appears when a line is divided “into extreme and mean ratio”) which seems to characterize the liquid phase in a certain mathematical sense. The equation requires the value of the critical temperature, avoids the knowledge of the density, and represents a complete transformation of a formula previously proposed by the author for different organic families; the new formula is tested for 36 refrigerant fluids belonging to the methane and ethane series. The investigated T_r range is from about 0.30 to about 0.99 (from the normal melting point to near the critical temperature, when the critical enhancement appears). The absolute mean deviations between calculated and experimental thermal conductivity data are generally less than 3%, and the maximum ones less than 6%. The experimental thermal conductivity data used for evaluation are clearly indicated for each compound. The new equation is proposed in general for all the refrigerant fluids of the methane and ethane series, but it can be used with acceptable mean deviations ($\pm 5\%$) also for refrigerant fluids for which the critical temperature is not available and few (also only one) experimental thermal conductivity data are available.