# EQUILIBRIUM DATA DETERMINATION FOR SYSTEM OF METHANE AND HEPTANE

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***Abstract.*** *This work presents vapor- liquid equilibrium determination for a binary system of methane and heptane. The static method and an equipment like the one that Van Ness used for this research has been used. Temperature and pressure ranges for operation are 80.6- 205 °F and 100- 3120 Psia, respectively.*
***Key words:*** *methane, heptane, eqiulibrium*

## Introduction

Various techniques are applied for phase equilibrium determination that generally are divided into two methods:

1) Static methods 2) Dynamic methods.

In static methods, the mixture of liquid and gas reaches to the equilibrium in a closed chamber and then sampling for analyzing is taken. At low pressures, since density of vapor phase is low, therefore sampling from vapor phase is taken (Inoue, 1975) [1] or concentration of vapor phase is calculated by gas chromatography technique (Holldrof & knapp, 1988) [2], (Lepori and Matteoli, 1988) [3].

Also, another analyzing method of vapor phase concentration is "Infrared Spectrum"(Mckeigue & Gualri, 1986) [4]. At high pressures, the concentration of liquid phase is determined by other methods (Prausnitz & Hermsen, 1962) [5]. A simpler method in static equilibrium instead of sampling, is the recording of variables of system such as equilibrium temperature and pressure (Van Ness & Gibbs, 1972) [6].

It should be mentioned that during this method, the liquid feed should be degassed before experiment because, in determination of real vapor pressure in the chamber, little quantity of gases in liquid feed causes some problems. For degassing, there are different methods: purification method with vacuum (bell, 1968) [7]and/ or vacuum distillation (Abbot and Van Ness, 1978) [8].

The second method in VLE calculation, is dynamic method in which there are one or two continuous phases. For the first time, the concept of continuous flow in phase equilibrium determination invented by Simnick, et al., 1977. The specialty of this method is that, a lot of samples may be simply taken and the residence time for equilibrium is short time. Another method of dynamic methods, is circulation method based on circulation of one phase, for example volatile substance as a gas is entered to the liquid and the exit gas is analyzed (Setier & Blanc, 1988) [9].

This method idiomatically is named" Recirculation of Gas Phase".

Hala (1967) reviewed over these equipments until 1965. A good type of these equipment was constructed by Malanoswki: (1980). In this apparatus, there was the possibility of circulation of two phase (vapor and liquid). Malanoswki (1982) reviewed different types of these apparatuses completely [11].

The selected method in this research is static method for equilibrium pressure determination that is the best and fast method with a high accuracy. The advantage of this method is that no sample from vapor or liquid is taken during experiments, therefore all problems and difficulties related to their analyses is eliminated.

## Experimental Apparatus

The apparatus used in this research is similar to the apparatus that Van Ness and Gibbs used [6].

The instruction of this equipment is very simple. This apparatus has an equilibrium cell that is equipped with an air bath. This cell works at a constant temperature and is equipped with a shaker. This cell is able to work from atmospheric pressure to 6000 Psia for transferring the vapor and liquid phase to this cell, two separate pumps are used that work with mercury piston and the accuracy of them is about 0.001 meat constant pressure. Before transferring each phase, the liquid phase should be degassed. For this purpose" Rasca cylinder" is used. The schematic diagram of this apparatus is in Figure 1.

## Experimental Procedure

The procedure of determination of experimental equilibrium data for Methane- Heptane system is as follows:

1. First, Heptane liquid with purity about 99.5% should be degassed. For this purpose, this liquid is transferred to rasca cylinder and with decreasing pressure by vacuum pump, the in solved gases in liquid is separated. This stage is repeated several times.
2. After degassing, Heptane is transferred to the equilibrium cell by injection pump. The volume of injected liquid is recorded.
3. The density of liquid is calculated by dens meter with accuracy about 0.0001, and the amount of injected mole or weight is indicated.
4. Then the second component (Methane) with purity about 99.99% is entered to the cell. Temperature and pressure should be constant during the injection, thus the amount of Methane mole is calculated.
5. For reaching to the thermal and thermodynamic equilibrium, system should be held under a specific conditions for six hours. Then equilibrium pressure and liquid volume is recorded.
6. For saving time and material, we keep this cell at various

temperatures and after reaching to the thermal equilibrium, the equilibrium pressure and liquid volume is recorded again.

7. Then the cell is drained and washed and then repeat all the stages with another amount of Methane for having various mole fractions (z).

## Experimental Example

First, 73.7288 cm$^3$ of Heptane is injected to the cell. This amount is equal to 0.5 mole of Heptane at 80.6 °F. Then 2.5 cm$^3$ Methane at a pressure about 3675 psig and ambient temperature (68 °F) is injected to the cell. The equilibrium pressure after several hours will be 100 psig.

Determination of equilibrium pressure and liquid volume is done at 105, 130, 155, 180 and 205 °F temperatures. For reaching to the thermal and thermodynamic equilibrium of each temperature, system is held for 6 hours. These experimental results are given in table 1.

## Experimental Results

The above experiment is repeated by adding other amounts of Methane
(5, 12.5, 21, 33, 45 & 50 cm$^3$) to the cell at pressure about 3675 psig and ambient temperature. These results are given in the tables 2 to 7.

**Table 1.** Experimental Results of 2.5 cc Methane injection to the system

| | | |
|---|---|---|
| 68 °F | = | Methane Injection Temperature |
| 2.5 cc | = | Methane Injection Volume |
| 73.7288 cc | = | Heptane Injection Volume |
| 3675psi | = | Methane Injection Pressure |

| Equilibrium temperature (°F) | Equilibrium pressure (psig) | Liquid phase volume (cc) |
|---|---|---|
| 80.6 | 100 | 75.131 |
| 105 | 107 | 76.694 |
| 130 | 118 | 78.933 |
| 155 | 120 | 79.670 |
| 180 | 130 | 81.501 |
| 205 | 140 | 82.951 |

Density of injected Methane at the above temperature and pressure is (0.1884 gr/cc).

**Table 2.** Experimental Results of 5cc Methane injection to the system

| | | |
|---|---|---|
| 70 °F | = | Methane Injection Temperature |
| 5 cc | = | Methane Injection Volume |
| 73.7288 cc | = | Heptane Injection Volume |
| 3675psi | = | Methane Injection Pressure |

| Equilibrium temperature (°F) | Equilibrium pressure (psig) | Liquid phase volume (cc) |
|---|---|---|
| 80.6 | 180 | 74.197 |
| 105 | 184 | 76.360 |
| 130 | 188 | 77.075 |
| 155 | 200 | 78.096 |
| 180 | 215 | 81.017 |
| 205 | 230 | 82.056 |

Density of injected Methane at the above temperature and pressure is (0.1873 gr/cc).

**Table 3.** Experimental Results of 12/5cc Methane injection to the system

| | | |
|---|---|---|
| 70.5 °F | = | Methane Injection Temperature |
| 12.5 cc | = | Methane Injection Volume |
| 73.7288 cc | = | Heptane Injection Volume |
| 3675psi | = | Methane Injection Pressure |

| Equilibrium temperature (°F) | Equilibrium pressure (psig) | Liquid phase volume (cc) |
|---|---|---|
| 80.6 | 368 | 75.390 |
| 105 | 394 | 77.755 |
| 130 | 420 | 78.395 |
| 155 | 450 | 80.094 |
| 180 | 490 | 83.134 |
| 205 | 519 | 83.973 |

Density of injected Methane at the above temperature and pressure is (0.1869 gr/cc).

**Table 4.** Experimental Results of 21cc Methane injection to the system

| | | |
|---|---|---|
| 69.5 °F | = | Methane Injection Temperature |
| 21 cc | = | Methane Injection Volume |
| 73.7288 cc | = | Heptane Injection Volume |
| 3675psi | = | Methane Injection Pressure |

| Equilibrium temperature (°F) | Equilibrium pressure (psig) | Liquid phase volume (cc) |
|---|---|---|
| 80.6 | 648 | 77.272 |
| 105 | 724 | 79.242 |
| 130 | 748 | 80.282 |
| 155 | 790 | 83.124 |
| 180 | 853 | 84.866 |
| 205 | 900 | 86.707 |

Density of injected Methane at the above temperature and pressure is (0.1876 gr/cc).

**Table 5.** Experimental Results of 33cc Methane injection to the system

| | | |
|---|---|---|
| 63 °F | = | Methane Injection Temperature |
| 33 cc | = | Methane Injection Volume |
| 73.7288 cc | = | Heptane Injection Volume |
| 3675psi | = | Methane Injection Pressure |

| Equilibrium temperature (°F) | Equilibrium pressure (psig) | Liquid phase volume (cc) |
|---|---|---|
| 80.6 | 1047 | 77.894 |
| 105 | 1132 | 80.466 |
| 130 | 1247 | 82.816 |
| 155 | 1390 | 84.068 |
| 180 | 1420 | 87.310 |
| 205 | 1450 | 90.050 |

Density of injected Methane at the above temperature and pressure is (0.1913 gr/cc).

**Table 6.** Experimental Results of 45cc Methane injection to the system

| | | |
|---|---|---|
| 60 °F | = | Methane Injection Temperature |
| 45 cc | = | Methane Injection Volume |
| 73.7288 cc | = | Heptane Injection Volume |
| 3675psi | = | Methane Injection Pressure |

| Equilibrium temperature (°F) | Equilibrium pressure (psig) | Liquid phase volume (cc) |
|---|---|---|
| 80.6 | 1360 | 78.112 |
| 105 | 1460 | 80.586 |
| 130 | 1585 | 83.437 |
| 155 | 1692 | 86.685 |
| 180 | 1808 | 89.034 |
| 205 | 1923 | 91.282 |

Density of injected Methane at the above temperature and pressure is (0.1931 gr/cc).

**Table 7.** Experimental Results of 50cc Methane injection to the system

| | | |
|---|---|---|
| 60 °F | = | Methane Injection Temperature |
| 50 cc | = | Methane Injection Volume |
| 73.7288 cc | = | Heptane Injection Volume |
| 3675psi | = | Methane Injection Pressure |

| Equilibrium temperature (°F) | Equilibrium pressure (psig) | Liquid phase volume (cc) |
|---|---|---|
| 80.6 | 1591 | 79.817 |
| 105 | 1670 | 83.489 |
| 130 | 1740 | 87.634 |
| 155 | 1860 | 89.614 |
| 180 | 2000 | 94.465 |
| 205 | 2120 | 98.114 |

Density of injected Methane at the above temperature and pressure is (0.1931 gr/cc).

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