

## Chapter 22

### VISCOSITY OF LIQUID

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#### ABSTRACT

Results for liquid viscosity as function of temperature are presented for a wide range of organic and inorganic chemicals. The major chemicals include many compound types. The results are provided in easy-to-use tables that are especially applicable for rapid engineering usage with the personal computer or hand calculator. The agreement of correlation and data is quite good.

#### INTRODUCTION

Liquid viscosity data are important in many engineering applications in the chemical processing and petroleum refining industries. The objective of this article is to provide the engineer with such viscosity data. The compilation of data is presented for a wide temperature range to enable the engineer to determine values at temperatures of interest.

#### LIQUID VISCOSITY CORRELATION

The correlation for liquid viscosity as a function of temperature is given by the equation shown below:

$$\log_{10} \eta_{\text{liq}} = A + B/T + C T + D T^2 \quad (22-1)$$

where

$\eta_{\text{liq}}$  = viscosity of liquid, centipoise

A, B, C and D = regression coefficients for chemical compound

T = temperature, K

The results for liquid viscosity are given in Tables 22-1 and 22-2. The tabulations are arranged by chemical formula to provide ease of use in quickly locating data. Many of the values for the liquid cover the full range from melting to critical point.

In preparing the compilation, a literature search was conducted to identify data source publications for organics (1-40) and inorganics (1-126). Both experimental values for the property under consideration and parameter values for estimation of the property are included in the source publications. The publications were screened for appropriate data. The compilation resulting from the screening is based on both experimental data and estimated values.

For organic compounds, liquid viscosities at low temperatures were primarily estimated using the Van Velzen method (29, group and structural contributions). The Przedziecki and Sridhar equation (29, corresponding states) and boiling point method (empirical) were also used for selected compounds. For liquid viscosities at high temperatures, both experimental data and estimates were extended using a modified Letsou and Stiel equation (29, corresponding states) for saturated liquids. Experimental data and estimates were then regressed to provide the same equation for all compounds.

For inorganic compounds, liquid viscosities for metals were primarily estimated using the Grosse method (64, melting point, liquid volume). For inorganics that are solids at ambient conditions, a modified Letsou and Stiel method (29, corresponding states, melting point, boiling point) was used. For inorganics that are gases and liquids at ambient conditions, a modified Letsou and Stiel method was also used. Experimental data and estimates were then regressed to provide the same equation for all compounds.

For gas and liquid viscosities, the experimental data for inorganics is very limited or scarce when compared to that available for organics. The estimation methods for inorganics are also very limited or scarce in comparison to organics. Thus, in the absence of experimental data and the scarcity of estimation methods, the estimates for inorganics should be considered as very rough approximations.

Very limited experimental data for liquid viscosities are available at temperatures in the region of the melting and critical point temperatures. Thus, the values in the regions of melting and critical point temperatures should be considered rough approximations. The values in the intermediate region (above melting and below critical point) are more accurate.

A comparison of correlation and experimental data for liquid viscosity is shown in Figure 22-1 for a representative chemical. The graph discloses good agreement of correlation and data.

#### EXAMPLES

The correlation results may be used for prediction and calculation of liquid viscosity. Examples are given below.

**Example 1** Calculate the liquid viscosity of cyclohexane (C<sub>6</sub>H<sub>12</sub>) at a temperature of 353.85 K (80.7 °C).

Substitution of the coefficients from the table and temperature into the correlation equation yields:

$$\log_{10} \eta_{\text{liq}} = + 4.7423 - 2.5322\text{E}+02/353.85 - 1.6927\text{E}-02*353.85 + 1.2472\text{E}-05*353.85^2 = -.4012$$

$$\eta_{\text{liq}} = 10^{-.4012}$$

$$\eta_{\text{liq}} = 0.397 \text{ centipoise}$$

The calculated and data values compare favorably (0.397 Vs 0.413, deviation = 3.87%).

**Example 2** Calculate the liquid viscosity of benzene (C<sub>6</sub>H<sub>6</sub>) at a temperature of 343.35 K (70.2 °C).

Substitution of the coefficients from the table and temperature into the correlation equation yields:

$$\log_{10} \eta_{\text{liq}} = - 7.4005 + 1.1815\text{E}+03/343.85 + 1.4888\text{E}-02*343.85 - 1.3713\text{E}-05*343.85^2 = -.4647$$

$$\eta_{\text{liq}} = 10^{-.4647}$$

$$\eta_{\text{liq}} = 0.343 \text{ centipoise}$$

The calculated and data values compare favorably (0.343 Vs 0.3507, deviation = 2.2%).

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