8
Physical Properties of Pure Fluids

8.1 Introduction

We will present the second main objective of Chemical Engineering Thermodynamics, the Evaluation of Thermophysical Properties (Section 1.14.2), by considering Pure Fluids, in this and the ensuing two Chapters; and Mixtures, in Chapters 11 through 15. (Actually Chapters 13 and 14 deal with Phase Equilibrium and Chapter 15 with Chemical Equilibrium, subjects whose study represents the third objective of Chemical Engineering Thermodynamics. Their separate consideration, thus, is intended to emphasize their importance in our profession.)

We start by discussing in this Chapter the Physical Properties of pure fluids:

* Volumetric: Pressure-Volume-Temperature (PVT) behavior, and
* Thermal: Enthalpies of Vaporization and Heat Capacities.

Values of these properties are essential in chemical engineering calculations (see Table 1.4 for example), such as the sizing of pipes and vessels, the evaluation of duties in heat exchangers, etc. In addition, they are required information in the determination of the Thermodynamic Properties of pure fluids, enthalpies, entropies, etc., that are considered in the next Chapter; and of mixture properties.

The importance of thermophysical properties has not become noticeable in our discussion so far because, for simplicity reasons:

* first, we assumed ideal gas behavior in all calculations involving gases; and
* second, we worked with steam, where - mainly due to its importance in the conversion of thermal energy into mechanical - the extensive information contained in the Steam Tables is available.

We know, of course, that gases behave as ideal ones in the limit of zero pressure, and that other compounds - besides steam - are important in chemical engineering calculations.
8.2 Objective and Approach

Experimental pressure-volume-temperature and thermal property data are available in the literature for a limited number of compounds only. In practice, therefore:

a. The operating conditions of temperature and pressure may be different than those of the experimental data, if available;

b. Considering the vast number of compounds of interest in chemical engineering applications, limited - or no - experimental data may be available in the typical case.

Our objective, therefore, is to develop familiarity with:

1. The experimental volumetric and thermal behavior of pure fluids and some of the corresponding data sources;

2. Correlations that can be used for extra- or interpolation purposes; and,

3. Estimation methods.

We will start with a description of the volumetric behavior of pure fluids, by considering first gases and then vapors and liquids. (The difference between gases and vapors is that a gas cannot be condensed when compressed isothermally; a vapor, can. The two terms are often used interchangeably, however.)

We proceed, then, to discuss some common characteristics in the PVT behavior of all pure fluids, which are helpful in its quantitative description and estimation that follows.

For the latter we present the two main approaches used:

a. the Corresponding States Principle, and

b. Equations of State

We will close the Chapter with a discussion of vapor pressures and the two thermal properties:

* enthalpies of vaporization; and

* heat capacities.

Note. Thermal properties are classified by some authors as thermodynamic rather than physical properties. To be consistent with our classification, however, that thermodynamic properties are derived ones and physical measurable ones, we discuss thermal properties in this Chapter.