$\mu = 2.5$. No definite trend in the change of the correction factor with temperature could be detected.

CALCULATION OF SOLUBILITIES

The solubility of gypsum or of insoluble anhydrite can be calculated by Equation 4, using the solubility product constant values of Tables I and II, and determining the activity coefficients by Equation 2. Above an ionic strength of 1.0, the calculated solubility must be corrected by a factor given by Equation 5.

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Critical Temperatures and Critical Pressures of the Ethane–*n*-Pentane System

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The critical temperatures and critical pressures of three ethane–*n*-pentane mixtures were established experimentally and were used to obtain the dependence of these critical values on composition. A visual *P-V-T* cell of the mercury piston type was used to determine these critical constants for binary mixtures, each having an ethane content of 0.562, 0.766, and 0.888 mole fraction. To accomplish this objective, the vapor-liquid phase behavior of each mixture was determined and utilized to obtain the pressure-temperature relationships having constant liquid volume per cent lines as parameters. All of these relationships converged to the critical point of each mixture. The resulting critical temperature-composition and critical pressure-composition relationships have been compared with the corresponding critical values reported in the literature for this system.

CONTINUING interest in the accurate determination of the critical temperatures and critical pressures of hydrocarbon mixtures requires that these critical properties be well established for binary systems. To assist in this direction, the critical behavior of the ethane–*n*-pentane system was investigated by determining the critical temperatures and critical pressures of three binary mixtures of these components.

These critical values were experimentally determined using a visual *P-V*-T cell in which mercury was used as the displacing fluids. The details of the experimental equipment and procedure used are described at length elsewhere (*1*). The hydrocarbons used in this study were of research grade and were obtained from the Phillips Petroleum Co. The purity of the ethane was claimed to be 99.96% while that of *n*-pentane was claimed to be 99.84%. These components were first introduced into a charging cell preceding the visual *P-V-T* cell where they were solidified with liquid nitrogen and then were exposed to vacuum. In order to ensure complete removal of any noncondensables, the charging cell and its contents were warmed to room temperature, were then again solidified with liquid nitrogen and evacuated. This procedure was repeated at least three times to ensure complete removal of any noncondensables in the hydrocarbon mixture.

ESTABLISHMENT OF CRITICAL POINT

A mixture of ethane and *n*-pentane was charged into the *P-V-T* cell, which was surrounded by an air bath whose temperature could be accurately regulated. The volume of the liquid and vapor phases existing in equilibrium with each other could be observed at all times visually with a cathetometer. The *P-V-T* cell was supported on a trunion and was rocked to hasten the establishment of equilibrium of its contents. The position of the vapor-liquid meniscus and the mercury-liquid meniscus existing at equilibrium conditions provided the necessary information to establish the liquid volume per cent prevailing at the temperature and pressure conditions within the cell. By holding the temperature constant, mercury was introduced into the cell to increase the pressure of the system. This approach was continued until a single homogeneous phase was obtained. Depending on the temperature of the system, this homogeneous phase could be either all liquid or all vapor. This procedure was repeated using different constant temperatures in the vicinity of the critical temperature of the mixture. Figure 1 presents the resulting pressure *vs.* liquid volume per cent isotherms for a mixture of 0.562 mole fraction ethane. These isotherms range from 256.8 to 286.1° F. and exhibit a complete reversal at 277.5, 281.9, and 286.1° F.,

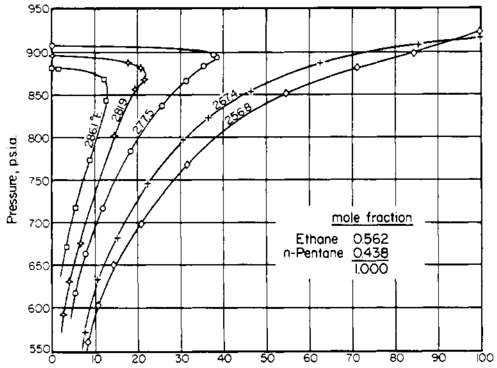

Figure 1. Isothermal pressure-liquid volume per cent relationships for an ethane–*n*-pentane mixture

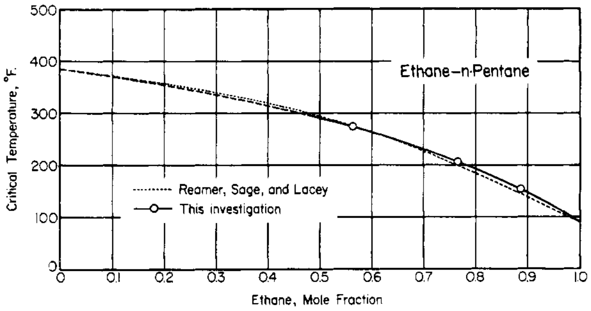

Figure 2. Relationships between pressure and temperature used to establish the critical temperature and critical pressure of an ethane–*n*-pentane mixture

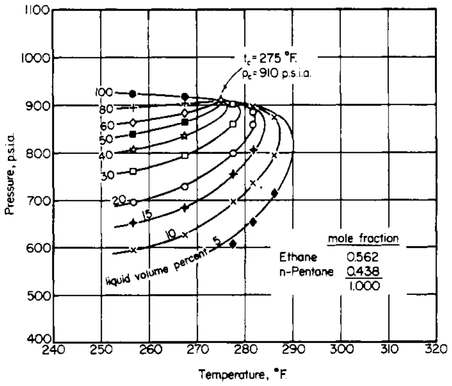

Figure 3. Critical temperature locus for the ethane–*n*-pentane system established from the experimental results of this study

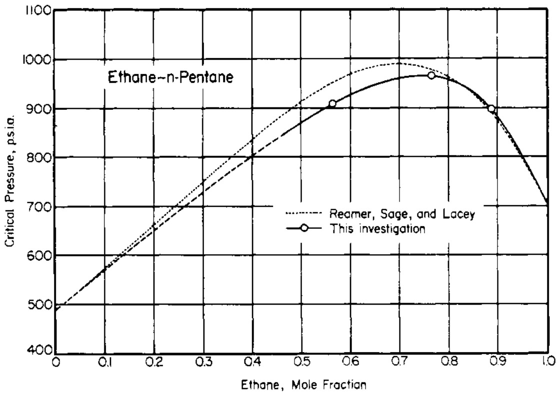

Figure 4. Critical pressure locus for the ethane–*n*-pentane system established from the experimental results of this study

indicating the existence of retrograde behavior of the first kind (*2*). A cross plot of the information of Figure 1 on the pressure *vs.* temperature plane produced relationships of constant liquid volume per cent, all of which converged to the critical point of the mixture as shown in Figure 2. The experimental values used to obtain the relationships of Figures 1 and 2 for a mixture containing 0.562 mole fraction ethane and for the other two additional mixtures can be found elsewhere (*1*).

The same approach was applied to the other two mixtures of ethane-*n*-pentane. Because of the temperature limitations of the Teflon and Buna-N rubber seals of the cell, pentane-rich compositions were not used in order to avoid temperatures within the cell above 325° F. For the three ethane-*n*-pentane mixtures investigated, the following critical temperatures and critical pressures were obtained:

Mole Fraction		Critical	Critical
Ethane	*n*-Pentane	Temperature, ° F.	Pressure, P.S.I.A.
0.562	0.438	275	910
0.766	0.235	208.5	965
0.888	0.112	153	897

These critical values have been related to composition to produce Figures 3 and 4. Figure 3 presents the critical temperature locus of the ethane-*n*-pentane system resulting from the experimental values of this study. In this figure is also included the critical locus resulting from the critical values reported by Reamer, Sage, and Lacey (*3*). The critical temperature locus of this study and that of Reamer, Sage, and Lacey are seen to be in good agreement with each other and show a maximum deviation of 11° F. at a composition of 0.85 mole fraction ethane.

The critical pressures established for the three mixtures of this study generate the locus presented in Figure 4. This relationship has been compared to that resulting from the critical pressures presented by Reamer, Sage, and Lacey (*3*). These two relationships exhibit good agreement for ethane compositions in the region, $0.80 \geqq x_2 \geqq 1.00$. However, this agreement fails to exist for $x_2 < 0.80$. A maximum deviation of 46 p.s.i.a. is encountered at $x_2 = 0.55$. This discrepancy may be due to the fact that the critical pressures reported by Reamer, Sage, and Lacey (*3*) are the result of extrapolations of their vapor-liquid equilibrium studies on the ethane-*n*-pentane system.

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