EXPERIMENTAL AND ANALYTICAL STUDIES OF HYDROCARBON YIELDS UNDER DRY-, STEAM-, AND STEAM WITH PROPANE-DISTILLATION

A Dissertation

by

MARCO ANTONIO RAMIREZ GARNICA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2004

Major Subject: Petroleum Engineering

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ABSTRACT

Experimental and Analytical Studies of Hydrocarbon Yields Under
Dry-, Steam-, and Steam with Propane-Distillation. (May 2004)
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Recent experimental and simulation studies - conducted at the Department of Petroleum Engineering at Texas A&M University - confirm oil production is accelerated when propane is used as an additive during steam injection. To better understand this phenomenon, distillation experiments were performed using seven-component synthetic oil consisting of equal weights of the following alkanes: n-C_5, n-C_6, n-C_7, n-C_8, n-C_9, n-C_{10}, and n-C_{15}. For comparison purposes, three distillation processes were investigated: dry-, steam-, and steam-propane-distillation, the latter at a propane:steam mass ratio of 0.05. The injection rate of nitrogen during dry- and steam-distillation was the same as that of propane during steam-propane distillation, 0.025 g/min, with steam injection rate kept at 0.5 g/min.

The distillation temperatures ranged from 115ºC to 300ºC and were increased in steps of 10ºC. The cell was kept at each temperature plateau (cut) for 30 minutes. Distillation pressures ranged from 0 psig for dry distillation to 998 psig for steam- and steam-propane distillation. The temperature-pressure combination used represented 15ºC superheated steam conditions. Distillate samples were collected at each cut, and the volume and weight of water and hydrocarbon measured. In addition, the composition of the hydrocarbon distillate was measured using a gas chromatograph.

Main results of the study may be summarized as follows. First, the hydrocarbon yield at 125ºC is highest with steam-propane distillation (74 wt%) compared to steam distillation (58 wt%), and lowest with dry distillation (36 wt%). This explains in part the oil production acceleration observed in steam-propane displacement experiments. Second, the final hydrocarbon yield at 300ºC however is the same for the three

distillation processes. This observation is in line with the fact that oil recoveries were very similar in steam- and steam-propane displacement experiments. Third, based on the yields of individual hydrocarbon components, steam-propane distillation lowers the apparent boiling points of the hydrocarbons significantly. This phenomenon may be the most fundamental effect of propane on hydrocarbon distillation, which results in a higher yield during steam-propane distillation and oil production acceleration during steam-propane displacement. Fourth, experimental *K*-values are higher in distillations with steam-propane for the components n-hexane, n-heptane, n-octane, and n-nonane. Fifth, vapor fugacity coefficients for each component are higher in distillations with steam-propane than with steam. Finally, Gibbs excess energy is overall lower in distillations with steam-propane than with steam.

The experimental results clearly indicate the importance of distillation on oil recovery during steam- or steam-propane injection. The experimental procedure and method of analysis developed in this study (for synthetic oil) will be beneficial to future researchers in understanding the effect of propane as steam additive on actual crude oils.

DEDICATION

In the Name of God,

For I am convinced that nothing can ever separate us from his love.

Death can't, and life can't.

The angels won't, and all the powers of hell itself cannot keep God's love away.

Our fears for today, our worries about tomorrow,

or where we are –high above the sky, or in the deepest ocean-

nothing will ever be able to separate us from the love of God

demonstrated by our Lord Jesus Christ when he died for us.

(*Romans 8:38-39, Holy Bible)*

Amen.

To my beloved parents Don Dagoberto and Doña Rosa Maria,

I love you both, God Bless you;

to my sweet and lovely daughter, Letzamani Betzay,

I love you, God bless you;

to my brothers, Jose, Andres, Gustavo, Rodolfo, and my sister Ana Karina,

for their unconditional love, God Bless you;

to all Garnica family and our root, Mama Doña Dionisia Salinas, for their love,

I love you All, God Bless you;

and to my friends, for all the marvelous years,

my sincere gratitude, God bless you.

Rejoice in the Lord always; again I will say, rejoice!

(*Philippians 4:4, Holy Bible)*

Amen.

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CHAPTER I

INTRODUCTION

In the past five years, studies have been conducted at the Department of Petroleum Engineering (Texas A&M University) to evaluate the feasibility of steam-propane injection for the Hamaca heavy oilfield (8^{o}API) and for the Duri intermediate oilfield (20^{o}API).[1-6] The experiments involved injecting steam simultaneously with propane at the top of a vertical cell containing a mixture of sand, oil and water. Superheated steam was injected at 170^{o}C and 3.5 ml/min (Hamaca) and 260^{o}C and 5.5 ml/min (Duri), with the cell outlet pressure at 50 psig (Hamaca) and 500 psig (Duri). Runs were made with propane:steam mass ratios (PSR) ranging from 0:100 to 5:100. With steam-propane injection (PSR 0.05) the following main results – when compared to pure steam injection – are observed.

(a) The start of oil production is accelerated by 19% (Hamaca) and 30% (Duri)
(b) Steam injectivity is three times higher
(c) The steam front velocity is higher, indicating greater partitioning of distillated fractions into the propane stream that appears to act as a very efficient carrier gas.

In addition, distillation experiments of two Venezuela crude oil types have been performed up to 300^{o}C. The following are the main results.

(a) For 25.1^{o}API crude oil, the yield with steam-propane distillation, 63 wt% of original oil, is significantly higher than that with pure steam distillation, 42 wt% of original oil (**Fig. 1.1**).

(b) For 34.2^{o}API crude oil, yields for steam-propane and for pure steam distillations are very similar, about 54wt% of original oil.

This dissertation follows the style and format of the *Journal of Petroleum Technology.*

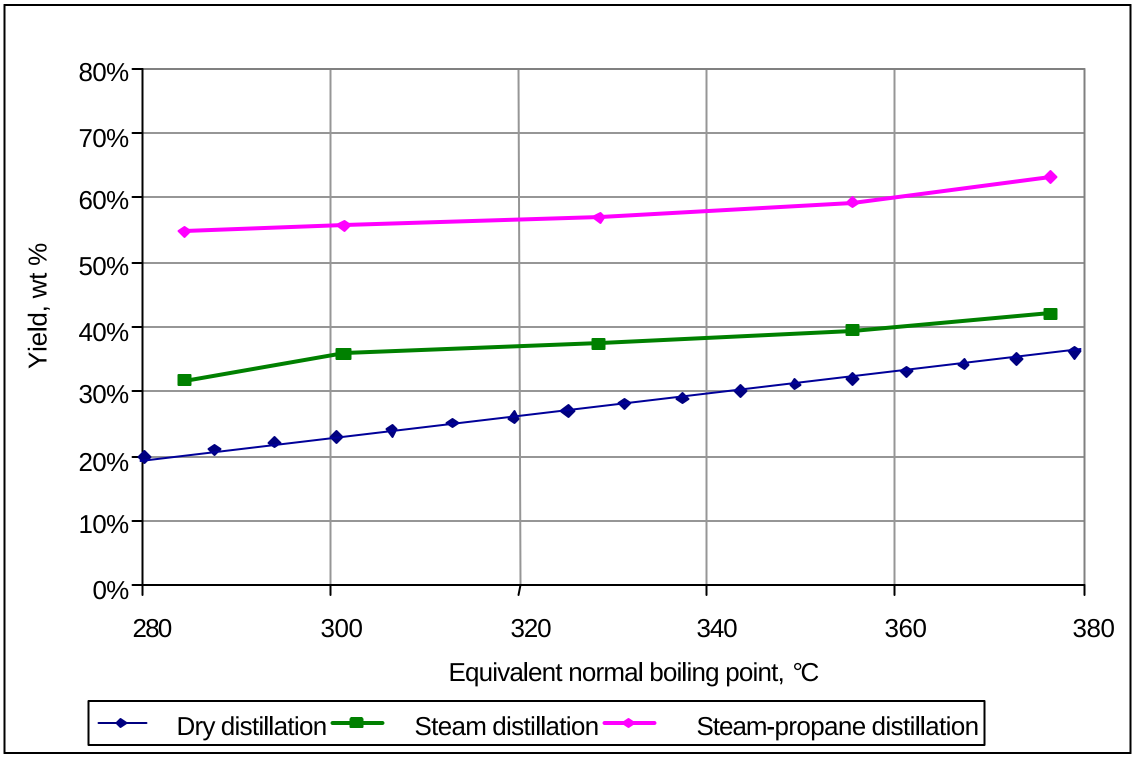


Fig. 1.1-Distillation of 25.1°API Venezuela crude oil.

To-date, there is no analytical model (we have only a tentative theory) to describe the process of production acceleration with steam-propane injection and the higher yields with steam-propane distillation. The proposed research aims at obtaining a better understanding of the process involved during steam-propane distillation and associated oil recovery mechanisms during steam-propane injection. The proposed research therefore focuses on propane as a steam additive during steam injection.

Steam injection is a well-known enhanced oil recovery (EOR) process that has been successfully used in the field for some fifty years. A description of the oil recovery mechanisms and physics under steam injection follows.

1.1 Heat and mass transport during steam injection

Steam is injected into a reservoir containing particularly intermediate and heavy oil – to improve the oil production rate and recovery. The injected steam is typically wet-steam with a steam quality of about 80%. The latent and sensible heat contained in the steam is imparted to both oil (and any other fluids in the reservoir) and the reservoir matrix, resulting in their temperature increase. Heating of the oil results in the following beneficial effects. [7,8]

(i) Oil viscosity is significantly reduced particularly for intermediate and heavy oils – resulting in lower flow resistance, thus increasing the oil production rate.

(ii) Steam distillation of the lighter hydrocarbon fractions – significant for lights oils – occur in the steam zone. The lighter fractions being in the gaseous phase can travel deeper into the colder regions of the reservoir, where they condense, reducing the oil viscosity, density, and interfacial tension. Oil viscosity reduction results in an increase in oil production rate. The produced oil is upgraded by reduction of the oil density. The oil recovery is increased due to reduction of interfacial tension and thus residual oil saturation.

(iii) The oil undergoes thermal expansion, which constitutes a drive mechanism.

During steam injection, the heat and mass transfer at the steam oil interface is a complex process that is not fully understood. To understand the process of steam-propane distillation, we need to understand the physics of distillation in general. The process of distillation is briefly described in the following.

1.2 Steam distillation

The boiling points of organic compounds can give important clues to other physical properties. A liquid boils when its vapor pressure is equal to the atmospheric pressure. Vapor pressure is determined by the kinetic energy of molecules. Kinetic energy is related to temperature and the mass and velocity of the molecules. When the temperature reaches the boiling point, the average kinetic energy of the liquid particles is sufficient to overcome the forces of attraction that hold molecules in the liquid state. Then these molecules break away from the liquid to form a gaseous phase. Molecules with the most independence in individual motions achieve sufficient kinetic energy (velocities) to escape into the vapor phase at lower temperatures. The vapor pressure will be higher and therefore the compound will boil at a lower temperature. Molecules that strongly interact or bond with each other through a variety of intermolecular forces cannot move easily or rapidly and therefore, do not achieve the kinetic energy necessary to escape the liquid state. Therefore, molecules with strong intermolecular forces will have higher boiling points.

Number of electrons per molecule, molecular polarizability, and contact between chains increases with increasing chain length resulting in greater intermolecular London attractive forces. The data may be plotted to graphically illustrate this trend. For hydrocarbons in general the higher the molecular weight the higher is the boiling point of the component (**Fig. 1.2**).

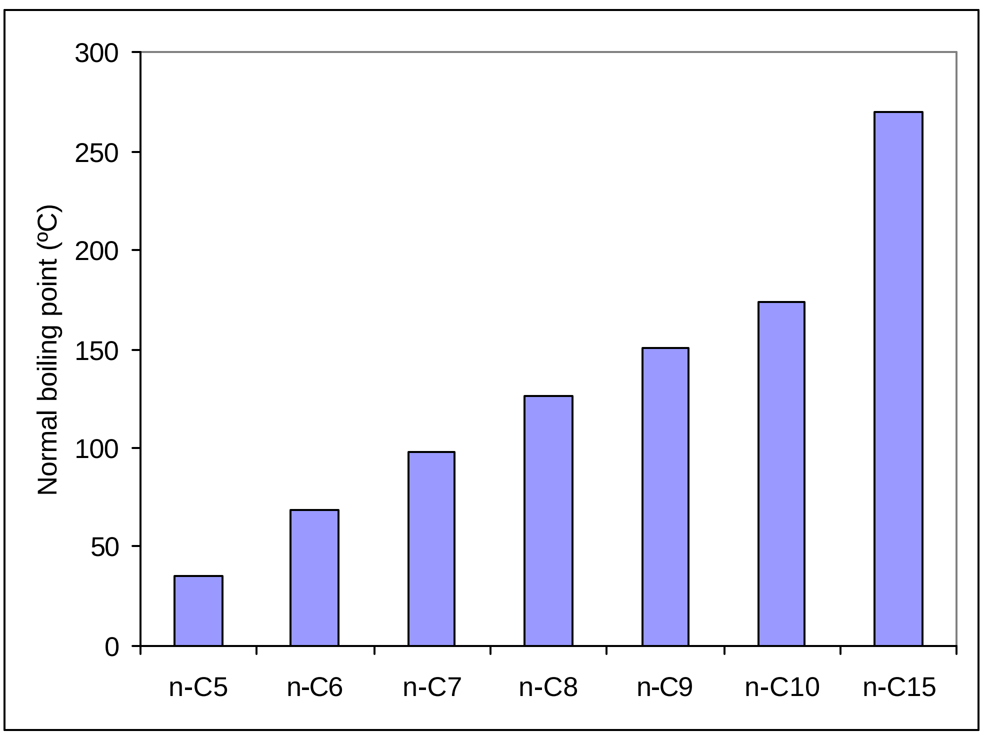


Fig. 1.2-Increase normal boiling point of alkanes with increasing carbon number.

Basically the hypothesis in this research is that, during steam-propane distillation of oil, the steam-propane vapor strips the more volatile components from the oil because it encourages a decrease of the boiling point of these components. The steam enriched with the propane and light components, flow through the steam zone to the condensation front where both steam and light hydrocarbons condense. The condensed hydrocarbons are miscible with the oil, reducing overall viscosity of liquid hydrocarbons. In other words, steam-propane distillation begins when the total vapor pressure (steam and propane) in the presence of two immiscible liquids (water and oil exerting its own vapor pressure at the temperature of the system) equals the total pressure on the system. The postulated role of propane is that it reduces the boiling point of some light oil components. As a result, oil will begin distilling at temperatures much lower than the normal boiling points of its constituents. As a consequence, the distillation yield increases.

The material balance on the synthetic hydrocarbons will help to model mathematically the partial distillation using steam/propane. The theory and experimental method presented in this work should be particularly useful in applications to the steam-propane flood process showing the importance of vaporization in total oil recovery. The value of this study is to establish laboratory distillation measurements to quantify oil recovery efficiency during steam-propane injection.

1.3 Research objectives

In this research, laboratory experiments will be conducted to determine the boiling points and yields during the distillation of a synthetic hydrocarbon. The major objectives of this research are as follows.

(a) To verify experimentally whether or not propane reduces the boiling point of some components in a hydrocarbon mixture.

(b) To investigate various fundamental mechanisms in steam-propane injection.

(c) To investigate the effect of propane in upgrading oil.

(d) To develop a new systematic procedure to analyze the performance of steam-propane injection in oil reservoirs.

CHAPTER II

LITERATURE REVIEW

The principal mechanism responsible for oil recovery in steam injection processes are thermal expansion of the oil, viscosity reduction, and steam distillation.[7,8] Steam distillation is the main mechanism that reduces the residual oil saturation behind the hot-water front during steamflood particularly for light and medium oils.[9] Therefore, understanding the distillation effect of steam and more recently the effect due to little concentration of propane in the steam on oil facilitates the prediction of fluid behavior in steam injection processes.[1-6] An exhaustive literature review of distillation and steam injection as an enhanced oil recovery was done and summarized in the following.

The first mathematical description of the distillation process was developed by Rayleigh (1901). In his classical analytical work, he described mathematically the batch distillation process but limited to binary mixtures.[10] Later, Holland and Welch (1957) developed steam batch distillation calculations for a mixture of volatile components that might be partially separated from its nonvolatile components at temperature such that volatile components do not decompose.[11] Their calculations were based on the theoretical requirement that the partial pressure of the steam in vapor stream rising from the still is less than the saturated pressure of steam at the temperature of the still. This assumes the absence of liquid water, and the batch process is carried out at the conditions of constant still temperature and constant total pressure. The total pressure is maintained constant by increasing the rate of flow of steam to compensate for the decrease of the concentration of the lower boiling components.

Later Willman *et al.* (1961) reported high oil recoveries by steam injection identifying the principal mechanisms responsible for additional oil as (1) thermal expansion oil, (2) viscosity reduction, and (3) steam distillation.[12] Recovery by steam injection is greater for lighter oils because they contain a greater fraction of steam-distillable components. Appreciable amounts of even low gravity crude oils are steam distillable, and that residual oil left after steam injection is essentially independent of the initial oil saturation. Finally, it was observed that residual oil was lower in gravity than the initial crude oil because it has been steam-stripped of light ends.

Sukkar (1966) proposed a method of calculating oil distillated during steamflooding of light oil.[13] The method used relative velocities of steam, condensing steam front and velocities that described the rate at which particular oil components were being distilled. The solution was influenced by reservoir properties and oil composition. Results of other investigators have indicated that steam distillation yield is independent of reservoir properties, and the author emphasized that the oil distilled is not necessarily oil recovered.

Barb (1969) developed some integral-difference equations describing the batch distillation column process.[14] Barb assumed that the mole fraction of each component in the liquid leaving a plate is equal to its mean value in the liquid holdup on the plate. This may not necessarily be true in the case of steam-propane distillation.

More recently Johnson *et al.* (1971) presented a method to calculate oil vaporization during steamflooding.[15] Three quantities were calculated sequentially as follows.

(a) The volume of steam condensed at the steam front,
(b) The volume of immobile oil left behind the hot-water zone, and
(c) Percentage of oil vaporized as a function of volume of steam and volume of immobile oil left behind the hot-water zone.

The oil vaporization involved a series of flash calculations for which an appropriate set of equilibrium ratios (K-values) was required. Oil composition corresponding to Bureau of Mines routine method to determine distillation fractions were used in the calculations. The results were in essence dictated by the selected K-values. Comparisons with experimental data showed that the method overestimated the amount of oil vaporized.

Volek and Pryor (1972) reduced oil viscosity and the residual oil saturation below that obtainable by waterflooding using steam distillation drive.[16] They studied the mechanisms involved in the steam distillation process, finding that steam driving light oil leaves a residual oil saturation of less than 8%, and increases the average gravity of the oil by recovering a greater fraction of the light components from the reservoir crude oil. This study was done only with light oil reservoir.

Alikhan and Ali (1974) found that an important effect involved in the steam displacement phase of the process is steam distillation of the light hydrocarbons.[17] Distilled fractions are carried farther downstream where they help to lower the viscosity of the cold-in place oil, increasing its mobility. They observed that light hydrocarbon injection was highly effective in the case where the core initially contained residual oil saturation as compared to straight steam slug injection but they did not give more importance and neither any explanation to this fact. They concluded that from the recovery point of view, it is advantageous to use a low viscosity light hydrocarbon slug and a small slug size. Their experimental study involved oil recovery from a porous medium by the injection of light hydrocarbon slug, followed by a steam slug, which is in turn, was driven by a conventional waterflood.

Alikhan and Ali also found that: the light hydrocarbon slug, injected prior to the steam slug in a core initially containing residual oil saturation, improved the oil recovery as compared to a straight steam slug run. The light hydrocarbon, in view of the prevailing adverse mobility ratio, mixes with the original in-place oil, and helps to lower its viscosity. The viscosity is further reduced by the heat from the injected steam slug, leading to an improvement in the mobility ratio, and hence an improvement in the displacement efficiency. The steam distillation effects recover a large proportion of the light hydrocarbon slug. It is concluded that from the recovery ratio (volume of oil recovered divided by hydrocarbon slug volume) point of view, it is advantageous to use a low viscosity light hydrocarbon slug, and a small slug size. The optimum slug size depends on the in-place oil, as well as the steam slug size, for a given steam temperature. The temperature profiles and the heat loss rate measurement indicated that the combination, light hydrocarbon slug-steam slug process, utilizes the maximum amount of heat injected.

The injected cold water effectively recovers the heat contained in the hot porous medium, transporting it farther downstream; however, the recovery of the heat contained in the adjacent formation is low. The authors showed that the process is highly effective particularly when the porous medium initially contains residual oil saturation. The displacement of oil by the proposed process involves a number of effects. The hydrocarbon slug is dispersed rapidly into the oil phase in view of the favorable mobility ratio involved. The increase in the oleic phase volume (assuming that initially the oil saturation is residual) leads to the development of an oil bank, at the rear of which there is an extensive transition zone containing the oil and the hydrocarbon in varying proportions. Effectively, this creates a graded oil viscosity zone, which is desirable in displacement by a number of mechanisms discussed by other authors. An important effect involved in the steam displacement phase of the process is steam distillation of the light hydrocarbons. The distilled fractions are carried farther downstream, where they help lower the viscosity of the cold in-place oil, thus increasing its mobility. On the whole, oil is efficiently displaced by the steam front, and at the same time its production is facilitated at the outlet end.

Alikhan and Ali[17] mention too that in the final phase of the process, cold water is injected to displace the in-place fluids. The cold water essentially leads to the transformation of the steam slug into a hot water bank. At the same time, the heat contained in the hot porous matrix near the inlet end is transported downstream. A fraction of the heat conducted into the adjacent formations is also recovered. As a result, the overall heat utilization efficiency of the process is improved. In addition to the effects considered above, gravity segregation of the fluids, and temperature variation of the relative permeabilities would affect the overall process.

Experimental results of Wu and Brown (1975) show that in saturated steam distillation, yields are mainly dependent on the oil composition and may not correlate with the crude API gravity.[18] Six crude oils ranging from 9^oAPI to 36^oAPI were used. Cumulative yields ranged from 7 to 68 volume percent. Results indicated that yields were independent of the porous medium used, steam injection rate and initial oil volume.

Wu and Brown research shows too that changes in steam saturation pressure and temperature have insignificant effect on the yields; however, superheated steam increases significantly the yields for some crude oils. The authors recognized too that steam distillation is one of the major mechanisms responsible for high oil recovery by steam flooding. Based on laboratory steam flood and fluid flow in porous media experiments they identified these mechanisms as: (1) steam distillation (including gas stripping), (2) steam displacement, (3) viscosity reduction, (4) thermal expansion, (5) gravity segregation, (6) relative permeability and capillary pressure variation, (7) solution gas drive, (8) oil-phase miscible drive, and (9) emulsion drive. The most important of these mechanisms, steam distillation and steam displacement, take place in the steam zone. In the steam zone, the pressure and temperature gradients are generally small indicating stable saturated steam conditions. The presence of steam vapor phase in the steam zone with two liquid phases (heated crude oil and hot water) induces vaporization of light oil fractions and water. These oil and water vapors are displaced downstream by the steam and condensed in the solvent and hot water banks. Rapid vaporization of oil and water disturbs and redistributes a portion of oil in the pores and, thus, effects a more efficient displacement of the crude oil by the injected steam.

Wu (1977) concluded that steam distillation is an important part of steam drive, which is responsible for the low residual oil saturation of a steamflood.[19] Steam distillation is a process of separating the light fractions from the crude oil by the action of steam.

Rhee and Doscher (1980) indicated the importance of the compositional effect on the solvent displacement mechanism in steamflooding.[20] Steam distillation process is affected strongly by the composition of the crude oil. Even crude oils having the same gravity can show significant differences in steam distillation characteristics depending on their compositions. Therefore, the effect of the composition should be considered carefully.

Wu and Elder (1981) established some correlations to estimate the amount of vaporized oil caused by steam distillation.[21] These correlations were based on 16 crude oils within a minimum standard error of 4.3%. Steam distillation yields of sixteen crude oils obtained from various parts of the United States were determined at a saturated-steam pressure of 215 psia. At the steam distillation factor of 15 ($V_w/V_{oi} = 15$) the yield ranges from 12 to 56% of initial oil volume. V_w is volume of steam (cold water equivalent) injected, and V_{oi} is original oil volume, both volumes expressed in the same unit. Main conclusions of their studies are as follows.

1. The effect of pressure on the ultimate steam distillation yields (when $V_w/V_{oi} > 15$) appears to be small. However, its effect may be significant for $V_w/V_{oi} < 15$).

2. Simple regression analysis results indicate the following.

(a) The steam distillation yield increases linearly with respect to the API gravity. The API gravity can predict the steam distillation yields within a standard error of 5.6% (in yield).

(b) The steam distillation yield decreases logarithmically with respect to the oil viscosity (100^{o}F). When the oil viscosity is less than 10cs (at 100^{o}F) the relationship is uncertain. Above 10 cs at 100^{o}F, the oil viscosity can be used to estimate the steam distillation yields within a standard error of 4.3%.

(c) The steam distillation yield increases as the characterization factor of the crude oils increases. However, this is not a good parameter for correlation.

(d) The steam distillation yield increases linearly with respect to the simulated distillation yield. This parameter can be used to predict the steam distillation within a standard error of 4.5%.

Duerksen and Hsueh (1983) reported a correlation between steam distillation yield, API gravity, and wax content of crude oils.[22] Research shows in a steam distillation of crude oils that for low-wax crude oils, steam distillation yield correlates closely with API gravity. For both high and low-wax crude oils, steam distillation yield correlates closely with API gravity and wax content. Vaporization, transport, and condensation of the hydrocarbons fractions are dynamic processes that displace the lighter hydrocarbon fractions and generate a distillate bank that miscibly drives the oil to producing wells.

Langhoff and Wu (1986) used the Holland and Welch method and a simulated distillation data to calculate crude-oil/water/vapor separations on a hexane/decane system and for 16 crude oils.[23] The approach satisfactorily predicted the overhead yields of 13 out of 16 crude oils with an average error of 12% (±3.6% in yield). The overhead yields obtained were expressed as a function of the steam distillation factor. This method required only simulated crude oil distillation data for the separation calculation.

A method using steam distillation tests to estimate 3-phase K-values of mixtures of pure hydrocarbons with water was developed by Billman (1989).[24] Three-phase separation data was obtained for temperature range from 150^{o}F to 500^{o}F and pressures from 0 psig to 1,000 psig in a constant volume cell. These conditions included a liquid water phase, a liquid hydrocarbon phase, and a vapor phase consisting of hydrocarbon and water vapors. The pure n-alkane components used ranged from n-hexane through n-dodecane. The author concluded that steam distillation data was useful in determining overall yields but did not provide compositional information for determining 3-phase K-values.

Later a new method to calculate 3-phase K-values of crude oil fractions was developed by Lanclos (1990).[25] This method was based upon the theoretical considerations developed by Billman with some modifications to increase the accuracy of the 3-phase K-values calculation procedure and to extend the procedure for the calculation of 3-phase K-values of crude oil fractions. The method of Lanclos assumed that the crude oils were composed of a mixture of pure hydrocarbon components due to lack of correlations relevant to crude oil fractions. The author concluded that the data obtained could be used to estimate 3-phase K-values of pure hydrocarbons ranging from n-C_5 to n-C_{12}. He observed too that the liquid hydrocarbon density-temperature correlations had very little effect on the 3-phase K-value calculations for all ranges of hydrocarbon components and crude oil fractions.

Lim (1992) developed a general method to calculate steam distillation yield and to quantify oil quality changes during steam injection.[26] Steam distillation data from the literature could be correlated with the steam distillation yield obtained from the Department of Energy (DOE) crude oil assays. They found that the steam distillation yield could be significant, even for heavy crude oils. Data from 454 California crude oil samples from the DOE were analyzed that gave the following relationship.

$$\text{Volume \% Yield} = 1.75 \times {}^{o}\text{API} \tag{1}$$

Forero (1992) developed a new semiempirical computer model to calculate 3-phase K-values of n-alkanes in the presence of an aqueous phase using 3-phase isochoric experimental data generated by Billman.[27] This method uses the vapor phase composition from the lab data and the Peng-Robinson equation of state. The 3-phase K-values for n-C_6, n-C_7, n-C_8, n-C_9, n-C_{10}, and n-C_{12} were calculated for temperatures raging from 200^{o}F to 500^{o}F. Results of this study indicated that the mutual solubility between the two liquids phases significantly affect the lighter hydrocarbon K-values at temperatures above

350^{o}F. For the heavier components the effect of mutual solubility is insignificant. The calculated 3-phase K-values were compared to the published 2-phase K-values obtained from Gas Processor's Association charts. The 3-phase K-values were considerably larger than published 2-phase K-values indicating the need for 3-phase K-values for reservoir process simulations.

Mokrys and Butler (1993) studied steam-propane as part of the "Vapex" process.[28] This process was designed to recover heavy oils effectively, and also obtain a partial upgrading of heavy crude in-situ. Simultaneous steam-propane injection into the scaled model is a variation on the Steam Assisted Gravity Drainage (SAGD) with propane forming a low temperature oil production zone that spreads laterally away from the steam zone at the injector/producer. In this process the steam creates a limited hot region in which propane is stripped from the draining oil and recycled internally. The cooler propane spreads laterally into the reservoir where it dilutes, upgrades and recovers oil. The steam is used to create a limited hot region in the vicinity of the injector/producer in which the propane is stripped from the draining oil and recycled into the laterally spreading, cooler propane chamber. As a result of this internal recycling mechanism the G/O ratios are low and the latent heat of propane vapor is transported to the oil/propane interface that is receding deeper into the cold reservoir. This was the first work where the propane-recovered oil could be upgraded in situ and thus is higher quality than the original oil.

The physical mechanism of lean gas injection into volatile oil reservoirs to recover oil by vaporization was studied by Espie *et al.* (1994).[29] In this research the composition of the gas used included C_3 at 1.26 mole%. The experiments were conducted at reservoir conditions using core from the Prudhoe Bay reservoir. They pointed out that reservoir oil recovery efficiency by vaporization depends upon thermodynamics partitioning of oil components into the gas. Finally, the principal findings of this study showed: (1) The C_{6+} recovery by vaporization after 9.47 PV of lean gas injected was 28.4% of the target oil remaining after the equilibrium gas-flood, (2) Compositional analysis of the effluent stream and the core residual oil showed high recovery of components up to C_{12} with steadily declining recoveries up to $C_{20,}$ (3) Mass balances over the total fluid, total hydrocarbons, C_{6+}, water and on a hydrocarbon component basis confirmed the accuracy of the experimental results.

Beladi (1995) reported results of research on determination of *K*-values.[30] The approach consisted of four parts.

(a) 3-phase isochoric distillation (SWID) tests were developed to obtain the vapor phase compositions of binary, ternary, quaternary, and crude oil systems in presence of water for the temperature range, 250°F to 500°F.

(b) Compositional empirical balance model (EMBM) was developed to calculate pure component mixtures, pseudo components and water three-phase K-values using lab vapor phase conditions.

(c) Corrections were devised for three-phase K-values of binary systems (C_8/H_2O through C_{20}/H_2O) for the temperature range 250°F to 500°F.

(d) Ternary, quaternary and crude oil systems multi-component three-phase K-values were calculated using EMBM. These 3-phase K-values were used to examine the binary 3-phase K-value and their applicability to multi-component and pseudo component systems.

A consistent pseudodization technique was used to calculate pseudo-component's K-values of crude oil. Also, empirical mutual solubility correlations are proposed for both the hydrocarbon solubility in aqueous phase and the water solubility in the oleic phase. EMBM incorporated the new correlations for mutual solubilities, critical properties, and fluid densities to calculate the 3-phase compositions. EMBM compositions were used to calculate the 3-phase K-values. A comparison between EMBM compositions and existing equation of state compositions (EOS) was provided. Commercial thermal compositional reservoir simulators use 2-phase K-values compensated by water vapor pressures instead of 3-phase K-values gas-oil-water equilibrium K-values. When reservoir simulation is performed on 3-phase processes the distillation mechanism and effects of water on the oleic phase are neglected. This is due to scarceness of the three-phase experimental data for the reservoir conditions of high temperatures at their saturation pressures. This research emphasizes the properties and phase behavior of n-decane and n-eicosane and crude oil pseudocomponents. This experimental set-up was used to perform:

(a) Static system pressure test (SPT): These tests are performed on every sample to obtain the saturation system pressures of hydrocarbon/water mixtures. It is important to have the static pressure data to insure that three-phase near equilibrium conditions are reached for SWID tests.

(b) Stage-wise isochoric distillation test (SWID): At each stage of the distillation the system is brought to equilibrium before the distillate samples are removed from the vapor phase. This test is conducted under a stepwise increase of temperature for each stage. For each stage the vapor phase is partially and slowly removed as distillate for compositional analysis. Knowing the composition of every component removed, the overall composition is calculated by material balance. The remaining components in the cell are used for the next stage of test at higher temperature.

A comprehensive semi-empirical (CSA) approach to calculate 3-phase water/hydrocarbons equilibrium was developed by Tandia (1995).[31] Lab data (stagewise isochoric distillation data) and Peng-Robinson EOS were used. The author considered mutual solubility between water and hydrocarbons. The CSA calculates phase equilibria by applying the thermodynamic equalities between phases and material balance of the systems. The approach also includes a self-tuning algorithm that allows the user to tune the input parameters, for instance vapor phase composition (y_i).

Goite (1999) reported experimental results of steam-propane injection for Morichal heavy oil.[3] Results appear to indicate optimal concentration of propane lies somewhere in the region of 5%. Significant oil production acceleration was observed.

Mamora and Sutadiwira (1999) developed an analytical model for light oil recovery by steam distillation for a vertical sand pack containing a 3-component liquid mixture, cyclohexane, n-octane, and water.[32] Study shows that steam distillation of oil does not occur at equilibrium conditions because it is a dynamic process. Moreover, oil recovery by steam distillation is largely dependent on the steam saturation point and injection rate. Their model describes the advance of steam-oil interface, temperature profile in the sand mix, and cyclohexane production, and it is in satisfactory agreement with the experimental data.

Following Goite (1999)'s study of propane as an additive in steam injection, Ferguson *et al.* (2000) continued the research using a constant steam mass rate.[1] Several tests were performed to determine the optimum propane-steam mass ratio. Acceleration of production was found in the steam-propane runs when compared to steam alone. The optimum propane/steam mass ratio was found to be around 5:100. The acceleration in oil production was thought to be due to the dry distillation process in which the lighter oil fractions are vaporized and carried by propane. On contact with the colder part of the reservoir, the light fractions condense and are miscible with the oil, thus lowering the interfacial tension and decreasing the viscosity of the oil.

Later Tinns (2001) carried out steam-propane experiments using the “optimum” found in Ferguson’s study, 5:100 propane-steam mass ratio, on a 21ºAPI Kulin oil.[4] The same effect of production acceleration was observed in these experiments. Viscosity and density measurements indicated an increment in API gravity and a reduction of viscosity in the produced oil. Furthermore, injectivity was improved with the addition of propane to the steam. A reduction in the maximum injection pressure from 85 psig to 78 psig was observed in the experiments.

Distillation study considering the injection of steam using propane as an additive was conducted by Plazas (2002).[6] The experimental study measured the yields for a light crude oil (34.2°API) and an intermediate crude oil (25.1°API). Propane:steam ratio of 5:100 was used in the distillation runs. Steam and steam-propane distillations were performed at five temperature cuts for each run, 110°C, 150°C, 200°C, 250°C and 300°C at slightly superheated conditions getting volumetric yields. A comparison with dry distillation was included. The steam distillation showed higher yield (43.1 wt%) and the steam-propane distillation gave an even higher yield (63.1 wt%), almost twice the yield obtained during dry distillation (36.0 wt%). These results indicated a remarkable improvement obtained using propane as an additive to steam distillation at the experimental conditions and for the intermediate oil only. For both crude oils, in general, viscosities of the distilled fractions were similar for both steam and steam-propane distillation.

Rivero (2002), conducted a series of experiments using steam-propane injection to evaluate the role of propane on Hamaca extra-heavy oil.[5] Four propane-steam mass ratios were used: 0:100, 2.5:100, 5:100, and 10:100. The same effect of production acceleration was observed in these experiments. The use of propane as an additive to steam resulted in injection pressures lower than those of pure steam injection, and that improvement of injectivity was observed even with propane-steam ratio as low as 2.5:100.

CHAPTER III

DISTILLATION THERMODYNAMIC ANALYSIS

To describe analytically dry-, steam-, and steam-propane distillation processes, thermodynamic description of the hydrocarbon synthetic mixture was made assuming thermodynamic liquid-vapor equilibrium exists during the processes of distillation.

Fig. 3.1 shows a sketch for the distillation process. Synthetic hydrocarbon is placed in a cell and the system (cell with hydrocarbon) is kept at constant pressure and temperature for a period of time at each temperature cut. The system is considered during each temperature cut to approximate thermodynamic equilibrium for each type of distillation: dry-, steam-, and steam-propane distillation.

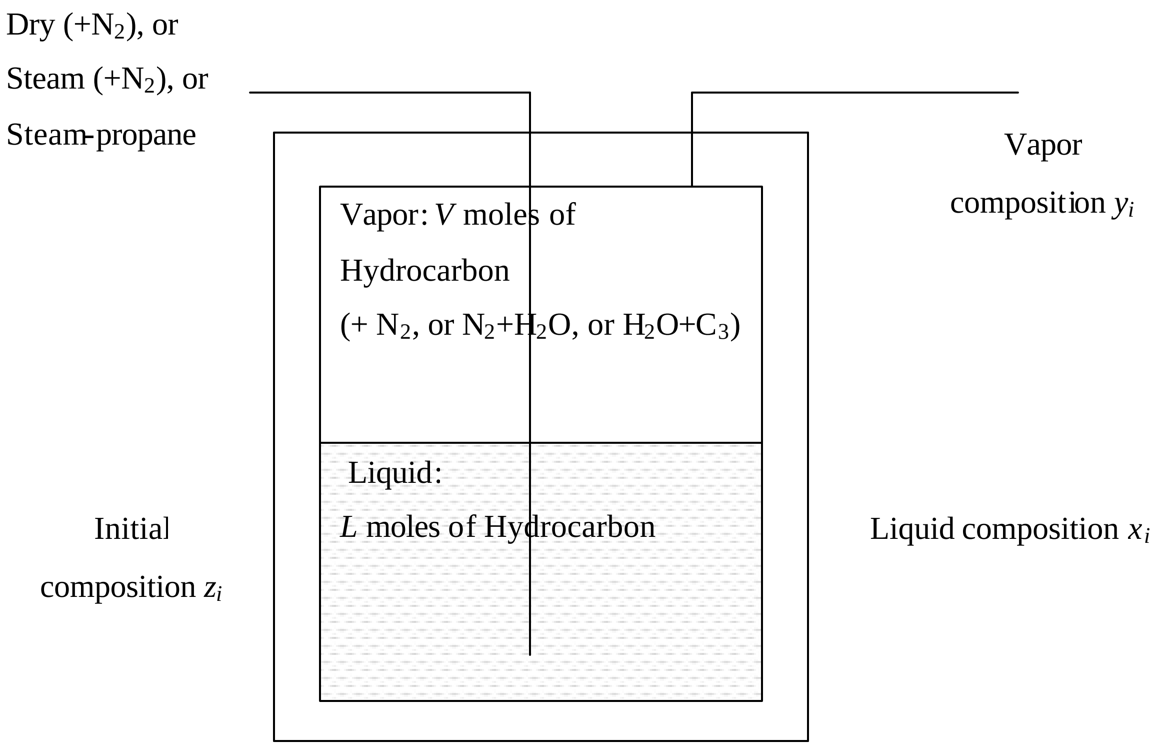


Fig. 3.1–Schematic diagram of distillation at constant *T* and *P*.

Two-phase flash calculation can be stated as follows. Given a number of initial moles F, with a mole fraction of components z_i, i = 1, 2, 3, ….., n find the number of moles in the gas and liquid phases, V and L, keeping pressure and temperature constants during the distillation process.

Assuming equilibrium, we can describe distillation at each temperature cut as a two-phase flash separation process.

$$Fz_i = x_i L + y_i V \quad i = 1, 2, \ldots, n \tag{2}$$

The mole fraction constraints assure that the total sum of mole fractions in a given phase is equal to unity

$$\sum_i^n x_i = 1 \tag{3}$$

$$\sum_i^n y_i = 1 \tag{4}$$

In Eqs. 3 and 4 there are $2n$ unknowns in x_i and y_i and two unknowns in V and L. A successive substitution technique permit searches only an unknown variable, the mole fraction of vapor V/F. The equilibrium ratio K_i is defined as

$$K_i = \frac{y_i}{x_i}, \quad i = 1, 2, \ldots, n \tag{5}$$

Combining the Eqs. 5 and 2 we have,

$$Lx_i + VK_i x_i = Fz_i, \quad i = 1, 2, \ldots, n \tag{6}$$

Now,

$$L = F - V \tag{7}$$

Combining the Eqs. 6 and 7 and solving for x_i we have,

$$x_i = \frac{z_i}{1 + (K_i - 1)(V/F)} \quad i = 1, 2, \ldots, n$$

(8)

Similarly, for y_i we have,

$$y_i = \frac{K_i z_i}{1 + (K_i - 1)(V/F)} \quad i = 1, 2, \ldots, n \tag{9}$$

Let define $b = V/f$, the mole fraction vaporized. Combining Eqs. 3 and 4 the flash condition is as follows.[33]

$$f(b) = -1 + \sum_i^n x_i = -1 + \sum_i^n \frac{z_i}{1 + b(K_i - 1)} = 0 \tag{10}$$

The corresponding Newton-Raphson algorithm is

$$b^{k+1} = b^k + \frac{-1+\sum_1^n \frac{z_i}{1+b(K_i-1)}}{\sum_i^n \frac{(K_i-1)z_i}{[1+b(K_i-1]^2}} \tag{11}$$

where k is the index of iteration.

An objective function that often leads to more rapid convergence is that of Rachford—Rice[34] that uses the following expression.

$$f(b) = \sum_1^n y_i - \sum_1^n x_i = 0 \tag{12}$$

Then the flash calculation using Rachford-Rice[33] is given by

$$f(b) = \sum_i^n \frac{(K_i-1)z_i}{1+b(K_i-1)} = 0 \tag{13}$$

and the Newton-Raphson algorithm[33] is given by

$$b^{k+1} = b^k + \frac{\sum_1^n \frac{(K_i-1)z_i}{1+b(K_i-1)}}{\sum_1^n \left[\frac{K_i-1}{1+b(K_i-1)}\right]^2 z_i} \tag{14}$$

On the other hand, as we know the equations that define the two-phase flash are the equality of chemical potentials. The chemical potential, G, of a component of a mixture is defined[35,36] as

$$dG_i = RTd\ln f_i \tag{15}$$

with a property called fugacity f_i. The reference value of fugacity in this equation is considered as

$$\lim_{P\to 0} f_i = y_i P = P_i \tag{16}$$

The meaning is that as system pressure P approaches to zero, the fluid approaches ideal behavior and the fugacity of a component approaches the partial pressure P_i of that component. A useful term is fugacity coefficient for each component in a mixture which is defined as the ratio of fugacity to partial pressure. That is,

$$f_i = \frac{f_i}{y_i P} \tag{17}$$

Fugacity coefficient for each component in a mixture can be defined[37] as

$$\ln f_i = \frac{1}{RT}\int_{\infty}^{V}\left(\frac{RT}{V_M} - (\frac{dP}{dn_i})_{T,V,n_i}\right)dV_M - \ln z \tag{18}$$

where z is z-factor and V_M specific volume. This fugacity coefficient can be evaluated using an Equation of State (EOS). One of the most used widely EOS equations in petroleum engineering is the Peng-Robinson EOS[38]. Peng-Robinson EOS is as follows.

$$\left[P + \frac{RT}{V_M - b} - \frac{a_T}{V_M(V_M + b)(b(V_M - b)}\right](V_M - b) = RT \tag{19}$$

This EOS arranged into cubic form is expressed as

$$V_M{}^3 - (\frac{RT}{P} - b)V_M{}^2 + (\frac{a_T}{P} - \frac{2bRT}{P} - 3b^2)V_M - b(\frac{a_T}{P} - \frac{bRT}{P} - b^2) = 0 \tag{20}$$

with

$$b = 0.07780\frac{RT_c}{P_c} \tag{21}$$

$$a_c = 0.45724\frac{R^2 T_c{}^2}{P_c} \tag{22}$$

The term b is a constant, and the term a_T varies with temperature; a_c is its values at the critical temperature. The term a_T resides in a, that is determined as

$$a_T = a_c a \tag{23}$$

where a is defined as

$$a = \left[1 + m(1 - T_r{}^{0.5})\right]^2 \tag{24}$$

with m given by

$$m = 0.3796 + 1.485w - 0.1644w^2 + 0.01667w^3 \tag{25}$$

where factor acentric w is a constant. The last correlation was expanded for w in the range of $0.1 < w < 2.0$.[39] Substitution of

$$V_M = zRT / P \tag{26}$$

into the Peng-Robinson EOS gives

$$z^3 - (1 - B)z^2 + (A - 2B - 3B^2)z - (AB - B^2 - B^3) = 0 \tag{27}$$

where

$$A = \frac{a_T P}{R^2 T^2} \tag{28}$$

and

$$B = \frac{bP}{RT} \tag{29}$$

which is a cubic equation with real coefficients. Thus, three values of z-factor are the roots of this cubic equation. These three roots are all real when pressure and temperature are on the vapor pressure line, which is when liquid and gas are present. One real root and two complex roots exist when temperature is above the critical temperature. If there is only one root, temperature is above the critical temperature, if there are three real roots, the largest is the z-factor of the equilibrium gas and the smallest is the z-factor of the equilibrium liquid. The cubic equation can be used to complete the integration of the EOS to evaluate the fugacity coefficient, resulting in the following[36].

$$\ln(\frac{f_g}{P}) = z_g - 1 - \ln(z_g - B) - \frac{A}{2^{1.5}B}\ln\left[\frac{z_g + (2^{0.5}+1)B}{z_g - (2^{0.5}-1)B}\right] \tag{30}$$

and

$$\ln(\frac{f_L}{P}) = z_L - 1 - \ln(z_L - B) - \frac{A}{2^{1.5}B}\ln\left[\frac{z_L + (2^{0.5}+1)B}{z_L - (2^{0.5}-1)B}\right] \tag{31}$$

Eqs. 30 and 31 are applied twice: once with the liquid z-factor and the other with the gas z-factor to calculate the fugacity of the liquid and the fugacity of the gas respectively.

When working with mixtures the same expressions apply except that aa and b are evaluated for a mixture using a set of mixing rules.[40] In our case, we used the most common mixing rule, the linear mixing rule for b.[41] That is,

$$b = \sum_i y_i b_i \tag{32}$$

and

$$a_T = \sum_i \sum_j y_i y_j (a_{T_i} a_{T_j})^{0.5} (1 - d_{ij}), \tag{33}$$

where subscripts i,j refer to components, and also

$$d_{ii} = d_{jj} = 0 \tag{34}$$

and

$$d_{ij} = d_{ji} \tag{35}$$

Some values of d_{ij} are reported in literature[40] and values of the coefficients for the individual components are calculated as

$$b_j = 0.07780 \frac{RT_{cj}}{P_{cj}} \tag{36}$$

and

$$a_{Tj} = a_{c_j} a_j \tag{37}$$

where

$$a_{c_j} = 0.45724 \frac{R^2 T_{cj}{}^2}{P_{cj}} \tag{38}$$

and

$$a_j = \left[1 + (0.3796 + 1.485 w_j - 0.1644 w_j^2 + 0.01667 w^3)(1 - T_{rj}{}^{0.5})\right]^2 \tag{39}$$

As before, Peng-Robinson EOS can be written as

$$z^3 - (1-B)z^2 + (A - 2B - 3B^2)z - (AB - B^2 - B^3) = 0 \tag{40}$$

where

$$A = \frac{a_T P}{R^2 T^2} \tag{41}$$

and

$$B = \frac{bP}{RT} \tag{42}$$

The three roots are all real when pressure and temperature are such that the mixture is two phase. There will be only one root and two complex roots when the mixture is single phase. When the roots are obtained, the lowest root is the z-factor of the liquid, and the highest root is the z-factor of the gas, and the middle root is discarded. Combining the Peng-Robinson EOS and the equation of fugacity coefficient for a mixture we have for each component

$$\ln f_j = -\ln(z - B) + (z-1)B'_j - \frac{A}{2^{1.5} B}(A'_j - B'_j) \ln\left[\frac{z + (2^{0.5}+1)B}{z - (2^{0.5}-1)B}\right] \tag{43}$$

where

$$B'_j = \frac{b_j}{b} \tag{44}$$

and

$$A'_j = \frac{1}{a_T}\left[2a_{Tj}^{0.5}\sum_i y_i a_{Ti}^{0.5}(1-d_{ij})\right] \tag{45}$$

The last three mathematical expressions are written twice: once for values of z, b, and a_T of the gas and again for values of z, b, and a_T of the liquid. The procedure for calculating vapor-liquid equilibria at a given temperature and pressure can be summarized as follows.[42] A flow chart of the calculation is shown in the **Fig. 3.2.**

Step 1. Values of a_{Tj} and b_j for each component of the mixture are calculated knowing the critical properties and acentric factors of the pure components. As first trial initial values of K_i at fixed temperature and pressure were guessed using the Wilson correlation. In this correlation, the ideal K-value of component i is given by

$$\ln K_i = 5.37(1+w_i)[1-T_{ci}/T]+\ln(P/P_{ci}) \tag{46}$$

where the T_{ci} and P_{ci} are the critical temperature and critical pressure of the component i, respectively.

Step 2. Solve flash calculation with the equation of Rachford-Rice Eq. 14 for b .

Step 3. Calculate x_i, y_i with Eqs. 8 and 9 and the compressibility factors of the liquid and vapor phases from Peng-Robinson EOS.

Step 4. Calculate f_i^L and f_i^V using Eq. 43.

Step 5. Then the values of liquid and gas fugacity for each component are obtained as follows.

$$f_{Li} = x_i P f_i^L \tag{47}$$

and

$$f_{Vi} = y_i P f_i^V \tag{48}$$

In terms of fugacities, the equilibrium condition is expressed as follows.

$$\hat{f}^V(T,P,y) = \hat{f}^L(T,P,x), \quad i = 1, 2, \ldots, n \tag{49}$$

Step 6. Update K_i given by Eq. 5, $K_i = y_i/x_i$.

Then equilibrium is obtained and the calculation is complete when the following is satisfied for each component.

$$f_i^V = f_i^L \tag{50}$$

Step 7. To complete the calculation according to the last expression, a method of successive substitution involving *K*-factors was applied to converge on a correct solution using an objective function given by

$$e = \frac{(K_i^C - K_i^T)^2}{K^T{}_i K_i^C} \tag{51}$$

where Ki^C are the *K*-factors calculated and the Ki^T are trial values of *K*-factors. Convergence is obtained when the sum of the objective function is less than a certain tolerance.

This last step completes the procedure used in this research. A program in Visual Basic was written involving the calculation of *K*-values, and fugacity coefficients. The program is run for number of components *n* for different conditions of temperature and pressure. The program is shown in the **Appendix C**. Binary interaction parameters d_{ij} for Peng-Robinson have been reported for a number of binary mixtures.[42]

The estimation of fugacity in liquid mixtures involving only hydrocarbons can be done using EOS such as Peng-Robinson's. Consequently, the sequence of calculations for species fugacities in liquid mixtures is similar for gaseous mixtures. Common thermodynamic notation for liquid mixtures containing any substance that do not permit to be describable by an EOS is to define an activity coefficient $g_i(T, P, x_i)$.[43] In our case we have the presence of steam of water and propane in contact with the hydrocarbon, and we are using this activity coefficient as property of the liquid.

The condition of equality of partial fugacities at equilibrium can be expressed in several ways involving activity and fugacity coefficients,

$$y_i \hat{f}_i^V P = x_i \hat{f}_i^L P \tag{52}$$

$$y_i \hat{f}_i^V P = g_i x_i f^o \tag{53}$$

$$y_i \hat{f}_i^V P = g_i x_i f_i^{sat} P_i^{sat} f_i^{sat} \exp\left[\int_{P^{sat}}^{P} (\bar{V}^L / RT) dP\right] \tag{54}$$

$$y_i \hat{f}_i^{V} P = g_i x_i f_i^{sat} P_i^{sat} (PF)_i \qquad (55)$$

where f^{sat} and f^{0} are fugacity at saturation condition and fugacity at standard condition respectively.

$$(PF)_i = \exp\left[\int_{P^{sat}}^{P} (\bar{V}^{L} / RT)\, dP\right] \qquad (56)$$

The exponential term in the last equation is called the Poynting Factor, which normally is different from unity at high and moderate pressures. Accordingly, the activity coefficient is given in terms of the properties of the liquid phase and vapor phase as

$$g_i = \frac{y_i f_i^{L} P}{x_i f_i^{sat} P_i^{sat} (PF)_i} \qquad (57)$$

The fugacity coefficients $\hat{f}_i^{V}$ and f_i^{sat} are obtained in our case from the same EOS Peng-Robinson following the same development described before for gaseous mixture, (with z^L is the liquid root for the compressibility factor -high density or small z) except that the liquid phase rather than vapor phase compressibility factor is used in the calculations. . The activity coefficients are calculated using compositions which were determined from gas chromatograph analysis for each kind of distillation process.

Alternatively activity coefficients for each component are closely related to excess Gibbs energy, G^{ex}, through the expression[44]

$$RT \ln g_i (P, T, x_i) = G_i^{ex}, \qquad (58)$$

and for the mixture as a whole

$$G^{ex} = RT \sum x_i \ln g_i \qquad (59)$$

We estimate the departure of the real system from the ideal mixture using excess Gibbs energy, which is a nonlinear function of composition, temperature, and pressure. Activity coefficients and excess Gibbs energy are in the Visual Basic program referred to in **Appendix B**.

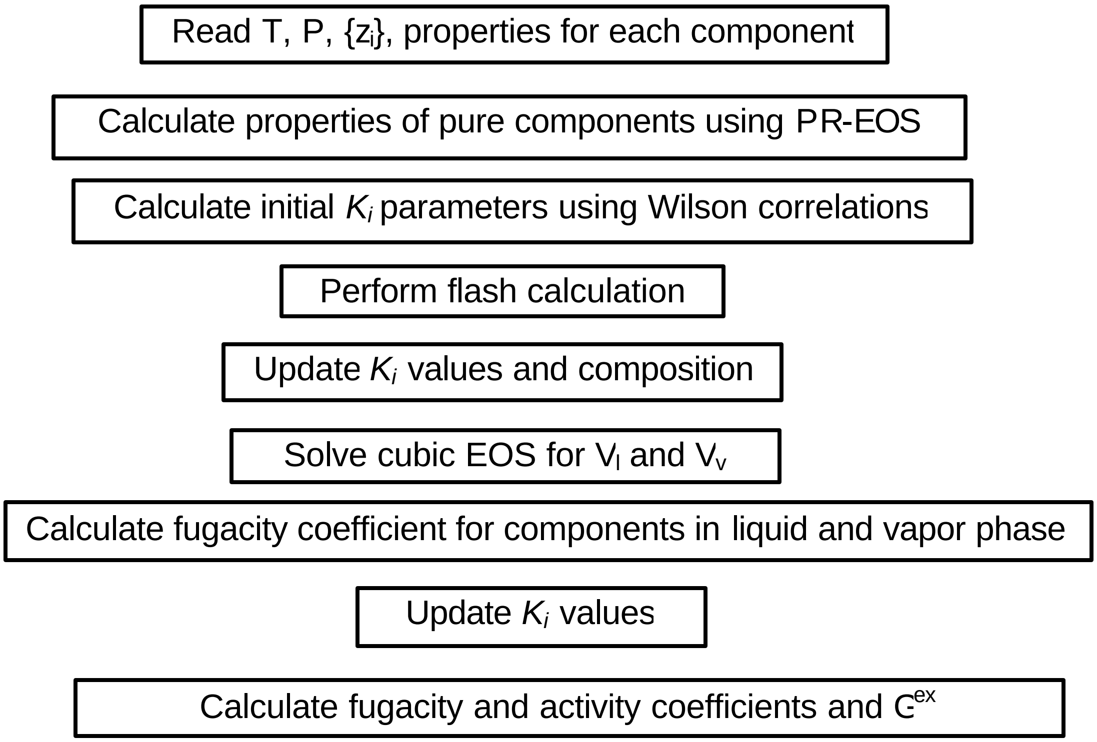


Fig. 3.2–Flow chart vapor-liquid equilibrium calculation.

CHAPTER IV

EXPERIMENTAL APPARATUS AND PROCEDURE

4.1 Experimental apparatus

The experimental set-up is comprised of five main parts: fluid injection system, injection cell, fluid production system, gas composition measurement system, and data recording system. A schematic diagram of the apparatus is shown in **Fig. 4.1** and **Table 4.1**.

4.1.1 Fluid injection system

Fluid injection system consists of three parts: nitrogen injection, steam injection, and propane injection.

(i) Nitrogen injection

Nitrogen is kept under pressure in a gas tank. A backpressure valve controls the gas injection pressure and a gas mass flow controller regulates the nitrogen gas mass injection rate in the case of dry- and steam-distillation at 0.025 g/min. The nitrogen is mixed with steam in the case of steam distillation at the steam generator inlet (**Fig. 4.2**)

(ii) Steam injection

A High Performance Liquid Chromatography (HPLC) pump feeds water to the steam generator at a constant rate of 0.5 g/min. The water is mixed with nitrogen in the case of steam distillation, and with propane in the case of steam-propane distillation at the steam generator in both cases.

(iii) Propane injection

Propane is kept under pressure in a gas tank. A gas mass flow controller regulates the gas injection rate until 120 psig (saturated pressure at ambient temperature approximately 20^{o}C). In the cases of higher pressure, the propane in liquid phase is pressurized with the ISCO syringe pump (**Fig. 4.3**), and a mass flow controller regulates the mass injection rate (0.025 g/min) during steam-propane distillation at 5:100 propane: steam mass ratio.

4.1.2 Distillation cell

The distillation cell (**Fig. 4.4**) is a stainless steel cylinder with an internal diameter of 5.4 cm and a height of 17.5 cm. The ends of the cell are sealed off by end caps that provide metal-to-metal seal. The top end cap is connected to a 1/8 in. line through which the distilled. A 1/8 inch injection line (connected at the top end cap) goes to the bottom of the cell, through which nitrogen, steam, or steam-propane is injected. A thermocouple (Type K) is inserted through the top end cap into the cell (the tip at the cell mid-height) to measure the temperature inside the cell. Three perforated plates are attached to the injection line and help diffusion of the injected gas (**Fig. 4.5**). The distillation cell is placed in a heating jacket (**Fig. 4.6).** The temperature of the heating jacket is controlled by a temperature controller.

A band heater is placed around the injection line and is connected to a temperature controller. This band heater is used to heat the injection tube to keep the steam injected at the required superheated conditions. Fiber flax wool is used to cover the top of the cell and minimize heat losses.

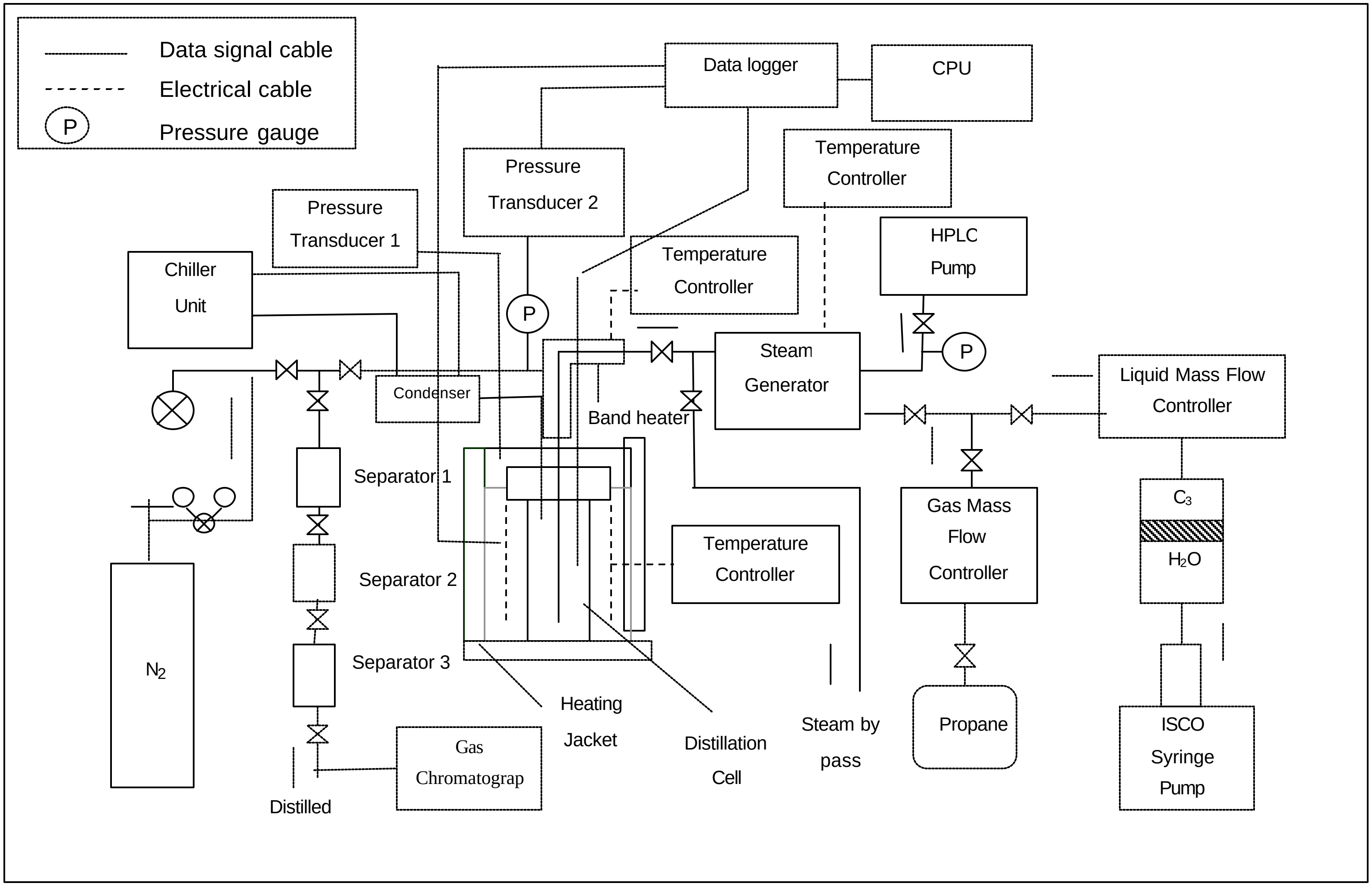


Fig. 4.1-Schematic diagram of experimental apparatus.

4.1.3 Fluid production system

The fluids leaving the cell pass through a water-cooled condenser at the condensed fluids then are collected at the separators (**Fig. 4.7**). A backpressure regulator (**Fig 4.8**) maintains the cell outlet pressure at a constant predetermined level during the experiment. A chiller unit provides cold water for the condenser kept at 10^{o}C during the distillation process. A three-stage separator system permits collection of condensed distillate at low pressure. The distillate is collected in a polypropylene tube after the third separator.

4.1.4 Gas chromatograph system

The distillate collected in the polypropylene tubes are kept at low temperature in a refrigerator. 0.1 micro liter of the distillate is injected into the HP 5890 III a Gas Chromatograph (**Fig. 4.9**) to determine the composition of the distillate.

4.1.5 Data measurement and recording system

A data logger and a personal computer (**Fig. 4.10**) are used to record the following parameters: time, cell temperature, jacket temperature, steam temperature, band heater temperature, injection pressure, outlet pressure, and propane or nitrogen injection rate. The parameters are recorded at 30-second intervals. The pressures in the cell are monitored using two pressure transducers.

A brief description of the main components of the apparatus follows.

1. HPLC pump

   A High Performance Liquid Chromatograph pump supplies water to the steam generator at a very accurate rate.

2. Steam generator

An electric powered steam generator of 1000 watts maximum power, and rated at a maximum pressure of 2000 psig and a maximum temperature of 1200^{o}F provides the steam necessary for the experiments.

3. Distillation cell

   The stainless steel cell with internal diameter 5.4 cm and a length of 17.5 cm (volume approximated of 400.79 cm^3).

4. Heating jacket

   The heating jacket is a 43.18 cm long and 27.94 cm OD stainless steel cylinder.

5. Temperature controllers

   A dual-circuit temperature controller is used to maintain constant temperature of the steam generator. A separate temperature controller controls the heating jacket temperature.

6. Three-stage separation and collection system

   It is used to reduce the pressure to enable sampling. The distillate is collected in polypropylene tubes at the third separator outlet.

7. Mass flow controller

   Regulates the mass rate of nitrogen and propane injected into the feed line to the steam generator. This mass flow controller regulates, in the case of propane, both liquid and vapor propane injection rates.

8. Gas chromatograph

   The gas chromatographs analyzes the composition of the condensed distillate samples collected at the end of the third separator.

9. Data logger/recording system

   Takes measurements and records pressure, temperature, and injection gas rate data every 30 seconds.

A complete view of the apparatus can be seen in **Fig. 4.11**.

TABLE 4.1- MAIN APPARATUS, MATERIALS AND EQUIPMENT USED

Water reservoir	4-liter plastic container
HPLC pump	Beckman. Model 100A
Steam generator	Custom-made by Texaco. Max. pressure: 2000 psig. Max. temperature: 1200 ºF
Distillation cell	Stainless steel tube. Long: 17.5 cm. I.D.: 5.4 cm.
Temperature controller	Digi-Sense. Model 2186-10A, 20 Amp peak
Temperature Controller	VICI Model ITC10399-220
Temperature Controller	Eurotherm Model 808
Mass Flow Controller	Brooks. Model 5850E series. Max. flow 1000 cm^3/min
Gas chromatographs (GC)	(2) Hewlett Packard 5890 Series III Column: J&W SB-1 capillary column
Data logger	Hewlett Packard data acquisition unit. Model 3497A with 44422A T-couple acquisition assembly.
Back-pressure regulator	Tescom Corporation. Max. pressure 1500 psig

TABLE 4.1.-CONTINUED

Chiller unit	PolyScience Model 9000 Refrigerated Constant Temperature Circulator
Pressure transducer	Validyne. model DP15-TL. Max. pressure: 320 psig.
Tubing	¼-in., 1/8-in. and 1/16-in. stainless steel tubing with Swagelock and Autoclave connections.
Control valves	Autoclave Engineers ¼-in. Whitey ¼-in., 1/8-in.
Thermocouples	Omega JMQSS-020. Type J. Sheath diameter .020-in.
Gauges	HEISE, CM-105620 and CM-105618, Bourdon tube 403 ST-ST. Max. pressure 500 psig.
Electronic balance	METTLER PM 4600 Delta Range. Capacity 10.45 kg.
Synthetic hydrocarbon	n-Pentane, n-Hexane, n-Heptane, n-Octane, n-Nonane, n-Decane, and n-Pentadecane at 99.99% pure.
Paint thinner	Commercial paint thinner
Nitrogen tank	Botco, Nitrogen compressed, 1500 psig.
Conical sample bottles	Nalgene Company. Nalgene Centrifuge Ware Polypropylene with HDPE screw cap. Size 50 ml. Sterile.

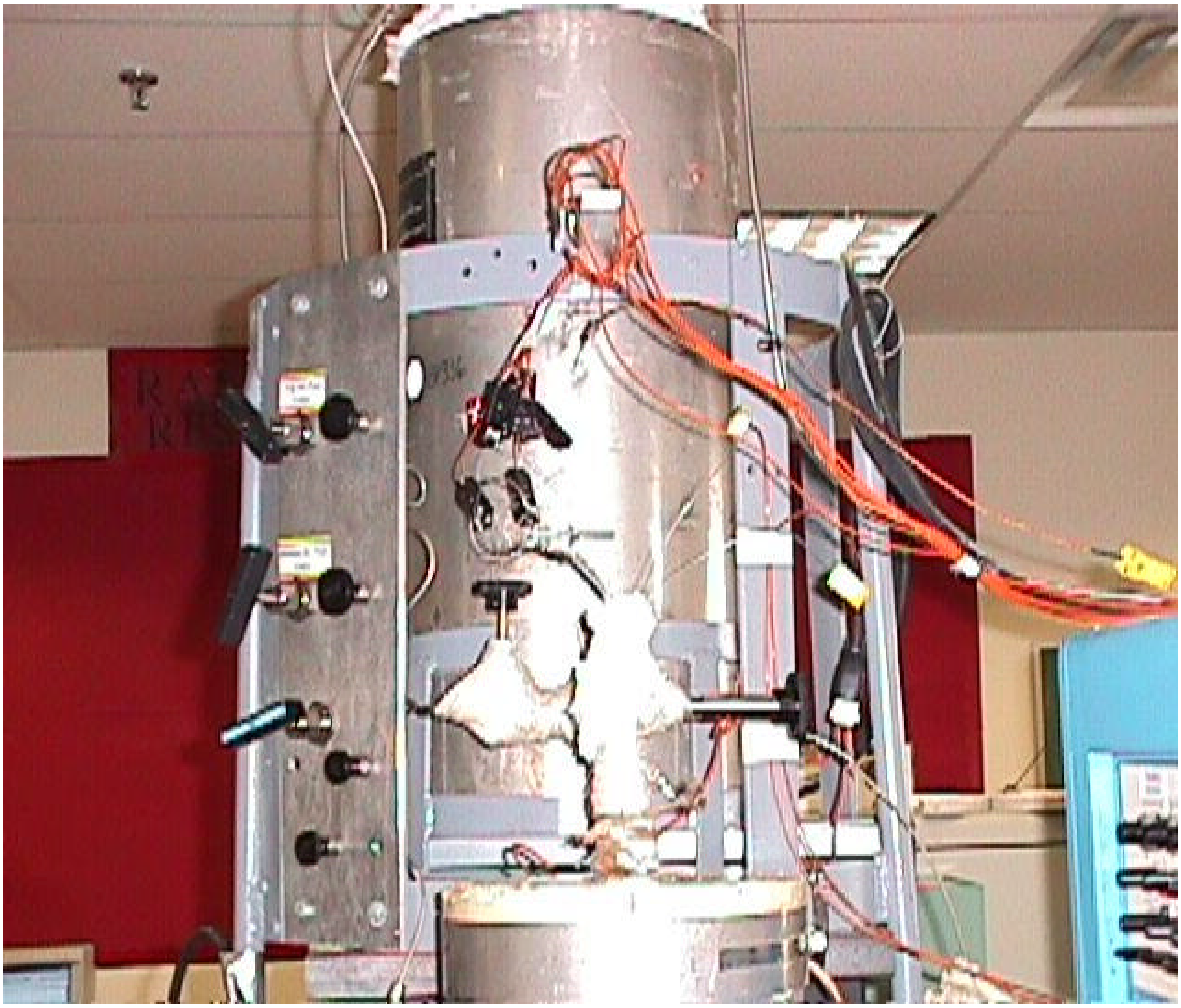


Fig. 4.2-Steam generator.

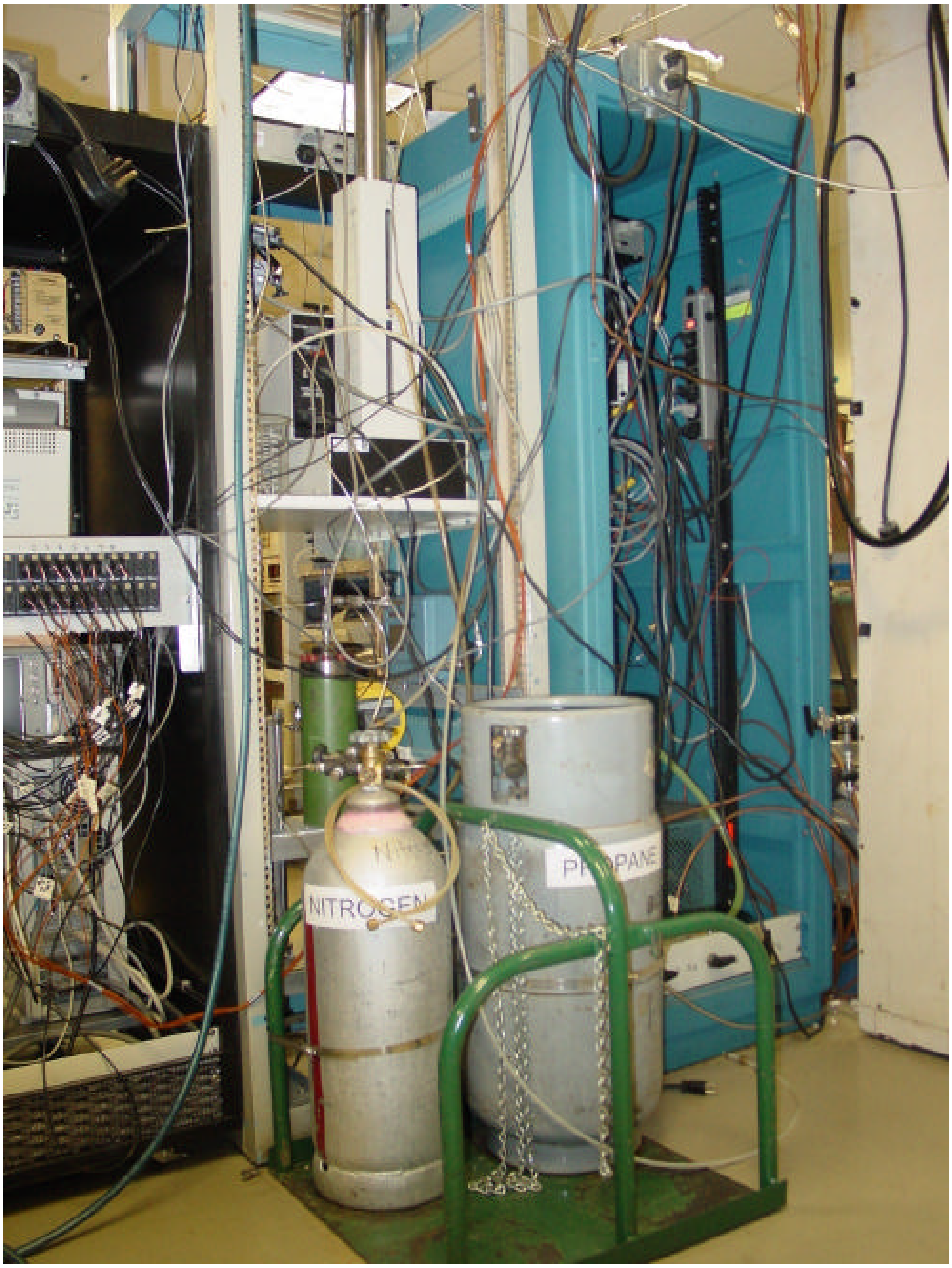


Fig. 4.3-ISCO syringe pump.

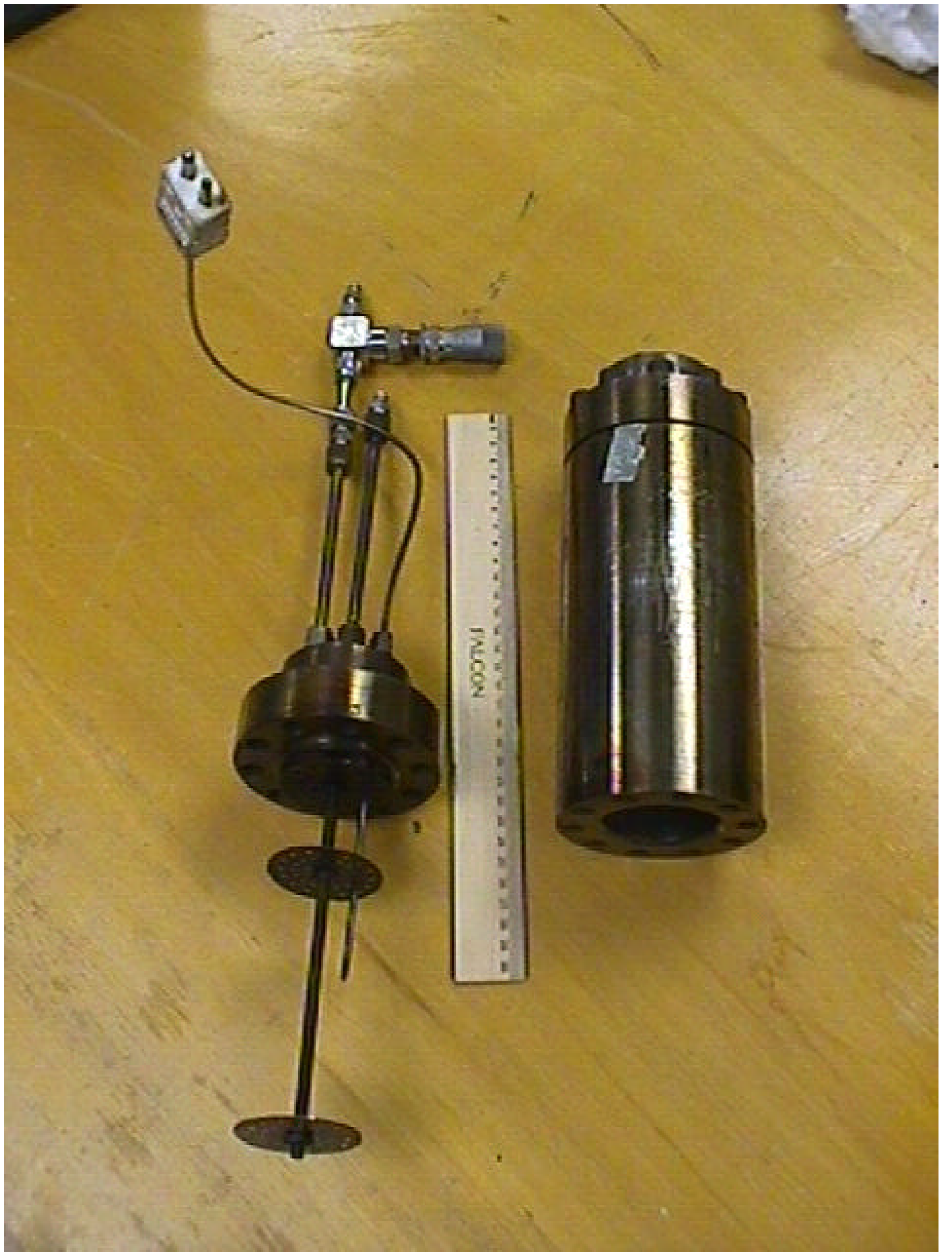


Fig. 4.4-Distillation cell.

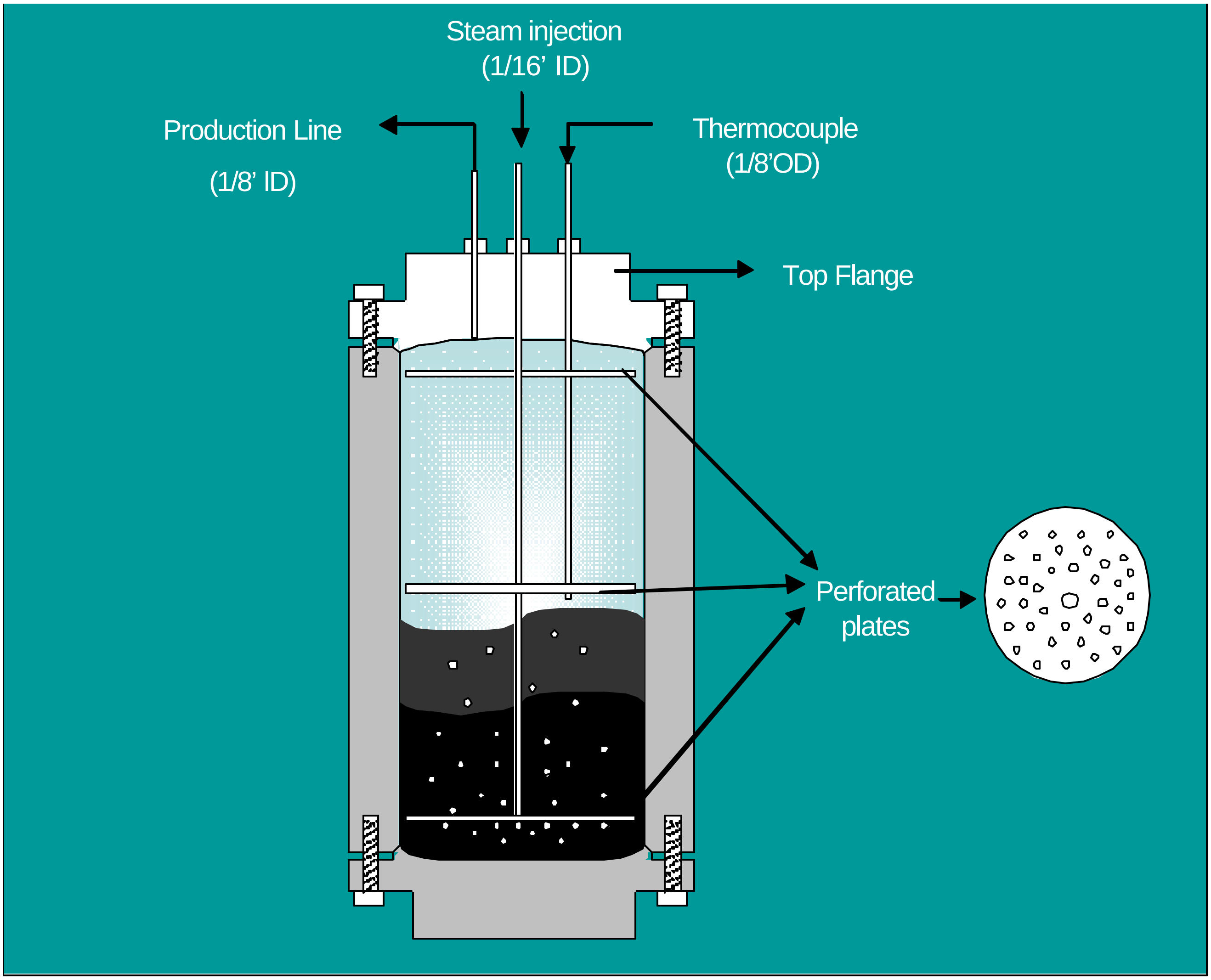


Fig. 4.5-Schematic diagram of distillation cell.

Fig. 4.6-Heating jacket.

Fig. 4.7-Three stage separator system.

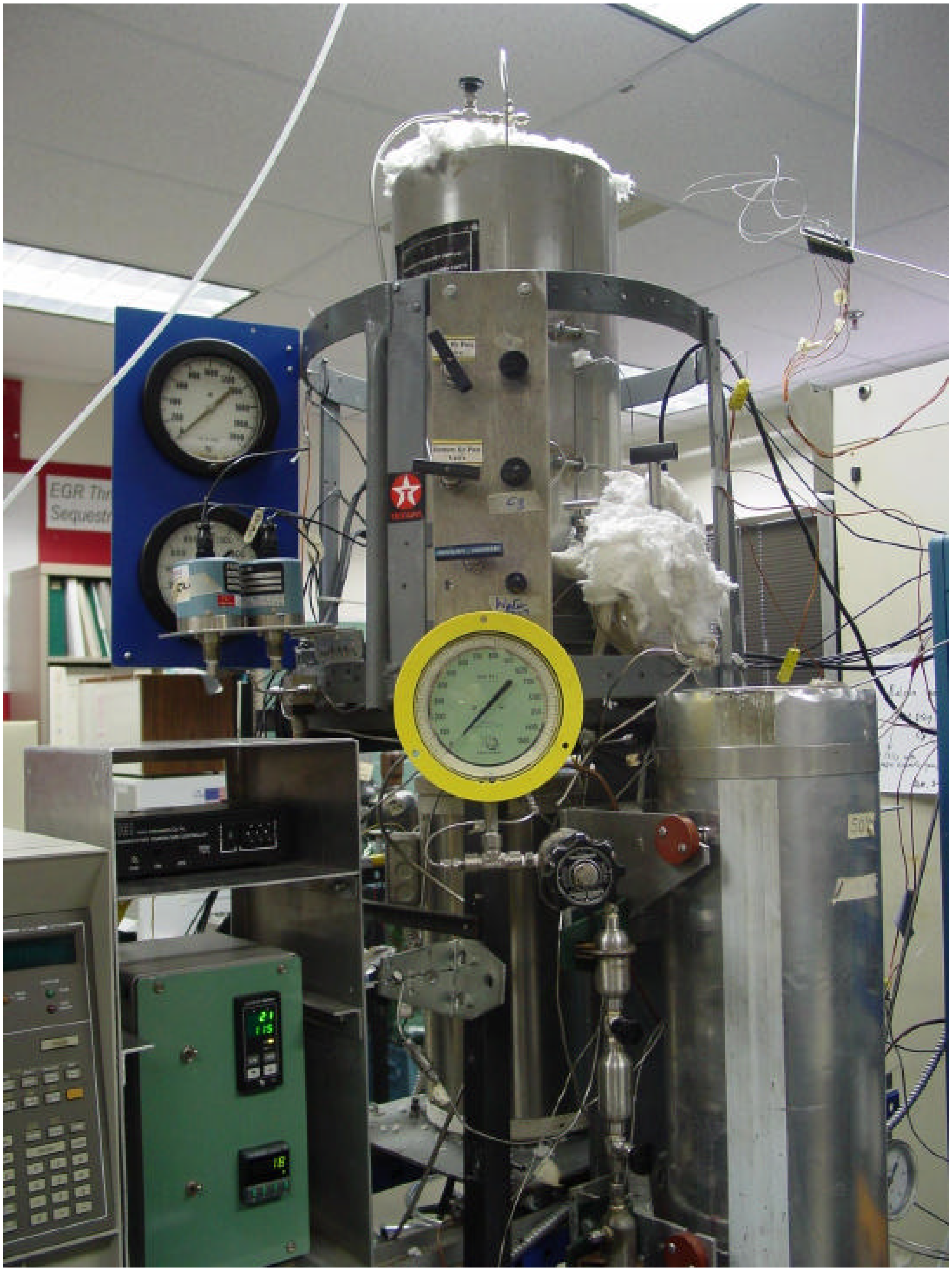
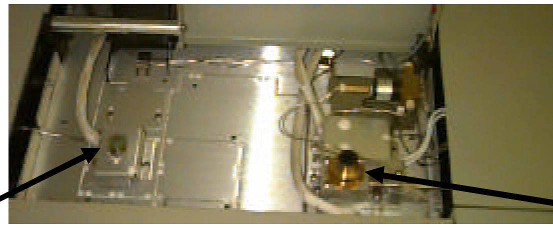


Fig. 4.8–Back pressure regulator.



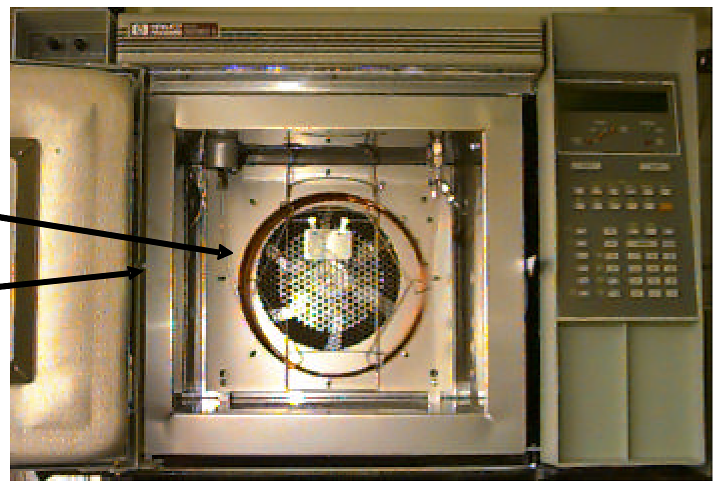


Fig. 4.9-HP 5890 III Gas Chromatograph.

Fig. 4.10-Data logger computer.

Fig. 4.11–Complete view of the apparatus.

4.2 Experimental procedure

First of all a mixture of alkanes is prepared in a conical glass flask of 400 ml capacity. 20 g of each n-alkane is weighed and poured into the flask that is then capped to avoid vaporization of any alkane. The mixture consists of seven analytical grade (99.99% purity) alkanes: n-pentane, n-hexane, n-heptane, n-octane, n-nonane, n-decane, and n-pentadecane. All the glass material used is previously cleaned and dried with nitrogen.

In the case of the apparatus, first the equipment and lines are thoroughly cleaned to prevent any contamination in the distillation process. Pressure transducers and mass flow controller are calibrated. This will be done every time before the experiment for each distillation. Pressure transducer is calibrated until 1000 psig. Mass flow controller is calibrated for nitrogen and propane. The pump for water is calibrated at a rate of 0.5 ml/min.

The synthetic hydrocarbon is poured into the cell previously weighed and filling up approximately half the cell volume (201.0 ml). Once the cell top end-cap is installed, it is pressure tested to 1000 psia with nitrogen, to test for leaks. After the pressure test a thermocouple is attached externally to the body of the cell with aluminum tape at approximately once third of depth of the cell.

The cell is placed inside the heating jacket, connecting all the lines. The valve connecting the steam generator to the distillation cell is closed. At this point the apparatus is pressure tested again with nitrogen until 1000 psig. After this pressure test the apparatus is ready for the experiment.

The temperature cuts for all the runs are the same, as shown in **Table 4.2**. A 30 minute distillation period was given to each temperature cut, when the samples were collected. The temperatures of the cuts represent 15ºC superheated steam temperature at the corresponding cell pressure. These temperatures were increased in steps of 10ºC until a maximum of 330ºC.

Therefore for one given case the experiment will follow the steps shown below.

(a) The steam generator is conditioned to the first temperature of the run (115ºC). In the case of dry distillation, nitrogen is injected into the steam generator, by-passing the cell. The same temperature conditioning to 115ºC is done with the distillation cell by means of a heating jacket. The pressure in the steam generator is increased by adding water at a rate of 0.5 g/min. If propane is used in the run it must be kept at a higher pressure than the steam generator (approximately 500 psig).

(b) In the case of dry distillation nitrogen is injected into the cell through the steam generator line. 5:100 mass ratio of nitrogen:water of the rate of water injected in steam distillation (0.5 g/min) is used, given a nitrogen injection rate of 0.025 g/min.

(c) In the case of steam-propane distillation, once the pressure and temperature conditions are stabilized (observing the values graphically recorded in the monitor of the recording system), the propane is injected into the steam generator. Subsequently the valve connecting the steam generator to the distillation cell is opened. The time at which injection starts is recorded.

(d) The distillate is collected during the 30 min of production, at 2-minute intervals, in a conical graduated polypropylene sample bottles from the third separator. A liquid hydrocarbon sample of 0.1 micro-liter is injected into the gas chromatographer to determine the composition of distillate. Cell inlet and outlet pressures are recorded. For steam-, and steam-propane distillations runs, distillates consist of water injected and the distilled fractions of the hydrocarbons. The oil and water liquid volumes and weights are recorded for each sample. The liquid samples are kept in a freezer after the readings of volume and weight to avoid evaporating some fractions.

(e) When the limiting temperature of 300ºC is reached, the valve connecting the steam generator and the cell is closed, and all electrical left equipment are turned off. The pressure and temperature of the system are left to drop overnight by natural cooling.

TABLE 4.2–TEMPERATURE CUTS FOR EACH DISTILLATION

Cut	Temperature, ºC	Pressure, psia	Pressure, psig
1	115	14.7	0.0
2	130	24.8	10.1
3	140	34.4	19.7
4	150	46.6	31.9
5	160	61.9	47.2
6	170	80.9	66.2
7	180	104.2	89.5
8	190	132.3	117.6
9	200	166.0	151.3
10	210	206.0	191.3
11	220	253.2	238.5
12	230	308.3	293.6
13	240	372.3	357.6
14	250	446.3	431.6
15	260	531.1	516.4
16	270	628.0	613.3
17	280	738.1	723.4
18	290	862.7	848.0
19	300	1003.0	988.3

CHAPTER V

EXPERIMENTAL RESULTS

This chapter contains the experimental data and results of analysis for each kind of distillation process: dry-, steam-, and steam-propane distillation. These experimental results include:

- Temperature profiles: inside steam-generator, the cell, heating jacket, band heater around the injection line before the cell
- Cumulative oil weight and volume
- Cumulative water weight and volume
- Pressure profiles: cell inlet pressure, cell outlet pressure, and cell differential of pressure
- Compositional analyses of distillate by gas chromatography are shown in the **Appendix A.**
- Material balance in each cut of pressure and temperature
- Profile of experimental pseudo *K*-values
- Profile of pseudo *K*-values calculated with a Visual Basic program shown in **Appendix B.**
- Fugacity coefficient for each component
- Activity coefficient for each component
- Excess Gibbs energy

The following parameters were kept constant for all the runs:

- Temperature and pressure in every cut (for 30 minutes)
- Nitrogen rate mass injection in dry distillations of 0.025 g/min
- Steam injection rate of 0.5 g/min
- Propane:steam mass ratio injection of 5:100
- Band heater at steam-, and steam-propane injection line at every temperature

The raw data is presented in **Appendix A** too. The calculations used to process the data are also shown in the **Appendix B** with the program used to calculate the thermodynamic properties of the mixture. The program is shown in the **Appendix C.** The properties of the mixture inside the cell for each run are shown in **Table 5.1**. A comparison of the three distillation processes is shown at the end of this chapter.

The data analyses and interpretations are presented individually for each run. In addition, a global comparison between the various cases is also made.

5.1 Dry distillation

The yields measured for the three dry distillation runs are summarized in **Tables 5.2-5.4,** including gas chromatograph analyses (GC) of the hydrocarbon distillate. A typical chromatogram for one analysis is shown in the **Appendix D**.

The temperature profiles of those runs are shown in **Figs. 5.1–5.3**. These plots indicate the good control of temperature during the whole process.

Dry distillation run no.1 showed an oil recovery of 92% until 747 min of distillation with an experimental error of 8.0%. Dry distillation run no. 2 showed an oil recovery of 97.2% with an experimental error of 1.9%, and finally dry distillation run no.3 showed an oil recovery of 97.2% with an experimental error of 2.8%. The experimental error was calculated based on a material balance of oil. The oil yield plots as function of temperature for the dry distillation runs are shown in **Figs. 5.4-5.6**. At 125ºC, 36 wt% of hydrocarbons are distilled off.

Figures 5.7-5.9 show the experimental pseudo *K*-values. All three runs showed n-pentane having the highest value. **Figures 5.10-5.12** indicate that the pseudo *K*-calculated are very similar for all the components of the mixture (practically 1) except at highest temperature, where some small variations are indicated. This means that the liquid and vapor composition are theoretically equal in both phases as shown in the **Figs. 5.13-5.15.** The plots show vapor composition during the distillation process. In **Figs. 5.16-5.18** the plots show changes in vapor fugacity coefficient for each component.

Activity coefficients during the distillation are shown **Figs. 5.19-5.21**. N-pentadecane, being the last component to boil off, has a high value of activity throughout the run. **Figures 5.22-5.24** show the distribution of the partial pressures of each component assuming the mixture was ideal. The plots show a distribution of partial pressure of the components for all range of temperature. Finally the curves of Gibbs excess energy for these dry distillation processes are in **Fig.5.25.** This plot shows how the Gibbs energy is increases to a peak value at around 230ºC-270º.

TABLE 5.1–PROPERTIES OF HYDROCARBON COMPONENTS[45]

Component	MW lb/lbmol	Specific gravity*	Liquid density lbm/ft^3	Pc, psia	Tc, °R	Vc, ft^3/lbm mol	z_c	*w*	Normal Boiling Point, °R
n-pentane	72.15	0.6301	39.30	488.6	845.4	4.87	0.2623	0.2510	556.6
n-hexane	86.17	0.6604	41.19	436.9	913.4	5.929	0.2643	0.2957	615.4
n-heptane	100.20	0.6828	42.58	396.8	972.5	6.924	0.2633	0.3506	668.8
n-octane	114.20	0.7086	44.19	360.6	1023.9	7.882	0.2587	0.3978	717.9
n-nonane	128.30	0.7271	45.35	332.0	1070.3	8.773	0.2536	0.4437	763.1
n-decane	142.30	0.7324	45.68	304.0	1111.8	9.661	0.2462	0.4902	805.2
n-pentadecane	212.42	0.7690	47.93	220.5	1272.69	14.109	0.2429	0.7060	977.67
Propane	44.09	0.5077	31.66	616.3	665.7	3.250	0.2804	0.1454	416.0

*Water=1

TABLE 5.2- OIL YIELDS AT DRY DISTILLATION RUN NO. 1

WEIGHT OF COMPONENTS (DRY DISTILLATION RUN 1)

Compound	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1275	17.8464	0.2474
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1359	19.0231	0.2207
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1467	20.5409	0.2050
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1486	20.8074	0.1822
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1484	20.7822	0.1620
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1485	20.7863	0.1461
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1444	20.2138	0.0952
N2			28.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2585

OIL YIELDS AT DISTILLATION TEMPERATURES (DRY DISTILLATION RUN 1)

Sample	Wt bottle g	Wt bottle + sample, g	Oil wt g	Oil vol ml	Wt in cell g	T(ºC)	Cum oil wt, g	Oil yield, wt%
1	11.603	35.292	23.689	35.00	116.311	99.20	23.6890	16.9207
2	11.166	30.036	18.870	27.00	97.441	109.90	42.5590	30.3993
3	12.368	17.788	5.420	8.00	92.021	120.00	47.9790	34.2707
4	12.855	18.098	5.243	7.50	86.778	130.50	53.2220	38.0157
5	12.824	24.254	11.430	16.00	75.348	139.40	64.6520	46.1800
6	12.562	21.485	8.923	13.00	66.425	149.60	73.5750	52.5536
7	12.628	22.225	9.597	14.00	56.828	161.20	83.1720	59.4086
8	12.692	20.678	7.986	11.00	48.842	171.60	91.1580	65.1129
9	12.454	18.961	6.507	9.50	42.335	181.70	97.6650	69.7607
10	12.610	16.711	4.101	6.00	38.234	191.70	101.7660	72.6900
11	12.551	15.569	3.018	4.00	35.216	201.20	104.7840	74.8457
12	12.660	13.881	1.221	1.50	33.995	201.20	106.0050	75.7179
13	12.598	16.130	3.532	5.00	30.463	210.80	109.5370	78.2407
14	12.564	13.812	1.248	1.70	29.215	219.60	110.7850	79.1321
15	12.626	14.965	2.339	3.25	26.876	231.10	113.1240	80.8029
16	12.442	13.404	0.962	1.30	25.914	240.40	114.0860	81.4900
17	12.982	14.147	1.165	1.70	24.749	249.50	115.2510	82.3221
18	12.576	14.460	1.884	2.50	22.865	259.40	117.1350	83.6679
19	12.559	16.547	3.988	5.50	18.877	268.50	121.1230	86.5164
20	12.583	18.929	6.346	8.50	12.531	279.10	127.4690	91.0493
21	12.485	12.617	0.132	0.25	12.399	289.10	127.6010	91.1436
22	12.687	12.713	0.026	0.10	12.373	299.30	127.6270	91.1621
Residual after ru	12.667	13.408	0.741	1.00	11.632	300.00	128.3680	91.6914
Residual incell	12.566	13.022	0.456	0.60	11.176	300.00	128.8240	92.0171
Total	300.308	429.132	128.824	183.90	1028.84		2331.16	

	Oil wt g	Oil vol ml
Difference	11.1760	17.1700
% Error	7.9829	8.5393

TABLE 5.3- OIL YIELDS AT DRY DISTILLATION RUN NO. 2

WEIGHT OF COMPONENTS (DRY DISTILLATION RUN 2)

Compound	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1295	18.1310	0.2513
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1358	19.0057	0.2205
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1406	19.6848	0.1964
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1443	20.2063	0.1769
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1450	20.3059	0.1583
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1463	20.4753	0.1439
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1492	20.8945	0.0984
N2	0.0000	0.0000	48.0000	0.0000				
Total	201.0700	140.0000		1.2746	1.0000	0.9907	138.7035	1.2457

OIL YIELDS AT DISTILLATION TEMPERATURES (DRY DISTILLATION RUN 2)

Sample	Wt bottle g	Wt bottle + sample, g	Oil wt g	Oil vol ml	Wt in cell g	T(ºC)	Cum oil wt, g	Oil yield, wt%
1	12.6450	33.6180	20.9730	34.0000	119.0270	99.20	20.9730	14.98
2	13.0310	35.2800	22.2490	33.0000	96.7780	109.90	43.2220	30.87
3	12.5720	17.6910	5.1190	7.5000	91.6590	120.00	48.3410	34.53
4	12.7420	23.7920	11.0500	16.0000	80.6090	132.30	59.3910	42.42
5	12.5410	24.7710	12.2300	19.0000	68.3790	141.10	71.6210	51.16
6	12.6330	19.8280	7.1950	11.0000	61.1840	150.10	78.8160	56.30
7	12.5510	20.5210	7.9700	12.0000	53.2140	159.90	86.7860	61.99
8	12.5770	19.9980	7.4210	11.0000	45.7930	169.50	94.2070	67.29
9	13.0480	19.7730	6.7250	9.5000	39.0680	180.40	100.9320	72.09
10	12.5850	16.3090	3.7240	5.5000	35.3440	191.40	104.6560	74.75
11	12.4680	16.5150	4.0470	6.0000	31.2970	202.10	108.7030	77.65
12	12.5500	14.1680	1.6180	2.5000	29.6790	211.00	110.3210	78.80
13	12.7230	15.5020	2.7790	4.0000	26.9000	221.90	113.1000	80.79
14	12.6400	14.6800	2.0400	3.0000	24.8600	233.10	115.1400	82.24
15	12.5600	14.8990	2.3390	3.5000	22.5210	243.50	117.4790	83.91
16	12.6410	14.7430	2.1020	3.0000	20.4190	251.10	119.5810	85.42
17	12.8310	15.5650	2.7340	3.5000	17.6850	260.20	122.3150	87.37
18	12.5470	21.5040	8.9570	12.0000	8.7280	271.50	131.2720	93.77
19	12.6480	14.6900	2.0420	3.0000	6.6860	281.70	133.3140	95.22
20	12.6230	12.9950	0.3720	0.5000	6.3140	290.40	133.6860	95.49
21	12.8110	12.8880	0.0770	0.2500	6.2370	300.50	133.7630	95.55
22	12.6840	12.9900	0.3060	0.2500	5.9310	300.30	134.0690	95.76
Residual after run			0.5000	0.2590	5.4310	300.30	134.5690	96.12
Residual oil in cell			1.4380	1.8800		300.30	136.0070	97.15
Total	278.6510	412.7200	136.0070	202.1390				

	Oil wt g	Oil vol ml
Difference	-136.0070	-1.0690
% Error	-97.1479	-0.5317

TABLE 5.4- OIL YIELDS AT DRY DISTILLATION RUN NO. 3

WEIGHT OF COMPONENTS (DRY DISTILLATION RUN 3)

Compound	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1108	15.5057	0.2149
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1307	18.2983	0.2123
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1412	19.7617	0.1972
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1496	20.9457	0.1834
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1540	21.5566	0.1681
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1561	21.8473	0.1535
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1577	22.0848	0.1040
N2			28.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2334

OIL YIELDS AT DISTILLATION TEMPERATURES (DRY DISTILLATION RUN 3)

Sample	Wt bottle g	Wt bottle + sample, g	Oil wt g	Oil vol ml	Wt in cell g	T(ºC)	Cum oil wt, g	Oil yield, wt%
1	12.517	39.242	26.725	42.50	113.28	98.00	26.725	19.09
2	24.916	46.922	22.006	34.80	91.27	115.00	48.731	34.81
3	25.029	34.172	9.143	13.80	82.13	131.10	57.874	41.34
4	25.145	33.949	8.804	12.90	73.32	141.20	66.678	47.63
5	25.594	40.728	15.134	22.10	58.19	153.20	81.812	58.44
6	25.360	30.543	5.183	7.40	53.01	163.30	86.995	62.14
7	25.119	32.454	7.335	10.50	45.67	173.30	94.330	67.38
8	25.219	30.970	5.751	8.00	39.92	181.50	100.081	71.49
9	25.460	30.534	5.074	7.00	34.85	190.90	105.155	75.11
10	24.922	27.631	2.709	3.70	32.14	200.10	107.864	77.05
11	25.261	27.907	2.646	3.65	29.49	210.20	110.510	78.94
12	25.377	27.688	2.311	3.20	27.18	220.20	112.821	80.59
13	25.293	27.916	2.623	3.50	24.56	230.30	115.444	82.46
14	25.008	26.400	1.392	1.00	23.16	239.60	116.836	83.45
15	25.613	27.023	1.410	1.40	21.75	249.50	118.246	84.46
16	25.270	27.246	1.976	2.75	19.78	259.50	120.222	85.87
17	24.899	29.340	4.441	6.15	15.34	269.50	124.663	89.05
18	25.259	29.179	3.920	4.90	11.42	281.40	128.583	91.85
19	25.103	27.340	2.237	3.05	9.18	289.60	130.820	93.44
20	24.717	24.941	0.224	0.45	8.96	300.00	131.044	93.60
21	25.184	27.030	1.846	0.50	7.11	300.00	132.890	94.92
Residual after ru	12.544	12.680	0.136	0.100	6.97	300.00	133.026	95.02
Residual incell	12.584	15.694	3.110	4.00	3.86	300.00	136.136	97.24
Total	541.393	677.529	136.136	197.35	832.51			

	Oil wt g	Oil vol ml
Difference	3.8640	3.7200
% Error	2.7600	1.8501

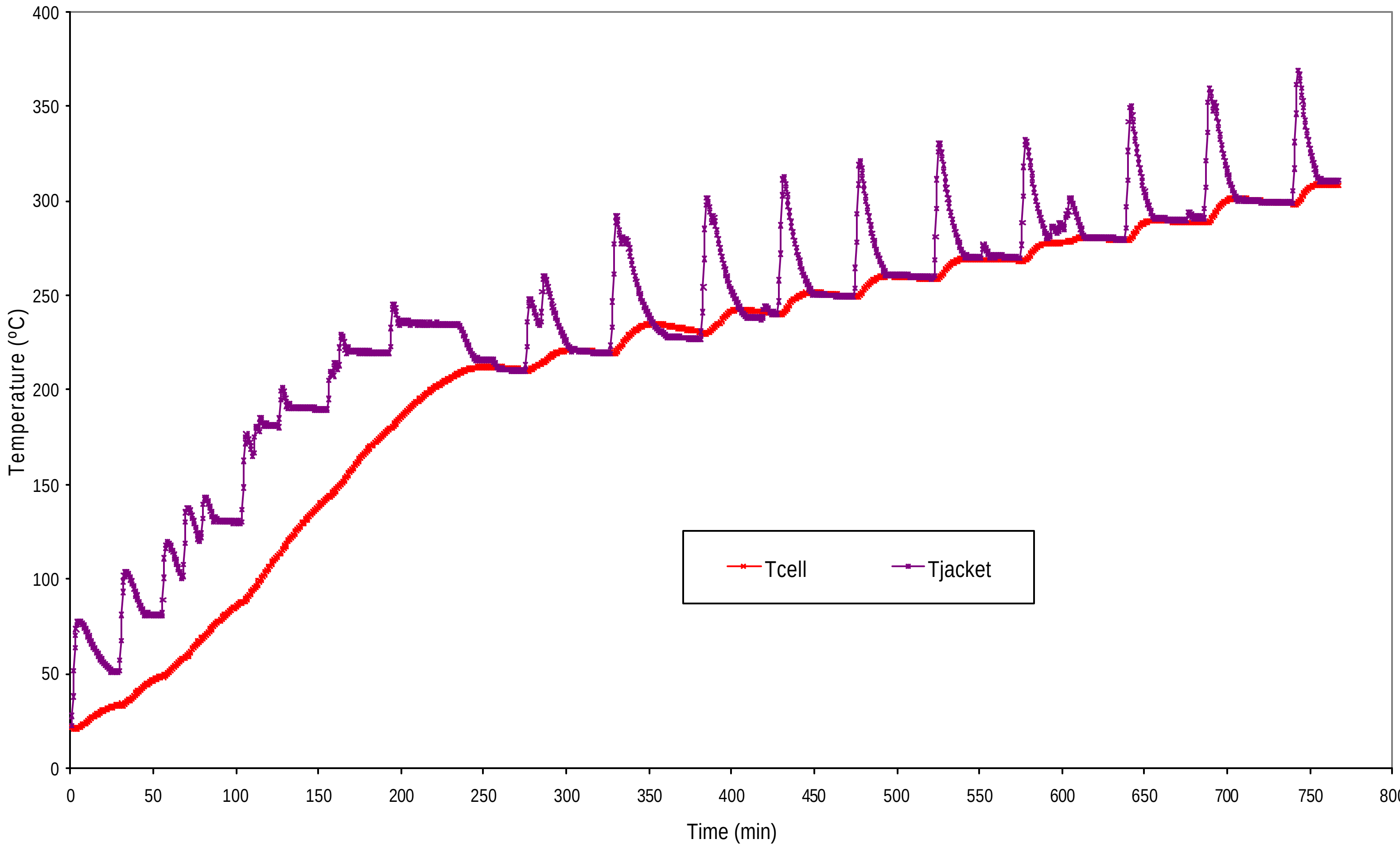


Fig. 5.1-Temperature vs. time (dry distillation run no. 1).

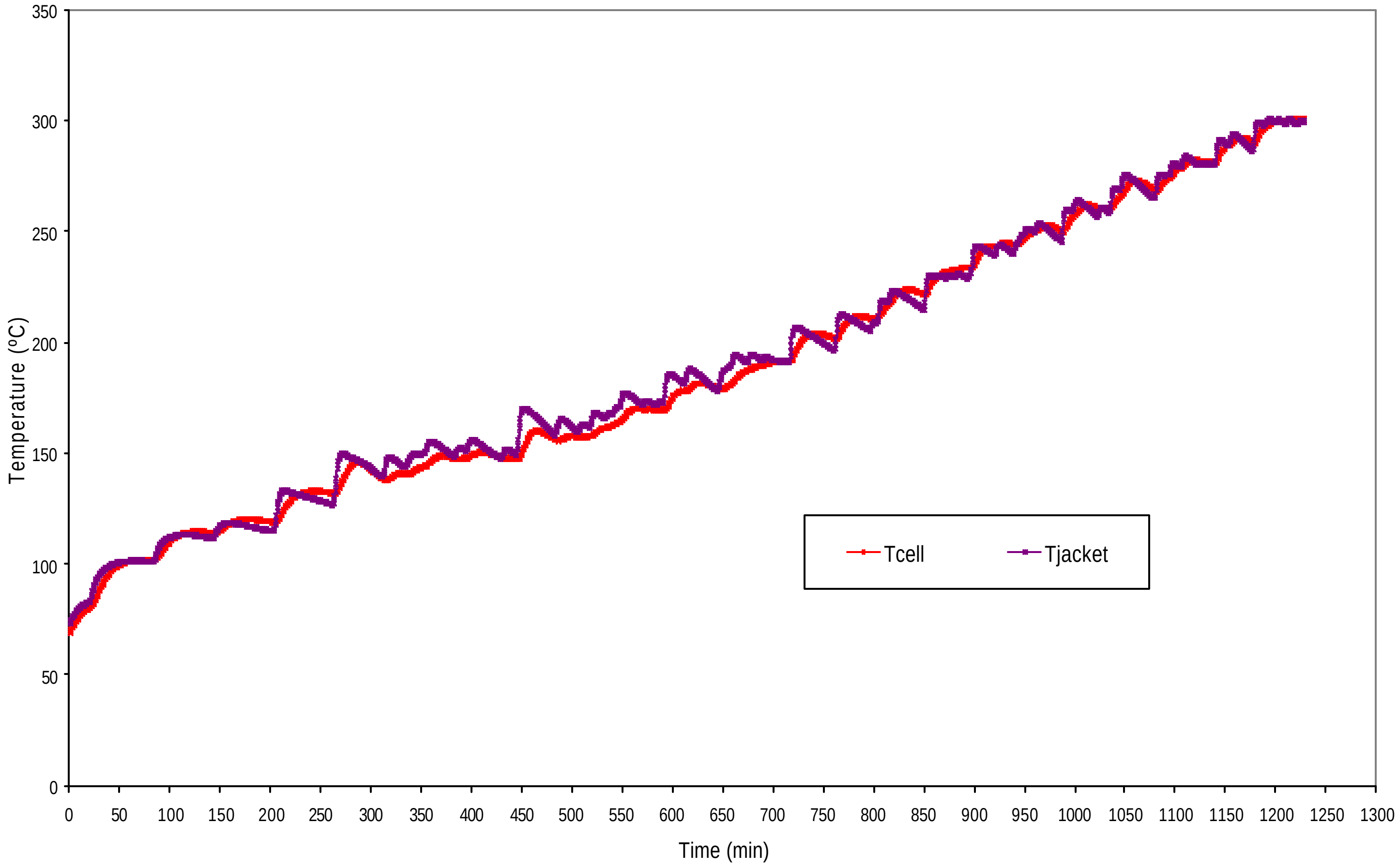


Fig. 5.2-Temperature vs. time (dry distillation run no. 2).

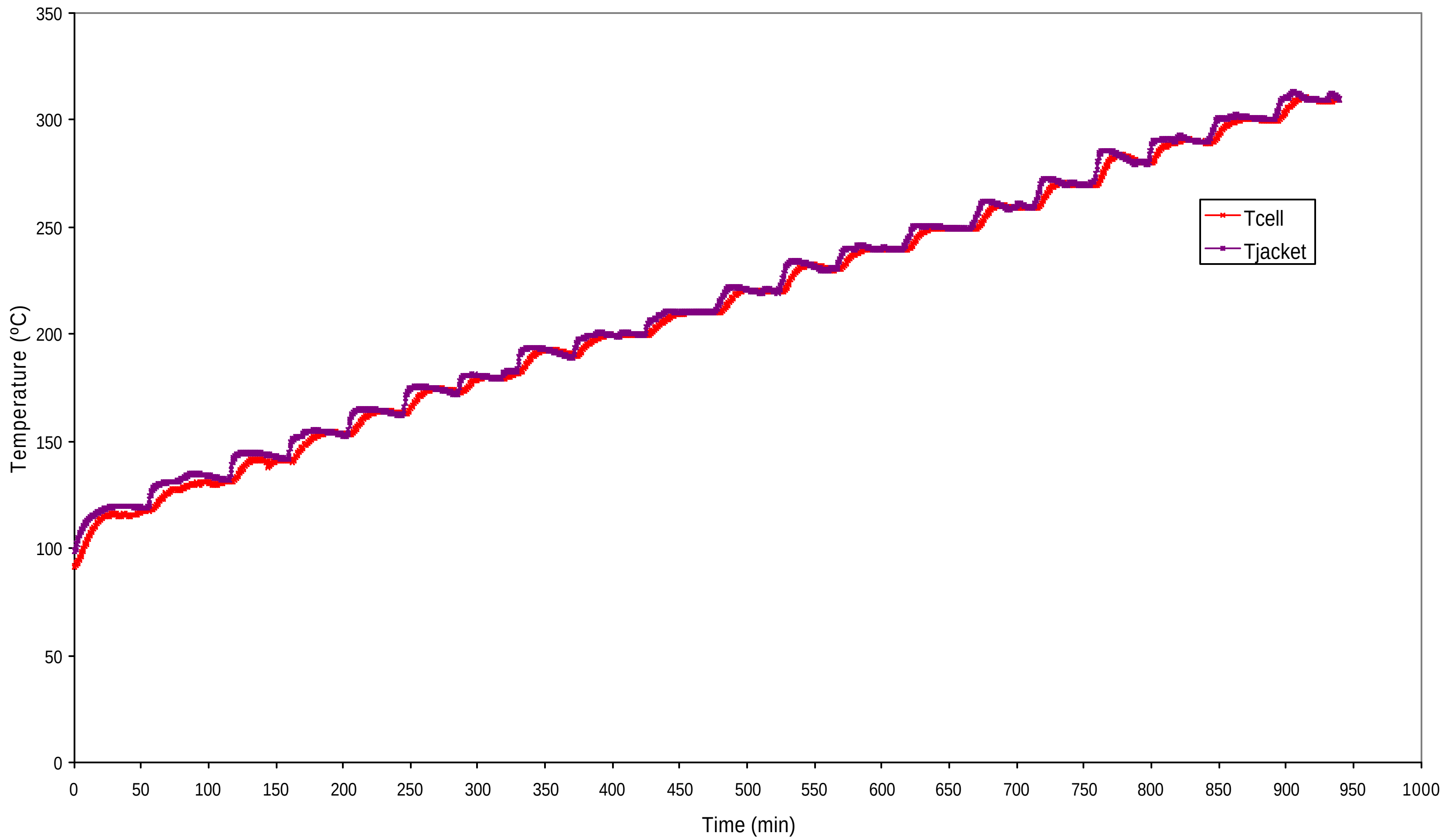


Fig. 5.3-Temperature vs. time (dry distillation run no. 3).

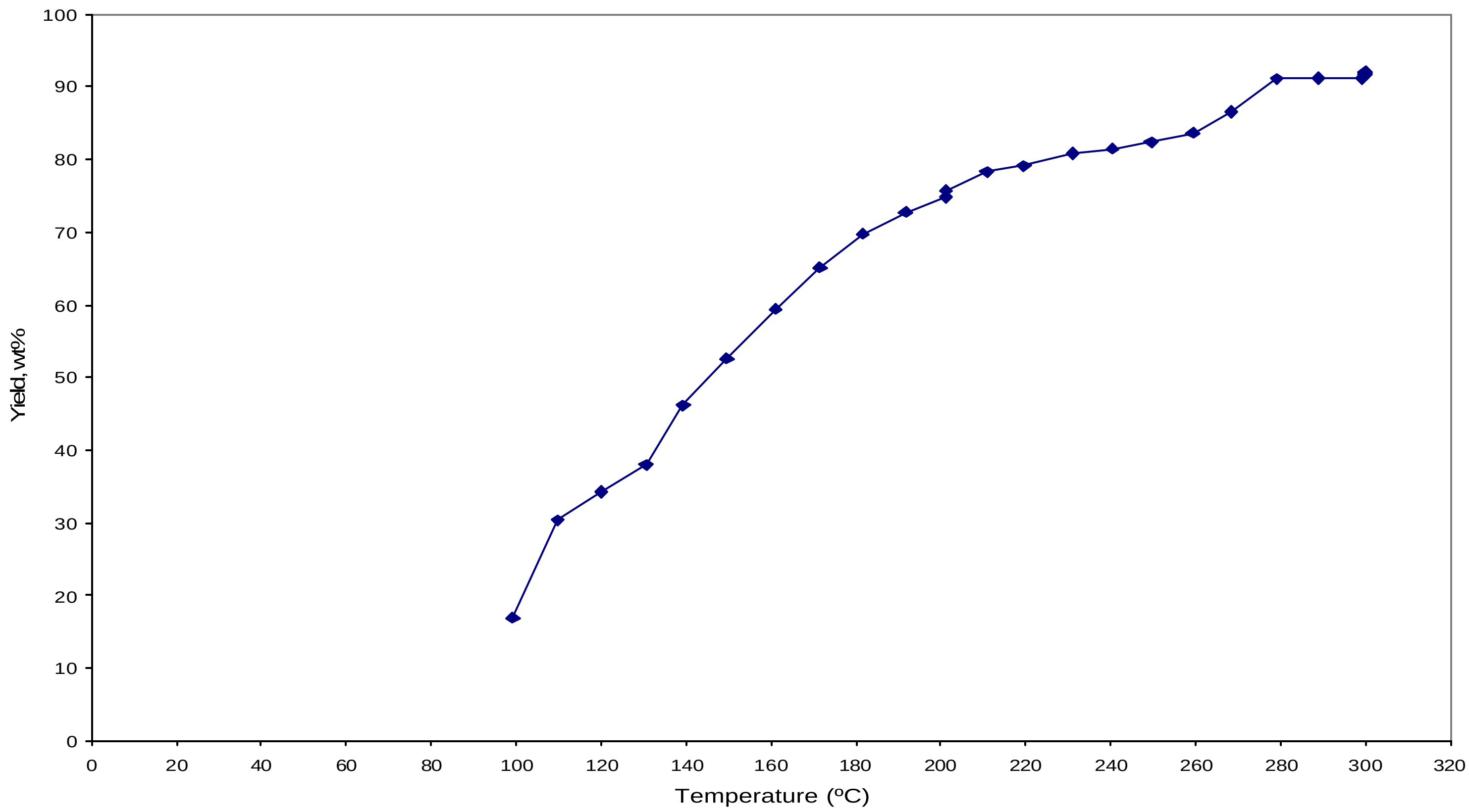


Fig. 5.4-Oil yield vs. time (dry distillation run no. 1).

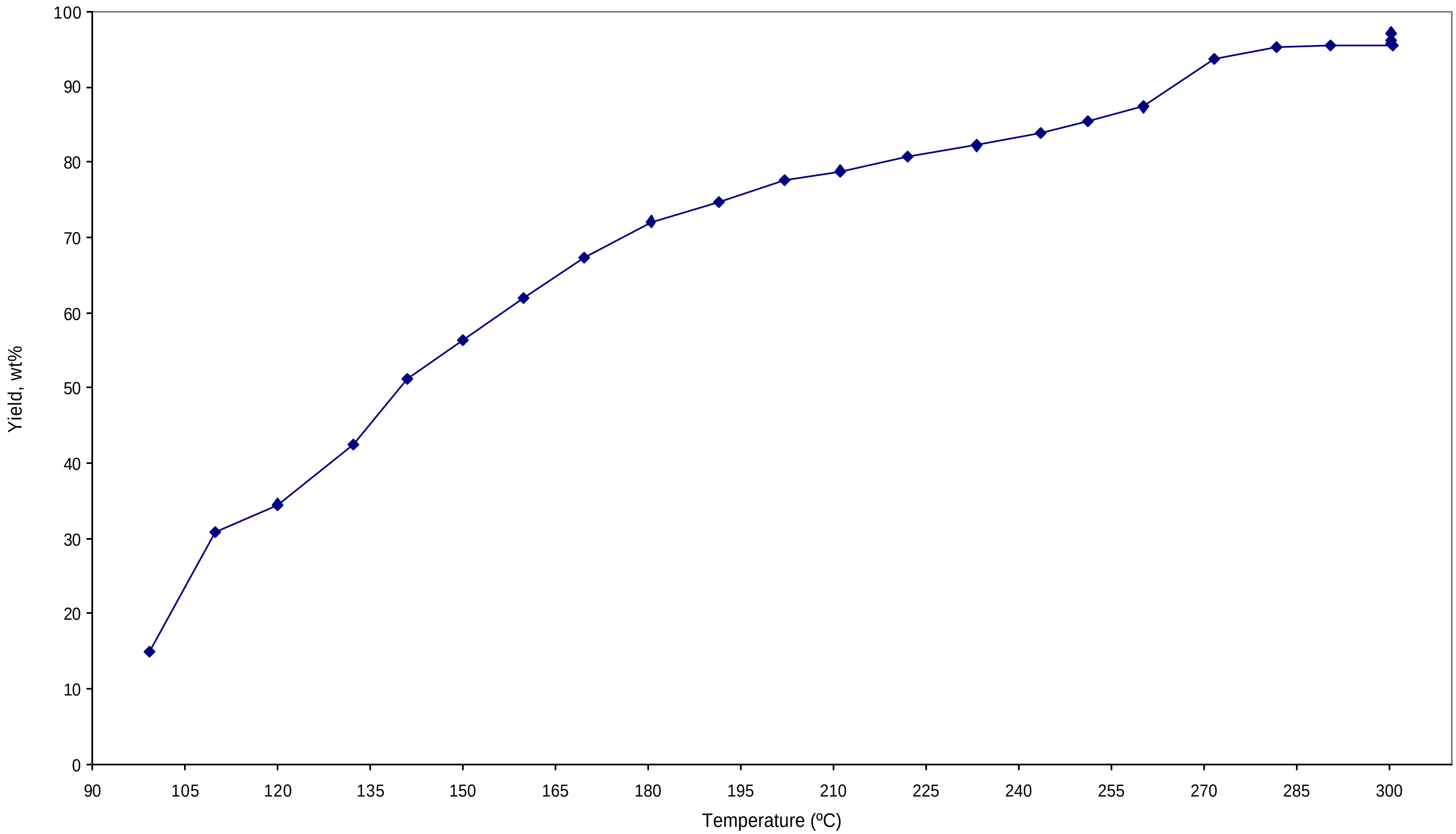


Fig. 5.5-Oil yield vs. time (dry distillation run no. 2).

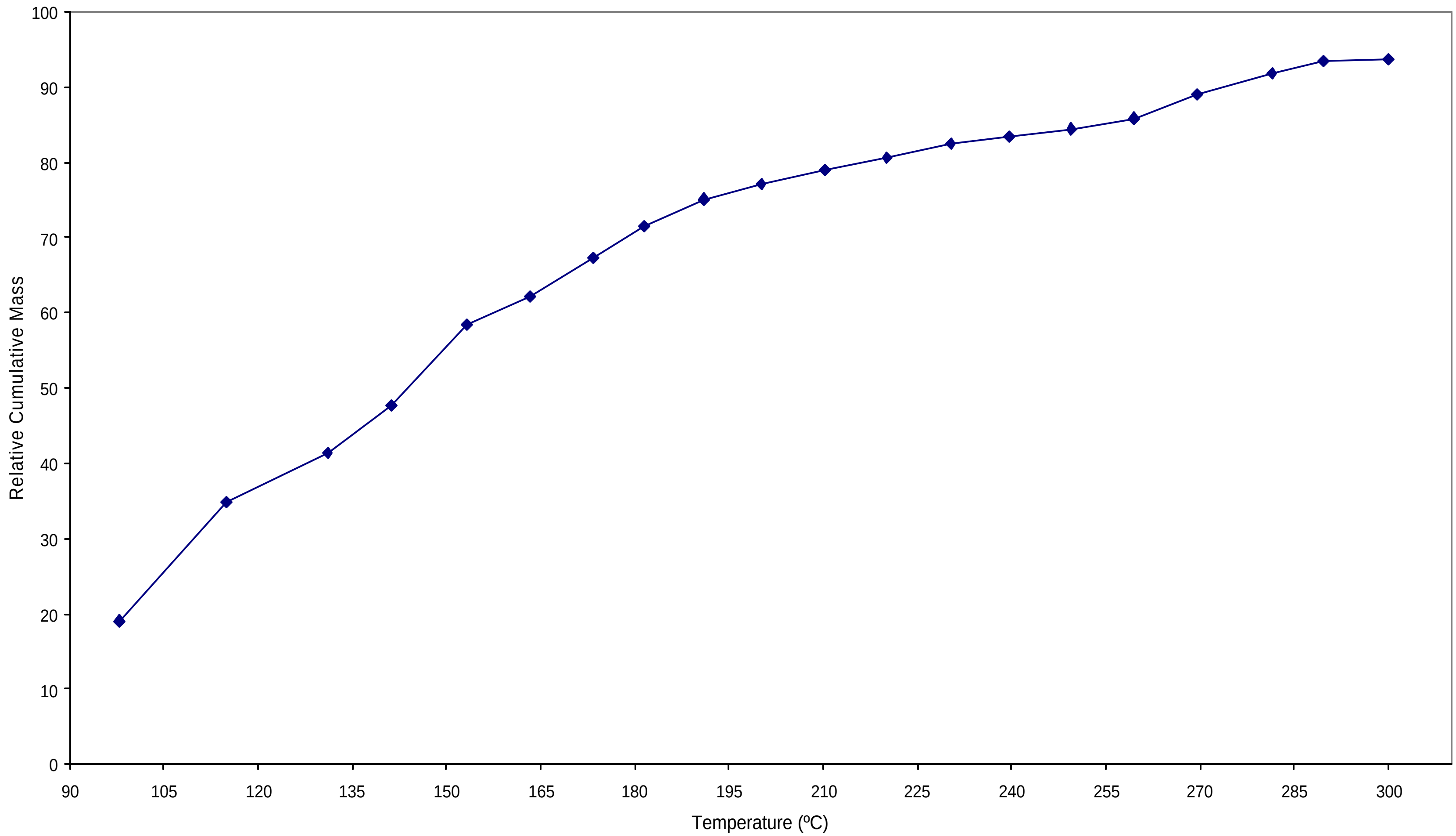


Fig. 5.6-Oil yield vs. time (dry distillation run no. 3).

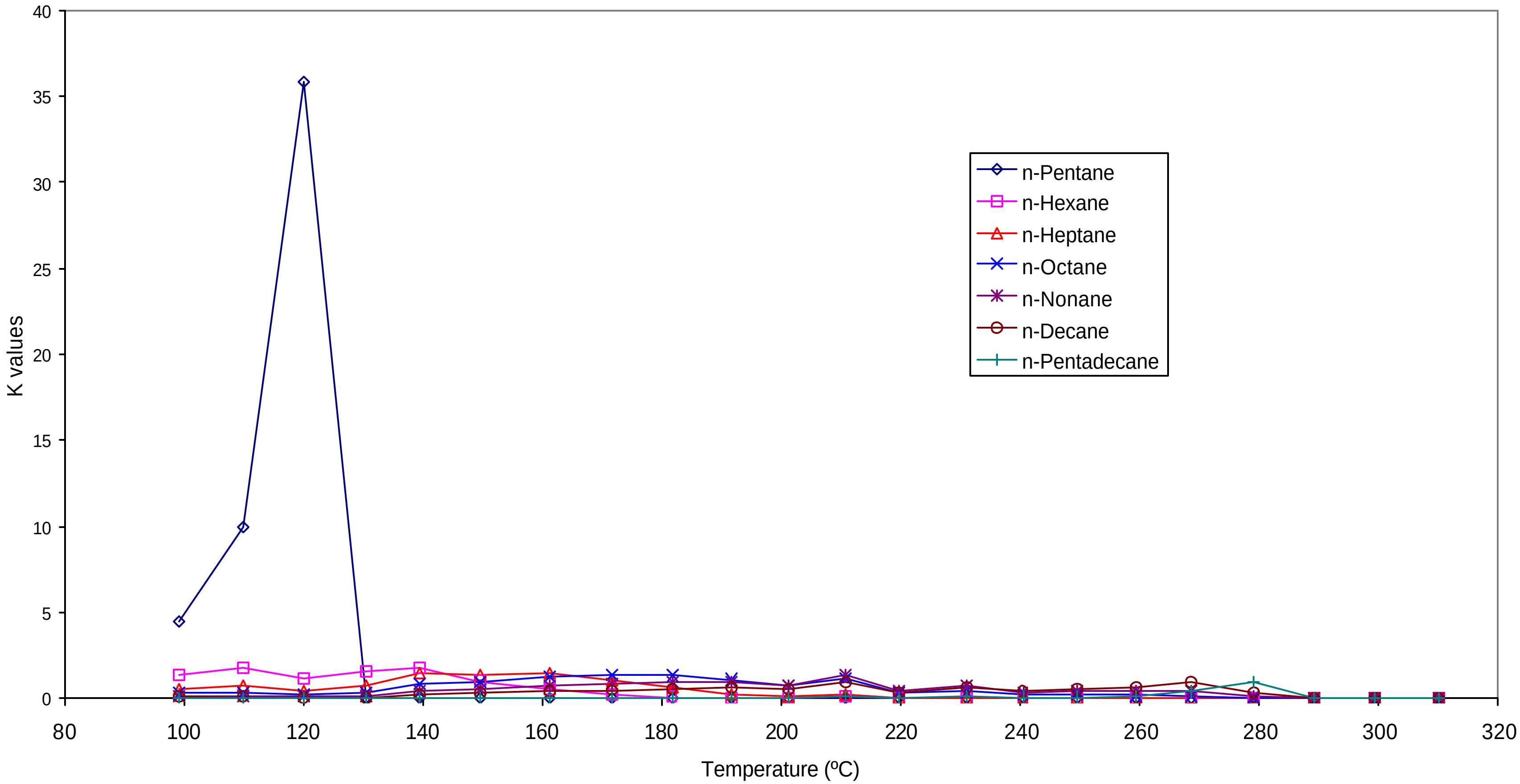


Fig. 5.7-Experimental *K*-values vs. temperature (dry distillation run no. 1).

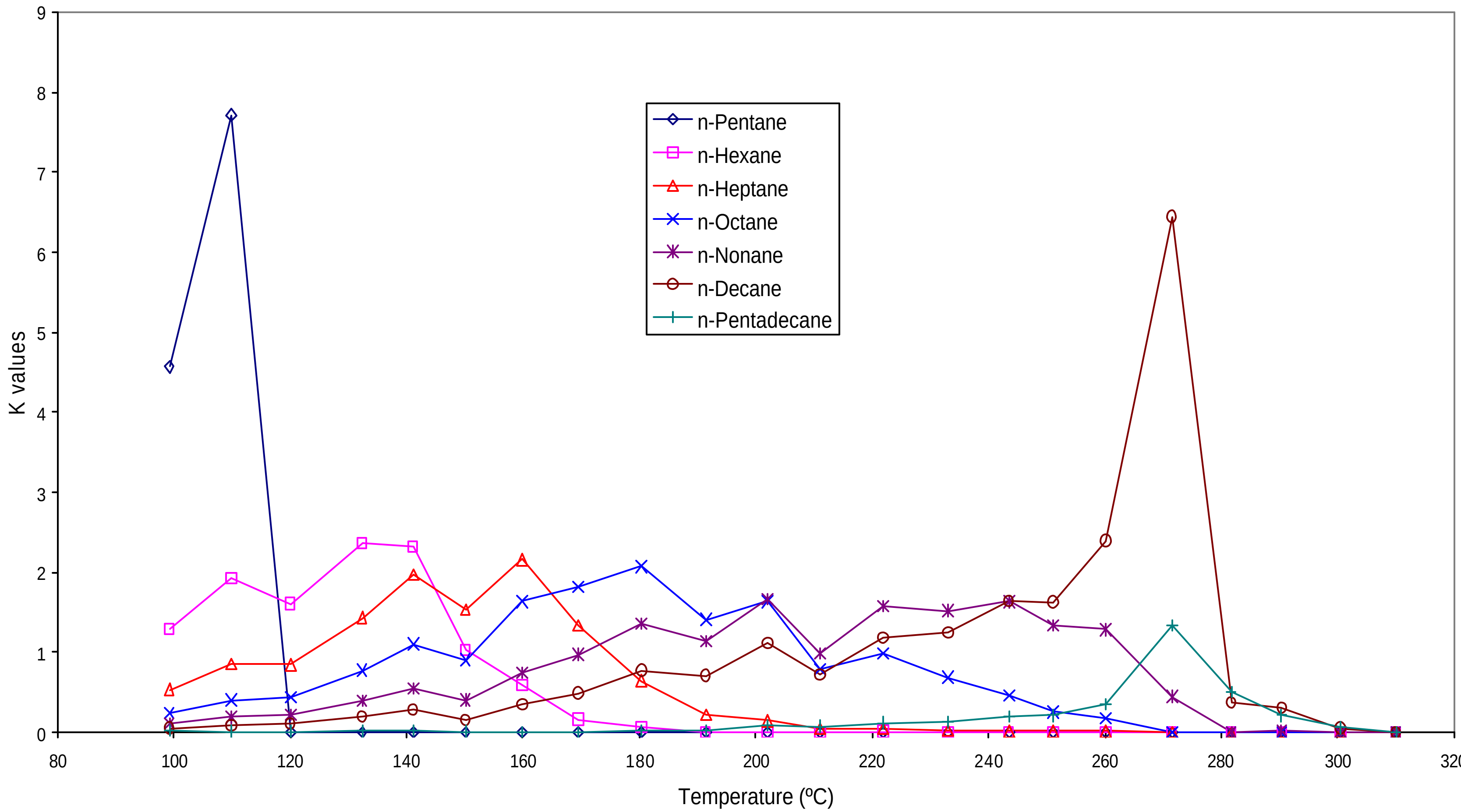


Fig. 5.8-Experimental *K*-values vs. temperature (dry distillation run no. 2).

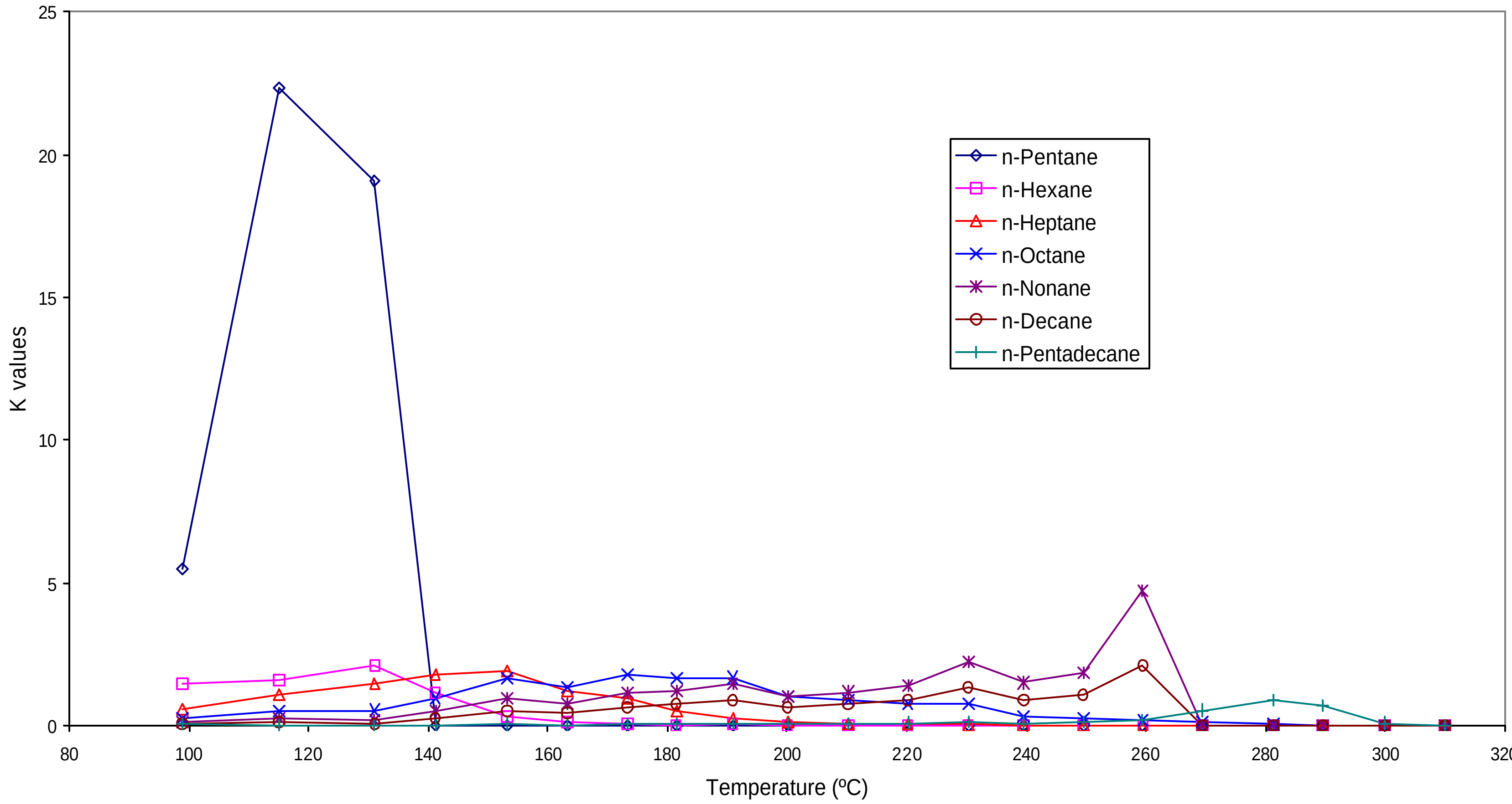


Fig. 5.9-Experimental *K*-values vs. temperature (dry distillation run no. 3).

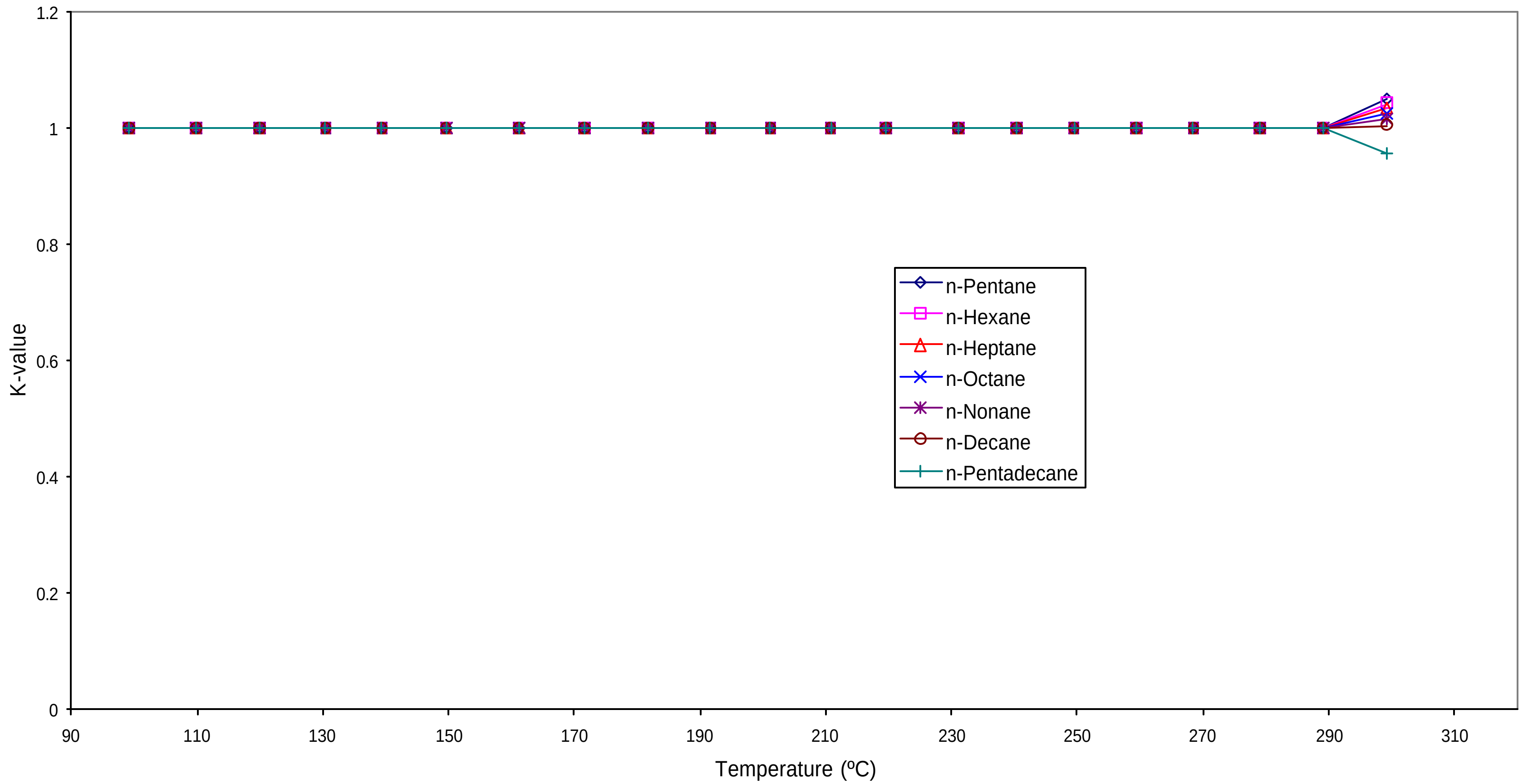


Fig. 5.10-*K*-values calculated vs. temperature (dry distillation run no. 1).

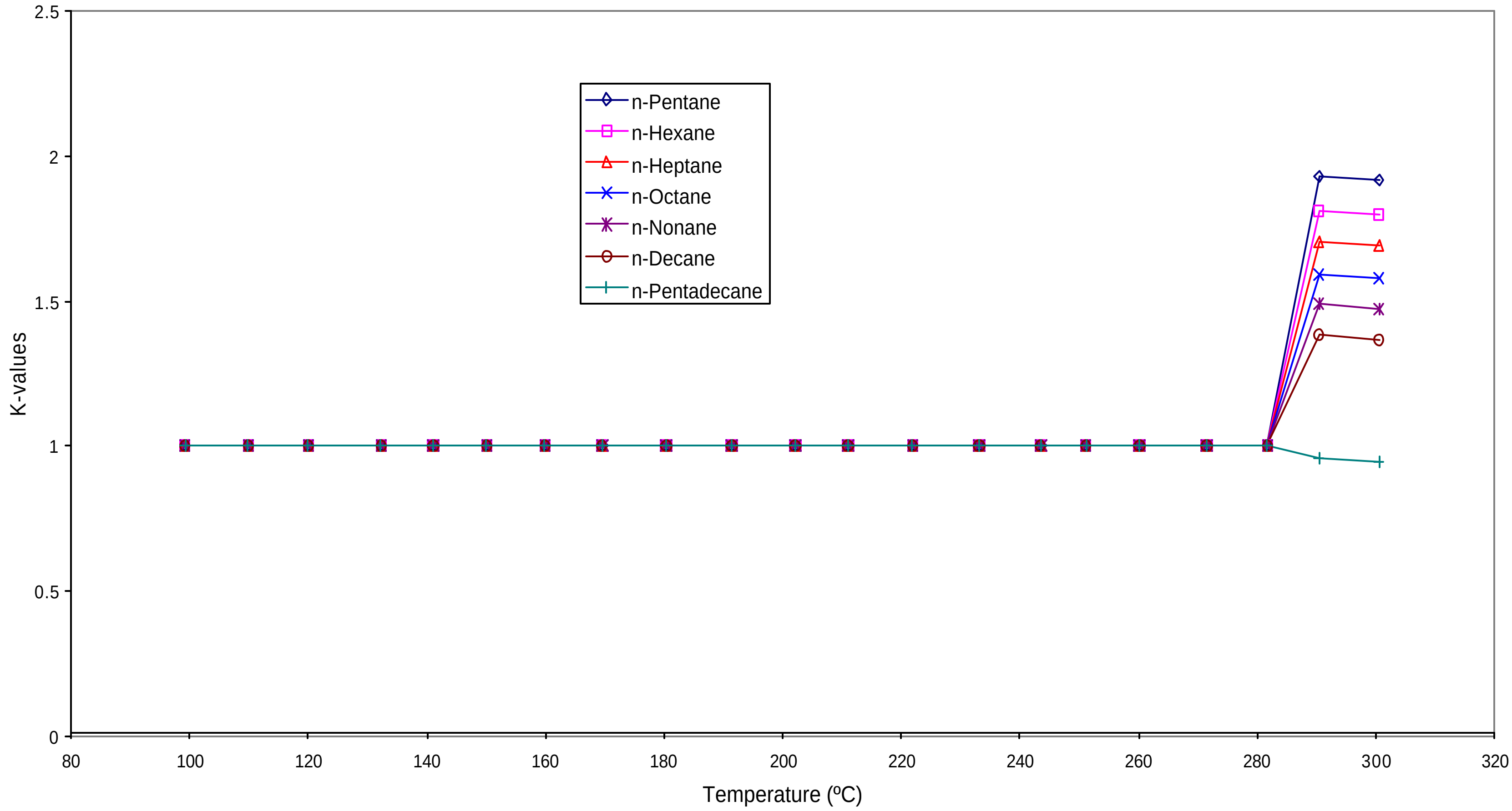


Fig. 5.11-*K*-values calculated vs. temperature (dry distillation run no. 2).

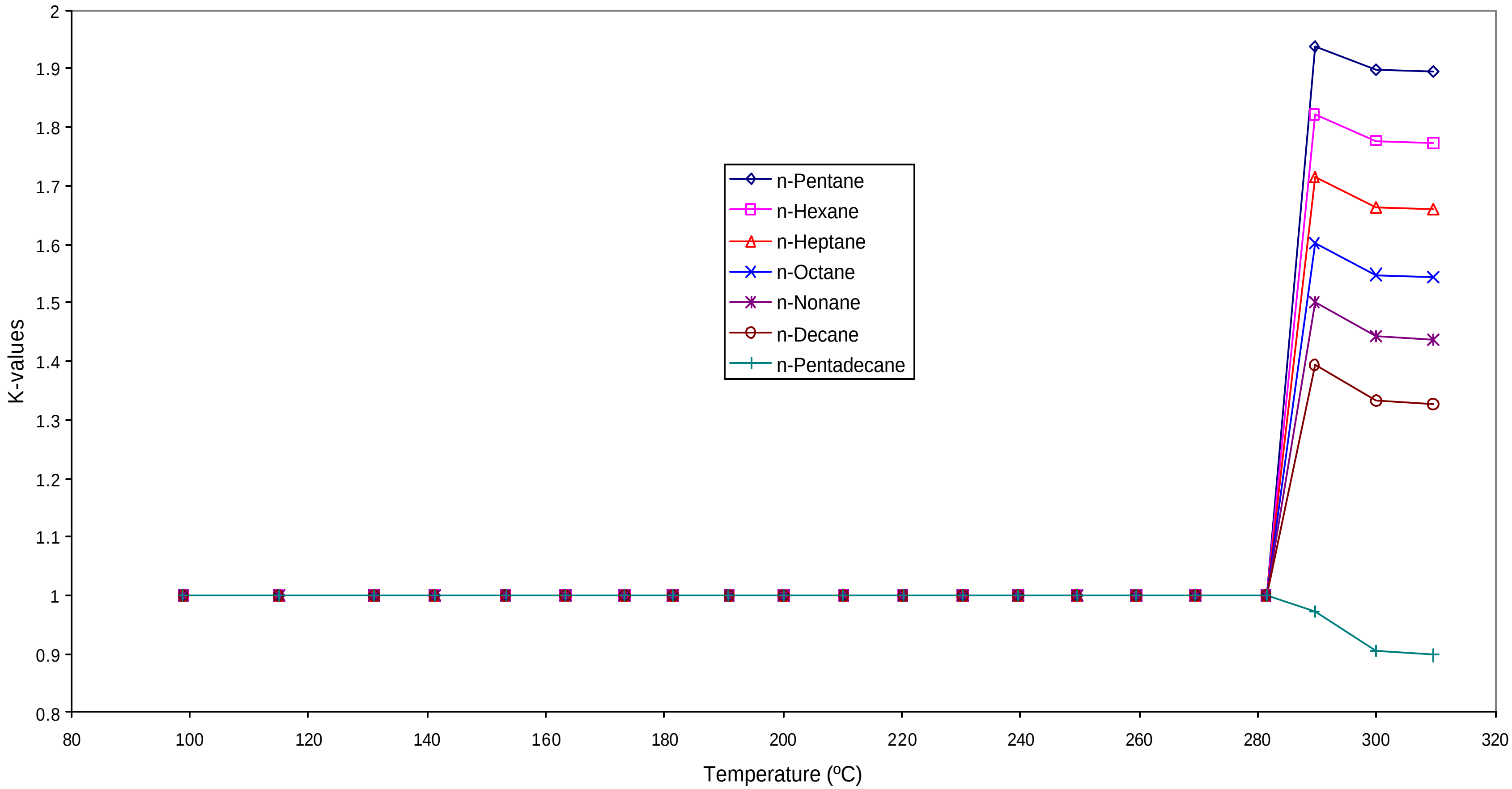


Fig. 5.12-*K*-values calculated vs. temperature (dry distillation run no. 3).

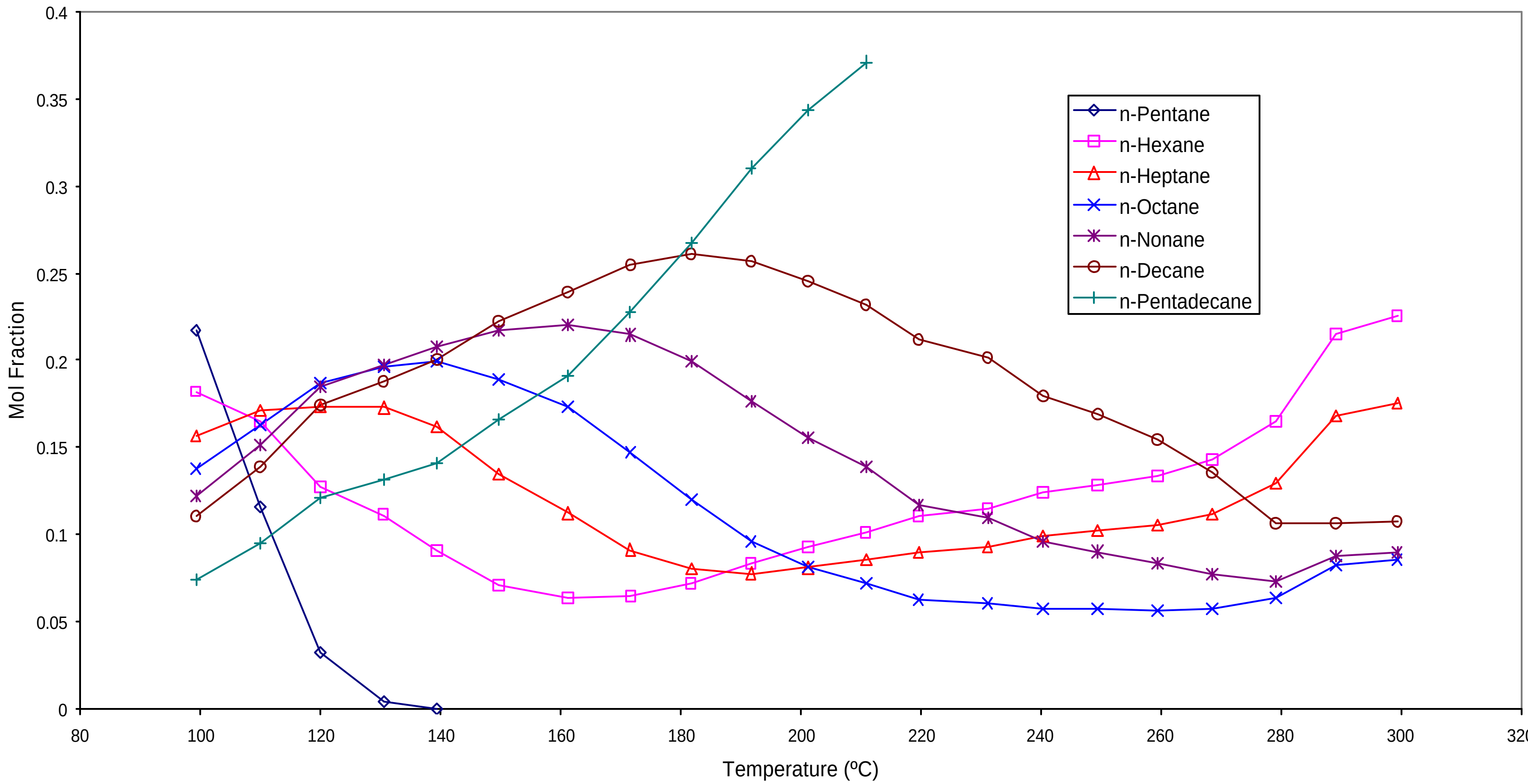


Fig. 5.13-Vapor composition vs. temperature (dry distillation run no. 1).

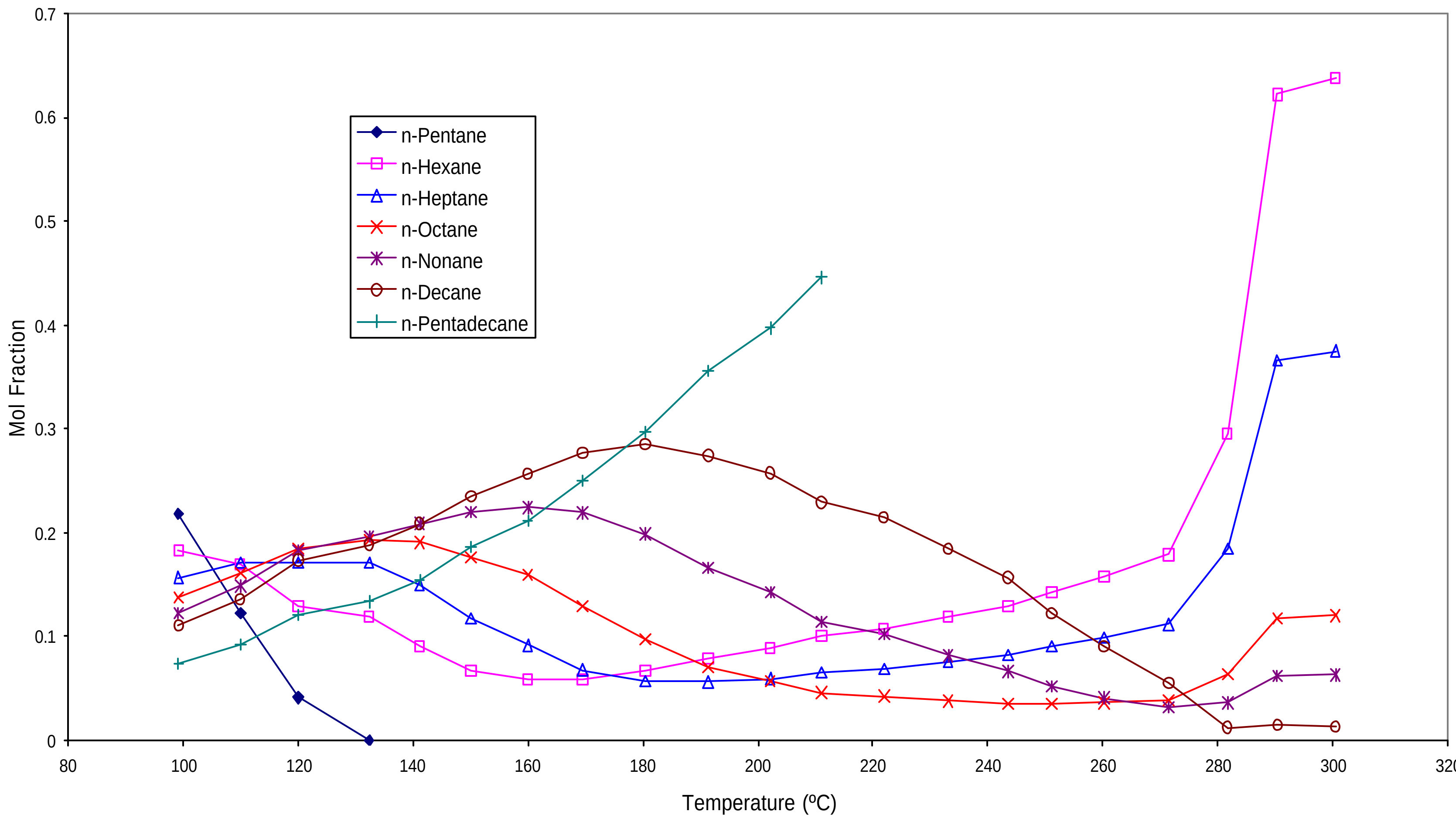


Fig. 5.14-Vapor composition vs. temperature (dry distillation run no. 2).

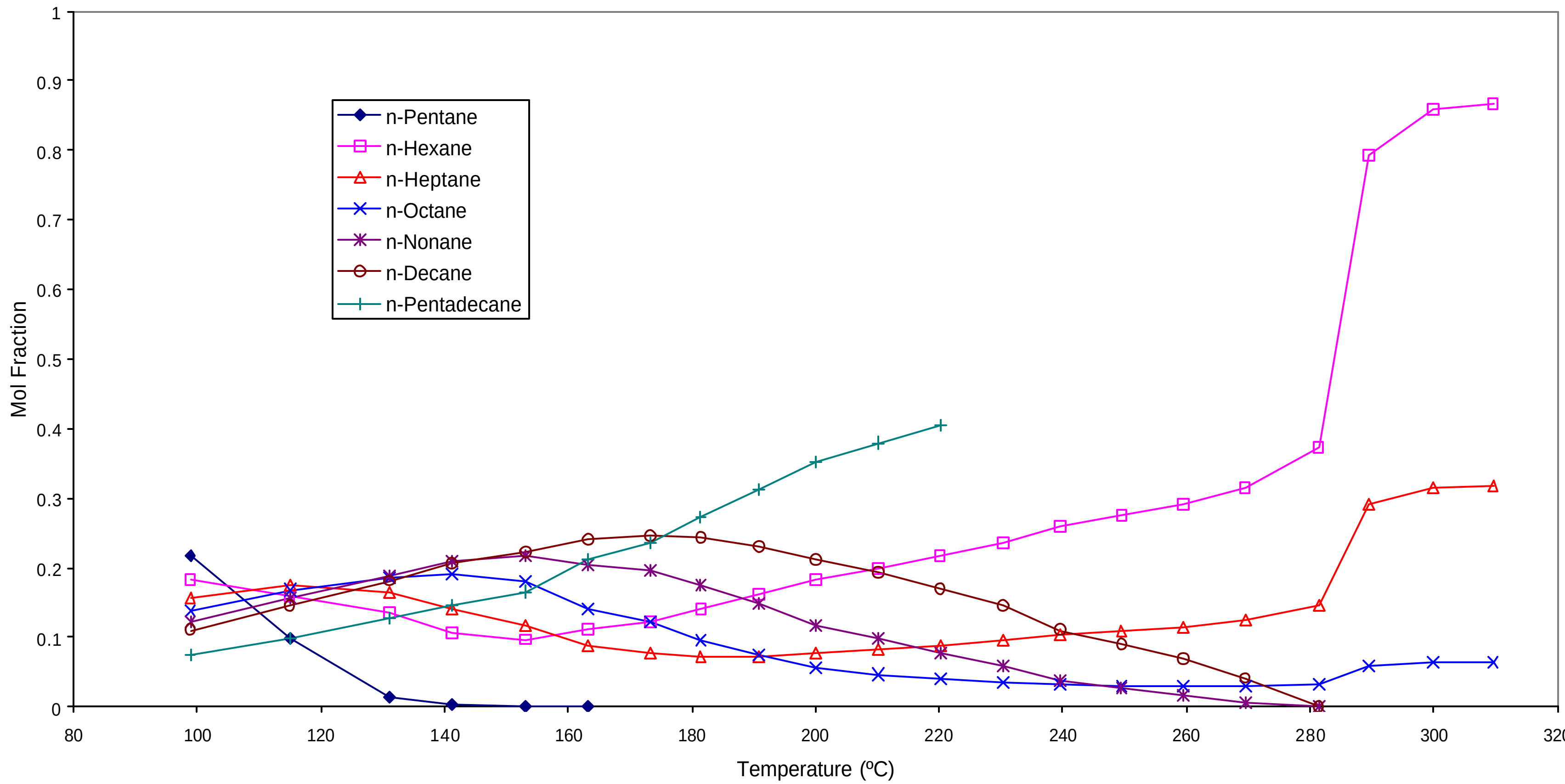


Fig. 5.15-Vapor composition vs. temperature (dry distillation run no. 3).

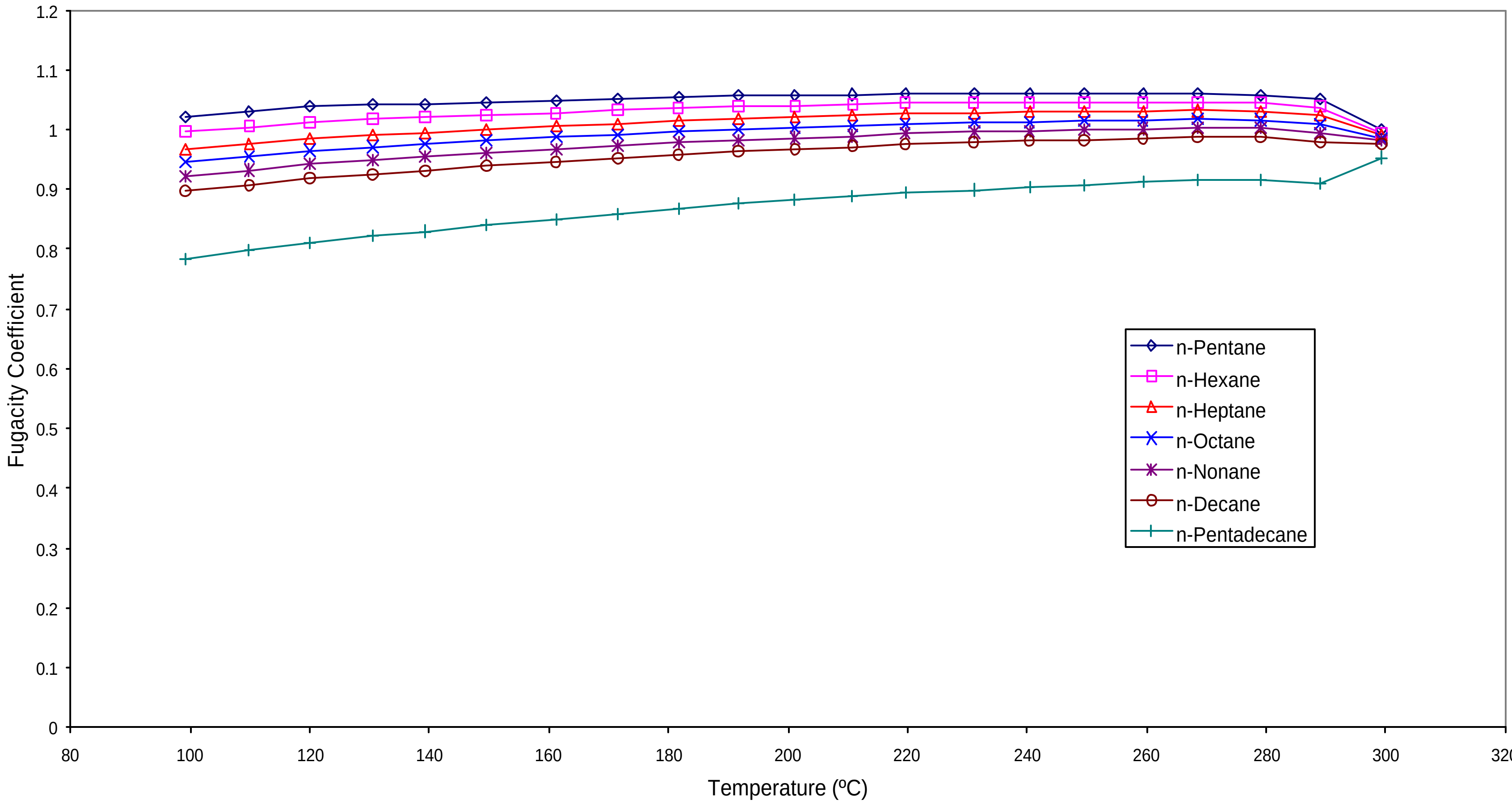


Fig. 5.16-Vapor fugacity coefficient vs. temperature (dry distillation run no. 1).

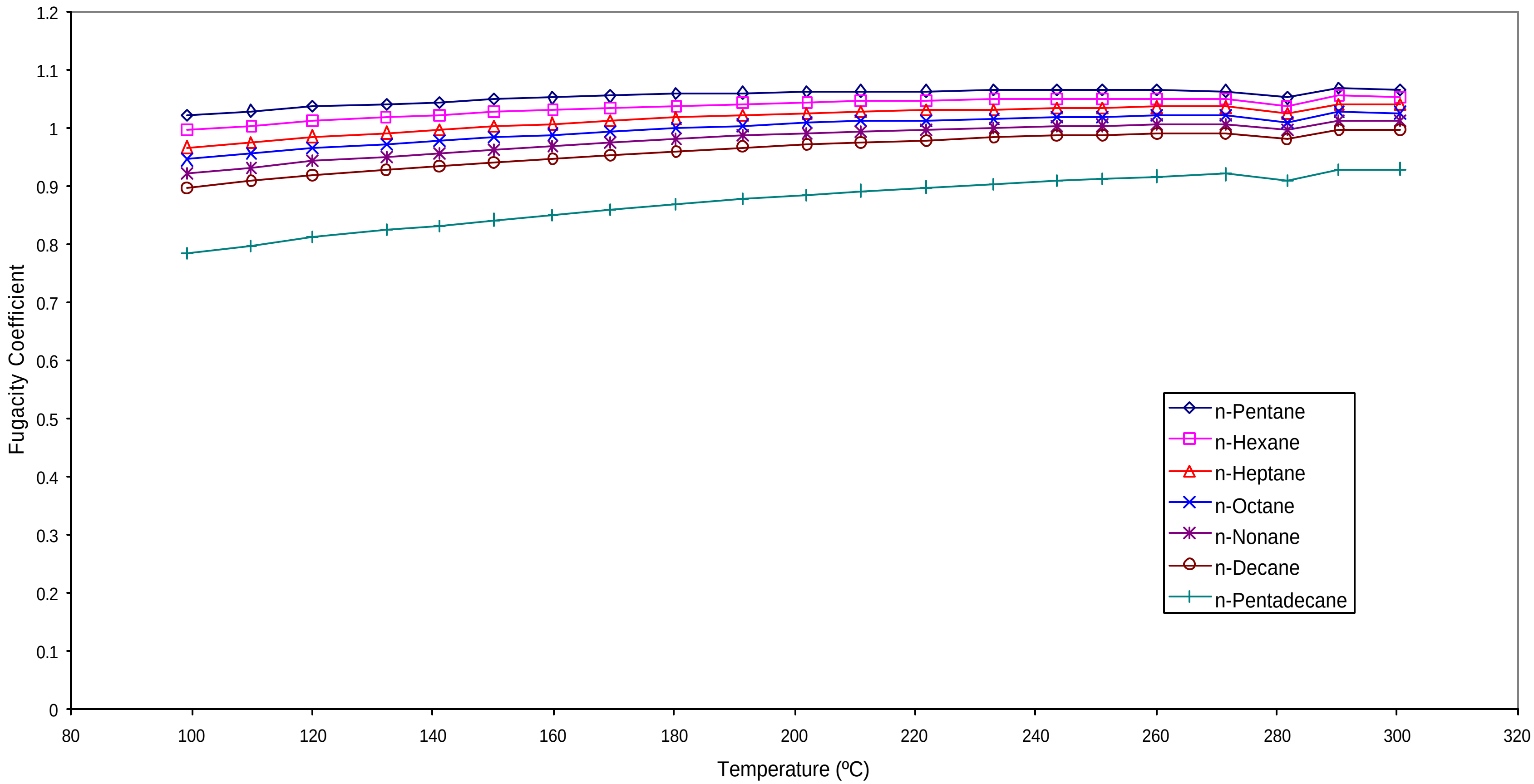


Fig. 5.17-Vapor fugacity coefficient vs. temperature (dry distillation run no. 2).

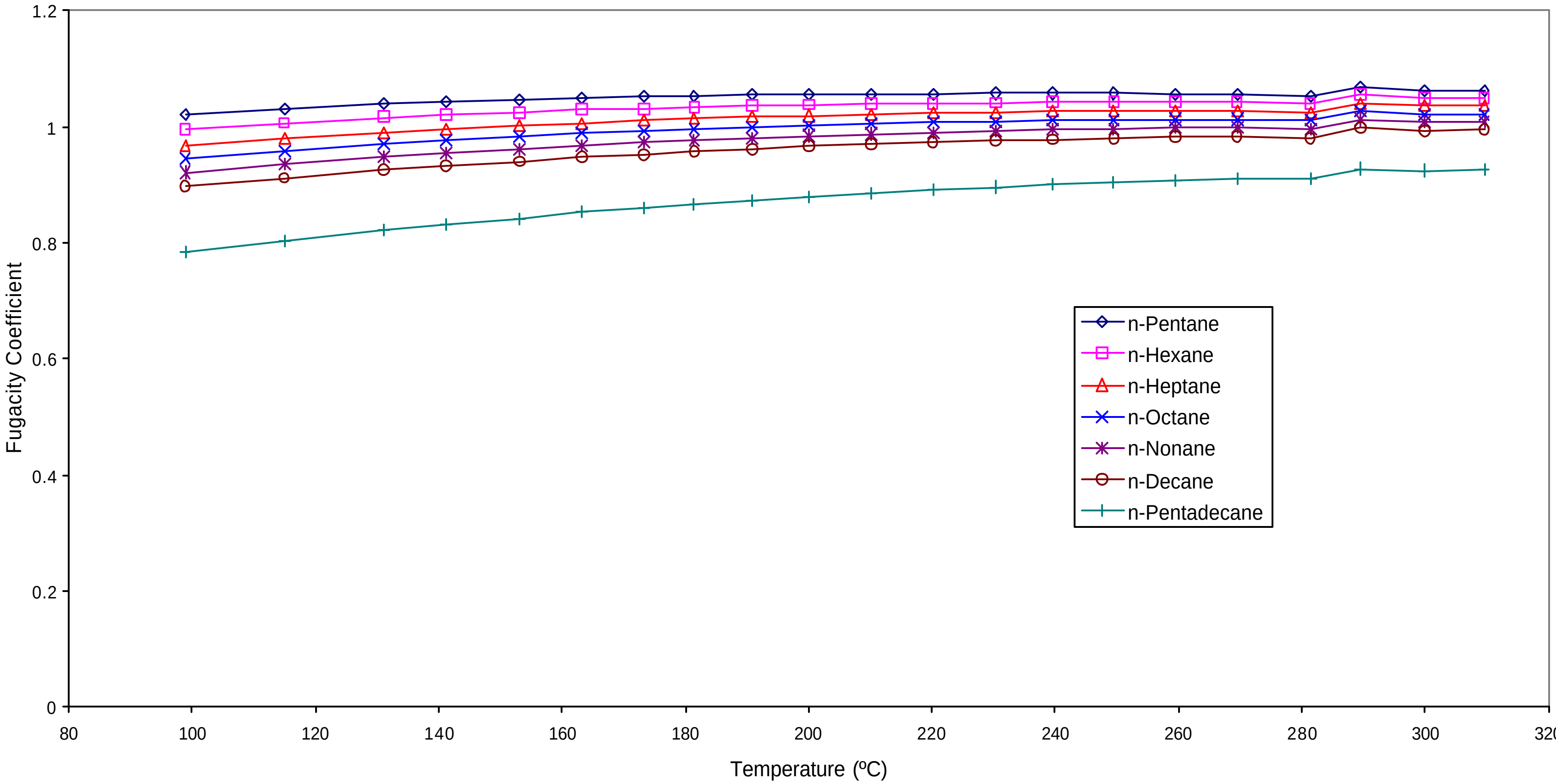


Fig. 5.18-Vapor fugacity coefficient vs. temperature (dry distillation run no. 3).

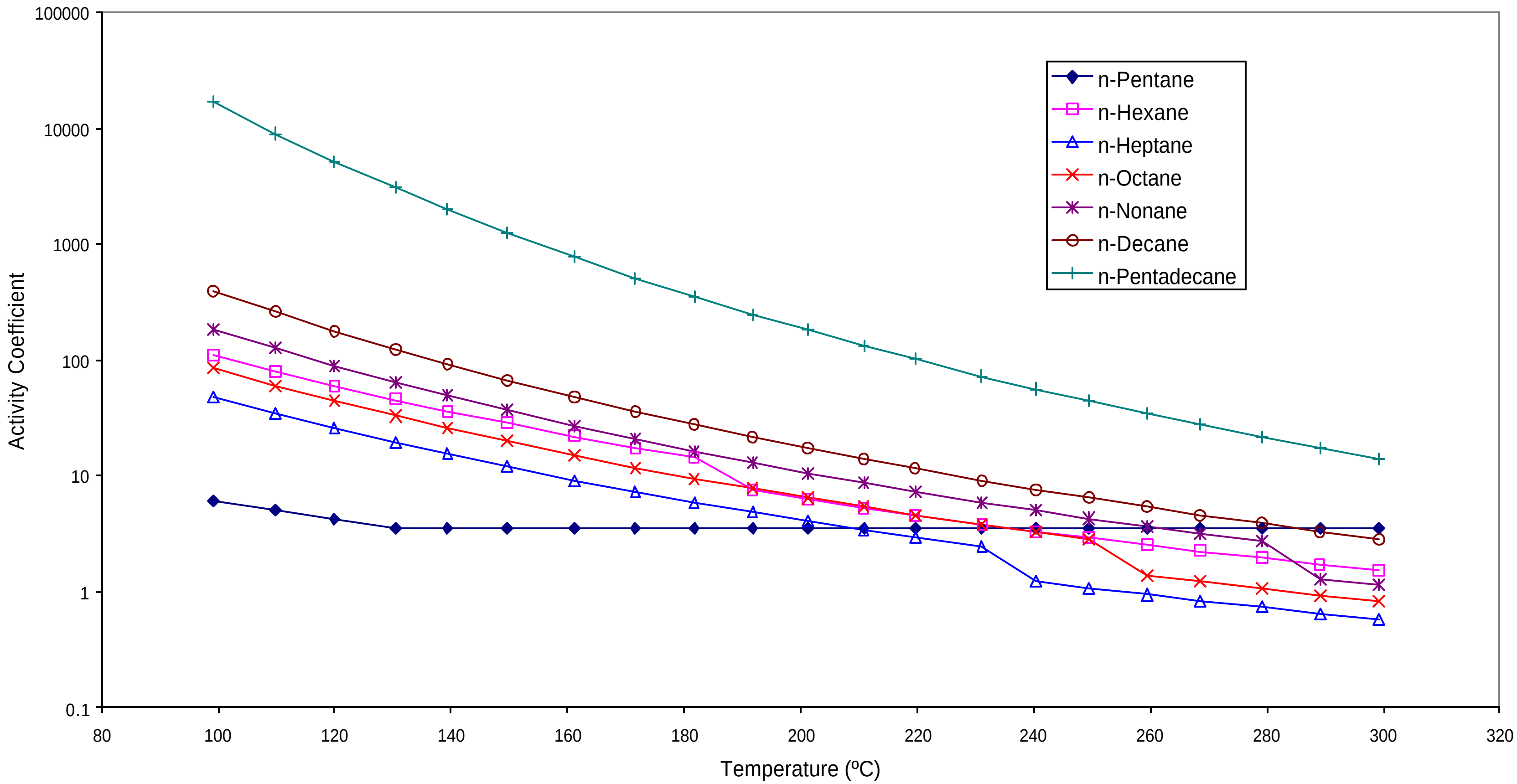


Fig. 5.19-Activity coefficient vs. temperature (dry distillation run no. 1).

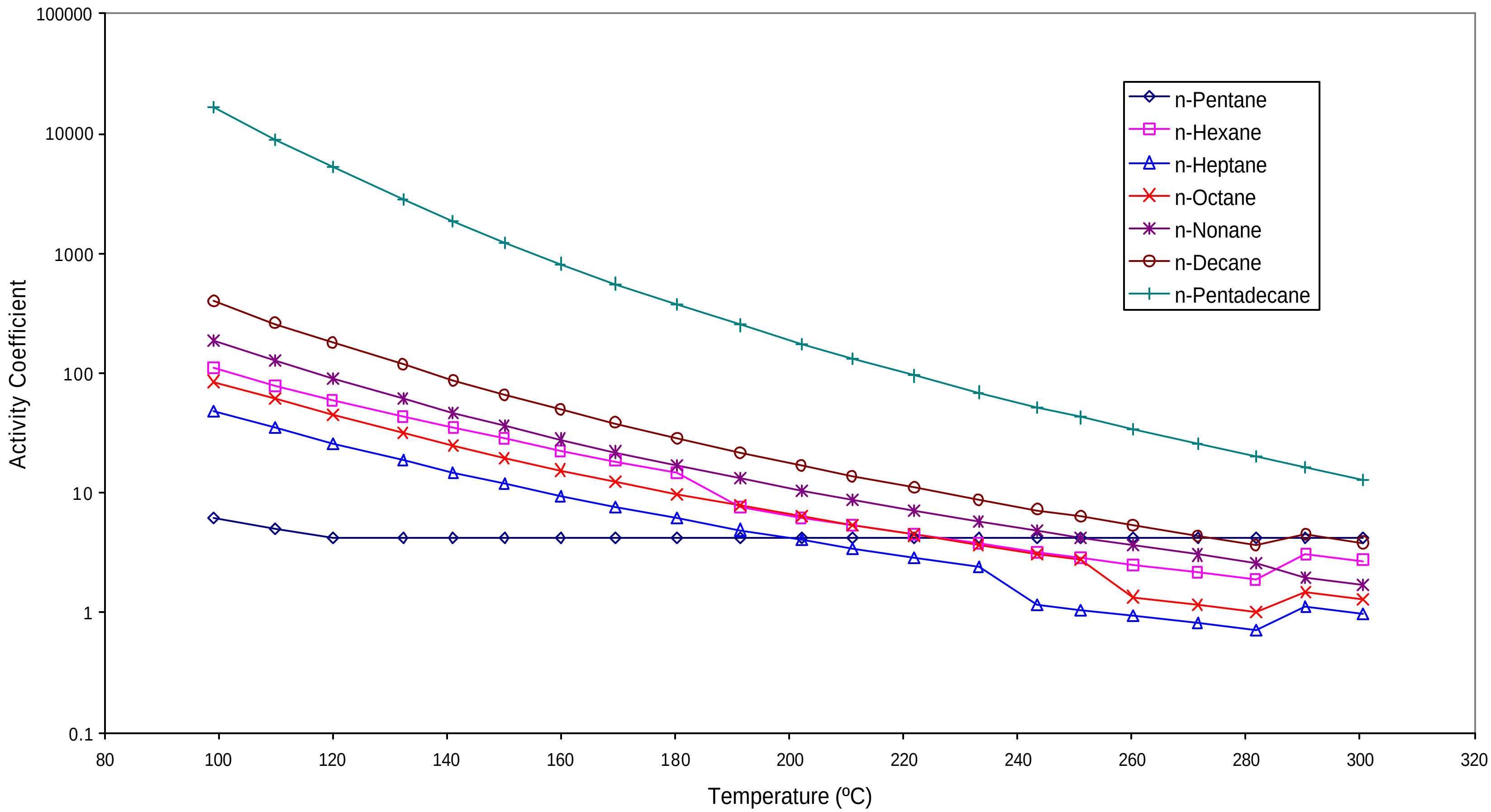


Fig. 5.20-Activity coefficient vs. temperature (dry distillation run no. 2).

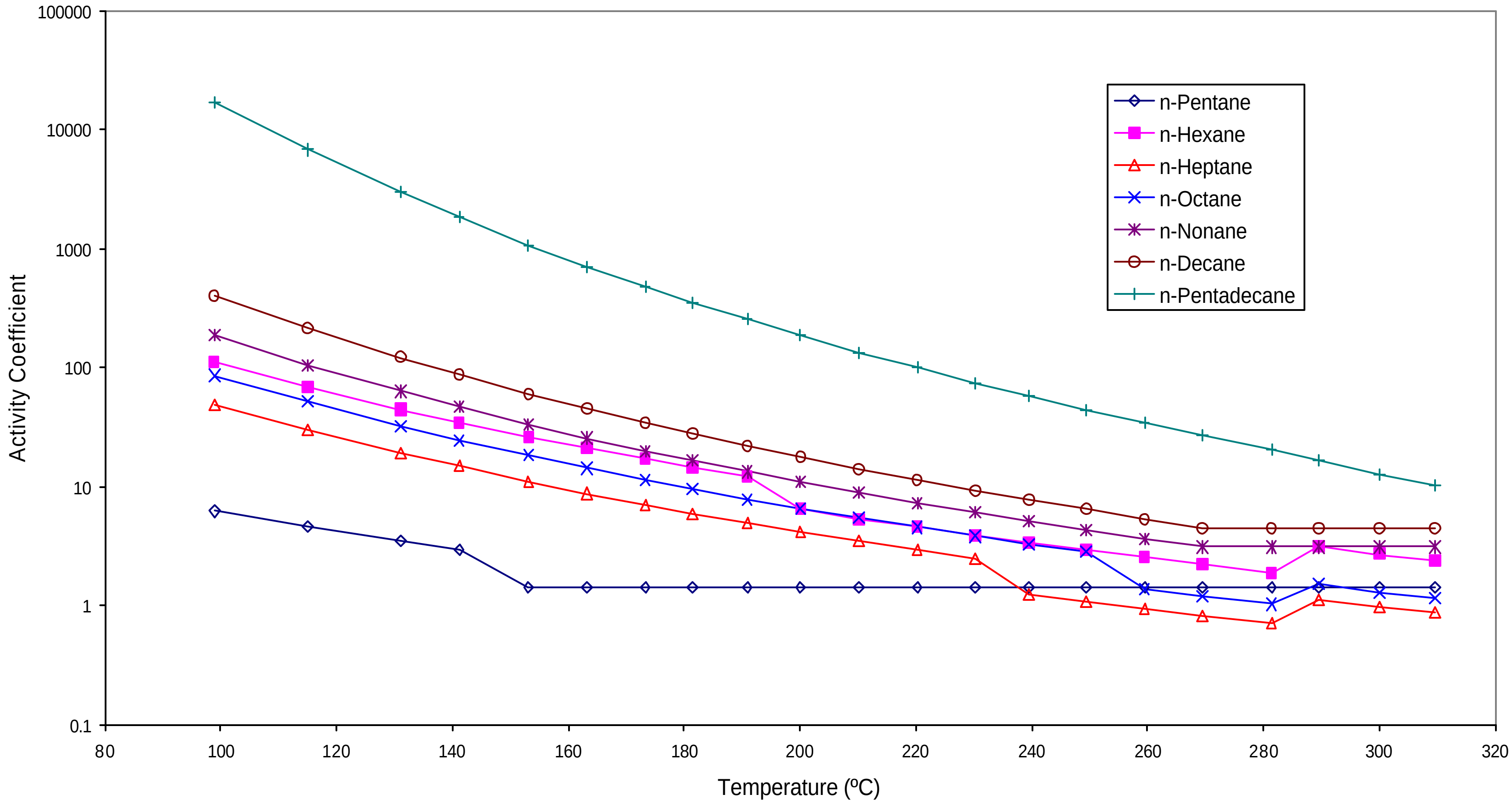


Fig. 5.21-Activity coefficient vs. temperature (dry distillation run no. 3).

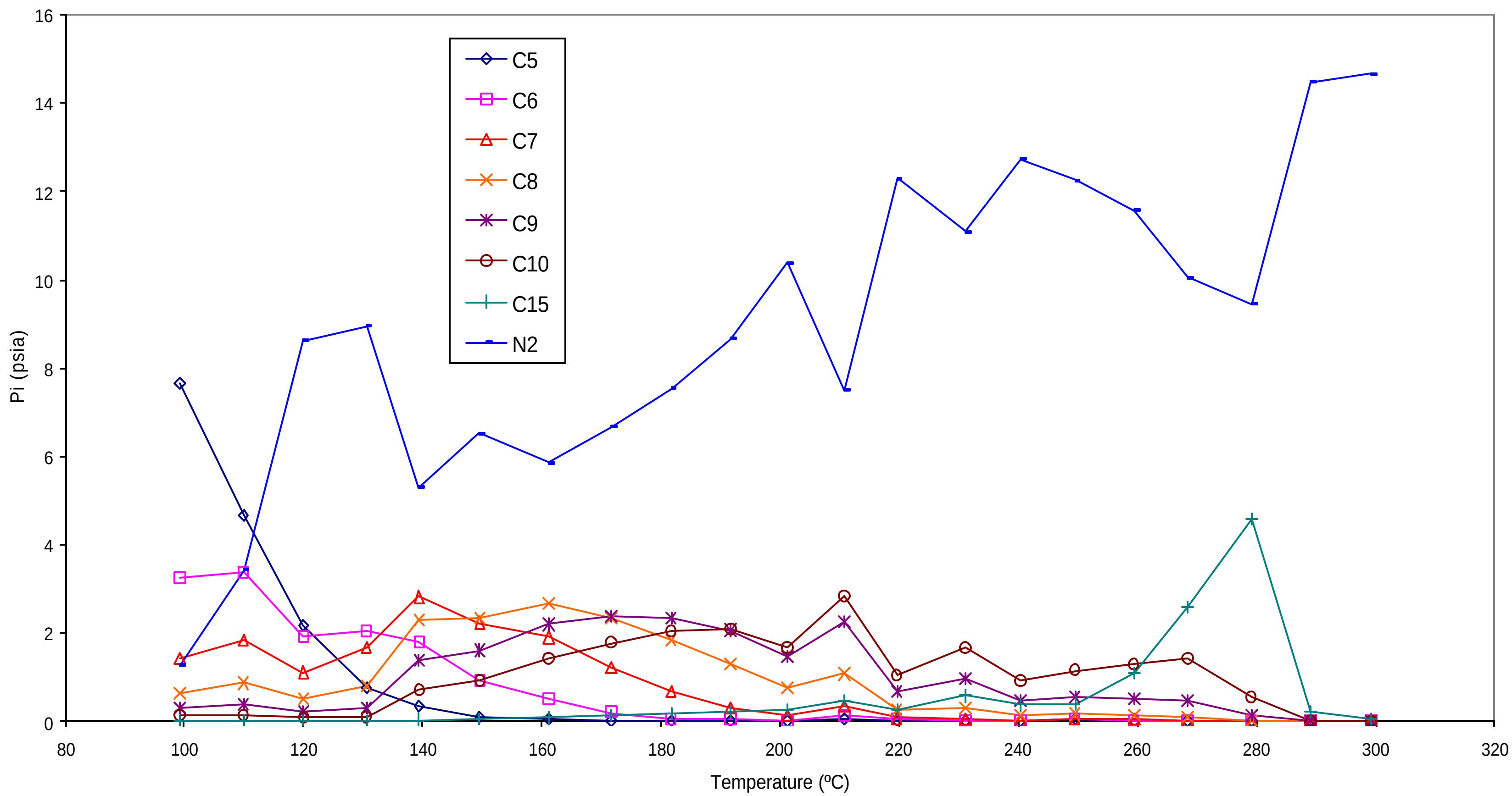


Fig. 5.22-Partial pressure vs. temperature (dry distillation run no. 1).

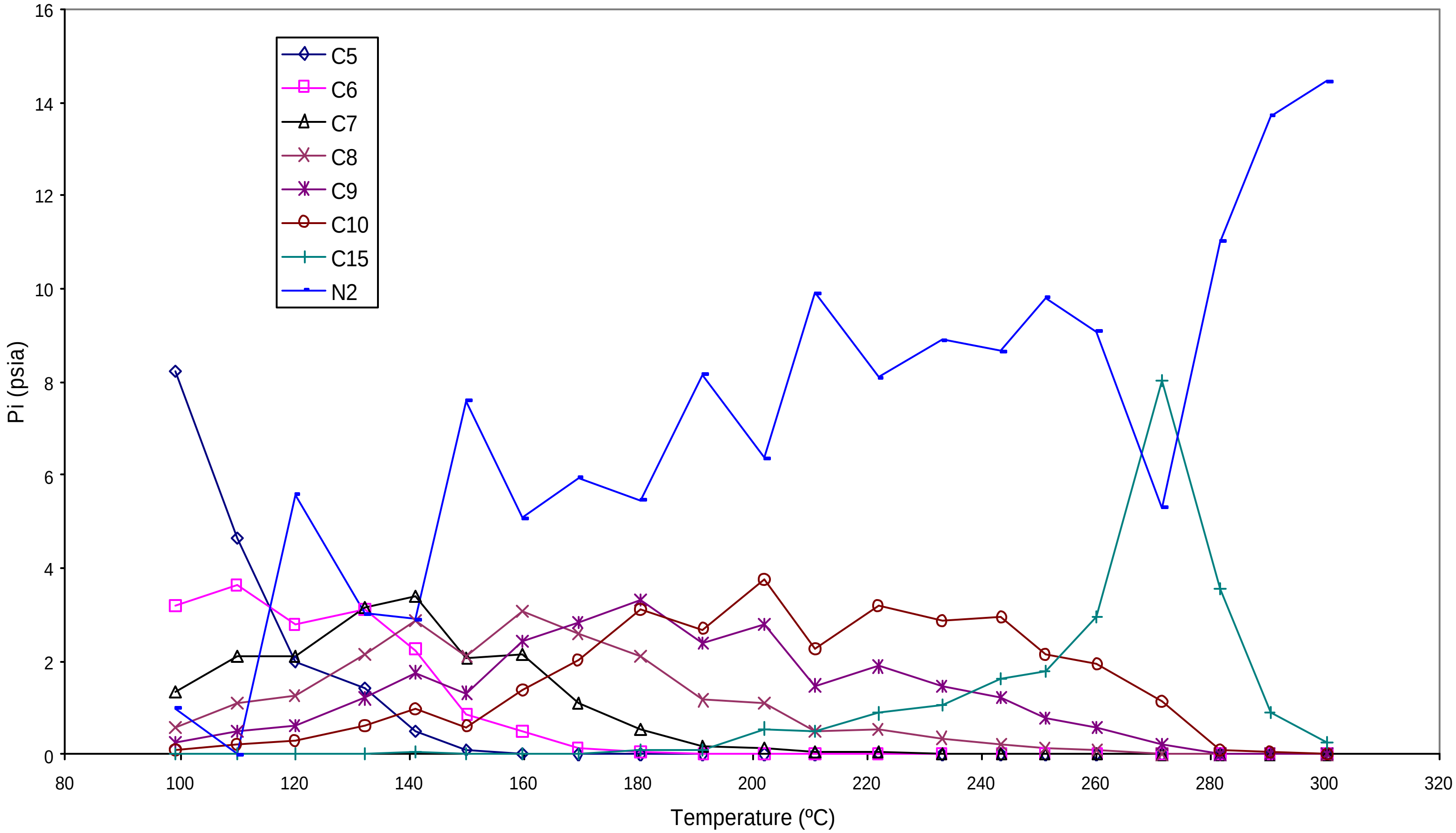


Fig. 5.23-Partial pressure vs. temperature (dry distillation run no. 2).

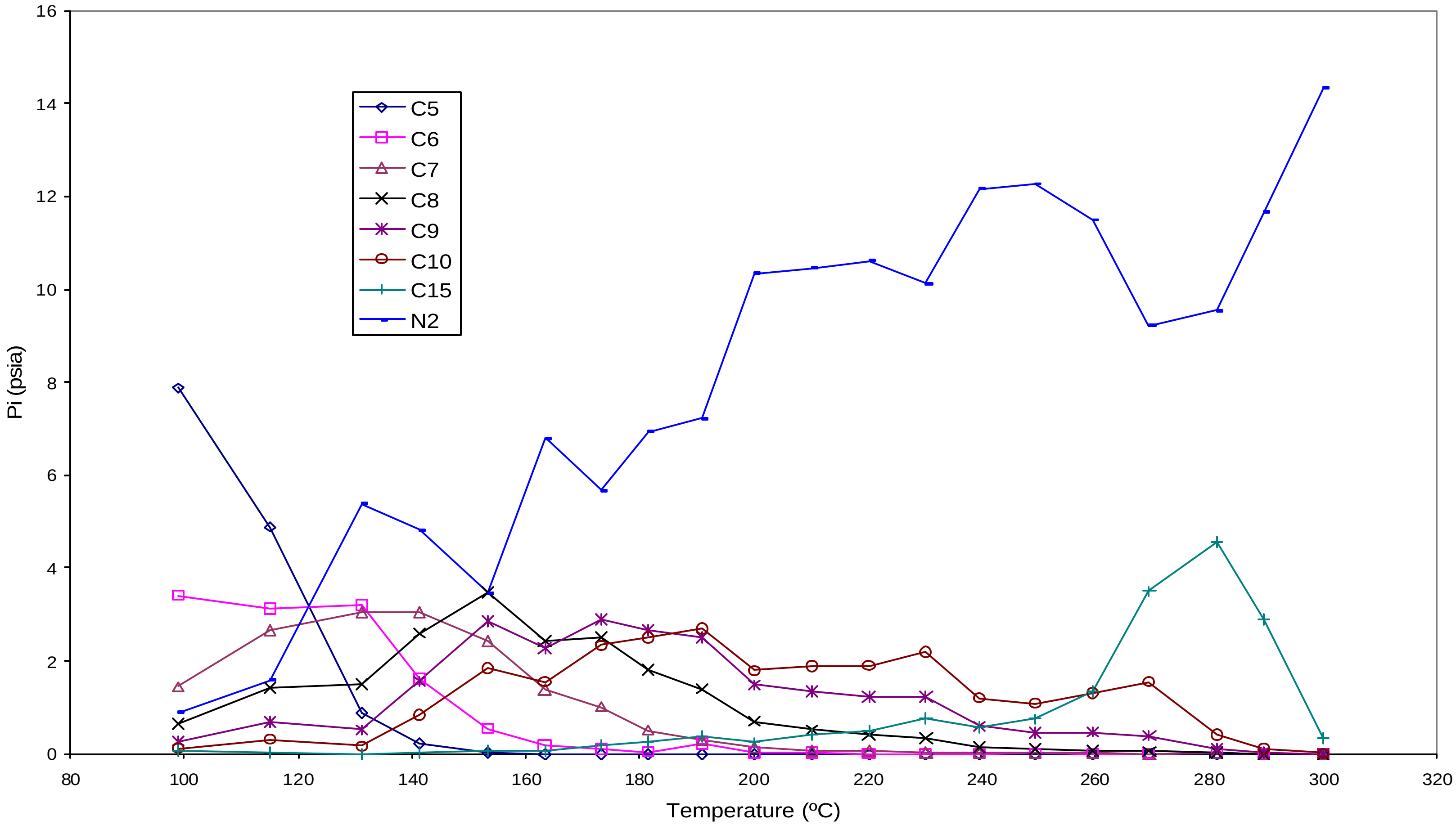


Fig. 5.24-Partial pressure vs. temperature (dry distillation run no. 3).

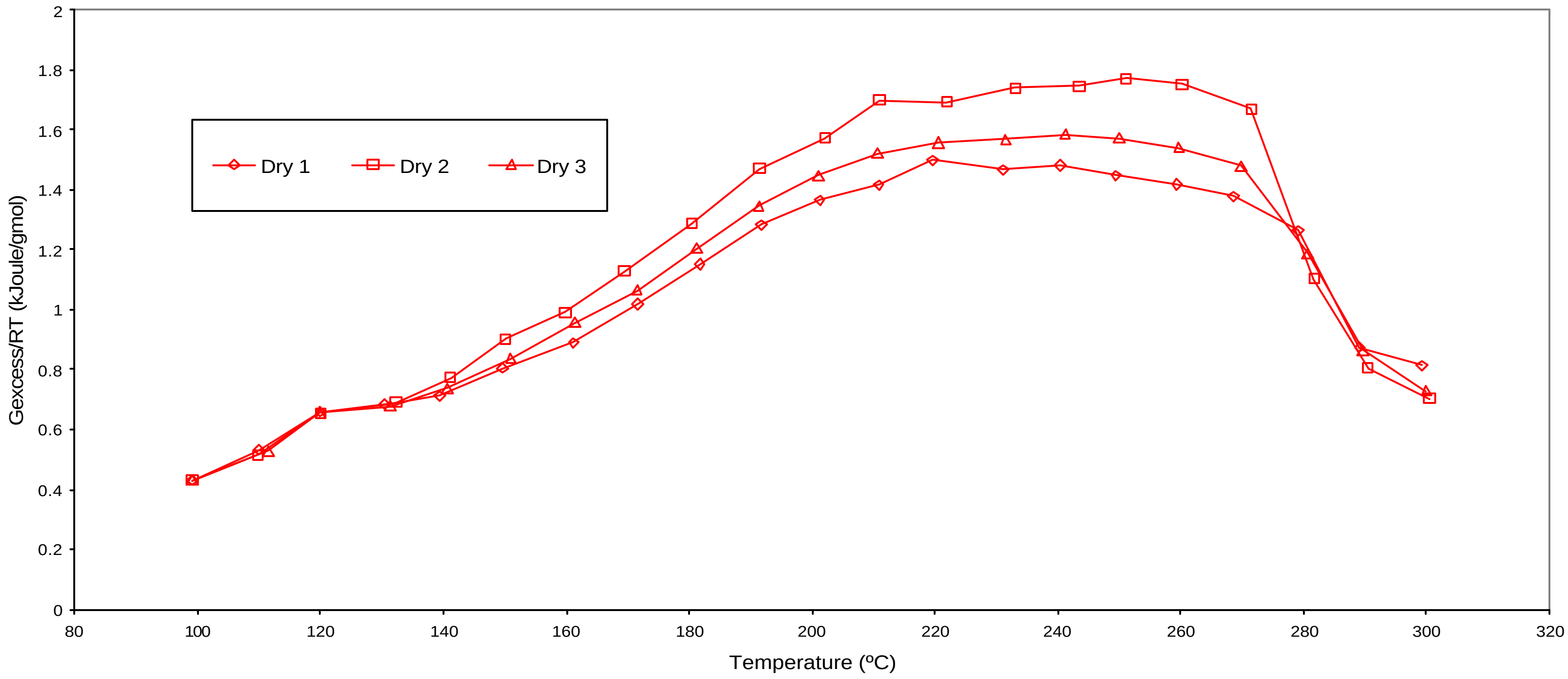


Fig. 5.25-Excess Gibbs energy vs. temperature (dry distillation run nos. 1- 3).

5.2 Steam distillation

The yields measured for the three steam distillation runs are shown in the **Tables 5.5-5.7,** including gas chromatograph analyses (GC) for the hydrocarbon distillate. A typical chromatogram for one analysis is shown in the **Appendix D**.

The temperature profiles of the three steam distillation runs are shown in **Figs. 5.26-5.28**. These plots show good control of temperature during the runs. The profiles of pressures during the runs are shown in **Figs. 5.29-5.31**, indicating very stable pressures at each cut.

The oil yield plots as a function of temperature for every steam distillation are shown in **Figs. 5.32-5.34.** Steam distillation run no. 1 showed an oil recovery of 91.2% at 210ºC with an experimental error of 5.3%. Steam distillation run no. 2 showed a recovery of 92.5% with an experimental error of 4.9% at 210ºC, and finally steam distillation run no. 3 showed a recovery of 90.1% with an experimental error of 7.1%.

The experimental error was calculated based on a material balance of oil. From the oil yield plots, it can be seen that about 58 wt% of the hydrocarbons are distilled off at 125ºC, much more than in the dry distillation runs (36 wt%).The water yield plots as function of temperature for every steam distillation run are shown in **Figs. 5.35-5.37.**

Figures 5.38-5.40 show the experimental pseudo *K*-values. The results indicate the highest values for the lightest components, and not only for n-pentane (as in dry distillation).

Figures 5.41-5.43 show calculated pseudo *K*-values. The variations of *K*-values imply that the compositions in the liquid and vapor phases are not the same as in the case of dry distillations. These compositions are shown F**igs. 5.44-5.49.** Those plots show the change of vapor and liquid composition during the steam distillation runs.

Figures 5.50-5.52 show vapor fugacity coefficient for each component for each steam distillation run. Vapor fugacity coefficients in the steam distillation runs do not show notable difference.

Activity coefficient during the steam distillation runs are shown in **Fig. 5.53-5.55**. Good agreement is observed for activity coefficients and fugacity coefficients between all three steam distillation runs. This indicates that the steam distillation runs have been conducted under very consistent conditions.

Figures 5.56-5.58 show distribution of the partial pressures of each component assuming the mixture was ideal. The plots show a distribution of partial pressures of the components for the whole range of temperature in the runs.

Finally the curves of Gibbs excess energy for these steam distillation runs are shown in **Fig. 5.59.** This plot shows the Gibbs energy increases with temperature to a peak at about 160º-170ºC, compared to a peak of about 230º-270ºC for dry distillation.

TABLE 5.5- OIL YIELDS AT STEAM DISTILLATION RUN NO. 1

WEIGHT OF COMPONENTS (STEAM DISTILLATION RUN 1)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1152	0.0000	0.0000
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1280	17.9176	0.2079
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1374	19.2375	0.1920
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1483	20.7621	0.1818
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1544	21.6157	0.1685
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1564	21.8931	0.1539
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1603	22.4422	0.1057
N2			28.0000					
Water			18.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	123.8683	1.0097

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM DISTILLATION RUN 1)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Wate ml	Cum water wt%
1	12.4680	35.6280	23.1600	0.0000	38.0000	38.0000	23.1600	97.30	23.16	16.54	0.0000	0.00
2	37.4290	98.8650	61.4360	2.4260	94.5000	92.0740	59.0100	115.00	82.17	58.69	2.4260	0.50
3	12.5100	41.1300	28.6200	17.9530	35.0000	17.0470	10.6670	130.20	92.84	66.31	20.3790	4.22
4	12.4440	44.4580	32.0140	18.3330	39.5000	21.1670	13.6810	140.00	106.52	76.08	38.7120	8.02
5	12.5330	41.8100	29.2770	18.1450	35.0000	16.8550	11.1320	151.40	117.65	84.04	56.8570	11.78
6	12.5060	33.9350	21.4290	19.8430	23.0000	3.1570	1.5860	160.00	119.24	85.17	76.7000	15.90
7	12.4120	33.0090	20.5970	20.0000	23.0000	3.0000	0.5970	169.20	119.83	85.60	96.7000	20.04
8	12.2830	40.3680	28.0850	25.5550	30.5000	2.0000	1.4000	181.00	121.23	86.60	122.2550	25.34
9	12.4990	34.1010	21.6020	19.8780	23.5000	3.6220	1.7240	190.00	122.96	87.83	142.1330	29.46
10	12.5270	37.2210	24.6940	22.0920	27.0000	4.9080	2.6020	200.00	125.56	89.69	164.2250	34.04
11	12.3730	37.2220	24.8490	23.5930	26.0000	2.4070	1.2560	209.10	126.82	90.58	187.8180	38.93
12	12.3670	33.9800	21.6130	21.1640	23.0000	1.8360	0.4490	219.00	127.26	90.90	208.9820	43.31
13	12.4800	37.2380	24.7580	24.7300	26.5000	1.7700	0.0280	231.00	127.29	90.92	233.7120	48.44
14	12.4000	34.4460	22.0460	21.9560	24.0000	2.0440	0.0900	240.90	127.38	90.99	255.6680	52.99
15	12.5370	32.0140	19.4770	19.4360	20.0000	0.5640	0.0410	251.00	127.42	91.02	275.1040	57.02
16	12.4970	30.0920	17.5950	17.5510	19.0000	1.4490	0.0440	261.30	127.47	91.05	292.6550	60.65
17	12.4470	34.7660	22.3190	22.2690	24.0000	1.7310	0.0500	271.00	127.52	91.08	314.9240	65.27
18	12.4200	31.5620	19.1420	19.1000	21.0000	1.9000	0.0420	280.70	127.56	91.11	334.0240	69.23
19	12.4440	37.0350	24.5910	24.5510	26.0000	1.4490	0.0400	291.50	127.60	91.14	358.5750	74.32
20	12.4160	37.7590	25.3430	25.3060	27.0000	1.6940	0.0370	301.30	127.64	91.17	383.8810	79.56
21	12.4560	36.7980	24.3420	24.3090	26.0000	1.6910	0.0330	312.00	127.67	91.19	434.2160	89.99
Residual after run	12.4120	42.2580	29.8460	24.9150	33.5000	8.5850	4.9310	312.00	132.60	94.71	434.2160	89.99
Residual incell	12.5210	13.6320	1.1110	1.1110	1.1110	0.0000	0.0000	312.00	132.60	94.71	434.2160	89.99
Total	311.3810	879.3270	567.9460	434.2160	666.1110	228.9500	132.6000		2697.98			

	Oil wt g	Oil vol ml
Difference	7.4000	27.8800
% Error	5.2857	13.8658

Beginning of Injection time =	70	min
Injection Rate =	0.50	ml/min
Total Injection Time =	965.00	min
Water injected =	482.50	ml
Water recovered =	434.22	ml
Water lost =	48.28	ml

TABLE 5.6- OIL YIELDS AT STEAM DISTILLATION RUN NO. 2

WEIGHT OF COMPONENTS (STEAM DISTILLATION RUN 2)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1221	17.1009	0.2370
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1412	19.7666	0.2294
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1408	19.7157	0.1968
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1488	20.8348	0.1824
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1495	20.9261	0.1632
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1496	20.9398	0.1472
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1480	20.7161	0.0975
N2			28.0000					
Water			18.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2534

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM DISTILLATION RUN 2)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Water ml	Cum water wt%
1	12.641	35.748	23.107	0.000	38.000	38.000	23.107	103.70	23.107	16.51	0.000	0.00
2	37.871	92.577	54.706	5.331	82.000	76.669	49.375	115.00	72.482	51.77	17.160	3.69
3	12.434	35.705	23.271	17.160	27.500	10.340	6.111	130.00	78.593	56.14	42.641	9.18
4	25.173	67.847	42.674	25.481	52.300	26.819	17.193	140.00	95.786	68.42	64.141	13.81
5	25.298	67.651	42.353	21.500	53.000	31.500	20.853	150.00	116.639	83.31	82.741	17.81
6	12.720	32.730	20.010	18.600	21.500	2.000	1.400	160.00	118.039	84.31	102.415	22.04
7	12.639	34.144	21.505	19.674	23.000	3.326	1.831	170.00	119.870	85.62	122.843	26.44
8	12.673	35.674	23.001	20.428	24.500	4.072	2.573	180.00	122.443	87.46	145.095	31.23
9	12.893	38.174	25.281	22.252	26.000	3.748	3.029	190.00	125.472	89.62	167.554	36.06
10	12.683	37.770	25.087	22.459	26.500	4.041	2.628	200.00	128.100	91.50	192.926	41.53
11	12.683	39.419	26.736	25.372	27.000	1.628	1.364	210.00	129.464	92.47	215.727	46.43
12	12.872	36.218	23.346	22.801	23.600	0.799	0.545	220.00	130.009	92.86	242.723	52.24
13	12.959	39.955	26.996	26.996	26.996	0.000	0.000	230.00	130.009	92.86	264.387	56.91
14	12.750	34.414	21.664	21.664	21.664	0.000	0.000	240.00	130.009	92.86	284.571	61.25
15	12.654	32.838	20.184	20.184	20.184	0.000	0.000	250.00	130.009	92.86	305.874	65.84
16	12.905	34.208	21.303	21.303	21.303	0.000	0.000	260.00	130.009	92.86	327.246	70.44
17	13.149	34.521	21.372	21.372	21.372	0.000	0.000	270.00	130.009	92.86	349.886	75.31
18	12.712	35.352	22.640	22.640	22.640	0.000	0.000	280.00	130.009	92.86	375.568	80.84
19	12.424	38.106	25.682	25.682	25.682	0.000	0.000	290.00	130.009	92.86	404.284	87.02
20	12.861	41.577	28.716	28.716	28.716	0.000	0.000	300.00	130.009	92.86	430.970	92.76
21	12.625	39.311	26.686	26.686	26.686	0.000	0.000	310.00	130.009	92.86	435.470	93.73
22	12.920	17.420	4.500	4.500	4.500	0.000	0.000	310.00	130.009	92.86	459.259	98.85
Cold Residal	12.824	39.798	26.974	23.789	29.000	5.211	3.185					
Residual in cell	12.824	39.798	26.974	23.789	29.000	5.211	3.185					
Total	343.363	941.157	597.794	464.590	673.64	208.15	133.19					

	Oil wt g	Oil vol ml
Difference	6.8060	7.0830
% Error	4.8614	3.5227

Beginning of Injection tir	102	min
Injection Rate =	0.50	ml/min
Total Injection Tir	946.00	min
Water injected	473.00	ml
Water recovere	464.59	ml
Water lost =	8.41	ml

TABLE 5.7- OIL YIELDS AT STEAM DISTILLATION RUN NO. 3

WEIGHT OF COMPONENTS (STEAM DISTILLATION RUN 3)

Comp.	Vo(cc)	Wo(gr)	MW	Mol	Mol Fraction	Frac. Weight GC	Wo(gr)	Mol
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1130	15.8190	0.2193
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1308	18.3161	0.2125
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1353	18.9394	0.1890
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1496	20.9476	0.1834
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1534	21.4810	0.1675
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1552	21.7253	0.1527
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1627	22.7716	0.1072
N2			28.0000					
Water			18.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2315

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Water ml	Cum water wt%
1	25.6430	48.5620	22.9190	0.0000	36.4000	36.40	22.9190	98.20	22.9190	16.37	0.0000	0.00
2	37.8020	100.6200	62.8180	8.3010	92.6780	84.38	54.5170	118.00	77.4360	55.31	8.3010	1.51
3	12.9000	29.6860	16.7860	14.7500	18.7500	4.00	2.5600	130.20	79.9960	57.14	23.0510	4.18
4	12.3140	37.3280	25.0140	17.0110	30.0110	13.00	8.4500	143.50	88.4460	63.18	40.0620	7.27
5	12.9170	44.4930	31.5760	20.4270	37.4270	17.00	11.1490	150.50	99.5950	71.14	60.4890	10.98
6	12.6000	47.8690	35.2690	19.8410	42.8410	23.00	15.4280	162.30	115.0230	82.16	80.3300	14.58
7	12.7170	36.4690	23.7520	20.3720	26.3720	5.70	3.6594	170.30	118.6824	84.77	100.7020	18.28
8	12.6980	41.7990	29.1010	26.7460	30.7460	3.90	2.3550	180.50	121.0374	86.46	127.4480	23.13
9	12.4710	38.3870	25.9160	23.5340	27.5340	3.90	2.5077	193.30	123.5451	88.25	150.9820	27.40
10	12.9090	33.1890	20.2800	19.5940	20.5940	1.00	0.6860	202.20	124.2311	88.74	170.5760	30.96
11	12.5290	36.6090	24.0800	22.6560	25.6560	2.30	1.5203	210.50	125.7514	89.82	193.2320	35.07
12	12.4770	34.0370	21.5600	21.2230	21.2230	0.55	0.3465	219.70	126.0979	90.07	214.4550	38.92
13	12.5560	35.1860	22.6300	22.6300	22.6300	0.00	0.0000	235.00	126.0979	90.07	237.0850	43.03
14	12.8370	31.8830	19.0460	19.0460	19.0460	0.00	0.0000	240.00	126.0979	90.07	256.1310	46.48
15	12.4350	38.9300	26.4950	26.4950	26.4950	0.00	0.0000	250.10	126.0979	90.07	282.6260	51.29
16	12.5300	33.6410	21.1110	21.1110	21.1110	0.00	0.0000	260.70	126.0979	90.07	303.7370	55.12
17	12.5110	40.9710	28.4600	28.4600	28.4600	0.00	0.0000	270.20	126.0979	90.07	332.1970	60.29
18	12.6220	34.0250	21.4030	21.4030	21.4030	0.00	0.0000	280.90	126.0979	90.07	353.6000	64.17
19	12.4960	41.6030	29.1070	29.1070	29.1070	0.00	0.0000	290.00	126.0979	90.07	382.7070	69.46
20	12.4700	52.1060	39.6360	39.0360	39.6360	0.60	0.4260	299.50	126.5239	90.37	421.7430	76.54
21	12.4890	21.5720	9.0830	9.0830	9.0830	0.00	0.0000	299.50	126.5239	90.37	430.8260	78.19
Cold Residal	12.8020	27.5580	14.7560	11.6940	15.6940	4.00	3.0620	300.00	129.5859	92.56	442.5200	80.31
Residual in cel	12.8240	13.9640	1.1400	0.7000	1.3940	0.69	0.4400	300.00	130.0259	92.88	443.2200	80.44
Total	328.5490	900.4870	571.9380	443.2200	644.2910	200.42	130.0259					

	Oil wt g	Oil vol ml
Difference	9.9741	0.6490
% Error	7.1244	0.3228

Beginning of Injection time =	226	min
Injection Rate =	0.50	ml/min
Total Injection Time =	1102.00	min
Water injected =	551.00	ml
Water recovered =	443.22	ml
Water lost =	107.78	ml

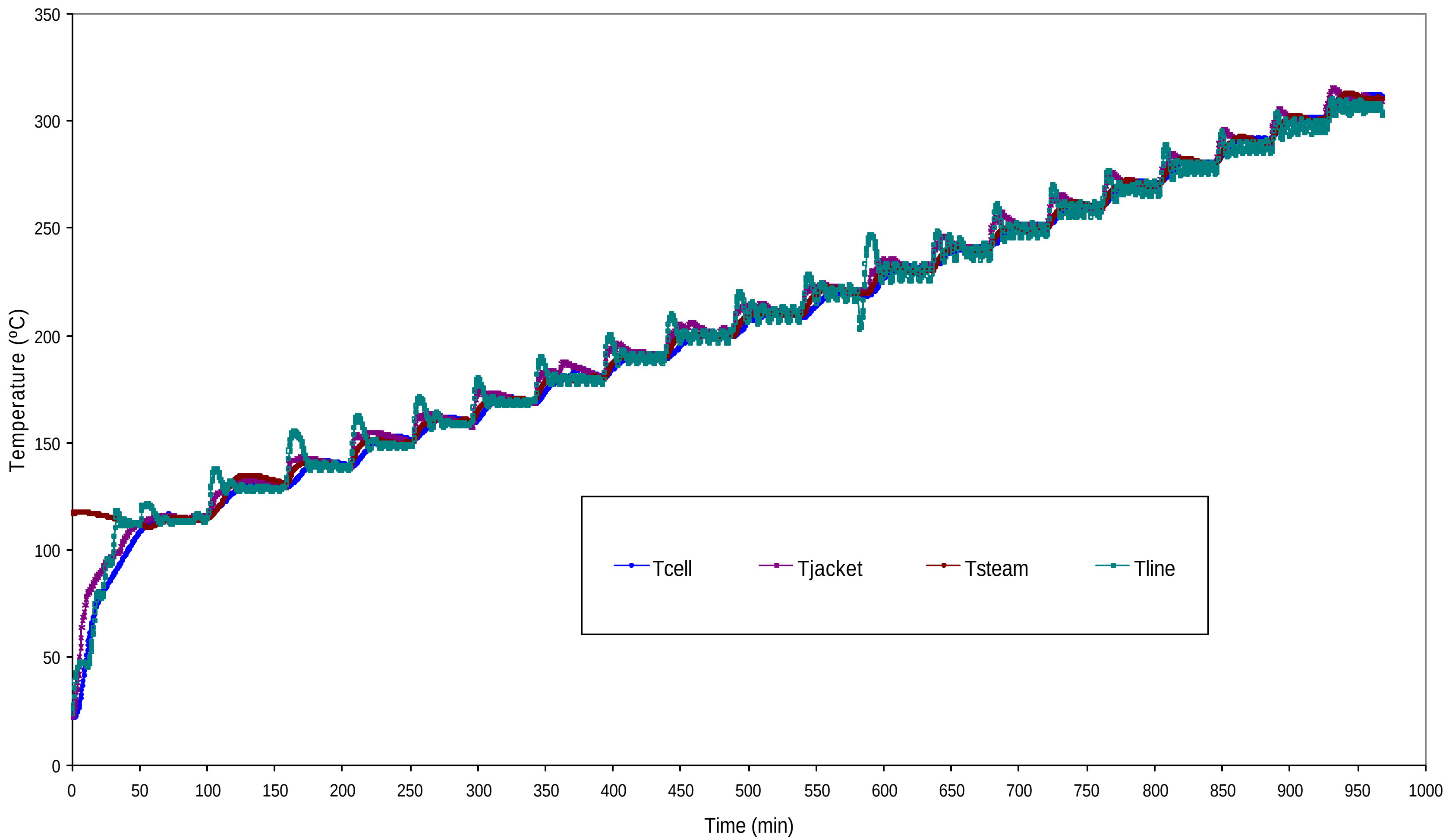


Fig. 5.26-Temperature vs. time (steam distillation run no. 1).

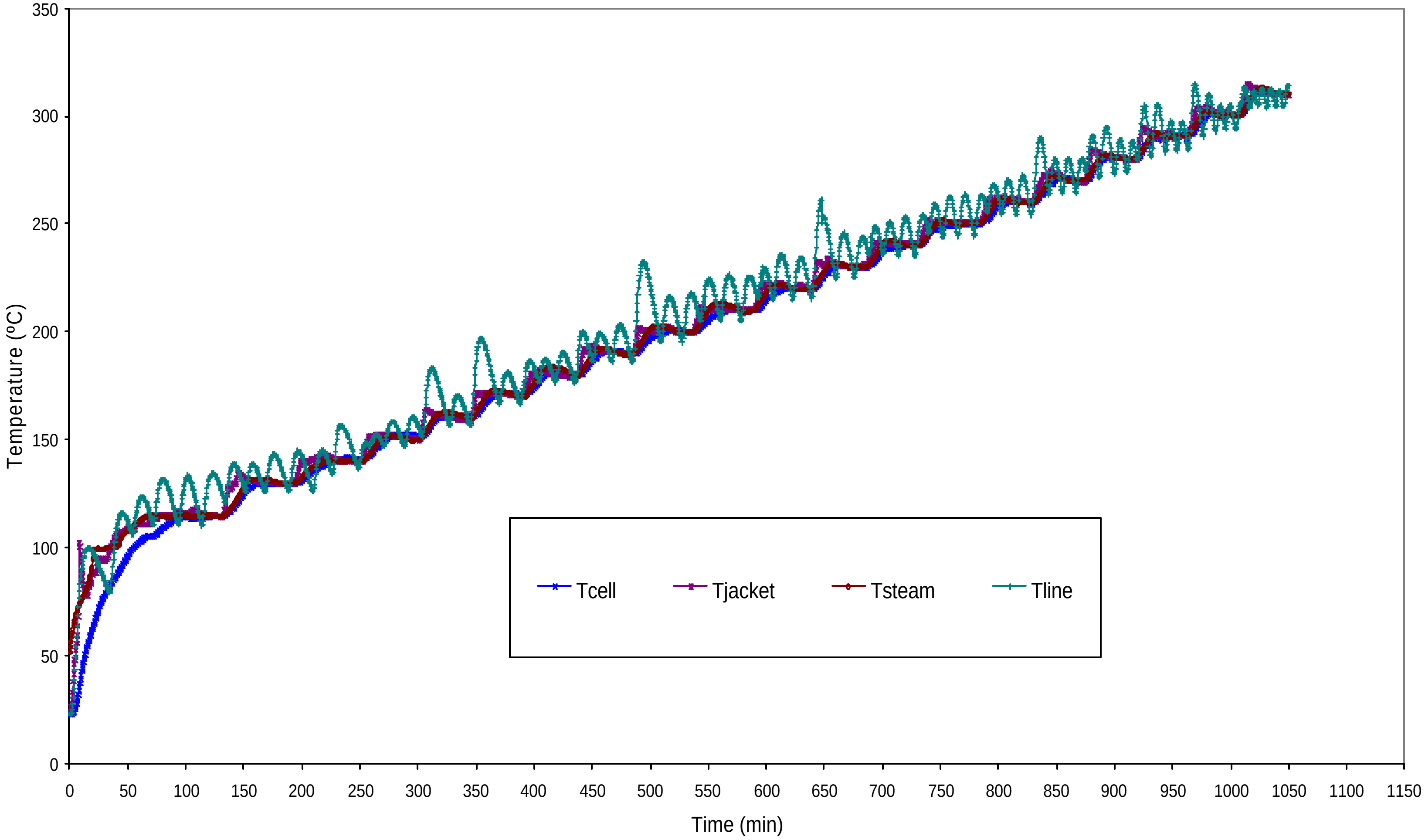


Fig. 5.27-Temperature vs. time (steam distillation run no. 2).

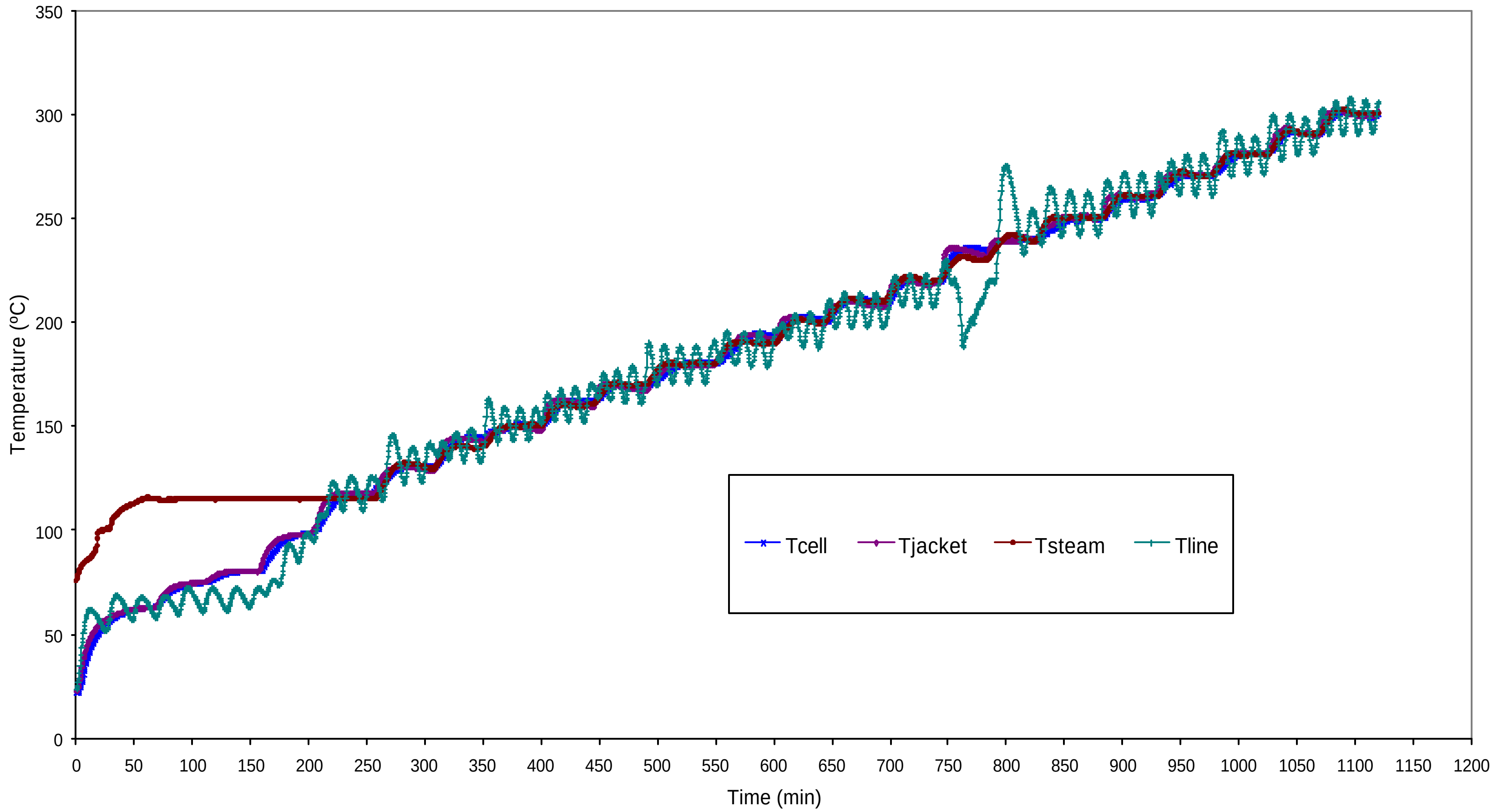


Fig. 5.28-Temperature vs. time (steam distillation run no. 3).

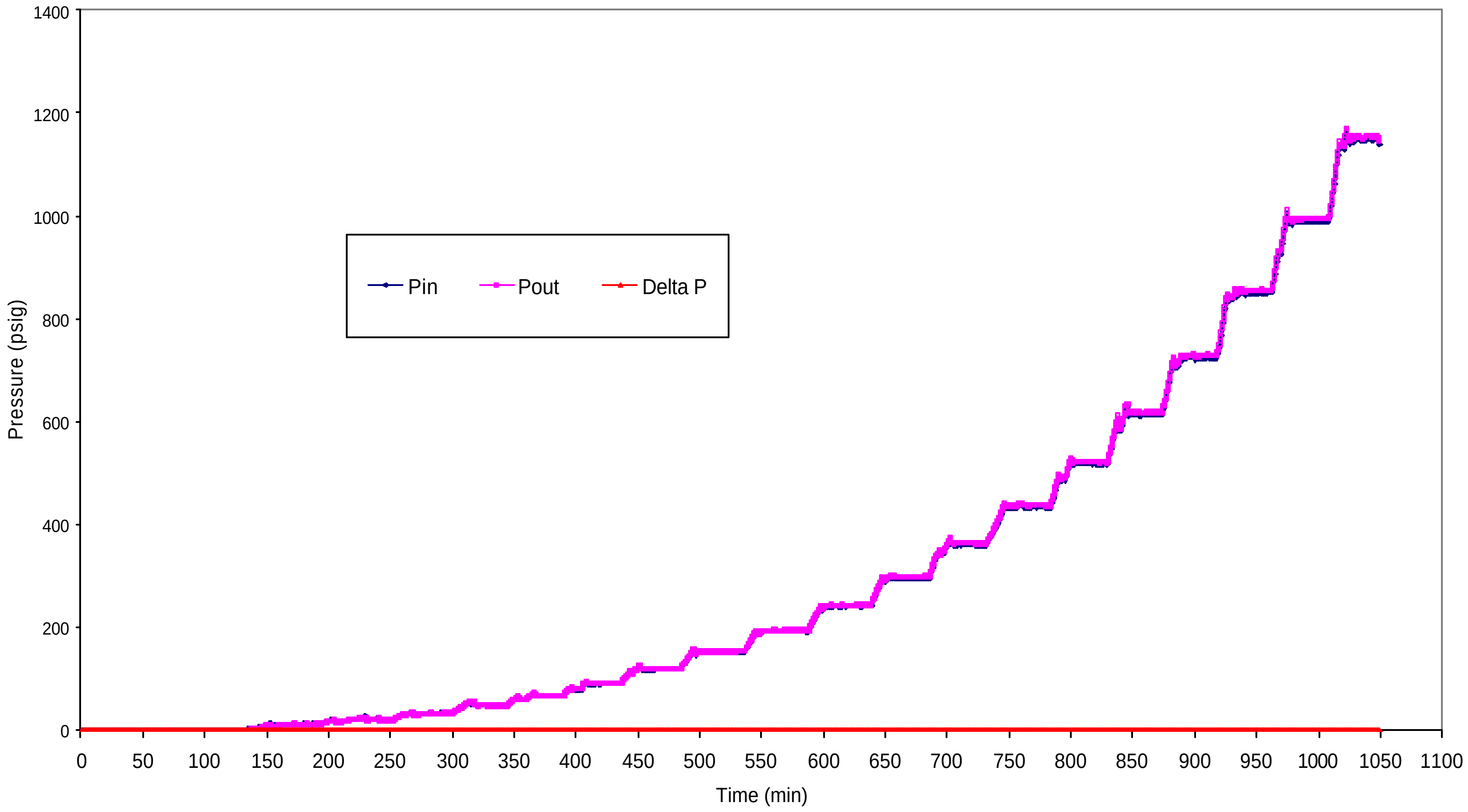


Fig. 5.29-Pressure vs. time (steam distillation run no. 1).

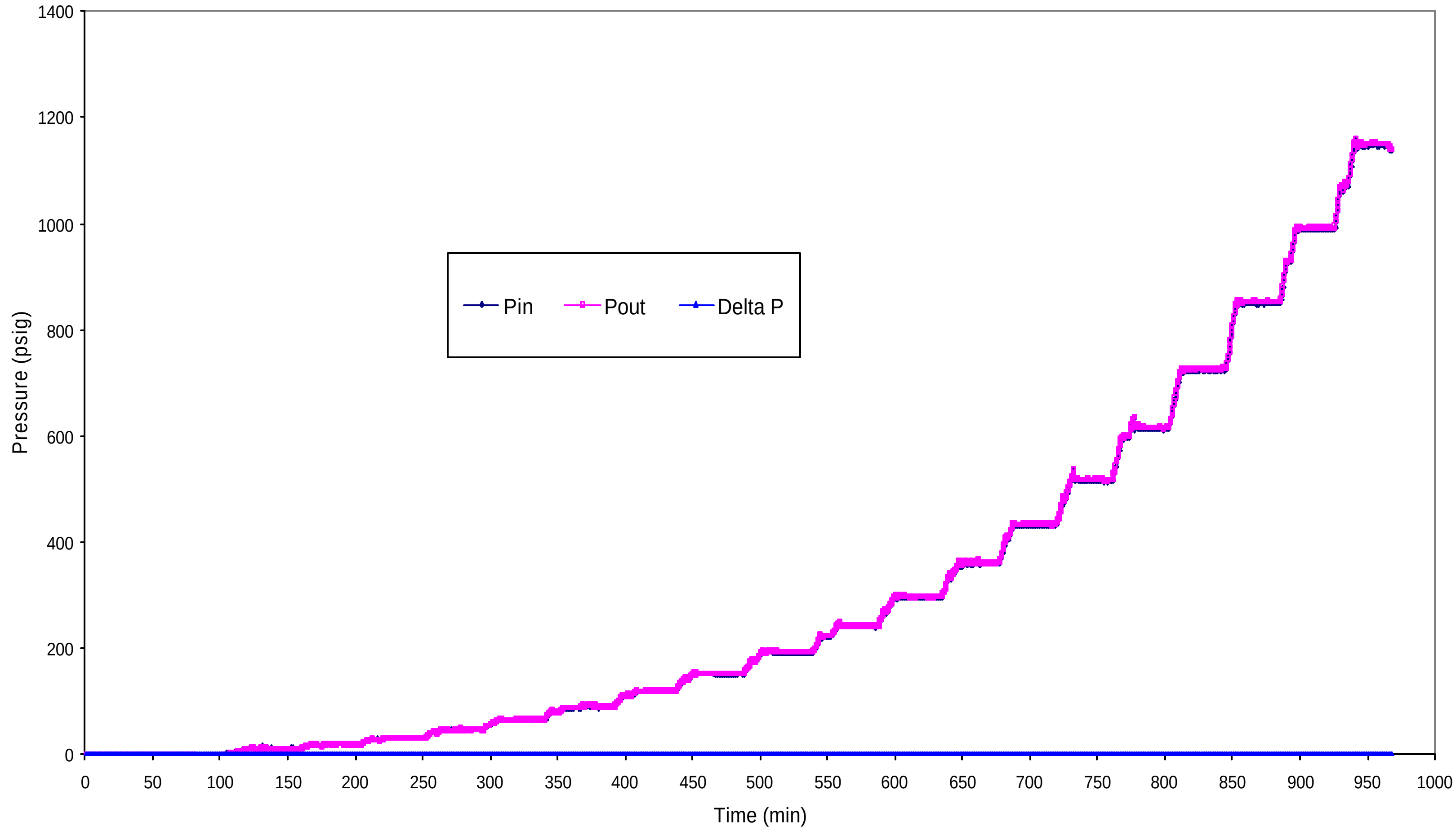


Fig. 5.30-Pressure vs. time (steam distillation run no. 2).

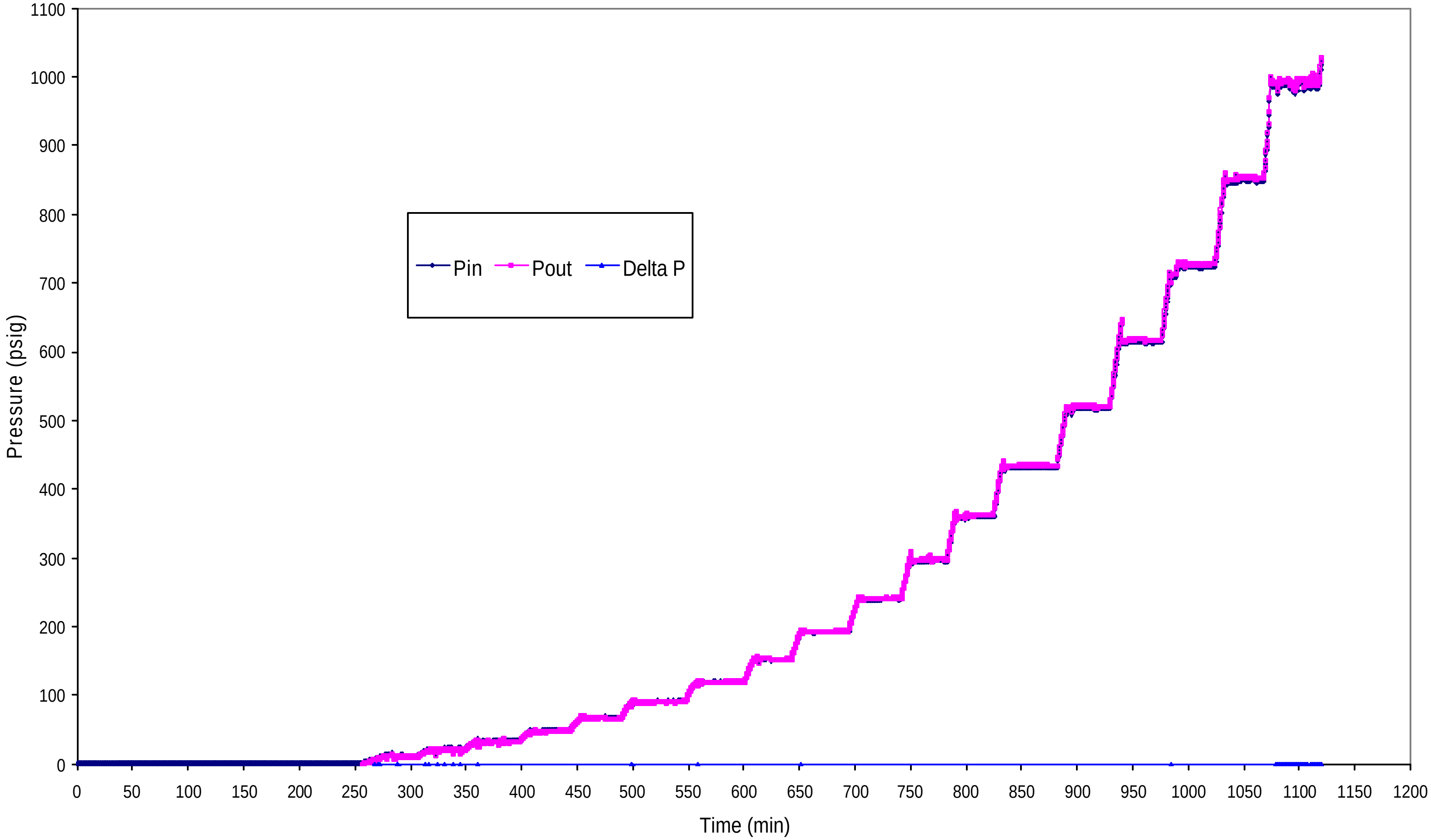


Fig. 5.31-Pressure vs. time (steam distillation run no. 3).

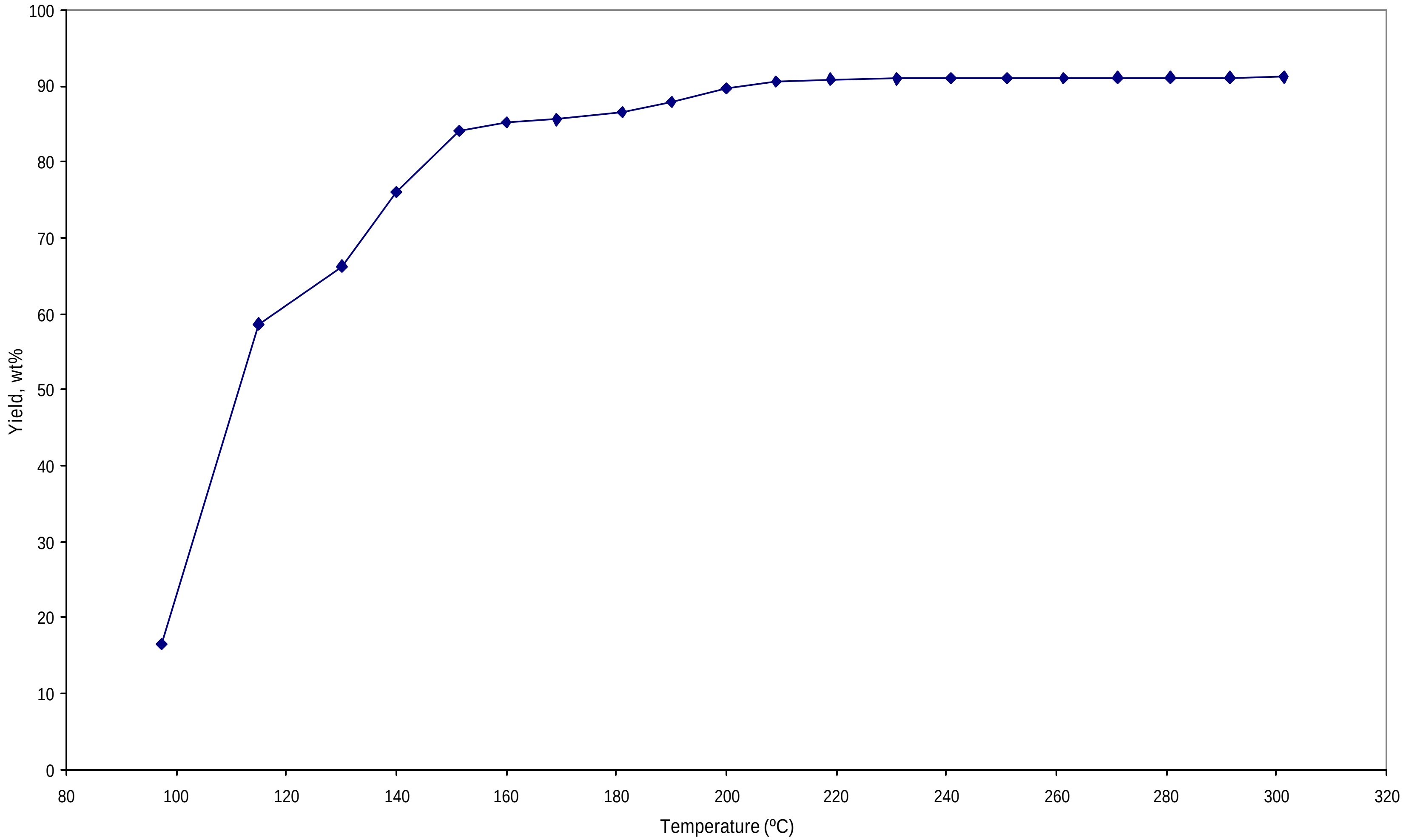


Fig. 5.32-Oil yield vs. time (steam distillation run no. 1).

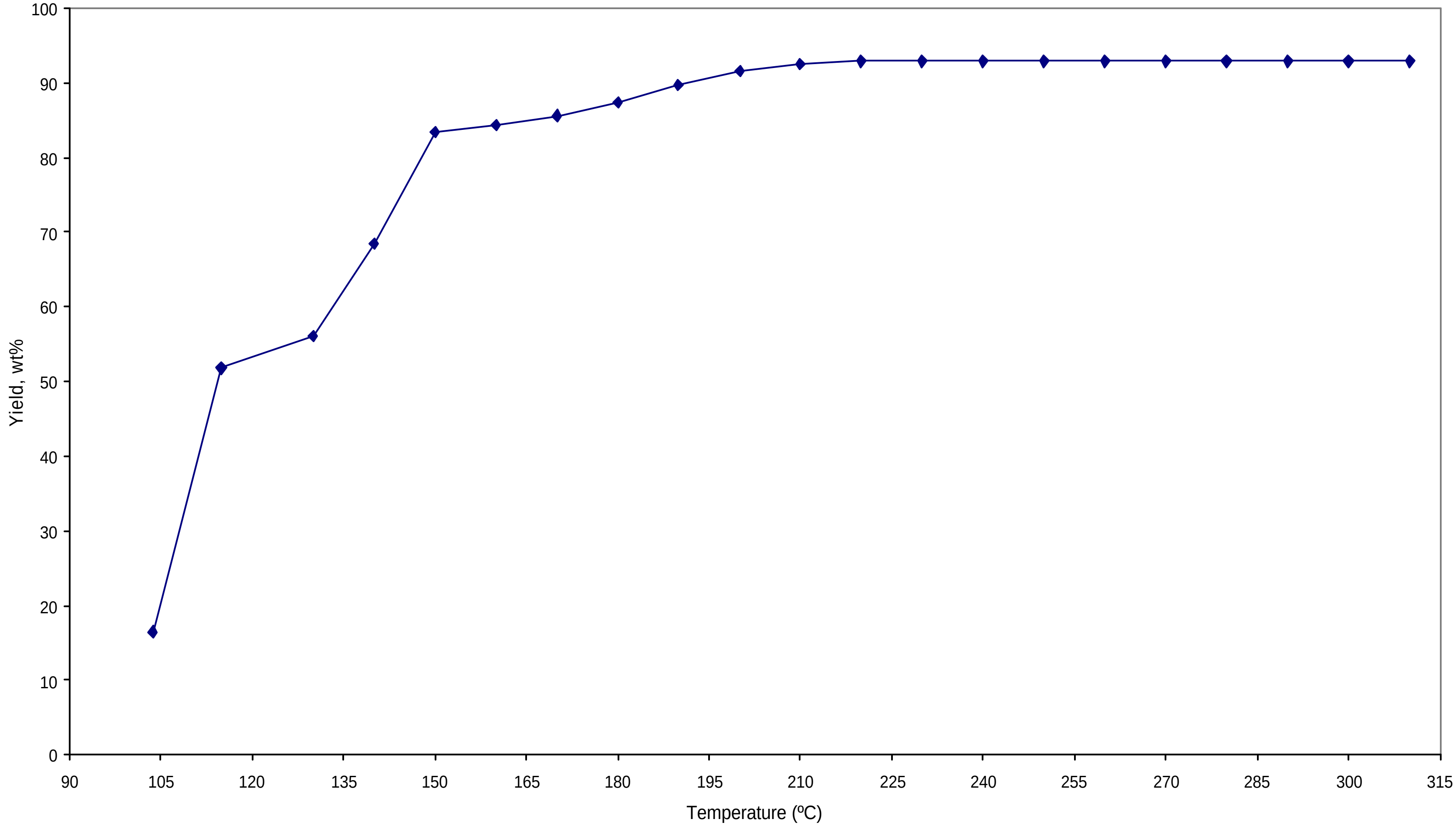


Fig. 5.33-Oil yield vs. time (steam distillation run no. 2).

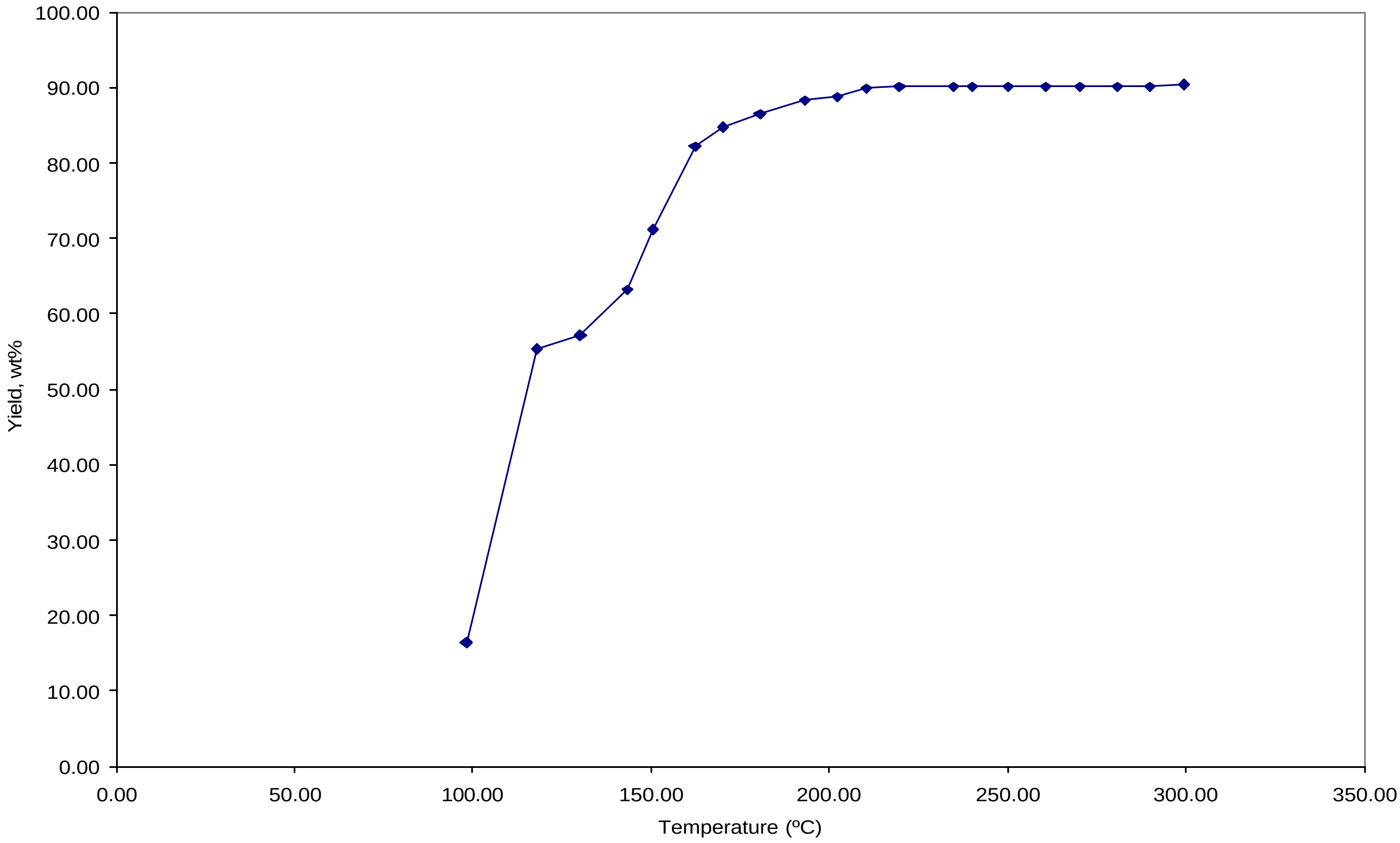


Fig. 5.34-Oil yield vs. time (steam distillation run no. 3).

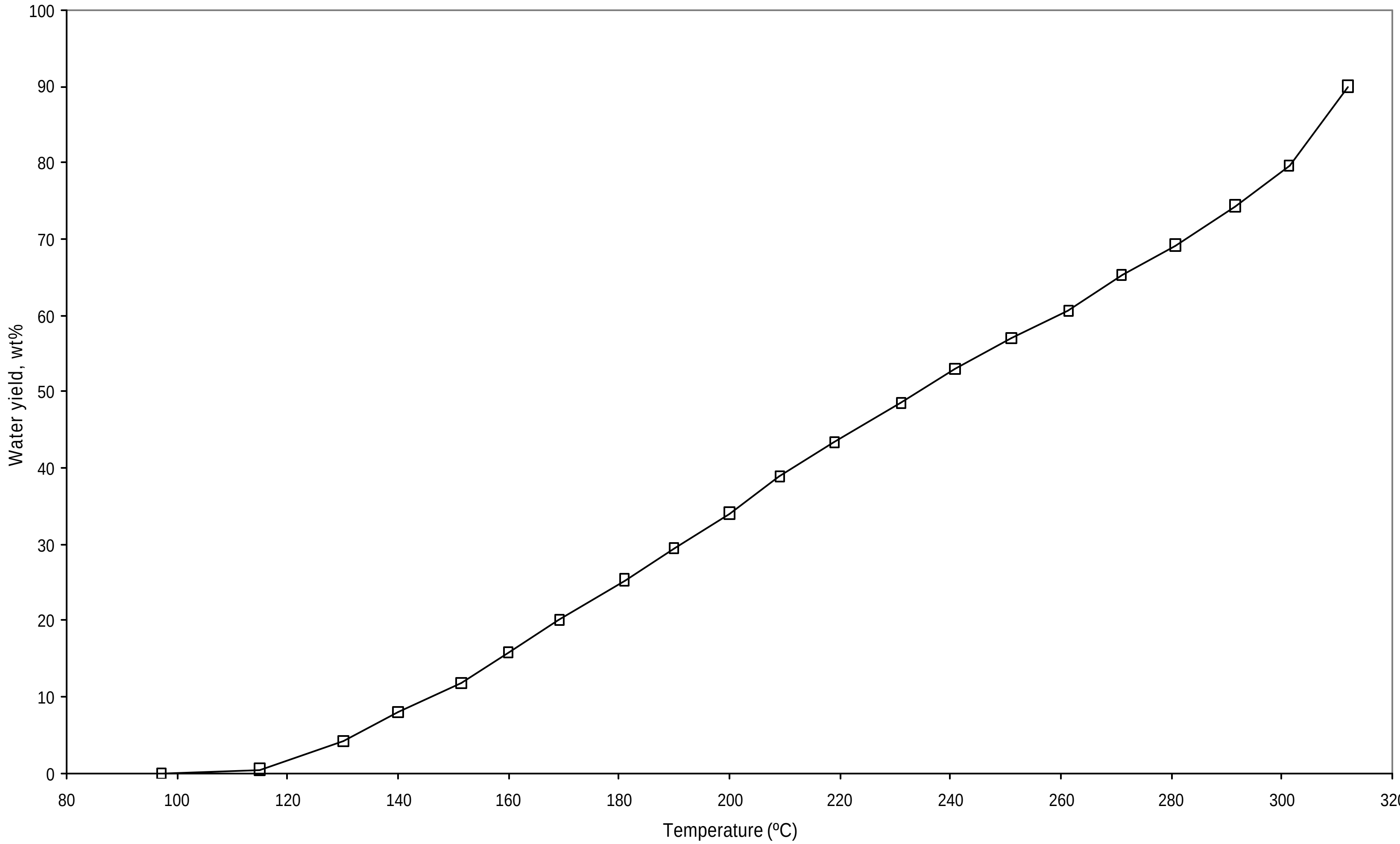


Fig. 5.35-Water yield vs. time (steam distillation run no. 1).

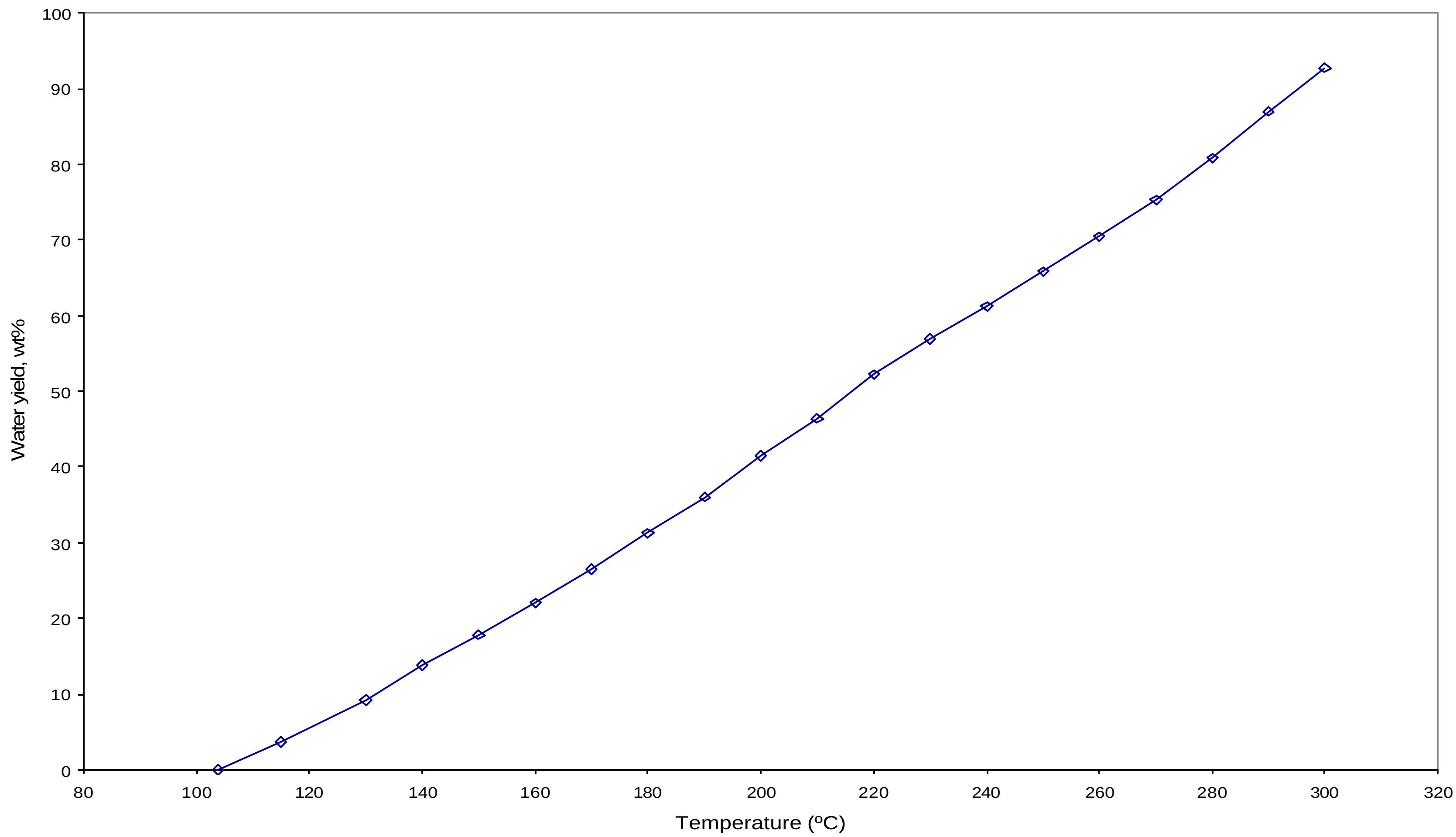


Fig. 5.36-Water yield vs. time (steam distillation run no. 2).

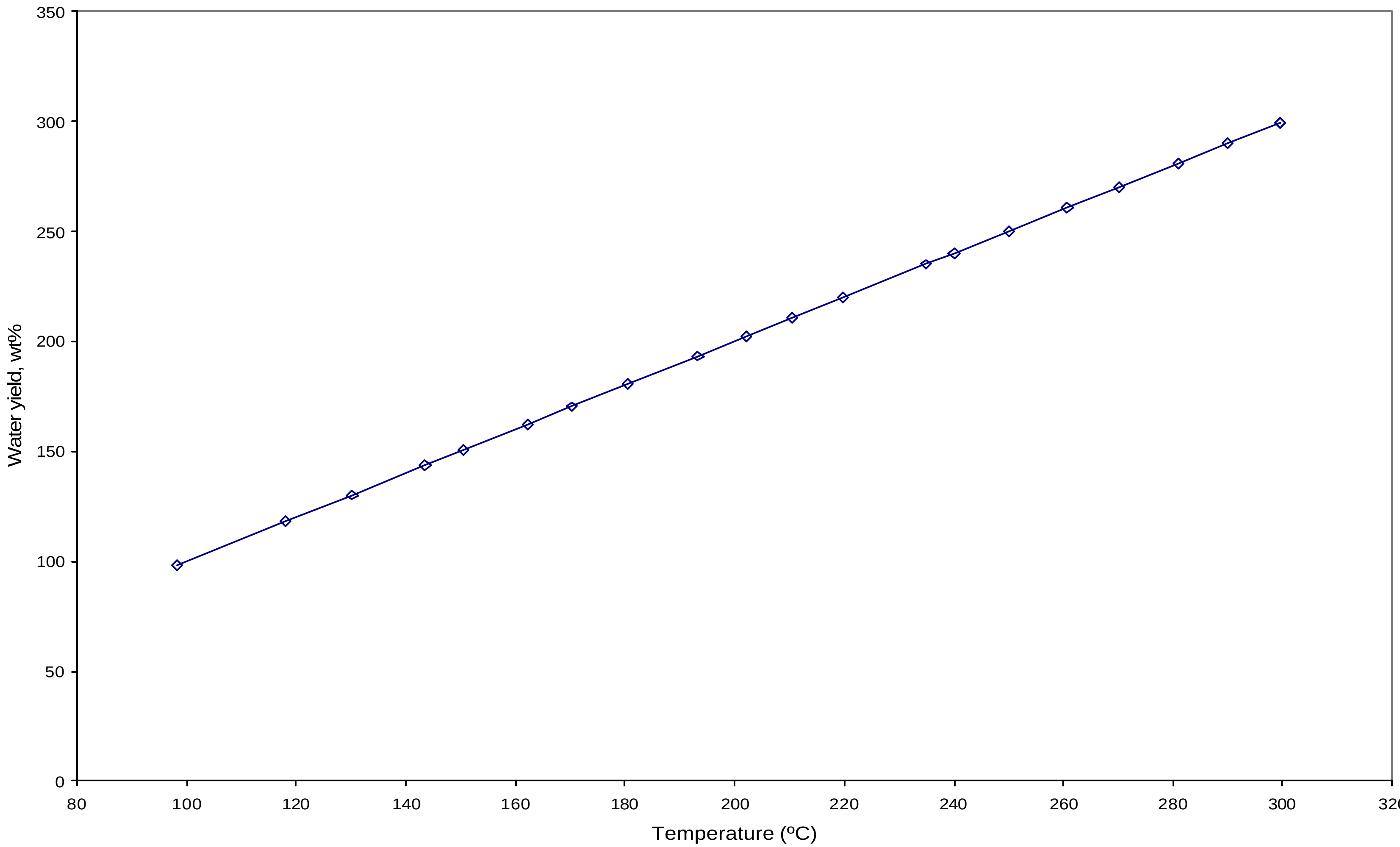


Fig. 5.37- Water yield vs. time (steam distillation run no. 3).

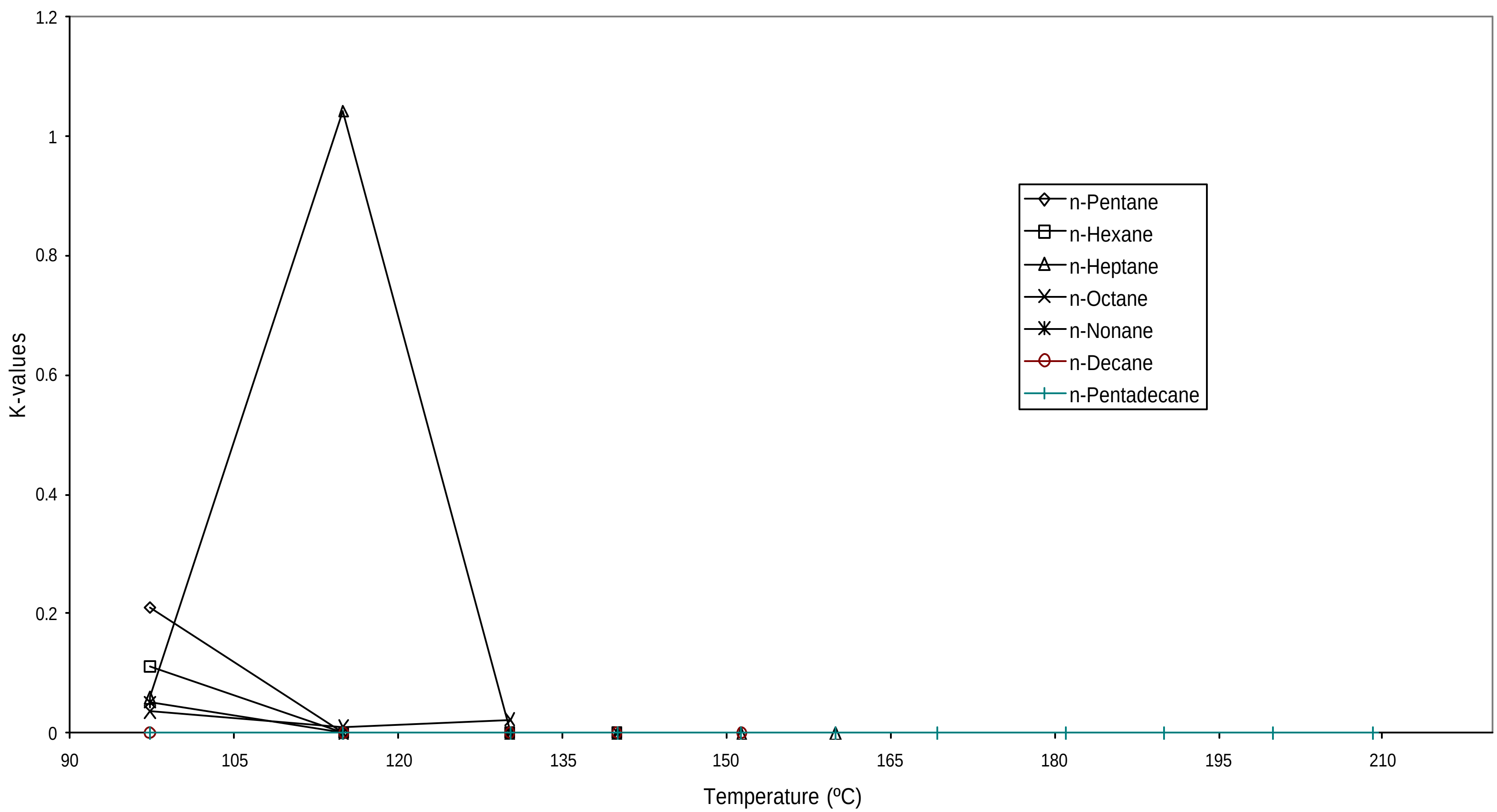


Fig. 5.38-Experimental *K*-values vs. temperature (steam distillation run no. 1).

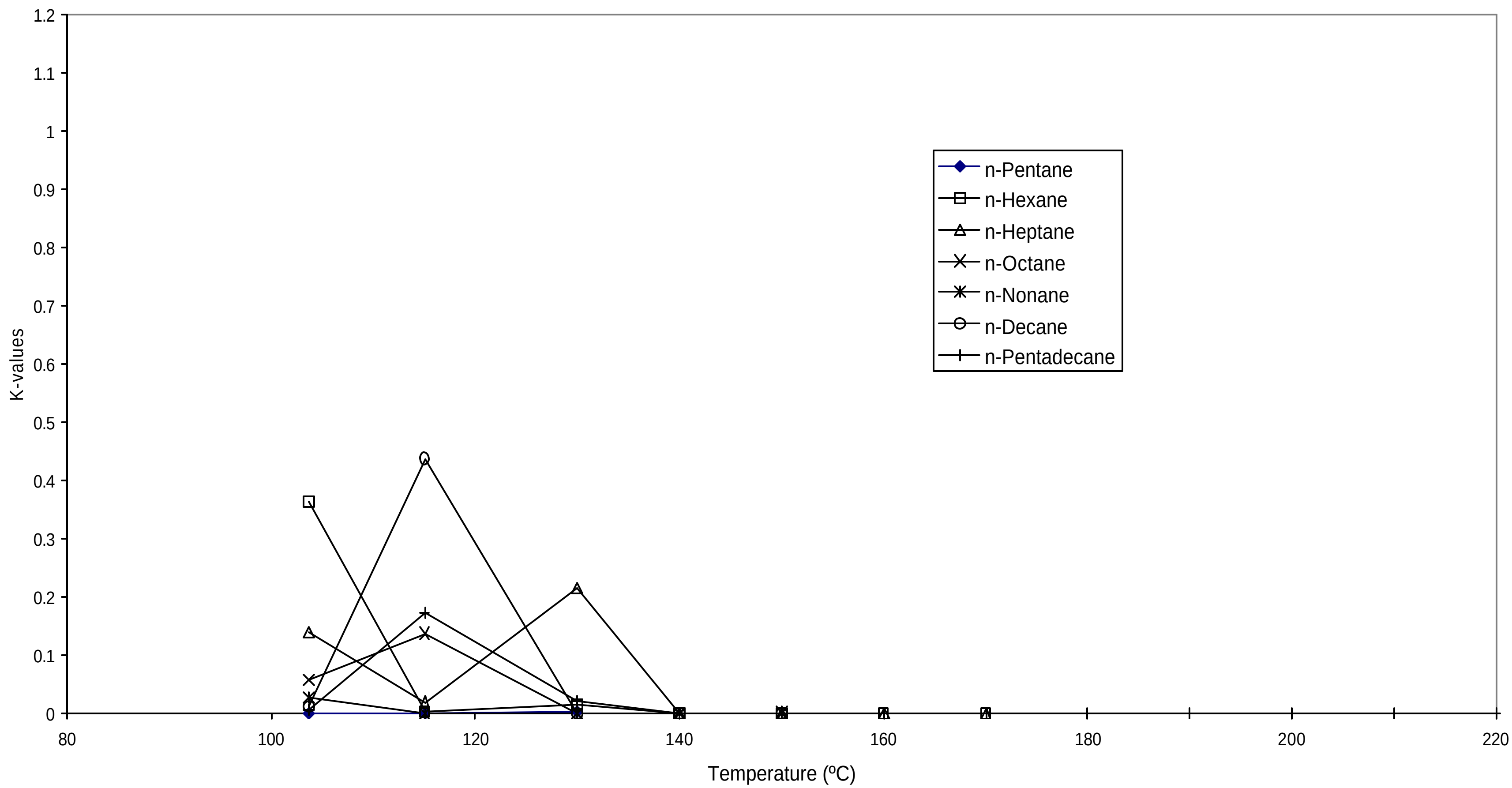


Fig. 5.39-Experimental *K*-values vs. temperature (steam distillation run no. 2).

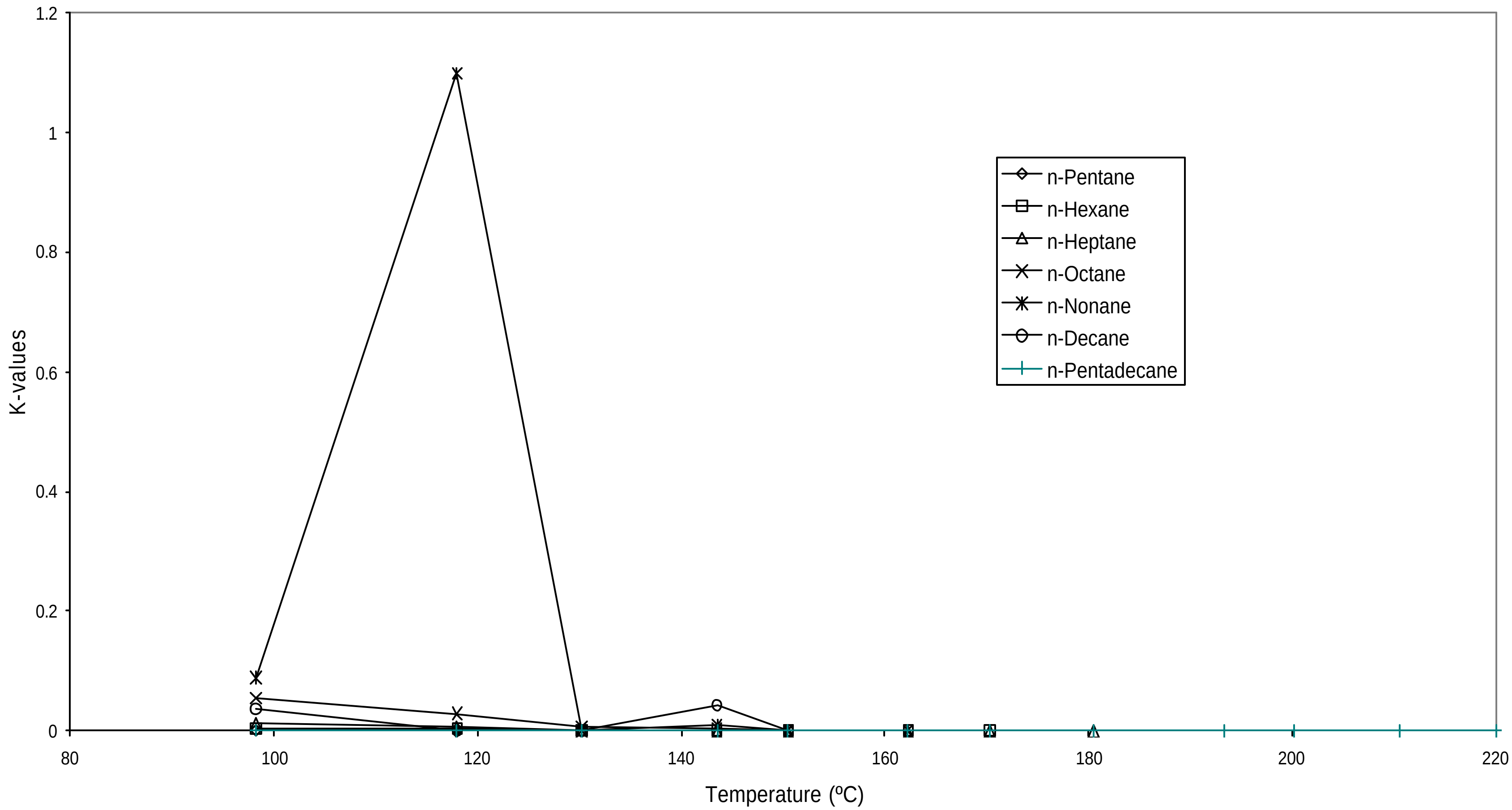


Fig. 5.40-Experimental *K*-values vs. temperature (steam distillation run no. 3).

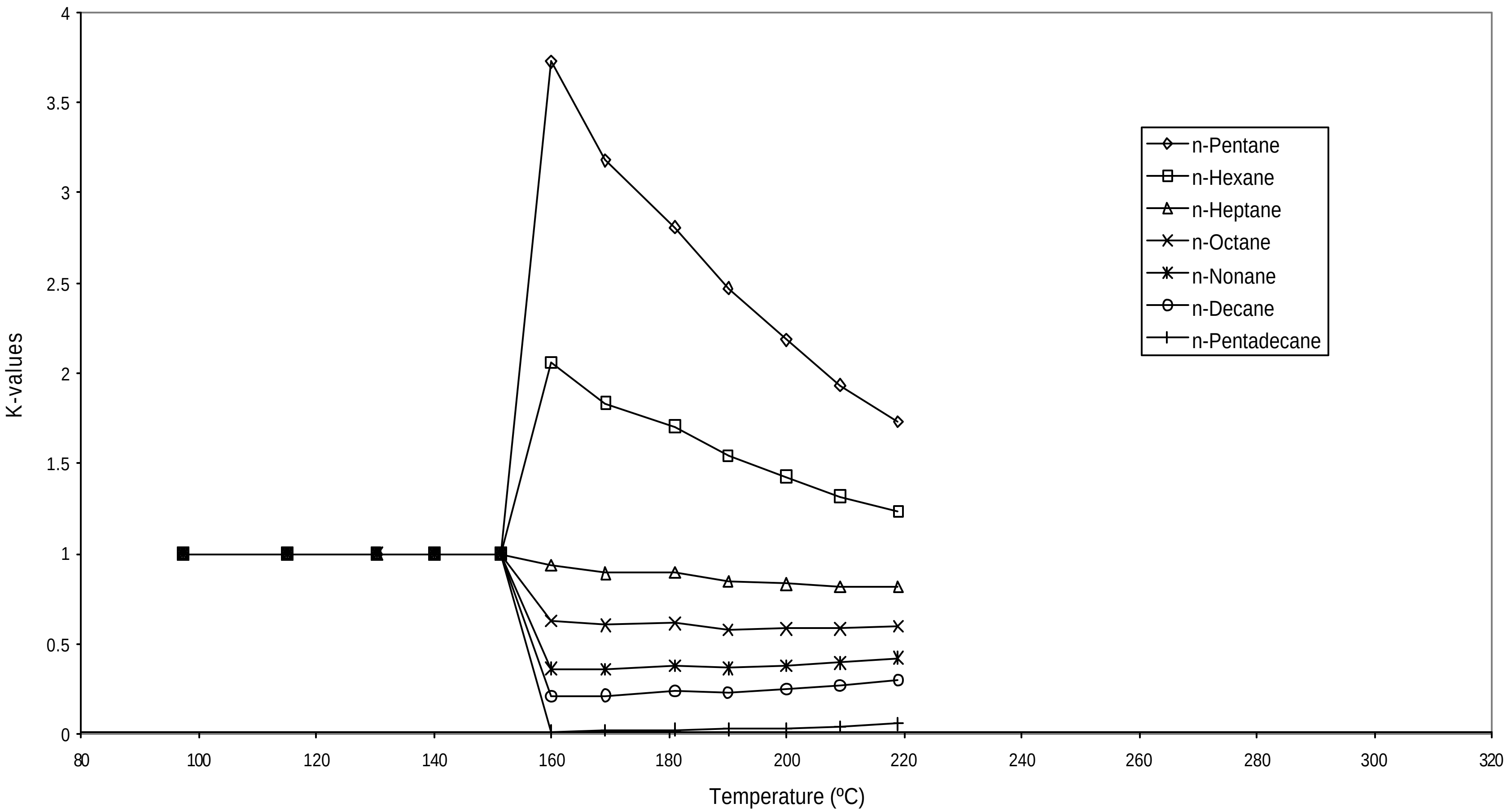


Fig. 5.41-Calculated *K*-values vs. temperature (steam distillation run no. 1).

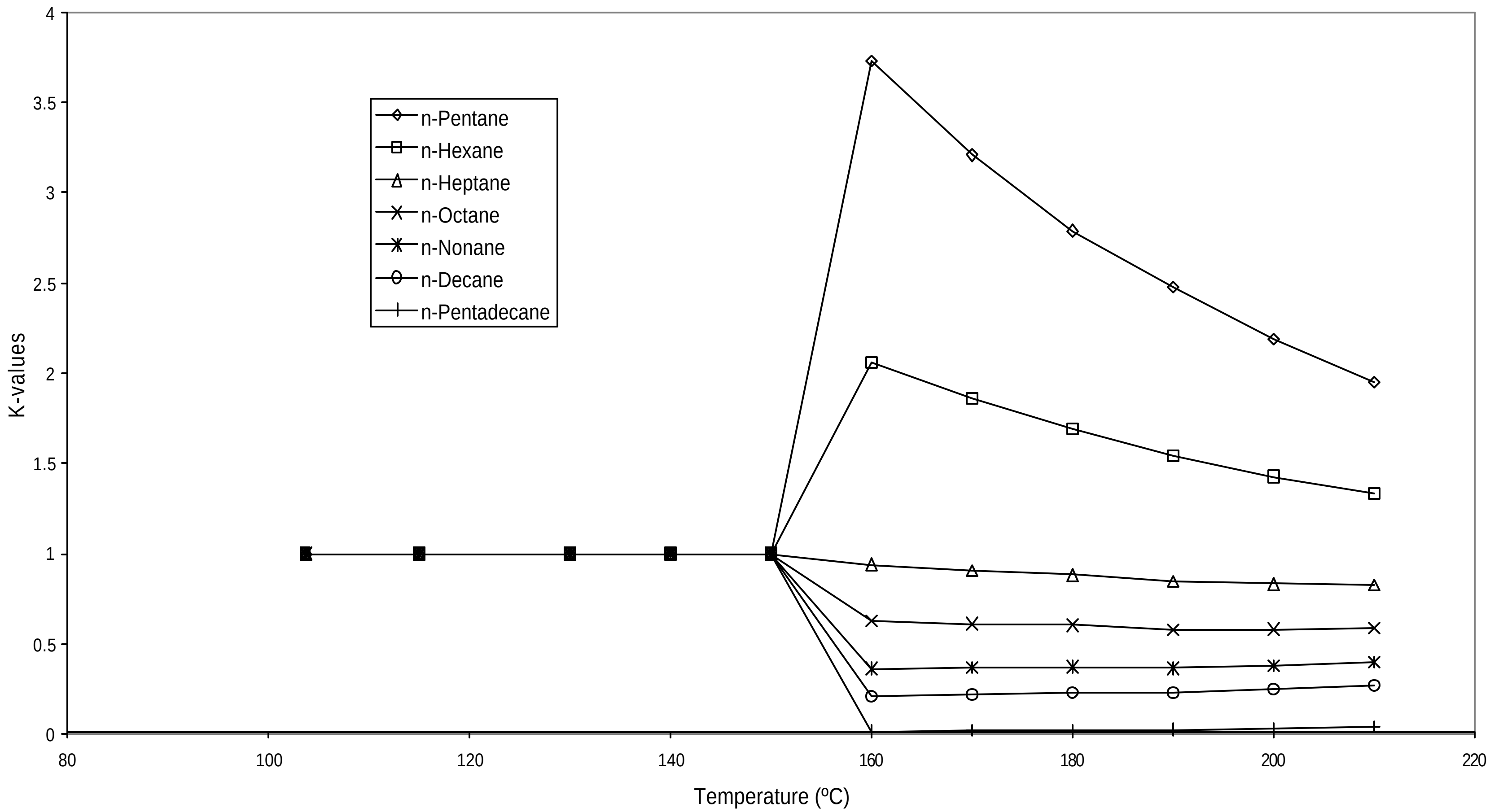


Fig. 5.42-Calculated *K*-values vs. temperature (steam distillation run no. 2).

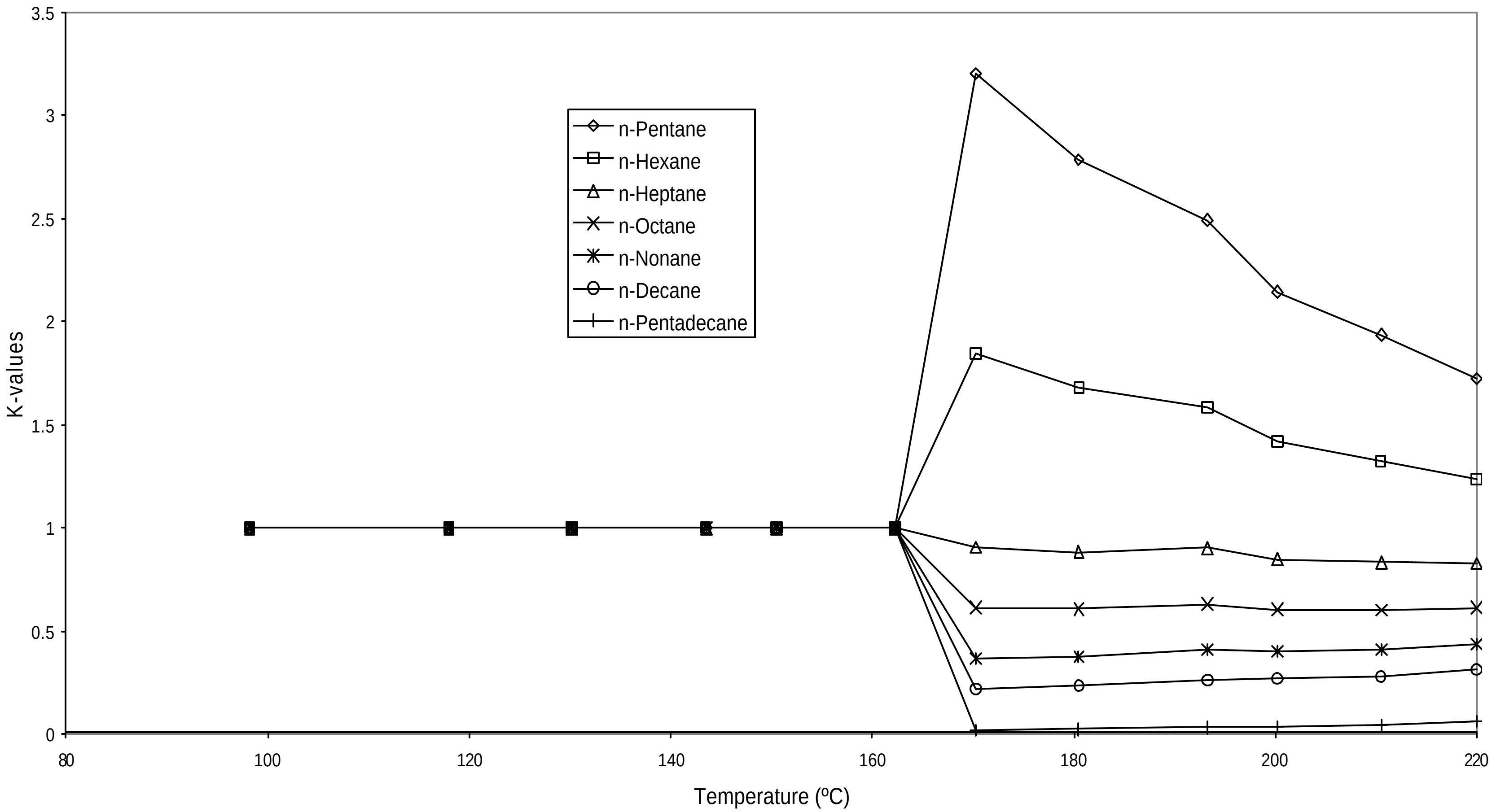


Fig. 5.43-Calculated *K*-values vs. temperature (steam distillation run no. 3).

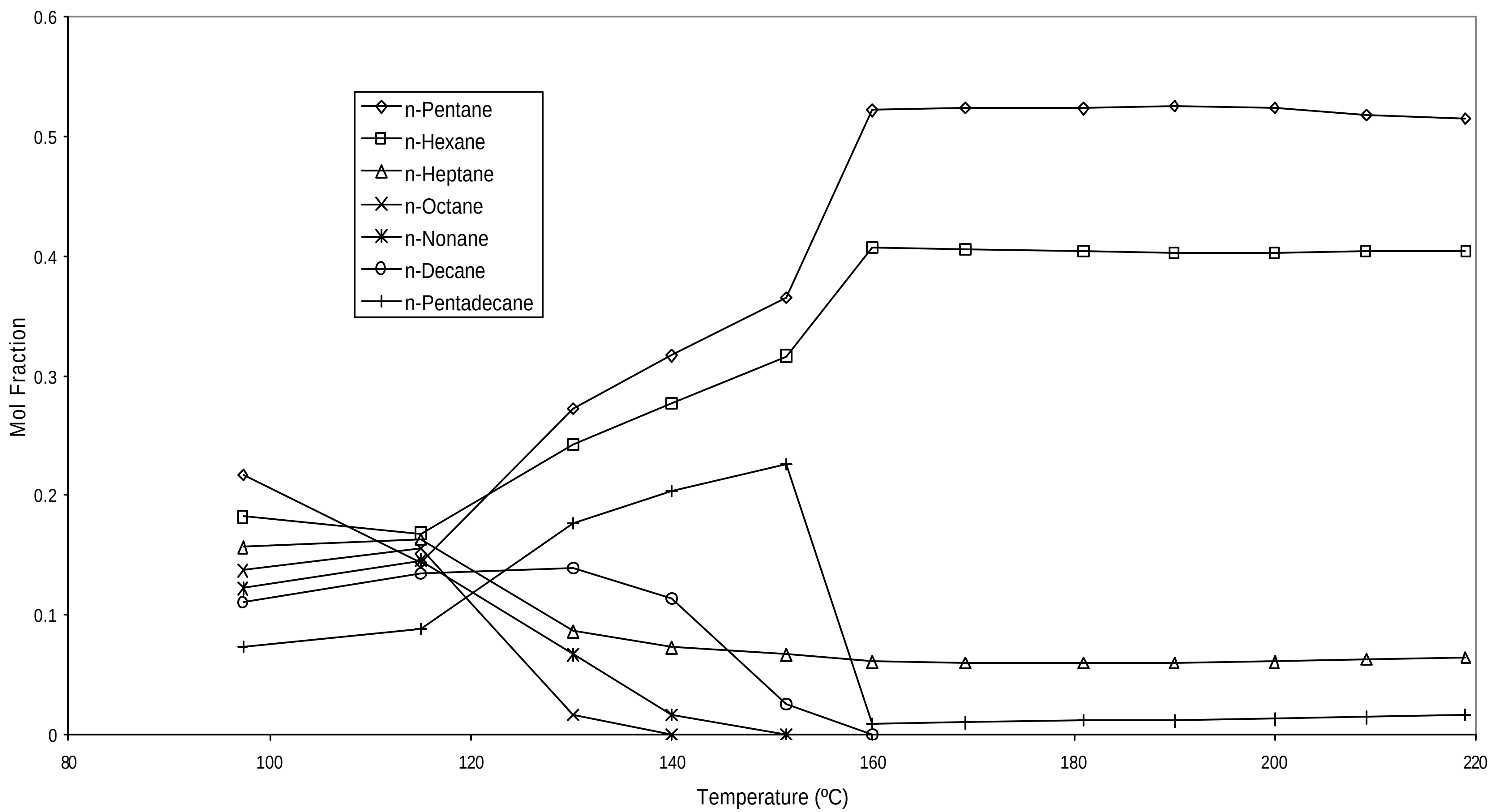


Fig. 5.44-Vapor composition vs. temperature (steam distillation run no. 1).

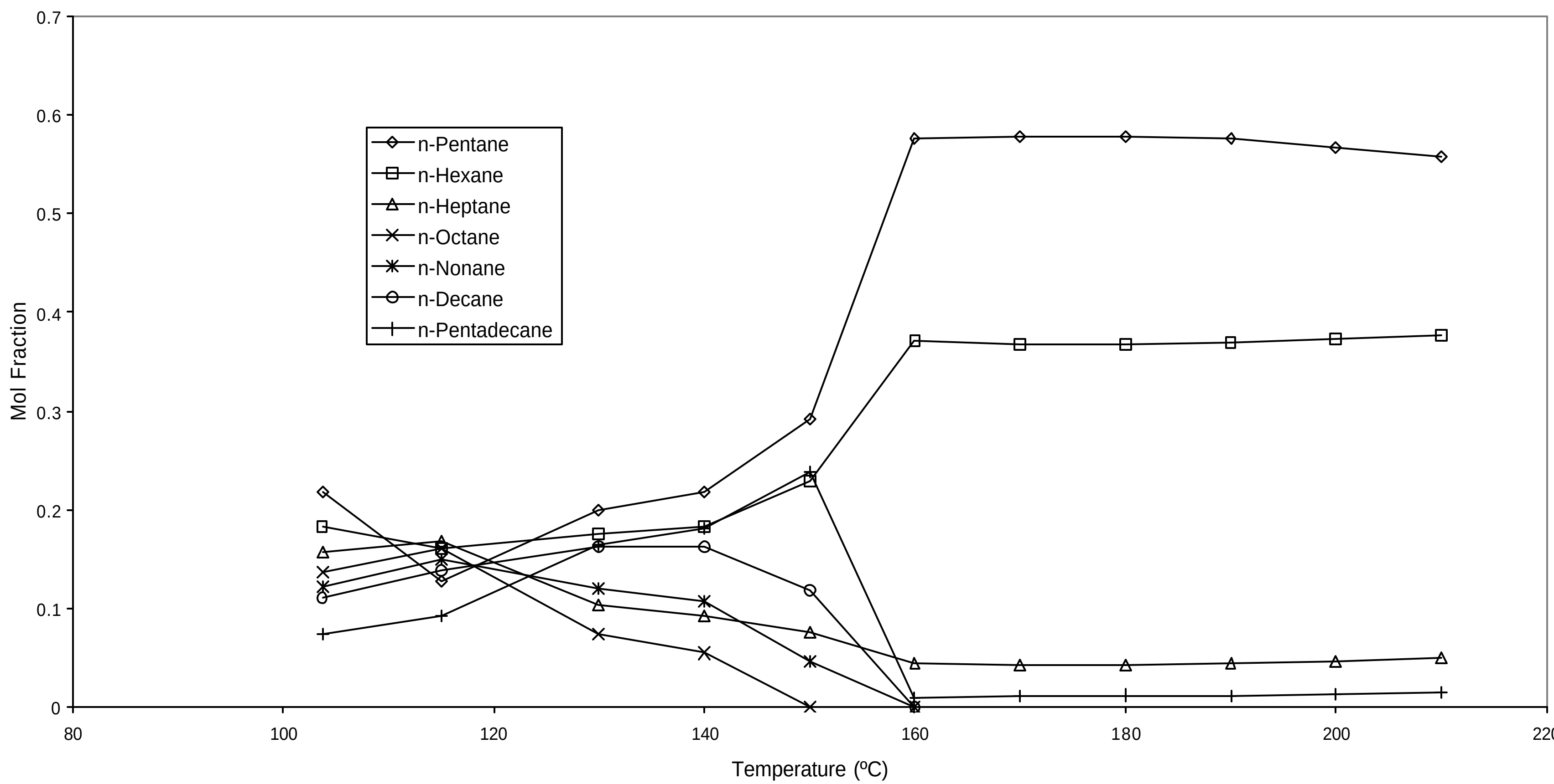


Fig. 5.45-Vapor composition vs. temperature (steam distillation run no. 2).

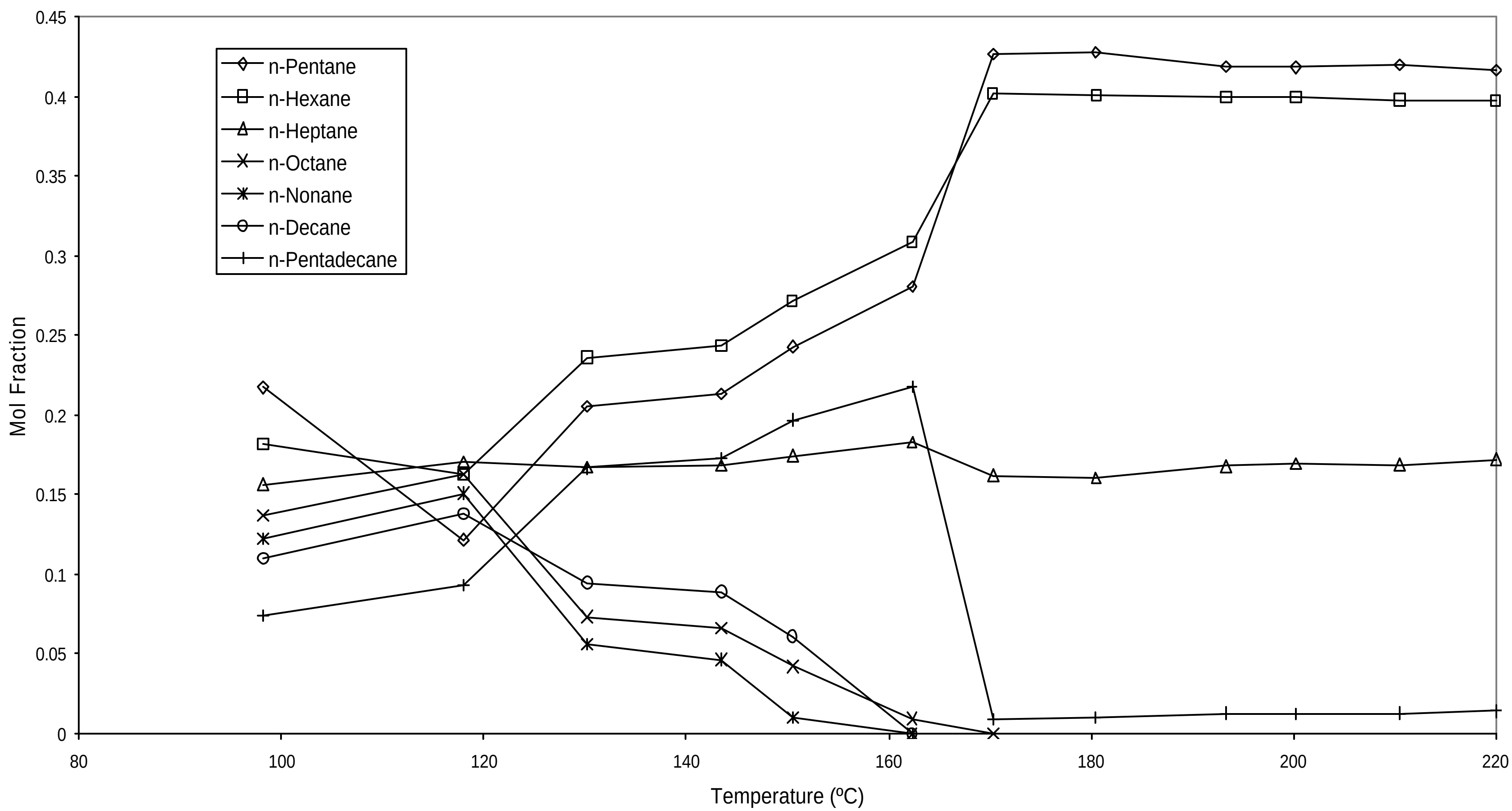


Fig. 5.46-Vapor composition vs. temperature (steam distillation run no. 3).

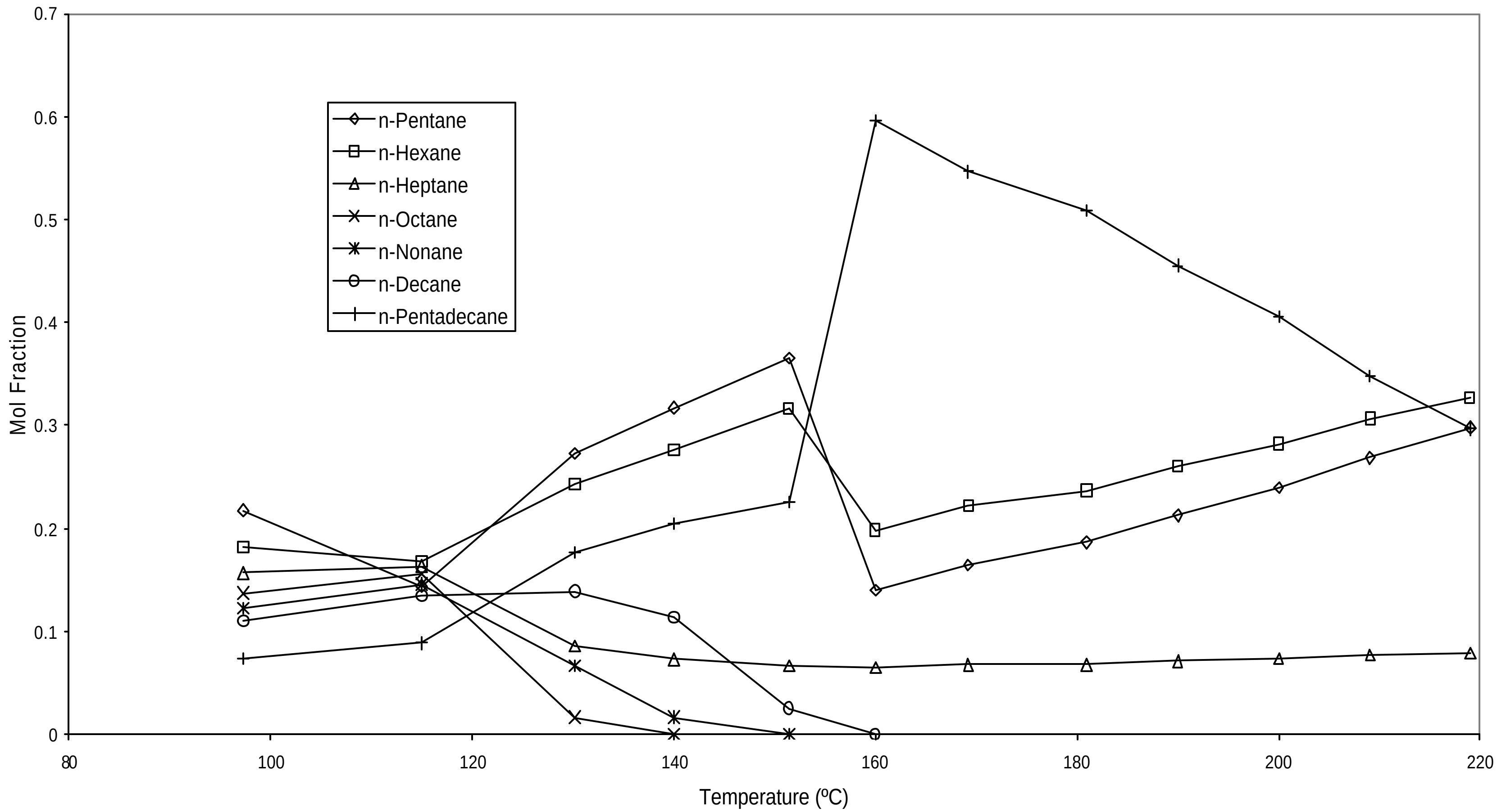


Fig. 5.47-Liquid composition vs. temperature (steam distillation run no. 1).

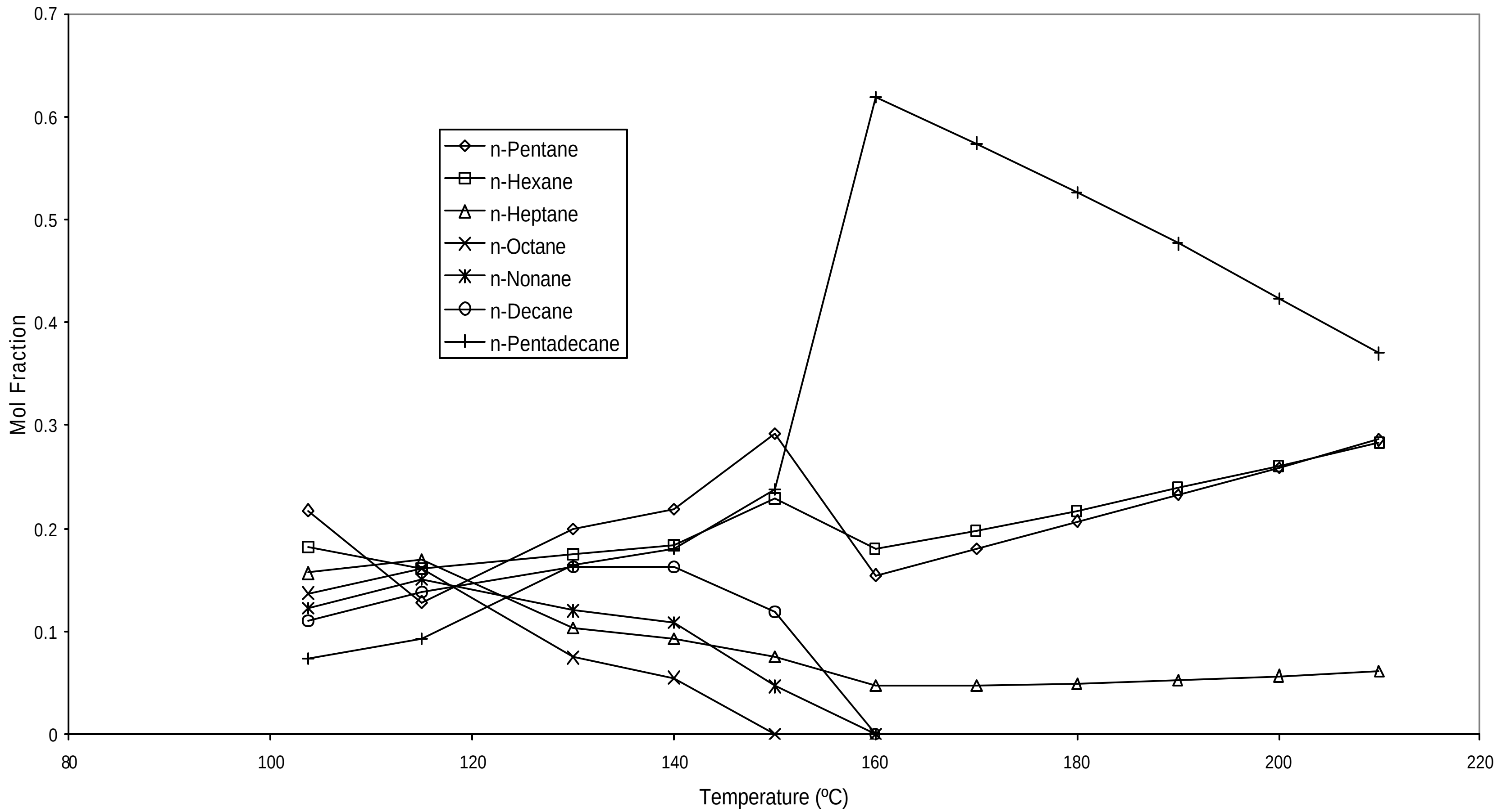


Fig. 5.48-Liquid composition vs. temperature (steam distillation run no. 2).

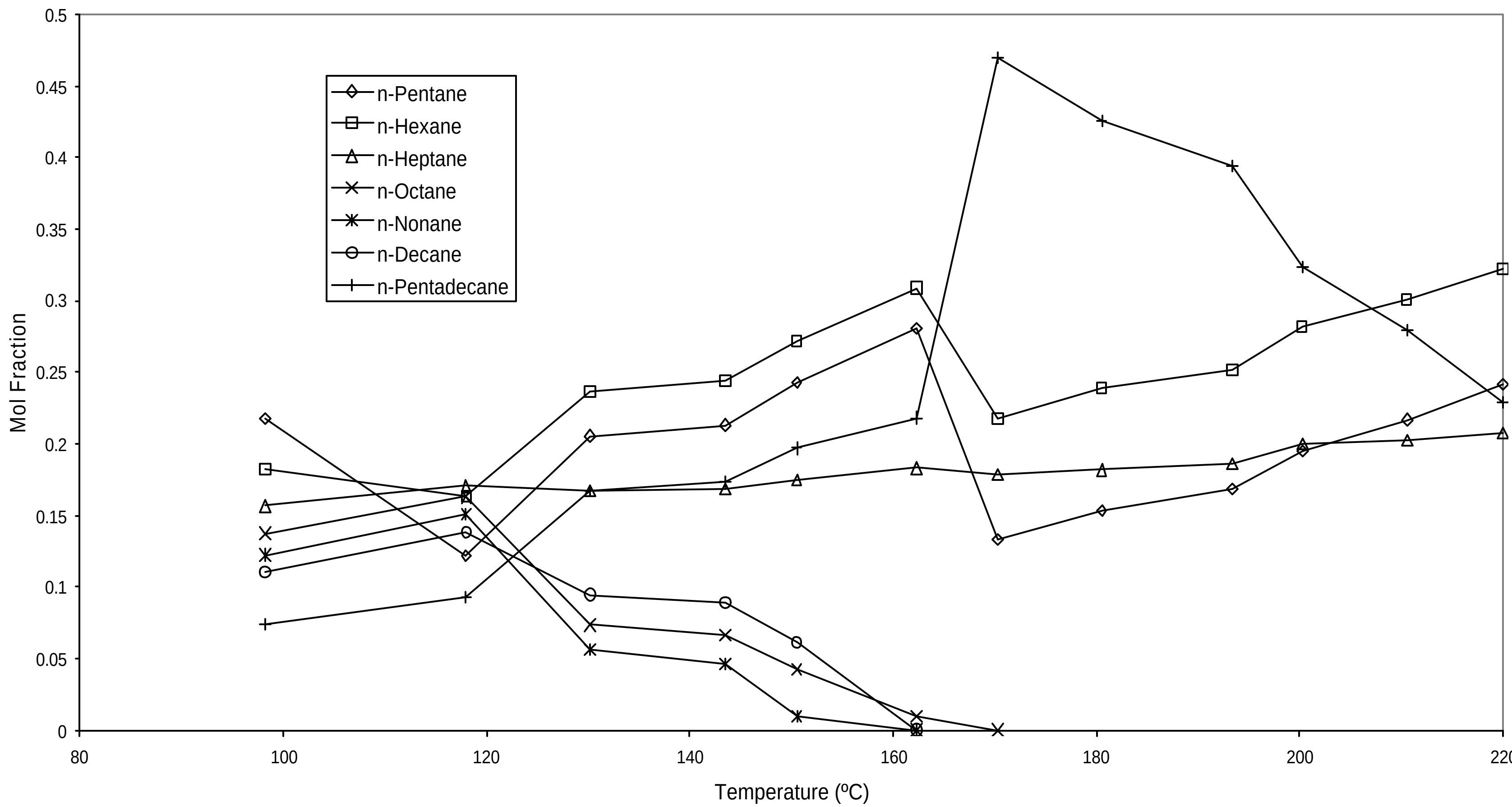


Fig. 5.49-Liquid composition vs. temperature (steam distillation run no. 3).

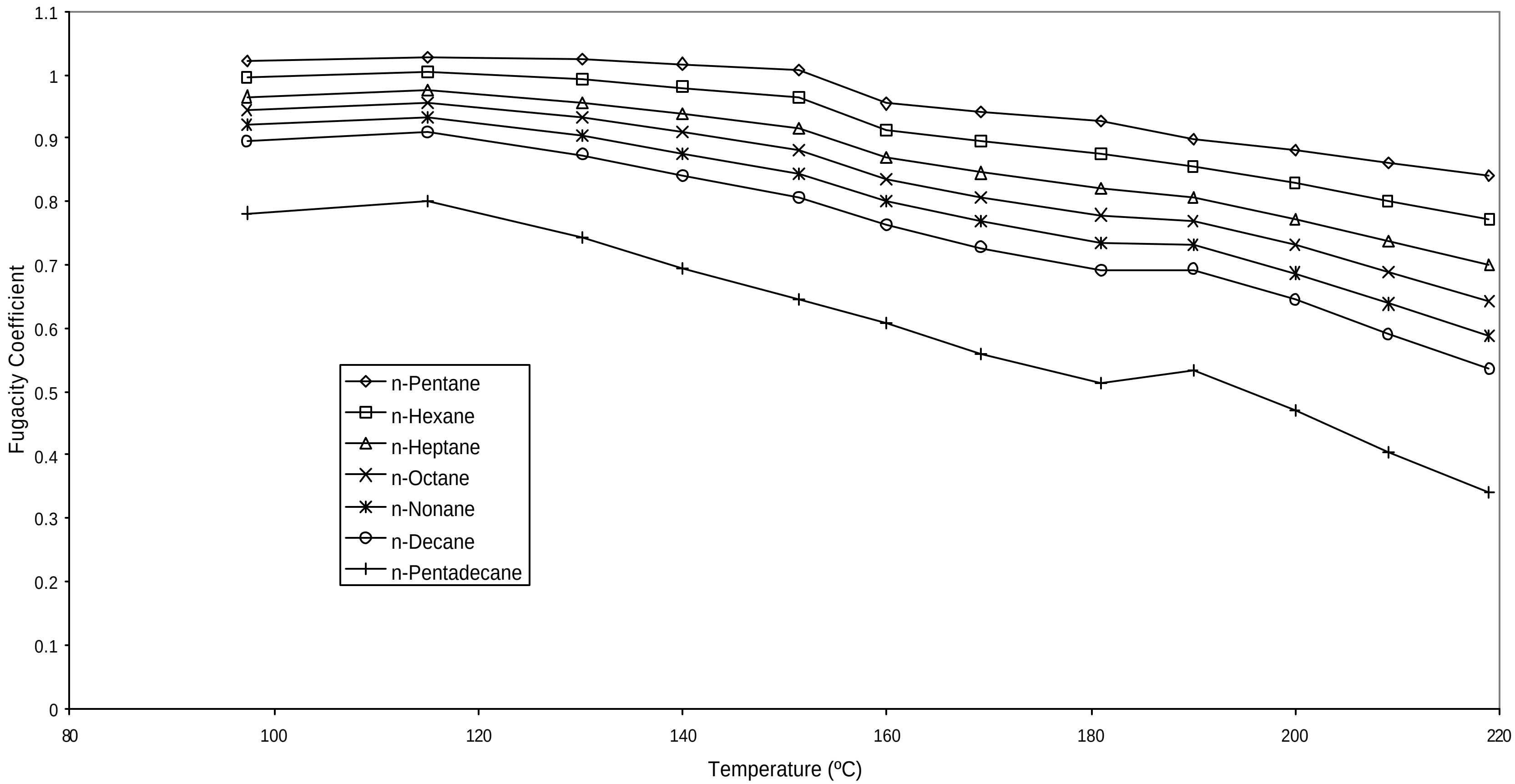


Fig. 5.50-Vapor fugacity coefficient vs. temperature (steam distillation run no. 1).

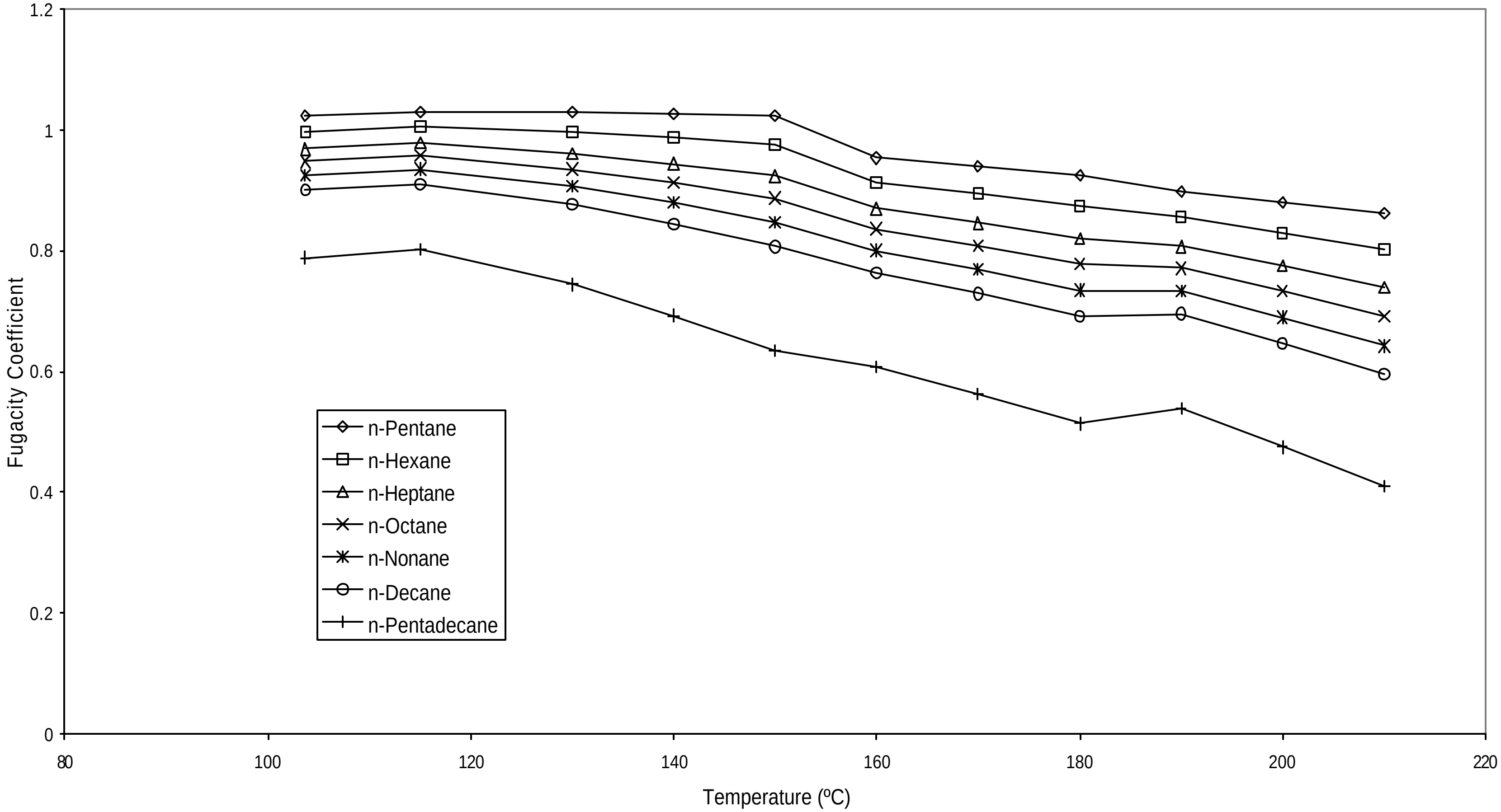


Fig. 5.51-Vapor fugacity coefficient vs. temperature (steam distillation run no. 2).

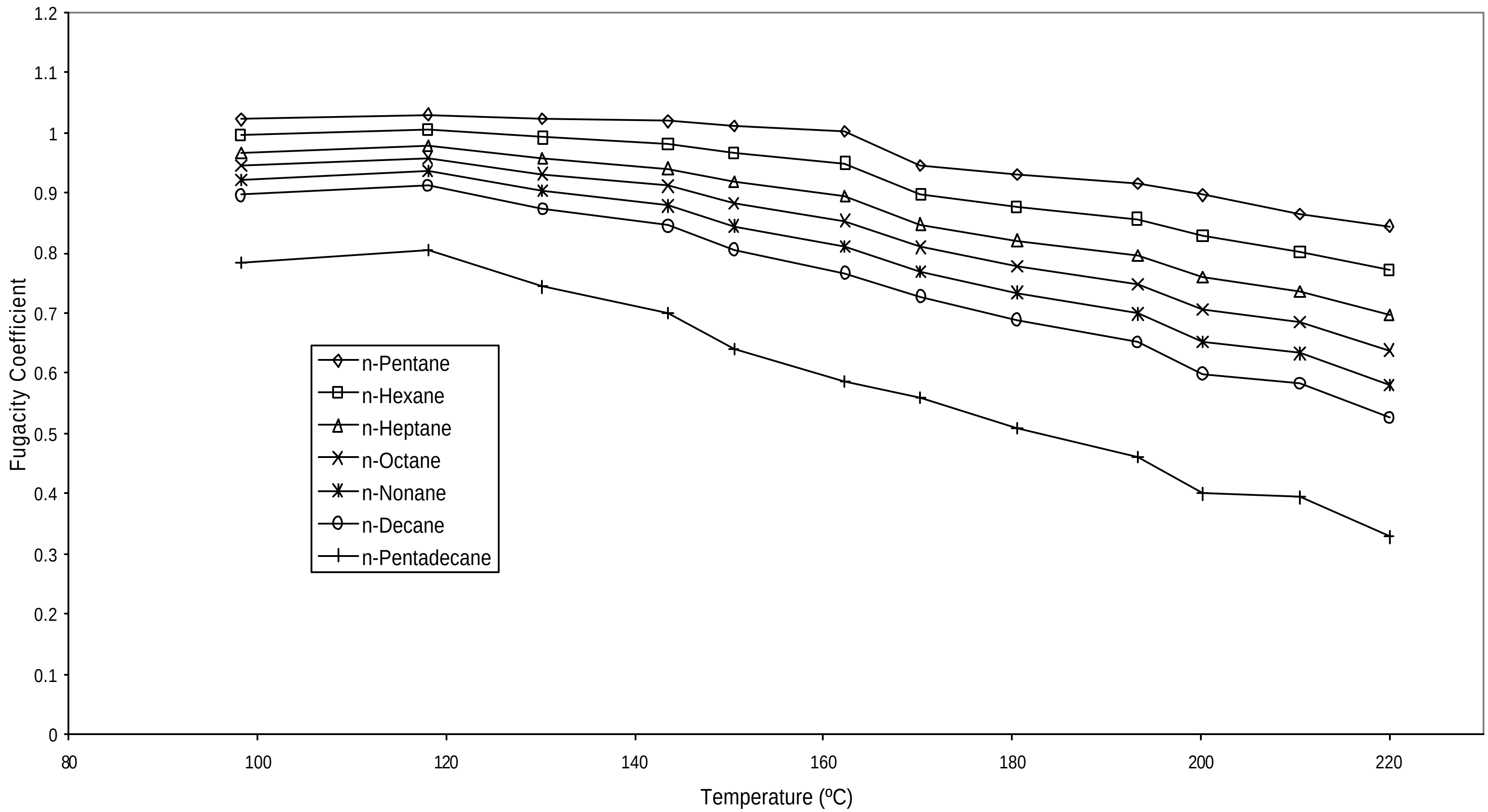


Fig. 5.52-Vapor fugacity coefficient vs. temperature (steam distillation run no. 3).

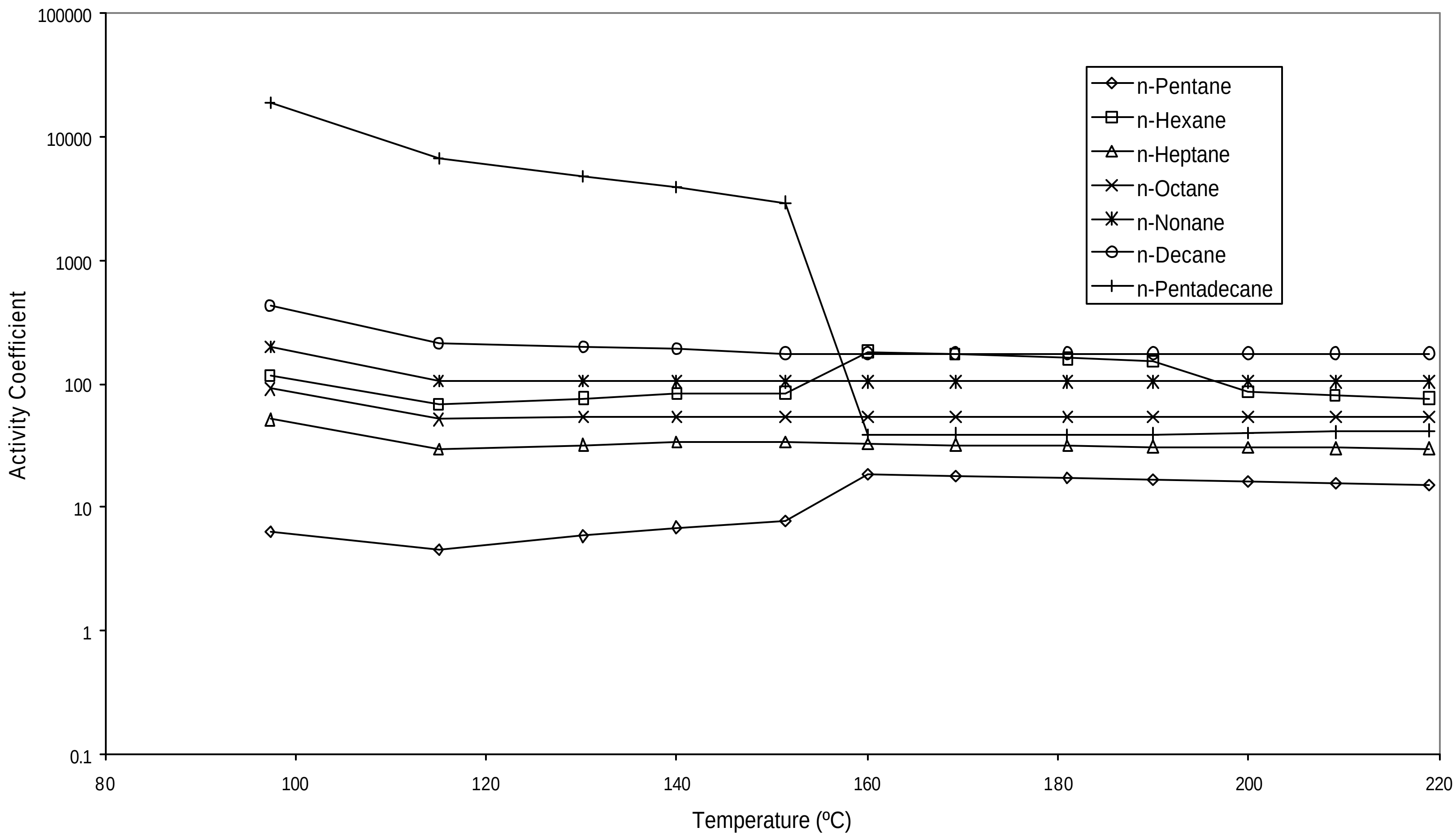


Fig. 5.53-Activity coefficient vs. temperature (steam distillation run no. 1).

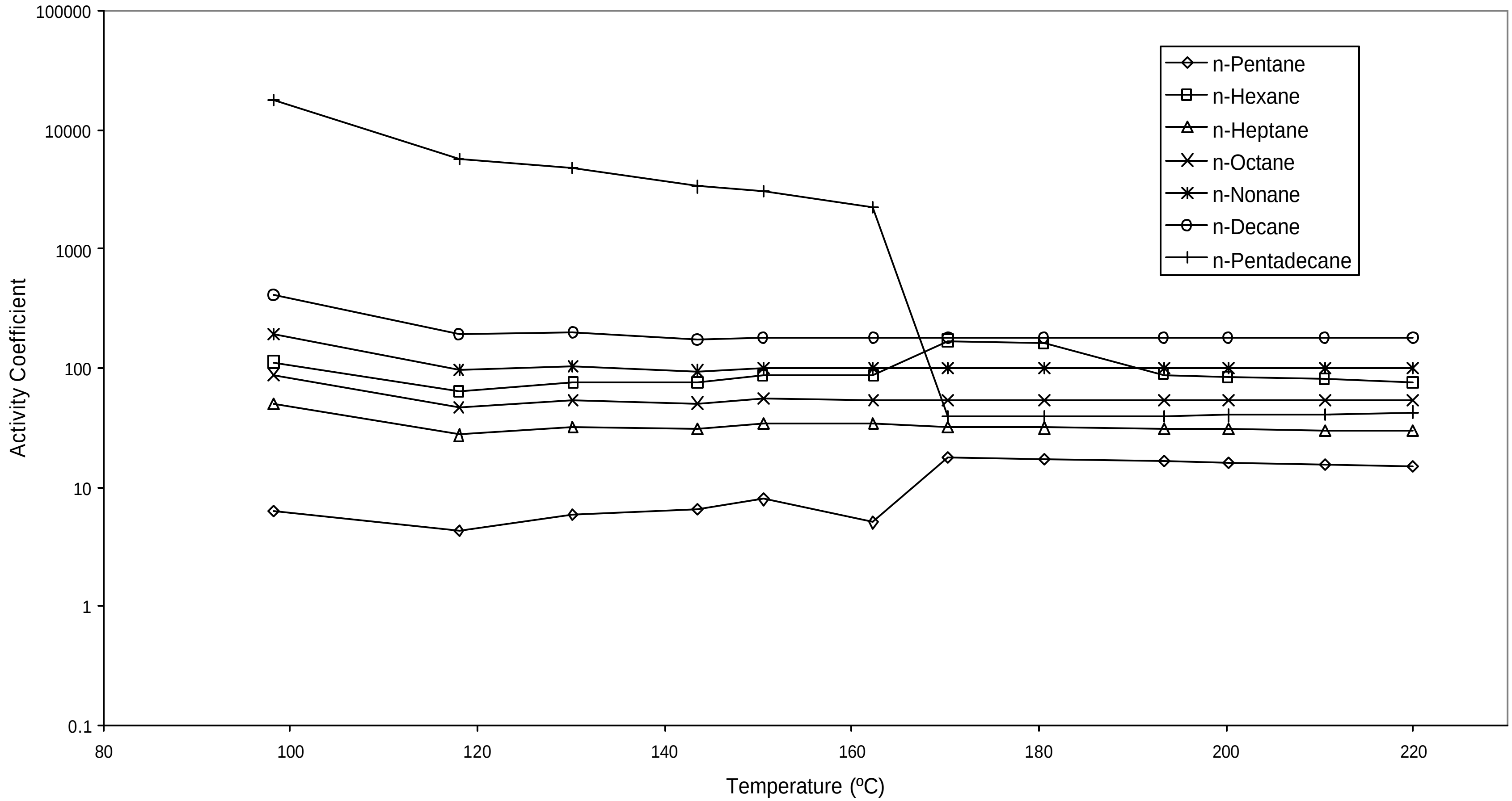


Fig. 5.54-Activity coefficient vs. temperature (steam distillation run no. 2).

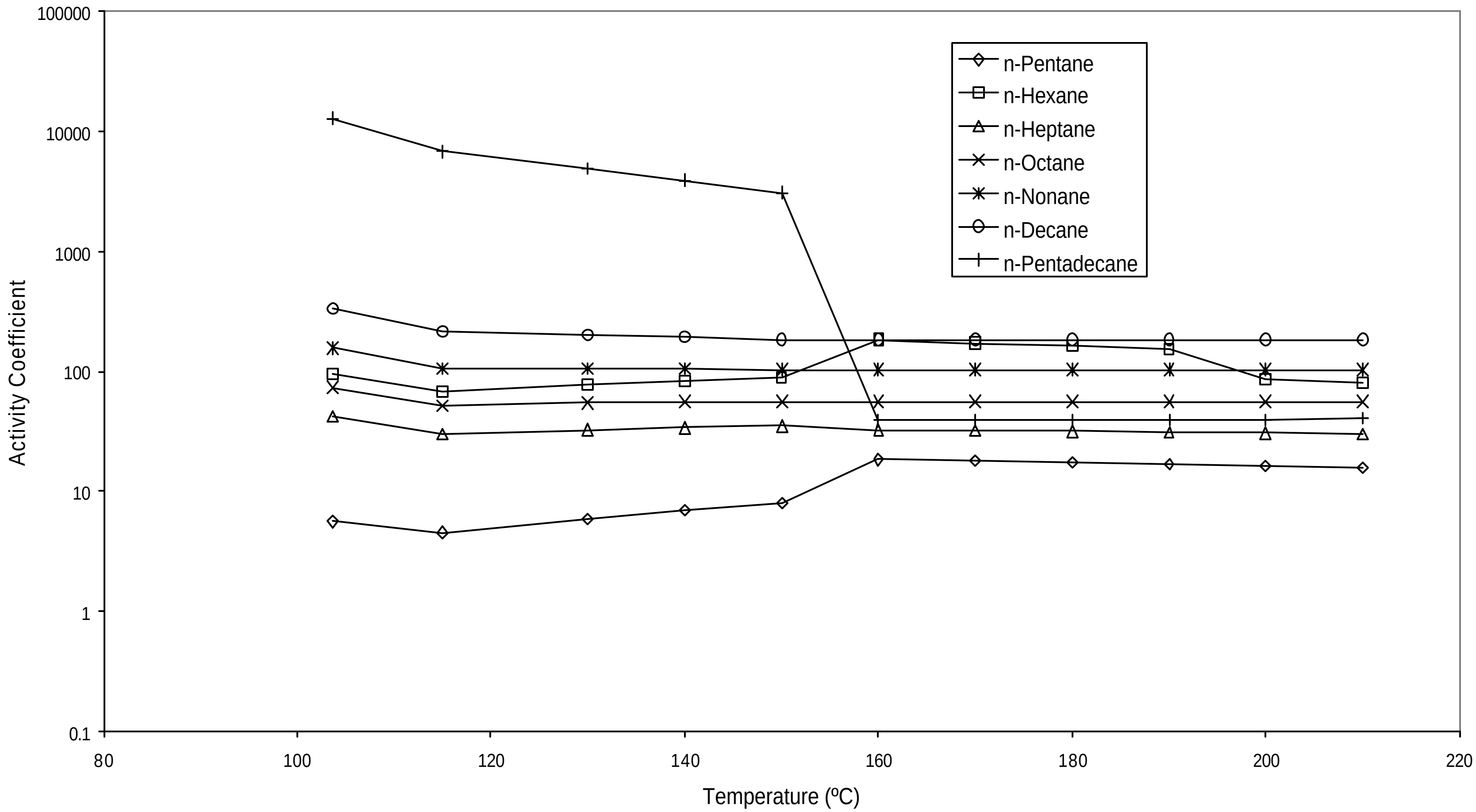


Fig. 5.55-Activity coefficient vs. temperature (steam distillation run no. 3).

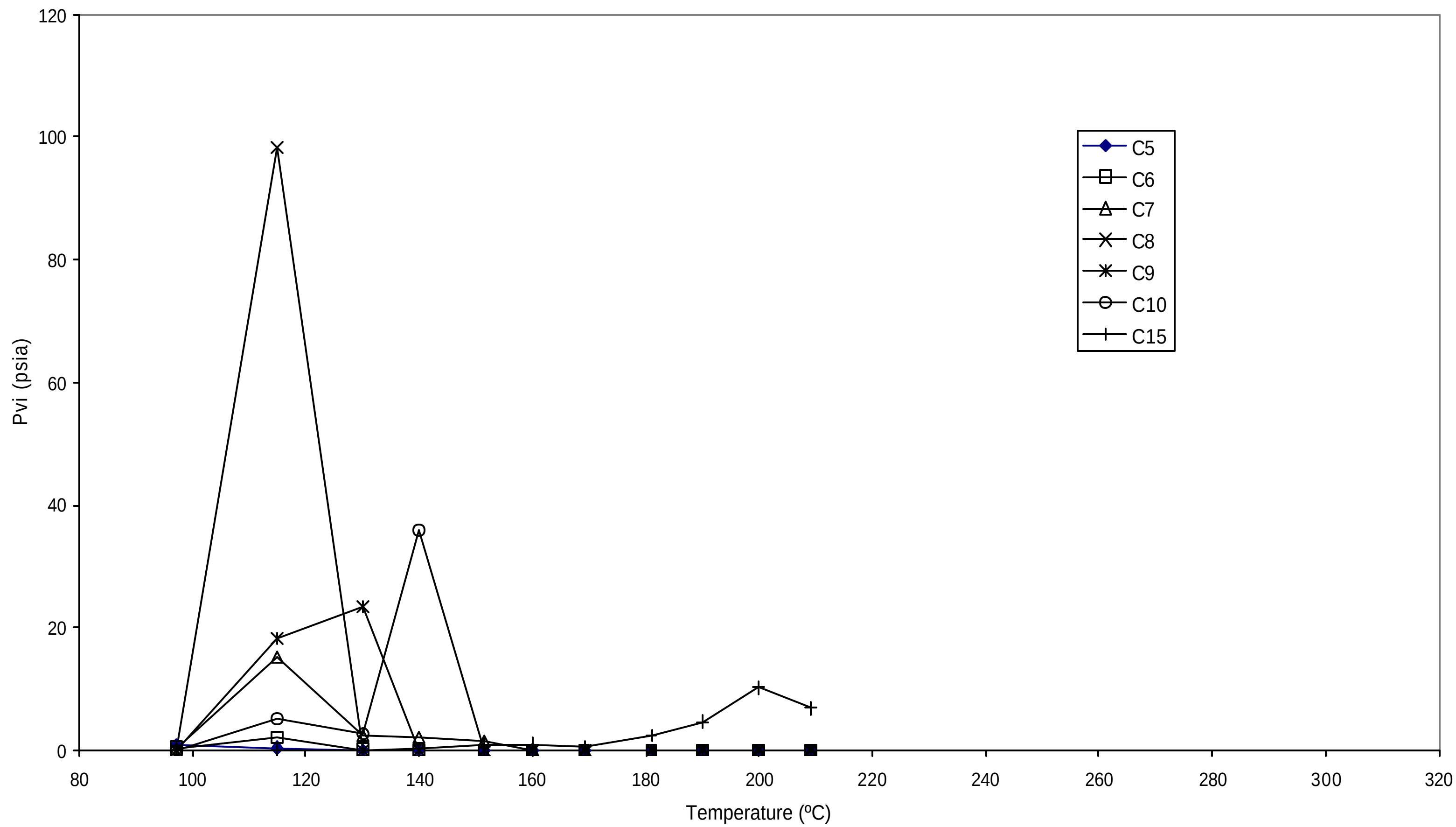


Fig. 5.56-Partial pressure vs. temperature (steam distillation run no. 1).

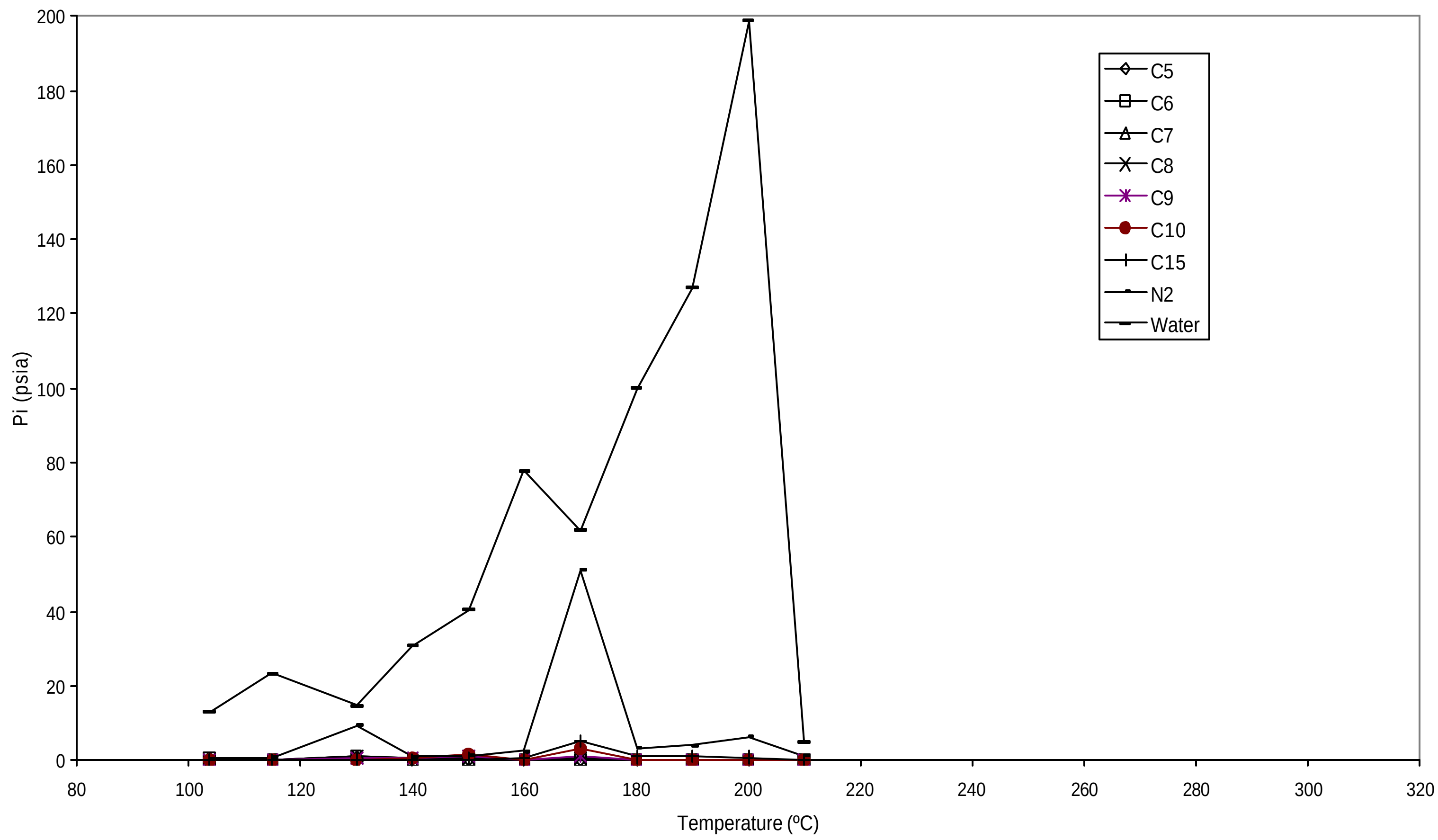


Fig. 5.57-Partial pressure vs. temperature (steam distillation run no. 2).

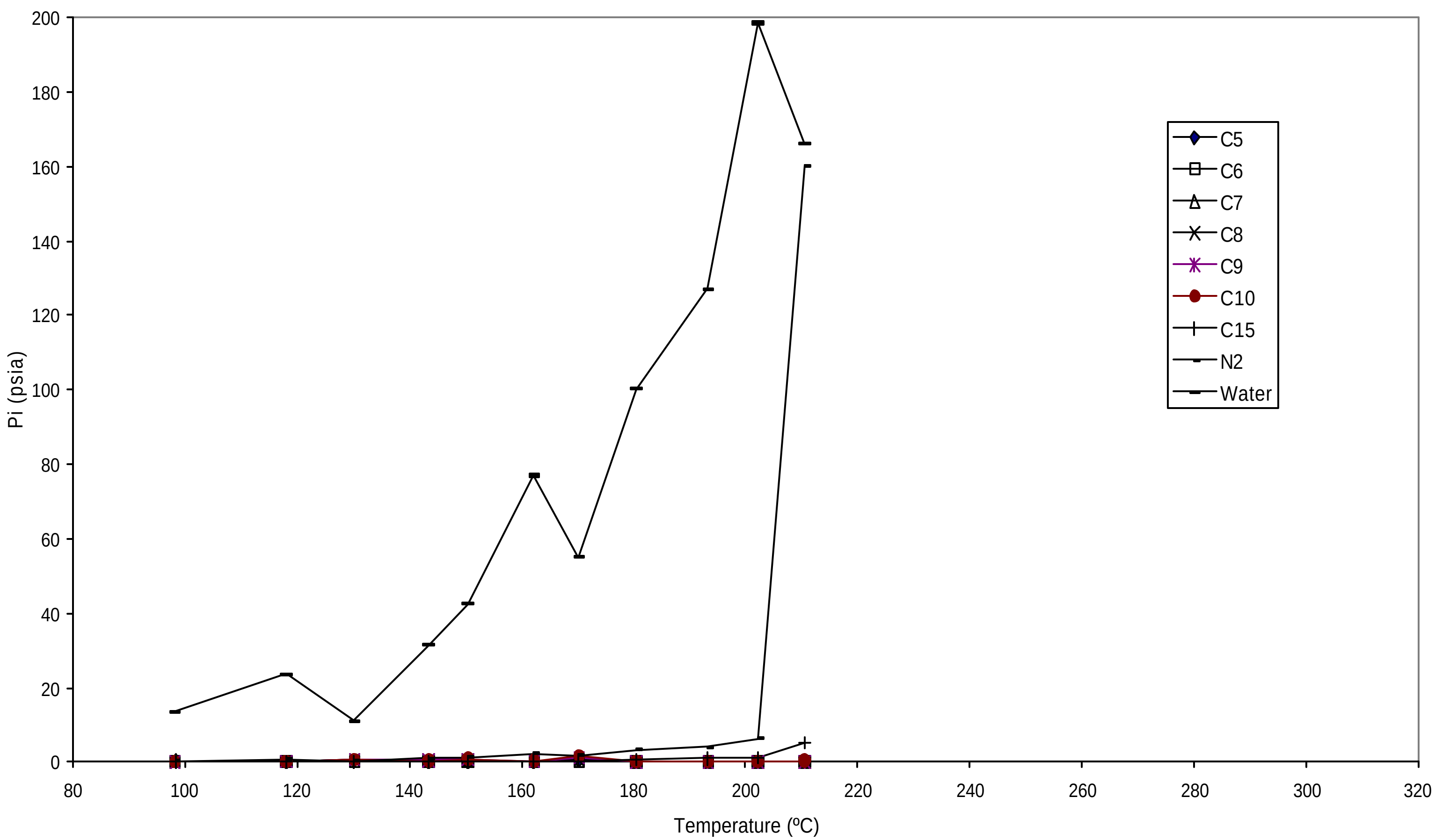


Fig. 5.58-Partial pressure vs. temperature (steam distillation run no. 3).

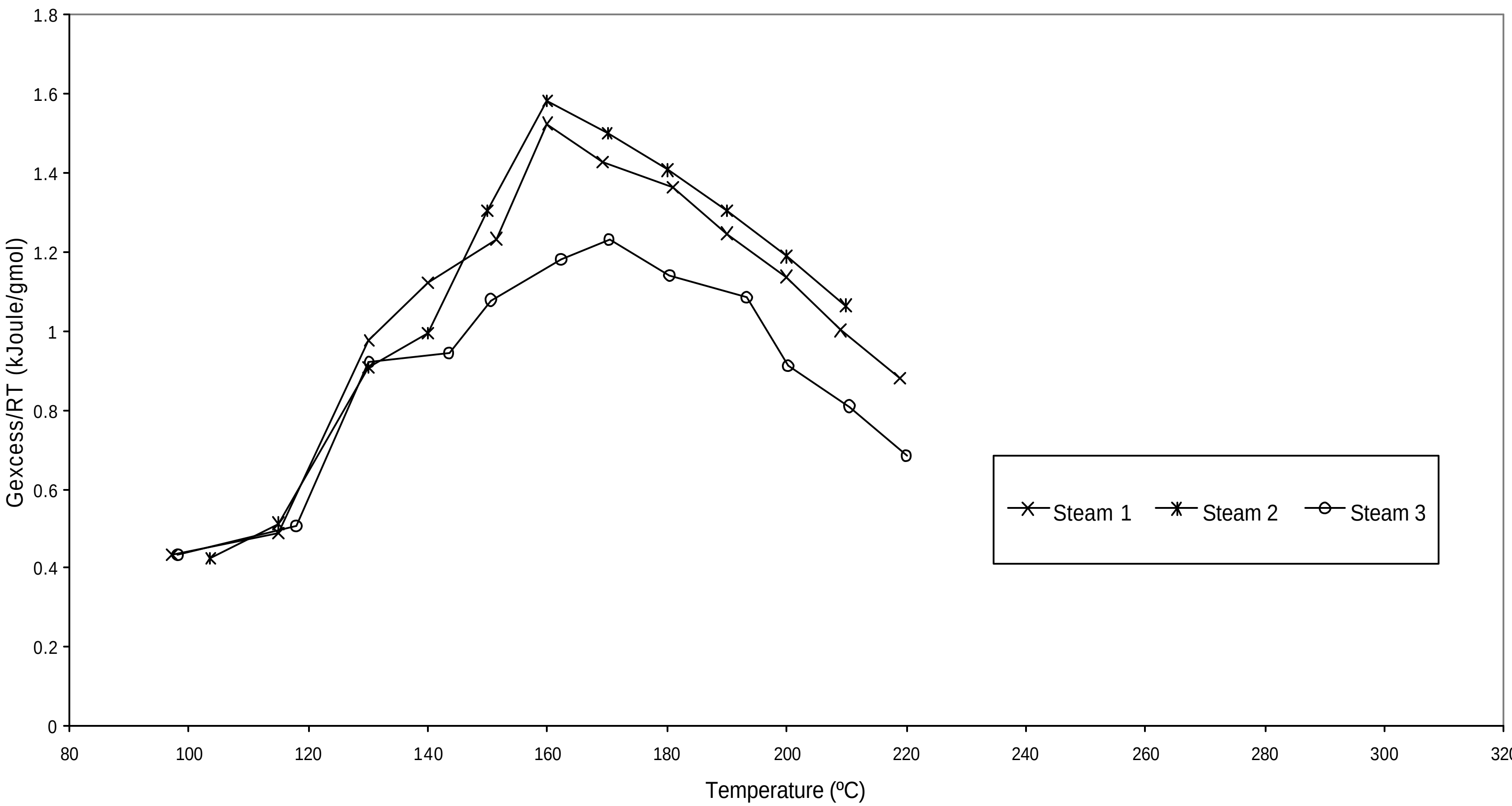


Fig. 5.59-Gibbs excess energy vs. temperature (steam distillation run nos. 1, 2, 3).

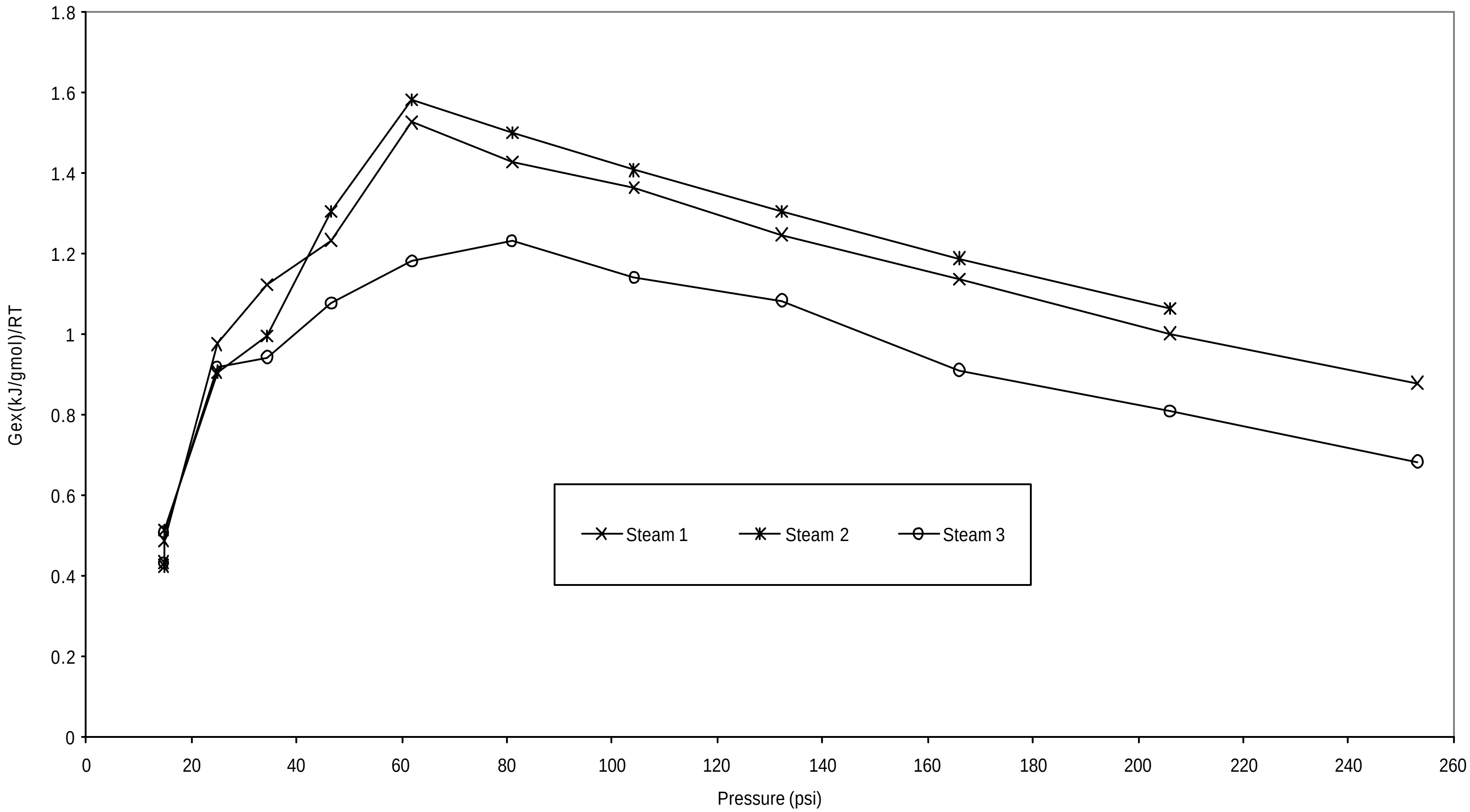


Fig. 5.60-Gibbs excess energy vs. pressure (steam distillation run nos. 1, 2, 3).

5.3 Steam propane-distillation

Measured distillate yields are summarized in **Tables 5.8** and **5.9** for the steam-propane runs, including gas chromatograph analyses (GC) for the hydrocarbon distillate. A typical chromatogram for one analysis is shown in the **Appendix**.

The temperature profiles for this run are shown in **Fig. 5.61** and **Fig. 5.62**. These plots indicate stable of temperatures at each cut during the runs. The profiles of pressures during runs are shown in **Figs. 5.63-5.64**.

The oil yield plots as a function of temperature for each steam-propane distillation run are shown in **Figs. 5.65-5.66.** Steam-propane distillation run no. 1 showed an oil recovery of 90.2% at 190ºC with an experimental error of 3.3%. Steam – propane distillation run no. 2 showed an oil recovery of 87% with an experimental error of 4.6% at 205ºC.

The experimental error was calculated considering the material balance of oil. From the oil yield plots one can observe that about 74 wt% of the hydrocarbons is distilled off at around 125ºC, much more than in the steam- or dry distillations processes (58 wt% and 36 wt% respectively).

The water yield plots as function of temperature for every steam distillation are shown in **Figures 5.67-5.68.**

Figures 5.69-5.70 show the experimental pseudo *K*-values. These plots show the highest values for the lightest components and that the distillation process finishes earlier than those in steam distillation and much earlier than those in dry distillation.

Figures 5.71-5.72 show calculated pseudo *K*-values. As with the steam distillation runs, variations of these *K*-values mean that the compositions in the liquid and vapor phases are not the same as in the case of the dry distillation runs. These hydrocarbon compositions are shown in the **Figs. 5.73-5.76.** These plots show the change of vapor and liquid composition during the distillation processes.

In **Figs. 5.77-5.78**, one can see the changes in vapor fugacity coefficient for each component. Vapor fugacity coefficients in the steam-propane distillations now show a notable difference compared to steam distillation runs: higher temperature lower fugacity coefficient, indicating that propane has direct and significant effect on vapor-liquid equilibrium. On the other hand, activity coefficient during the steam–propane distillation runs shows a decrease at about 170ºC, thereafter, remaining fairly constant. This is shown in **Fig. 5.79 and Fig. 5.80.** This could be the difference in distillation with propane.

Figures 5.81-5.82 show the distribution of partial pressures of each component if the mixture were ideal. The plots show a narrow distribution of partial pressures of the components as a function of temperature, the distillation process ending around 220ºC.

Finally the curves of Gibbs excess energy for the steam-propane runs are shown **Fig. 5.83-5.84.** The Gibbs excess energy increases to a peak at about 120º-160ºC, a much lower temperature compared to that for steam distillation (160º-170ºC) and dry distillation (230º-270ºC).

TABLE 5.8- OIL YIELDS AT STEAM-PROPANE DISTILLATION RUN NO. 1

WEIGHT OF COMPONENTS (STEAM PROPANE DISTILLATION RUN 1)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2175	0.2772	0.1221	17.1009	0.2370
C6	30.3500	20.0000	86.1772	0.1821	0.2321	0.1412	19.7666	0.2294
C7	29.2400	20.0000	100.2040	0.1566	0.1996	0.1408	19.7157	0.1968
C8	28.6300	20.0000	114.2309	0.1374	0.1751	0.1488	20.8348	0.1824
C9	27.8600	20.0000	128.2578	0.1223	0.1559	0.1495	20.9261	0.1632
C10	27.0300	20.0000	142.3000	0.1103	0.1405	0.1496	20.9398	0.1472
C15	26.0100	20.0000	212.4191	0.0739	0.0942	0.1480	20.7161	0.0975
C3			44.0960					
water			28.0000					
Total	201.0700	140.0000		1.0000	1.2746	1.0000	140.0000	1.2534

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM PEOPANE DISTILLATION RUN 1)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Water ml	Cum water wt%
1	12.334	30.105	17.771	0.000	29.000	29.000	17.771	95.70	17.771	12.69	0.0000	0.0000
2	50.631	138.124	87.493	7.264	131.000	123.736	80.229	116.20	98.000	70.00	7.2640	1.4586
6	12.557	46.090	33.533	20.147	41.000	20.853	13.386	133.80	111.386	79.56	27.4110	5.5042
7	12.726	34.193	21.467	16.434	24.000	7.566	5.033	144.20	116.419	83.16	43.8450	8.8042
8	12.723	33.123	20.400	18.345	23.000	4.655	2.055	151.60	118.474	84.62	62.1900	12.4880
9	12.901	33.965	21.064	19.201	23.000	3.799	1.863	165.40	120.337	85.96	81.3910	16.3436
10	12.847	34.692	21.845	19.810	23.000	2.000	2.035	170.30	122.372	87.41	101.2010	20.3215
11	12.594	34.022	21.428	19.718	23.000	3.282	1.710	180.20	124.082	88.63	120.9190	24.2809
12	12.405	37.473	25.068	23.741	27.000	3.259	1.327	190.30	125.409	89.58	144.6600	29.0482
13	12.770	29.553	16.783	15.585	18.000	2.415	1.198	199.80	126.607	90.43	160.2450	32.1777
14	12.811	34.494	21.683	20.852	23.000	2.148	0.831	210.40	127.438	91.03	181.0970	36.3649
15	12.590	34.861	22.271	21.271	24.000	2.729	1.000	219.40	128.438	91.74	202.3680	40.6361
16	12.672	44.183	31.511	30.913	33.000	2.087	0.598	229.70	129.036	92.17	233.2810	46.8436
17	12.690	39.569	26.879	26.636	28.000	1.364	0.243	239.60	129.279	92.34	259.9170	52.1922
18	12.719	34.372	21.653	21.048	23.000	1.952	0.605	249.80	129.884	92.77	280.9650	56.4187
19	12.924	35.029	22.105	21.506	23.500	1.994	0.599	260.30	130.483	93.20	302.4710	60.7371
20	12.746	44.390	31.644	31.121	32.000	0.879	0.523	270.00	131.006	93.58	333.5920	66.9863
21	12.529	37.353	24.824	24.435	26.000	1.565	0.389	280.80	131.395	93.85	358.0270	71.8930
22	12.988	38.954	25.966	25.907	27.000	1.093	0.059	290.70	131.454	93.90	383.9340	77.0952
23	13.174	41.053	27.879	27.000	29.000	2.000	0.879	300.40	132.333	94.52	410.9340	82.5169
Cold Residal	12.618	16.135	3.517	3.455	4.500	1.045	0.062	310.00	132.395	94.57	432.7090	86.8894
Residual in cell	12.613	33.932	21.319	18.320	20.000	1.680	2.999	310.00	135.394	96.71		
Total	317.562	885.665	568.103	432.709	655.00	221.10	135.39					

	Oil wt g	Oil vol ml
Difference	4.6060	20.0310
% Error	3.2900	9.9622

Beginning of Injection time =	111	min
Injection Rate =	0.50	ml/min
Total Injection Time =	996.00	min
Water injected =	498.00	ml
Water recovered =	432.71	ml
Water lost =	65.29	ml

TABLE 5.9- OIL YIELDS AT STEAM-PROPANE DISTILLATION RUN NO. 2

WEIGHT OF COMPONENTS (STEAM PROPANE DISTILLATION RUN 2)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fractio	/t frac. (G	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1221	17.1009	0.2370
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1412	19.7666	0.2294
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1408	19.7157	0.1968
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1488	20.8348	0.1824
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1495	20.9261	0.1632
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1496	20.9398	0.1472
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1480	20.7161	0.0975
C3		0.0000	44.0900			0.0000		
Water			18.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2534

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM PEOPANE DISTILLATION RUN 2)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Water ml	Cum water wt%
1	12.623	37.009	24.386	0.000	39.000	39.000	24.386	108.00	24.386	17.42	0.0000	0.00
2	37.820	114.396	76.576	7.127	113.000	105.873	69.449	114.70	93.835	67.03	7.1270	1.49
3	12.341	43.315	30.974	17.130	39.000	21.870	13.844	130.10	107.679	76.91	24.2570	5.07
4	12.628	42.433	29.805	25.538	33.000	7.462	4.267	141.30	111.946	79.96	49.7950	10.42
5	12.702	37.897	25.195	23.135	27.000	3.865	2.060	151.50	114.006	81.43	72.9300	15.26
6	12.576	34.416	21.840	20.093	23.000	2.907	1.747	160.50	115.753	82.68	93.0230	19.46
7	12.413	34.987	22.574	20.398	24.500	2.000	1.400	170.80	117.153	83.68	113.4210	23.73
8	12.718	35.048	22.330	21.041	24.500	3.459	1.289	180.50	118.442	84.60	134.4620	28.13
9	12.705	37.565	24.860	23.500	26.500	3.000	1.360	190.50	119.802	85.57	157.9620	33.05
10	12.582	29.547	16.965	15.945	18.500	2.555	1.020	200.80	120.822	86.30	173.9070	36.38
11	12.716	35.954	23.238	22.120	25.000	2.880	1.118	211.10	121.940	87.10	196.0270	41.01
12	12.852	33.774	20.922	20.473	22.000	1.527	0.449	221.00	122.389	87.42	216.5000	45.29
13	12.681	35.683	23.002	22.783	23.002	0.219	0.219	231.10	122.608	87.58	239.2830	50.06
14	12.766	38.440	25.674	25.655	25.674	0.019	0.019	241.10	122.627	87.59	264.9380	55.43
15	12.745	35.731	22.986	22.802	22.986	0.184	0.184	251.00	122.811	87.72	287.7400	60.20
16	12.764	37.842	25.078	24.953	25.078	0.125	0.125	261.10	122.936	87.81	312.6930	65.42
17	12.456	44.607	32.151	32.066	32.151	0.085	0.085	270.80	123.021	87.87	344.7590	72.13
18	12.717	37.725	25.008	24.867	25.008	0.141	0.141	280.80	123.162	87.97	369.6260	77.33
19	12.766	44.232	31.466	31.167	31.466	0.299	0.299	290.80	123.461	88.19	400.7930	83.85
20	12.684	45.406	32.722	32.346	32.722	0.376	0.376	300.70	123.837	88.46	433.1390	90.61
21	12.601	14.210	1.609	1.609	1.609	0.000	0.000	310.00	123.837	88.46	434.7480	90.95
22	12.714	39.125	26.411	21.574	29.000	7.426	4.837	310.00	128.674	91.91	456.3220	95.46
Cold Residal	12.601	14.210	1.609	1.609	1.609	0.000	0.000	310.00	128.674	91.91		
Residual in cell	12.714	39.125	26.411	21.574	29.000	7.426	4.837	310.00	133.511	95.37		
Total	328.885	942.677	613.792	479.505	694.305	212.698	133.511		2787.312		4783.452	

	Oil wt g	Oil vol ml
Difference	6.4890	11.6280
% Error	4.6350	5.7831

Beginning of Injection	95.00	min
Injection Rate =	0.50	ml/min
Total Injection Time =	956.00	min
Water injected =	478.00	ml
Water recovered =	479.51	ml
Water lost	1.51	ml

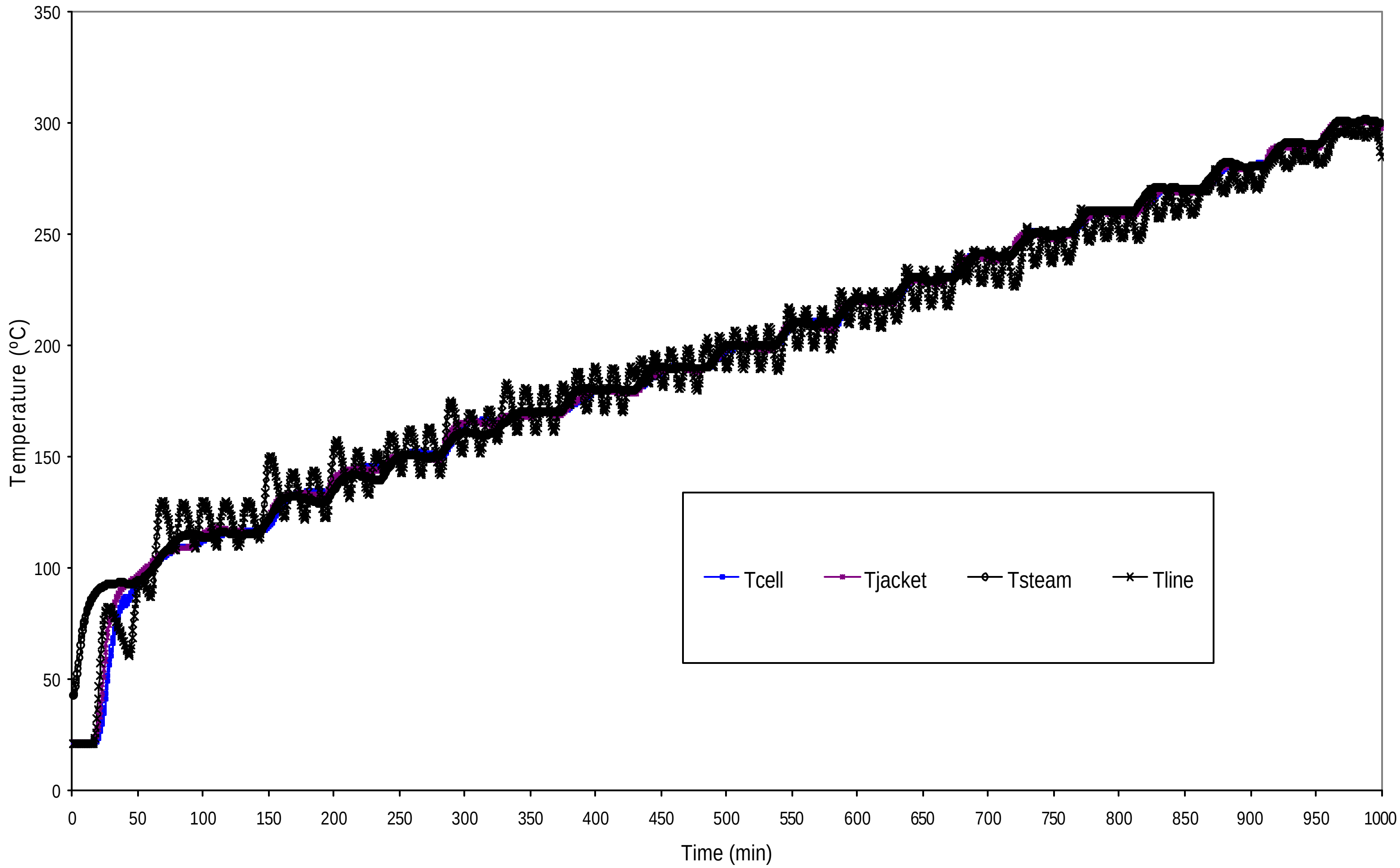


Fig. 5.61-Temperature vs. time (steam-propane distillation run no. 1).

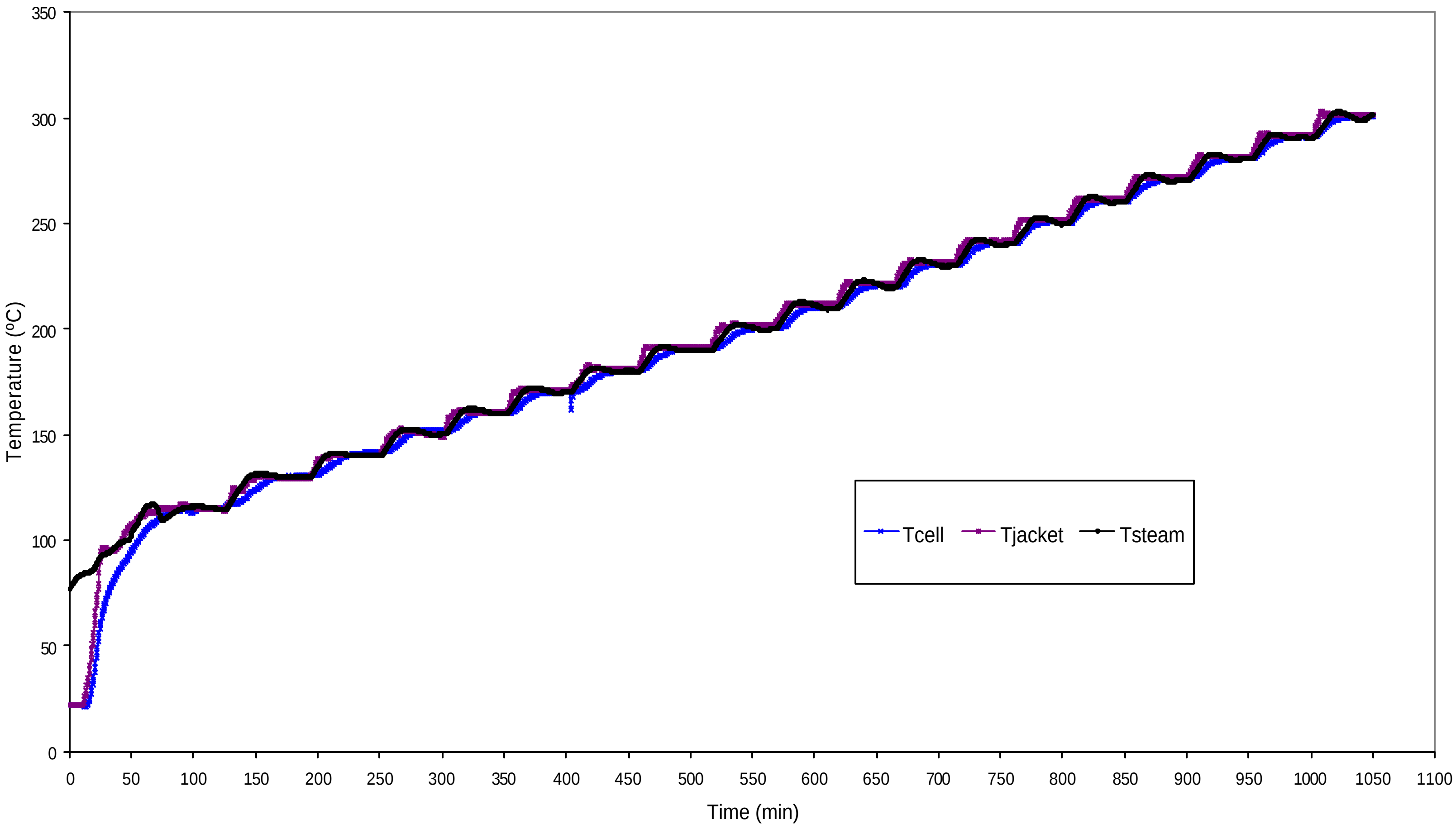


Fig. 5.62-Temperature vs. time (steam-propane distillation run no. 2).

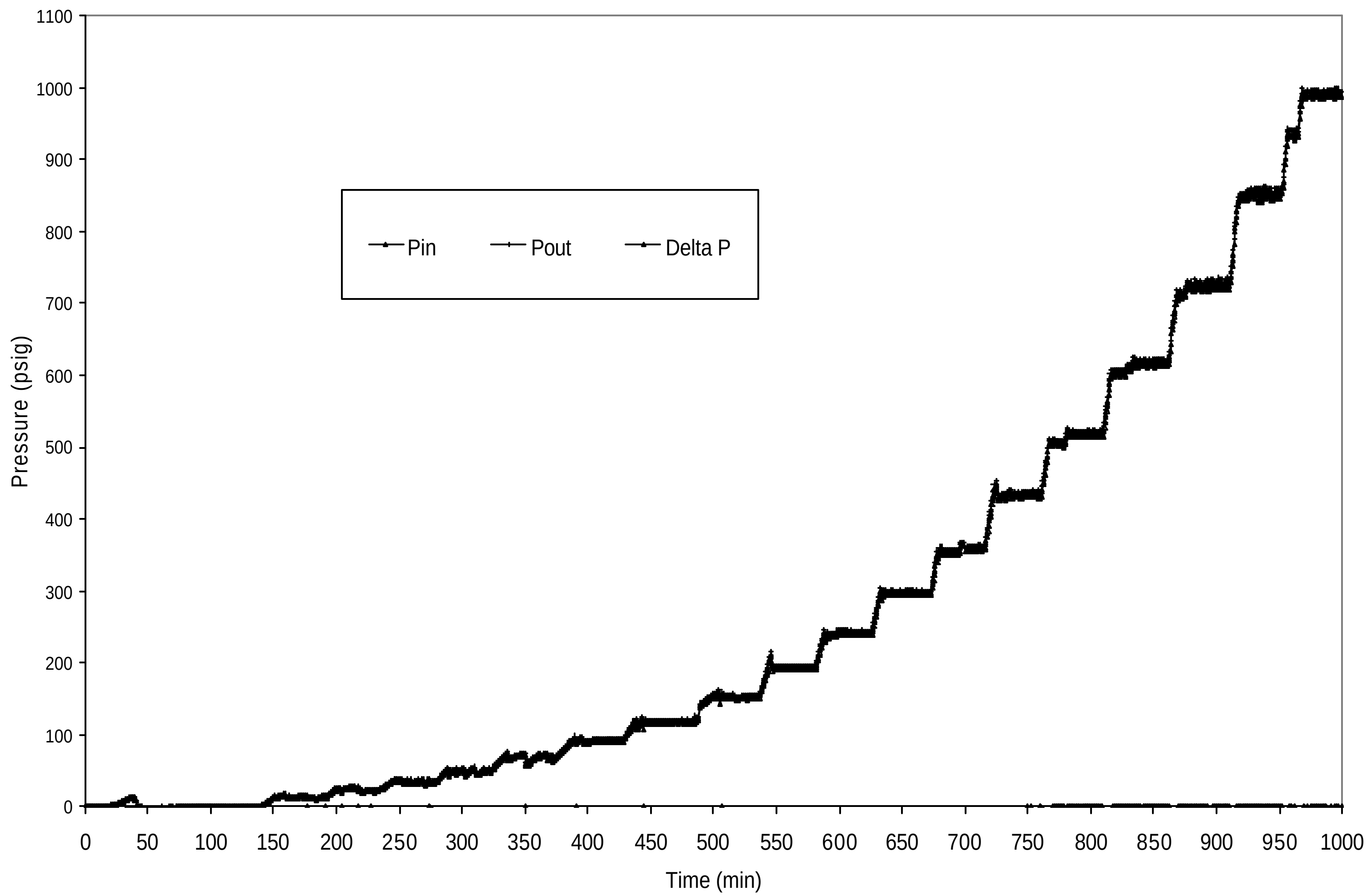


Fig. 5.63-Pressure vs. time (steam-propane distillation run no. 1).

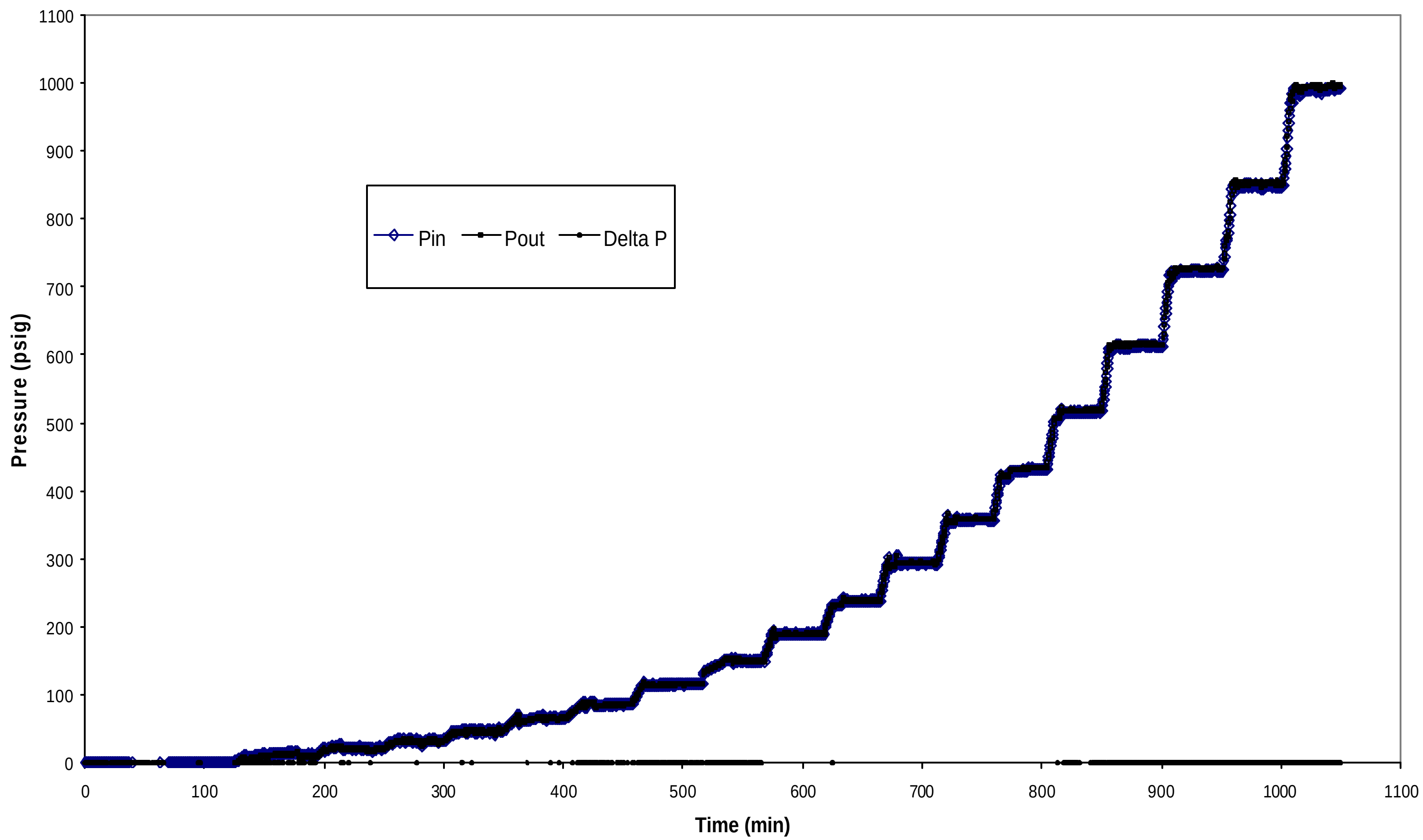


Fig. 5.64-Pressure vs. time (steam-propane distillation run no. 2).

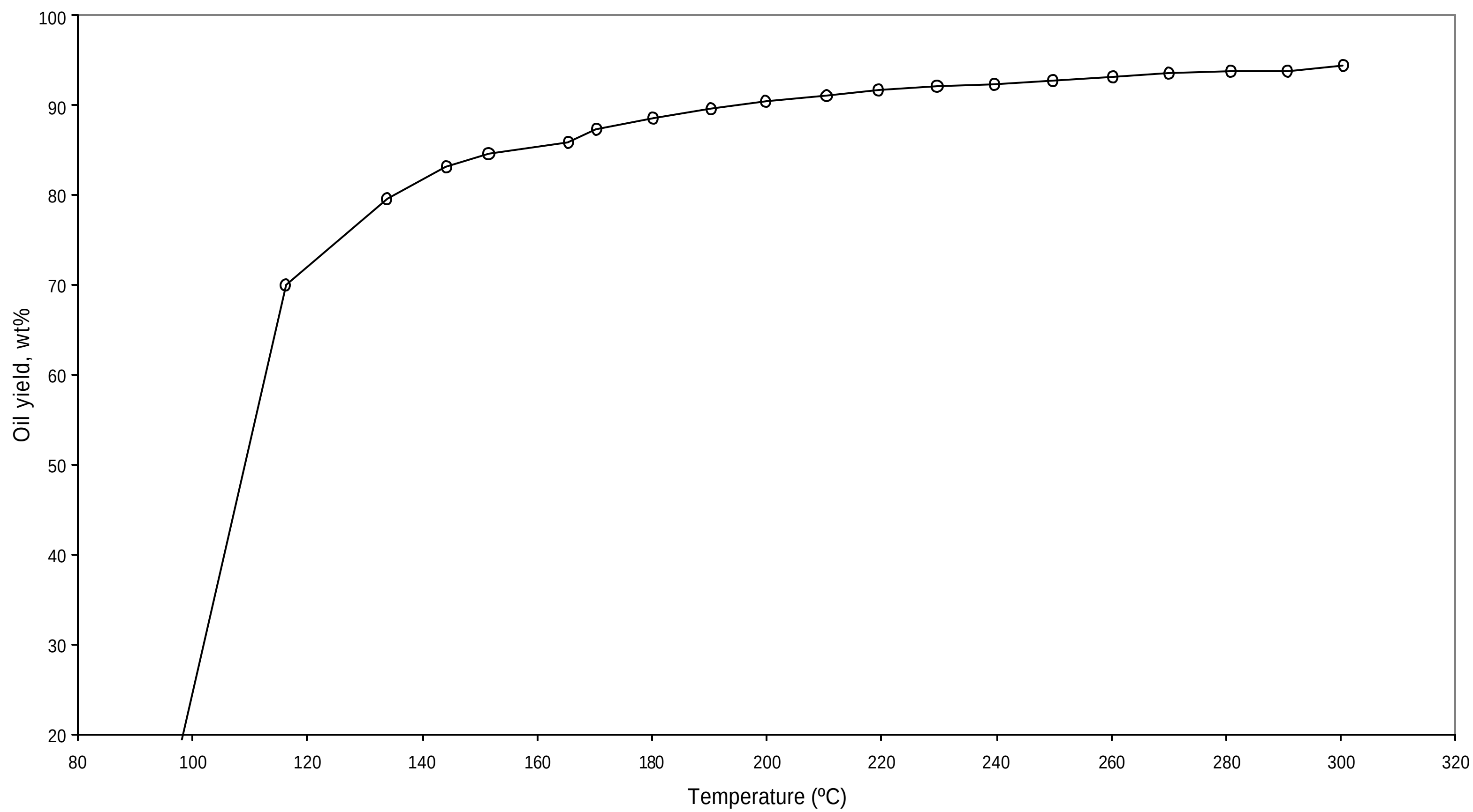


Fig. 5.65-Oil yield vs. time (steam-propane distillation run no. 1).

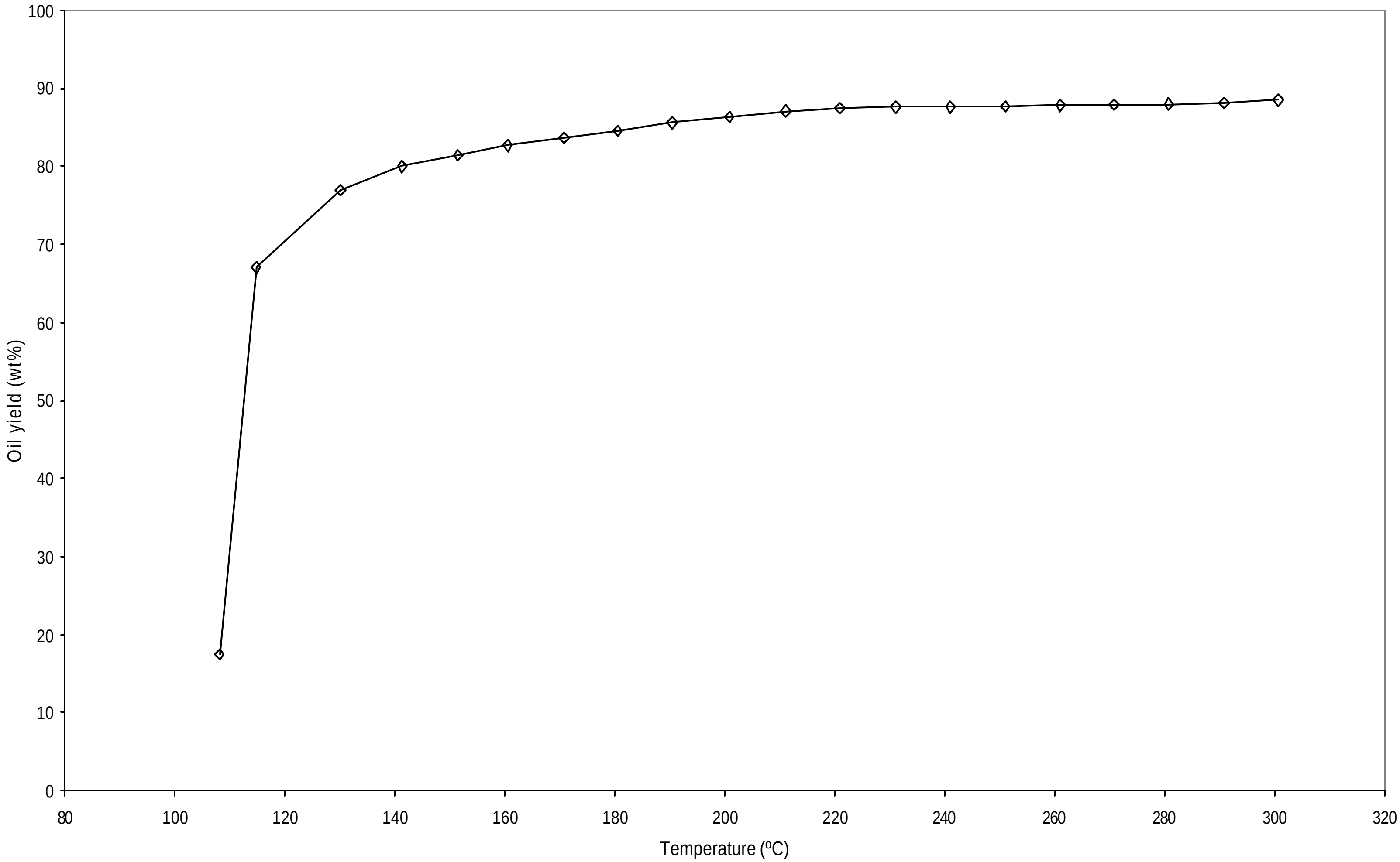


Fig. 5.66-Oil yield vs. time (steam-propane distillation run no. 2).

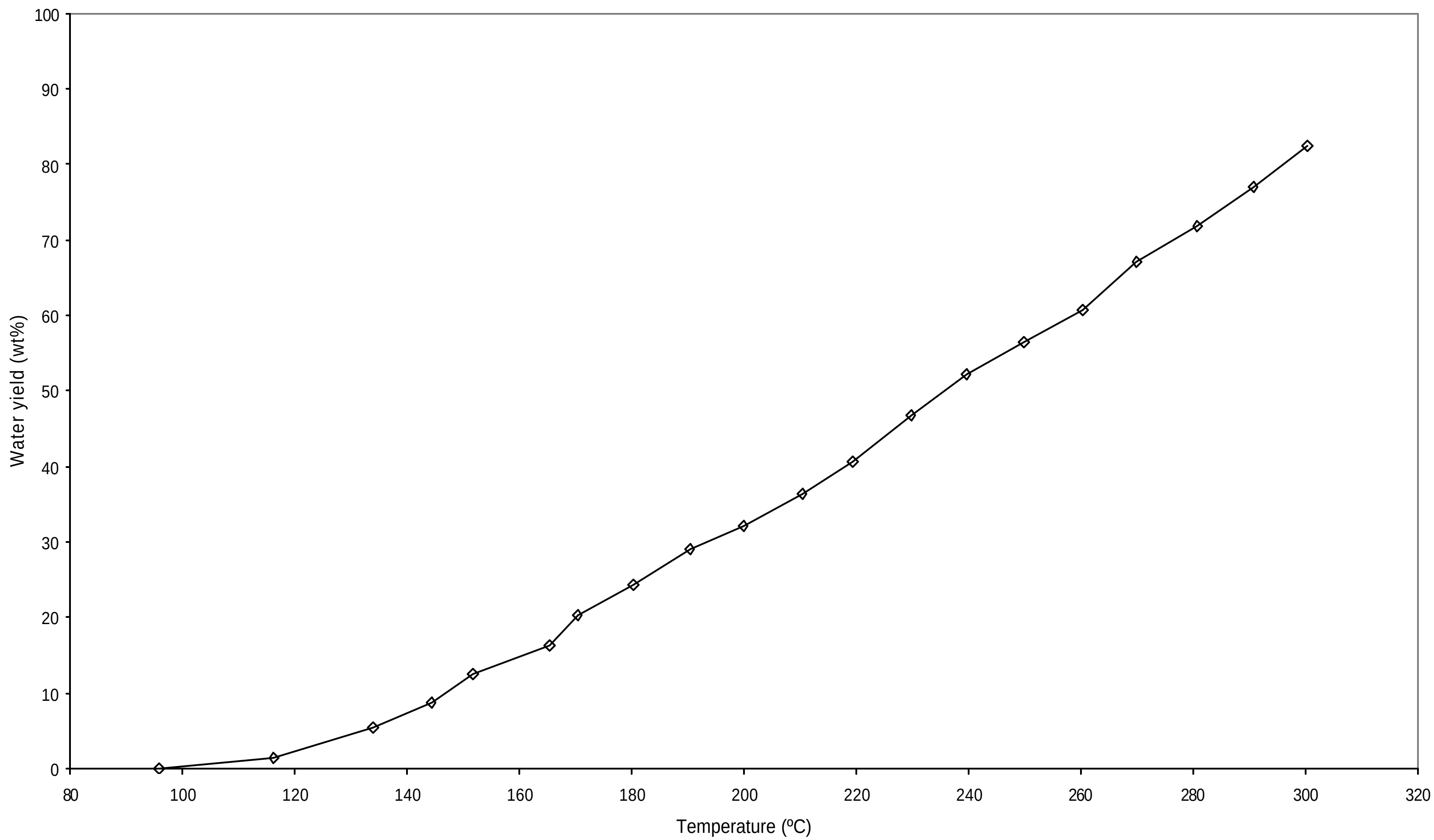


Fig. 5.67 - Water yield vs. time (steam-propane distillation run no. 1).

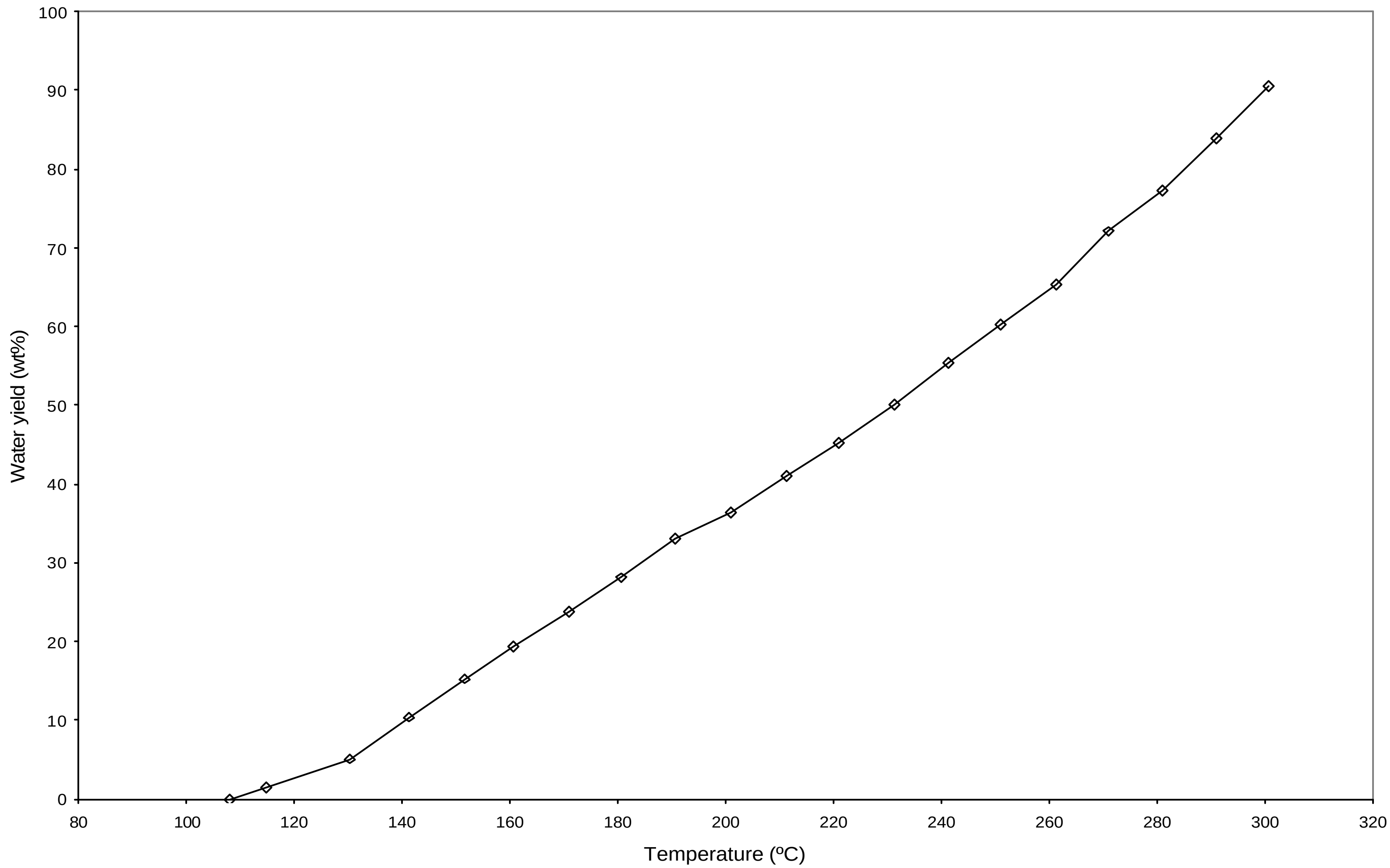


Fig. 5.68-Water yield vs. time (steam-propane distillation run no. 2).

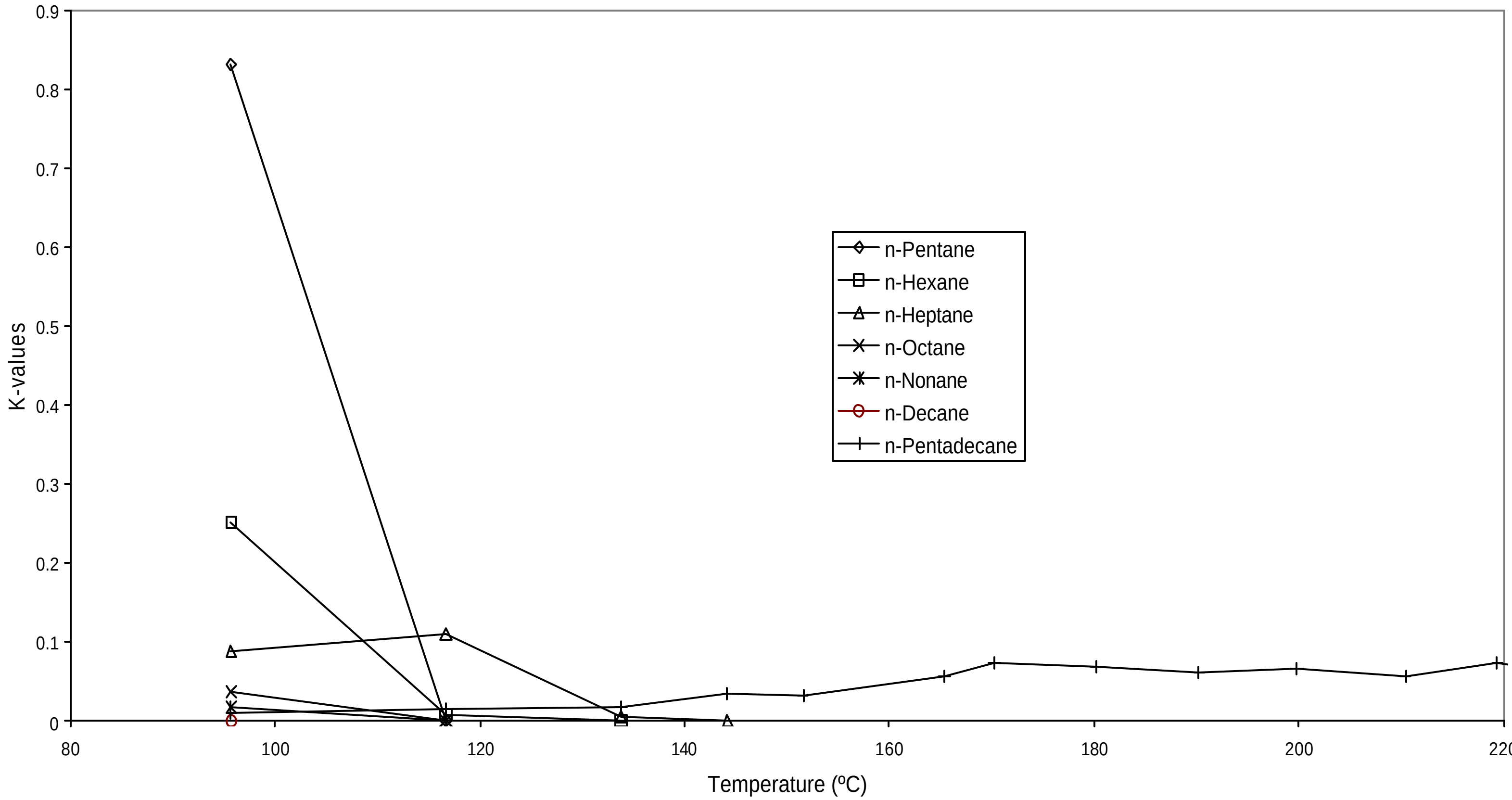


Fig. 5.69-Experimental *K*-values vs. temperature (steam-C_3 distillation run no. 1).

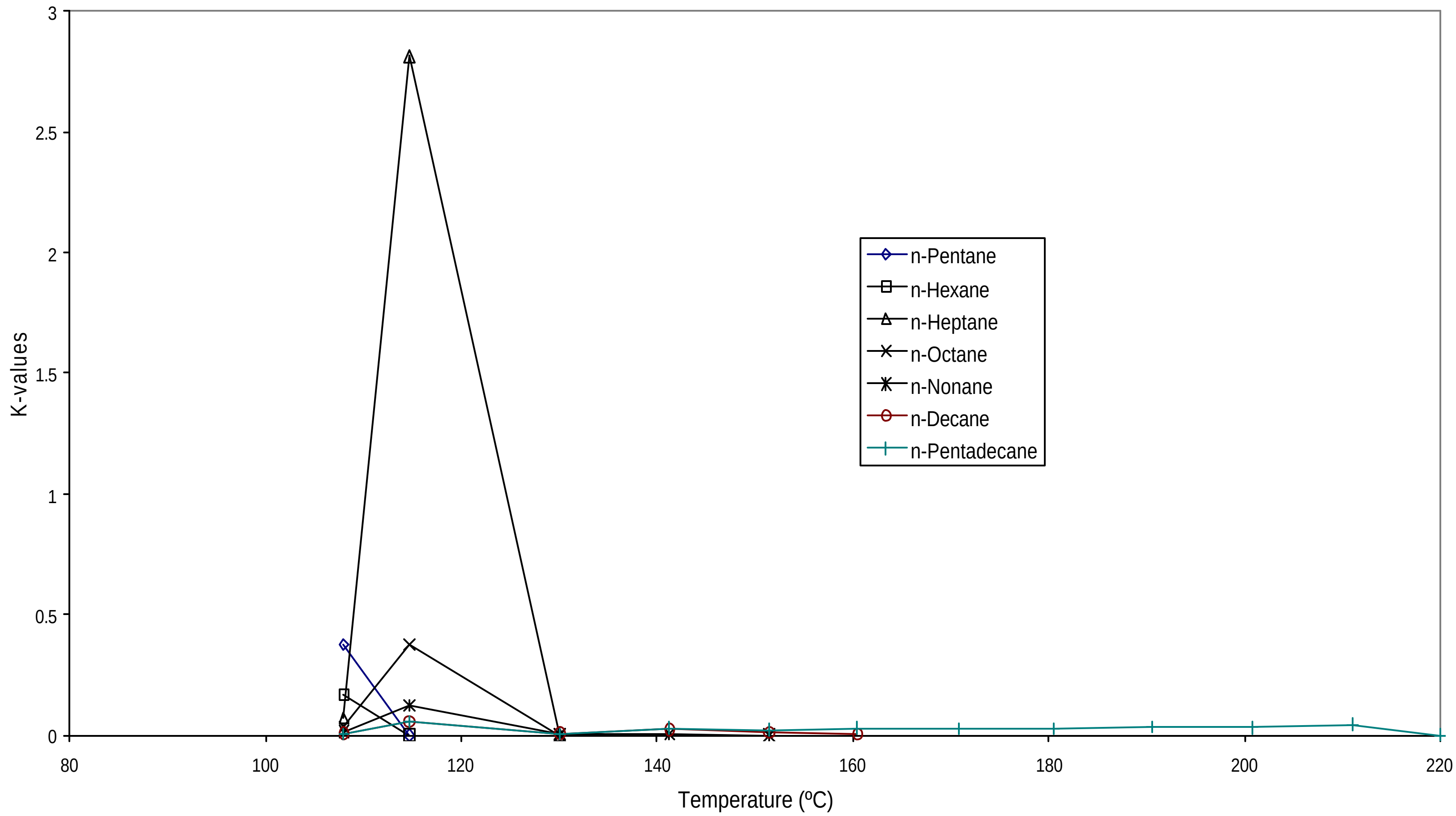


Fig. 5.70-Experimental *K*-values vs. temperature (steam-C_3 distillation run no. 2).

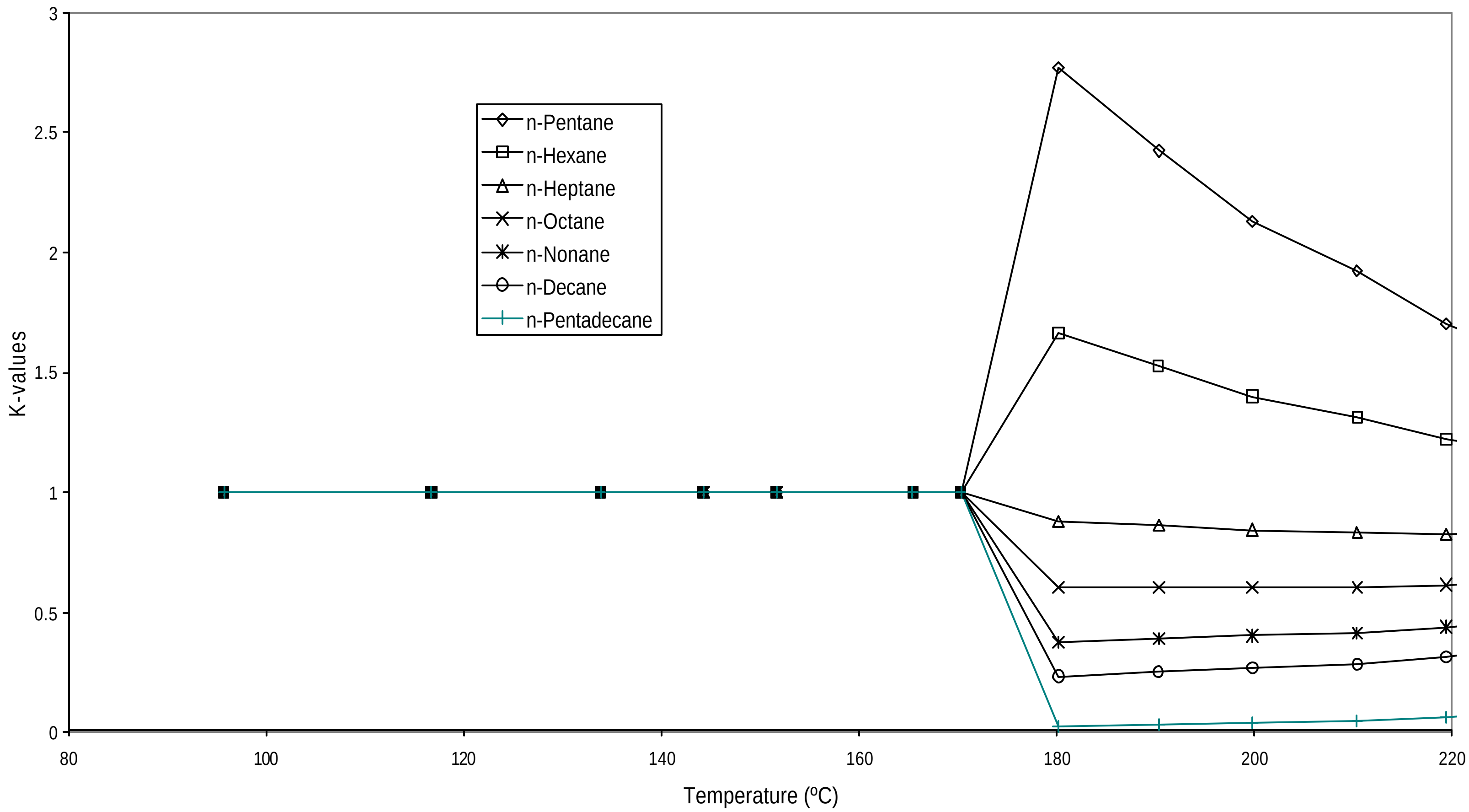


Fig. 5.71-Calculated *K*-values vs. temperature (steam- C_3 distillation run no. 1).

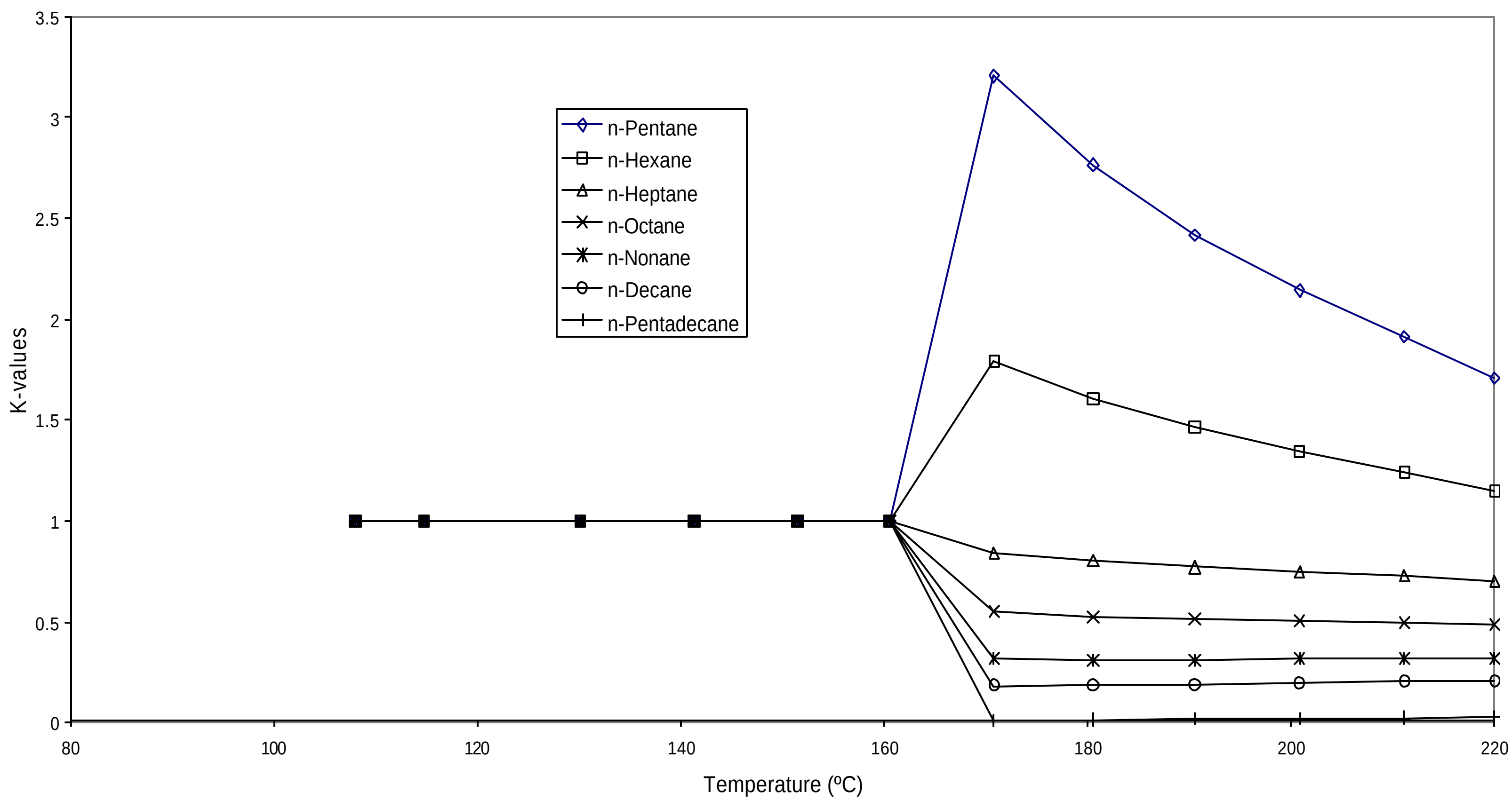


Fig. 5.72-Calculated *K*-values vs. temperature (steam- C_3 distillation run no. 2).

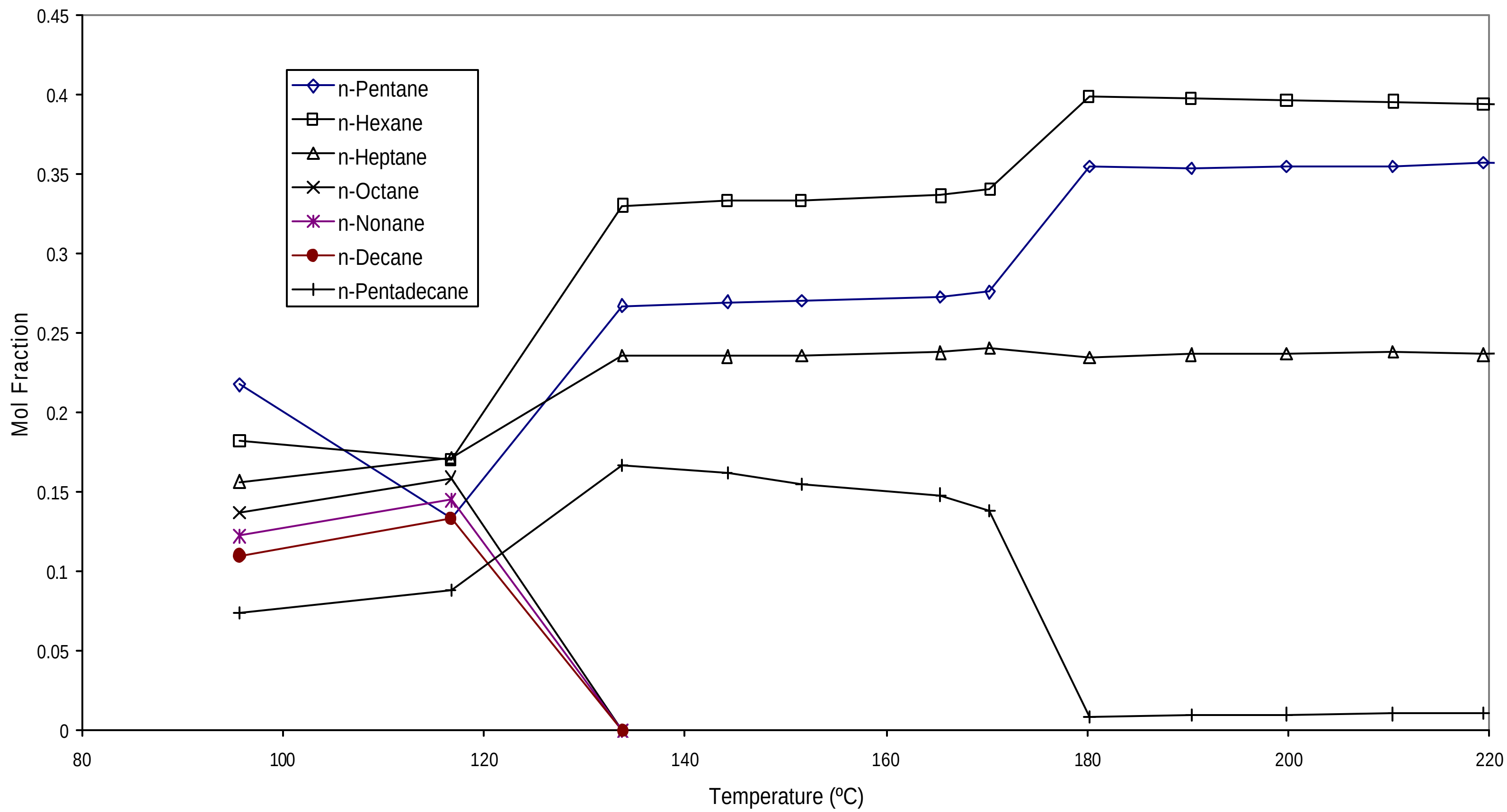


Fig. 5.73-Vapor composition vs. temperature (steam- C_3 distillation run no.1).

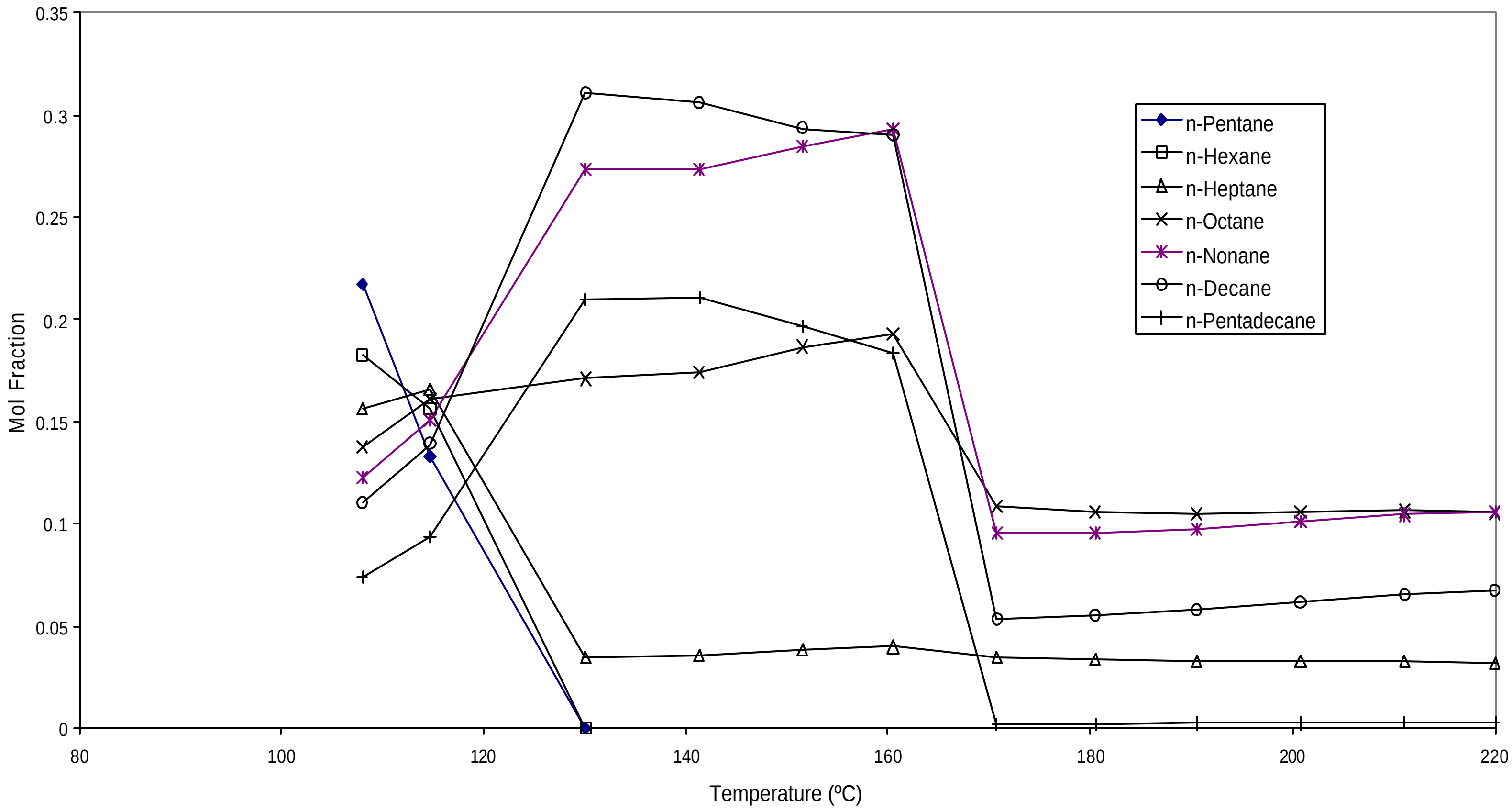


Fig. 5.74-Vapor composition vs. temperature (steam- C_3 distillation run no.2).

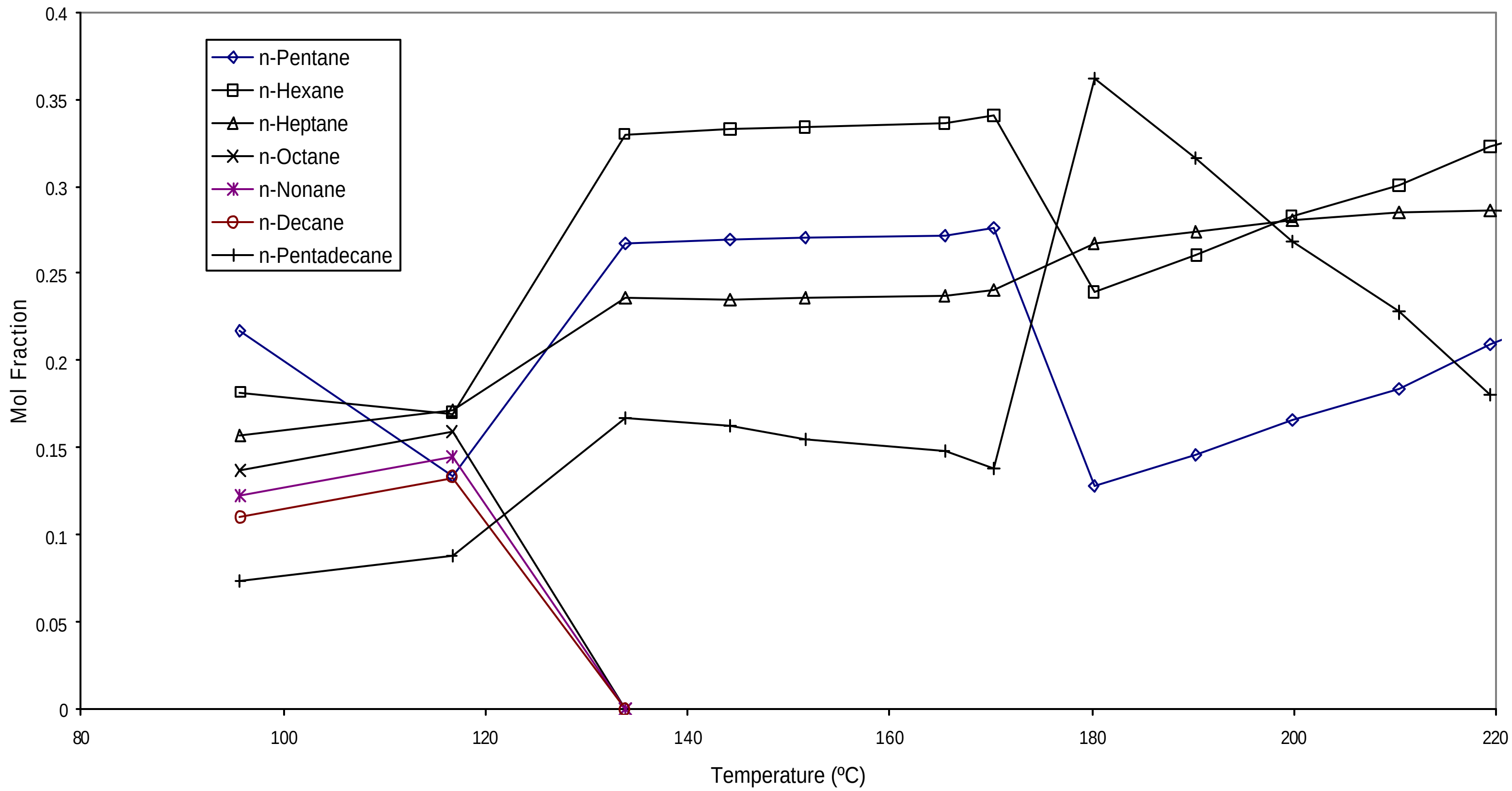


Fig. 5.75-Liquid composition vs. temperature (steam- C_3 distillation run no.1).

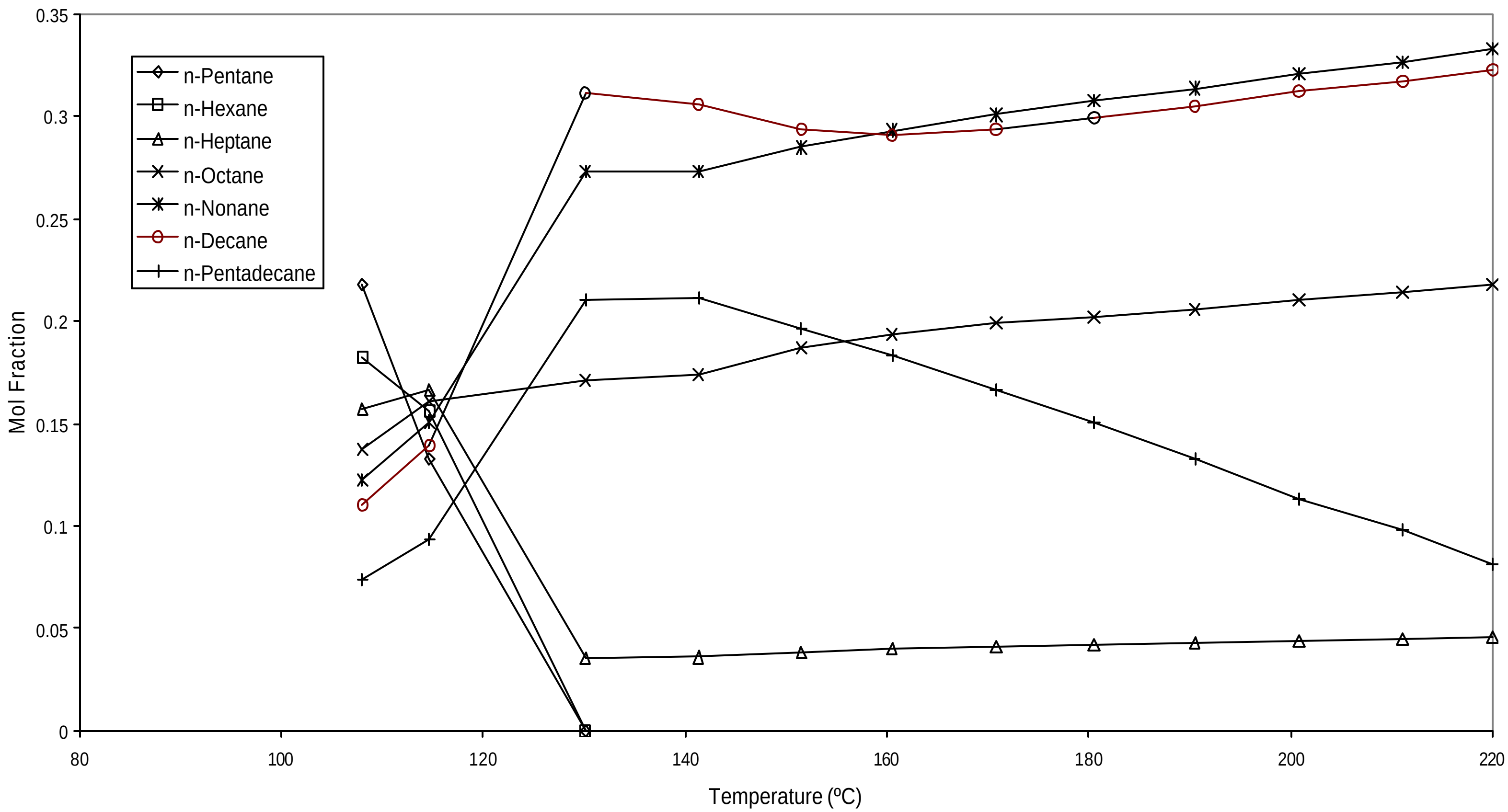


Fig. 5.76-Liquid composition vs. temperature (steam- C_3 distillation run no. 2).

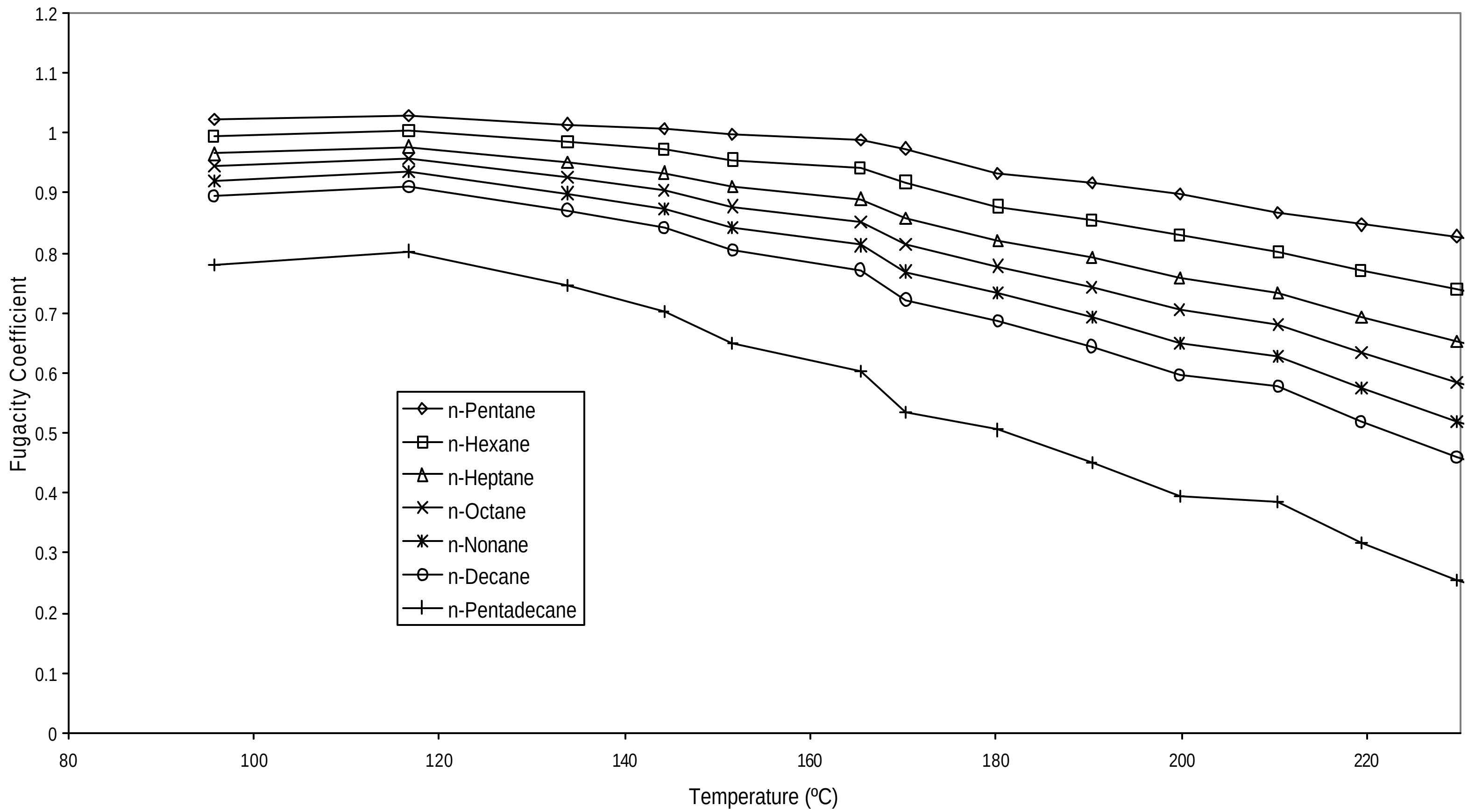


Fig. 5.77-Vapor fugacity coefficient vs. temperature (steam- C_3 distillation run no. 1).

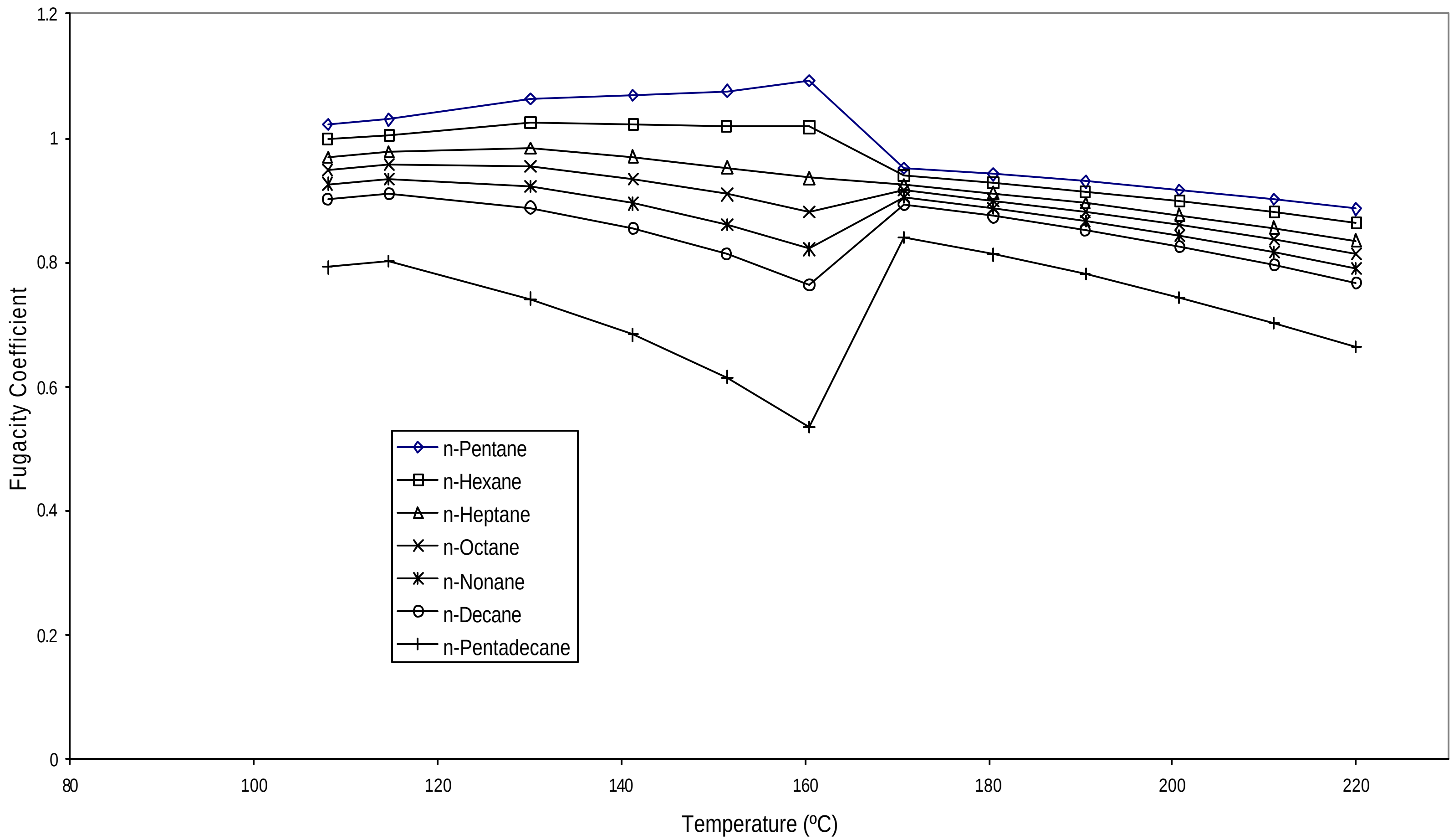


Fig. 5.78-Vapor fugacity coefficient vs. temperature (steam- C_3 distillation run no. 2).

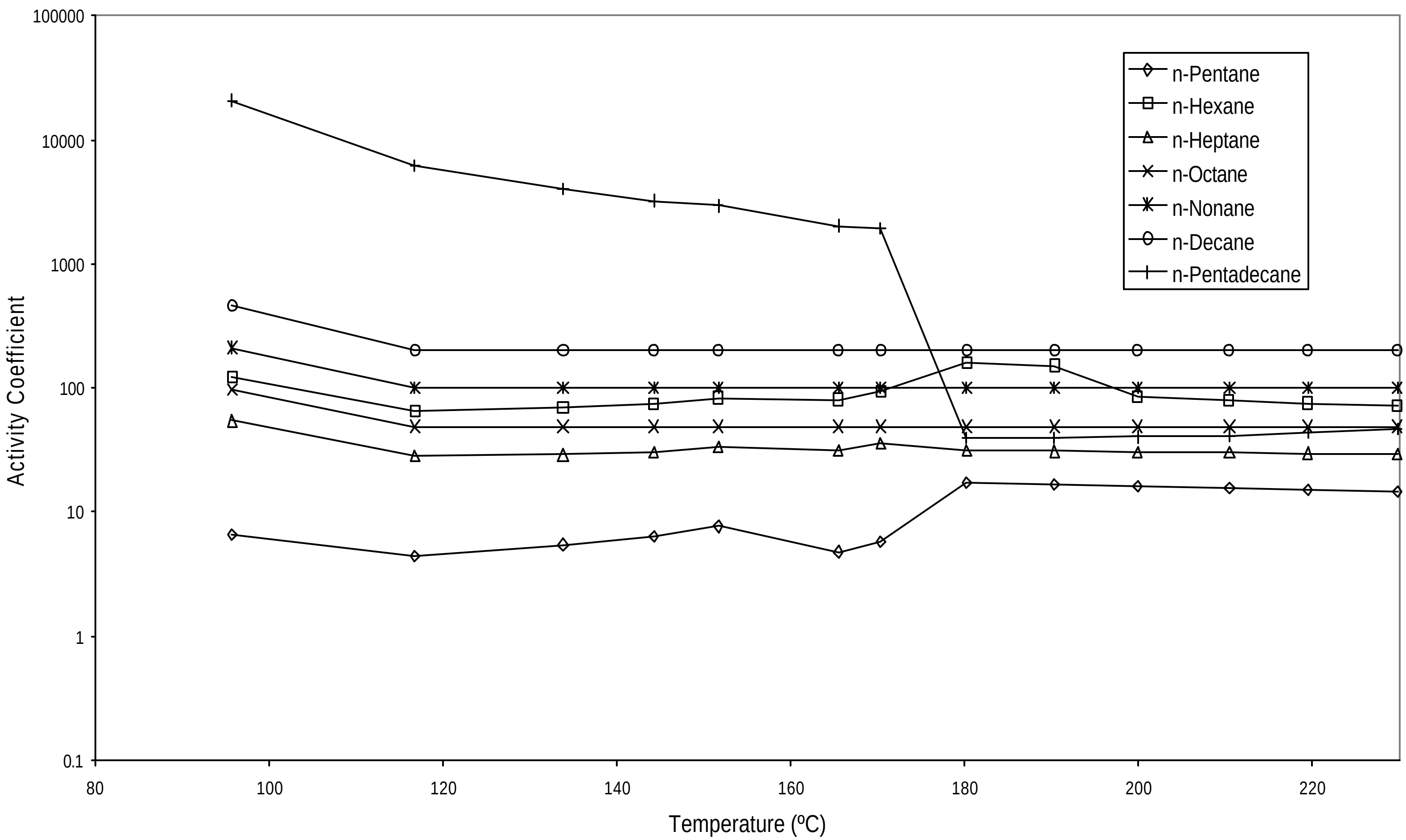


Fig. 5.79-Activity coefficient vs. temperature (steam- C_3 distillation run no. 1).

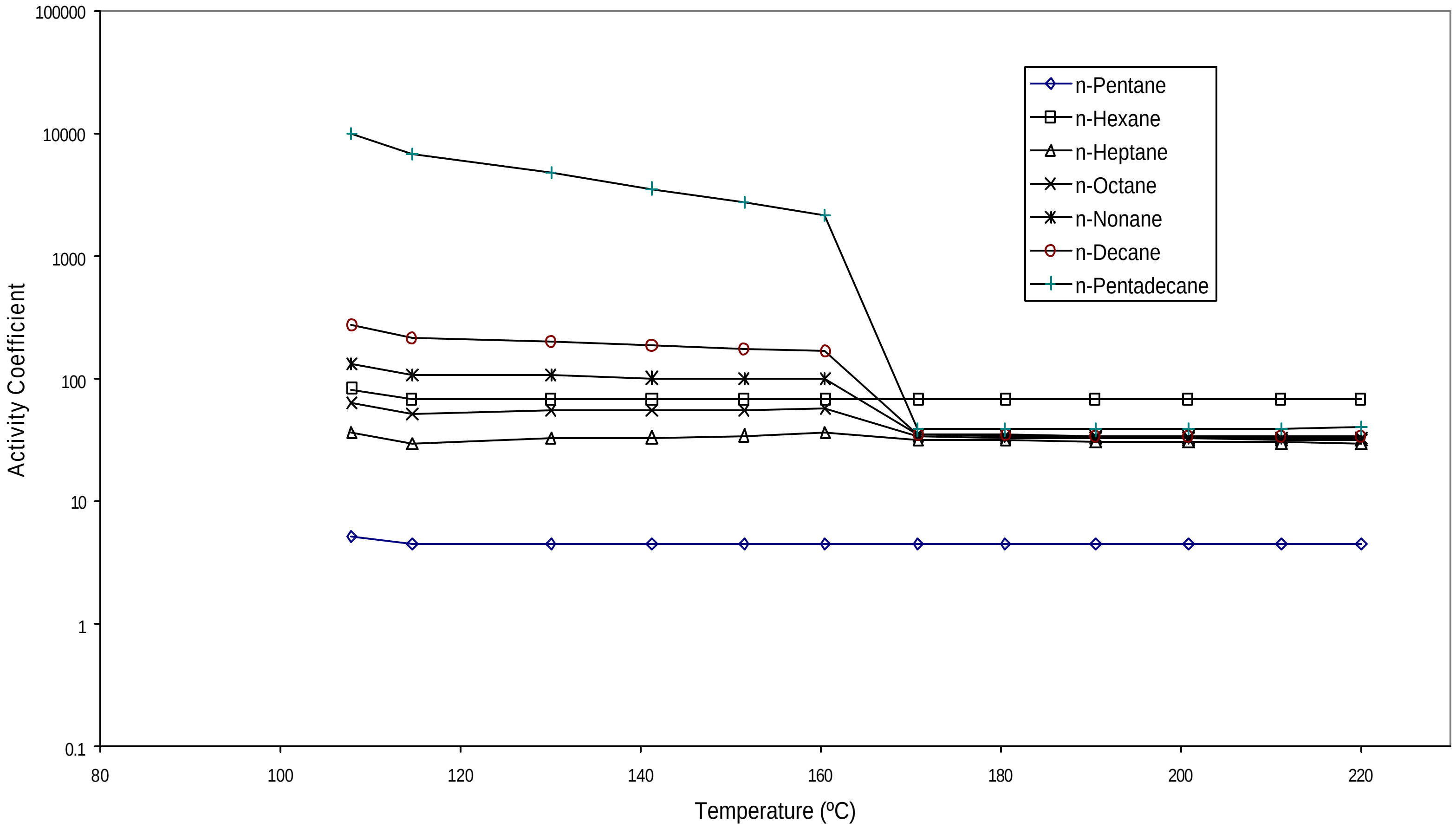


Fig. 5.80-Activity coefficient vs. temperature (steam- C_3 distillation run no. 2).

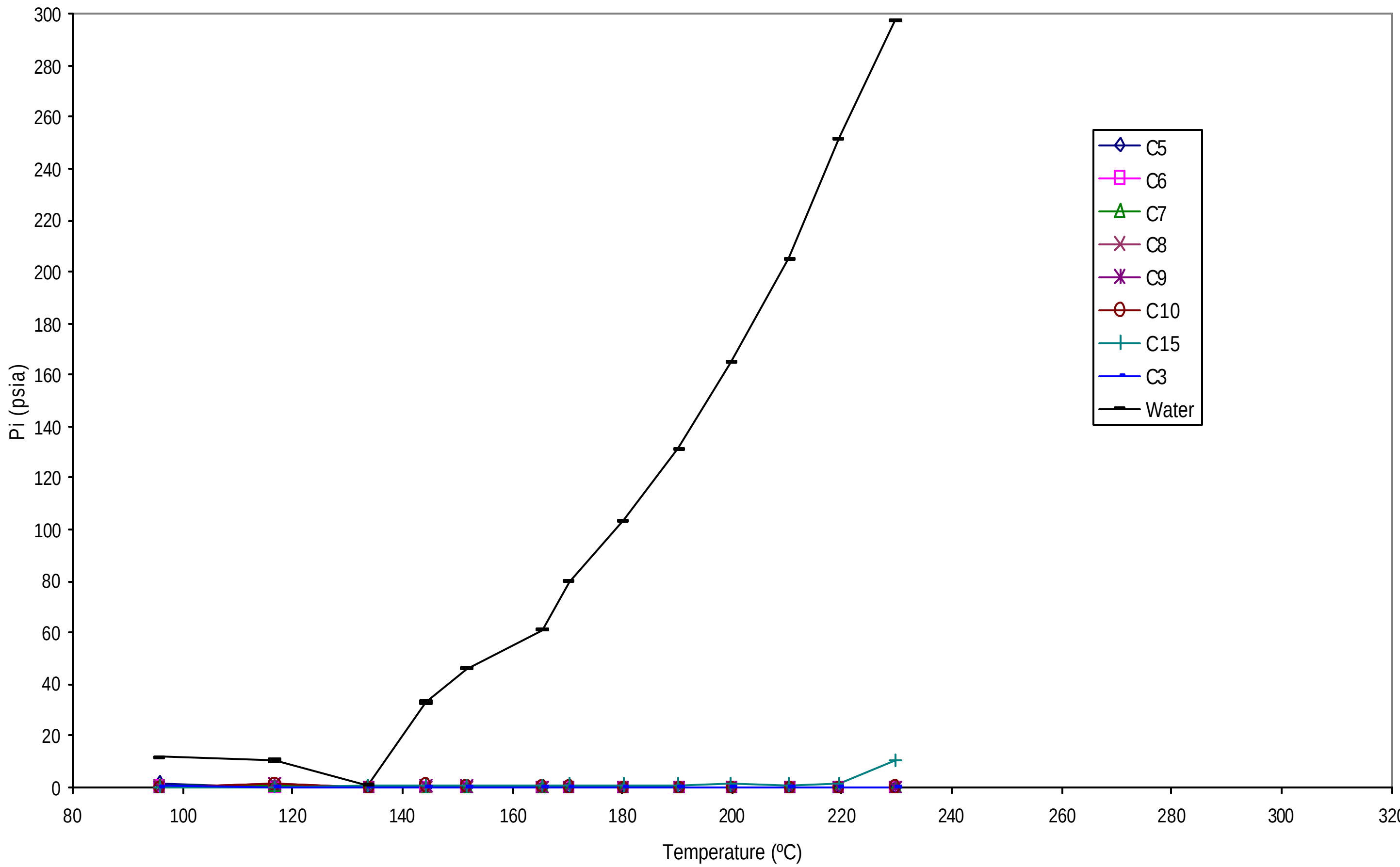


Fig. 5.81-Partial pressure vs. temperature (steam- C_3 distillation run no. 1).

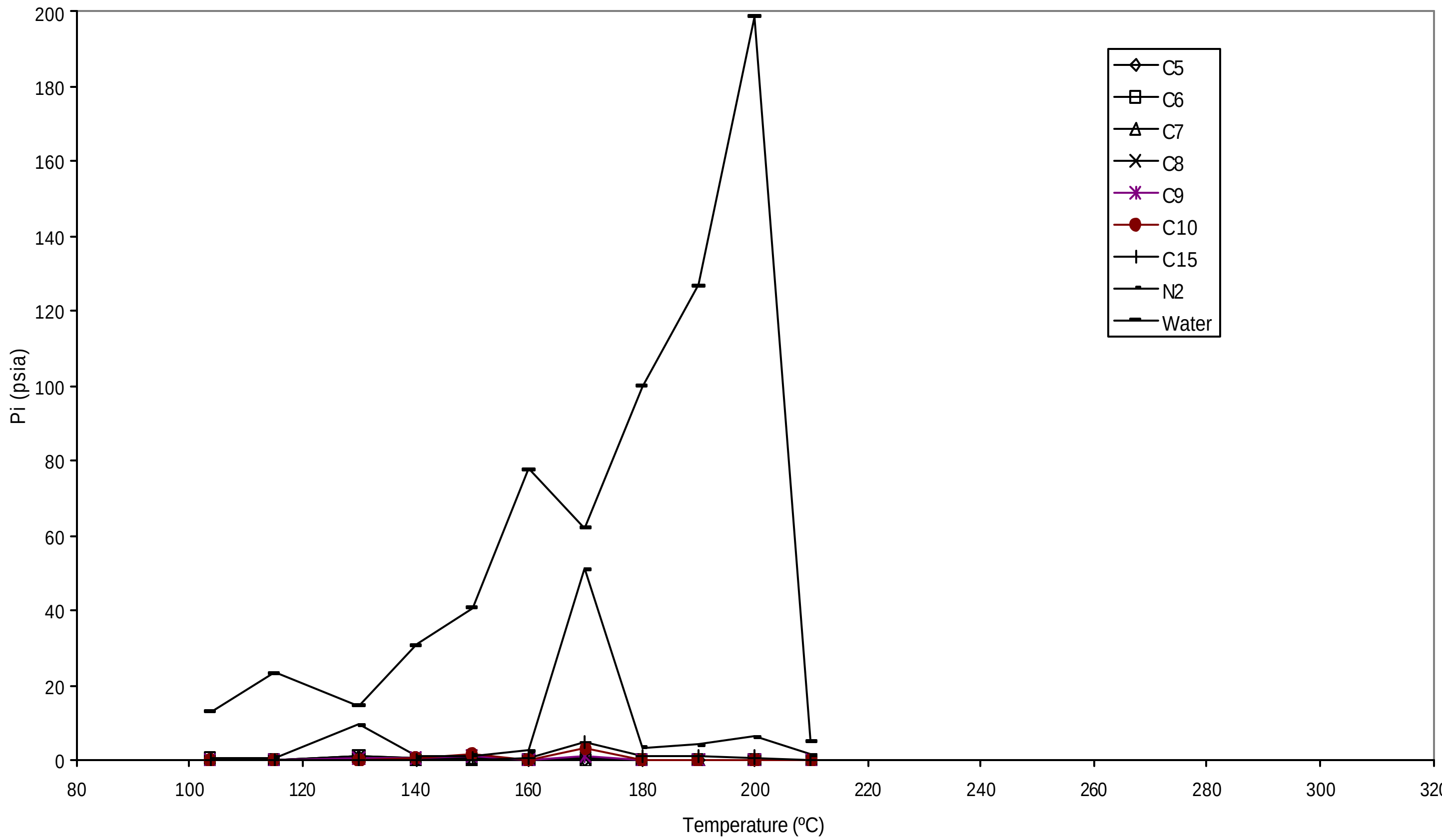


Fig. 5.82-Partial pressure vs. temperature (steam- C_3 distillation run no. 2).

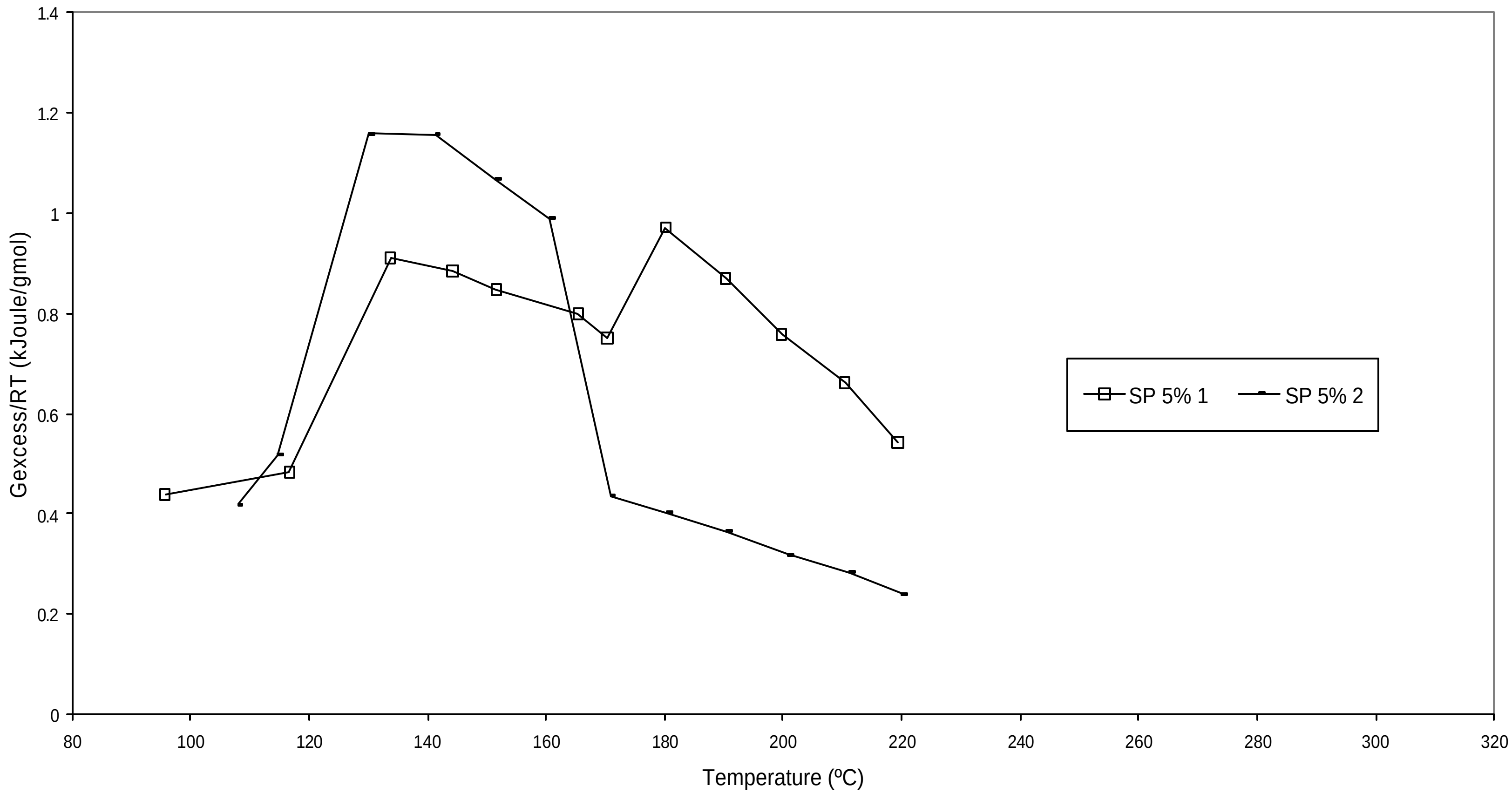


Fig. 5.83-Gibbs excess energy vs. temperature (steam- C_3 distillation run nos. 1, 2).

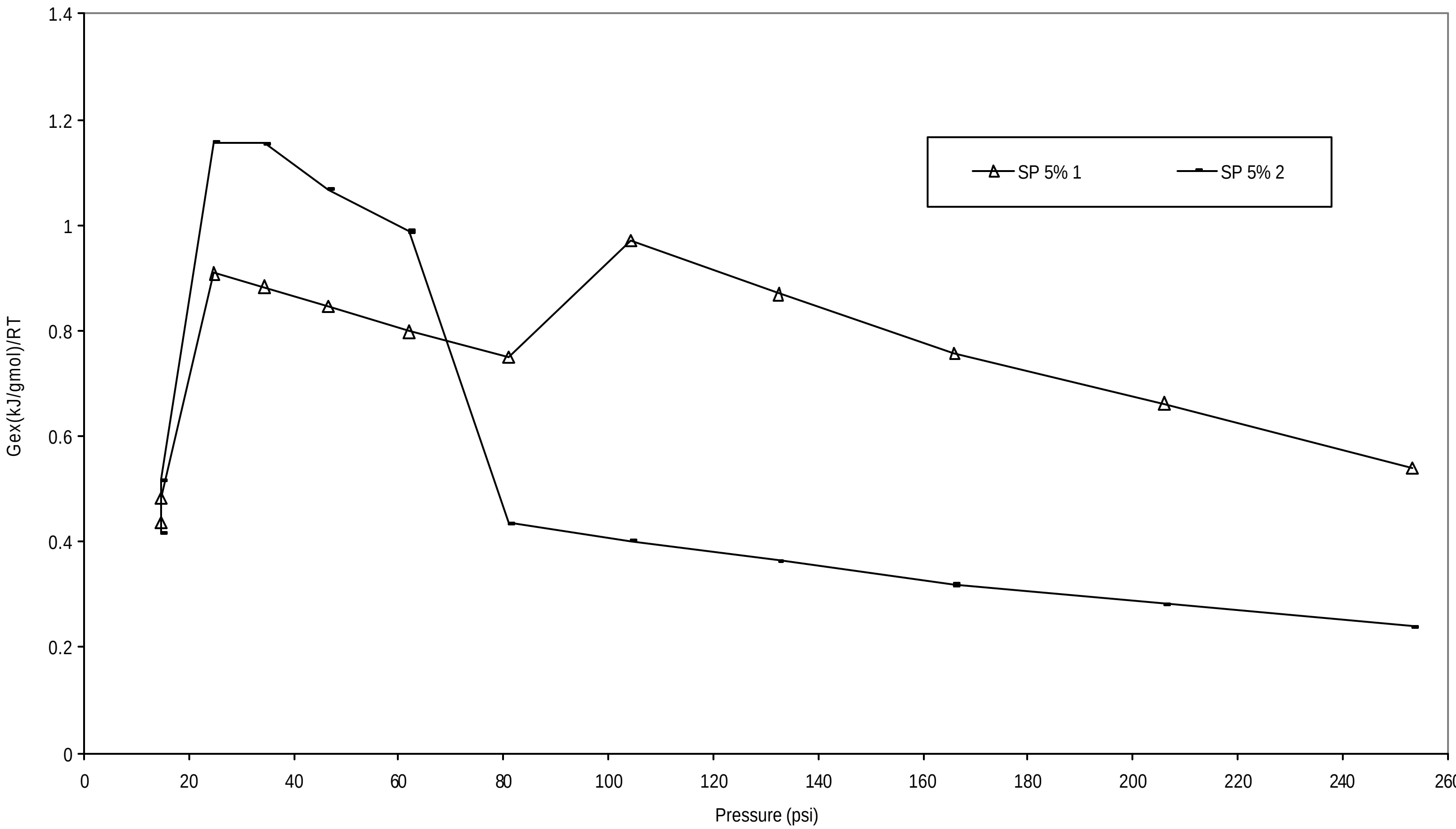


Fig. 5.84-Gibbs excess energy vs. pressure (steam- C_3 distillation run nos. 1, 2).

5.4 Comparison and discussion of experimental results

The individual run average oil yields for each distillation, type is shown in **Figs. 5.85-5.86**. As can be seen from these plots, the oil yield with steam-propane distillation is higher than with steam distillation and even much higher than with dry distillation. In order to see clearer the results of the distillations process, a set of plots of weight versus temperature for each component is shown in the **Figs. 5.87-5.88**. In these plots the normal boiling at 1 atmosphere for each compound is represented by a vertical line for comparison. From these plots one can see that the steam-propane distillations are completed before steam and dry distillation. In addition, for n-octane until n-pentadecane, the peaks of yields with steam-propane are higher than with steam or dry distillation.

Figures 5.89-5.91 show the experimental pseudo *K*-values for dry-, steam-, and steam-propane distillation. We can observe that in general the *K*-values decrease from dry to steam-propane distillation; however, the *K*-value trend is completed much earlier in the case of steam-propane distillation. Having the lowest boiling point, n-pentane shows the highest value. In **Figs. 5.92-5.99**, one can see the changes of vapor fugacity coefficient for each component for each type of distillation. Comparison of vapor fugacity coefficients show that, from n-heptane until n-pentadecane, fugacity coefficient values are higher in steam-propane distillation than in dry- and steam distillation. Activity coefficients during the three distillations for each component are shown in **Figs. 5.100-5.107.** These plots show activity coefficients being higher in steam and steam-propane distillations from the beginning of the distillation. Finally the curves of Gibbs excess energy for the three distillation types show Gibbs excess energy to decrease continuously with increase in temperature (Figs**. 5.108-5.113**).

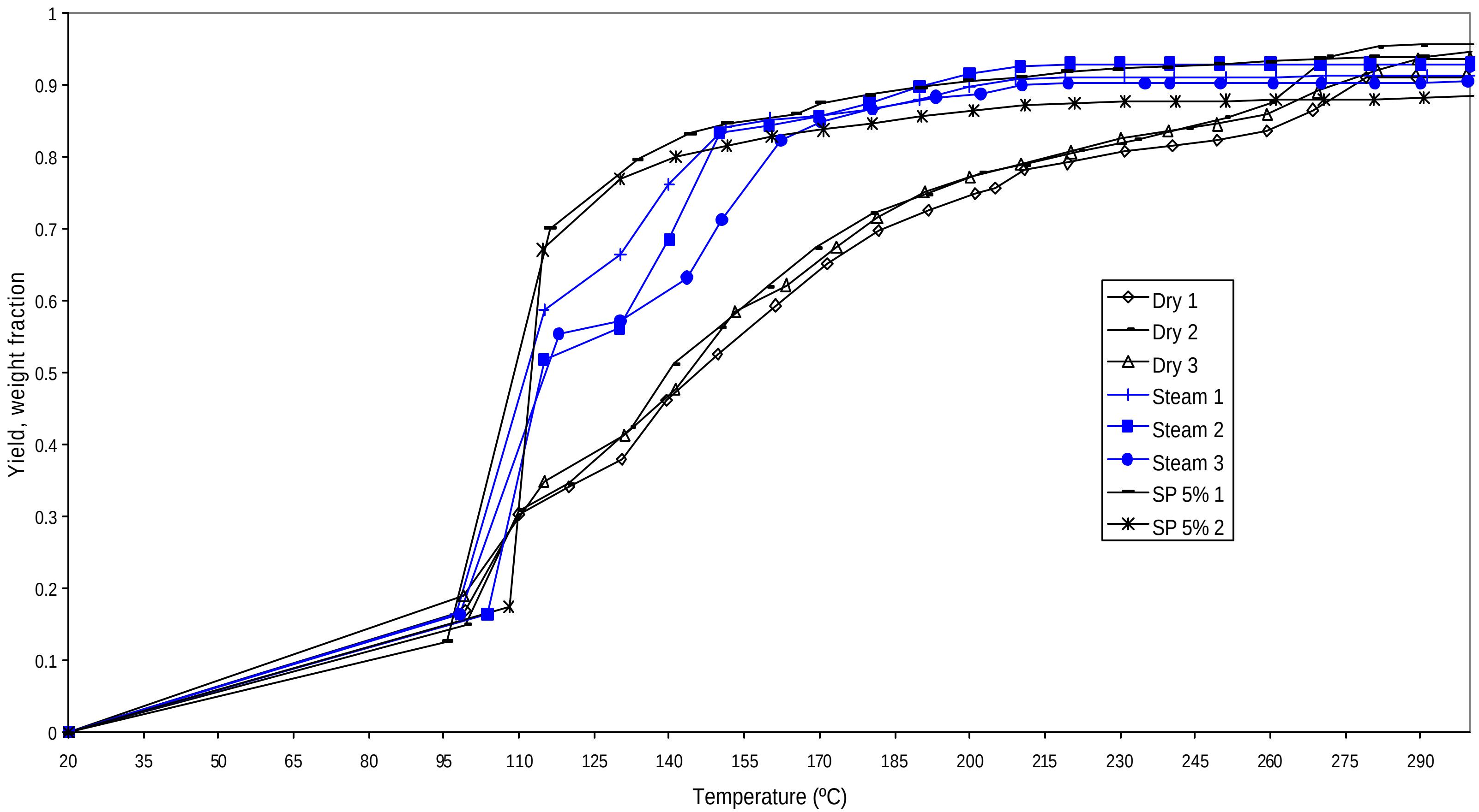


Fig. 5.85-Oil yield vs. temperature (dry-, steam-, steam- C_3 distillations).

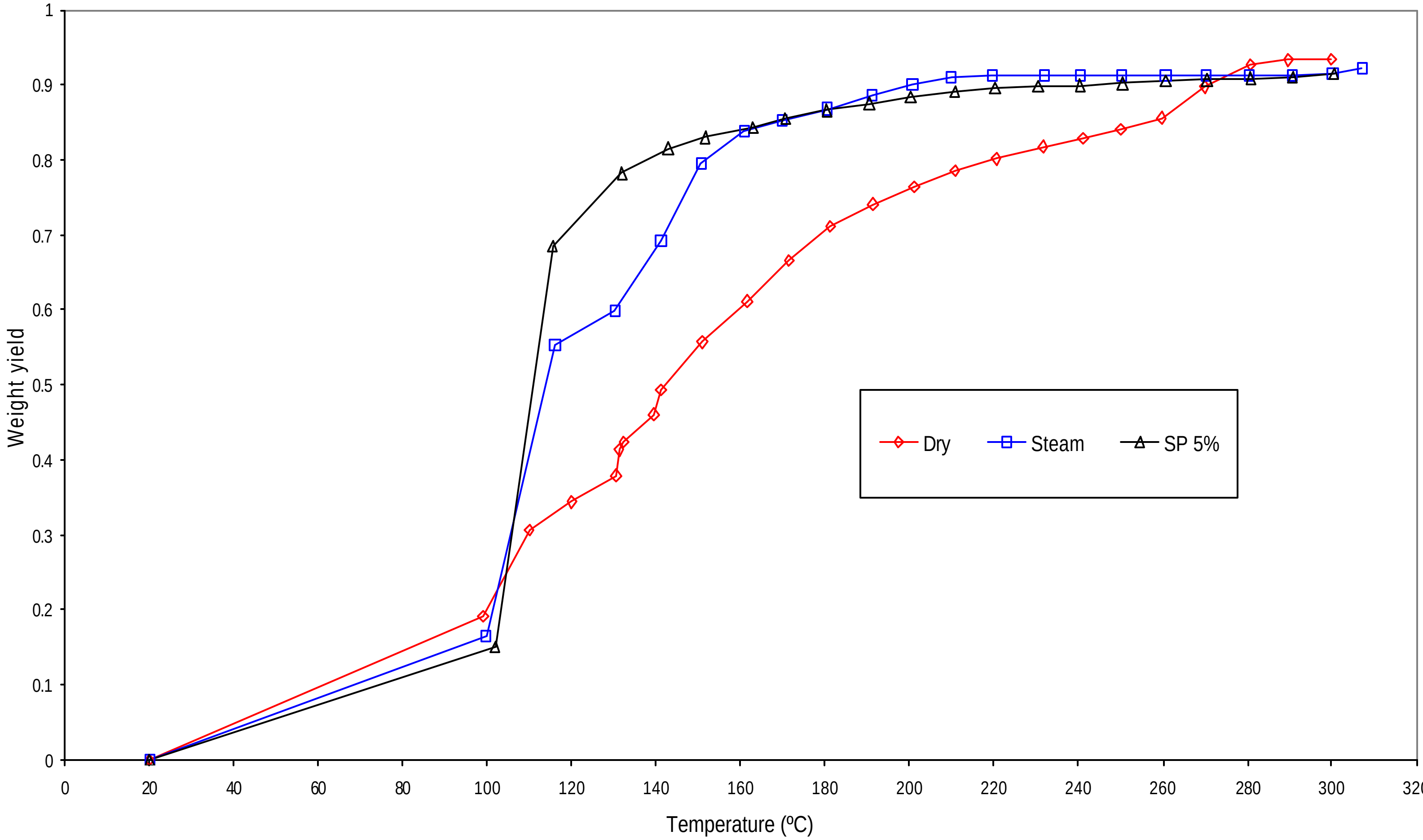


Fig. 5.86-Oil yield average vs. temperature (dry-, steam-, steam- C_3 distillations).

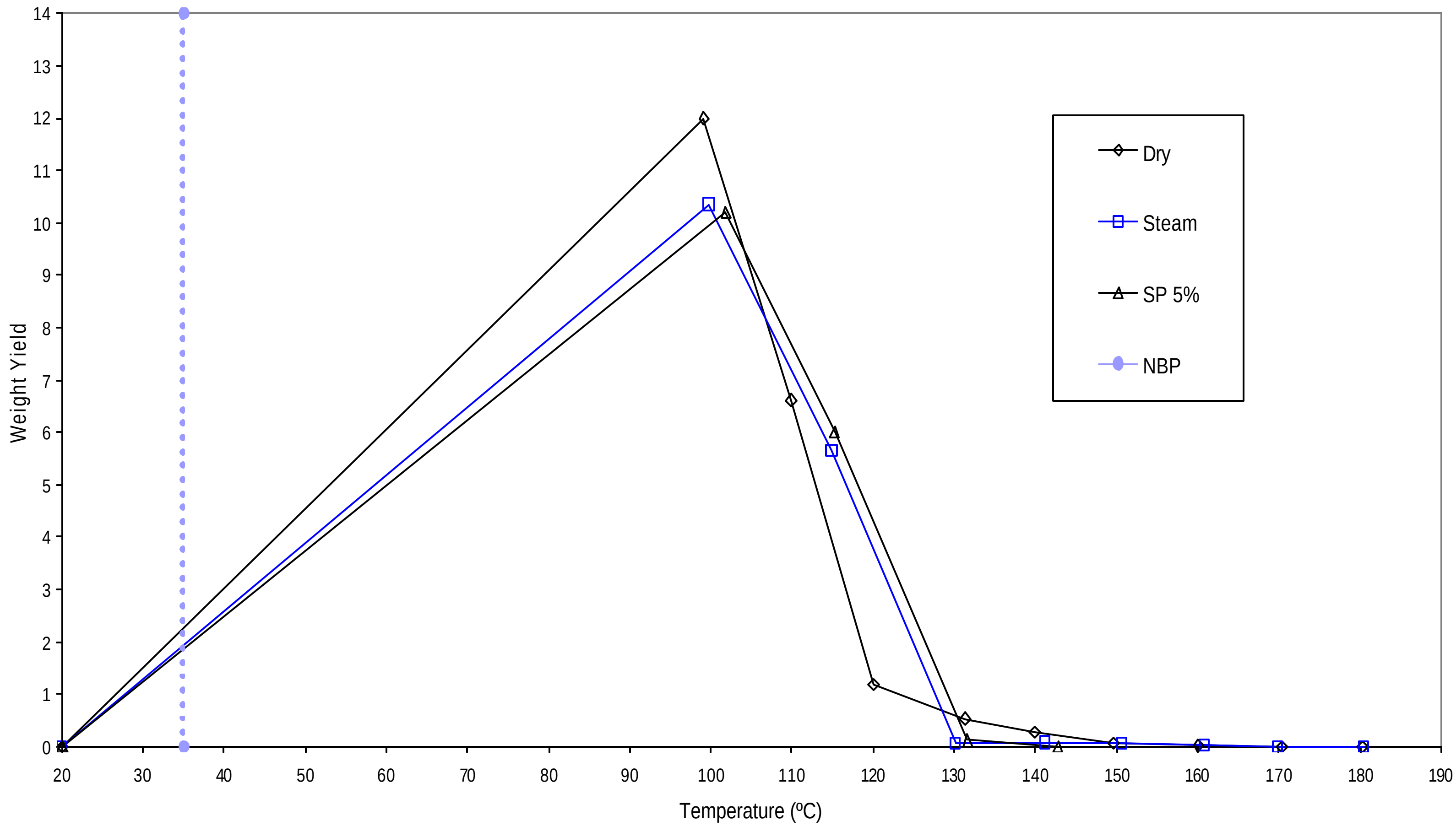


Fig. 5.87-n-C5 weight yield average vs. temperature (dry-, steam-, steam- C_3 distillation).

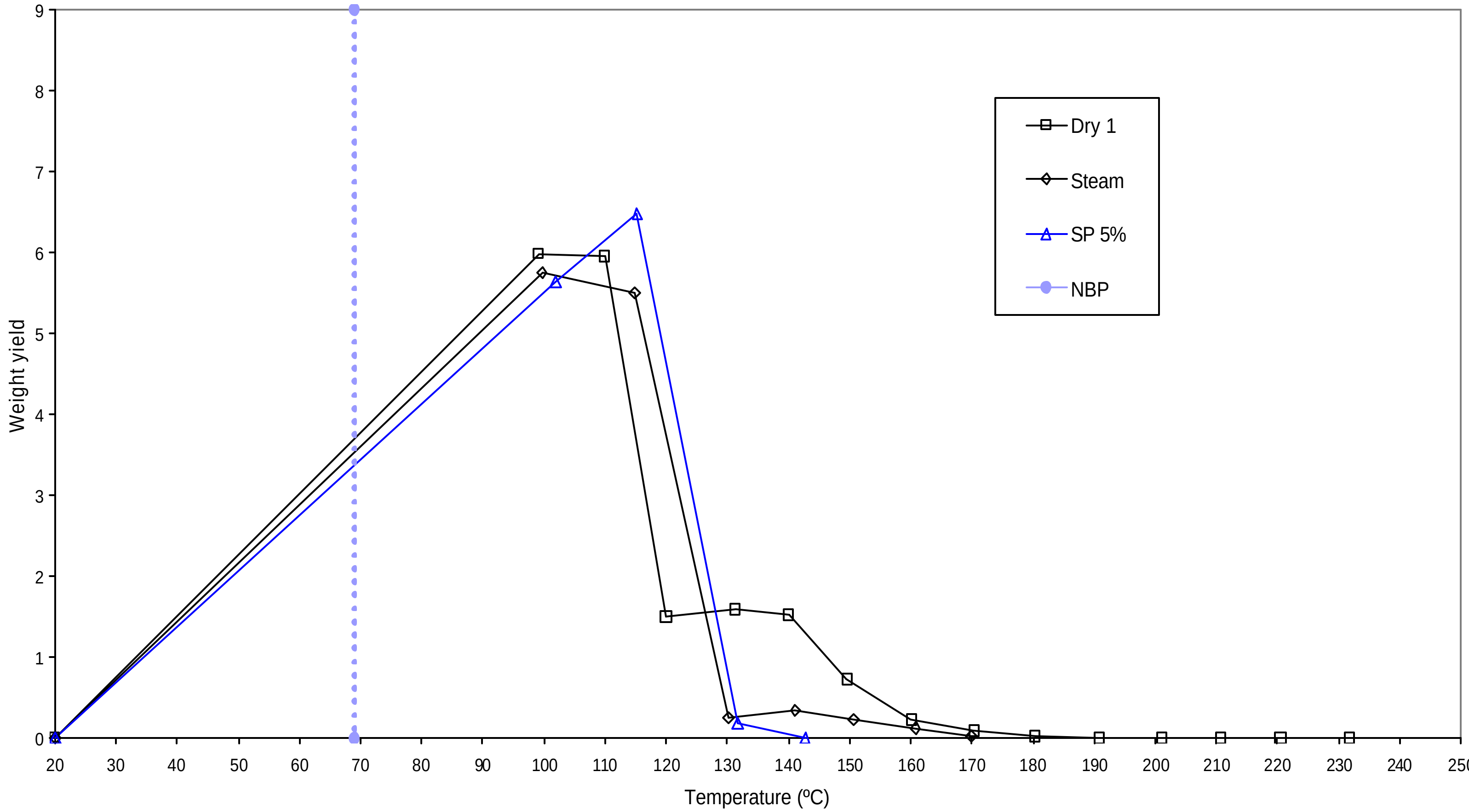


Fig. 5.88-n-C6 weight yield average vs. temperature (dry-, steam-, steam- C_3 distillation).

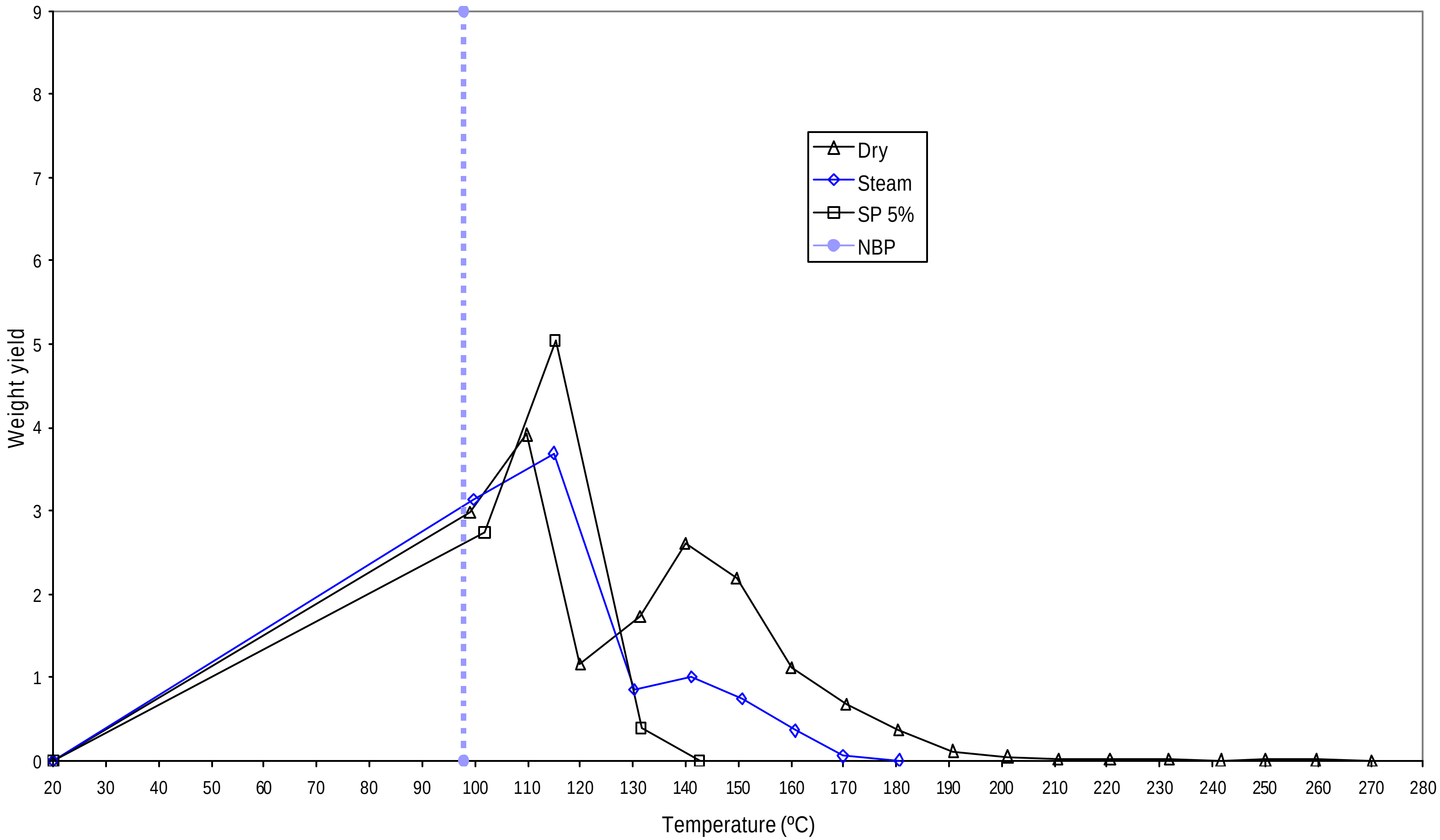


Fig. 5.89-n-C7 weight yield average vs. temperature (dry-, steam-, steam- C_3 distillation).

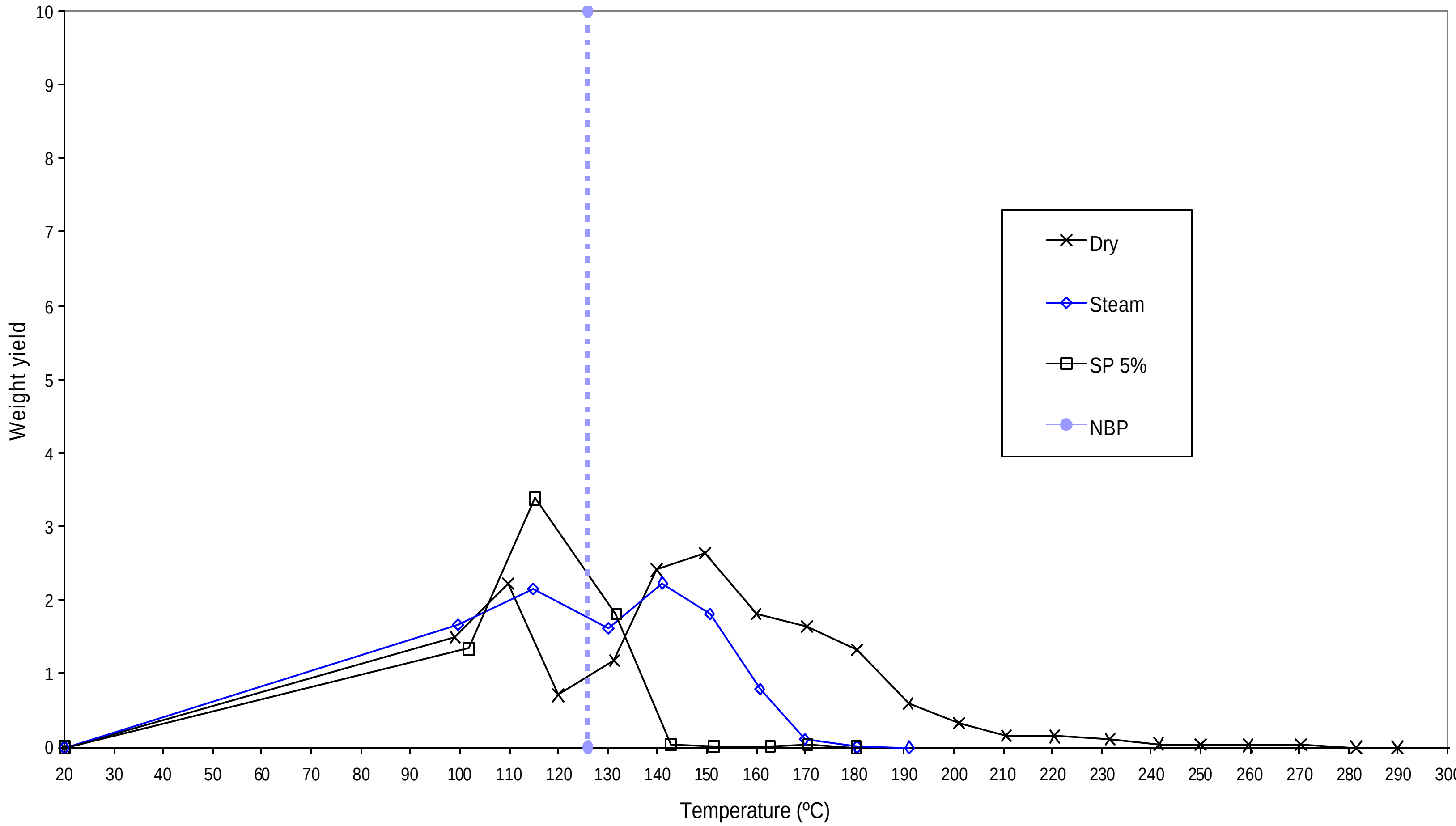


Fig. 5.90-n-C8 weight yield average vs. temperature (dry-, steam-, steam- C_3 distillation).

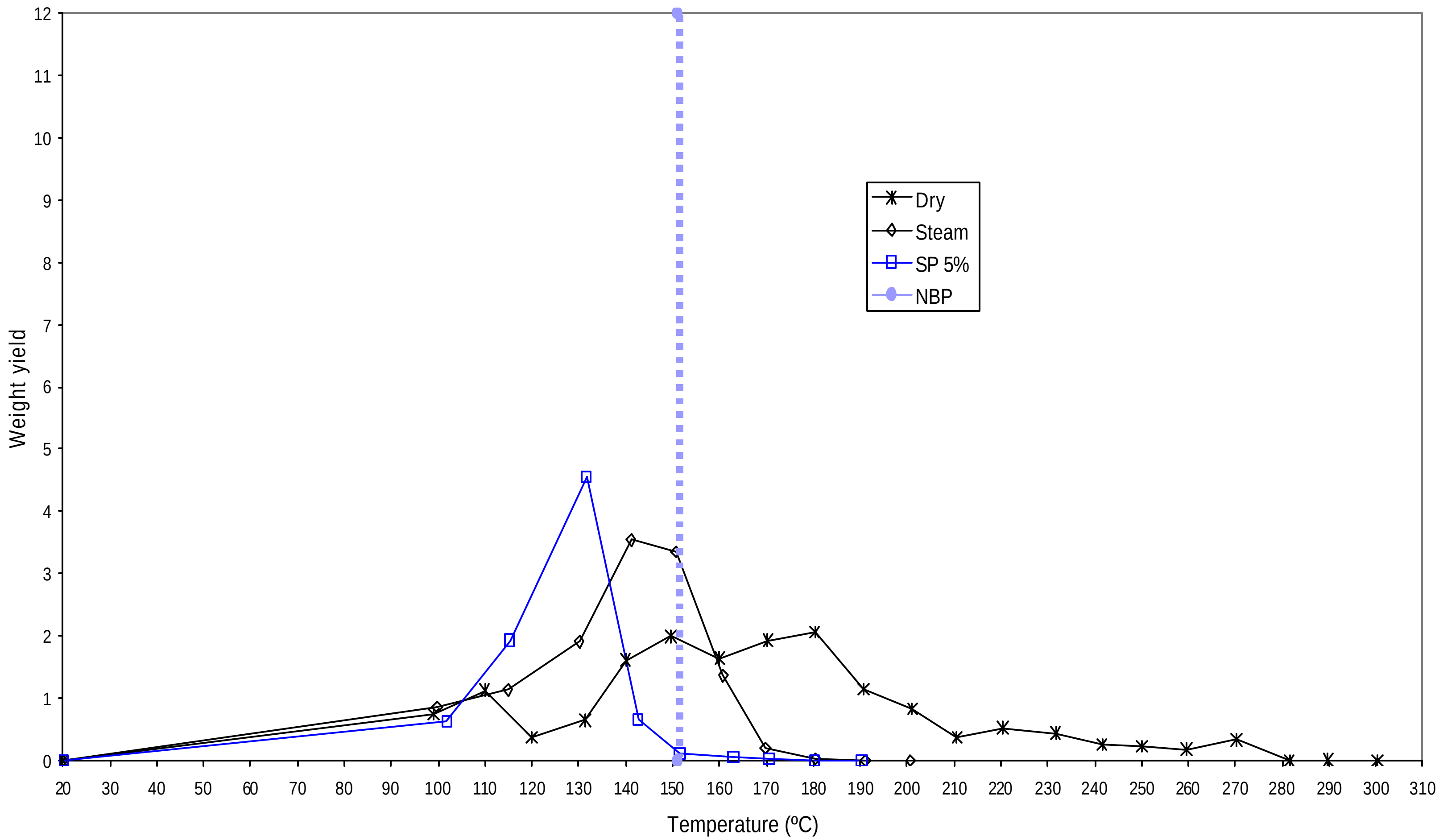


Fig. 5.91-n-C9 weight yield average vs. temperature (dry-, steam-, steam- C_3 distillation).

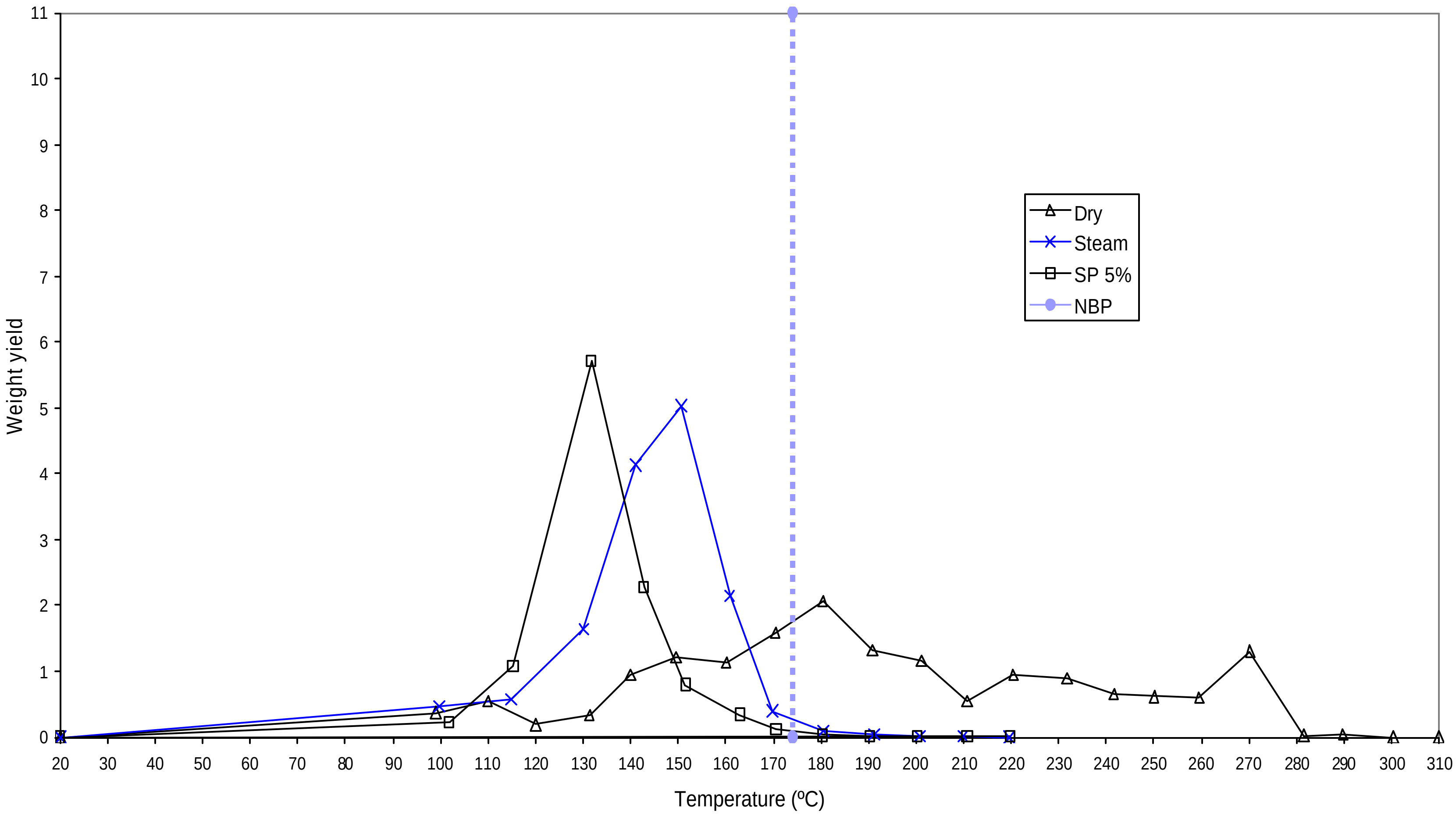


Fig. 5.92-n-C10 weight yield average vs. temperature (dry-, steam-, steam- C_3 distillation).

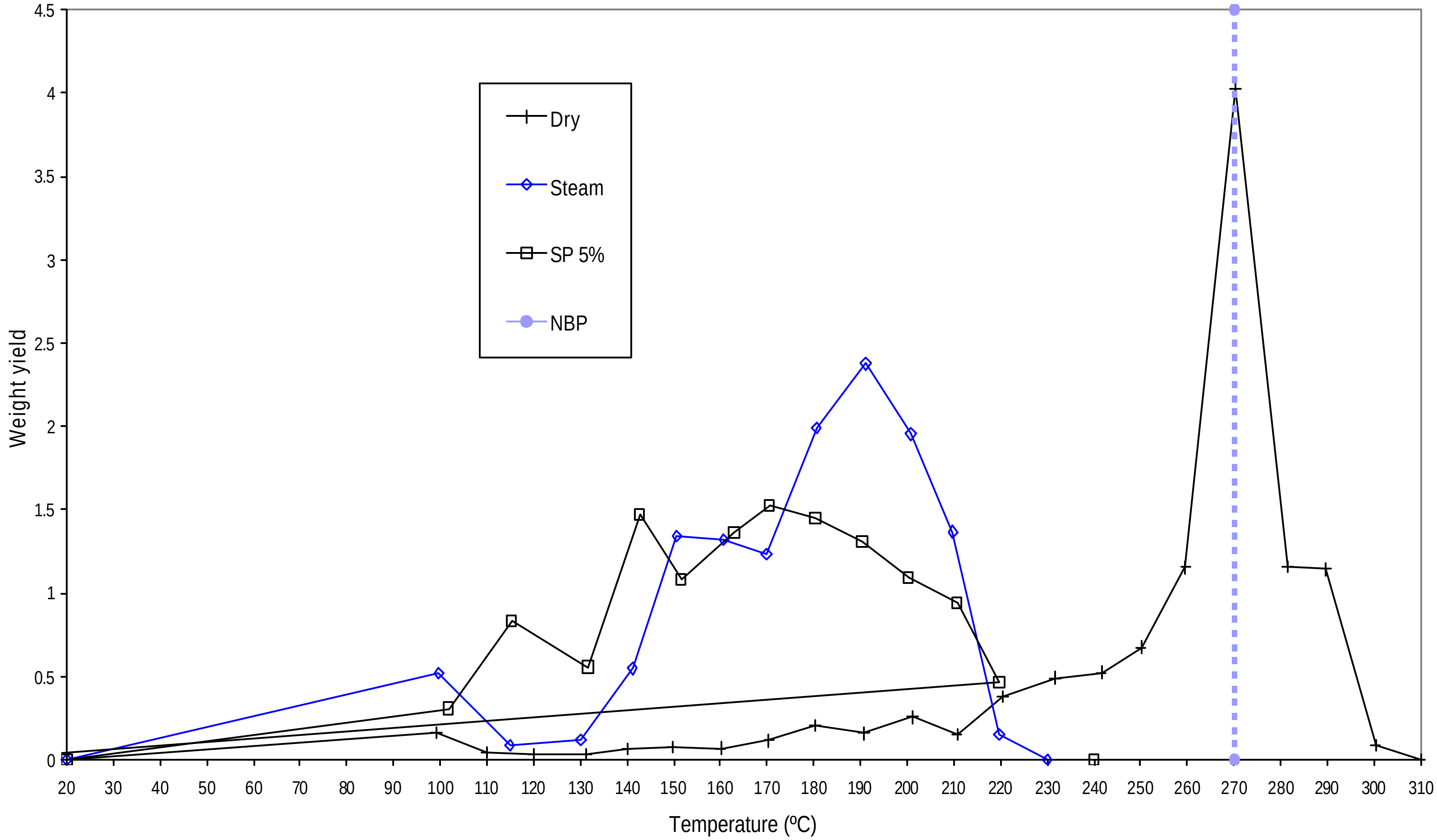


Fig. 5.93-n-C15 weight yield average vs. temperature (dry-, steam-, steam- C_3 distillation).

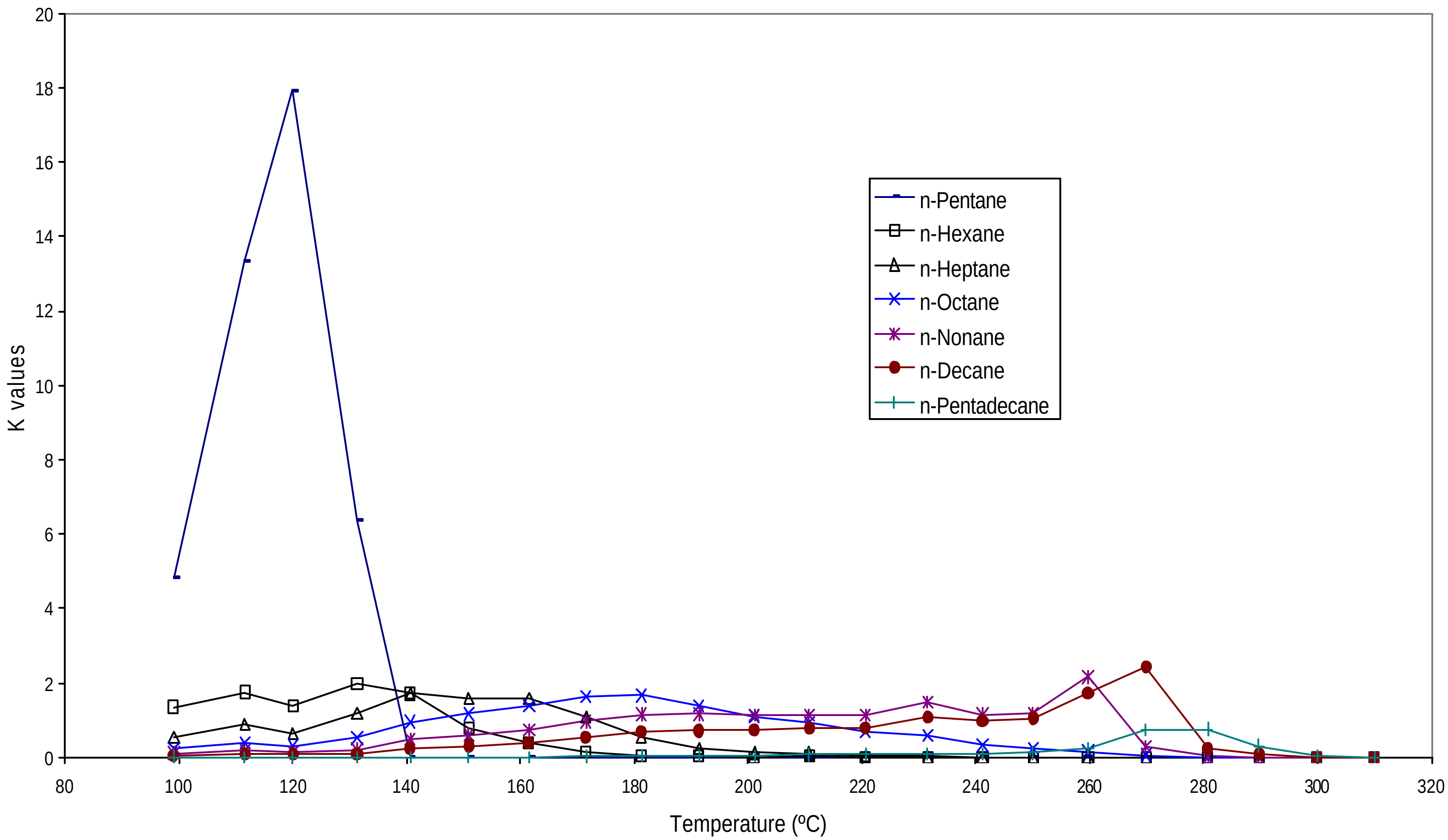


Fig. 5.94-Experimental *K*-values vs. temperature (dry distillation).

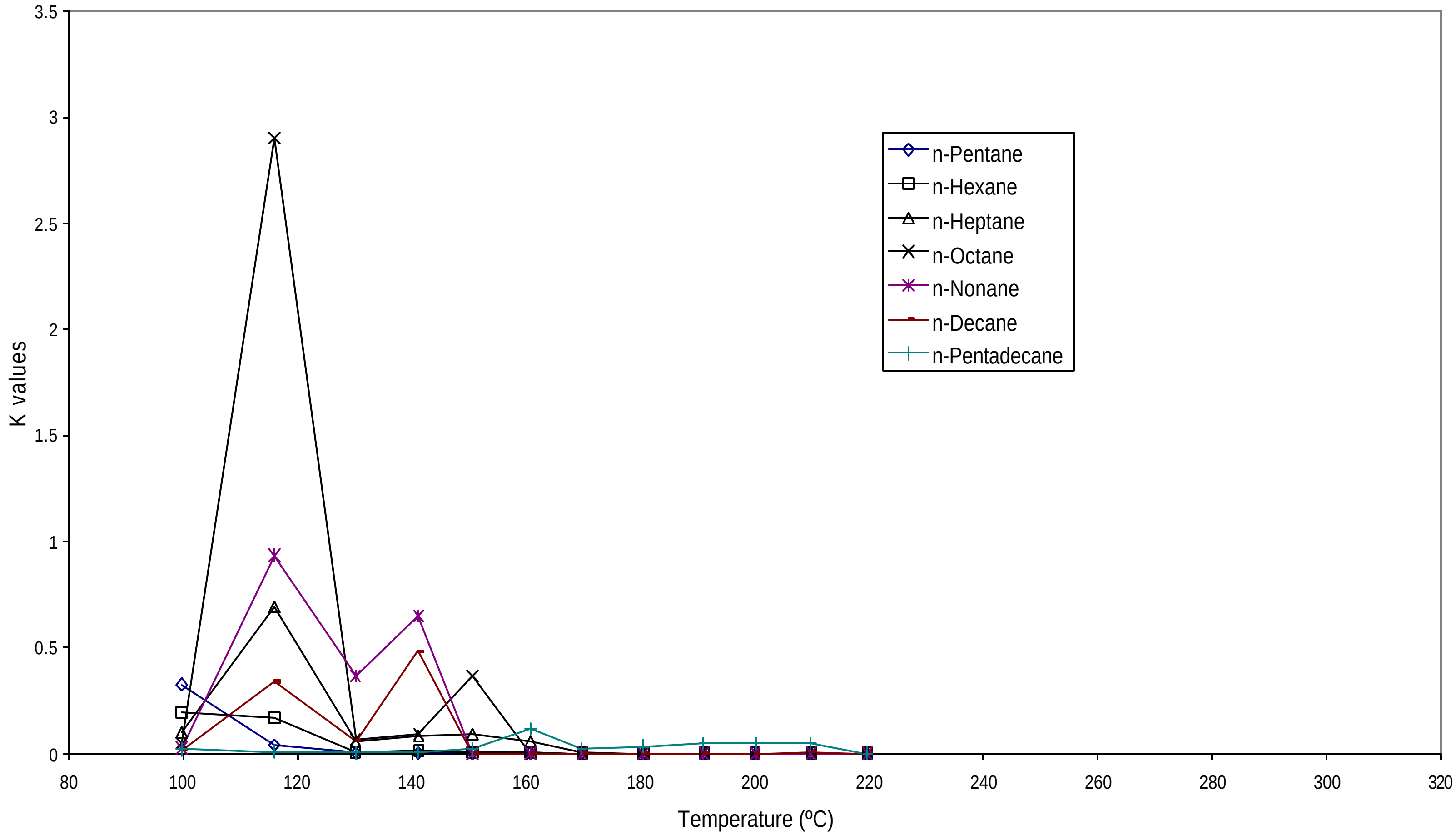


Fig. 5.95-Experimental *K*-values vs. temperature (steam distillation).

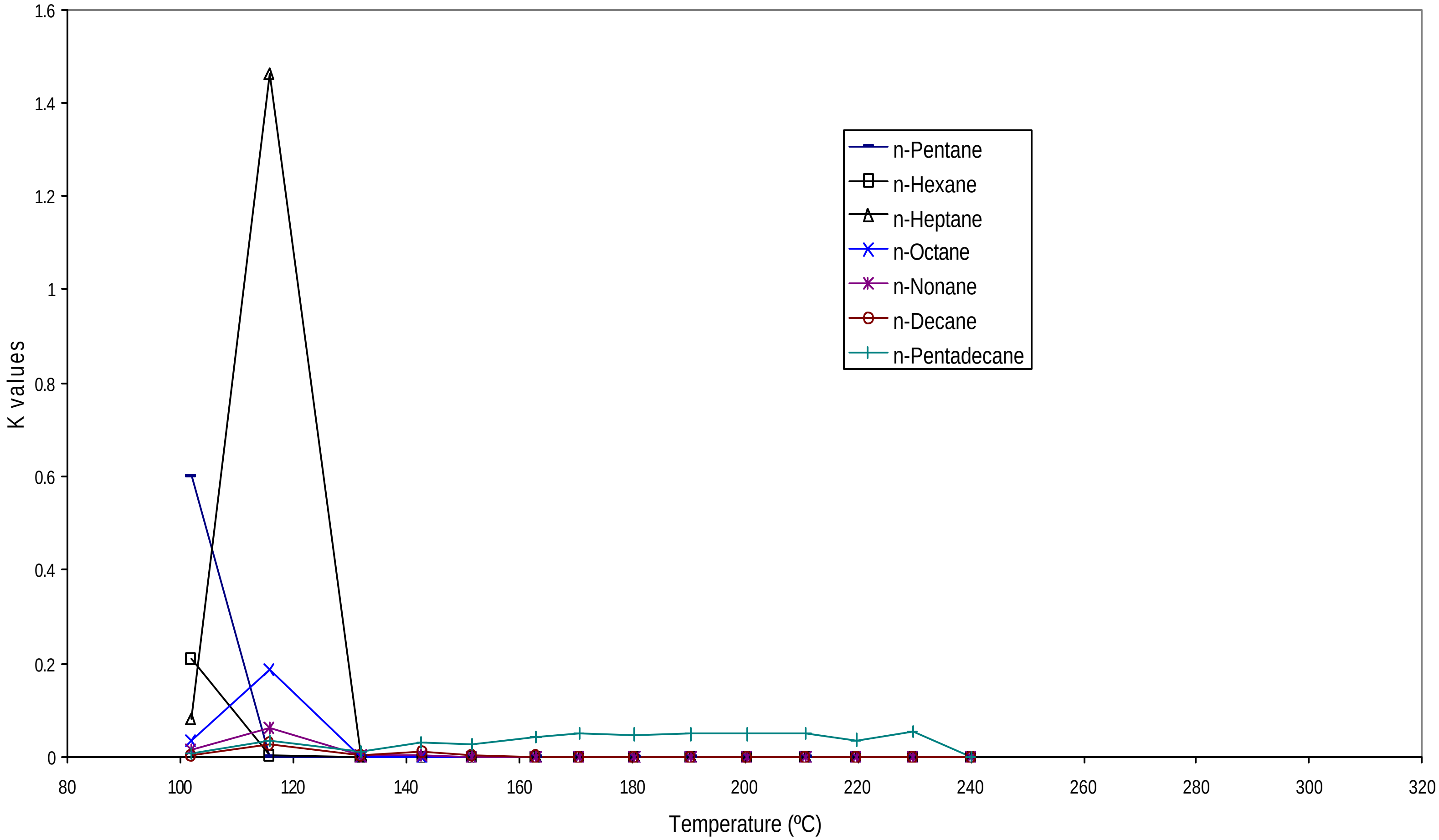


Fig. 5.96-Experimental *K*-values vs. temperature (steam-C_3 distillation).

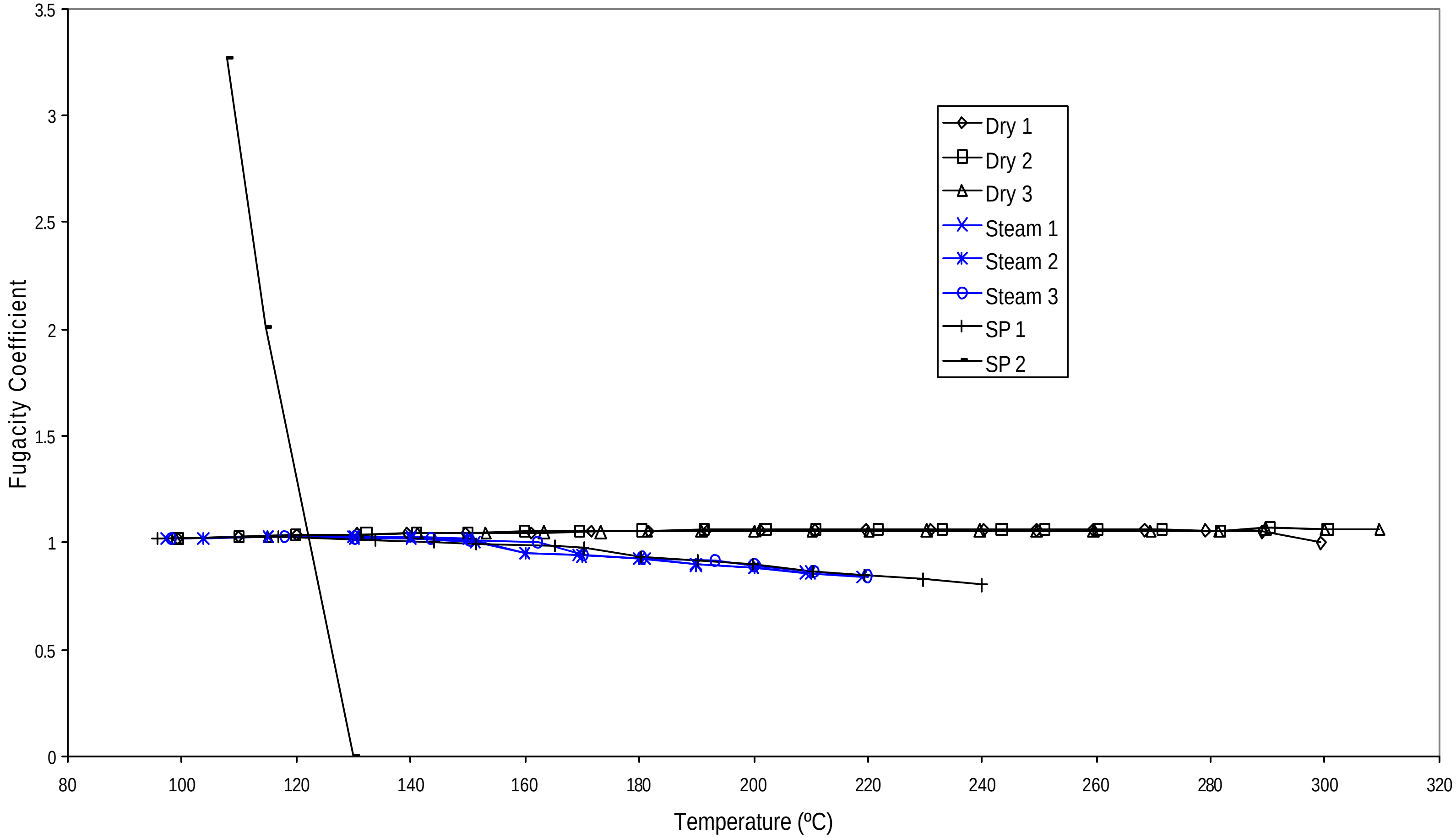


Fig. 5.97-n-C5: Vapor fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

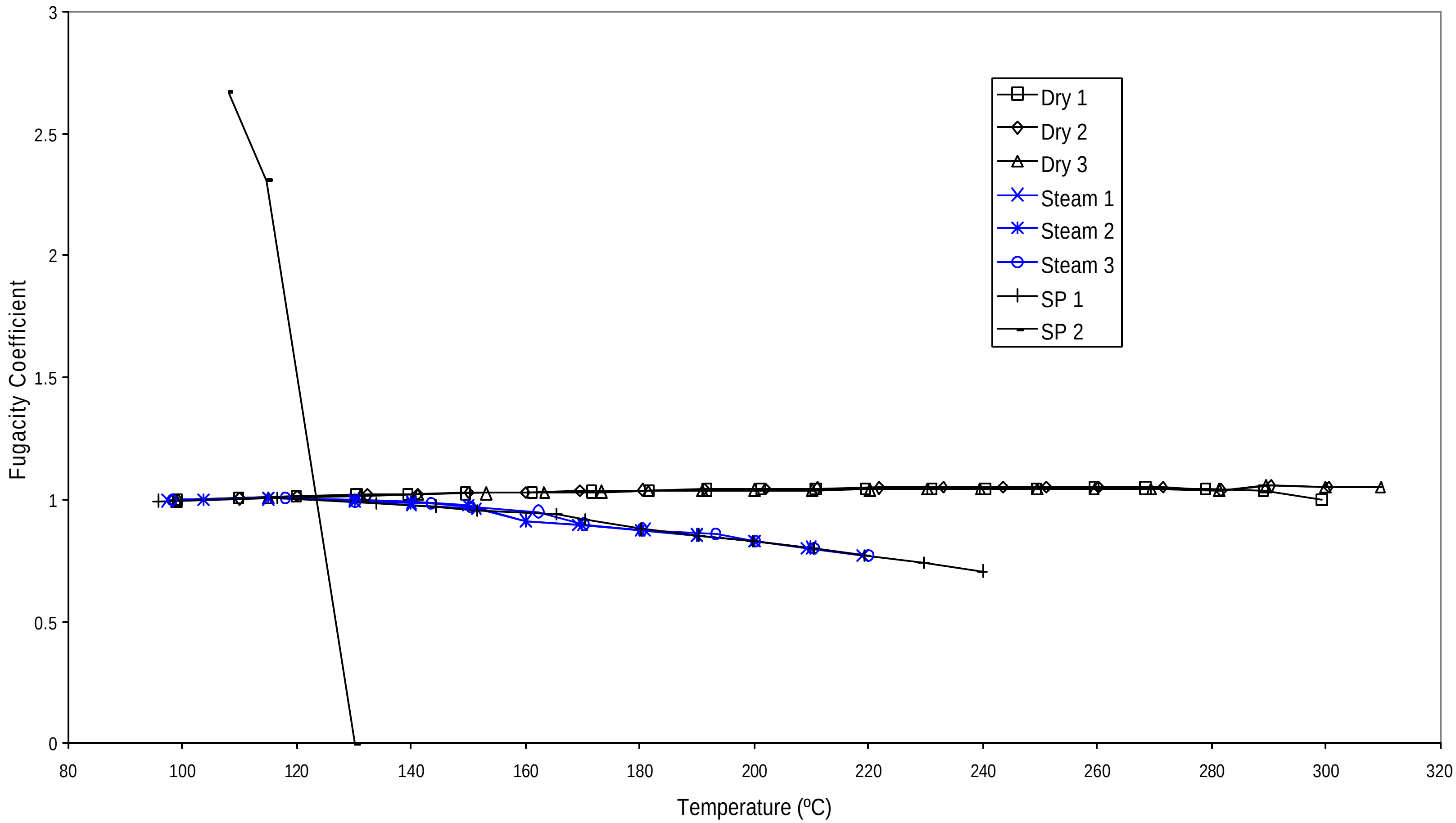


Fig. 5.98-n-C6: Vapor fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

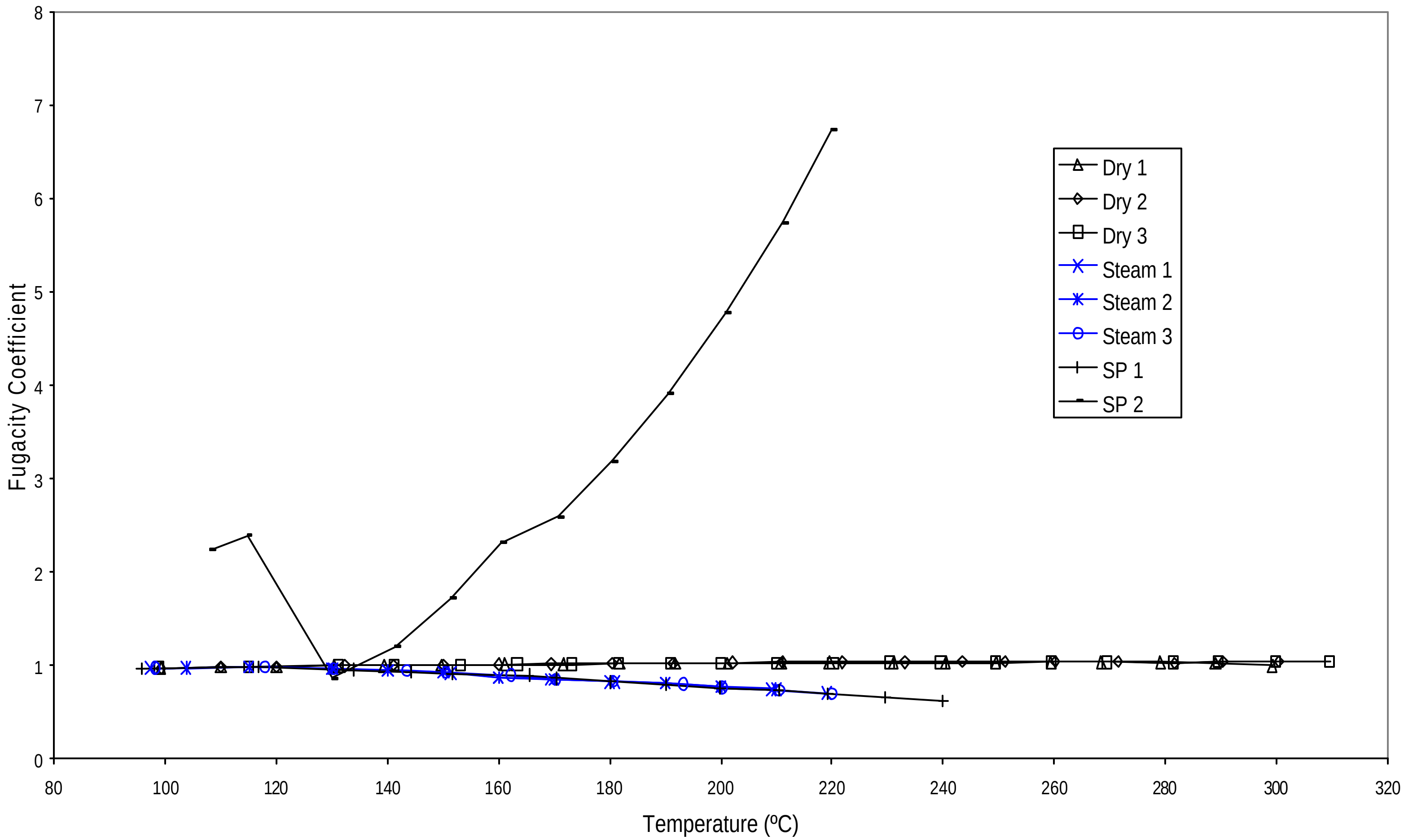


Fig. 5.99-n-C7: Vapor fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

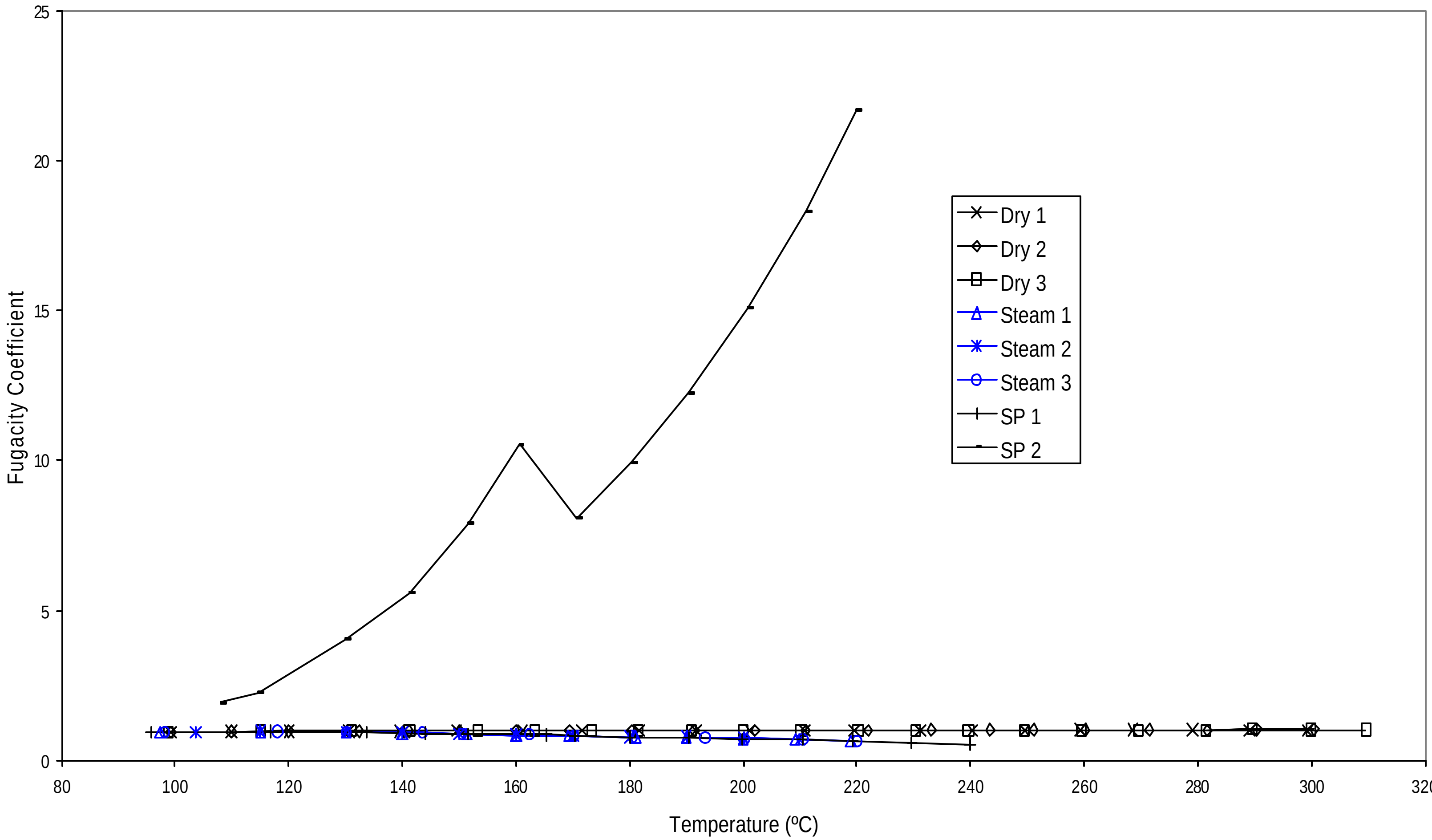


Fig. 5.100-n-C8: Vapor fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

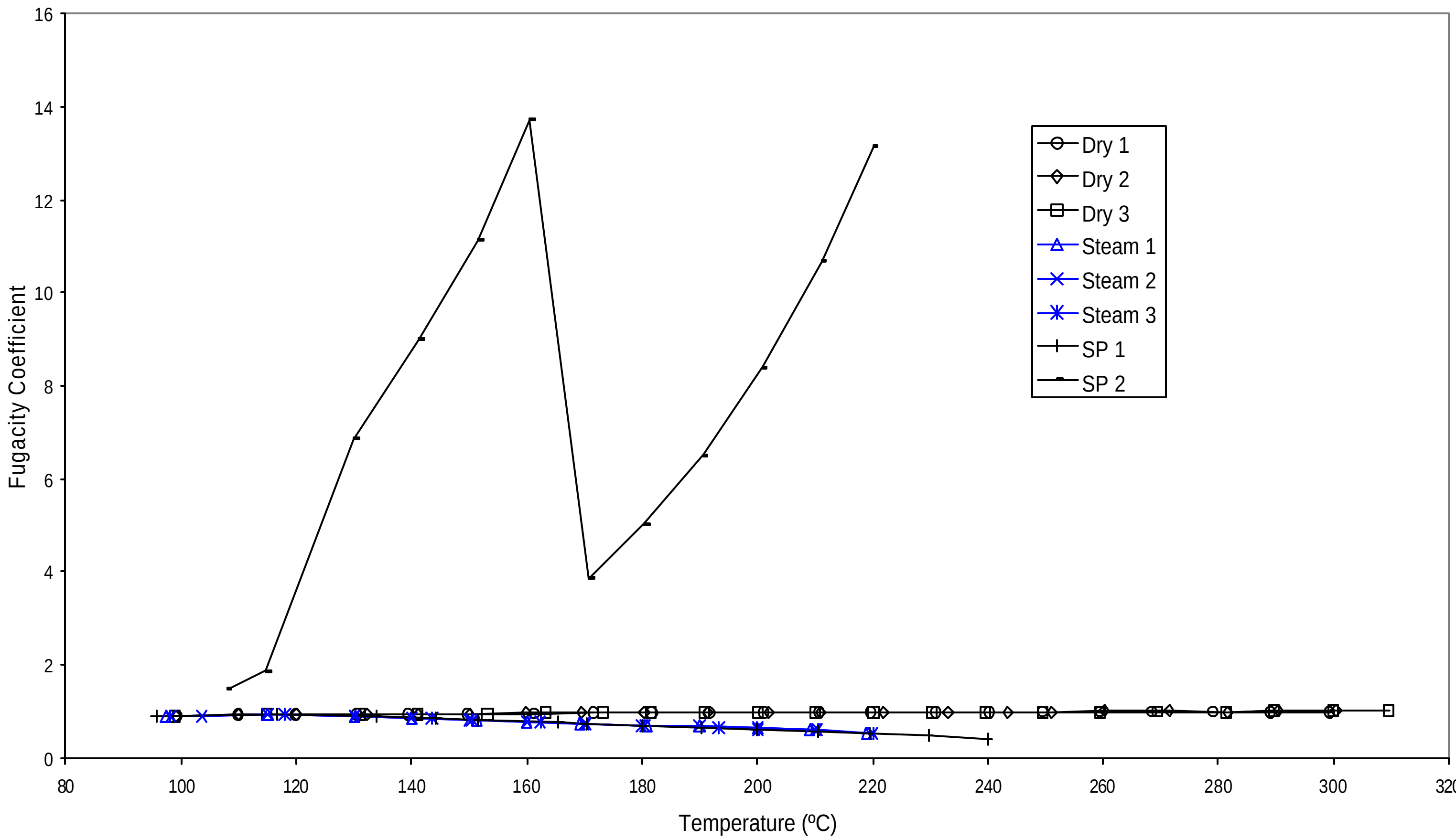


Fig. 5.101-n-C9: Vapor fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

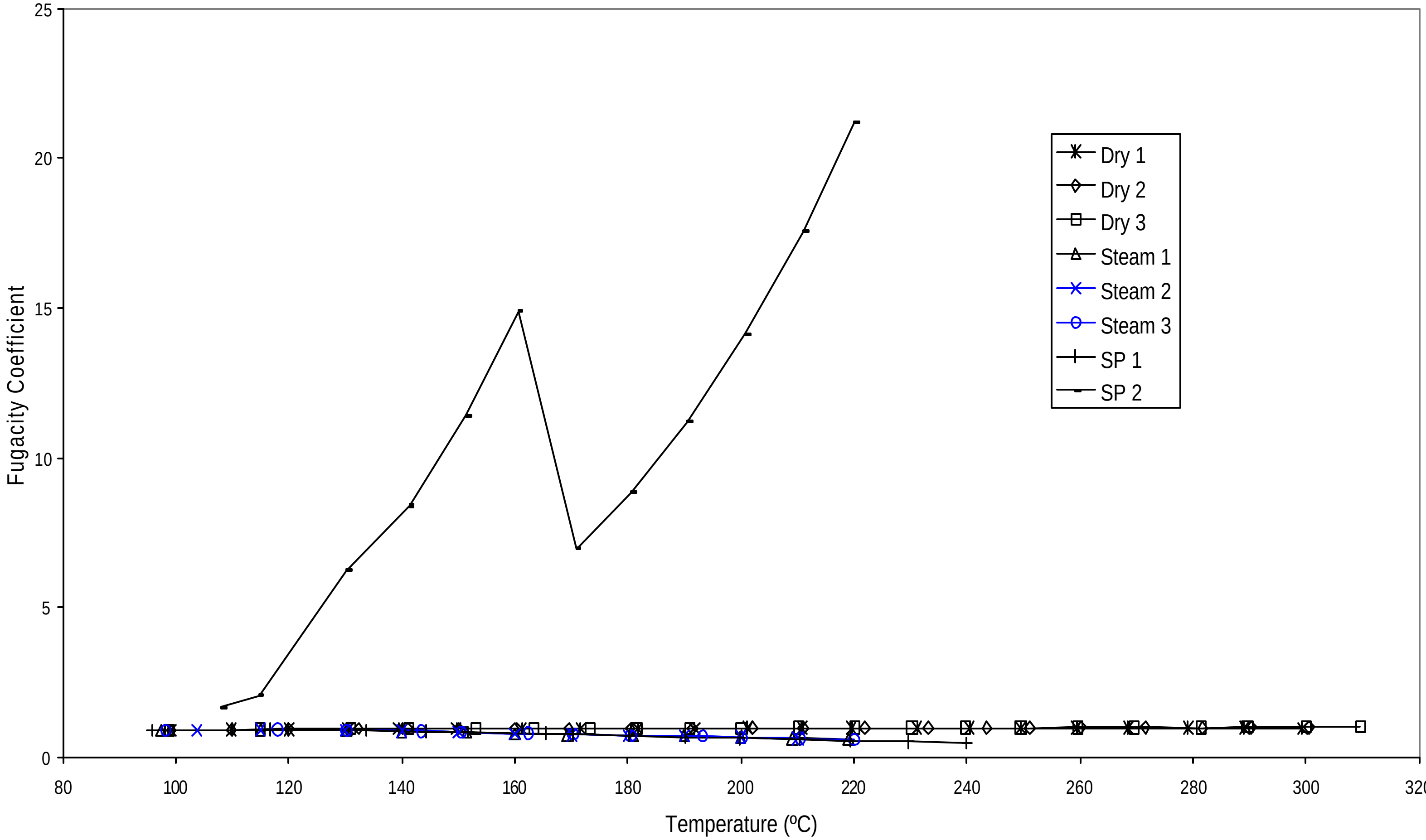


Fig. 5.102-n-C10: Vapor fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

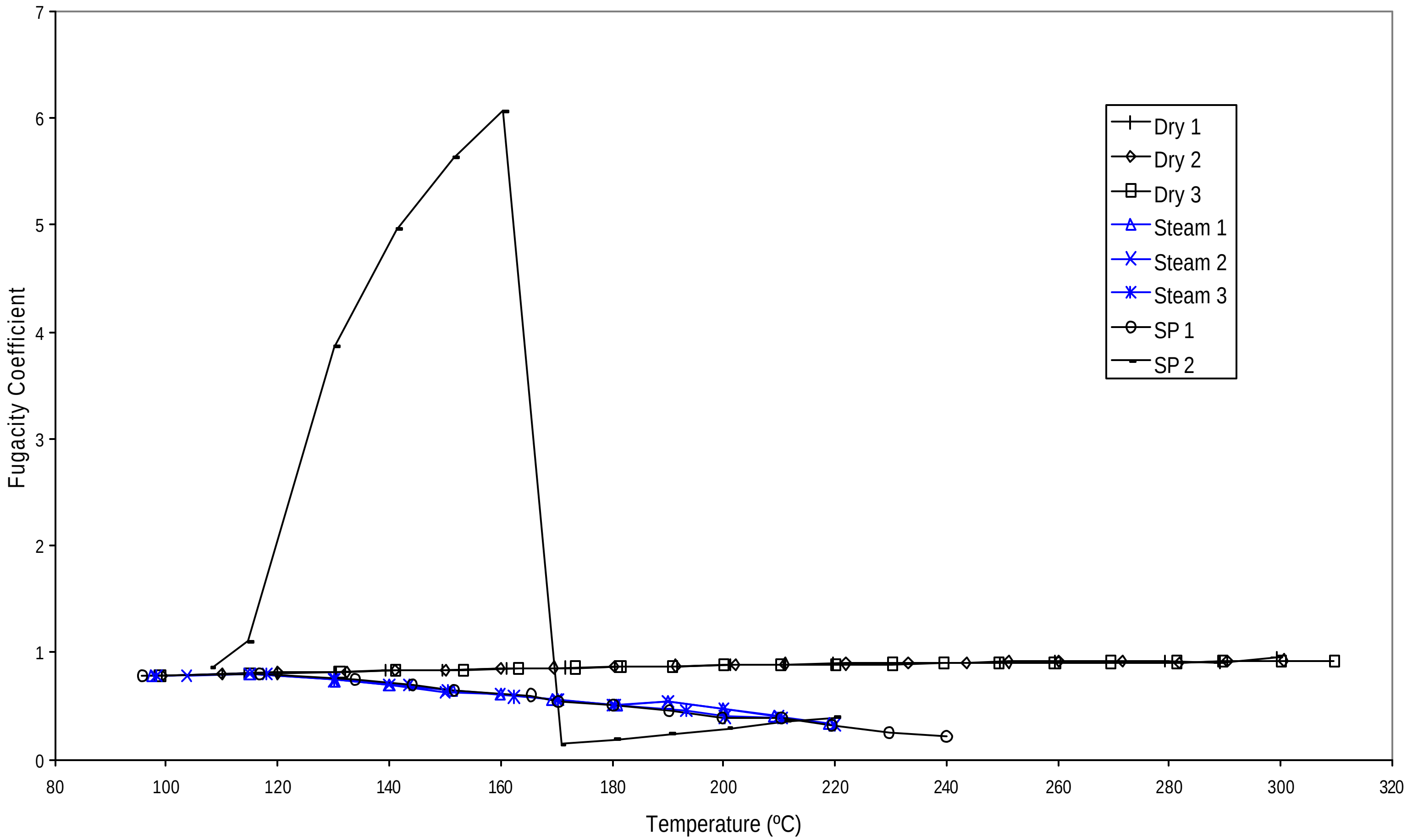


Fig. 5.103-n-C15: Vapor fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

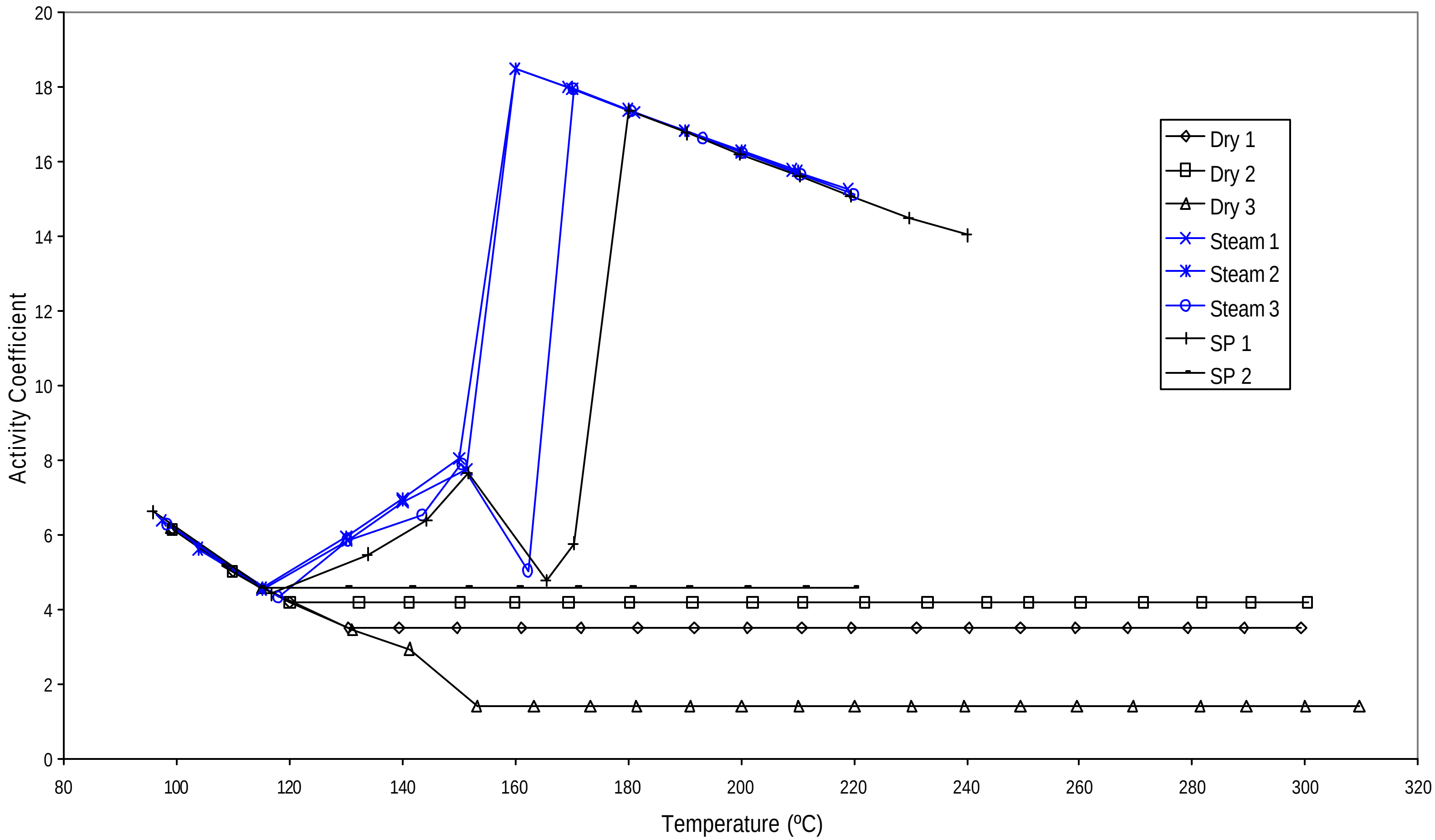


Fig. 5.104-n-C5: Activity fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

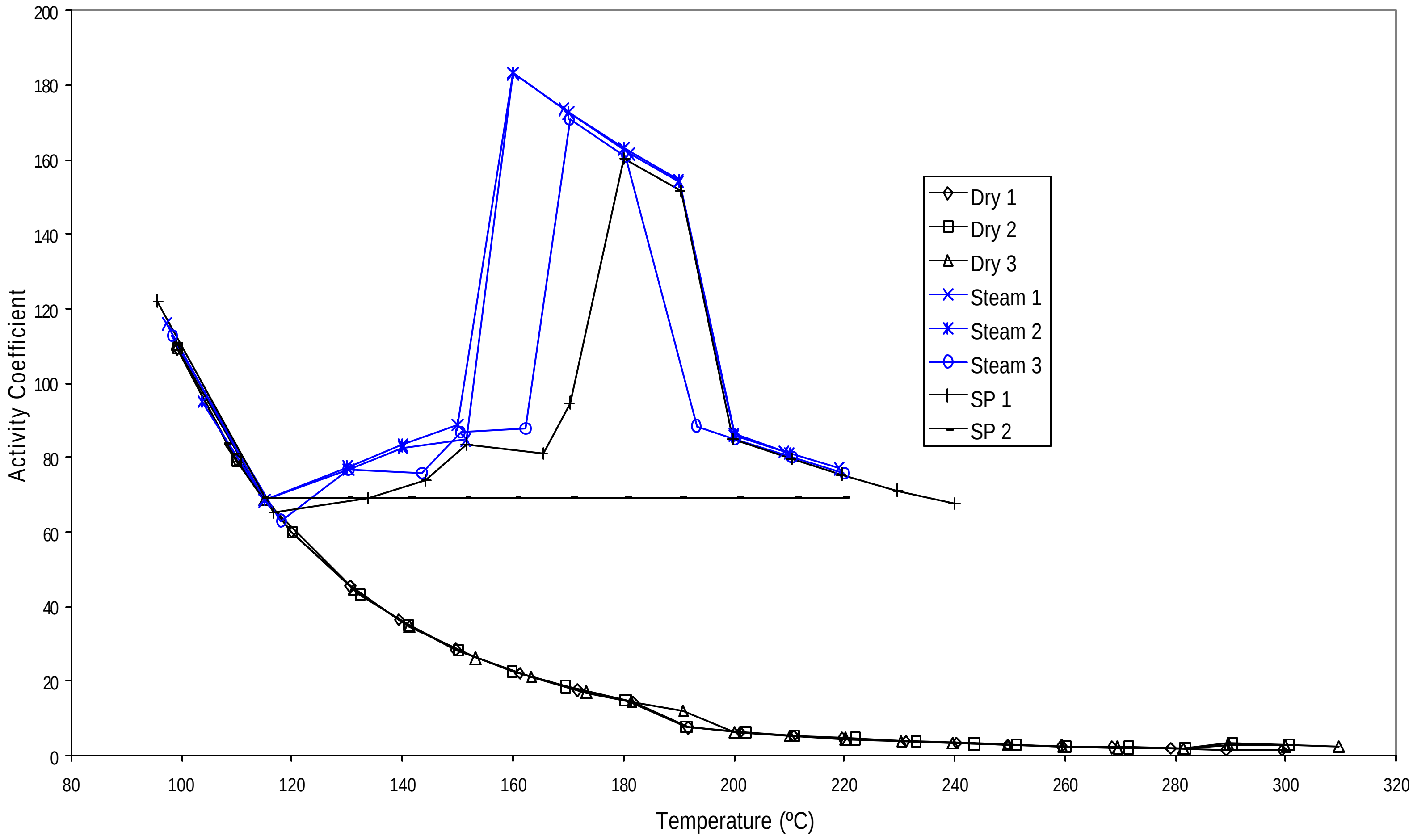


Fig. 5.105-n-C6: Activity fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

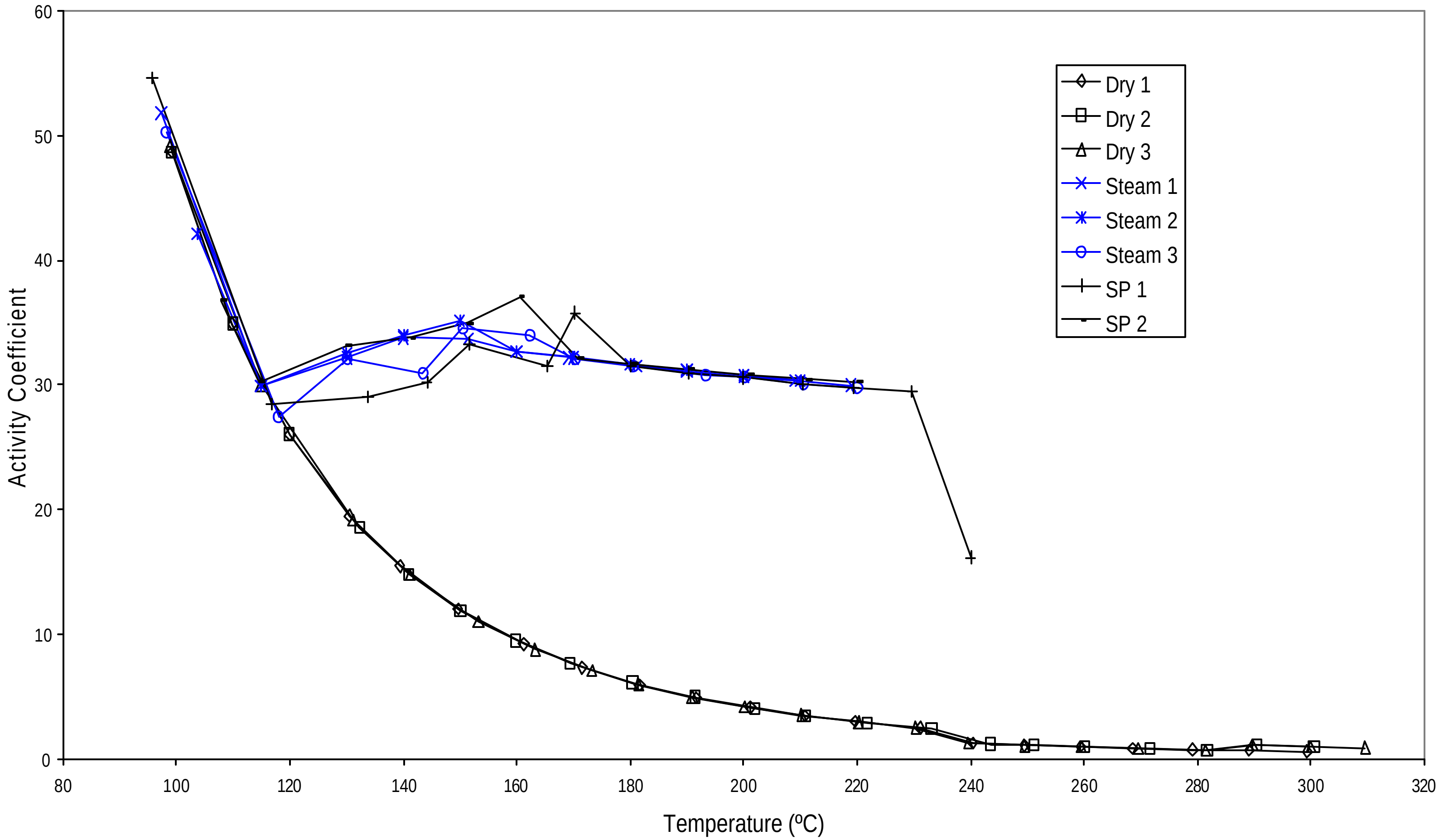


Fig. 5.106-n-C7: Activity fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

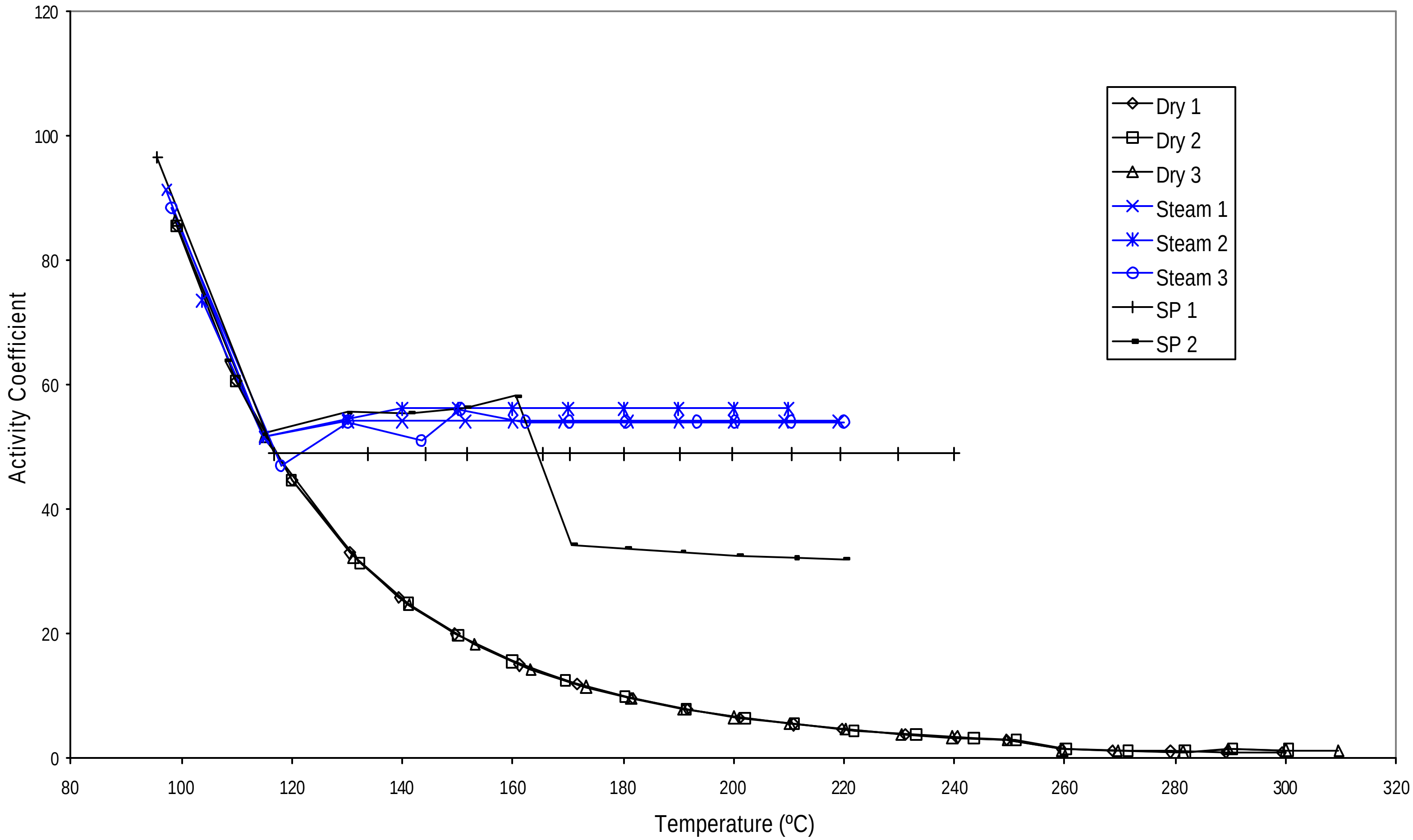


Fig. 5.107-n-C8: Activity fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

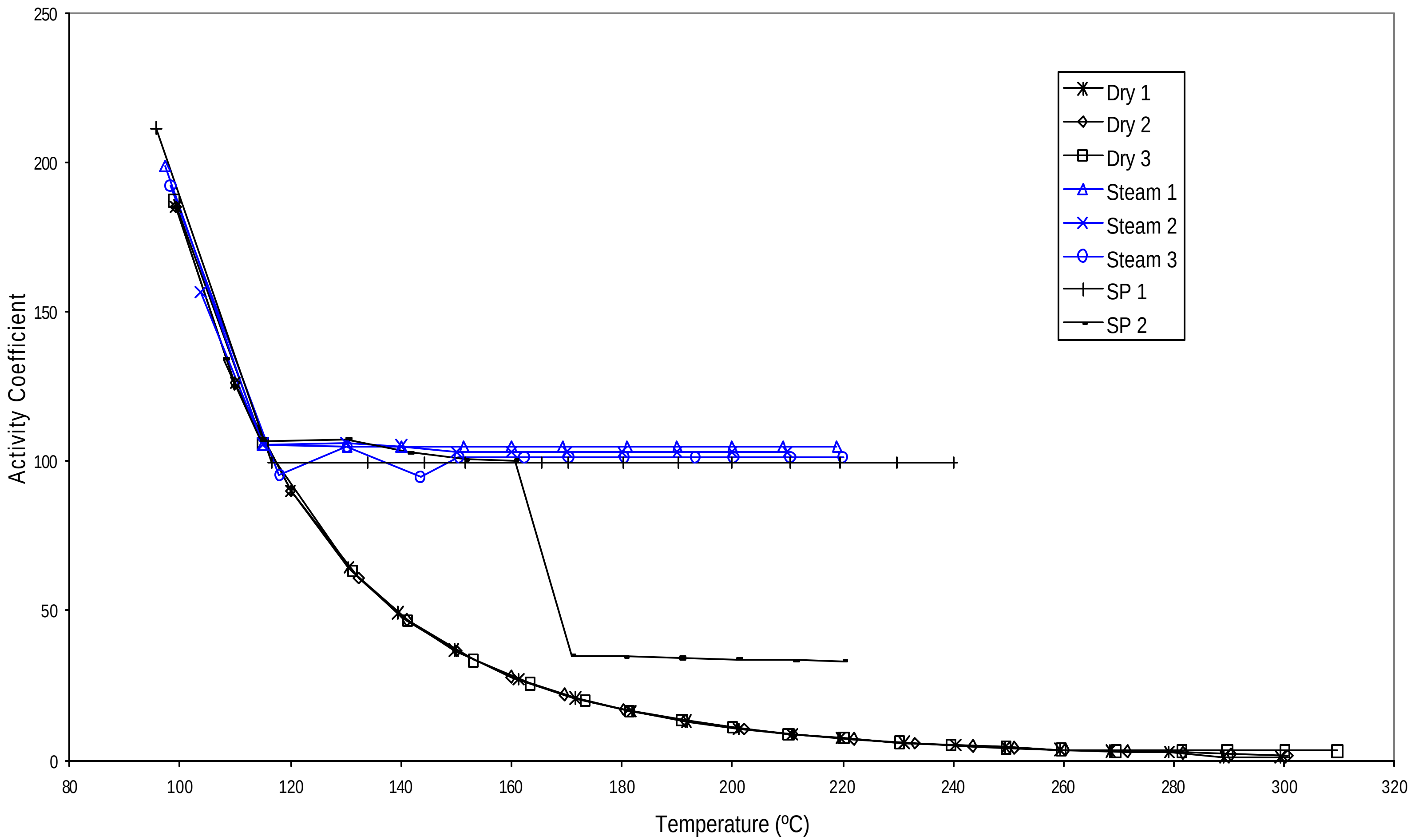


Fig. 5.108-n-C9: Activity fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

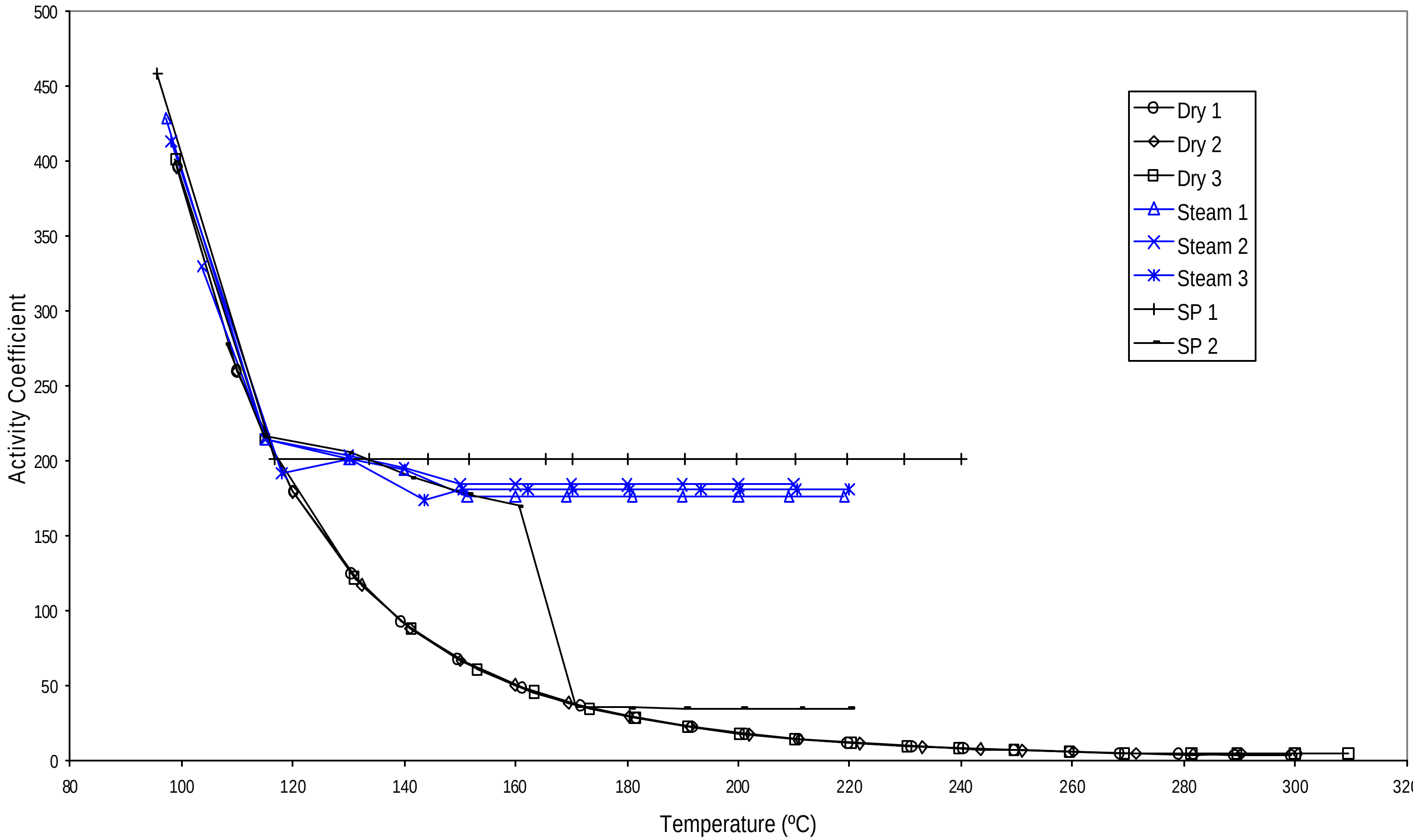


Fig. 5.109-n-C10: Activity fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

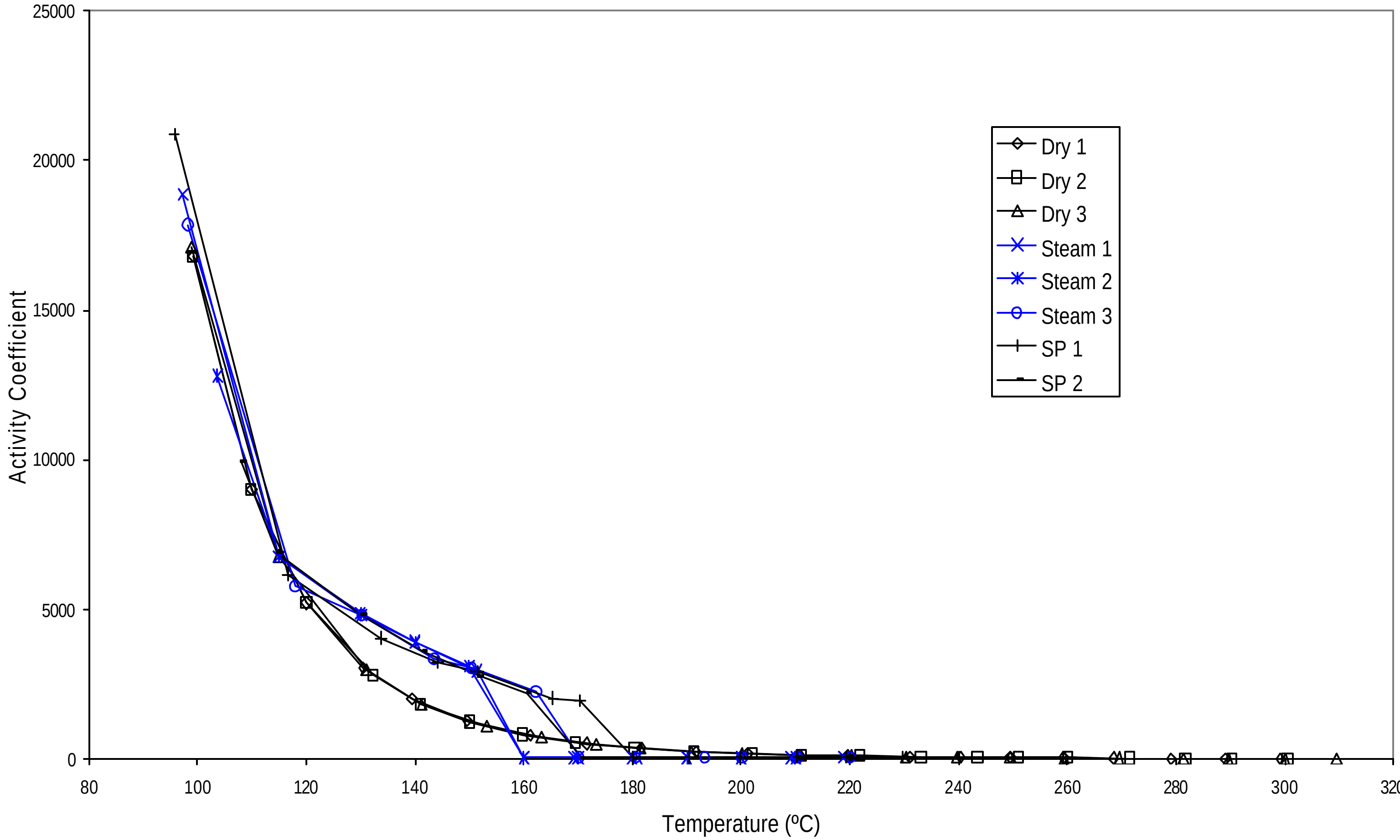


Fig. 5.110-n-C15: Activity fugacity coefficient vs. temperature (dry-, steam-, steam-C_3 distillation).

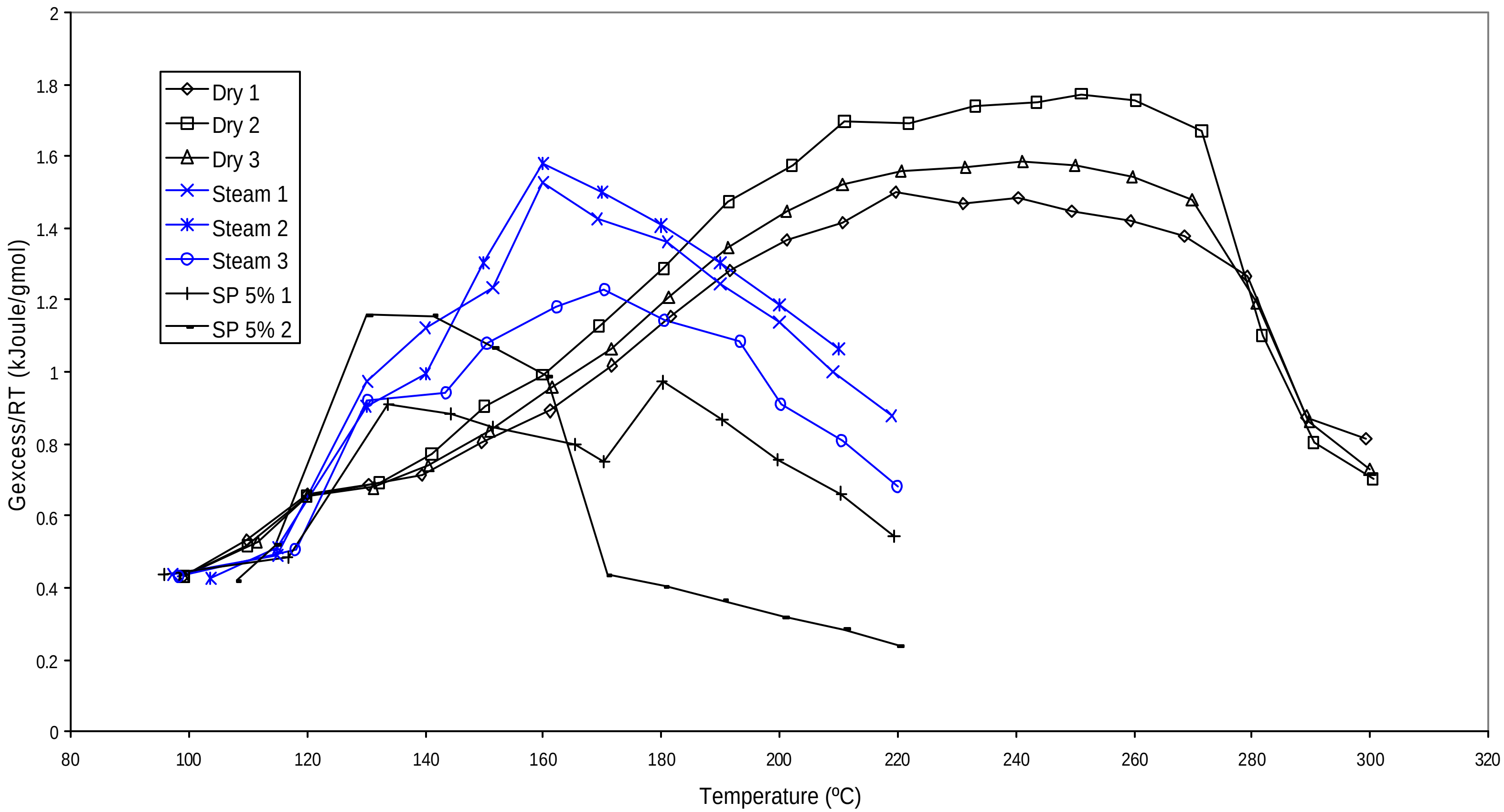


Fig. 5.111-G^{excess} vs. temperature (dry-, steam-, steam- C_3 distillation).

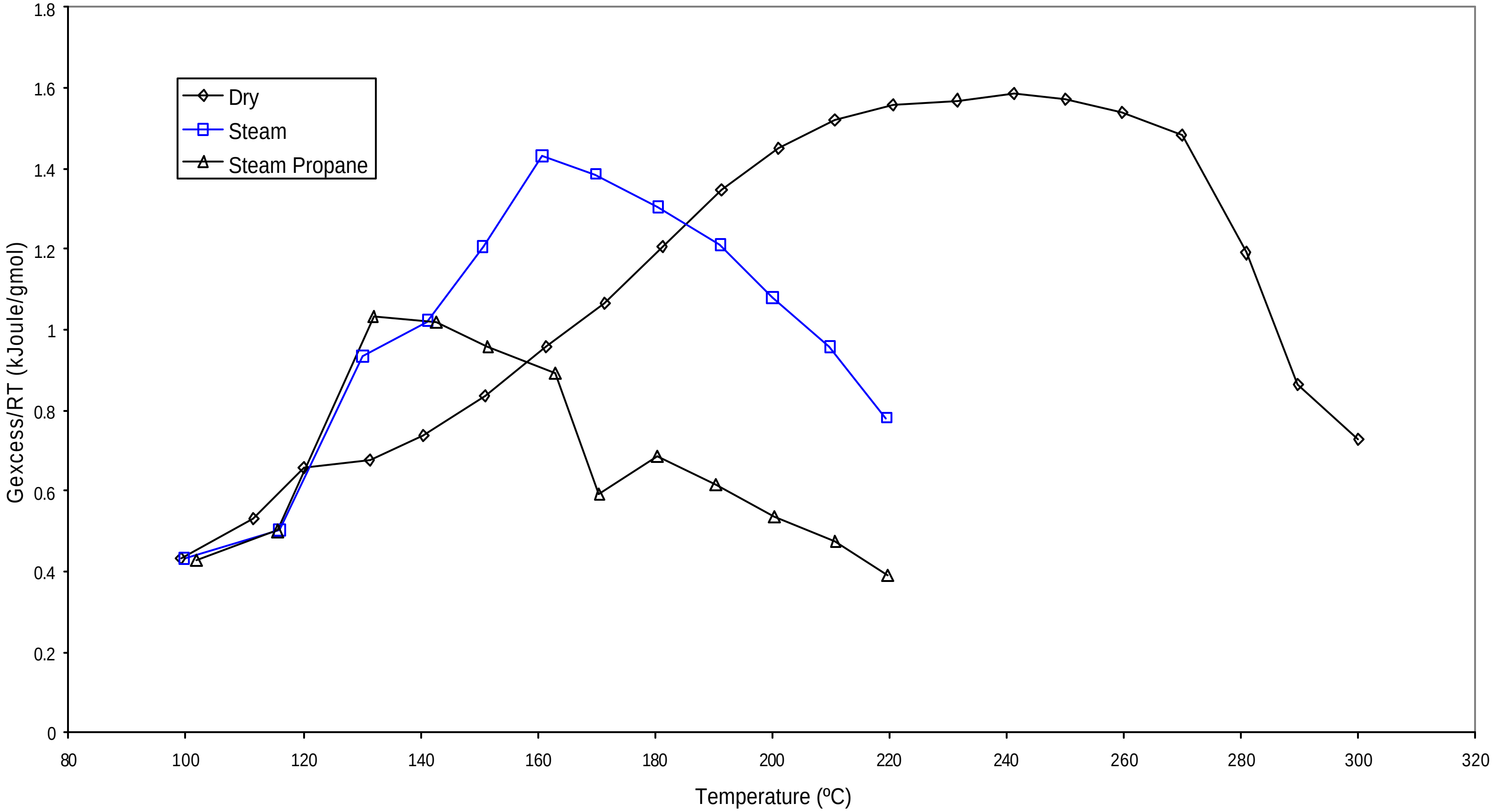


Fig. 5.112-Average G^{excess} vs. temperature (dry-, steam-, steam- C_3 distillation).

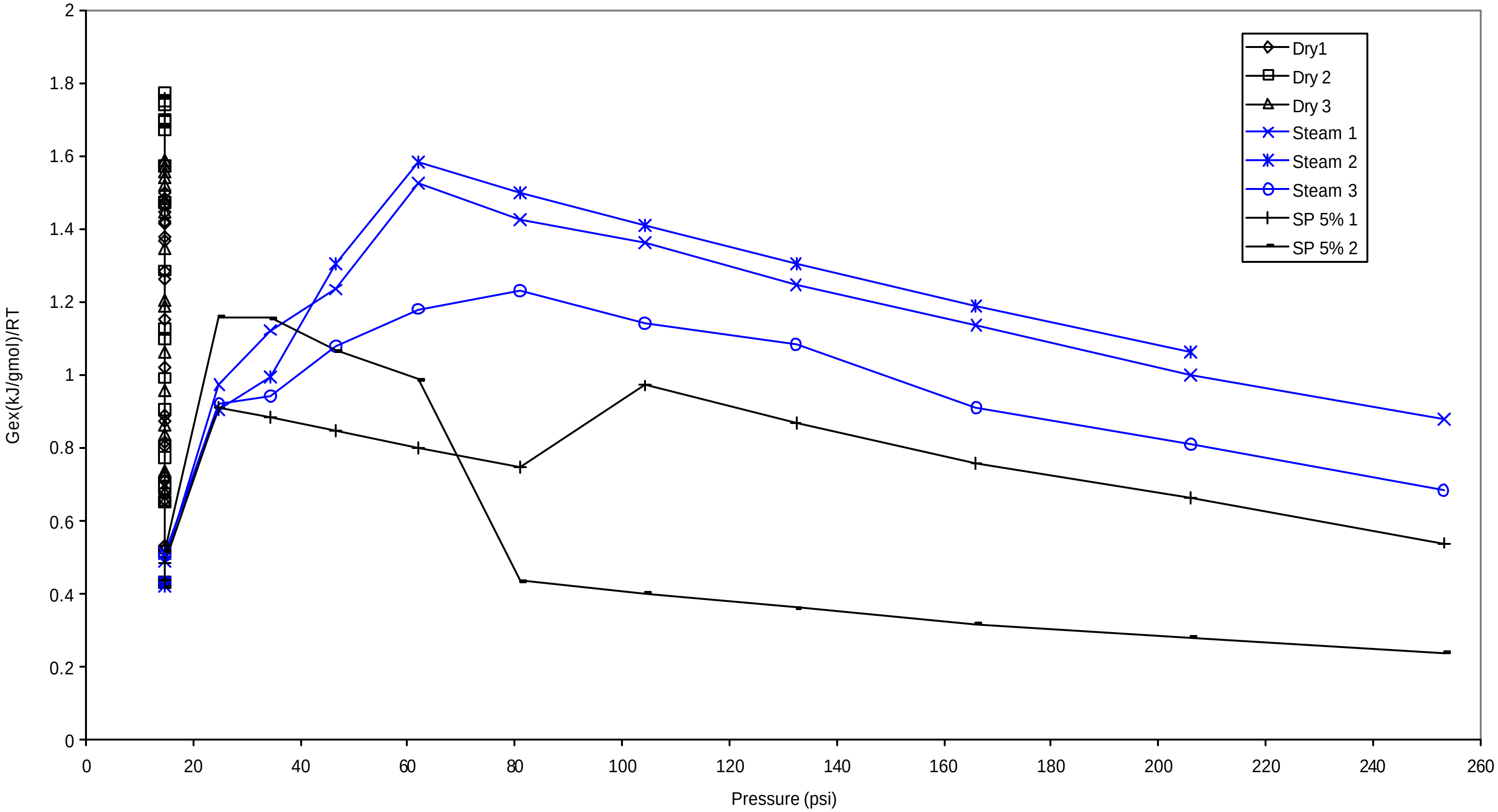


Fig. 5.113-G^{excess} vs. pressure (dry-, steam-, steam- C_3 distillation).

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The overall objective of my research was to investigate the effect of propane as a steam additive on the distillation yield of synthetic oil, and by inference, on crude oil in general.

6.1 Summary

Distillation experiments were performed using a 7-component n-alkane mixture – in equal proportion (20g): n-pentane, n-hexane, n-heptane, n-octane, n-nonane, n-decane, and n-pentadecane. Three distillation processes were used: dry-, steam-, and steam-propane (PSR 0.05).Dry distillation experiments were carried out at one atmosphere, temperature range of 115°-300°C. Steam- and steam-propane distillation experiments were conducted at superheated steam conditions (15°C above T_{sat}), temperature/pressure range of 115°C/0 psig - 300°C/998 psig. Produced hydrocarbon distillate weight and composition were determined at each temperature cut. Using experimental data, we determined K-values, fugacity coefficient, and Gibb's excess energy to understand and describe the thermodynamic effect of propane on distillation of the synthetic hydrocarbon mixture.

6.2 Conclusions

Based on the experimental results and analysis of the data, the following conclusions may be drawn.

1. Difference in oil yield is largest at about 130°C: 70 wt% (steam-propane), 60 wt% (steam), and 40 wt% (dry distillation). Final yield at 300°C is about the same in all cases, 96 wt% (4 wt% residual at end of experiment). These observations are in line

with the production acceleration (yet similar oil recoveries) obtained by researchers for steam- and steam-propane displacement experiments with actual crude oil.

2. Based on peak production, components appear to boil off at lower temperatures with steam-propane injection than with pure steam injection (with reference to dry distillation). Lowering of hydrocarbon boiling points by steam-propane injection appears to be the fundamental phenomenon that can explain: (1) higher yields during distillation of the synthetic oil, and (2) production acceleration, reduction in produced oil density and viscosity, and improved steam injectivity during steam-propane displacement of crude oils.

3. *K*-values for each component peak at a lower temperature with steam-propane injection than with pure steam injection which is lower than that with dry distillation. *K*-value peaks occur close to the apparent boiling point of each component in the mixture.

4. Vapor fugacity coefficient of each component is largest in the temperature range where a large fraction of the component is present in the vapor phase, and vice versa.

5. Gibb's excess energy peaks correspond to temperatures where a large fraction of the components are distilled off. Peaks occur at lower temperatures for steam-propane distillation than for steam distillation which is lower than with dry distillation.

6.3 Recommendations

1. Propane may not be the only or ideal steam additive. It is therefore recommended to investigate the effect of other alkanes on distillation yield (v. gr. C_2, n-C_4, n-C_5, etc.) or a "cocktail" of the light n-alkanes.

2. Perform distillation experiments using more hydrocarbon components – including varying the proportion of the components- before proceeding to using crude oils to fully understand the process.

NOMENCLATURE

ACRONYMS

EOS Equation of State

PF Poynting Factor

LETTERS

A	$=a_TP/R^2T^2$, derived parameter of Peng-Robinson EOS
A'_j	derived parameter of Peng-Robinson EOS for mixtures
a_c	attraction parameter of Peng-Robinson EOS at critical conditions, (psia ft^3 ^oR/lbmol)
a_T	attraction parameter of Peng-Robinson EOS, $(ft^3/lbmol)^2$
B	$= bP/RT$, derived parameter of the Peng-Robinson EOS
B'_j	derived parameter of Peng-Robinson EOS for mixtures
b	residual volume parameter of the Peng-Robinson EOS, ft^3/lbmol
b_i	residual volume parameter of the Peng-Robinson EOS of species i in a mixture, liters/gmol, ft^3/lbmol
F	total mass or mol number of a system
f	fugacity, psia
f_g	gas fugacity, psia
f_L	liquid fugacity, psia
G	specific Gibbs energy, Kjoules/gmol
K_i	$= y_i/x_i$, vaporization equilibrium ratio
K_i^C	$= y_i/x_i$, vaporization equilibrium ratio calculated
K_i^T	$= y_i/x_i$, trial vaporization equilibrium ratio
L	amount of a liquid phase, number gram of moles
m	parameter of Peng-Robinson EOS as acentric factor function and reduced temperature
n	number of the species in the system
P	pressure of a system, psia
P_c	critical pressure, psia
P_i	partial pressure of a species i, psia

R	universal gas constant
T	temperature, ^oC
T_c	critical temperature, ^oC
V	amount of vapor phase, number gram of moles
V_M	specific volume in Peng-Robinson equation, ft^3/lbmol
x_i	mole fraction of a species in a liquid-phase mixture
y_i	mole fraction of a species in a vapor-phase mixture
z_g	gas compressibility factor
z_i	mole fraction of a species in all phases of a system
z_L	liquid compressibility factor
z	$= PV/RT$, compressibility factor

GREEK LETTERS

a	parameter of Peng-Robinson EOS
ß	mole fraction vaporized
$?_i$	activity coefficient of species i
d_{ij}	binary interaction parameters for Peng-Robinson EOS
e	objective function
f_i	$= f_i/P$, fugacity coefficient of a species i in a mixture
f_i^V	$= f_i/P$, fugacity coefficient of a species i in a vapor phase mixture
f_i^L	$= f_i/P$, fugacity coefficient of a species i in a liquid phase mixture
$?$	acentric factor

SUBSCRIPTS

i	index for a species in a mixture

SUPERSCRIPTS

k	iteration index
sat	property at saturation conditions, as in P^{sat} = vapor pressure
V	vapor phase
L	liquid phase

REFERENCES

1. Ferguson, M.A., Mamora, D.D., and Goite, J.G.: "Steam-Propane Injection for Production Enhancement of Heavy Morichal Oil," paper 69689 presented at the 2001 International Thermal Operations and Heavy Oil Symposium, Porlamar, Venezuela, 12-14 March.

2. Goite, J.G., Mamora, D.D. and Fergurson, M.A.: "Experimental Study of Morichal Heavy Oil Recovery Using Combined Steam and Propane Injection," paper 69566 presented at the 2001 SPE Latin American and Caribbean Petroleum Engineering Conference, Buenos Aires, 25–28 March.

3. Goite, J.G.: Experimental Study of Morichal Heavy Oil Recovery Using Combined Steam and Propane Injection, MS Thesis, Texas A&M U., College Station, TX(1999).

4. Tinss, J.C.: Experimental Studies of Steam-Propane Injection to Enhance Recovery of an Intermediate Crude Oil, MS Thesis, Texas A&M U., College Station, TX (2001).

5. Rivero, J.A.: Experimental Study of Enhancement of Injectivity and in-situ Oil Upgrading by Steam-Propane Injection for the Hamaca Heavy Oil Field, MS Thesis, Texas A&M U., College Station, TX (2002).

6. Plazas, P.G.: Experimental Study of Oil Fields and Properties of Light and Medium Venezuelan Crude Oils under Steam and Steam Propane Distillation, MS Thesis, Texas A&M U., College Station, TX (2002).

7. Prats, M.: *Thermal Recovery*, Monograph Series, SPE, New York City (1986) **7,** 1.

8. Green, D and Willhite, G.P.: *Enhanced Oil Recovery*, Textbook Series, SPE, Richardson, TX (1998) **6,** 1.

9. Maitland, G.C., Rigby, M., Smith,E.B., Wakeham, W.A., *Intermolecular Forces: Their Origin and Determination*, App.1, Clarendon Press, Oxford, 1981.

10. Rayleigh, J.W.S., "Scientific Papers", *Philosophical Magazine and J. Sci*., Series 6, **4**(23), 521-537 (1902).

11. Holland, C.D. and Welch, N.E.: "Steam Batch Distillation Calculations", *Petroleum Refiner* (May 1957) 251.

12. Willman, B.T. *et al.:* "Laboratory Studies of Oil Recovery by Steam Injection," *JPT*. (June 1971) 731.

13. Sukkar, J.K.: "Calculation of Oil Distilled during Steam Flooding of Light Crude," paper 1609 presented at the 1966 SPE of AIME Annual Meeting, Dallas, TX, 2-5 October.

14. Barb,D.K.: Solution of Problems Involving the Separation of Multi-Component Mixtures by Batch Distillation, PhD Dissertation, Texas A&M University, College Station, TX (Jan. 1967).

15. Johnson, F.S., Walker, C.J. and Bayazeed, A.F.: "Oil Vaporization during Steamflooding" *JPT* (July 1971) 731.

16. Volek, C.W. and Pryor, J.A.: "Steam Distillation Drive – Brea Field, California," *JPT* (August 1972) 899.

17. Alikhan, A.A. and Ali, S.M.F.: "Heavy Oil Recovery by Steam-Driven Hydrocarbon Slugs from Linear Porous Media," paper 5019 presented at the 1974 SPE of AIME, Houston, TX, 6-9 October.

18. Wu, C.H. and Brown, A.: "A Laboratory Study on Steam Distillation in Porous Media," paper 5569 presented at the 1975 SPE Annual Meeting, Dallas, TX, 28 September -1 October.

19. Wu, C.H.: "A Critical Review of Steamflooding," paper 6550 presented at the 1977 SPE Annual Meeting, Bakersfield, CA, 13 -15 April.

20. Rhee, S.W. and Doscher, T.M.: "A Method for Predicting Oil Recovery by Steamflooding Including the Effects of Distillation and Gravity Override," *Soc. Pet. Eng. J.* (Aug. 1980) 249-266.

21. Wu, C.H. and Elder, R.B.: "Correlation of Crude Oil Steam Distillation Yields With Basic Crude Oil Properties," *SPEJ* (December 1983) 937.

22. Duerksen, J.H. and Hsueh, L.: "Steam Distillation of Crude Oils," *SPEJ* (April 1983) 265.

23. Langhoff, J.A. and Wu, C.H.: "Calculation of High Temperature Crude Oil/Water/Vapor Using Simulated Distillation Data," *SPERE* (Sept. 1986) 483-489.

24. Billman, A.L.: Estimation of 3-Phase Separation K-Values Using Laboratory 3-Phase Separation Tests, MS Thesis, Texas A&M University, College Station, TX (Dec. 1989).

25. Lanclos, R.P.: A Three-Phase K-Value Study for Pure Hydrocarbon/Water and Crude Oil/Water Systems, MS Thesis, Texas A&M University, College Station, TX (Dec. 1990).

26. Lim, K.T.: Steam Distillation Effect and Oil Quality Change during Steam Injection, MS Thesis, Stanford U., Palo Alto, CA (1991).

27. Forero, R.: Three-Phase K-Values for n-Alkanes Co-Existing With Water at High Temperatures, MS Thesis, Texas A&M University, College Station, TX (May 1992).

28. Mokrys, I.J. and Butler, R.M.: "In-Situ Upgrading of Heavy Oils and Bitumen by Propane Deasphalting: The Vapex Process," paper 25452 presented at the 1993 SPE Production and Operations Symposium, Oklahoma City, OK, 21-23 March.

29. Espie, A.A. *et al.*: "An Evaluation of Oil Recovery by Vaporization," paper 27812 presented at the SPE/DOE Ninth Symposium on Improved Oil Recovery, Tulsa, OK, 7-20 April, 1994.

30. Beladi, M.K.: Three-Phase Hydrocarbon/Water Separation and K-Values, PhD Dissertation, Texas A&M University, College Station, TX (Dec. 1995).

31. Tandia, B.K.: A New Comprehensive Semiempirical Approach to Calculate Three-Phase Water/Hydrocarbons Equilibria, MS Thesis, Texas A&M University, College Station, TX (Dec. 1995).

32. Mamora, D.D. and Sutadiwiria, G.: "An Analytical Model for Light Oil Recovery by Steam Distillation," paper 54094 presented at the 1999 SPE International Thermal Operations and Heavy Oil Symposium, Bakersfield, CA, 17-19 March.

33. Walas, S.M. *Phase Equilibria in Chemical Engineering*, Butterworth-Heinemann, Boston, MA (1985).

34. Rachford, H.H. and Rice, J.D.: "Procedure for Use of Electronic Digital Computers in Calculating Flash Vaporization Hydrocarbon Equilibrium," *Trans. Soc. Pet. Eng.* (1952) **195,** 327.

35. Smith, J.M. and Van Ness, H.C.: *Introduction to Chemical Engineering Thermodynamics,* fourth edition, McGraw-Hill Book Co. Inc., New York City (1987).

36. McCain, W.D.: *The Properties of Petroleum Fluids,* second edition, PennWell Publishing Co., Tulsa, OK (1990).

37. Sandler, S.I.: *Chemical and Engineering Thermodynamics*, second edition, John Wiley & Sons, Inc. New York City, NY (1989).

38. Peng D.Y. and Robinson, D.B.: “A New Two-Constant Equation of State,” *I.E.C. Fun.* (1965) **15**, 59-64.

39. Robinson, D.B., Kalara, H., and Rempis, H.: “The Equilibrium Phase Properties of a Synthetic Sour Gas Mixture and a Simulated Natural Gas Mixture,” *GPA Research Report No. RR-31*, Tulsa, OK, May 1978.

40. Knapp. H. *et al.*: “*Vapor-Liquid Equilibria for Mixtures of Low Boiling Substances*”, DECHEMA Chemistry Data Series, (1982) **VI,** 320.

41. Orbey, H. and Sandler, S.I.: *Cubic Equations of State and Their Mixing Rules*, Cambridge University Press, Cambridge 1998.

42. Firoozabadi, A.: *Thermodynamics of Hydrocarbon Reservoirs,* first edition, McGraw-Hill Book Co. Inc., New York City, NY (1999).

43. Prausnitz, J.M. *et al.*: *Computer Calculations for Multicomponent Vapor-Liquid and Liquid-Liquid Equilibria*, first edition, Prentice-Hall, Inc., Englewood Cliffs, NJ (1980).

44. Prausnitz, J.M. and Chueh, P.L.: *Computer Calculations for High-Pressure Vapor-Liquid Equilibria,* first edition, Prentice-Hall, Inc., Englewood Cliffs, NJ (1980).

45. Dean, J.A.: *Lange’s Handbook of Chemistry*, fifteenth edition, McGraw Hill, New York City, NY (1998).

APPENDIX A

Experimental Data and Directly Calculated Results for All Runs

This Appendix is the compilation of data analysis results, and material balance for each cut and run.

TABLE A-1-OIL YIELD AT DRY DISTILLATION RUN NO. 1

WEIGHT OF COMPONENTS (DRY DISTILLATION RUN 1)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1275	17.8464	0.2474
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1359	19.0231	0.2207
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1467	20.5409	0.2050
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1486	20.8074	0.1822
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1484	20.7822	0.1620
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1485	20.7863	0.1461
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1444	20.2138	0.0952
N2			28.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2585

OIL YIELDS AT DISTILLATION TEMPERATURES (DRY DISTILLATION RUN 1)

Sample	Wt bottle g	Wt bottle + sample, g	Oil wt g	Oil vol ml	Wt in cell g	T(ºC)	Cum oil wt, g	Oil yield, wt%
1	11.603	35.292	23.689	35.00	116.311	99.20	23.6890	16.9207
2	11.166	30.036	18.870	27.00	97.441	109.90	42.5590	30.3993
3	12.368	17.788	5.420	8.00	92.021	120.00	47.9790	34.2707
4	12.855	18.098	5.243	7.50	86.778	130.50	53.2220	38.0157
5	12.824	24.254	11.430	16.00	75.348	139.40	64.6520	46.1800
6	12.562	21.485	8.923	13.00	66.425	149.60	73.5750	52.5536
7	12.628	22.225	9.597	14.00	56.828	161.20	83.1720	59.4086
8	12.692	20.678	7.986	11.00	48.842	171.60	91.1580	65.1129
9	12.454	18.961	6.507	9.50	42.335	181.70	97.6650	69.7607
10	12.610	16.711	4.101	6.00	38.234	191.70	101.7660	72.6900
11	12.551	15.569	3.018	4.00	35.216	201.20	104.7840	74.8457
12	12.660	13.881	1.221	1.50	33.995	201.20	106.0050	75.7179
13	12.598	16.130	3.532	5.00	30.463	210.80	109.5370	78.2407
14	12.564	13.812	1.248	1.70	29.215	219.60	110.7850	79.1321
15	12.626	14.965	2.339	3.25	26.876	231.10	113.1240	80.8029
16	12.442	13.404	0.962	1.30	25.914	240.40	114.0860	81.4900
17	12.982	14.147	1.165	1.70	24.749	249.50	115.2510	82.3221
18	12.576	14.460	1.884	2.50	22.865	259.40	117.1350	83.6679
19	12.559	16.547	3.988	5.50	18.877	268.50	121.1230	86.5164
20	12.583	18.929	6.346	8.50	12.531	279.10	127.4690	91.0493
21	12.485	12.617	0.132	0.25	12.399	289.10	127.6010	91.1436
22	12.687	12.713	0.026	0.10	12.373	299.30	127.6270	91.1621
Residual after run	12.667	13.408	0.741	1.00	11.632	300.00	128.3680	91.6914
Residual incell	12.566	13.022	0.456	0.60	11.176	300.00	128.8240	92.0171
Total	300.308	429.132	128.824	183.90	1028.84		2331.16	

	Oil wt g	Oil vol ml
Difference	11.1760	17.1700
% Error	7.9829	8.5393

TABLE A-2-MAT. BAL. CUTS 1, 2 (DRY DISTILLATION RUN NO. 1)

Sample 1	Cut @ 99.2 ºC				
Component	Frac. Weigth GC	Weight(gr)	Mol	yi	Pi
C5	0.4956	11.7410	0.1627	0.5203	7.6478
C6	0.2515	5.9576	0.0691	0.2210	3.2490
C7	0.1287	3.0492	0.0304	0.0973	1.4301
C8	0.0662	1.5686	0.0137	0.0439	0.6454
C9	0.0343	0.8128	0.0063	0.0203	0.2978
C10	0.0183	0.4334	0.0030	0.0097	0.1431
C15	0.0053	0.1265	0.0006	0.0019	0.0280
N2	0.0000	0.7500	0.0268	0.0856	1.2588
Total	1.0000	24.4390	0.3128	1.0000	14.7000

Material Balance
Initial Mass - Sample Weight = Residual Mass   Inj Time = 30.0000
Residual Mass = 115.56   N2 mass = 0.7500

Residual 1	Cut @ 99.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	8.2590	0.1145	4.4931	0.1158	66.0486
C6	14.0424	0.1629	1.3409	0.1648	19.7112
C7	16.9508	0.1692	0.5685	0.1711	8.3575
C8	18.4314	0.1614	0.2690	0.1632	3.9540
C9	19.1872	0.1496	0.1339	0.1513	1.9681
C10	19.5666	0.1375	0.0700	0.1391	1.0291
C15	19.8735	0.0936	0.0201	0.0946	0.2956
Total	116.3110	0.9886		1.0000	101.3643

Sample 2	Cut @ 109.9 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.3436	6.4845	0.0899	0.3176	4.6685
C6	0.2961	5.5879	0.0648	0.2291	3.3682
C7	0.1870	3.5290	0.0352	0.1244	1.8294
C8	0.1014	1.9129	0.0167	0.0592	0.8699
C9	0.0491	0.9273	0.0072	0.0255	0.3756
C10	0.0227	0.4283	0.0030	0.0106	0.1564
C15	0.0000	0.0000	0.0000	0.0000	0.0000
N2	0.0000	1.8500	0.0661	0.2335	3.4321
Total	1.0000	18.8700	0.2830	1.0000	14.7000

Material Balance
Initial Mass - Sample Weight = Residual Mass   Inj Time = 74.0000
Residual Mass = 96.69   N2 mass = 1.8500

Residual 2	Cut @ 109.9 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	1.7745	0.0246	9.9646	0.0319	146.4789
C6	8.4545	0.0981	1.8023	0.1271	26.4932
C7	13.4218	0.1339	0.7170	0.1736	10.5395
C8	16.5184	0.1446	0.3158	0.1874	4.6420
C9	18.2599	0.1424	0.1385	0.1845	2.0356
C10	19.1383	0.1345	0.0610	0.1743	0.8971
C15	19.8735	0.0936	0.0000	0.1212	0.0000
Total	97.4410	0.7717		1.0000	191.0863

TABLE A-3-MAT. BAL. CUTS 3, 4 (DRY DISTILLATION RUN NO. 1)

Sample 3	Cut @ 120 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.2883	1.5627	0.0217	0.1481	2.1770
C6	0.3034	1.6445	0.0191	0.1305	1.9180
C7	0.2049	1.1105	0.0111	0.0758	1.1139
C8	0.1115	0.6044	0.0053	0.0362	0.5318
C9	0.0538	0.2915	0.0023	0.0155	0.2284
C10	0.0250	0.1355	0.0010	0.0065	0.0957
C15	0.0077	0.0419	0.0002	0.0013	0.0198
N2	0.0000	2.4000	0.0857	0.5861	8.6153
Total	0.9946	5.3909	0.1463	1.0000	14.7000
Material Balance					
			Inj Time =	96.0000	
Residual Mass =	91.30		N2 mass =	2.4000	
Residual 3	Cut @ 120 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.2118	0.0029	35.8770	0.0041	527.3924
C6	6.8100	0.0790	1.1742	0.1111	17.2603
C7	12.3113	0.1229	0.4386	0.1728	6.4472
C8	15.9141	0.1393	0.1847	0.1959	2.7146
C9	17.9684	0.1401	0.0789	0.1970	1.1595
C10	19.0027	0.1335	0.0347	0.1878	0.5098
C15	19.8317	0.0934	0.0103	0.1313	0.1508
Total	92.0501	0.7111		1.0000	555.6347

Sample 4	Cut @ 130.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0995	0.5214	0.0072	0.0524	0.7697
C6	0.3180	1.6671	0.0193	0.1401	2.0602
C7	0.3034	1.5908	0.0159	0.1150	1.6907
C8	0.1670	0.8757	0.0077	0.0555	0.8165
C9	0.0701	0.3675	0.0029	0.0208	0.3051
C10	0.0262	0.1371	0.0010	0.0070	0.1026
C15	0.0065	0.0342	0.0002	0.0012	0.0171
N2	0.0000	2.3500	0.0839	0.6080	8.9381
Total	0.9906	5.1939	0.1380	1.0000	14.7000
Material Balance					
			Inj Time =	94.0000	
Residual Mass =	86.11		N2 mass =	2.3500	
Residual 4	Cut @ 130.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	5.1429	0.0597	1.5530	0.0902	22.8296
C7	10.7205	0.1070	0.7109	0.1618	10.4509
C8	15.0383	0.1316	0.2790	0.1991	4.1014
C9	17.6010	0.1372	0.1000	0.2075	1.4705
C10	18.8656	0.1326	0.0348	0.2005	0.5119
C15	19.7975	0.0932	0.0083	0.1409	0.1216
Total	87.1658	0.6613		1.0000	39.4860

TABLE A-4-MAT. BAL. CUTS 5, 6 (DRY DISTILLATION RUN NO. 1)

Sample 5	Cut @ 139.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0258	0.2947	0.0041	0.0249	0.3667
C6	0.1519	1.7363	0.0201	0.1231	1.8093
C7	0.2753	3.1463	0.0314	0.1918	2.8196
C8	0.2560	2.9259	0.0256	0.1565	2.3001
C9	0.1711	1.9557	0.0152	0.0931	1.3693
C10	0.0982	1.1225	0.0079	0.0482	0.7084
C15	0.0072	0.0826	0.0004	0.0024	0.0349
N2	0.0000	1.6500	0.0589	0.3600	5.2917
Total	0.9855	11.2639	0.1637	1.0000	14.7000
Material Balance					
			Inj Time =	66.0000	
Residual Mass =	74.84		N2 mass =	1.6500	

Residual 5	Cut @ 139.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	3.4066	0.0395	1.7456	0.0705	25.6596
C7	7.5742	0.0756	1.4226	0.1348	20.9127
C8	12.1124	0.1060	0.8273	0.1891	12.1613
C9	15.6452	0.1220	0.4281	0.2176	6.2933
C10	17.7431	0.1247	0.2167	0.2224	3.1850
C15	19.7149	0.0928	0.0143	0.1655	0.2109
Total	76.1966	0.5606		1.0000	68.4228

Sample 6	Cut @ 149.6 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0070	0.0623	0.0009	0.0061	0.0901
C6	0.0855	0.7632	0.0089	0.0628	0.9236
C7	0.2407	2.1476	0.0214	0.1520	2.2350
C8	0.2880	2.5697	0.0225	0.1596	2.3460
C9	0.2221	1.9818	0.0155	0.1096	1.6114
C10	0.1426	1.2727	0.0089	0.0634	0.9327
C15	0.0099	0.0887	0.0004	0.0030	0.0435
N2	0.0000	1.7500	0.0625	0.4434	6.5178
Total	0.9959	8.8860	0.1410	1.0000	14.7000
Material Balance					
			Inj Time =	70.0000	
Residual Mass =	65.96		N2 mass =	1.7500	

Residual 6	Cut @ 149.6 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	2.6434	0.0307	0.9893	0.0635	14.5434
C7	5.4267	0.0542	1.3561	0.1121	19.9350
C8	9.5427	0.0835	0.9228	0.1729	13.5650
C9	13.6635	0.1065	0.4970	0.2205	7.3063
C10	16.4704	0.1157	0.2648	0.2396	3.8925
C15	19.6262	0.0924	0.0155	0.1913	0.2276
Total	67.3729	0.4830		1.0000	59.4697

TABLE A-5-MAT. BAL. CUTS 7, 8 (DRY DISTILLATION RUN NO. 1)

Sample 7	Cut @ 161.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0035	0.0336	0.0005	0.0035	0.0509
C6	0.0415	0.3981	0.0046	0.0343	0.5049
C7	0.1822	1.7490	0.0175	0.1298	1.9074
C8	0.2901	2.7844	0.0244	0.1812	2.6637
C9	0.2692	2.5837	0.0201	0.1498	2.2014
C10	0.1951	1.8723	0.0132	0.0978	1.4378
C15	0.0162	0.1550	0.0007	0.0054	0.0797
N2	0.0000	1.5000	0.0536	0.3982	5.8542
Total	0.9978	9.5761	0.1345	1.0000	14.7000
Material Balance					
			Inj Time =	60.0000	
Residual Mass =	56.38		N2 mass =	1.5000	
Residual 7	Cut @ 161.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	2.2453	0.0261	0.5306	0.0647	7.8003
C7	3.6777	0.0367	1.4232	0.0912	20.9210
C8	6.7583	0.0592	1.2329	0.1470	18.1242
C9	11.0798	0.0864	0.6978	0.2146	10.2583
C10	14.5981	0.1026	0.3838	0.2548	5.6422
C15	19.4712	0.0917	0.0238	0.2277	0.3502
Total	57.8304	0.4026		1.0000	63.0962

Sample 8	Cut @ 171.6 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0009	0.0074	0.0001	0.0009	0.0128
C6	0.0176	0.1404	0.0016	0.0138	0.2028
C7	0.1214	0.9697	0.0097	0.0819	1.2043
C8	0.2675	2.1366	0.0187	0.1583	2.3276
C9	0.3062	2.4449	0.0191	0.1614	2.3722
C10	0.2548	2.0346	0.0143	0.1210	1.7793
C15	0.0288	0.2297	0.0011	0.0092	0.1346
N2	0.0000	1.5000	0.0536	0.4535	6.6665
Total	0.9972	7.9635	0.1181	1.0000	14.7000
Material Balance					
Residual Mass =	48.42		Inj Time =	60.0000	
			N2 mass =	1.5000	
Residual 8	Cut @ 171.6 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	2.1049	0.0244	0.1909	0.0722	2.8068
C7	2.7080	0.0270	1.0249	0.0799	15.0665
C8	4.6216	0.0405	1.3232	0.1197	19.4513
C9	8.6348	0.0673	0.8104	0.1991	11.9131
C10	12.5635	0.0883	0.4635	0.2611	6.8137
C15	19.2415	0.0906	0.0342	0.2679	0.5023
Total	49.8743	0.3381		1.0000	56.5538

TABLE A-6-MAT. BAL. CUTS 9, 10 (DRY DISTILLATION RUN NO. 1)

Sample 9	Cut @ 181.7ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0069	0.0449	0.0005	0.0050	0.0733
C7	0.0731	0.4757	0.0047	0.0454	0.6680
C8	0.2280	1.4837	0.0130	0.1243	1.8276
C9	0.3296	2.1446	0.0167	0.1601	2.3528
C10	0.3195	2.0788	0.0146	0.1398	2.0555
C15	0.0429	0.2792	0.0013	0.0126	0.1850
N2	0.0000	1.5000	0.0536	0.5128	7.5378
Total	1.0000	6.5070	0.1045	1.0000	14.7000
Material Balance					
Residual Mass =	41.91		Inj Time =	60.0000	
			N2 mass =	1.5000	
Residual 9	Cut @ 181.7ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	2.0600	0.0239	0.0599	0.0832	0.8812
C7	2.2322	0.0223	0.5859	0.0776	8.6123
C8	3.1379	0.0275	1.2998	0.0956	19.1073
C9	6.4902	0.0506	0.9084	0.1762	13.3533
C10	10.4846	0.0737	0.5451	0.2565	8.0124
C15	18.9623	0.0893	0.0405	0.3108	0.5951
Total	43.3673	0.2872		1.0000	50.5615

Sample 10	Cut @ 191.7 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0043	0.0177	0.0002	0.0027	0.0399
C7	0.0387	0.1586	0.0016	0.0209	0.3070
C8	0.1873	0.7681	0.0067	0.0887	1.3038
C9	0.3341	1.3702	0.0107	0.1409	2.0715
C10	0.3746	1.5362	0.0108	0.1424	2.0932
C15	0.0610	0.2502	0.0012	0.0155	0.2284
N2	0.0000	1.2500	0.0446	0.5889	8.6562
Total	1.0000	4.1010	0.0758	1.0000	14.7000
Material Balance					
			Inj Time =	50	
Residual Mass =	37.81		N2 mass =	1.25	
Residual 10	Cut @ 191.7 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	2.0422	0.0237	0.0293	0.0926	0.4314
C7	2.0736	0.0207	0.2584	0.0808	3.7979
C8	2.3698	0.0207	1.0946	0.0810	16.0909
C9	5.1200	0.0399	0.9038	0.1559	13.2860
C10	8.9485	0.0629	0.5797	0.2456	8.5223
C15	18.7121	0.0881	0.0451	0.3441	0.6637
Total	39.2663	0.2560		1.0000	42.7921

TABLE A-7-MAT. BAL. CUTS 11, 12 (DRY DISTILLATION RUN NO. 1)

Sample 11	Cut @ 201.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0022	0.0068	0.0001	0.0010	0.0153
C7	0.0257	0.0776	0.0008	0.0102	0.1500
C8	0.1487	0.4488	0.0039	0.0518	0.7614
C9	0.3220	0.9717	0.0076	0.0999	1.4681
C10	0.4081	1.2315	0.0087	0.1141	1.6771
C15	0.0897	0.2707	0.0013	0.0168	0.2469
N2	0.0000	1.5000	0.0536	0.7062	10.3812
Total	0.9964	3.0071	0.0759	1.0000	14.7000
Material Balance					
			Inj Time =	60.0000	
Residual Mass =	34.80		N2 mass =	1.5000	
Residual 11	Cut @ 201.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	2.0354	0.0236	0.0103	0.1010	0.1510
C7	1.9960	0.0199	0.1197	0.0852	1.7599
C8	1.9210	0.0168	0.7199	0.0719	10.5830
C9	4.1483	0.0323	0.7218	0.1384	10.6103
C10	7.7170	0.0542	0.4917	0.2320	7.2286
C15	18.4414	0.0868	0.0452	0.3714	0.6649
Total	36.2592	0.2337		1.0000	30.9978

Sample 12	Cut @ 210.8 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0039	0.0137	0.0002	0.0036	0.0531
C6	0.0139	0.0492	0.0006	0.0109	0.1601
C7	0.0338	0.1195	0.0012	0.0227	0.3341
C8	0.1242	0.4388	0.0038	0.0732	1.0766
C9	0.2906	1.0264	0.0080	0.1526	2.2429
C10	0.4085	1.4427	0.0101	0.1933	2.8416
C15	0.1040	0.3672	0.0017	0.0330	0.4845
N2	0.0000	0.7500	0.0268	0.5107	7.5072
Total	0.9789	3.4575	0.0524	1.0000	14.7000
			Inj Time =	30	
Residual Mass =	31.34		N2 mass =	0.75	
Residual 12	Cut @ 210.8 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.9862	0.0230	0.0984	0.1107	1.4466
C7	1.8766	0.0187	0.2528	0.0899	3.7155
C8	1.4822	0.0130	1.1756	0.0623	17.2806
C9	3.1219	0.0243	1.3056	0.1169	19.1918
C10	6.2742	0.0441	0.9131	0.2117	13.4224
C15	18.0742	0.0851	0.0807	0.4085	1.1860
Total	32.8153	0.2083		1.0000	56.2428

TABLE A-8-MAT. BAL. CUTS 13, 14 (DRY DISTILLATION RUN NO. 1)

Sample 13	Cut @ 219.6 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0035	0.0044	0.0001	0.0011	0.0165
C6	0.0101	0.0127	0.0001	0.0027	0.0397
C7	0.0242	0.0302	0.0003	0.0055	0.0815
C8	0.0927	0.1157	0.0010	0.0186	0.2735
C9	0.2605	0.3251	0.0025	0.0466	0.6844
C10	0.4383	0.5470	0.0038	0.0706	1.0381
C15	0.1706	0.2129	0.0010	0.0184	0.2706
N2	0.0000	1.2750	0.0455	0.8364	12.2958
Total	1.0000	1.2480	0.0544	1.0000	14.7000
Material Balance					
			Inj Time =	51	
Residual Mass =	30.10		N2 mass =	1.275	
Residual 13	Cut @ 219.6 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	-0.0044	0.0000		0.0000	0.0000
C6	1.9736	0.0229	0.0235	0.1148	0.3455
C7	1.8464	0.0184	0.0600	0.0924	0.8817
C8	1.3665	0.0120	0.3102	0.0600	4.5592
C9	2.7968	0.0218	0.4258	0.1093	6.2594
C10	5.7272	0.0402	0.3499	0.2018	5.1436
C15	17.8613	0.0841	0.0437	0.4216	0.6418
Total	31.5673	0.1994		1.0000	17.8313

Sample 14	Cut @ 231.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0044	0.0103	0.0001	0.0018	0.0271
C7	0.0136	0.0318	0.0003	0.0049	0.0716
C8	0.0687	0.1607	0.0014	0.0216	0.3175
C9	0.2342	0.5478	0.0043	0.0656	0.9641
C10	0.4474	1.0464	0.0074	0.1129	1.6598
C15	0.2317	0.5419	0.0026	0.0392	0.5758
N2	0.0000	1.3750	0.0491	0.7540	11.0841
Total	1.0000	2.3390	0.0651	1.0000	14.7000
Material Balance					
			Inj Time =	55.0000	
Residual Mass =	27.76		N2 mass =	1.3750	
Residual 14	Cut @ 231.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	-0.0044	0.0000		0.0000	0.0000
C6	1.9632	0.0228	0.0148	0.1242	0.2179
C7	1.8146	0.0181	0.0494	0.0987	0.7255
C8	1.2058	0.0106	0.3753	0.0576	5.5171
C9	2.2490	0.0175	0.6860	0.0956	10.0842
C10	4.6808	0.0329	0.6296	0.1793	9.2548
C15	17.3194	0.0815	0.0881	0.4446	1.2953
Total	29.2283	0.1834		1.0000	27.0947

TABLE A-9-MAT. BAL. CUTS 15, 16 (DRY DISTILLATION RUN NO. 1)

Sample 15	Cut @ 240.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0036	0.0035	0.0000	0.0008	0.0122
C7	0.0109	0.0105	0.0001	0.0022	0.0317
C8	0.0569	0.0547	0.0005	0.0099	0.1455
C9	0.2117	0.2036	0.0016	0.0328	0.4820
C10	0.4470	0.4300	0.0030	0.0624	0.9174
C15	0.2700	0.2597	0.0012	0.0252	0.3712
N2	0.0000	1.1750	0.0420	0.8667	12.7400
Total	1.0000	0.9620	0.0484	1.0000	14.7000
Material Balance					
			Inj Time =	47.0000	
Residual Mass =	26.79		N2 mass =	1.1750	
Residual 15	Cut @ 240.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	-0.0044	0.0000		0.0000	0.0000
C6	1.9598	0.0227	0.0065	0.1285	0.0950
C7	1.8041	0.0180	0.0212	0.1017	0.3118
C8	1.1511	0.0101	0.1738	0.0569	2.5549
C9	2.0453	0.0159	0.3638	0.0901	5.3483
C10	4.2508	0.0299	0.3697	0.1688	5.4343
C15	17.0597	0.0803	0.0556	0.4539	0.8178
Total	28.2663	0.1770		1.0000	14.5621
Sample 16	Cut @ 249.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0083	0.0097	0.0001	0.0028	0.0410
C6	0.0121	0.0141	0.0002	0.0034	0.0498
C7	0.0164	0.0191	0.0002	0.0039	0.0581
C8	0.0532	0.0620	0.0005	0.0113	0.1655
C9	0.2036	0.2372	0.0018	0.0384	0.5643
C10	0.4631	0.5395	0.0038	0.0787	1.1566
C15	0.2433	0.2835	0.0013	0.0277	0.4071
N2	0.0000	1.1250	0.0402	0.8338	12.2576
Total	1.0000	1.1650	0.0482	1.0000	14.7000
Material Balance					
			Inj Time =	45.0000	
Residual Mass =	25.63		N2 mass =	1.1250	
Residual 16	Cut @ 249.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.9457	0.0226	0.0254	0.1335	0.3731
C7	1.7850	0.0178	0.0375	0.1054	0.5510
C8	1.0891	0.0095	0.1997	0.0564	2.9353
C9	1.8081	0.0141	0.4604	0.0834	6.7685
C10	3.7113	0.0261	0.5101	0.1542	7.4982
C15	16.7763	0.0790	0.0593	0.4671	0.8716
Total	27.1154	0.1691		1.0000	18.9976

TABLE A-10-MAT. BAL. CUTS 17, 18 (DRY DISTILLATION RUN NO. 1)

Sample 17	Cut @ 259.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0019	0.0036	0.0000	0.0009	0.0133
C6	0.0052	0.0097	0.0001	0.0021	0.0304
C7	0.0091	0.0172	0.0002	0.0032	0.0464
C8	0.0305	0.0574	0.0005	0.0092	0.1356
C9	0.1334	0.2513	0.0020	0.0359	0.5284
C10	0.3612	0.6806	0.0048	0.0877	1.2899
C15	0.4587	0.8642	0.0041	0.0746	1.0973
N2	0.0000	1.2000	0.0429	0.7863	11.5587
Total	1.0000	1.8840	0.0545	1.0000	14.7000
Material Balance					
			Inj Time =	48	
Residual Mass =	23.75		N2 mass =	1.2	
Residual 17	Cut @ 259.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.9360	0.0225	0.0145	0.1427	0.2131
C7	1.7678	0.0176	0.0282	0.1120	0.4140
C8	1.0317	0.0090	0.1608	0.0573	2.3645
C9	1.5568	0.0121	0.4664	0.0771	6.8557
C10	3.0307	0.0213	0.6488	0.1352	9.5377
C15	15.9120	0.0749	0.1569	0.4757	2.3069
Total	25.2350	0.1575		1.0000	21.6919

Sample 18	Cut @ 268.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0028	0.0114	0.0001	0.0019	0.0275
C7	0.0038	0.0151	0.0002	0.0021	0.0314
C8	0.0131	0.0521	0.0005	0.0065	0.0951
C9	0.0723	0.2881	0.0022	0.0319	0.4682
C10	0.2470	0.9849	0.0069	0.0981	1.4425
C15	0.6611	2.6364	0.0124	0.1760	2.5867
N2	0.0000	1.3500	0.0482	0.6836	10.0486
Total	1.0000	3.9880	0.0705	1.0000	14.7000
Material Balance					
			Inj Time =	54.0000	
Residual Mass =	19.76		N2 mass =	1.3500	
Residual 18	Cut @ 268.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.9246	0.0223	0.0113	0.1652	0.1662
C7	1.7527	0.0175	0.0165	0.1294	0.2425
C8	0.9796	0.0086	0.1019	0.0634	1.4983
C9	1.2687	0.0099	0.4353	0.0732	6.3983
C10	2.0458	0.0144	0.9226	0.1064	13.5624
C15	13.2757	0.0625	0.3806	0.4624	5.5944
Total	21.2470	0.1352		1.0000	27.4621

TABLE A-11-MAT. BAL. CUTS 19, 20 (DRY DISTILLATION RUN NO. 1)

Sample 19	Cut @ 279.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0156	0.0987	0.0008	0.0088	0.1292
C10	0.0740	0.4693	0.0033	0.0377	0.5540
C15	0.9105	5.7780	0.0272	0.3108	4.5688
N2	0.0000	1.5750	0.0563	0.6427	9.4480
Total	1.0000	6.3460	0.0875	1.0000	14.7000
Material Balance					
			Inj Time =	63.0000	
Residual Mass =	13.41		N2 mass =	1.5750	
Residual 19	Cut @ 279.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.9246	0.0223	0.0000	0.2150	0.0000
C7	1.7527	0.0175	0.0000	0.1684	0.0000
C8	0.9796	0.0086	0.0000	0.0825	0.0000
C9	1.1700	0.0091	0.1001	0.0878	1.4719
C10	1.5765	0.0111	0.3534	0.1066	5.1952
C15	7.4977	0.0353	0.9149	0.3397	13.4485
Total	14.9010	0.1039		1.0000	20.1156

Sample 20	Cut @ 289.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0067	0.0009	0.0000	0.0002	0.0024
C10	0.0258	0.0034	0.0000	0.0006	0.0083
C15	0.9675	0.1277	0.0006	0.0141	0.2075
N2	0.0000	1.1750	0.0420	0.9852	14.4819
Total	1.0000	0.1320	0.0426	1.0000	14.7000
Material Balance					
			Inj Time =	47.0000	
Residual Mass =	13.28		N2 mass =	1.1750	
Residual 20	Cut @ 289.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.9246	0.0223	0.0000	0.2163	0.0000
C7	1.7527	0.0175	0.0000	0.1694	0.0000
C8	0.9796	0.0086	0.0000	0.0830	0.0000
C9	1.1691	0.0091	0.0018	0.0883	0.0270
C10	1.5731	0.0111	0.0053	0.1071	0.0772
C15	7.3700	0.0347	0.0420	0.3360	0.6175
Total	14.7690	0.1033		1.0000	0.7217

TABLE A-12-MAT. BAL. CUT 21 (DRY DISTILLATION RUN NO. 1)

Sample 21	Cut @ 299.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0096	0.0002	0.0000	0.0000	0.0007
C10	0.0238	0.0006	0.0000	0.0001	0.0016
C15	0.9667	0.0251	0.0001	0.0029	0.0432
N2	0.0000	1.1250	0.0402	0.9969	14.6546
Total	1.0000	0.0260	0.0403	1.0000	14.7000
Material Balance					
			Inj Time =	45	
Residual Mass =	13.25		N2 mass =	1.125	
Residual 21	Cut @ 299.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.9246	0.0223	0.0000	0.2165	0.0000
C7	1.7527	0.0175	0.0000	0.1696	0.0000
C8	0.9796	0.0086	0.0000	0.0831	0.0000
C9	1.1688	0.0091	0.0005	0.0884	0.0080
C10	1.5724	0.0111	0.0010	0.1071	0.0148
C15	7.3448	0.0346	0.0088	0.3352	0.1287
Total	14.7430	0.1031		1.0000	0.1515

TABLE A-13-OIL YIELD (DRY DISTILLATION RUN NO. 2)

WEIGHT OF COMPONENTS (DRY DISTILLATION RUN 2)

Compound	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1295	18.1310	0.2513
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1358	19.0057	0.2205
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1406	19.6848	0.1964
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1443	20.2063	0.1769
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1450	20.3059	0.1583
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1463	20.4753	0.1439
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1492	20.8945	0.0984
N2	0.0000	0.0000	48.0000	0.0000				
Total	201.0700	140.0000		1.2746	1.0000	0.9907	138.7035	1.2457

OIL YIELDS AT DISTILLATION TEMPERATURES (DRY DISTILLATION RUN 2)

Sample	Wt bottle g	Wt bottle + sample, g	Oil wt g	Oil vol ml	Wt in cell g	T(ºC)	Cum oil wt, g	Oil yield, wt%
1	12.6450	33.6180	20.9730	34.0000	119.0270	99.20	20.9730	14.98
2	13.0310	35.2800	22.2490	33.0000	96.7780	109.90	43.2220	30.87
3	12.5720	17.6910	5.1190	7.5000	91.6590	120.00	48.3410	34.53
4	12.7420	23.7920	11.0500	16.0000	80.6090	132.30	59.3910	42.42
5	12.5410	24.7710	12.2300	19.0000	68.3790	141.10	71.6210	51.16
6	12.6330	19.8280	7.1950	11.0000	61.1840	150.10	78.8160	56.30
7	12.5510	20.5210	7.9700	12.0000	53.2140	159.90	86.7860	61.99
8	12.5770	19.9980	7.4210	11.0000	45.7930	169.50	94.2070	67.29
9	13.0480	19.7730	6.7250	9.5000	39.0680	180.40	100.9320	72.09
10	12.5850	16.3090	3.7240	5.5000	35.3440	191.40	104.6560	74.75
11	12.4680	16.5150	4.0470	6.0000	31.2970	202.10	108.7030	77.65
12	12.5500	14.1680	1.6180	2.5000	29.6790	211.00	110.3210	78.80
13	12.7230	15.5020	2.7790	4.0000	26.9000	221.90	113.1000	80.79
14	12.6400	14.6800	2.0400	3.0000	24.8600	233.10	115.1400	82.24
15	12.5600	14.8990	2.3390	3.5000	22.5210	243.50	117.4790	83.91
16	12.6410	14.7430	2.1020	3.0000	20.4190	251.10	119.5810	85.42
17	12.8310	15.5650	2.7340	3.5000	17.6850	260.20	122.3150	87.37
18	12.5470	21.5040	8.9570	12.0000	8.7280	271.50	131.2720	93.77
19	12.6480	14.6900	2.0420	3.0000	6.6860	281.70	133.3140	95.22
20	12.6230	12.9950	0.3720	0.5000	6.3140	290.40	133.6860	95.49
21	12.8110	12.8880	0.0770	0.2500	6.2370	300.50	133.7630	95.55
22	12.6840	12.9900	0.3060	0.2500	5.9310	300.30	134.0690	95.76
Residual after run			0.5000	0.2590	5.4310	300.30	134.5690	96.12
Residual oil in cell			1.4380	1.8800		300.30	136.0070	97.15
Total	278.6510	412.7200	136.0070	202.1390				

	Oil wt g	Oil vol ml
Difference	3.9930	1.0690
% Error	2.8521	0.5317

TABLE A-14-MAT. BAL. CUTS 1, 2 (DRY DISTILLATION RUN NO. 2)

Sample 1	Cut @ 99.2 ºC				
Component	Frac. Weigth G(	Weight(gr)	Mol	yi	Pi
C5	0.5238	10.9864	0.1523	0.5590	8.2166
C6	0.2442	5.1208	0.0594	0.2181	3.2064
C7	0.1187	2.4894	0.0248	0.0912	1.3406
C8	0.0581	1.2190	0.0107	0.0392	0.5758
C9	0.0279	0.5849	0.0046	0.0167	0.2461
C10	0.0138	0.2904	0.0020	0.0075	0.1101
C15	0.0039	0.0817	0.0004	0.0014	0.0207
N2	0.0000	0.8750	0.0182	0.0669	0.9837
Total	0.9904	20.7725	0.2724	1.0000	14.7000
			Inj Time =	35	
Residual Mass =	119.23		N2 mass =	0.875	

Residual 1	Cut @ 99.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.0136	0.1249	4.5654	0.1224	67.1121
C6	14.8792	0.1727	1.2891	0.1692	18.9496
C7	17.5106	0.1747	0.5325	0.1713	7.8279
C8	18.7810	0.1644	0.2431	0.1611	3.5738
C9	19.4151	0.1514	0.1128	0.1483	1.6588
C10	19.7096	0.1385	0.0552	0.1357	0.8113
C15	19.9183	0.0938	0.0154	0.0919	0.2258
N2	0.0000	0.0000	0.0000		
Total	119.2275	1.0204		1.0000	100.1593

Sample 2	Cut @ 109.9 ºC				
Component	Frac. Weigth G(	Weigth(gr)	Mol	yi	Pi
C5	0.3028	6.7370	0.0934	0.3148	4.6277
C6	0.2838	6.3136	0.0733	0.2470	3.6309
C7	0.1934	4.3021	0.0429	0.1447	2.1278
C8	0.1133	2.5210	0.0221	0.0744	1.0938
C9	0.0597	1.3293	0.0104	0.0349	0.5136
C10	0.0302	0.6724	0.0047	0.0159	0.2342
C15	0.0038	0.0849	0.0004	0.0013	0.0198
N2	0.0000	2.3750	0.0495		0.0000
Total	0.9870	21.9603	0.2966	0.8332	12.2478
			Inj Time =	95	
Residual Mass =	97.27		N2 mass =	2.375	

Residual 2	Cut @ 109.9 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	2.2766	0.0316	7.7147	0.0408	113.4068
C6	8.5656	0.0994	1.9216	0.1285	28.2477
C7	13.2085	0.1318	0.8491	0.1705	12.4822
C8	16.2600	0.1423	0.4042	0.1841	5.9418
C9	18.0858	0.1410	0.1916	0.1824	2.8167
C10	19.0372	0.1338	0.0921	0.1730	1.3537
C15	19.8334	0.0934	0.0112	0.1207	0.1641
N2	0.0000	0.0000	0.0000		
Total	97.2671	0.7733		1.0000	164.4130

TABLE A-15-MAT. BAL. CUTS 3, 4 (DRY DISTILLATION RUN NO. 2)

Sample3	Cut @ 120 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.1614	0.8264	0.0115	0.1348	1.9809
C6	0.2730	1.3973	0.0162	0.1908	2.8042
C7	0.2405	1.2313	0.0123	0.1446	2.1252
C8	0.1611	0.8245	0.0072	0.0849	1.2483
C9	0.0917	0.4693	0.0037	0.0431	0.6329
C10	0.0490	0.2510	0.0018	0.0208	0.3051
C15	0.0045	0.0230	0.0001	0.0013	0.0187
N2	0.0000	1.5500	0.0323	0.3799	5.5848
Total	0.9812	5.0228	0.0850	1.0000	14.7000
			Inj Time =	62	
Residual Mass =	92.24		N2 mass =	1.55	

Residual 3	Cut @ 120 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	7.1684	0.0832	1.6064	0.1188	23.6135
C7	11.9772	0.1195	0.8472	0.1706	12.4542
C8	15.4355	0.1351	0.4402	0.1929	6.4708
C9	17.6165	0.1374	0.2196	0.1961	3.2276
C10	18.7861	0.1320	0.1101	0.1885	1.6187
C15	19.8104	0.0933	0.0096	0.1331	0.1407
Total	90.7941	0.7005		1.0000	47.5254

Sample 4	Cut @ 132.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0854	0.9433	0.0131	0.0957	1.4062
C6	0.2254	2.4905	0.0289	0.2114	3.1082
C7	0.2651	2.9292	0.0292	0.2139	3.1440
C8	0.2075	2.2926	0.0201	0.1468	2.1585
C9	0.1301	1.4372	0.0112	0.0820	1.2052
C10	0.0744	0.8218	0.0058	0.0423	0.6211
C15	0.0057	0.0629	0.0003	0.0022	0.0318
N2	0.0000	1.3500	0.0281	0.2058	3.0249
Total	0.9934	10.9774	0.1367	1.0000	14.7000
			Inj Time =	54	
Residual Mass =	81.27		N2 mass =	1.35	

Residual 4	Cut @ 132.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	4.6779	0.0543	2.3565	0.0897	34.6413
C7	9.0480	0.0903	1.4330	0.1493	21.0648
C8	13.1430	0.1151	0.7721	0.1902	11.3501
C9	16.1793	0.1261	0.3932	0.2085	5.7801
C10	17.9643	0.1262	0.2025	0.2087	2.9767
C15	19.7475	0.0930	0.0141	0.1537	0.2071
Total	80.7600	0.6050		1.0000	76.0201

TABLE A-16-MAT. BAL. CUTS 5, 6 (DRY DISTILLATION RUN NO. 2)

Sample 5	Cut @ 141.1ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0289	0.3538	0.0049	0.0350	0.5148
C6	0.1512	1.8488	0.0215	0.1532	2.2523
C7	0.2642	3.2312	0.0322	0.2303	3.3855
C8	0.2545	3.1129	0.0273	0.1946	2.8610
C9	0.1767	2.1605	0.0168	0.1203	1.7685
C10	0.1079	1.3198	0.0093	0.0662	0.9737
C15	0.0076	0.0932	0.0004	0.0031	0.0460
N2	0.0000	1.3250	0.0276	0.1971	2.8981
Total	0.9910	12.1201	0.1400	1.0000	14.7000
			Inj Time =	53	
Residual Mass =	69.15		N2 mass =	1.325	
Residual 5	Cut @ 141.1ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	2.8291	0.0328	2.3218	0.0660	34.1303
C7	5.8168	0.0580	1.9737	0.1167	29.0132
C8	10.0300	0.0878	1.1027	0.1765	16.2099
C9	14.0188	0.1093	0.5476	0.2197	8.0492
C10	16.6445	0.1170	0.2817	0.2351	4.1415
C15	19.6544	0.0925	0.0168	0.1860	0.2476
Total	68.9937	0.4975		1.0000	91.7915

Sample 6	Cut @ 150.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0089	0.0639	0.0009	0.0068	0.1000
C6	0.0921	0.6626	0.0077	0.0591	0.8690
C7	0.2542	1.8287	0.0183	0.1403	2.0626
C8	0.2971	2.1377	0.0187	0.1439	2.1150
C9	0.2091	1.5048	0.0117	0.0902	1.3260
C10	0.1048	0.7540	0.0053	0.0407	0.5988
C15	0.0092	0.0660	0.0003	0.0024	0.0351
N2	0.0000	3.2250	0.0672	0.5166	7.5934
Total	0.9753	7.0176	0.1301	1.0000	14.7000
Material Balance					
			Inj Time =	129	
Residual Mass =	62.13		N2 mass =	3.225	
Residual 6	Cut @ 150.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	2.1665	0.0251	1.0240	0.0577	15.0534
C7	3.9881	0.0398	1.5353	0.0914	22.5692
C8	7.8924	0.0691	0.9069	0.1587	13.3309
C9	12.5140	0.0976	0.4026	0.2240	5.9183
C10	15.8905	0.1117	0.1589	0.2564	2.3353
C15	19.5884	0.0922	0.0113	0.2118	0.1658
Total	62.0399	0.4355		1.0000	59.3728

TABLE A-17-MAT. BAL. CUTS 7, 8 (DRY DISTILLATION RUN NO. 2)

Sample 7	Cut @ 159.9 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0023	0.0187	0.0003	0.0025	0.0371
C6	0.0386	0.3078	0.0036	0.0348	0.5118
C7	0.1876	1.4955	0.0149	0.1455	2.1386
C8	0.3091	2.4635	0.0216	0.2102	3.0903
C9	0.2716	2.1648	0.0169	0.1645	2.4186
C10	0.1747	1.3922	0.0098	0.0954	1.4019
C15	0.0050	0.0395	0.0002	0.0018	0.0266
N2	0.0000	1.7000	0.0354	0.3452	5.0751
Total	0.9889	7.8818	0.1026	1.0000	14.7000
			Inj Time =	68	
Residual Mass =	54.25		N2 mass =	1.7	
Residual 7	Cut @ 159.9 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.8588	0.0216	0.5949	0.0585	8.7450
C7	2.4926	0.0249	2.1556	0.0675	31.6873
C8	5.4289	0.0475	1.6304	0.1289	23.9662
C9	10.3492	0.0807	0.7516	0.2189	11.0478
C10	14.4984	0.1019	0.3450	0.2764	5.0715
C15	19.5489	0.0920	0.0073	0.2497	0.1066
Total	54.1768	0.3686		1.0000	80.6244

Sample 8	Cut @ 169.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0123	0.0915	0.0011	0.0106	0.1554
C7	0.1016	0.7538	0.0075	0.0749	1.1013
C8	0.2718	2.0173	0.0177	0.1759	2.5853
C9	0.3345	2.4821	0.0194	0.1927	2.8331
C10	0.2676	1.9861	0.0140	0.1390	2.0432
C15	0.0067	0.0500	0.0002	0.0023	0.0345
N2	0.0000	1.9500	0.0406	0.4046	5.9472
Total	0.9946	7.3809	0.1004	1.0000	14.7000
Residual Mass =	46.87		Inj Time =	78	
			N2 mass =	1.95	
Residual 8	Cut @ 169.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7673	0.0205	0.1592	0.0664	2.3399
C7	1.7388	0.0174	1.3332	0.0562	19.5981
C8	3.4116	0.0299	1.8184	0.0967	26.7298
C9	7.8671	0.0613	0.9702	0.1986	14.2623
C10	12.5123	0.0879	0.4881	0.2848	7.1753
C15	19.4989	0.0918	0.0079	0.2973	0.1160
Total	46.7959	0.3088		1.0000	70.2214

TABLE A-18-MAT. BAL. CUTS 9, 10 (DRY DISTILLATION RUN NO. 2)

Sample 9	Cut @ 180.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0053	0.0354	0.0004	0.0050	0.0730
C7	0.0444	0.2988	0.0030	0.0360	0.5294
C8	0.2032	1.3664	0.0120	0.1445	2.1241
C9	0.3558	2.3929	0.0187	0.2254	3.3131
C10	0.3716	2.4989	0.0176	0.2121	3.1184
C15	0.0151	0.1018	0.0005	0.0058	0.0851
N2	0.0000	1.4750	0.0307	0.3712	5.4569
Total	0.9954	6.6941	0.0828	1.0000	14.7000
			Inj Time =	59	
Residual Mass =	40.17		N2 mass =	1.475	

Residual 9	Cut @ 180.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7319	0.0201	0.0634	0.0783	0.9319
C7	1.4400	0.0144	0.6434	0.0560	9.4585
C8	2.0452	0.0179	2.0720	0.0697	30.4590
C9	5.4742	0.0427	1.3557	0.1662	19.9288
C10	10.0134	0.0704	0.7740	0.2741	11.3776
C15	19.3971	0.0913	0.0163	0.3557	0.2392
Total	40.1018	0.2567		1.0000	72.3951

Sample 10	Cut @ 191.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0224	0.0836	0.0008	0.0133	0.1949
C8	0.1534	0.5711	0.0050	0.0795	1.1689
C9	0.3503	1.3047	0.0102	0.1618	2.3781
C10	0.4399	1.6383	0.0115	0.1831	2.6917
C15	0.0264	0.0982	0.0005	0.0074	0.1081
N2	0.0000	1.6750	0.0349	0.5550	8.1583
Total	0.9924	3.6958	0.0629	1.0000	14.7000
Residual Mass =	36.48		Inj Time=	67	
			N2 mass=	1.675	

Residual 10	Cut @ 191.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7319	0.0201	0.0000	0.0879	0.0000
C7	1.3565	0.0135	0.2241	0.0592	3.2942
C8	1.4741	0.0129	1.4095	0.0564	20.7201
C9	4.1695	0.0325	1.1384	0.1421	16.7342
C10	8.3751	0.0589	0.7117	0.2573	10.4618
C15	19.2989	0.0909	0.0185	0.3972	0.2721
Total	36.4060	0.2288		1.0000	51.4824

TABLE A-19-MAT. BAL. CUTS 11, 12 (DRY DISTILLATION RUN NO. 2)

Sample 11	Cut @ 202.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0124	0.0504	0.0005	0.0097	0.1430
C8	0.1083	0.4382	0.0038	0.0742	1.0913
C9	0.3101	1.2549	0.0098	0.1893	2.7834
C10	0.4639	1.8774	0.0132	0.2553	3.7531
C15	0.1030	0.4167	0.0020	0.0380	0.5580
N2	0.0000	1.0750	0.0224		0.0000
Total	0.9977	4.0375	0.0517	0.5666	8.3289
			Inj Time =	43	
Residual Mass =	32.44		N2 mass =	1.075	
Residual 11	Cut @ 202.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.7319	0.0201	0.0000	0.1007	0.0000
C7	1.3061	0.0130	0.1489	0.0653	2.1890
C8	1.0359	0.0091	1.6330	0.0455	24.0047
C9	2.9146	0.0227	1.6621	0.1139	24.4324
C10	6.4977	0.0457	1.1154	0.2289	16.3959
C15	18.8822	0.0889	0.0852	0.4456	1.2522
Total	32.3684	0.1995		1.0000	68.2743

Sample 12	Cut @ 211 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0076	0.0122	0.0001	0.0035	0.0515
C8	0.0818	0.1323	0.0012	0.0333	0.4891
C9	0.2786	0.4508	0.0035	0.1009	1.4839
C10	0.4728	0.7649	0.0054	0.1544	2.2692
C15	0.1593	0.2577	0.0012	0.0348	0.5121
N2	0.0000	1.1250	0.0234	0.6731	9.8942
Total	1.0000	1.6180	0.0348	1.0000	14.7000
			Inj Time =	45	
Residual Mass =	30.82		N2 mass =	1.125	
Residual 12	Cut @ 211 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	1.7319	0.0201	0.0000	0.1068	0.0000
C7	1.2939	0.0129	0.0510	0.0686	0.7498
C8	0.9036	0.0079	0.7911	0.0421	11.6298
C9	2.4638	0.0192	0.9884	0.1021	14.5294
C10	5.7328	0.0403	0.7207	0.2142	10.5948
C15	18.6245	0.0877	0.0747	0.4661	1.0987
Total	30.7504	0.1881		1.0000	38.6025

TABLE A-20-MAT. BAL. CUTS 13, 14 (DRY DISTILLATION RUN NO. 2)

Sample 13	Cut @ 221.9 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0014	0.0038	0.0001	0.0012	0.0180
C6	0.0015	0.0042	0.0000	0.0011	0.0167
C7	0.0057	0.0158	0.0002	0.0037	0.0546
C8	0.0649	0.1805	0.0016	0.0371	0.5455
C9	0.2525	0.7016	0.0055	0.1285	1.8886
C10	0.4744	1.3182	0.0093	0.2176	3.1985
C15	0.1961	0.5449	0.0026	0.0602	0.8857
N2	0.0000	1.1250	0.0234	0.5505	8.0923
Total	0.9964	2.7689	0.0426	1.0000	14.7000
			Inj Time =	45	
Residual Mass =	28.05		N2 mass =	1.125	

Residual 13	Cut @ 221.9 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7277	0.0200	0.0096	0.1186	0.1409
C7	1.2780	0.0128	0.0492	0.0755	0.7234
C8	0.7231	0.0063	0.9908	0.0375	14.5643
C9	1.7622	0.0137	1.5804	0.0813	23.2314
C10	4.4145	0.0310	1.1854	0.1836	17.4252
C15	18.0797	0.0851	0.1196	0.5036	1.7586
Total	27.9853	0.1690		1.0000	57.8438

Sample 14	Cut @ 233.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0035	0.0071	0.0001	0.0021	0.0302
C8	0.0468	0.0954	0.0008	0.0243	0.3569
C9	0.2173	0.4432	0.0035	0.1004	1.4765
C10	0.4665	0.9516	0.0067	0.1944	2.8573
C15	0.2626	0.5358	0.0025	0.0733	1.0776
N2	0.0000	1.0000	0.0208	0.6055	8.9014
Total	0.9966	2.0331	0.0344	1.0000	14.7000
			Inj Time =	40	
Residual Mass =	26.02		N2 mass =	1	

Residual 14	Cut @ 233.1 oC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7277	0.0200	0.0000	0.1290	0.0000
C7	1.2709	0.0127	0.0252	0.0816	0.3701
C8	0.6277	0.0055	0.6868	0.0354	10.0959
C9	1.3190	0.0103	1.5181	0.0662	22.3163
C10	3.4629	0.0243	1.2415	0.1566	18.2507
C15	17.5439	0.0826	0.1380	0.5313	2.0281
Total	25.9522	0.1554		1.0000	53.0610

TABLE A-21-MAT. BAL. CUTS 15, 16 (DRY DISTILLATION RUN NO. 2)

Sample 15	Cut @ 243.5 oC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0020	0.0048	0.0000	0.0013	0.0192
C8	0.0286	0.0669	0.0006	0.0161	0.2373
C9	0.1669	0.3905	0.0030	0.0840	1.2342
C10	0.4411	1.0317	0.0073	0.2000	2.9393
C15	0.3613	0.8452	0.0040	0.1097	1.6130
N2	0.0000	1.0250	0.0214	0.5889	8.6570
Total	1.0000	2.3390	0.0363	1.0000	14.7000
			Inj Time =	41	
Residual Mass =	23.68		N2 mass =	1.025	
Residual 15	Cut @ 243.52 oC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7277	0.0200	0.0000	0.1427	0.0000
C7	1.2662	0.0126	0.0145	0.0899	0.2138
C8	0.5608	0.0049	0.4621	0.0349	6.7932
C9	0.9286	0.0072	1.6297	0.0515	23.9561
C10	2.4312	0.0171	1.6447	0.1216	24.1773
C15	16.6987	0.0786	0.1962	0.5594	2.8835
Total	23.6132	0.1405		1.0000	58.0239

Sample 16	Cut @ 251.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0022	0.0046	0.0000	0.0012	0.0174
C8	0.0188	0.0396	0.0003	0.0091	0.1331
C9	0.1258	0.2645	0.0021	0.0539	0.7923
C10	0.3789	0.7964	0.0056	0.1463	2.1499
C15	0.4743	0.9970	0.0047	0.1227	1.8031
N2	0.0000	1.2250	0.0255	0.6669	9.8042
Total	1.0000	2.1020	0.0383	1.0000	14.7000
			Inj Time =	49	
Residual Mass =	21.58		N2 mass =	1.225	
Residual 16	Cut @ 251.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7277	0.0200	0.0000	0.1569	0.0000
C7	1.2616	0.0126	0.0120	0.0985	0.1771
C8	0.5212	0.0046	0.2536	0.0357	3.7284
C9	0.6640	0.0052	1.3303	0.0405	19.5552
C10	1.6348	0.0115	1.6268	0.0899	23.9133
C15	15.7017	0.0739	0.2120	0.5785	3.1170
Total	21.5112	0.1278		1.0000	50.4911

TABLE A-22-MAT. BAL. CUTS 17, 18 (DRY DISTILLATION RUN NO. 2)

Sample 17	Cut @ 260.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0023	0.0063	0.0001	0.0016	0.0229
C8	0.0111	0.0305	0.0003	0.0066	0.0970
C9	0.0767	0.2098	0.0016	0.0405	0.5947
C10	0.2767	0.7565	0.0053	0.1315	1.9328
C15	0.6331	1.7309	0.0081	0.2015	2.9628
N2	0.0000	1.2000	0.0250	0.6183	9.0897
Total	1.0000	2.7340	0.0404	1.0000	14.7000
			Inj Time =	48	
Residual Mass =	18.84		N2 mass =	1.2	
Residual 17	Cut @ 260.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7277	0.0200	0.0000	0.1784	0.0000
C7	1.2553	0.0125	0.0140	0.1115	0.2058
C8	0.4907	0.0043	0.1726	0.0382	2.5376
C9	0.4542	0.0035	1.2835	0.0315	18.8677
C10	0.8784	0.0062	2.3933	0.0549	35.1819
C15	13.9708	0.0658	0.3443	0.5854	5.0613
Total	18.7772	0.1124		1.0000	61.8543

Sample 18	Cut @ 271.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0159	0.1426	0.0011	0.0160	0.2355
C10	0.0851	0.7624	0.0054	0.0772	1.1352
C15	0.8990	8.0521	0.0379	0.5464	8.0320
N2	0.0000	1.2000	0.0250	0.3604	5.2973
Total	1.0000	8.9570	0.0694	1.0000	14.7000
			Inj Time =	48	
Residual Mass =	9.89		N2 mass =	1.2	
Residual 18	Cut @ 271.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7277	0.0200	0.0000	0.2949	0.0000
C7	1.2553	0.0125	0.0000	0.1843	0.0000
C8	0.4907	0.0043	0.0000	0.0632	0.0000
C9	0.3117	0.0024	0.4482	0.0357	6.5880
C10	0.1160	0.0008	6.4400	0.0120	94.6679
C15	5.9187	0.0279	1.3331	0.4099	19.5964
Total	9.8202	0.0680		1.0000	120.8523

TABLE A-23-MAT. BAL. CUTS 19, 20 (DRY DISTILLATION RUN NO. 2)

Sample 19	Cut @ 281.7 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0032	0.0064	0.0001	0.0023	0.0337
C6	0.0020	0.0041	0.0000	0.0012	0.0179
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0156	0.0318	0.0002	0.0057	0.0844
C15	0.9758	1.9926	0.0094	0.2411	3.5442
N2	0.0000	1.4000	0.0292	0.7496	11.0198
Total	0.9965	2.0349	0.0389	1.0000	14.7000
			Inj Time =	56	
Residual Mass =	7.85		N2 mass =	1.4	
Residual 19	Cut @ 281.7 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7236	0.0200	0.0024	0.3429	0.0349
C7	1.2553	0.0125	0.0000	0.2148	0.0000
C8	0.4907	0.0043	0.0000	0.0737	0.0000
C9	0.3117	0.0024	0.0000	0.0417	0.0000
C10	0.0842	0.0006	0.3778	0.0101	5.5535
C15	3.9261	0.0185	0.5075	0.3169	7.4607
Total	7.7917	0.0583		1.0000	13.0490

Sample 20	Cut @ 290.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0023	0.0009	0.0000	0.0003	0.0042
C9	0.0101	0.0037	0.0000	0.0011	0.0160
C10	0.0292	0.0109	0.0001	0.0029	0.0419
C15	0.9584	0.3565	0.0017	0.0626	0.9209
N2	0.0000	1.2000	0.0250	0.9331	13.7170
Total	1.0000	0.3720	0.0268	1.0000	14.7000
			Inj Time =	48	
Residual Mass =	7.48		N2 mass =	1.2	
Residual 20	Cut @ 290.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7236	0.0200	0.0000	0.3538	0.0000
C7	1.2553	0.0125	0.0000	0.2216	0.0000
C8	0.4899	0.0043	0.0037	0.0758	0.0551
C9	0.3080	0.0024	0.0256	0.0425	0.3769
C10	0.0733	0.0005	0.3131	0.0091	4.6021
C15	3.5696	0.0168	0.2108	0.2972	3.0982
Total	7.4197	0.0565		1.0000	8.1323

TABLE A-24-MAT. BAL. CUT 21 (DRY DISTILLATION RUN NO. 2)

Sample 21	Cut @ 300.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0072	0.0006	0.0000	0.0002	0.0030
C10	0.0189	0.0015	0.0000	0.0005	0.0071
C15	0.9739	0.0750	0.0004	0.0167	0.2448
N2	0.0000	1.0000	0.0208	0.9827	14.4451
Total	1.0000	0.0770	0.0212	1.0000	14.7000
			Inj Time =	40	
Residual Mass =	7.40		N2 mass =	1	
Residual 21	Cut @ 300.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	1.7236	0.0200	0.0000	0.3561	0.0000
C7	1.2553	0.0125	0.0000	0.2230	0.0000
C8	0.4899	0.0043	0.0000	0.0763	0.0000
C9	0.3074	0.0024	0.0048	0.0427	0.0702
C10	0.0719	0.0005	0.0537	0.0090	0.7892
C15	3.4946	0.0165	0.0569	0.2929	0.8357
Total	7.3427	0.0562		1.0000	1.6952

TABLE A-25-OIL YIELD AT DRY DISTILLATION RUN NO. 3

WEIGHT OF COMPONENTS (DRY DISTILLATION RUN 3)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1108	15.5057	0.2149
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1307	18.2983	0.2123
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1412	19.7617	0.1972
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1496	20.9457	0.1834
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1540	21.5566	0.1681
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1561	21.8473	0.1535
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1577	22.0848	0.1040
N2			28.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2334

OIL YIELDS AT DISTILLATION TEMPERATURES (DRY DISTILLATION RUN 3)

Sample	Wt bottle g	Wt bottle + sample, g	Oil wt g	Oil vol ml	Wt in cell g	T(ºC)	Cum oil wt, g	Oil yield, wt%
1	12.517	39.242	26.725	42.50	113.28	98.00	26.725	19.09
2	24.916	46.922	22.006	34.80	91.27	115.00	48.731	34.81
3	25.029	34.172	9.143	13.80	82.13	131.10	57.874	41.34
4	25.145	33.949	8.804	12.90	73.32	141.20	66.678	47.63
5	25.594	40.728	15.134	22.10	58.19	153.20	81.812	58.44
6	25.360	30.543	5.183	7.40	53.01	163.30	86.995	62.14
7	25.119	32.454	7.335	10.50	45.67	173.30	94.330	67.38
8	25.219	30.970	5.751	8.00	39.92	181.50	100.081	71.49
9	25.460	30.534	5.074	7.00	34.85	190.90	105.155	75.11
10	24.922	27.631	2.709	3.70	32.14	200.10	107.864	77.05
11	25.261	27.907	2.646	3.65	29.49	210.20	110.510	78.94
12	25.377	27.688	2.311	3.20	27.18	220.20	112.821	80.59
13	25.293	27.916	2.623	3.50	24.56	230.30	115.444	82.46
14	25.008	26.400	1.392	1.00	23.16	239.60	116.836	83.45
15	25.613	27.023	1.410	1.40	21.75	249.50	118.246	84.46
16	25.270	27.246	1.976	2.75	19.78	259.50	120.222	85.87
17	24.899	29.340	4.441	6.15	15.34	269.50	124.663	89.05
18	25.259	29.179	3.920	4.90	11.42	281.40	128.583	91.85
19	25.103	27.340	2.237	3.05	9.18	289.60	130.820	93.44
20	24.717	24.941	0.224	0.45	8.96	300.00	131.044	93.60
21	25.184	27.030	1.846	0.50	7.11	300.00	132.890	94.92
Residual after run	12.544	12.680	0.136	0.100	6.97	300.00	133.026	95.02
Residual incell	12.584	15.694	3.110	4.00	3.86	300.00	136.136	97.24
Total	541.393	677.529	136.136	197.35	832.51			

	Oil wt g	Oil vol ml
Difference	3.8640	3.7200
% Error	2.7600	1.8501

TABLE A-26-MAT. BAL. CUTS 1, 2 (DRY DISTILLATION RUN NO. 3)

Sample 1	Cut @ 98.9 ºC				
Component	Frac. Weigth GC	Weight(gr)	Mol	yi	Pi
C5	0.4966	13.2703	0.1839	0.5356	7.8730
C6	0.2575	6.8817	0.0799	0.2325	3.4182
C7	0.1266	3.3825	0.0338	0.0983	1.4449
C8	0.0636	1.6984	0.0149	0.0433	0.6364
C9	0.0307	0.8209	0.0064	0.0186	0.2740
C10	0.0148	0.3944	0.0028	0.0081	0.1186
C15	0.0104	0.2767	0.0013	0.0038	0.0558
N2	0.0000	0.5750	0.0205	0.0598	0.8790
Total	1.0000	26.7250	0.3434	1.0000	14.7000
			Inj Time =	23	
Residual Mass =	113.27		N2 mass =	0.575	

Residual 1	Cut @ 98.9 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	6.7297	0.0933	5.4648	0.0980	80.3319
C6	13.1183	0.1522	1.4538	0.1599	21.3709
C7	16.6175	0.1658	0.5641	0.1743	8.2923
C8	18.3016	0.1602	0.2572	0.1683	3.7806
C9	19.1791	0.1495	0.1186	0.1571	1.7437
C10	19.6056	0.1378	0.0558	0.1448	0.8196
C15	19.7233	0.0929	0.0389	0.0976	0.5716
Total	113.2750	0.9517		1.0000	116.9105

Sample2	Cut @ 115 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.2702	5.9450	0.0824	0.3326	4.8885
C6	0.2063	4.5389	0.0527	0.2126	3.1248
C7	0.2043	4.4948	0.0449	0.1810	2.6613
C8	0.1242	2.7334	0.0239	0.0966	1.4197
C9	0.0668	1.4692	0.0115	0.0462	0.6796
C10	0.0338	0.7437	0.0052	0.0211	0.3101
C15	0.0044	0.0962	0.0005	0.0018	0.0269
N2		0.7500	0.0268	0.1081	1.5892
Total	0.9098	20.0211	0.2478	1.0000	14.7000
				Inj Time =	30
Residual Mass =	93.25			N2 mass =	0.75

Residual 2	Cut @ 115 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.7847	0.0109	22.3436	0.0149	328.4511
C6	8.5794	0.0996	1.5603	0.1362	22.9359
C7	12.1227	0.1210	1.0935	0.1656	16.0742
C8	15.5682	0.1363	0.5178	0.1865	7.6118
C9	17.7099	0.1381	0.2447	0.1890	3.5965
C10	18.8619	0.1326	0.1163	0.1814	1.7093
C15	19.6271	0.0924	0.0145	0.1264	0.2125
N2	0.0000	0.0000	0.0000		0.0000
Total	93.2539	0.7307		1.0000	380.5913

TABLE A-27-MAT. BAL. CUTS 3, 4 (DRY DISTILLATION RUN NO. 3)

Sample 3	Cut @ 131.1ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0701	0.6408	0.0089	0.0598	0.8791
C6	0.3057	2.7947	0.0324	0.2184	3.2100
C7	0.3383	3.0931	0.0309	0.2079	3.0554
C8	0.1874	1.7130	0.0150	0.1010	1.4844
C9	0.0727	0.6650	0.0052	0.0349	0.5132
C10	0.0262	0.2399	0.0017	0.0114	0.1669
C15	0.0000	0.0000	0.0000	0.0000	0.0000
N2	0.0000	1.5250	0.0545	0.3667	5.3911
Total	1.0004	9.1465	0.1485	1.0000	14.7000
			Inj Time =	61	
Residual Mass =	84.11		N2 mass =	1.525	

Residual 3	Cut @ 131.1ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.1439	0.0020	19.0883	0.0031	280.5983
C6	5.7847	0.0671	2.0712	0.1054	30.4461
C7	9.0296	0.0901	1.4686	0.1415	21.5879
C8	13.8552	0.1213	0.5301	0.1905	7.7918
C9	17.0450	0.1329	0.1672	0.2087	2.4586
C10	18.6220	0.1309	0.0552	0.2055	0.8120
C15	19.6271	0.0924	0.0000	0.1451	0.0000
Total	84.1075	0.6367		1.0000	343.6946

Sample 4	Cut @ 141.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0146	0.1286	0.0018	0.0149	0.2185
C6	0.1287	1.1331	0.0131	0.1097	1.6123
C7	0.2817	2.4801	0.0248	0.2065	3.0350
C8	0.2750	2.4208	0.0212	0.1768	2.5987
C9	0.1852	1.6305	0.0127	0.1060	1.5589
C10	0.1100	0.9688	0.0068	0.0568	0.8349
C15	0.0048	0.0421	0.0002	0.0017	0.0243
N2	0.0000	1.1000	0.0393	0.3277	4.8174
Total	1.0000	8.8040	0.1199	1.0000	14.7000
			Inj Time =	44	
Residual Mass =	75.30		N2 mass =	1.1	

Residual 4	Cut @ 141.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0153	0.0002		0.0004	0.0000
C6	4.6516	0.0540	1.1300	0.0971	16.6107
C7	6.5495	0.0654	1.7566	0.1175	25.8216
C8	11.4344	0.1001	0.9821	0.1800	14.4367
C9	15.4145	0.1202	0.4907	0.2161	7.2130
C10	17.6532	0.1241	0.2546	0.2231	3.7423
C15	19.5850	0.0922	0.0100	0.1658	0.1465
Total	75.3035	0.5561		1.0000	67.9709

TABLE A-28-MAT. BAL. CUTS 5, 6 (DRY DISTILLATION RUN NO. 3)

Sample 5	Cut @ 153.2 oC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0014	0.0204	0.0003	0.0017	0.0249
C6	0.0350	0.5299	0.0061	0.0368	0.5414
C7	0.1835	2.7774	0.0277	0.1660	2.4404
C8	0.2981	4.5118	0.0395	0.2366	3.4775
C9	0.2738	4.1436	0.0323	0.1935	2.8444
C10	0.1962	2.9699	0.0209	0.1250	1.8375
C15	0.0120	0.1810	0.0009	0.0051	0.0750
N2	0.0000	1.1000	0.0393	0.2353	3.4589
Total	1.0000	15.1340	0.1670	1.0000	14.7000
			Inj Time=	44	
Residual Mass =	60.17		N2 mass=	1.1	

Residual 5	Cut @ 153.2 oC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	4.1217	0.0478	0.3299	0.1116	4.8499
C7	3.7721	0.0376	1.8896	0.0879	27.7777
C8	6.9225	0.0606	1.6726	0.1414	24.5880
C9	11.2709	0.0879	0.9435	0.2051	13.8692
C10	14.6833	0.1032	0.5191	0.2408	7.6305
C15	19.4040	0.0913	0.0239	0.2132	0.3518
Total	60.1745	0.4285		1.0000	79.0670

Sample 6	Cut @ 163.3oC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0169	0.0878	0.0010	0.0129	0.1890
C7	0.1455	0.7541	0.0075	0.0950	1.3958
C8	0.2898	1.5020	0.0131	0.1659	2.4387
C9	0.3019	1.5648	0.0122	0.1539	2.2628
C10	0.2293	1.1887	0.0084	0.1054	1.5493
C15	0.0165	0.0856	0.0004	0.0051	0.0747
N2	0.0000	1.0250	0.0366	0.4619	6.7896
Total	1.0000	5.1830	0.0793	1.0000	14.7000
Material Balance					
			Inj Time=	41	
Residual Mass =	54.99		N2 mass=	1.025	

Residual 6	Cut @ 163.3 oC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	4.0339	0.0468	0.1060	0.1213	1.5579
C7	3.0180	0.0301	1.2164	0.0781	17.8813
C8	5.4205	0.0475	1.3489	0.1230	19.8289
C9	9.7061	0.0757	0.7848	0.1961	11.5371
C10	13.4946	0.0948	0.4288	0.2458	6.3035
C15	19.3184	0.0909	0.0216	0.2357	0.3171
Total	54.9915	0.3858		1.0000	57.4258

TABLE A-29-MAT. BAL. CUTS 7, 8 (DRY DISTILLATION RUN NO. 3)

Sample 7	Cut @ 173.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0073	0.0533	0.0006	0.0065	0.0960
C7	0.0891	0.6538	0.0065	0.0688	1.0120
C8	0.2514	1.8438	0.0161	0.1703	2.5035
C9	0.3264	2.3942	0.0187	0.1970	2.8953
C10	0.2919	2.1412	0.0150	0.1588	2.3338
C15	0.0339	0.2487	0.0012	0.0124	0.1816
N2	0.0000	1.0250	0.0366	0.3862	5.6778
Total	1.0000	7.3350	0.0948	1.0000	14.7000
			Inj Time =	41	
Residual Mass =	47.65		N2 mass =	1.025	

Residual 7	Cut @ 173.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	3.9806	0.0462	0.0463	0.1410	0.6807
C7	2.3642	0.0236	0.9561	0.0720	14.0550
C8	3.5768	0.0313	1.7822	0.0956	26.1981
C9	7.3119	0.0570	1.1320	0.1740	16.6406
C10	11.3534	0.0798	0.6520	0.2435	9.5847
C15	19.0697	0.0898	0.0451	0.2740	0.6628
Total	47.6565	0.3277		1.0000	67.8219

Sample 8	Cut @ 181.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0032	0.0184	0.0002	0.0026	0.0376
C7	0.0504	0.2900	0.0029	0.0347	0.5101
C8	0.2034	1.1697	0.0102	0.1228	1.8047
C9	0.3364	1.9345	0.0151	0.1808	2.6583
C10	0.3510	2.0185	0.0142	0.1701	2.5000
C15	0.0556	0.3199	0.0015	0.0181	0.2654
N2	0.0000	1.1000	0.0393	0.4710	6.9239
Total	1.0000	5.7510	0.0834	1.0000	14.7000
			Inj Time =	44	
Residual Mass =	41.90		N2 mass =	1.1	

Residual 8	Cut @ 181.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	3.9622	0.0460	0.0158	0.1622	0.2320
C7	2.0741	0.0207	0.4753	0.0730	6.9873
C8	2.4070	0.0211	1.6520	0.0743	24.2851
C9	5.3774	0.0419	1.2230	0.1479	17.9776
C10	9.3349	0.0656	0.7351	0.2314	10.8056
C15	18.7498	0.0883	0.0580	0.3113	0.8526
Total	41.9055	0.2835		1.0000	61.1401

TABLE A-30-MAT. BAL. CUTS 9, 10 (DRY DISTILLATION RUN NO. 3)

Sample 9	Cut @ 190.9 oC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0181	0.0916	0.0011	0.0139	0.2046
C7	0.0309	0.1568	0.0016	0.0205	0.3010
C8	0.1637	0.8306	0.0073	0.0952	1.3989
C9	0.3311	1.6802	0.0131	0.1714	2.5203
C10	0.3929	1.9934	0.0140	0.1833	2.6951
C15	0.0796	0.4039	0.0019	0.0249	0.3658
N2	0.0000	1.0500	0.0375	0.4908	7.2145
Total	1.0163	5.1565	0.0764	1.0000	14.7000
			Inj Time =	42	
Residual Mass =	36.74		N2 mass =	1.05	

Residual 9	Cut @190.9oC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	3.8706	0.0449	0.0758	0.1836	1.1143
C7	1.9174	0.0191	0.2618	0.0782	3.8478
C8	1.5764	0.0138	1.6869	0.0564	24.7972
C9	3.6972	0.0288	1.4550	0.1178	21.3882
C10	7.3415	0.0516	0.8693	0.2109	12.7793
C15	18.3460	0.0864	0.0705	0.3530	1.0361
Total	36.7491	0.2446		1.0000	64.9628

Sample 10	Cut @ 200.1 oC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0025	0.0069	0.0001	0.0012	0.0174
C7	0.0232	0.0627	0.0006	0.0093	0.1367
C8	0.1351	0.3660	0.0032	0.0476	0.6996
C9	0.3206	0.8686	0.0068	0.1006	1.4786
C10	0.4310	1.1676	0.0082	0.1219	1.7916
C15	0.0876	0.2372	0.0011	0.0166	0.2439
N2	0.0000	1.3250	0.0473	0.7029	10.3323
Total	1.0000	2.7090	0.0673	1.0000	14.7000
Material Balance					
			Inj Time =	53	
Residual Mass =	34.03		N2 mass =	1.325	

Residual 10	Cut @ 200.1 oC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	3.8637	0.0448	0.0059	0.1996	0.0870
C7	1.8547	0.0185	0.1128	0.0824	1.6586
C8	1.2104	0.0106	1.0088	0.0472	14.8299
C9	2.8286	0.0221	1.0245	0.0982	15.0605
C10	6.1739	0.0434	0.6310	0.1931	9.2758
C15	18.1087	0.0852	0.0437	0.3795	0.6426
Total	34.0401	0.2246		1.0000	41.5544

TABLE A-31-MAT. BAL. CUTS 11, 12 (DRY DISTILLATION RUN NO. 3)

Sample 11	Cut @ 210.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0020	0.0052	0.0001	0.0009	0.0136
C7	0.0136	0.0361	0.0004	0.0055	0.0811
C8	0.0990	0.2620	0.0023	0.0351	0.5163
C9	0.2895	0.7661	0.0060	0.0915	1.3444
C10	0.4517	1.1952	0.0084	0.1286	1.8905
C15	0.1441	0.3814	0.0018	0.0275	0.4041
N2	0.0000	1.3000	0.0464	0.7109	10.4500
Total	1.0000	2.6460	0.0653	1.0000	14.7000
			Inj Time =	52	
Residual Mass =	31.39		N2 mass =	1.3	

Residual 11	Cut @ 210.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	3.8585	0.0448	0.0043	0.2176	0.0626
C7	1.8186	0.0181	0.0625	0.0882	0.9193
C8	0.9484	0.0083	0.8703	0.0404	12.7936
C9	2.0626	0.0161	1.1701	0.0782	17.2006
C10	4.9786	0.0350	0.7563	0.1700	11.1174
C15	17.7274	0.0835	0.0678	0.4056	0.9962
Total	31.3941	0.2057		1.0000	43.0898

Sample 12	Cut @ 220.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0011	0.0026	0.0000	0.0005	0.0077
C7	0.0087	0.0201	0.0002	0.0034	0.0507
C8	0.0780	0.1803	0.0016	0.0272	0.3996
C9	0.2671	0.6172	0.0048	0.0829	1.2179
C10	0.4621	1.0678	0.0075	0.1292	1.8993
C15	0.1830	0.4229	0.0020	0.0343	0.5039
N2	0.0000	1.1750	0.0420	0.7225	10.6209
Total	1.0000	2.3110	0.0581	1.0000	14.7000
			Inj Time =	47	
Residual Mass =	29.08		N2 mass =	1.175	

Residual 12	Cut @ 220.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	3.8559	0.0447	0.0022	0.2360	0.0327
C7	1.7985	0.0179	0.0364	0.0946	0.5358
C8	0.7681	0.0067	0.7666	0.0355	11.2685
C9	1.4454	0.0113	1.3942	0.0594	20.4940
C10	3.9108	0.0275	0.8915	0.1449	13.1050
C15	17.3044	0.0815	0.0798	0.4296	1.1730
Total	29.0831	0.1896		1.0000	46.6090

TABLE A-32-OIL YIELD AT STEAM DISTILLATION RUN NO. 1

WEIGHT OF COMPONENTS (STEAM DISTILLATION RUN 1)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1152	16.1317	0.2236
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1280	17.9176	0.2079
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1374	19.2375	0.1920
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1483	20.7621	0.1818
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1544	21.6157	0.1685
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1564	21.8931	0.1539
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1603	22.4422	0.1057
N2			28.0000					
Water			18.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2333

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM DISTILLATION RUN 1)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Water ml	Cum water wt%
1	12.4680	35.6280	23.1600	0.0000	38.0000	38.0000	23.1600	97.30	23.16	16.54	0.0000	0.00
2	37.4290	98.8650	61.4360	2.4260	94.5000	92.0740	59.0100	115.00	82.17	58.69	2.4260	0.50
3	12.5100	41.1300	28.6200	17.9530	35.0000	17.0470	10.6670	130.20	92.84	66.31	20.3790	4.22
4	12.4440	44.4580	32.0140	18.3330	39.5000	21.1670	13.6810	140.00	106.52	76.08	38.7120	8.02
5	12.5330	41.8100	29.2770	18.1450	35.0000	16.8550	11.1320	151.40	117.65	84.04	56.8570	11.78
6	12.5060	33.9350	21.4290	19.8430	23.0000	3.1570	1.5860	160.00	119.24	85.17	76.7000	15.90
7	12.4120	33.0090	20.5970	20.0000	23.0000	3.0000	0.5970	169.20	119.83	85.60	96.7000	20.04
8	12.2830	40.3680	28.0850	25.5550	30.5000	2.0000	1.4000	181.00	121.23	86.60	122.2550	25.34
9	12.4990	34.1010	21.6020	19.8780	23.5000	3.6220	1.7240	190.00	122.96	87.83	142.1330	29.46
10	12.5270	37.2210	24.6940	22.0920	27.0000	4.9080	2.6020	200.00	125.56	89.69	164.2250	34.04
11	12.3730	37.2220	24.8490	23.5930	26.0000	2.4070	1.2560	209.10	126.82	90.58	187.8180	38.93
12	12.3670	33.9800	21.6130	21.1640	23.0000	1.8360	0.4490	219.00	127.26	90.90	208.9820	43.31
13	12.4800	37.2380	24.7580	24.7300	26.5000	1.7700	0.0280	231.00	127.29	90.92	233.7120	48.44
14	12.4000	34.4460	22.0460	21.9560	24.0000	2.0440	0.0900	240.90	127.38	90.99	255.6680	52.99
15	12.5370	32.0140	19.4770	19.4360	20.0000	0.5640	0.0410	251.00	127.42	91.02	275.1040	57.02
16	12.4970	30.0920	17.5950	17.5510	19.0000	1.4490	0.0440	261.30	127.47	91.05	292.6550	60.65
17	12.4470	34.7660	22.3190	22.2690	24.0000	1.7310	0.0500	271.00	127.52	91.08	314.9240	65.27
18	12.4200	31.5620	19.1420	19.1000	21.0000	1.9000	0.0420	280.70	127.56	91.11	334.0240	69.23
19	12.4440	37.0350	24.5910	24.5510	26.0000	1.4490	0.0400	291.50	127.60	91.14	358.5750	74.32
20	12.4160	37.7590	25.3430	25.3060	27.0000	1.6940	0.0370	301.30	127.64	91.17	383.8810	79.56
21	12.4560	36.7980	24.3420	24.3090	26.0000	1.6910	0.0330	312.00	127.67	91.19	434.2160	89.99
Residual after run	12.4120	42.2580	29.8460	24.9150	33.5000	8.5850	4.9310	312.00	132.60	94.71	434.2160	89.99
Residual incell	12.5210	13.6320	1.1110	1.1110	1.1110	0.0000	0.0000	312.00	132.60	94.71	434.2160	89.99
Total	311.3810	879.3270	567.9460	434.2160	666.1110	228.9500	132.6000		2697.98			

	Oil wt g	Oil vol ml
Difference	7.4000	27.8800
% Error	5.2857	13.8658

Beginning of Injection time =	70	min
Injection Rate =	0.50	ml/min
Total Injection Time =	965.00	min
Water injected =	482.50	ml
Water recovered =	434.22	ml
Water lost =	48.28	ml

TABLE A-33-MAT. BAL. CUTS 1, 2 (STEAM DISTILLATION RUN NO. 1)

Sample 1	Cut @ 97.3 ºC				
Component	Frac. Weigth GC	Weight(gr)	Mol	yi	Pi
C5	0.4105	9.5073	0.1318	0.0580	0.8528
C6	0.2305	5.3393	0.0620	0.0273	0.4010
C7	0.1504	3.4841	0.0348	0.0153	0.2250
C8	0.0872	2.0193	0.0177	0.0078	0.1144
C9	0.0484	1.1202	0.0087	0.0038	0.0565
C10	0.0297	0.6889	0.0048	0.0021	0.0313
C15	0.0432	1.0009	0.0047	0.0021	0.0305
N2	0.0000	1.7500	0.0625	0.0275	0.4045
Water	0.0000	35.0000	1.9444	0.8561	12.5840
Total			2.2714	1.0000	14.7000
			Inj Time =	70	
Residual Mass =	116.84		N2 mass =	1.75	
			Water =	35	
Residual 1	Cut @ 97.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.4927	0.1454	0.4029	0.1440	5.9234
C6	14.6607	0.1701	0.3642	0.1684	5.3536
C7	16.5159	0.1648	0.2110	0.1632	3.1011
C8	17.9807	0.1574	0.1123	0.1558	1.6509
C9	18.8798	0.1472	0.0593	0.1457	0.8722
C10	19.3111	0.1357	0.0357	0.1343	0.5244
C15	18.9991	0.0894	0.0527	0.0885	0.7745
Total	116.8400	1.0101		1.0000	18.1999

Sample 2	Cut @ 115 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0132	0.7785	0.0108	0.0078	0.1153
C6	0.0732	4.3198	0.0501	0.0364	0.5356
C7	0.2075	12.2451	0.1222	0.0888	1.3057
C8	0.2892	17.0637	0.1494	0.1086	1.5961
C9	0.2481	14.6393	0.1141	0.0830	1.2195
C10	0.1617	9.5444	0.0671	0.0488	0.7166
C15	0.0071	0.4193	0.0020	0.0014	0.0211
N2	0.0000	0.7500	0.0268	0.0195	0.2862
Water	0.0000	15.0000	0.8333	0.6057	8.9039
Total			1.3758	1.0000	14.7000
			Inj Time =	30	
Residual Mass =	57.83		N2 mass =	0.75	
			Water =	15	
Residual 2	Cut @ 115 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.7143	0.1346	0.0288	0.2723	0.4234
C6	10.3409	0.1200	0.1501	0.2427	2.2069
C7	4.2708	0.0426	1.0304	0.0862	15.1472
C8	0.9170	0.0080	6.6875	0.0162	98.3056
C9	4.2405	0.0331	1.2407	0.0669	18.2384
C10	9.7667	0.0686	0.3512	0.1388	5.1628
C15	18.5798	0.0875	0.0081	0.1769	0.1192
Total	57.8300	0.4944		1.0000	139.6035

TABLE A-34-MAT. BAL. CUTS 3, 4 (STEAM DISTILLATION RUN NO. 1)

Sample 3	Cut @ 130.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0031	0.0331	0.0005	0.0003	0.0066
C6	0.0234	0.2496	0.0029	0.0017	0.0418
C7	0.1109	1.1829	0.0118	0.0069	0.1704
C8	0.2505	2.6724	0.0234	0.0136	0.3377
C9	0.3151	3.3607	0.0262	0.0152	0.3783
C10	0.2754	2.9380	0.0206	0.0120	0.2981
C15	0.0216	0.2302	0.0011	0.0006	0.0156
N2	0.0000	1.4250	0.0509	0.0296	0.7347
Water	0.0000	28.5000	1.5833	0.9202	22.8568
Total			1.7207	1.0000	24.8400
			Inj Time =	57	
Residual Mass =	47.16		N2 mass =	1.425	
			Water =	28.5	
Residual 3	Cut @ 130.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6811	0.1342	0.0008	0.3170	0.0209
C6	10.0913	0.1171	0.0061	0.2766	0.1512
C7	3.0879	0.0308	0.0942	0.0728	2.3411
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.8798	0.0069	0.9398	0.0162	23.3442
C10	6.8287	0.0480	0.1058	0.1134	2.6293
C15	18.3495	0.0864	0.0031	0.2041	0.0767
Total	48.9183	0.4233		1.0000	28.5633
Sample 4	Cut @ 140 oC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0019	0.0257	0.0004	0.0002	0.0083
C6	0.0084	0.1145	0.0013	0.0009	0.0309
C7	0.0465	0.6359	0.0063	0.0043	0.1475
C8	0.1625	2.2238	0.0195	0.0132	0.4525
C9	0.3192	4.3664	0.0340	0.0230	0.7914
C10	0.4034	5.5187	0.0388	0.0262	0.9015
C15	0.0582	0.7960	0.0037	0.0025	0.0871
N2	0.0000	1.2000	0.0429	0.0290	0.9963
Water	0.0000	24.0000	1.3333	0.9007	30.9945
Total			1.4803	1.0000	34.4100
			Inj Time =	48	
Residual Mass =	33.48		N2 mass =	1.2	
			Water =	24	
Residual 4	Cut @ 140 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6555	0.1338	0.0007	0.3657	0.0226
C6	9.9768	0.1158	0.0028	0.3164	0.0976
C7	2.4520	0.0245	0.0641	0.0669	2.2059
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	1.3099	0.0092	1.0414	0.0252	35.8345
C15	17.5536	0.0826	0.0112	0.2258	0.3857
Total	40.9478	0.3659		1.0000	38.5463

TABLE A-35-MAT. BAL. CUTS 5, 6 (STEAM DISTILLATION RUN NO. 1)

Sample 5	Cut @ 151.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0024	0.0272	0.0003	0.0002	0.0105
C7	0.0255	0.2839	0.0028	0.0020	0.0944
C8	0.1103	1.2283	0.0108	0.0077	0.3583
C9	0.2634	2.9316	0.0229	0.0163	0.7617
C10	0.4631	5.1552	0.0362	0.0259	1.2073
C15	0.1353	1.5058	0.0071	0.0051	0.2362
N2	0.0000	1.1500	0.0411	0.0294	1.3687
Water	0.0000	23.0000	1.2778	0.9134	42.5827
Total			1.3989	1.0000	46.6200
			Inj Time =	46	
Residual Mass =	22.35		N2 mass =	1.15	
			Water =	23	
Residual 5	Cut @ 151.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6555	0.1338	0.0000	0.3863	0.0000
C6	9.9496	0.1155	0.0007	0.3332	0.0316
C7	2.1680	0.0216	0.0324	0.0624	1.5121
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	16.0478	0.0755	0.0232	0.2181	1.0834
Total	37.8209	0.3465		1.0000	2.6271

Sample 6	Cut @ 160 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0095	0.0151	0.0002	0.0001	0.0073
C8	0.0242	0.0384	0.0003	0.0003	0.0164
C9	0.0699	0.1109	0.0009	0.0007	0.0422
C10	0.3187	0.5054	0.0036	0.0028	0.1732
C15	0.5777	0.9162	0.0043	0.0034	0.2103
N2	0.0000	1.1000	0.0393	0.0309	1.9156
Water	0.0000	22.0000	1.2222	0.9618	59.5951
Total			1.2707	1.0000	61.9600
			Inj Time=	44	
Residual Mass =	20.76		N2 mass=	1.1	
			Water =	22	
Residual 6	Cut @ 160 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6555	0.1338	0.0000	0.3913	0.0000
C6	9.9496	0.1155	0.0000	0.3376	0.0000
C7	2.1530	0.0215	0.0019	0.0628	0.1167
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	15.1316	0.0712	0.0163	0.2083	1.0097
Total	36.8896	0.3420		1.0000	1.1265

TABLE A-36-MAT. BAL. CUTS 7, 8 (STEAM DISTILLATION RUN NO. 1)

Sample 7	Cut @ 169.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0012	0.0007	0.0000	0.0000	0.0006
C6	0.0048	0.0029	0.0000	0.0000	0.0020
C7	0.0099	0.0059	0.0001	0.0000	0.0036
C8	0.0165	0.0098	0.0001	0.0001	0.0053
C9	0.0319	0.0190	0.0001	0.0001	0.0091
C10	0.1409	0.0841	0.0006	0.0004	0.0362
C15	0.7949	0.4746	0.0022	0.0017	0.1368
N2	0.0000	1.1500	0.0411	0.0311	2.5152
Water	0.0000	23.0000	1.2778	0.9665	78.2512
Total			1.3220	1.0000	80.9600
			Inj Time =	46	
Residual Mass =	20.17		N2 mass =	1.15	
			Water =	23	
Residual 7	Cut @ 169.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6548	0.1338	0.0000	0.3940	0.0015
C6	9.9467	0.1154	0.0001	0.3398	0.0060
C7	2.1470	0.0214	0.0007	0.0631	0.0575
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	14.6570	0.0690	0.0083	0.2031	0.6735
Total	36.4055	0.3397		1.0000	0.7384

Sample 8	Cut @ 181 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0071	0.0099	0.0001	0.0001	0.0055
C10	0.0410	0.0574	0.0004	0.0003	0.0286
C15	0.9519	1.3327	0.0063	0.0043	0.4451
N2	0.0000	1.2750	0.0455	0.0310	3.2304
Water	0.0000	25.5000	1.4167	0.9644	100.5005
Total			1.4690	1.0000	104.2100
			Inj Time =	51	
Residual Mass =	18.77		N2 mass =	1.275	
			Water =	25.5	
Residual 8	Cut @ 181 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6548	0.1338	0.0000	0.4014	0.0000
C6	9.9467	0.1154	0.0000	0.3462	0.0000
C7	2.1470	0.0214	0.0000	0.0643	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	13.3243	0.0627	0.0227	0.1881	2.3656
Total	35.0729	0.3334		1.0000	2.3656

TABLE A-37-MAT. BAL. CUT 9, 10 (STEAM DISTILLATION RUN NO. 1)

Sample 9	Cut @ 190 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0181	0.0312	0.0002	0.0002	0.0218
C15	0.9819	1.6928	0.0080	0.0060	0.7947
N2	0.0000	1.1500	0.0411	0.0309	4.0959
Water	0.0000	23.0000	1.2778	0.9629	127.4275
Total			1.3270	1.0000	132.3400
			Inj Time =	46	
Residual Mass =	17.04		N2 mass =	1.15	
			Water =	23	
Residual 9	Cut @ 190 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6548	0.1338	0.0000	0.4112	0.0000
C6	9.9467	0.1154	0.0000	0.3547	0.0000
C7	2.1470	0.0214	0.0000	0.0658	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	11.6315	0.0548	0.0357	0.1683	4.7231
Total	33.3800	0.3254		1.0000	4.7231

Sample 10	Cut @ 200 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0081	0.0211	0.0001	0.0001	0.0170
C15	0.9919	2.5809	0.0122	0.0084	1.3953
N2	0.0000	1.2500	0.0446	0.0309	5.1268
Water	0.0000	25.0000	1.3889	0.9606	159.5008
Total			1.4458	1.0000	166.0400
			Inj Time =	50	
Residual Mass =	14.44		N2 mass =	1.25	
			Water =	25	
Residual 10	Cut @ 200 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6548	0.1338	0.0000	0.4272	0.0000
C6	9.9467	0.1154	0.0000	0.3684	0.0000
C7	2.1470	0.0214	0.0000	0.0684	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	9.0506	0.0426	0.0618	0.1360	10.2592
Total	30.7991	0.3133		1.0000	10.2592

TABLE A-38-MAT. BAL. CUT 11 (STEAM DISTILLATION RUN NO. 1)

Sample 11	Cut @ 209.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0086	0.0108	0.0001	0.0001	0.0107
C15	0.9914	1.2452	0.0059	0.0040	0.8228
N2	0.0000	1.2750	0.0455	0.0310	6.3914
Water	0.0000	25.5000	1.4167	0.9649	198.8451
Total			1.4681	1.0000	206.0700
			Inj Time =	51	
Residual Mass =	13.18		N2 mass =	1.275	
			Water =	25.5	
Residual 11	Cut @ 209.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.6548	0.1338	0.0000	0.4353	0.0000
C6	9.9467	0.1154	0.0000	0.3755	0.0000
C7	2.1470	0.0214	0.0000	0.0697	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	7.8054	0.0367	0.0334	0.1195	6.8833
Total	29.5539	0.3074		1.0000	6.8833

TABLE A-39-OIL YIELD AT STEAM DISTILLATION RUN NO. 2

WEIGHT OF COMPONENTS (STEAM DISTILLATION RUN 2)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1221	17.1009	0.2370
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1412	19.7666	0.2294
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1408	19.7157	0.1968
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1488	20.8348	0.1824
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1495	20.9261	0.1632
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1496	20.9398	0.1472
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1480	20.7161	0.0975
N2			28.0000					
Water			18.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2534

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM DISTILLATION RUN 2)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Water ml	Cum water wt%
1	12.641	35.748	23.107	0.000	38.000	38.000	23.107	103.70	23.107	16.51	0.000	0.00
2	37.871	92.577	54.706	5.331	82.000	76.669	49.375	115.00	72.482	51.77	17.160	3.69
3	12.434	35.705	23.271	17.160	27.500	10.340	6.111	130.00	78.593	56.14	42.641	9.18
4	25.173	67.847	42.674	25.481	52.300	26.819	17.193	140.00	95.786	68.42	64.141	13.81
5	25.298	67.651	42.353	21.500	53.000	31.500	20.853	150.00	116.639	83.31	82.741	17.81
6	12.720	32.730	20.010	18.600	21.500	2.000	1.400	160.00	118.039	84.31	102.415	22.04
7	12.639	34.144	21.505	19.674	23.000	3.326	1.831	170.00	119.870	85.62	122.843	26.44
8	12.673	35.674	23.001	20.428	24.500	4.072	2.573	180.00	122.443	87.46	145.095	31.23
9	12.893	38.174	25.281	22.252	26.000	3.748	3.029	190.00	125.472	89.62	167.554	36.06
10	12.683	37.770	25.087	22.459	26.500	4.041	2.628	200.00	128.100	91.50	192.926	41.53
11	12.683	39.419	26.736	25.372	27.000	1.628	1.364	210.00	129.464	92.47	215.727	46.43
12	12.872	36.218	23.346	22.801	23.600	0.799	0.545	220.00	130.009	92.86	242.723	52.24
13	12.959	39.955	26.996	26.996	26.996	0.000	0.000	230.00	130.009	92.86	264.387	56.91
14	12.750	34.414	21.664	21.664	21.664	0.000	0.000	240.00	130.009	92.86	284.571	61.25
15	12.654	32.838	20.184	20.184	20.184	0.000	0.000	250.00	130.009	92.86	305.874	65.84
16	12.905	34.208	21.303	21.303	21.303	0.000	0.000	260.00	130.009	92.86	327.246	70.44
17	13.149	34.521	21.372	21.372	21.372	0.000	0.000	270.00	130.009	92.86	349.886	75.31
18	12.712	35.352	22.640	22.640	22.640	0.000	0.000	280.00	130.009	92.86	375.568	80.84
19	12.424	38.106	25.682	25.682	25.682	0.000	0.000	290.00	130.009	92.86	404.284	87.02
20	12.861	41.577	28.716	28.716	28.716	0.000	0.000	300.00	130.009	92.86	430.970	92.76
21	12.625	39.311	26.686	26.686	26.686	0.000	0.000	310.00	130.009	92.86	435.470	93.73
22	12.920	17.420	4.500	4.500	4.500	0.000	0.000	310.00	130.009	92.86	459.259	98.85
Cold Residal	12.824	39.798	26.974	23.789	29.000	5.211	3.185					
Residual in cell	12.824	39.798	26.974	23.789	29.000	5.211	3.185					
Total	343.363	941.157	597.794	464.590	673.64	208.15	133.19					

	Oil wt g	Oil vol ml
Difference	6.8060	7.0830
% Error	4.8614	3.5227

Beginning of Injection time =	102	min
Injection Rate =	0.50	ml/min
Total Injection Tim	946.00	min
Water injected =	473.00	ml
Water recovered	464.59	ml
Water lost =	8.41	ml

TABLE A-40-MAT. BAL. CUTS 1, 2 (STEAM DISTILLATION RUN NO. 2)

Sample 1	Cut @103.7 ºC				
Component	Frac. Weigth GC	Weight(gr)	Mol	yi	Pi
C5	0.4660	10.7687	0.1493	0.0466	0.6855
C6	0.2668	6.1639	0.0715	0.0223	0.3285
C7	0.1347	3.1134	0.0311	0.0097	0.1427
C8	0.0702	1.6218	0.0142	0.0044	0.0652
C9	0.0340	0.7848	0.0061	0.0019	0.0281
C10	0.0166	0.3826	0.0027	0.0008	0.0124
C15	0.0118	0.2718	0.0013	0.0004	0.0059
N2	0.0000	2.5500	0.0911	0.0285	0.4183
H2O	1.0000	51.0000	2.8333	0.8853	13.0134
total			3.2005	1.0000	14.7000
			Inj Time =	102	
Residual Mass =	116.89		N2 mass =	2.55	
			Water =	51	
Residual 1	Cut @103.7 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.2313	0.1279	0.3639	0.1281	5.3497
C6	13.8361	0.1606	0.1390	0.1608	2.0430
C7	16.8866	0.1685	0.0575	0.1688	0.8455
C8	18.3782	0.1609	0.0275	0.1611	0.4047
C9	19.2152	0.1498	0.0127	0.1500	0.1873
C10	19.6174	0.1379	0.0061	0.1381	0.0894
C15	19.7282	0.0929	0.0043	0.0930	0.0632
Total	116.8930	0.9985		1.0000	8.9828

Sample 2	Cut @ 115 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0252	1.2457	0.0173	0.0130	0.1904
C6	0.1109	5.4744	0.0635	0.0477	0.7005
C7	0.2256	11.1397	0.1112	0.0834	1.2258
C8	0.2767	13.6612	0.1196	0.0897	1.3187
C9	0.2164	10.6835	0.0833	0.0625	0.9185
C10	0.1374	6.7832	0.0477	0.0358	0.5256
C15	0.0078	0.3872	0.0018	0.0014	0.0201
N2	0.0000	0.7750	0.0277	0.0208	0.3052
H2O	1.0000	15.5000	0.8611	0.6459	9.4952
total			1.3331	1.0000	14.7000
			Inj Time=	31	
Residual Mass =	67.52		N2 mass=	0.775	
			Water =	15.5	
Residual 2	Cut @ 115 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.9855	0.1107	0.0648	0.1997	0.9532
C6	8.3617	0.0970	0.2721	0.1751	4.0002
C7	5.7469	0.0574	0.8057	0.1035	11.8437
C8	4.7170	0.0413	1.2038	0.0745	17.6959
C9	8.5317	0.0665	0.5205	0.1200	7.6510
C10	12.8341	0.0902	0.2197	0.1628	3.2293
C15	19.3410	0.0911	0.0083	0.1643	0.1223
Total	67.5180	0.5541		1.0000	45.4957

TABLE A-41-MAT. BAL. CUTS 3, 4 (STEAM DISTILLATION RUN NO. 2)

Sample 3	Cut @ 130 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0158	0.0964	0.0013	0.0007	0.0184
C6	0.0691	0.4225	0.0049	0.0027	0.0676
C7	0.1754	1.0719	0.0107	0.0059	0.1475
C8	0.2581	1.5774	0.0138	0.0077	0.1904
C9	0.2580	1.5767	0.0123	0.0068	0.1695
C10	0.2105	1.2866	0.0090	0.0050	0.1247
C15	0.0130	0.0795	0.0004	0.0002	0.0052
N2	0.0000	1.5250	0.0545	0.0302	0.7510
H2O	1.0000	30.5000	1.6944	0.9406	23.3656
total			1.8014	1.0000	24.8400
			Inj Time =	61	
Residual Mass =	61.41		N2 mass =	1.525	
			Water =	30.5	
Residual 3	Cut @ 130 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.8891	0.1093	0.0034	0.2180	0.0845
C6	7.9392	0.0921	0.0148	0.1836	0.3681
C7	4.6750	0.0467	0.0639	0.0930	1.5861
C8	3.1395	0.0275	0.1399	0.0548	3.4757
C9	6.9550	0.0542	0.0631	0.1081	1.5683
C10	11.5475	0.0811	0.0310	0.1618	0.7707
C15	19.2615	0.0907	0.0011	0.1808	0.0285
Total	61.4070	0.5017		1.0000	7.8820
Sample 4	Cut @ 140 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0095	0.1634	0.0023	0.0012	0.0426
C6	0.0415	0.7131	0.0083	0.0045	0.1556
C7	0.1112	1.9111	0.0191	0.0104	0.3585
C8	0.2039	3.5060	0.0307	0.0168	0.5770
C9	0.2777	4.7749	0.0372	0.0203	0.6999
C10	0.3121	5.3659	0.0377	0.0206	0.7089
C15	0.0441	0.7587	0.0036	0.0020	0.0671
N2	0.0000	1.4750	0.0527	0.0288	0.9903
H2O	1.0000	29.5000	1.6389	0.8954	30.8101
total			1.8304	1.0000	34.4100
			Inj Time =	59	
Residual Mass =	44.21		N2 mass =	1.475	
			Water =	29.5	
Residual 4	Cut @ 140 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.7258	0.1071	0.0042	0.2925	0.1455
C6	7.2262	0.0839	0.0197	0.2291	0.6791
C7	2.7639	0.0276	0.1383	0.0754	4.7584
C8	0.0000	0.0000		0.0000	0.0000
C9	2.1801	0.0170	0.4380	0.0464	15.0726
C10	6.1817	0.0434	0.1736	0.1187	5.9735
C15	18.5028	0.0871	0.0082	0.2380	0.2822
Total	44.5804	0.3661		1.0000	26.9113

TABLE A-42-MAT. BAL. CUTS 5, 6 (STEAM DISTILLATION RUN NO. 2)

Sample 5	Cut @ 150 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0058	0.1211	0.0017	0.0011	0.0500
C6	0.0260	0.5417	0.0063	0.0040	0.1873
C7	0.0732	1.5257	0.0152	0.0097	0.4538
C8	0.1587	3.3095	0.0290	0.0185	0.8634
C9	0.2646	5.5187	0.0430	0.0275	1.2823
C10	0.3711	7.7390	0.0544	0.0348	1.6208
C15	0.1006	2.0974	0.0099	0.0063	0.2943
N2	0.0000	1.2250	0.0438	0.0280	1.3038
H2O	1.0000	24.5000	1.3611	0.8701	40.5642
total			1.5643	1.0000	46.6200
			Inj Time =	49	
Residual Mass =	19.71		N2 mass =	1.225	
			Water =	24.5	
Residual 5	Cut @ 150 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6046	0.1054	0.0028	0.3867	0.1294
C6	6.6845	0.0776	0.0141	0.2846	0.6582
C7	1.2382	0.0124	0.2147	0.0453	10.0084
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	16.4055	0.0772	0.0223	0.2834	1.0385
Total	31.9328	0.2726		1.0000	11.8345

Sample 6	Cut @ 160 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0017	0.0023	0.0000	0.0007	0.0423
C6	0.0064	0.0090	0.0001	0.0022	0.1356
C7	0.0181	0.0253	0.0003	0.0053	0.3288
C8	0.0459	0.0642	0.0006	0.0118	0.7328
C9	0.0885	0.1239	0.0010	0.0203	1.2588
C10	0.2458	0.3441	0.0024	0.0509	3.1517
C15	0.5938	0.8313	0.0039	0.0823	5.1011
N2	0.0000	1.1000	0.0393	0.8265	51.2089
Total	1.0000	1.4000	0.0475	1.0000	61.9600
			Inj Time =	44	
Residual Mass =	18.31		N2 mass =	1.1	
Residual 6	Cut @ 160 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6023	0.1054	0.0017	0.3928	0.1078
C6	6.6755	0.0775	0.0076	0.2888	0.4697
C7	1.2129	0.0121	0.1176	0.0451	7.2868
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	15.5742	0.0733	0.3012	0.2733	18.6638
Total	31.0649	0.2683		1.0000	26.5281

TABLE A-43-MAT. BAL. CUTS 7, 8 (STEAM DISTILLATION RUN NO. 2)

Sample 7	Cut @ 170 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0031	0.0057	0.0001	0.0000	0.0034
C8	0.0116	0.0213	0.0002	0.0001	0.0114
C9	0.0238	0.0435	0.0003	0.0003	0.0207
C10	0.1073	0.1965	0.0014	0.0010	0.0842
C15	0.8542	1.5641	0.0074	0.0055	0.4488
N2	0.0000	1.1500	0.0411	0.0309	2.5035
H2O	1.0000	23.0000	1.2778	0.9621	77.8880
total			1.3282	1.0000	80.9600
			Inj Time =	46	
Residual Mass =	16.48		N2 mass =	1.15	
			Water =	23	
Residual 7	Cut @ 170 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6023	0.1054	0.0000	0.4040	0.0000
C6	6.6755	0.0775	0.0000	0.2970	0.0000
C7	1.2073	0.0120	0.0009	0.0462	0.0744
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	14.0101	0.0660	0.0219	0.2529	1.7750
Total	29.4952	0.2608		1.0000	1.8494

Sample 8	Cut @ 180 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0034	0.0087	0.0001	0.0001	0.0068
C8	0.0062	0.0159	0.0001	0.0001	0.0109
C9	0.0104	0.0269	0.0002	0.0002	0.0164
C10	0.0343	0.0882	0.0006	0.0005	0.0485
C15	0.9457	2.4333	0.0115	0.0086	0.8967
N2	0.0000	1.1500	0.0411	0.0308	3.2148
H2O	1.0000	23.0000	1.2778	0.9598	100.0159
total			1.3314	1.0000	104.2100
			Inj Time =	46	
Residual Mass =	13.91		N2 mass =	1.15	
			Water =	23	
Residual 8	Cut @ 180 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6023	0.1054	0.0000	0.4227	0.0000
C6	6.6755	0.0775	0.0000	0.3107	0.0000
C7	1.1986	0.0120	0.0014	0.0480	0.1414
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	11.5767	0.0545	0.0394	0.2186	4.1015
Total	27.0532	0.2493		1.0000	4.2429

TABLE A-44-MAT. BAL. CUT 9, 10 (STEAM DISTILLATION RUN NO. 2)

Sample 9	Cut @ 190 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0059	0.0178	0.0001	0.0001	0.0132
C10	0.0125	0.0380	0.0003	0.0002	0.0254
C15	0.9816	2.9732	0.0140	0.0101	1.3321
N2	0.0000	1.2000	0.0429	0.0308	4.0786
H2O	1.0000	24.0000	1.3333	0.9588	126.8907
total			1.3906	1.0000	132.3400
	10.88		Inj Time =	48	
Residual Mass =			N2 mass =	1.2	
			Water =	24	

Residual 9	Cut @ 190 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6023	0.1054	0.0000	0.4478	0.0000
C6	6.6755	0.0775	0.0000	0.3292	0.0000
C7	1.1986	0.0120	0.0000	0.0508	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	8.6035	0.0405	0.0585	0.1721	7.7384
Total	24.0800	0.2353		1.0000	7.7384

Sample 10	Cut @ 200 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0057	0.0150	0.0001	0.0001	0.0116
C15	0.9943	2.6130	0.0123	0.0082	1.3587
N2	0.0000	1.3000	0.0464	0.0309	5.1281
H2O	1.0000	26.0000	1.4444	0.9609	159.5416
total			1.5033	1.0000	166.0400
			Inj Time =	52	
Residual Mass =	8.25		N2 mass =	1.3	
			Water =	26	

Residual 10	Cut @ 200 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6023	0.1054	0.0000	0.4725	0.0000
C6	6.6755	0.0775	0.0000	0.3474	0.0000
C7	1.1986	0.0120	0.0000	0.0536	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	5.9905	0.0282	0.0647	0.1265	10.7434
Total	21.4669	0.2230		1.0000	10.7434

TABLE A-45-MAT. BAL. CUT 11 (STEAM DISTILLATION RUN NO. 2)

Sample 11	Cut @ 210 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0039	0.0053	0.0000	0.0000	0.0051
C15	0.9961	1.3587	0.0064	0.0043	0.8803
N2	0.0000	1.3000	0.0464	0.0310	6.3898
H2O	1.0000	26.0000	1.4444	0.9647	198.7947
total			1.4973	1.0000	206.0700
			Inj Time =	52	
Residual Mass =	6.89		N2 mass =	1.3	
			Water =	26	
Residual 11	Cut @ 210 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0097	0.0001	0.0022	0.0114	0.4534
C15	1.2543	0.0059	0.0043	0.9886	0.8904
Total	1.2640	0.0060		1.0000	1.3438

TABLE A-46-OIL YIELD AT STEAM DISTILLATION RUN NO. 3

WEIGHT OF COMPONENTS (STEAM DISTILLATION RUN 3)

Comp.	Vo(cc)	Wo(gr)	MW	Mol	Mol Fraction	Frac. Weight GC	Wo(gr)	Mol
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1130	15.8190	0.2193
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1308	18.3161	0.2125
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1353	18.9394	0.1890
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1496	20.9476	0.1834
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1534	21.4810	0.1675
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1552	21.7253	0.1527
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1627	22.7716	0.1072
N2			28.0000					
Water			18.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2315

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM DISTILLATION RUN 3)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield wt%	Cum Water ml	Cum water wt%
1	25.6430	48.5620	22.9190	0.0000	36.4000	36.40	22.9190	98.20	22.9190	16.37	0.0000	0.00
2	37.8020	100.6200	62.8180	8.3010	92.6780	84.38	54.5170	118.00	77.4360	55.31	8.3010	1.51
3	12.9000	29.6860	16.7860	14.7500	18.7500	4.00	2.5600	130.20	79.9960	57.14	23.0510	4.18
4	12.3140	37.3280	25.0140	17.0110	30.0110	13.00	8.4500	143.50	88.4460	63.18	40.0620	7.27
5	12.9170	44.4930	31.5760	20.4270	37.4270	17.00	11.1490	150.50	99.5950	71.14	60.4890	10.98
6	12.6000	47.8690	35.2690	19.8410	42.8410	23.00	15.4280	162.30	115.0230	82.16	80.3300	14.58
7	12.7170	36.4690	23.7520	20.3720	26.3720	5.70	3.6594	170.30	118.6824	84.77	100.7020	18.28
8	12.6980	41.7990	29.1010	26.7460	30.7460	3.90	2.3550	180.50	121.0374	86.46	127.4480	23.13
9	12.4710	38.3870	25.9160	23.5340	27.5340	3.90	2.5077	193.30	123.5451	88.25	150.9820	27.40
10	12.9090	33.1890	20.2800	19.5940	20.5940	1.00	0.6860	202.20	124.2311	88.74	170.5760	30.96
11	12.5290	36.6090	24.0800	22.6560	25.6560	2.30	1.5203	210.50	125.7514	89.82	193.2320	35.07
12	12.4770	34.0370	21.5600	21.2230	21.2230	0.55	0.3465	219.70	126.0979	90.07	214.4550	38.92
13	12.5560	35.1860	22.6300	22.6300	22.6300	0.00	0.0000	235.00	126.0979	90.07	237.0850	43.03
14	12.8370	31.8830	19.0460	19.0460	19.0460	0.00	0.0000	240.00	126.0979	90.07	256.1310	46.48
15	12.4350	38.9300	26.4950	26.4950	26.4950	0.00	0.0000	250.10	126.0979	90.07	282.6260	51.29
16	12.5300	33.6410	21.1110	21.1110	21.1110	0.00	0.0000	260.70	126.0979	90.07	303.7370	55.12
17	12.5110	40.9710	28.4600	28.4600	28.4600	0.00	0.0000	270.20	126.0979	90.07	332.1970	60.29
18	12.6220	34.0250	21.4030	21.4030	21.4030	0.00	0.0000	280.90	126.0979	90.07	353.6000	64.17
19	12.4960	41.6030	29.1070	29.1070	29.1070	0.00	0.0000	290.00	126.0979	90.07	382.7070	69.46
20	12.4700	52.1060	39.6360	39.0360	39.6360	0.60	0.4260	299.50	126.5239	90.37	421.7430	76.54
21	12.4890	21.5720	9.0830	9.0830	9.0830	0.00	0.0000	299.50	126.5239	90.37	430.8260	78.19
Cold Residal	12.8020	27.5580	14.7560	11.6940	15.6940	4.00	3.0620	300.00	129.5859	92.56	442.5200	80.31
Residual in cell	12.8240	13.9640	1.1400	0.7000	1.3940	0.69	0.4400	300.00	130.0259	92.88	443.2200	80.44
Total	328.5490	900.4870	571.9380	443.2200	644.2910	200.42	130.0259					

	Oil wt g	Oil vol ml
Difference	9.9741	0.6490
% Error	7.1244	0.3228

Beginning of Injection time =	226	min
Injection Rate =	0.50	ml/min
Total Injection Time =	1102.00	min
Water injected =	551.00	ml
Water recovered =	443.22	ml
Water lost =	107.78	ml

TABLE A-47-MAT. BAL. CUTS 1, 2 (STEAM DISTILLATION RUN NO. 3)

Sample 1	Cut @ 98.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.4901	11.2321	0.1557	0.0259	0.3807
C6	0.2616	5.9958	0.0696	0.0116	0.1702
C7	0.1283	2.9409	0.0293	0.0049	0.0718
C8	0.0628	1.4388	0.0126	0.0021	0.0308
C9	0.0297	0.6815	0.0053	0.0009	0.0130
C10	0.0146	0.3341	0.0023	0.0004	0.0057
C15	0.0129	0.2960	0.0014	0.0002	0.0034
N2	0.0000	5.0000	0.1786	0.0297	0.4367
water	0.0000	100.0000	5.5556	0.9243	13.5876
Total			6.0104	1.0000	14.7000
			Inj Time=	200	
Residual Mass =	117.08		N2 mass=	5	
			Water =	100	
Residual 1	Cut @ 98.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	8.7679	0.1215	0.2128	0.1217	3.1279
C6	14.0042	0.1625	0.0711	0.1628	1.0454
C7	17.0591	0.1702	0.0286	0.1705	0.4209
C8	18.5612	0.1625	0.0129	0.1628	0.1893
C9	19.3185	0.1506	0.0059	0.1509	0.0861
C10	19.6659	0.1382	0.0028	0.1384	0.0415
C15	19.7040	0.0928	0.0025	0.0929	0.0367
Total	117.0810	0.9983		1.0000	4.9478

Sample 2	Cut @ 118 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0147	0.8010	0.0111	0.0054	0.0790
C6	0.0562	3.0621	0.0355	0.0172	0.2528
C7	0.1476	8.0469	0.0803	0.0389	0.5712
C8	0.2579	14.0608	0.1231	0.0596	0.8756
C9	0.2836	15.4607	0.1205	0.0583	0.8575
C10	0.2279	12.4269	0.0873	0.0423	0.6212
C15	0.0121	0.6587	0.0031	0.0015	0.0221
N2	0.0000	1.4000	0.0500	0.0242	0.3557
water	0.0000	28.0000	1.5556	0.7527	11.0651
Total			2.0666	1.0000	14.7000
			Inj Time=	56	
Residual Mass =	62.56		N2 mass=	1.4	
			Water =	28	
Residual 2	Cut @ 118 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.9670	0.1104	0.0261	0.2055	0.3843
C6	10.9421	0.1270	0.0728	0.2363	1.0696
C7	9.0122	0.0899	0.2322	0.1674	3.4128
C8	4.5004	0.0394	0.8124	0.0733	11.9420
C9	3.8579	0.0301	1.0420	0.0560	15.3180
C10	7.2391	0.0509	0.4464	0.0947	6.5614
C15	19.0453	0.0897	0.0090	0.1669	0.1322
Total	62.5639	0.5373		1.0000	38.8203

TABLE A-48-MAT. BAL. CUTS 3, 4 (STEAM DISTILLATION RUN NO. 3)

Sample 3	Cut @ 130.2 ºC				
Comp.	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0104	0.0266	0.0004	0.0002	0.0062
C6	0.0417	0.1067	0.0012	0.0008	0.0207
C7	0.1183	0.3028	0.0030	0.0020	0.0506
C8	0.2366	0.6056	0.0053	0.0036	0.0888
C9	0.3057	0.7825	0.0061	0.0041	0.1022
C10	0.2663	0.6817	0.0048	0.0032	0.0802
C15	0.0211	0.0541	0.0003	0.0002	0.0043
N2	0.0000	1.2750	0.0455	0.0307	0.7626
water	0.0000	25.5000	1.4167	0.9551	23.7245
Total			1.4833	1.0000	24.8400
			Inj Time=	51	
Residual Mass =	60.00		N2 mass=	1.275	
			Water =	25.5	

Residual 3	Cut @ 130.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.9404	0.1101	0.0012	0.2132	0.0290
C6	10.8354	0.1257	0.0034	0.2435	0.0851
C7	8.7094	0.0869	0.0121	0.1684	0.3006
C8	3.8948	0.0341	0.0541	0.0660	1.3444
C9	3.0754	0.0240	0.0886	0.0464	2.1998
C10	6.5573	0.0461	0.0362	0.0893	0.8988
C15	18.9912	0.0894	0.0010	0.1732	0.0246
Total	60.0039	0.5163		1.0000	4.8823

Sample 4	Cut @ 143.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0106	0.0897	0.0012	0.0010	0.0329
C6	0.0393	0.3323	0.0039	0.0030	0.1020
C7	0.1037	0.8761	0.0087	0.0067	0.2312
C8	0.2046	1.7287	0.0151	0.0116	0.4002
C9	0.2963	2.5034	0.0195	0.0150	0.5161
C10	0.3154	2.6654	0.0187	0.0144	0.4953
C15	0.0301	0.2545	0.0012	0.0009	0.0317
N2	0.0000	1.0750	0.0384	0.0295	1.0152
water	0.0000	21.5000	1.1944	0.9179	31.5854
Total			1.3013	1.0000	34.4100
			Inj Time=	43	
Residual Mass =	51.55		N2 mass=	1.075	
			Water =	21.5	

Residual 4	Cut @ 143.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.8507	0.1088	0.0039	0.2430	0.1353
C6	10.5031	0.1219	0.0109	0.2721	0.3746
C7	7.8333	0.0782	0.0385	0.1746	1.3245
C8	2.1661	0.0190	0.2747	0.0423	9.4515
C9	0.5720	0.0045	1.5064	0.0100	51.8340
C10	3.8920	0.0274	0.2357	0.0611	8.1102
C15	18.7368	0.0882	0.0047	0.1970	0.1608
Total	51.5539	0.4478		1.0000	71.3910

TABLE A-49-MAT. BAL. CUTS 5, 6 (STEAM DISTILLATION RUN NO. 3)

Sample 5	Cut @ 150.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0069	0.0772	0.0011	0.0007	0.0335
C6	0.0260	0.2903	0.0034	0.0023	0.1054
C7	0.0715	0.7969	0.0080	0.0053	0.2487
C8	0.1574	1.7545	0.0154	0.0103	0.4804
C9	0.2739	3.0541	0.0238	0.0160	0.7448
C10	0.3781	4.2155	0.0296	0.0199	0.9265
C15	0.0861	0.9605	0.0045	0.0030	0.1414
N2	0.0000	1.2250	0.0438	0.0294	1.3684
water	0.0000	24.5000	1.3611	0.9131	42.5710
Total			1.4906	1.0000	46.6200
			Inj Time=	49	
Residual Mass =	40.40		N2 mass=	1.225	
			Water =	24.5	
Residual 5	Cut @ 150.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.7735	0.1077	0.0026	0.2807	0.1192
C6	10.2128	0.1185	0.0073	0.3088	0.3412
C7	7.0364	0.0702	0.0292	0.1830	1.3594
C8	0.4116	0.0036	1.0975	0.0094	51.1658
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	17.7763	0.0837	0.0139	0.2181	0.6485
Total	43.2106	0.3838		1.0000	53.6341

Sample 6	Cut @ 162.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0067	0.1028	0.0014	0.0010	0.0628
C6	0.0246	0.3790	0.0044	0.0031	0.1939
C7	0.0673	1.0387	0.0104	0.0074	0.4569
C8	0.1463	2.2566	0.0198	0.0141	0.8707
C9	0.2498	3.8547	0.0301	0.0214	1.3246
C10	0.3624	5.5916	0.0393	0.0280	1.7318
C15	0.1429	2.2046	0.0104	0.0074	0.4574
N2	0.0000	1.1250	0.0402	0.0286	1.7708
water	0.0000	22.5000	1.2500	0.8891	55.0912
Total			1.4058	1.0000	61.9600
			Inj Time=	45	
Residual Mass =	24.98		N2 mass=	1.125	
			Water =	22.5	
Residual 6	Cut @ 162.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6706	0.1063	0.0034	0.3007	0.2089
C6	9.8338	0.1141	0.0097	0.3227	0.6007
C7	5.9977	0.0599	0.0436	0.1693	2.6988
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	15.5717	0.0733	0.0356	0.2073	2.2063
Total	39.0739	0.3536		1.0000	5.7146

TABLE A-50-MAT. BAL. CUTS 7, 8 (STEAM DISTILLATION RUN NO. 3)

Sample 7	Cut @ 170.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0044	0.0160	0.0002	0.0002	0.0134
C6	0.0150	0.0548	0.0006	0.0005	0.0384
C7	0.0406	0.1486	0.0015	0.0011	0.0894
C8	0.0862	0.3155	0.0028	0.0021	0.1665
C9	0.1500	0.5490	0.0043	0.0032	0.2581
C10	0.2495	0.9129	0.0064	0.0048	0.3869
C15	0.4543	1.6626	0.0078	0.0058	0.4720
N2	0.0000	1.1500	0.0411	0.0306	2.4769
water	0.0000	23.0000	1.2778	0.9518	77.0583
Total			1.3425	1.0000	80.9600
			Inj Time=	46	
Residual Mass =	21.32		N2 mass=	1.15	
			Water =	23	
Residual 7	Cut @ 170.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6546	0.1061	0.0005	0.3089	0.0434
C6	9.7790	0.1135	0.0014	0.3304	0.1161
C7	5.8491	0.0584	0.0065	0.1700	0.5261
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	13.9091	0.0655	0.0306	0.1907	2.4756
Total	37.1918	0.3434		1.0000	3.1613

Sample 8	Cut @ 180.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0112	0.0264	0.0002	0.0001	0.0128
C10	0.0524	0.1235	0.0009	0.0005	0.0540
C15	0.9364	2.2051	0.0104	0.0062	0.6461
N2	0.0000	1.4500	0.0518	0.0309	3.2231
water	0.0000	29.0000	1.6111	0.9622	100.2740
Total			1.6744	1.0000	104.2100
			Inj Time=	58	
Residual Mass =	18.96		N2 mass=	1.45	
			Water =	29	
Residual 8	Cut @ 180.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6546	0.1061	0.0000	0.3186	0.0000
C6	9.7790	0.1135	0.0000	0.3407	0.0000
C7	5.8491	0.0584	0.0000	0.1753	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	11.7040	0.0551	0.0375	0.1654	3.9053
Total	34.9867	0.3330		1.0000	3.9053

TABLE A-51-MAT. BAL. CUT 9, 10 (STEAM DISTILLATION RUN NO. 3)

Sample 9	Cut @ 193.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0180	0.0452	0.0003	0.0002	0.0280
C15	0.9820	2.4625	0.0116	0.0077	1.0209
N2	0.0000	1.3000	0.0464	0.0309	4.0887
water	0.0000	26.0000	1.4444	0.9612	127.2025
Total			1.5028	1.0000	132.3400
			Inj Time=	52	
Residual Mass =	16.45		N2 mass=	1.3	
			Water =	26	
Residual 9	Cut @ 193.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6546	0.1061	0.0000	0.3300	0.0000
C6	9.7790	0.1135	0.0000	0.3530	0.0000
C7	5.8491	0.0584	0.0000	0.1816	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	9.2415	0.0435	0.0570	0.1353	7.5430
Total	32.5241	0.3214		1.0000	7.5430

Sample 10	Cut @ 200.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0060	0.0041	0.0000	0.0000	0.0044
C10	0.0186	0.0128	0.0001	0.0001	0.0124
C15	0.9753	0.6691	0.0031	0.0026	0.4331
N2	0.0000	1.0500	0.0375	0.0311	5.1568
water	0.0000	21.0000	1.1667	0.9662	160.4333
Total			1.2074	1.0000	166.0400
			Inj Time=	42	
Residual Mass =	15.77		N2 mass=	1.05	
			Water =	21	
Residual 10	Cut @ 200.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6546	0.1061	0.0000	0.3333	0.0000
C6	9.7790	0.1135	0.0000	0.3565	0.0000
C7	5.8491	0.0584	0.0000	0.1834	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	8.5724	0.0404	0.0206	0.1268	3.4162
Total	31.8551	0.3183		1.0000	3.4162

TABLE A-52-MAT. BAL. CUT 11 (STEAM DISTILLATION RUN NO. 3)

Sample 11	Cut @ 210.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0139	0.0211	0.0001	0.0001	0.0221
C15	0.9861	1.4992	0.0071	0.0051	1.0513
N2	0.0000	1.2000	0.0429	0.0310	6.3840
water	0.0000	24.0000	1.3333	0.9638	198.6126
Total			1.3834	1.0000	206.0700
			Inj Time=	48	
Residual Mass =	14.25		N2 mass=	1.2	
			Water =	24	
Residual 11	Cut @ 210.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	7.6546	0.1061	0.0000	0.3409	0.0000
C6	9.7790	0.1135	0.0000	0.3646	0.0000
C7	5.8491	0.0584	0.0000	0.1875	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	7.0732	0.0333	0.0477	0.1070	9.8266
Total	30.3559	0.3112		1.0000	9.8266

TABLE A-53-OIL YIELD AT STEAM-C_3 DIST. RUN NO. 1

WEIGHT OF COMPONENTS (STEAM PROPANE DISTILLATION RUN 1)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2175	0.2772	0.1221	17.1009	0.2370
C6	30.3500	20.0000	86.1772	0.1821	0.2321	0.1412	19.7666	0.2294
C7	29.2400	20.0000	100.2040	0.1566	0.1996	0.1408	19.7157	0.1968
C8	28.6300	20.0000	114.2309	0.1374	0.1751	0.1488	20.8348	0.1824
C9	27.8600	20.0000	128.2578	0.1223	0.1559	0.1495	20.9261	0.1632
C10	27.0300	20.0000	142.3000	0.1103	0.1405	0.1496	20.9398	0.1472
C15	26.0100	20.0000	212.4191	0.0739	0.0942	0.1480	20.7161	0.0975
C3			44.0960					
water			28.0000					
Total	201.0700	140.0000		1.0000	1.2746	1.0000	140.0000	1.2534

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM PEOPANE DISTILLATION RUN 1)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Water ml	Cum water wt%
1	12.334	30.105	17.771	0.000	29.000	29.000	17.771	95.70	17.771	12.69	0.0000	0.0000
2	50.631	138.124	87.493	7.264	131.000	123.736	80.229	116.20	98.000	70.00	7.2640	1.4586
6	12.557	46.090	33.533	20.147	41.000	20.853	13.386	133.80	111.386	79.56	27.4110	5.5042
7	12.726	34.193	21.467	16.434	24.000	7.566	5.033	144.20	116.419	83.16	43.8450	8.8042
8	12.723	33.123	20.400	18.345	23.000	4.655	2.055	151.60	118.474	84.62	62.1900	12.4880
9	12.901	33.965	21.064	19.201	23.000	3.799	1.863	165.40	120.337	85.96	81.3910	16.3436
10	12.847	34.692	21.845	19.810	23.000	2.000	2.035	170.30	122.372	87.41	101.2010	20.3215
11	12.594	34.022	21.428	19.718	23.000	3.282	1.710	180.20	124.082	88.63	120.9190	24.2809
12	12.405	37.473	25.068	23.741	27.000	3.259	1.327	190.30	125.409	89.58	144.6600	29.0482
13	12.770	29.553	16.783	15.585	18.000	2.415	1.198	199.80	126.607	90.43	160.2450	32.1777
14	12.811	34.494	21.683	20.852	23.000	2.148	0.831	210.40	127.438	91.03	181.0970	36.3649
15	12.590	34.861	22.271	21.271	24.000	2.729	1.000	219.40	128.438	91.74	202.3680	40.6361
16	12.672	44.183	31.511	30.913	33.000	2.087	0.598	229.70	129.036	92.17	233.2810	46.8436
17	12.690	39.569	26.879	26.636	28.000	1.364	0.243	239.60	129.279	92.34	259.9170	52.1922
18	12.719	34.372	21.653	21.048	23.000	1.952	0.605	249.80	129.884	92.77	280.9650	56.4187
19	12.924	35.029	22.105	21.506	23.500	1.994	0.599	260.30	130.483	93.20	302.4710	60.7371
20	12.746	44.390	31.644	31.121	32.000	0.879	0.523	270.00	131.006	93.58	333.5920	66.9863
21	12.529	37.353	24.824	24.435	26.000	1.565	0.389	280.80	131.395	93.85	358.0270	71.8930
22	12.988	38.954	25.966	25.907	27.000	1.093	0.059	290.70	131.454	93.90	383.9340	77.0952
23	13.174	41.053	27.879	27.000	29.000	2.000	0.879	300.40	132.333	94.52	410.9340	82.5169
Cold Residal	12.618	16.135	3.517	3.455	4.500	1.045	0.062	310.00	132.395	94.57	432.7090	86.8894
Residual in cell	12.613	33.932	21.319	18.320	20.000	1.680	2.999	310.00	135.394	96.71		
Total	317.562	885.665	568.103	432.709	655.00	221.10	135.39					

	Oil wt g	Oil vol ml
Difference	4.6060	20.0310
% Error	3.2900	9.9622

Beginning of Injection time =	111	min
Injection Rate =	0.50	ml/min
Total Injection Time =	996.00	min
Water injected =	498.00	ml
Water recovered =	432.71	ml
Water lost =	65.29	ml

TABLE A-54-MAT. BAL. CUTS 1, 2 (STEAM-C_3 DIST. RUN NO. 1)

Sample 1	Cut @ 95.7ºC				
Component	Frac. Weigth GC	Weight(gr)	Mol	yi	Pi
C5	0.5544	9.8528	0.1366	0.1107	1.6279
C6	0.2563	4.5552	0.0529	0.0429	0.6301
C7	0.1067	1.8959	0.0189	0.0153	0.2255
C8	0.0473	0.8405	0.0074	0.0060	0.0877
C9	0.0217	0.3853	0.0030	0.0024	0.0358
C10	0.0000	0.0000	0.0000	0.0000	0.0000
C15	0.0136	0.2413	0.0011	0.0009	0.0135
C3	0.0000	1.3750	0.0312	0.0253	0.3717
water	0.0000	27.5000	0.9821	0.7964	11.7077
Total			1.2332	1.0000	14.7000
			Inj Time =	55	
Residual Mass =	122.23		C3 mass =	1.375	
			Water =	27.5	
Residual 1	Cut @ 95.7 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1472	0.1406	0.8305	0.1333	12.2086
C6	15.4448	0.1792	0.2523	0.1699	3.7083
C7	18.1041	0.1807	0.0896	0.1713	1.3167
C8	19.1595	0.1677	0.0375	0.1590	0.5516
C9	19.6147	0.1529	0.0168	0.1450	0.2470
C10	20.0000	0.1405	0.0000	0.1333	0.0000
C15	19.7587	0.0930	0.0104	0.0882	0.1535
C3	0.0000	0.0000			
Total	122.2290	1.0548		1.0000	18.1857

Sample 2	Cut @ 116.7ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0059	0.4763	0.0055	0.0025	0.0371
C7	0.0706	5.6617	0.0565	0.0258	0.3793
C8	0.2551	20.4673	0.1792	0.0818	1.2029
C9	0.3508	28.1438	0.2194	0.1002	1.4732
C10	0.2905	23.3049	0.1638	0.0748	1.0995
C15	0.0138	1.1037	0.0052	0.0024	0.0349
C3	0.0134	1.0712	0.0243	0.0111	0.1631
water	0.0000	43.0000	1.5357	0.7014	10.3100
Total			2.1896	1.0000	14.7000
Material Balance			Inj Time=	86	
			C3 mass=	2.15	
Residual Mass =	43.07		Water =	43	
Residual 2	Cut @ 116.7ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1472	0.1406	0.0000	0.2672	0.0000
C6	14.9685	0.1737	0.0076	0.3300	0.1124
C7	12.4424	0.1242	0.1094	0.2359	1.6079
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	18.6550	0.0878	0.0142	0.1669	0.2091
C3	0.0000	0.0000		0.0000	0.0000
Total	56.2131	0.5263		1.0000	1.9294

TABLE A-55-MAT. BAL. CUTS 3, 4 (STEAM-C_3 DIST. RUN NO. 1)

Sample 3	Cut @ 133.8 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0104	0.1388	0.0014	0.0013	0.0333
C8	0.1103	1.4765	0.0129	0.0125	0.3110
C9	0.3393	4.5416	0.0354	0.0343	0.8519
C10	0.4666	6.2453	0.0439	0.0425	1.0558
C15	0.0497	0.6657	0.0031	0.0030	0.0754
C3	0.0238	0.3181	0.0072	0.0070	0.1735
water	0.0000	26.0000	0.9286	0.8993	22.3391
Total			1.0325	1.0000	24.8400
			Inj Time =	52	
Residual Mass =	30.00		C3 mass =	1.3	
			Water =	26	
Residual 3	Cut @ 133.8 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1472	0.1406	0.0000	0.2695	0.0000
C6	14.9685	0.1737	0.0000	0.3329	0.0000
C7	12.3036	0.1228	0.0057	0.2353	0.1416
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	17.9893	0.0847	0.0187	0.1623	0.4645
C3	0.0000	0.0000		0.0000	0.0000
Total	55.4086	0.5218		1.0000	0.6062

Sample 4	Cut @ 144.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0181	0.0911	0.0008	0.0010	0.0349
C9	0.1914	0.9633	0.0075	0.0096	0.3286
C10	0.5873	2.9557	0.0208	0.0264	0.9088
C15	0.1746	0.8789	0.0041	0.0053	0.1810
C3	0.0286	0.1441	0.0033	0.0042	0.1429
water	0.0000	21.0000	0.7500	0.9536	32.8138
Total			0.7865	1.0000	34.4100
			Inj Time =	42	
Residual Mass =	25.11		C3 mass =	1.05	
			Water =	21	
Residual 4	Cut @ 144.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1472	0.1406	0.0000	0.2700	0.0000
C6	14.9685	0.1737	0.0000	0.3334	0.0000
C7	12.3036	0.1228	0.0000	0.2357	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	17.1104	0.0806	0.0340	0.1546	1.1707
C3	0.1441	0.0033	0.6624	0.0063	22.7919
Total	54.5297	0.5209		1.0000	1.1707

TABLE A-56-MAT. BAL. CUTS 5, 6 (STEAM-C_3 DIST. RUN NO. 1)

Sample 5	Cut @ 151.6 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0018	0.0036	0.0000	0.0001	0.0028
C6	0.0031	0.0065	0.0001	0.0001	0.0043
C7	0.0036	0.0074	0.0001	0.0001	0.0042
C8	0.0103	0.0212	0.0002	0.0002	0.0106
C9	0.0797	0.1638	0.0013	0.0016	0.0729
C10	0.4852	0.9971	0.0070	0.0086	0.4001
C15	0.4120	0.8467	0.0040	0.0049	0.2276
C3	0.0042	0.0087	0.0002	0.0002	0.0113
water	0.0000	22.5000	0.8036	0.9843	45.8861
Total			0.8164	1.0000	46.6200
			Inj Time =	45	
Residual Mass =	23.07		C3 mass =	1.125	
			Water =	22.5	
Residual 5	Cut @ 151.6 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1436	0.1406	0.0002	0.2722	0.0105
C6	14.9620	0.1736	0.0003	0.3361	0.0127
C7	12.2963	0.1227	0.0004	0.2376	0.0177
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	16.2637	0.0766	0.0329	0.1482	1.5356
C3	0.1354	0.0031	0.0644	0.0059	3.0006
Total	53.6656	0.5166		1.0000	1.5765

Sample 6	Cut @ 165.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0016	0.0029	0.0000	0.0001	0.0033
C6	0.0031	0.0058	0.0001	0.0001	0.0054
C7	0.0046	0.0085	0.0001	0.0001	0.0069
C8	0.0116	0.0215	0.0002	0.0002	0.0154
C9	0.0381	0.0710	0.0006	0.0007	0.0451
C10	0.2487	0.4633	0.0033	0.0043	0.2653
C15	0.6848	1.2757	0.0060	0.0079	0.4893
C3	0.0076	0.0142	0.0003	0.0004	0.0262
water	0.0000	21.0000	0.7500	0.9862	61.1031
Total			0.7605	1.0000	61.9600
			Inj Time =	42	
Residual Mass =	24.92		C3 mass =	1.05	
			Water =	21	
Residual 6	Cut @ 165.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1407	0.1405	0.0002	0.2756	0.0066
C6	14.9563	0.1736	0.0003	0.3403	0.0089
C7	12.2877	0.1226	0.0005	0.2404	0.0160
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	14.9880	0.0706	0.0571	0.1383	1.9642
C3	0.1212	0.0027	0.0786	0.0054	2.7036
Total	52.3727	0.5100		1.0000	1.9957

TABLE A-57-MATERIAL BAL. CUTS 7, 8 (STEAM-C_3 DIST. RUN NO. 1)

Sample 7	Cut @ 170.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0020	0.0040	0.0000	0.0001	0.0042
C7	0.0026	0.0053	0.0001	0.0001	0.0048
C8	0.0058	0.0118	0.0001	0.0001	0.0092
C9	0.0140	0.0285	0.0002	0.0002	0.0199
C10	0.0820	0.1668	0.0012	0.0013	0.1050
C15	0.8747	1.7801	0.0084	0.0093	0.7507
C3	0.0189	0.0385	0.0009	0.0010	0.0783
water	0.0000	25.0000	0.8929	0.9880	79.9879
Total			0.9037	1.0000	80.9600
			Inj Time =	50	
Residual Mass =	22.92		C3 mass =	1.25	
			Water =	25	
Residual 7	Cut @ 170.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1407	0.1405	0.0000	0.2807	0.0000
C6	14.9522	0.1735	0.0001	0.3465	0.0120
C7	12.2824	0.1226	0.0002	0.2448	0.0194
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	13.2079	0.0622	0.0747	0.1242	6.0452
C3	0.0826	0.0019	0.2584	0.0037	20.9176
Total	50.5832	0.5007		1.0000	6.0767

Sample 8	Cut @ 180.2 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0068	0.0117	0.0001	0.0001	0.0093
C10	0.0246	0.0421	0.0003	0.0003	0.0301
C15	0.9606	1.6426	0.0077	0.0075	0.7852
C3	0.0076	0.0142	0.0003	0.0003	0.0327
water	0.0000	28.5000	1.0179	0.9918	103.3528
Total			1.0263	1.0000	104.2100
Residual Mass =	21.22		Inj Time =	57	
			C3 mass =	1.425	
			Water =	28.5	
Residual 8	Cut @ 180.2 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1407	0.1405	0.0000	0.2853	0.0000
C6	14.9522	0.1735	0.0000	0.3522	0.0000
C7	12.2824	0.1226	0.0000	0.2488	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	11.5653	0.0544	0.0682	0.1105	7.1042
C3	0.0684	0.0016	0.0996	0.0032	10.3759
Total	48.9407	0.4926		1.0000	7.1042

TABLE A-58-MAT. BAL. CUTS 9, 10 (STEAM-C_3 DIST. RUN NO. 1)

Sample 9	Cut @ 190.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0046	0.0061	0.0000	0.0000	0.0064
C10	0.0136	0.0180	0.0001	0.0001	0.0170
C15	0.9629	1.2777	0.0060	0.0061	0.8050
C3	0.0189	0.0251	0.0006	0.0006	0.0763
water	0.0000	27.5000	0.9821	0.9932	131.4354
Total			0.9889	1.0000	132.3400
			Inj Time =	55	
Residual Mass =	19.92		C3 mass =	1.375	
			Water =	27.5	

Residual 9	Cut @ 190.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1407	0.1405	0.0000	0.2892	0.0000
C6	14.9522	0.1735	0.0000	0.3570	0.0000
C7	12.2824	0.1226	0.0000	0.2522	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	10.2876	0.0484	0.0610	0.0996	8.0786
C3	0.0433	0.0010	0.2852	0.0020	37.7428
Total	47.6630	0.4860		1.0000	8.0786

Sample 10	Cut @ 199.8 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0038	0.0045	0.0000	0.0000	0.0063
C10	0.0087	0.0105	0.0001	0.0001	0.0131
C15	0.9839	1.1788	0.0055	0.0059	0.9862
C3	0.0035	0.0043	0.0001	0.0001	0.0171
water	0.0000	26.0000	0.9286	0.9938	165.0174
Total			0.9343	1.0000	166.0400
			Inj Time =	52	
Residual Mass =	18.73		C3 mass =	1.3	
			Water =	26	

Residual 10	Cut @ 199.8 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1407	0.1405	0.0000	0.2926	0.0000
C6	14.9522	0.1735	0.0000	0.3612	0.0000
C7	12.2824	0.1226	0.0000	0.2552	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	9.1089	0.0429	0.0665	0.0893	11.0478
C3	0.0391	0.0009	0.0560	0.0018	9.2963
Total	46.4842	0.4804		1.0000	11.0478

TABLE A-59-MAT. BAL. CUTS 11, 12 (STEAM-C_3 DIST. RUN NO. 1)

Sample 11	Cut @ 210.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0047	0.0039	0.0000	0.0000	0.0078
C10	0.0100	0.0083	0.0001	0.0001	0.0149
C15	0.9574	0.7956	0.0037	0.0046	0.9557
C3	0.0102	0.0085	0.0002	0.0002	0.0493
water	0.0000	22.5000	0.8036	0.9950	205.0422
Total			0.8076	1.0000	206.0700
			Inj Time =	45	
Residual Mass =	17.92		C3 mass =	1.125	
			Water =	22.5	
Residual 11	Cut @ 210.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1407	0.1405	0.0000	0.2950	0.0000
C6	14.9522	0.1735	0.0000	0.3642	0.0000
C7	12.2824	0.1226	0.0000	0.2573	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	8.3132	0.0391	0.0565	0.0821	11.6354
C3	0.0305	0.0007	0.1645	0.0015	33.8948
Total	45.6886	0.4765		1.0000	11.6354

Sample 12	Cut @ 219.4 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0066	0.0066	0.0000	0.0001	0.0144
C15	0.9356	0.9356	0.0044	0.0054	1.3796
C3	0.0171	0.0171	0.0004	0.0005	0.1212
water	0.0000	22.5000	0.8036	0.9940	251.7047
Total			0.8084	1.0000	253.2200
			Inj Time=	45	
Residual Mass =	16.98		C3 mass=	1.125	
			Water =	22.5	
Residual 12	Cut @ 219.4 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1407	0.1405	0.0000	0.2980	0.0000
C6	14.9522	0.1735	0.0000	0.3679	0.0000
C7	12.2824	0.1226	0.0000	0.2599	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	7.3776	0.0347	0.0740	0.0736	18.7359
C3	0.0135	0.0003	0.7384	0.0006	186.9903
Total	0.0000	0.4717		1.0000	18.7359

TABLE A-60-MAT. BAL. CUT 13 (STEAM-C_3 DIST. RUN NO. 1)

Sample 13	Cut @ 229.7 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0057	0.0047	0.0001	0.0002	0.0600
C15	0.9943	0.8263	0.0115	0.0340	10.4714
C3	0.0000	0.0000	0.0000	0.0000	0.0000
water	0.0000	23.5000	0.3257	0.9658	297.8186
Total			0.3372	1.0000	308.3500
			Inj Time =	47	
Residual Mass =	16.15		C3 mass =	1.175	
			Water =	23.5	
Residual 13	Cut @ 229.7 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	10.1407	0.6042	0.0000	0.2821	0.0000
C6	14.9522	0.6896	0.0000	0.3219	0.0000
C7	12.2824	0.5515	0.0000	0.2575	0.0000
C8	0.0000	0.0000		0.0000	0.0000
C9	0.0000	0.0000		0.0000	0.0000
C10	0.0000	0.0000		0.0000	0.0000
C15	6.5514	0.2964	0.2454	0.1384	75.6837
C3	0.0135	0.0004	0.0000	0.0002	0.0000
Total	43.9267	2.1421		1.0000	75.6837

TABLE A-61-OIL YIELD AT STEAM-C_3 DIST. RUN NO. 2

WEIGHT OF COMPONENTS (STEAM PROPANE DISTILLATION RUN 2)

Comp.	Vol, ml	Wt, g	MW	Moles	Mole fraction	Wt frac. (GC)	Wt, g (GC)	Moles (GC)
C5	31.9500	20.0000	72.1503	0.2772	0.2175	0.1221	17.1009	0.2370
C6	30.3500	20.0000	86.1772	0.2321	0.1821	0.1412	19.7666	0.2294
C7	29.2400	20.0000	100.2040	0.1996	0.1566	0.1408	19.7157	0.1968
C8	28.6300	20.0000	114.2309	0.1751	0.1374	0.1488	20.8348	0.1824
C9	27.8600	20.0000	128.2578	0.1559	0.1223	0.1495	20.9261	0.1632
C10	27.0300	20.0000	142.3000	0.1405	0.1103	0.1496	20.9398	0.1472
C15	26.0100	20.0000	212.4191	0.0942	0.0739	0.1480	20.7161	0.0975
C3		0.0000	44.0900			0.0000		
Water			18.0000					
Total	201.0700	140.0000		1.2746	1.0000	1.0000	140.0000	1.2534

OIL YIELDS AT DISTILLATION TEMPERATURES (STEAM PEOPANE DISTILLATION RUN 2)

Sample	Wt bottle g	Wt bottle + sample, g	Total wt g	Water vol ml	Total vol ml	Oil vol Voil	Oil wt Woil	T(oC)	Cum oil wt, g	Oil yield, wt%	Cum Water ml	Cum water wt%
1	12.623	37.009	24.386	0.000	39.000	39.000	24.386	108.00	24.386	17.42	0.0000	0.00
2	37.820	114.396	76.576	7.127	113.000	105.873	69.449	114.70	93.835	67.03	7.1270	1.49
3	12.341	43.315	30.974	17.130	39.000	21.870	13.844	130.10	107.679	76.91	24.2570	5.07
4	12.628	42.433	29.805	25.538	33.000	7.462	4.267	141.30	111.946	79.96	49.7950	10.42
5	12.702	37.897	25.195	23.135	27.000	3.865	2.060	151.50	114.006	81.43	72.9300	15.26
6	12.576	34.416	21.840	20.093	23.000	2.907	1.747	160.50	115.753	82.68	93.0230	19.46
7	12.413	34.987	22.574	20.398	24.500	2.000	1.400	170.80	117.153	83.68	113.4210	23.73
8	12.718	35.048	22.330	21.041	24.500	3.459	1.289	180.50	118.442	84.60	134.4620	28.13
9	12.705	37.565	24.860	23.500	26.500	3.000	1.360	190.50	119.802	85.57	157.9620	33.05
10	12.582	29.547	16.965	15.945	18.500	2.555	1.020	200.80	120.822	86.30	173.9070	36.38
11	12.716	35.954	23.238	22.120	25.000	2.880	1.118	211.10	121.940	87.10	196.0270	41.01
12	12.852	33.774	20.922	20.473	22.000	1.527	0.449	221.00	122.389	87.42	216.5000	45.29
13	12.681	35.683	23.002	22.783	23.002	0.219	0.219	231.10	122.608	87.58	239.2830	50.06
14	12.766	38.440	25.674	25.655	25.674	0.019	0.019	241.10	122.627	87.59	264.9380	55.43
15	12.745	35.731	22.986	22.802	22.986	0.184	0.184	251.00	122.811	87.72	287.7400	60.20
16	12.764	37.842	25.078	24.953	25.078	0.125	0.125	261.10	122.936	87.81	312.6930	65.42
17	12.456	44.607	32.151	32.066	32.151	0.085	0.085	270.80	123.021	87.87	344.7590	72.13
18	12.717	37.725	25.008	24.867	25.008	0.141	0.141	280.80	123.162	87.97	369.6260	77.33
19	12.766	44.232	31.466	31.167	31.466	0.299	0.299	290.80	123.461	88.19	400.7930	83.85
20	12.684	45.406	32.722	32.346	32.722	0.376	0.376	300.70	123.837	88.46	433.1390	90.61
21	12.601	14.210	1.609	1.609	1.609	0.000	0.000	310.00	123.837	88.46	434.7480	90.95
22	12.714	39.125	26.411	21.574	29.000	7.426	4.837	310.00	128.674	91.91	456.3220	95.46
Cold Residal	12.601	14.210	1.609	1.609	1.609	0.000	0.000	310.00	128.674	91.91		
Residual in ce	12.714	39.125	26.411	21.574	29.000	7.426	4.837	310.00	133.511	95.37		
Total	328.885	942.677	613.792	479.505	694.305	212.698	133.511		2787.312		4783.452	

	Oil wt g	Oil vol ml
Difference	6.4890	11.6280
% Error	4.6350	5.7831

Beginning of Injection time	95.00	min
Injection Rate =	0.50	ml/min
Total Injection Time =	956.00	min
Water injected =	478.00	ml
Water recovered =	479.51	ml
Water lost =	1.51	ml

TABLE A-62-MAT. BAL. CUTS 1, 2 (STEAM-C_3 DIST. RUN NO. 2)

Sample 1	Cut @108 ºC				
Component	Frac. Weigth GC	Weight(gr)	Mol	yi	Pi
C5	0.4316	10.5260	0.1459	0.0498	0.7327
C6	0.2753	6.7141	0.0779	0.0266	0.3913
C7	0.1461	3.5617	0.0355	0.0121	0.1785
C8	0.0753	1.8367	0.0161	0.0055	0.0808
C9	0.0365	0.8906	0.0069	0.0024	0.0349
C10	0.0189	0.4617	0.0032	0.0011	0.0163
C15	0.0153	0.3723	0.0018	0.0006	0.0088
C3	0.0009	0.0229	0.0005	0.0002	0.0026
water	0.0000	47.5000	2.6389	0.9016	13.2541
Total			2.9268	1.0000	14.7000
			Inj Time =	95	
Residual Mass =	115.64		C3 mass =	2.375	
			Water =	47.5	
Residual 1	Cut @108 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	9.4740	0.1313	0.3748	0.1330	5.5090
C6	13.2859	0.1542	0.1705	0.1562	2.5058
C7	16.4383	0.1640	0.0731	0.1662	1.0744
C8	18.1633	0.1590	0.0341	0.1611	0.5014
C9	19.1094	0.1490	0.0157	0.1509	0.2311
C10	19.5383	0.1373	0.0080	0.1391	0.1172
C15	19.6277	0.0924	0.0064	0.0936	0.0941
C3	0.0000	0.0000		0.0000	0.0000
Total	115.6369	0.9872		1.0000	10.0329

Sample 2	Cut @ 114.7 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.1733	12.0377	0.1668	0.1084	1.5929
C6	0.2376	16.5005	0.1915	0.1244	1.8281
C7	0.2188	15.1973	0.1517	0.0985	1.4480
C8	0.1621	11.2566	0.0985	0.0640	0.9408
C9	0.0967	6.7126	0.0523	0.0340	0.4997
C10	0.0560	3.8876	0.0273	0.0177	0.2608
C15	0.0555	3.8567	0.0182	0.0118	0.1733
C3	0.0000	0.0000	0.0000	0.0000	0.0000
water	0.0000	15.0000	0.8333	0.5412	7.9563
Total			1.5397	1.0000	14.7000
			Inj Time =	30	
Residual Mass =	46.19		C3 mass =	0.75	
			Water =	15	
Residual 2	Cut @ 114.7 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2410	0.0124	2.8135	0.0350	41.3581
C8	6.9067	0.0605	0.3744	0.1709	5.5043
C9	12.3968	0.0967	0.1244	0.2732	1.8287
C10	15.6508	0.1100	0.0571	0.3109	0.8389
C15	15.7709	0.0742	0.0562	0.2099	0.8259
C3	0.0000	0.0000		0.0000	0.0000
Total	51.9662	0.3537		1.0000	50.3559

TABLE A-63-MAT. BAL. CUTS 3, 4 (STEAM-C_3 DIST. RUN NO. 2)

Sample 3	Cut @ 130.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0293	0.0513	0.0004	0.0002	0.0059
C9	0.2166	0.3032	0.0024	0.0012	0.0309
C10	0.4841	0.6240	0.0044	0.0023	0.0574
C15	0.2199	0.2990	0.0014	0.0007	0.0184
C3	0.0213	0.0218	0.0005	0.0003	0.0065
water	0.0000	34.0000	1.8889	0.9952	24.7209
Total			1.8980	1.0000	24.8400
			Inj Time =	68	
Residual Mass =	44.91		C3 mass =	1.7	
			Water =	34	

Residual 3	Cut @ 130.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2410	0.0124	0.0000	0.0359	0.0000
C8	6.8554	0.0600	0.0014	0.1739	0.0338
C9	12.0936	0.0943	0.0046	0.2732	0.1133
C10	15.0267	0.1056	0.0076	0.3060	0.1876
C15	15.4719	0.0728	0.0035	0.2110	0.0873
C3	0.0000	0.0000		0.0000	0.0000
Total	50.6886	0.3451		1.0000	0.4219

Sample 4	Cut @ 141.3 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0849	0.3623	0.0028	0.0018	0.0604
C10	0.3758	1.6037	0.0113	0.0070	0.2411
C15	0.4818	2.0557	0.0097	0.0060	0.2071
C3	0.0119	0.0508	0.0012	0.0007	0.0246
water	0.0000	28.5000	1.5833	0.9845	33.8767
Total			1.6083	1.0000	34.4100
			Inj Time =	57	
			C3 mass =	1.425	
Residual Mass =	40.89		Water =	28.5	

Residual 4	Cut @ 141.3 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2410	0.0124	0.0000	0.0385	0.0000
C8	6.8554	0.0600	0.0000	0.1868	0.0000
C9	11.7313	0.0915	0.0062	0.2846	0.2124
C10	13.4230	0.0943	0.0239	0.2935	0.8215
C15	13.4162	0.0632	0.0306	0.1965	1.0535
C3	0.0000	0.0000		0.0000	0.0000
Total	46.6668	0.3214		1.0000	2.0874

TABLE A-64-MAT. BAL. CUTS 5, 6 (STEAM-C_3 DIST. RUN NO. 2)

Sample 5	Cut @ 151.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0290	0.0597	0.0005	0.0003	0.0149
C10	0.2868	0.5909	0.0042	0.0029	0.1329
C15	0.6369	1.3120	0.0062	0.0042	0.1978
C3	0.0173	0.0356	0.0008	0.0006	0.0258
water	0.0000	26.0000	1.4444	0.9920	46.2486
Total			1.4560	1.0000	46.6200
			Inj Time =	52	
Residual Mass =	38.93		C3 mass =	1.3	
			Water =	26	
Residual 5	Cut @ 151.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2410	0.0124	0.0000	0.0399	0.0000
C8	6.8554	0.0600	0.0000	0.1932	0.0000
C9	11.6716	0.0910	0.0011	0.2930	0.0508
C10	12.8321	0.0902	0.0098	0.2904	0.4578
C15	12.1041	0.0570	0.0231	0.1835	1.0778
C3	0.0000	0.0000		0.0000	0.0000
Total	44.7043	0.3106		1.0000	1.5865

Sample 6	Cut @ 160.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0205	0.0358	0.0003	0.0002	0.0124
C10	0.1285	0.2244	0.0016	0.0011	0.0699
C15	0.8271	1.4450	0.0068	0.0049	0.3015
C3	0.0150	0.0263	0.0006	0.0004	0.0264
water	0.0000	25.0000	1.3889	0.9934	61.5499
Total			1.3981	1.0000	61.9600
			Inj Time =	50	
Residual Mass =	37.22		C3 mass =	1.25	
			Water =	25	
Residual 6	Cut @ 160.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2410	0.0124	0.0000	0.0410	0.0000
C8	6.8554	0.0600	0.0000	0.1988	0.0000
C9	11.6358	0.0907	0.0007	0.3005	0.0411
C10	12.6077	0.0886	0.0038	0.2935	0.2381
C15	10.6591	0.0502	0.0293	0.1662	1.8137
C3	0.0000	0.0000		0.0000	0.0000
Total	42.9991	0.3019		1.0000	2.0930

TABLE A-65-MAT. BAL. CUTS 7, 8 (STEAM-C_3 DIST. RUN NO. 2)

Sample 7	Cut @ 170.8 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0027	0.0038	0.0000	0.0000	0.0022
C8	0.0459	0.0642	0.0006	0.0004	0.0320
C9	0.0123	0.0173	0.0001	0.0001	0.0077
C10	0.0361	0.0505	0.0004	0.0002	0.0202
C15	0.9008	1.2612	0.0059	0.0042	0.3375
C3	0.0164	0.0230	0.0005	0.0004	0.0296
water	0.0000	25.5000	1.4167	0.9947	80.5309
Total			1.4242	1.0000	80.9600
			Inj Time =	51	
Residual Mass =	35.82		C3 mass =	1.275	
			Water =	25.5	
Residual 7	Cut @ 170.8 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0518
C7	1.2372	0.0123	0.0006	0.0419	0.1585
C8	6.7912	0.0595	0.0020	0.2016	0.0249
C9	11.6186	0.0906	0.0003	0.3072	0.0674
C10	12.5572	0.0882	0.0008	0.2993	2.2494
C15	9.3980	0.0442	0.0278	0.1500	0.0000
C3	0.0000	0.0000		0.0000	0.0000
Total	41.6021	0.2949		1.0000	2.5520

Sample 8	Cut @ 180.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0118	0.0152	0.0001	0.0001	0.0072
C15	0.9716	1.2524	0.0059	0.0038	0.4005
C3	0.0166	0.0214	0.0005	0.0003	0.0329
water	0.0000	27.5000	1.5278	0.9958	103.7693
Total			1.5343	1.0000	104.2100
			Inj Time =	55	
Residual Mass =	37.09		C3 mass =	1.375	
			Water =	27.5	
Residual 8	Cut @ 180.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2372	0.0123	0.0000	0.0427	0.0000
C8	6.7912	0.0595	0.0000	0.2058	0.0000
C9	11.6186	0.0906	0.0000	0.3136	0.0000
C10	12.5421	0.0881	0.0002	0.3051	0.0237
C15	8.1455	0.0383	0.0289	0.1327	3.0168
C3	0.0000	0.0000		0.0000	0.0000
Total	40.3345	0.2889		1.0000	3.0406

TABLE A-66-MAT. BAL. CUTS 9, 10 (STEAM-C_3 DIST. RUN NO. 2)

Sample 9	Cut @ 190.5 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0087	0.0119	0.0001	0.0001	0.0072
C15	0.9866	1.3418	0.0063	0.0041	0.5448
C3	0.0047	0.0064	0.0001	0.0001	0.0124
water	0.0000	27.5000	1.5278	0.9957	131.7755
Total			1.5343	1.0000	132.3400
			Inj Time =	55	
Residual Mass =	35.74		C3 mass =	1.375	
			Water =	27.5	
Residual 9	Cut @ 190.5 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2372	0.0123	0.0000	0.0437	0.0000
C8	6.7912	0.0595	0.0000	0.2105	0.0000
C9	11.6186	0.0906	0.0000	0.3207	0.0231
C10	12.5302	0.0881	0.0002	0.3117	4.8048
C15	6.8038	0.0320	0.0363	0.1134	0.0000
C3	0.0000	0.0000		0.0000	0.0000
Total	38.9809	0.2825		1.0000	4.8279

Sample 10	Cut @ 200.8 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0060	0.0062	0.0000	0.0000	0.0047
C15	0.9895	1.0092	0.0048	0.0031	0.5147
C3	0.0045	0.0046	0.0001	0.0001	0.0113
water	0.0000	27.5000	1.5278	0.9968	165.5093
Total			1.5327	1.0000	166.0400
			Inj Time =	55	
Residual Mass =	34.72		C3 mass =	1.375	
			Water =	27.5	
Residual 10	Cut @ 200.8 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2372	0.0123	0.0000	0.0445	0.0000
C8	6.7912	0.0595	0.0000	0.2141	0.0000
C9	11.6186	0.0906	0.0000	0.3262	0.0000
C10	12.5240	0.0880	0.0001	0.3170	0.0148
C15	5.7945	0.0273	0.0316	0.0982	5.2394
C3	0.0000	0.0000		0.0000	0.0000
Total	37.9655	0.2777		1.0000	5.2542

TABLE A-67-MAT. BAL. CUT 11 (STEAM-C_3 DIST. RUN NO. 2)

Sample 11	Cut @ 211.1 ºC				
Component	Frac. Weigth GC	Weigth(gr)	Mol	yi	Pi
C5	0.0000	0.0000	0.0000	0.0000	0.0000
C6	0.0000	0.0000	0.0000	0.0000	0.0000
C7	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0095	0.0106	0.0001	0.0001	0.0110
C15	0.9744	1.0893	0.0051	0.0037	0.7579
C3	0.0073	0.0082	0.0002	0.0001	0.0275
water	0.0000	25.0000	1.3889	0.9961	205.2735
Total			1.3943	1.0000	206.0700
			Inj Time =	50	
Residual Mass =	33.62		C3 mass =	1.25	
			Water =	25	
Residual 11	Cut @ 211.1 ºC				
Component	Weigth(gr)	Mol	Ki	xi	Pvi
C5	0.0000	0.0000		0.0000	0.0000
C6	0.0000	0.0000		0.0000	0.0000
C7	1.2372	0.0123	0.0000	0.0453	0.0000
C8	6.7912	0.0595	0.0000	0.2182	0.0000
C9	11.6186	0.0906	0.0000	0.3325	0.0341
C10	12.5134	0.0879	0.0002	0.3227	9.3233
C15	4.7052	0.0222	0.0452	0.0813	0.0000
C3	0.0000	0.0000		0.0000	0.0000
Total	36.8655	0.2725		1.0000	9.3575

APPENDIX B

Thermodynamic Parameters Calculated Using Program in Appendix C

This Appendix is a compilation of analyses results obtained using our program on every cut data cases.

TABLE B.1-ANALYSIS RESULTS EXAMPLE (DRY DIST. RUN NO.1)

Component's Number	7	(Input Data)
Cut Number?	21	(Input Data)
System Temperature (ºC)	299.30	(Input data)
System Temperature (°F)	570.74	
System Temperature (°R)	1030.41	
Ideal Gas Constant (psi*ft^3/lb-mol*ºR)	10.730	
System Pressure (psia)	14.70	(Input data)

Press to run the program

Pure Componentes Properties (Input Data)							
Property	n-Pentane	n-Hexane	n-Heptane	Octane	Nonane	Decane	Pentadecane
Tc (°F)	385.7300	453.7300	512.8300	564.2300	[illegible]85.7300	652.2800	813.0200
Tc (°R)	845.4000	913.4000	972.5000	1023.9000	1070.3700	1111.8000	1272.6900
Pc (psia)	488.6000	436.9000	396.8000	360.6000	332.0000	304.0000	220.5000
M_w (lbm/lbmole)	72.1500	86.1700	100.2000	114.2000	128.3000	142.3000	212.4200
Zc	0.2623	0.2643	0.2633	0.2587	0.2536	0.2462	0.2429
Overall composition Zi (Input data)	0	0.216271644	0.169383319	0.083041664	0.088268988	0.107050621	0.335983763
Acentric Factor w	0.0104	0.1995	0.4898	0.3978	0.4437	0.4902	0.7060
Parachor	232.0000	271.0000	311.0000	352.0000	391.71805	431.66705	631.75447
	Binary Interaction Coefficients (Input data)						
	n-C5	n-C6	n-C7	n-C8	n-C9	n-C10	n-C15
n-C5	0.000	0.000	0.007	0.000	0.000	0.000	0.000
n-C6	0.000	0.000	-0.008	0.000	0.000	0.000	0.000
n-C7	0.007	-0.008	0.000	0.000	0.000	0.000	0.000
n-C8	0.000	0.000	0.000	0.000	0.000	0.000	0.000
n-C9	0.000	0.000	0.000	0.000	0.000	0.000	0.000
n-C10	0.000	0.000	0.000	0.000	0.000	0.000	0.000
n-C15	0.000	0.000	0.000	0.000	0.000	0.000	0.000
n-C3	0.027	0.001	0.006	0.000	0.000	0.000	0.000
Water	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Antoine's Parameter (Input Data)						
A	6.852960	6.876010	6.896770	6.918680	6.938930	6.943650	7.023590
B	1064.840000	1771.170000	1264.900000	1351.990000	1431.820000	1495.170000	1789.950000
C	233.010000	224.410000	216.540000	209.150000	202.010000	193.860000	161.380000
RESULTS (Output data)							
	n-Pentane	n-Hexane	n-Heptane	n-Octane	n-Nonane	n-Decane	n-Pentadecane
Liquid molar Composition	0.0000	0.2163	0.1694	0.0830	0.0883	0.1071	0.3360
Vapor molar composition	0.0000	0.2255	0.1751	0.0851	0.0896	0.1076	0.3215
Fugacity Liquid (psia)	0.0000	3.2982	2.5508	1.2330	1.2928	1.5443	4.5050
Fugacity Vapor (psia)	0.0000	3.2982	2.5508	1.2330	1.2928	1.5443	4.5050
Fugacity Liquid Coefficient	1.0504	1.0374	1.0245	1.0101	0.9963	0.9814	0.9121
Fugacity Vapor Coefficient	0.9991	0.9951	0.9909	0.9859	0.9812	0.9763	0.9532
Equilibrium Constant Ki values	1.0514	1.0426	1.0339	1.0245	1.0153	1.0052	0.9569
Liquid Density of i (lb/ft^3)	0.0000	0.0278	0.0253	0.0141	0.0169	0.0227	0.1065
Vapor Density of i (lb/ft^3)	0.0000	0.0265	0.0239	0.0132	0.0157	0.0209	0.0930
Specific Volume Liquid of i (ft^3/lb)	0.0000	35.9722	39.4988	70.6903	59.1953	44.0076	9.3931
Specific Volume Vapor of i (ft^3/lb)	0.0000	37.7850	41.8389	75.5632	63.8470	47.9470	10.7499
Z of Liquid	0.8913						
Z of Vapor	0.9761						
Molar Volume of Liquid (ft^3/lb mole)	670.3816						
Molar Volume of Vapor (ft63/lb mole)	734.1560						
Liquid Density of mixture (lb/ft^3)	0.2133						
Vapor Density of mixture (lb/ft^3)	0.1931						
Specific Volume Liquid (ft^3/lb)	4.6873						
Specific Volume Vapor (ft^3/lb)	5.1775						
Surface Tension (dynes/cm)	1.6852E-13						
z(i)	0.00000000	0.21627164	0.16938332	0.08304166	0.08826899	0.10705062	0.33598376

TABLE B.2-ANALYSIS RESULTS FOR DRY DIST. RUN NO. 1

	Liquid Fugacity (psia)																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7	14.7	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.6	181.7	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.30
n-Pentane	3.2672	1.7530	0.4863	0.0632	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	2.6649	2.4337	1.8936	1.6617	1.3533	1.0618	0.9597	0.9818	1.0994	1.2702	1.4152	1.5472	1.6974	1.7625	1.9080	1.9748	2.0529	2.1932	2.5369	3.2778	3.2982
n-Heptane	2.2250	2.4557	2.5155	2.5172	2.3666	1.9829	1.6570	1.3539	1.1920	1.1611	1.2132	1.2821	1.3561	1.3956	1.4935	1.5406	1.5970	1.6991	1.9610	2.5341	2.5508
n-Octane	1.9086	2.2923	2.6593	2.7968	2.8548	2.7283	2.5086	2.1431	1.7532	1.4072	1.1959	1.0647	0.9245	0.8919	0.8573	0.8493	0.8422	0.8573	0.9478	1.2247	1.2330
n-Nonane	1.6573	2.0740	2.5570	2.7492	2.9112	3.0729	3.1347	3.0686	2.8627	2.5454	2.2609	2.0129	1.7057	1.6000	1.4021	1.3239	1.2271	1.1358	1.0781	1.2846	1.2928
n-Decane	1.4531	1.8563	2.3543	2.5567	2.7461	3.0697	3.3316	3.5675	3.6780	3.6335	3.4939	3.3130	3.0346	2.9022	2.5862	2.4395	2.2341	1.9619	1.5432	1.5364	1.5443
n-Pentadecane	0.8510	1.1099	1.4455	1.5854	1.7192	2.0435	2.3896	2.8753	3.4162	3.9988	4.4596	4.8468	5.3654	5.5726	5.9057	6.0552	6.2599	6.3968	6.2294	4.5432	4.5050

	Vapor Fugacity (psia)																				
Cut	1	2	3	4	5	6	7	8	9	10	11.00	12.00	13.00	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.30
n-Pentane	3.2672	1.7531	0.4863	0.0632	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	2.6649	2.4337	1.8936	1.6617	1.3533	1.0618	0.9597	0.9818	1.0994	1.2702	1.4152	1.5472	1.6974	1.7625	1.9080	1.9748	2.0529	2.1932	2.5369	3.2778	3.2982
n-Heptane	2.2250	2.4557	2.5155	2.5172	2.3666	1.9829	1.6570	1.3539	1.1920	1.1611	1.2132	1.2821	1.3561	1.3956	1.4935	1.5406	1.5970	1.6991	1.9610	2.5341	2.5508
n-Octane	1.9086	2.2923	2.6594	2.7968	2.8548	2.7283	2.5086	2.1431	1.7532	1.4072	1.1959	1.0647	0.9245	0.8919	0.8573	0.8493	0.8422	0.8573	0.9478	1.2247	1.2330
n-Nonane	1.6573	2.0740	2.5570	2.7492	2.9112	3.0729	3.1347	3.0686	2.8628	2.5454	2.2609	2.0129	1.7057	1.6000	1.4021	1.3239	1.2271	1.1358	1.0781	1.2846	1.2928
n-Decane	1.4531	1.8563	2.3543	2.5567	2.7461	3.0697	3.3316	3.5675	3.6780	3.6335	3.4939	3.3130	3.0346	2.9022	2.5862	2.4394	2.2341	1.9619	1.5432	1.5364	1.5443
n-Pentadecane	0.8510	1.1099	1.4455	1.5854	1.7192	2.0435	2.3896	2.8753	3.4162	3.9988	4.4596	4.8468	5.3654	5.5726	5.9057	6.0552	6.2599	6.3968	6.2294	4.5432	4.5050

	K's Calculated																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.30
n-Pentane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0514
n-Hexane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0426
n-Heptane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0339
n-Octane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0245
n-Nonane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0153
n-Decane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0052
n-Pentadecane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9569

	K's Experimental																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.30
n-Pentane	4.49	9.96	35.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Hexane	1.34	1.80	1.17	1.55	1.75	0.99	0.53	0.19	0.06	0.03	0.01	0.10	0.02	0.01	0.01	0.03	0.01	0.01	0.00	0.00	0.00
n-Heptane	0.57	0.72	0.44	0.71	1.42	1.36	1.42	1.02	0.59	0.26	0.12	0.25	0.06	0.05	0.02	0.04	0.03	0.02	0.00	0.00	0.00
n-Octane	0.27	0.32	0.18	0.28	0.83	0.92	1.23	1.32	1.30	1.09	0.72	1.18	0.31	0.38	0.17	0.20	0.16	0.10	0.00	0.00	0.00
n-Nonane	0.13	0.14	0.08	0.10	0.43	0.50	0.70	0.81	0.91	0.90	0.72	1.31	0.43	0.69	0.36	0.46	0.47	0.44	0.10	0.00	0.00
n-Decane	0.07	0.06	0.03	0.03	0.22	0.26	0.38	0.46	0.55	0.58	0.49	0.91	0.35	0.63	0.37	0.51	0.65	0.92	0.35	0.01	0.00
n-Pentadecane	0.02	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.05	0.05	0.08	0.04	0.09	0.06	0.06	0.16	0.38	0.91	0.04	0.01

TABLE B.2-CONTINUED

x(i)

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.30
n-Pentane	0.2175	0.1158	0.0319	0.0041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1648	0.1271	0.1111	0.0902	0.0705	0.0635	0.0647	0.0722	0.0832	0.0926	0.1010	0.1107	0.1148	0.1242	0.1285	0.1335	0.1427	0.1652	0.2150	0.2163
n-Heptane	0.1566	0.1711	0.1736	0.1728	0.1618	0.1348	0.1121	0.0912	0.0799	0.0776	0.0808	0.0852	0.0899	0.0924	0.0987	0.1017	0.1054	0.1120	0.1294	0.1684	0.1694
n-Octane	0.1374	0.1632	0.1874	0.1959	0.1991	0.1891	0.1729	0.1470	0.1197	0.0956	0.0810	0.0719	0.0623	0.0600	0.0576	0.0569	0.0564	0.0573	0.0634	0.0825	0.0830
n-Nonane	0.1223	0.1513	0.1845	0.1970	0.2075	0.2176	0.2205	0.2146	0.1991	0.1762	0.1559	0.1384	0.1169	0.1093	0.0956	0.0901	0.0834	0.0771	0.0732	0.0878	0.0883
n-Decane	0.1103	0.1391	0.1743	0.1878	0.2005	0.2224	0.2396	0.2548	0.2611	0.2565	0.2456	0.2320	0.2117	0.2018	0.1793	0.1688	0.1542	0.1352	0.1064	0.1066	0.1071
n-Pentadecane	0.0739	0.0946	0.1212	0.1313	0.1409	0.1655	0.1913	0.2277	0.2679	0.3108	0.3441	0.3714	0.4085	0.4216	0.4446	0.4539	0.4671	0.4757	0.4624	0.3397	0.3360

y(i)

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7000	14.7000	14.7000
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.1000	289.1000	299.3000
n-Pentane	0.2175	0.1158	0.0319	0.0041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1648	0.1271	0.1111	0.0902	0.0705	0.0635	0.0647	0.0722	0.0832	0.0926	0.1010	0.1107	0.1148	0.1242	0.1285	0.1335	0.1427	0.1652	0.2150	0.2255
n-Heptane	0.1566	0.1711	0.1736	0.1728	0.1618	0.1348	0.1121	0.0912	0.0799	0.0776	0.0808	0.0852	0.0899	0.0924	0.0987	0.1017	0.1054	0.1120	0.1294	0.1684	0.1751
n-Octane	0.1374	0.1632	0.1874	0.1959	0.1991	0.1891	0.1729	0.1470	0.1197	0.0956	0.0810	0.0719	0.0623	0.0600	0.0576	0.0569	0.0564	0.0573	0.0634	0.0825	0.0851
n-Nonane	0.1223	0.1513	0.1845	0.1970	0.2075	0.2176	0.2205	0.2146	0.1991	0.1762	0.1559	0.1384	0.1169	0.1093	0.0956	0.0901	0.0834	0.0771	0.0732	0.0878	0.0896
n-Decane	0.1103	0.1391	0.1743	0.1878	0.2005	0.2224	0.2396	0.2548	0.2611	0.2565	0.2456	0.2320	0.2117	0.2018	0.1793	0.1688	0.1542	0.1352	0.1064	0.1066	0.1076
n-Pentadecane	0.0739	0.0946	0.1212	0.1313	0.1409	0.1655	0.1913	0.2277	0.2679	0.3108	0.3441	0.3714	0.4085	0.4216	0.4446	0.4539	0.4671	0.4757	0.4624	0.3397	0.3215

Liq. Fug. Coeff.

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7000
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.3000
n-Pentane	1.0220	1.0299	1.0380	1.0409	1.0430	1.0463	1.0489	1.0519	1.0545	1.0566	1.0579	1.0587	1.0599	1.0599	1.0602	1.0601	1.0601	1.0597	1.0579	1.0507	1.0504
n-Hexane	0.9956	1.0044	1.0132	1.0172	1.0201	1.0244	1.0281	1.0319	1.0353	1.0382	1.0401	1.0416	1.0434	1.0441	1.0449	1.0453	1.0458	1.0459	1.0445	1.0373	1.0374
n-Heptane	0.9666	0.9763	0.9858	0.9911	0.9952	1.0005	1.0054	1.0102	1.0145	1.0183	1.0211	1.0234	1.0259	1.0275	1.0290	1.0300	1.0312	1.0318	1.0309	1.0240	1.0245
n-Octane	0.9452	0.9554	0.9654	0.9712	0.9756	0.9813	0.9867	0.9920	0.9967	1.0009	1.0040	1.0067	1.0095	1.0115	1.0133	1.0146	1.0160	1.0169	1.0163	1.0094	1.0101
n-Nonane	0.9215	0.9323	0.9428	0.9493	0.9544	0.9608	0.9669	0.9728	0.9780	0.9828	0.9865	0.9896	0.9929	0.9954	0.9977	0.9994	1.0012	1.0024	1.0022	0.9953	0.9963
n-Decane	0.8964	0.9079	0.9189	0.9262	0.9319	0.9389	0.9458	0.9523	0.9582	0.9635	0.9677	0.9714	0.9751	0.9783	0.9809	0.9830	0.9853	0.9869	0.9870	0.9802	0.9814
n-Pentadecane	0.7837	0.7978	0.8111	0.8215	0.8298	0.8397	0.8499	0.8590	0.8674	0.8752	0.8818	0.8877	0.8934	0.8991	0.9037	0.9076	0.9117	0.9148	0.9165	0.9097	0.9121

Vap.Fug. Coeff.

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.30
n-Pentane	1.0220	1.0299	1.0380	1.0409	1.0430	1.0463	1.0489	1.0519	1.0545	1.0566	1.0579	1.0587	1.0599	1.0599	1.0602	1.0601	1.0601	1.0597	1.0579	1.0507	0.9991
n-Hexane	0.9956	1.0044	1.0132	1.0172	1.0201	1.0244	1.0281	1.0319	1.0353	1.0382	1.0401	1.0416	1.0434	1.0441	1.0449	1.0453	1.0458	1.0459	1.0445	1.0373	0.9951
n-Heptane	0.9666	0.9763	0.9858	0.9911	0.9952	1.0005	1.0054	1.0102	1.0145	1.0183	1.0211	1.0234	1.0259	1.0275	1.0290	1.0300	1.0312	1.0318	1.0309	1.0240	0.9909
n-Octane	0.9452	0.9554	0.9654	0.9712	0.9756	0.9813	0.9867	0.9920	0.9967	1.0009	1.0040	1.0067	1.0095	1.0115	1.0133	1.0146	1.0160	1.0169	1.0163	1.0094	0.9859
n-Nonane	0.9215	0.9323	0.9428	0.9493	0.9544	0.9608	0.9669	0.9728	0.9780	0.9828	0.9865	0.9896	0.9929	0.9954	0.9977	0.9994	1.0012	1.0024	1.0022	0.9953	0.9812
n-Decane	0.8964	0.9079	0.9189	0.9262	0.9319	0.9389	0.9458	0.9523	0.9582	0.9635	0.9677	0.9714	0.9751	0.9783	0.9809	0.9830	0.9853	0.9869	0.9870	0.9802	0.9763
n-Pentadecane	0.7837	0.7978	0.8111	0.8215	0.8298	0.8397	0.8499	0.8590	0.8674	0.8752	0.8818	0.8877	0.8934	0.8991	0.9037	0.9076	0.9117	0.9148	0.9165	0.9097	0.9532

TABLE B.2-CONTINUED

	z(i)																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.30
n-Pentane	0.2175	0.1158	0.0319	0.0041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1648	0.1271	0.1111	0.0902	0.0705	0.0635	0.0647	0.0722	0.0832	0.0926	0.1010	0.1107	0.1148	0.1242	0.1285	0.1335	0.1427	0.1652	0.2150	0.2163
n-Heptane	0.1566	0.1711	0.1736	0.1728	0.1618	0.1348	0.1121	0.0912	0.0799	0.0776	0.0808	0.0852	0.0899	0.0924	0.0987	0.1017	0.1054	0.1120	0.1294	0.1684	0.1694
n-Octane	0.1374	0.1632	0.1874	0.1959	0.1991	0.1891	0.1729	0.1470	0.1197	0.0956	0.0810	0.0719	0.0623	0.0600	0.0576	0.0569	0.0564	0.0573	0.0634	0.0825	0.0830
n-Nonane	0.1223	0.1513	0.1845	0.1970	0.2075	0.2176	0.2205	0.2146	0.1991	0.1762	0.1559	0.1384	0.1169	0.1093	0.0956	0.0901	0.0834	0.0771	0.0732	0.0878	0.0883
n-Decane	0.1103	0.1391	0.1743	0.1878	0.2005	0.2224	0.2396	0.2548	0.2611	0.2565	0.2456	0.2320	0.2117	0.2018	0.1793	0.1688	0.1542	0.1352	0.1064	0.1066	0.1071
n-Pentadecane	0.0739	0.0946	0.1212	0.1313	0.1409	0.1655	0.1913	0.2277	0.2679	0.3108	0.3441	0.3714	0.4085	0.4216	0.4446	0.4539	0.4671	0.4757	0.4624	0.3397	0.3360

	Activity coeff.																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7	14.7	14.7	14.7
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.5	279.1	289.1	299.3
n-Pentane	6.16	5.03	4.21	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51
n-Hexane	109.21	79.45	60.02	45.41	36.31	28.51	21.98	17.65	14.42	7.48	6.30	5.34	4.61	3.84	3.33	2.91	2.54	2.24	1.95	1.71	1.51
n-Heptane	48.67	34.92	26.06	19.49	15.45	12.02	9.19	7.33	5.95	4.90	4.10	3.46	2.98	2.47	1.22	1.08	0.95	0.84	0.74	0.65	0.58
n-Octane	85.56	60.54	44.61	32.97	25.87	19.90	15.02	11.86	9.54	7.77	6.45	5.40	4.62	3.79	3.26	2.83	1.37	1.22	1.06	0.93	0.83
n-Nonane	185.25	126.27	90.04	64.45	49.30	36.90	27.05	20.83	16.38	13.07	10.65	8.74	7.36	5.93	5.02	4.30	3.66	3.17	2.70	1.30	1.15
n-Decane	396.28	260.02	179.31	124.28	92.67	67.48	48.03	36.08	27.74	21.67	17.33	13.97	11.57	9.14	7.63	6.44	5.40	4.62	3.88	3.29	2.82
n-Pentadecane	16799.79	9001.57	5210.88	3056.13	1997.98	1263.65	775.17	514.27	353.03	248.12	180.44	132.80	101.62	72.78	56.34	44.31	34.52	27.71	21.65	17.18	13.85

	Exc.Gibbs Energy																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	130.50	139.40	149.60	161.20	171.60	181.70	191.70	201.20	210.80	219.60	231.10	240.40	249.50	259.40	268.50	279.10	289.10	299.30
G^excess(kJoules/gmol)	4.77	5.88	7.27	7.58	7.88	8.91	9.85	11.27	12.74	14.19	15.11	15.65	16.57	16.24	16.39	16.02	15.69	15.24	13.98	9.67	9.00
G^excess(kJoules/gmol)/RT	0.43	0.53	0.66	0.69	0.71	0.81	0.89	1.02	1.15	1.28	1.37	1.42	1.50	1.47	1.48	1.45	1.42	1.38	1.26	0.87	0.81

TABLE B.3-ANALYSIS RESULTS FOR DRY DIST. RUN NO. 2

	Liquid Fugacity (psia)																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7	14.7	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.5	180.4	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.50
n-Pentane	3.2672	1.8523	0.6224	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	2.6649	2.4966	1.9138	1.7764	1.3475	0.9959	0.8743	0.8897	1.0134	1.1987	1.3483	1.5495	1.6447	1.8284	1.9898	2.2022	2.4223	2.7534	4.4992	9.6438	9.8679
n-Heptane	2.2250	2.4562	2.4695	2.4877	2.1870	1.7197	1.3532	1.0041	0.8401	0.8407	0.8916	0.9873	1.0391	1.1449	1.2399	1.3678	1.5000	1.6976	2.7744	5.6031	5.7305
n-Octane	1.9086	2.2615	2.6114	2.7560	2.7321	2.5514	2.3053	1.8836	1.4204	1.0293	0.8357	0.6757	0.6264	0.5594	0.5290	0.5235	0.5357	0.5739	0.9378	1.7705	1.8057
n-Nonane	1.6573	2.0319	2.5265	2.7389	2.9307	3.1095	3.1896	3.1354	2.8622	2.4093	2.0684	1.6644	1.4964	1.1950	0.9750	0.7605	0.5990	0.4665	0.5230	0.9240	0.9319
n-Decane	1.4531	1.8105	2.3362	2.5688	2.8641	3.2520	3.5704	3.8750	4.0192	3.8940	3.6737	3.2828	3.0825	2.6520	2.2689	1.7657	1.3082	0.8005	0.1727	0.2056	0.1826
n-Pentadecane	0.8510	1.0771	1.4392	1.6109	1.8795	2.3008	2.6475	3.1542	3.7960	4.5889	5.1682	5.8402	6.1507	6.6917	7.1012	7.5064	7.7936	7.9164	5.4756	4.1490	3.8277

	Vapor Fugacity (psia)																				
Cut	1	2	3	4	5	6	7	8	9	10	11.00	12.00	13.00	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.50
n-Pentane	3.2672	1.8523	0.6224	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	2.6649	2.4966	1.9138	1.7764	1.3475	0.9959	0.8743	0.8897	1.0134	1.1987	1.3483	1.5495	1.6447	1.8284	1.9898	2.2022	2.4223	2.7534	4.4992	9.6438	9.8679
n-Heptane	2.2250	2.4562	2.4695	2.4877	2.1870	1.7197	1.3532	1.0041	0.8401	0.8407	0.8916	0.9873	1.0391	1.1449	1.2399	1.3678	1.5000	1.6976	2.7744	5.6031	5.7305
n-Octane	1.9086	2.2615	2.6114	2.7560	2.7321	2.5514	2.3053	1.8836	1.4204	1.0293	0.8357	0.6757	0.6264	0.5594	0.5290	0.5235	0.5357	0.5739	0.9378	1.7705	1.8057
n-Nonane	1.6573	2.0319	2.5265	2.7389	2.9307	3.1095	3.1896	3.1354	2.8622	2.4093	2.0684	1.6644	1.4964	1.1950	0.9750	0.7605	0.5990	0.4665	0.5230	0.9240	0.9319
n-Decane	1.4531	1.8105	2.3362	2.5688	2.8641	3.2520	3.5704	3.8750	4.0192	3.8940	3.6737	3.2828	3.0825	2.6520	2.2689	1.7657	1.3082	0.8005	0.1727	0.2056	0.1826
n-Pentadecane	0.8510	1.0772	1.4392	1.6109	1.8795	2.3008	2.6475	3.1542	3.7961	4.5889	5.1682	5.8402	6.1507	6.6917	7.1012	7.5064	7.7936	7.9164	5.4756	4.1490	3.8277

	K's Calculated																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.50
n-Pentane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.9305	1.9196
n-Hexane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.8141	1.8020
n-Heptane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.7044	1.6914
n-Octane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.5928	1.5786
n-Nonane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.4898	1.4749
n-Decane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.3825	1.3667
n-Pentadecane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9603	0.9430

	K's Experimental																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.50
n-Pentane	4.57	7.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Hexane	1.29	1.92	1.61	2.36	2.32	1.02	0.59	0.16	0.06	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Heptane	0.53	0.85	0.85	1.43	1.97	1.54	2.16	1.33	0.64	0.22	0.15	0.05	0.05	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00
n-Octane	0.24	0.40	0.44	0.77	1.10	0.91	1.63	1.82	2.07	1.41	1.63	0.79	0.99	0.69	0.46	0.25	0.17	0.00	0.00	0.00	0.00
n-Nonane	0.11	0.19	0.22	0.39	0.55	0.40	0.75	0.97	1.36	1.14	1.66	0.99	1.58	1.52	1.63	1.33	1.28	0.45	0.00	0.03	0.00
n-Decane	0.06	0.09	0.11	0.20	0.28	0.16	0.34	0.49	0.77	0.71	1.12	0.72	1.19	1.24	1.64	1.63	2.39	6.44	0.38	0.31	0.05
n-Pentadecane	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.09	0.07	0.12	0.14	0.20	0.21	0.34	1.33	0.51	0.21	0.06

TABLE B.3-CONTINUED

	x(i)																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.50
n-Pentane	0.2175	0.1224	0.0408	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1692	0.1285	0.1188	0.0897	0.0660	0.0577	0.0585	0.0664	0.0783	0.0879	0.1007	0.1068	0.1186	0.1290	0.1427	0.1569	0.1784	0.2949	0.3429	0.3538
n-Heptane	0.1566	0.1713	0.1705	0.1706	0.1493	0.1167	0.0914	0.0675	0.0562	0.0560	0.0592	0.0653	0.0686	0.0755	0.0816	0.0899	0.0985	0.1115	0.1843	0.2148	0.2216
n-Octane	0.1374	0.1611	0.1841	0.1929	0.1902	0.1765	0.1587	0.1289	0.0967	0.0697	0.0564	0.0455	0.0421	0.0375	0.0354	0.0349	0.0357	0.0382	0.0632	0.0737	0.0758
n-Nonane	0.1223	0.1483	0.1824	0.1961	0.2085	0.2197	0.2240	0.2189	0.1986	0.1662	0.1421	0.1139	0.1021	0.0813	0.0662	0.0515	0.0405	0.0315	0.0357	0.0417	0.0425
n-Decane	0.1103	0.1357	0.1730	0.1885	0.2087	0.2351	0.2564	0.2764	0.2848	0.2741	0.2573	0.2289	0.2142	0.1836	0.1566	0.1216	0.0899	0.0549	0.0120	0.0101	0.0091
n-Pentadecane	0.0739	0.0919	0.1207	0.1331	0.1537	0.1860	0.2118	0.2497	0.2973	0.3557	0.3972	0.4456	0.4661	0.5036	0.5313	0.5594	0.5785	0.5854	0.4099	0.3169	0.2972

	y(i)																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7000	14.7000	14.7000
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.7000	290.4000	300.5000
n-Pentane	0.2175	0.1224	0.0408	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1692	0.1285	0.1188	0.0897	0.0660	0.0577	0.0585	0.0664	0.0783	0.0879	0.1007	0.1068	0.1186	0.1290	0.1427	0.1569	0.1784	0.2949	0.6220	0.6375
n-Heptane	0.1566	0.1713	0.1705	0.1706	0.1493	0.1167	0.0914	0.0675	0.0562	0.0560	0.0592	0.0653	0.0686	0.0755	0.0816	0.0899	0.0985	0.1115	0.1843	0.3661	0.3748
n-Octane	0.1374	0.1611	0.1841	0.1929	0.1902	0.1765	0.1587	0.1289	0.0967	0.0697	0.0564	0.0455	0.0421	0.0375	0.0354	0.0349	0.0357	0.0382	0.0632	0.1173	0.1197
n-Nonane	0.1223	0.1483	0.1824	0.1961	0.2085	0.2197	0.2240	0.2189	0.1986	0.1662	0.1421	0.1139	0.1021	0.0813	0.0662	0.0515	0.0405	0.0315	0.0357	0.0621	0.0626
n-Decane	0.1103	0.1357	0.1730	0.1885	0.2087	0.2351	0.2564	0.2764	0.2848	0.2741	0.2573	0.2289	0.2142	0.1836	0.1566	0.1216	0.0899	0.0549	0.0120	0.0140	0.0125
n-Pentadecane	0.0739	0.0919	0.1207	0.1331	0.1537	0.1860	0.2118	0.2497	0.2973	0.3557	0.3972	0.4456	0.4661	0.5036	0.5313	0.5594	0.5785	0.5854	0.4099	0.3043	0.2803

	Liq. Fug. Coeff.																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7000
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.5000
n-Pentane	1.0220	1.0292	1.0376	1.0411	1.0444	1.0485	1.0513	1.0545	1.0575	1.0604	1.0618	1.0635	1.0636	1.0643	1.0646	1.0648	1.0645	1.0634	1.0514	2.0616	2.0462
n-Hexane	0.9956	1.0037	1.0128	1.0176	1.0217	1.0266	1.0302	1.0342	1.0381	1.0418	1.0440	1.0463	1.0472	1.0486	1.0494	1.0501	1.0503	1.0497	1.0378	1.9132	1.8976
n-Heptane	0.9666	0.9756	0.9855	0.9917	0.9968	1.0026	1.0072	1.0121	1.0170	1.0217	1.0249	1.0279	1.0297	1.0320	1.0337	1.0349	1.0357	1.0358	1.0242	1.7747	1.7593
n-Octane	0.9452	0.9548	0.9651	0.9719	0.9773	0.9834	0.9885	0.9937	0.9990	1.0041	1.0078	1.0111	1.0133	1.0160	1.0180	1.0195	1.0206	1.0210	1.0095	1.6353	1.6195
n-Nonane	0.9215	0.9318	0.9425	0.9502	0.9561	0.9628	0.9684	0.9743	0.9802	0.9859	0.9901	0.9939	0.9967	1.0000	1.0025	1.0043	1.0058	1.0067	0.9953	1.5086	1.4928
n-Decane	0.8964	0.9073	0.9186	0.9272	0.9337	0.9409	0.9472	0.9536	0.9602	0.9665	0.9714	0.9756	0.9790	0.9828	0.9858	0.9880	0.9899	0.9913	0.9799	1.3791	1.3632
n-Pentadecane	0.7837	0.7974	0.8109	0.8231	0.8321	0.8415	0.8505	0.8594	0.8687	0.8777	0.8852	0.8916	0.8976	0.9039	0.9091	0.9128	0.9165	0.9200	0.9088	0.8907	0.8761

	Vap.Fug. Coeff.																				
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.50
n-Pentane	1.0220	1.0292	1.0376	1.0411	1.0444	1.0485	1.0513	1.0545	1.0575	1.0604	1.0618	1.0635	1.0636	1.0643	1.0646	1.0648	1.0645	1.0634	1.0514	1.0679	1.0659
n-Hexane	0.9956	1.0037	1.0128	1.0176	1.0217	1.0266	1.0302	1.0342	1.0381	1.0418	1.0440	1.0463	1.0472	1.0486	1.0494	1.0501	1.0503	1.0497	1.0378	1.0546	1.0530
n-Heptane	0.9666	0.9757	0.9855	0.9918	0.9968	1.0026	1.0072	1.0121	1.0170	1.0217	1.0249	1.0279	1.0297	1.0320	1.0337	1.0349	1.0357	1.0358	1.0242	1.0413	1.0402
n-Octane	0.9452	0.9548	0.9651	0.9719	0.9773	0.9834	0.9885	0.9937	0.9990	1.0041	1.0078	1.0111	1.0133	1.0160	1.0180	1.0195	1.0206	1.0210	1.0095	1.0267	1.0259
n-Nonane	0.9215	0.9318	0.9425	0.9502	0.9561	0.9628	0.9684	0.9743	0.9802	0.9859	0.9901	0.9939	0.9967	1.0000	1.0025	1.0042	1.0058	1.0067	0.9953	1.0126	1.0122
n-Decane	0.8964	0.9073	0.9186	0.9272	0.9337	0.9409	0.9472	0.9536	0.9602	0.9665	0.9714	0.9756	0.9790	0.9828	0.9859	0.9880	0.9899	0.9913	0.9799	0.9975	0.9974
n-Pentadecane	0.7837	0.7974	0.8109	0.8231	0.8321	0.8415	0.8505	0.8594	0.8687	0.8777	0.8852	0.8916	0.8976	0.9039	0.9091	0.9128	0.9165	0.9200	0.9088	0.9276	0.9290

TABLE B.3-CONTINUED

Cut	z(i) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.50
n-Pentane	0.2175	0.1224	0.0408	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1692	0.1285	0.1188	0.0897	0.0660	0.0577	0.0585	0.0664	0.0783	0.0879	0.1007	0.1068	0.1186	0.1290	0.1427	0.1569	0.1784	0.2949	0.3429	0.3538
n-Heptane	0.1566	0.1713	0.1705	0.1706	0.1493	0.1167	0.0914	0.0675	0.0562	0.0560	0.0592	0.0653	0.0686	0.0755	0.0816	0.0899	0.0985	0.1115	0.1843	0.2148	0.2216
n-Octane	0.1374	0.1611	0.1841	0.1929	0.1902	0.1765	0.1587	0.1289	0.0967	0.0697	0.0564	0.0455	0.0421	0.0375	0.0354	0.0349	0.0357	0.0382	0.0632	0.0737	0.0758
n-Nonane	0.1223	0.1483	0.1824	0.1961	0.2085	0.2197	0.2240	0.2189	0.1986	0.1662	0.1421	0.1139	0.1021	0.0813	0.0662	0.0515	0.0405	0.0315	0.0357	0.0417	0.0425
n-Decane	0.1103	0.1357	0.1730	0.1885	0.2087	0.2351	0.2564	0.2764	0.2848	0.2741	0.2573	0.2289	0.2142	0.1836	0.1566	0.1216	0.0899	0.0549	0.0120	0.0101	0.0091
n-Pentadecane	0.0739	0.0919	0.1207	0.1331	0.1537	0.1860	0.2118	0.2497	0.2973	0.3557	0.3972	0.4456	0.4661	0.5036	0.5313	0.5594	0.5785	0.5854	0.4099	0.3169	0.2972

Cut	Coefficient Activity 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7	14.7	14.7	14.7
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.5	281.7	290.4	300.5
n-Pentane	6.16	5.03	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20
n-Hexane	109.21	79.40	59.99	43.35	34.87	28.24	22.67	18.49	14.84	7.55	6.23	5.34	4.46	3.73	3.19	2.86	2.52	2.16	1.88	3.11	2.73
n-Heptane	48.67	34.90	26.05	18.58	14.81	11.90	9.48	7.68	6.13	4.94	4.05	3.46	2.88	2.41	1.18	1.06	0.94	0.81	0.71	1.11	0.98
n-Octane	85.56	60.51	44.60	31.35	24.75	19.69	15.53	12.46	9.83	7.84	6.37	5.40	4.45	3.69	3.12	2.78	1.36	1.18	1.02	1.49	1.31
n-Nonane	185.25	126.20	90.01	60.97	46.96	36.46	28.05	21.99	16.93	13.20	10.49	8.74	7.06	5.74	4.78	4.21	3.63	3.04	2.58	1.94	1.69
n-Decane	396.28	259.86	179.25	116.94	87.84	66.58	49.96	38.28	28.76	21.90	17.03	13.96	11.06	8.82	7.23	6.28	5.35	4.41	3.69	4.53	3.85
n-Pentadecane	16799.79	8996.67	5209.58	2798.49	1848.62	1238.46	819.17	559.01	371.10	251.46	175.78	132.52	95.24	69.11	52.08	42.74	34.02	25.94	20.23	16.35	12.97

Cut	Excess Gibbs Energy 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	99.20	109.90	120.00	132.30	141.10	150.10	159.90	169.50	180.40	191.40	202.10	211.00	221.90	233.10	243.50	251.10	260.20	271.50	281.70	290.40	300.50
G^excess(kJoules/gmol)	4.77	5.71	7.24	7.64	8.54	9.99	10.96	12.46	14.22	16.27	17.38	18.78	18.73	19.23	19.33	19.61	19.38	18.48	12.18	8.89	7.78

TABLE B.4-ANALYSIS RESULTS FOR DRY DIST. RUN NO. 3

	Liquid Fugacity (psia)																			
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7	14.7	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.5	190.9	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60	300.00	309.60
n-Pentane	3.2671	1.4859	0.2274	0.0480	0.0059	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	2.6647	2.3664	2.0345	1.5817	1.4616	1.6885	1.8392	2.1424	2.4695	2.8018	3.0496	3.3283	3.6115	3.9870	4.2110	4.4495	4.8140	5.6933	12.3050	13.2528	13.3690
n-Heptane	2.2247	2.5076	2.4094	2.0718	1.7294	1.2999	1.1587	1.0724	1.0905	1.1718	1.2370	1.3266	1.4256	1.5616	1.6441	1.7323	1.8706	2.2132	4.4751	4.8006	4.8426
n-Octane	1.9084	2.3716	2.6597	2.7341	2.5983	2.0540	1.7929	1.3982	1.0911	0.8309	0.6966	0.5972	0.5258	0.4647	0.4447	0.4336	0.4389	0.4940	0.9062	0.9675	0.9756
n-Nonane	1.6570	2.1610	2.6343	2.9311	3.0552	2.9191	2.8042	2.4982	2.1317	1.7052	1.4252	1.1377	0.8671	0.5525	0.3933	0.2547	0.0990	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4528	1.9399	2.4674	2.8187	3.0830	3.3535	3.4407	3.4253	3.2698	2.9938	2.7521	2.4310	2.0781	1.5867	1.2957	1.0041	0.6042	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8507	1.1517	1.5263	1.7737	2.0525	2.6698	2.9785	3.4892	3.9959	4.5653	4.9411	5.3136	5.6596	6.0457	6.2430	6.3919	6.4775	5.9769	4.7238	3.5079	3.3911

	Vapor Fugacity (psia)																			
Cut	1	2	3	4	5	6	7	8	9	10	11.00	12.00	13.00	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60	300.00	309.60
n-Pentane	3.2671	1.4859	0.2274	0.0480	0.0059	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	2.6647	2.3664	2.0345	1.5817	1.4616	1.6885	1.8392	2.1425	2.4695	2.8018	3.0496	3.3283	3.6115	3.9870	4.2110	4.4495	4.8140	5.6932	12.3050	13.2527	13.3690
n-Heptane	2.2247	2.5076	2.4094	2.0718	1.7294	1.2999	1.1587	1.0724	1.0905	1.1718	1.2370	1.3266	1.4256	1.5616	1.6441	1.7323	1.8706	2.2132	4.4751	4.8006	4.8426
n-Octane	1.9084	2.3716	2.6597	2.7341	2.5983	2.0540	1.7929	1.3982	1.0911	0.8309	0.6966	0.5972	0.5258	0.4647	0.4447	0.4336	0.4389	0.4940	0.9062	0.9675	0.9756
n-Nonane	1.6570	2.1610	2.6343	2.9311	3.0552	2.9191	2.8042	2.4982	2.1317	1.7052	1.4252	1.1377	0.8671	0.5525	0.3933	0.2547	0.0990	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4528	1.9399	2.4674	2.8187	3.0830	3.3535	3.4407	3.4253	3.2698	2.9938	2.7521	2.4310	2.0781	1.5867	1.2957	1.0041	0.6042	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8507	1.1517	1.5263	1.7738	2.0525	2.6698	2.9785	3.4892	3.9959	4.5654	4.9411	5.3136	5.6596	6.0457	6.2430	6.3919	6.4775	5.9769	4.7237	3.5079	3.3911

	K's Calculated																			
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60	300.00	309.60
n-Pentane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.9385	1.8983	1.8956
n-Hexane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.8229	1.7772	1.7737
n-Heptane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.7137	1.6635	1.6595
n-Octane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.6027	1.5481	1.5434
n-Nonane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.5002	1.4422	1.4370
n-Decane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.3932	1.3321	1.3264
n-Pentadecane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9716	0.9045	0.8977

	K's Experimental																			
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	0.00
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60	300.00	310.00
n-Pentane	5.46	22.34	19.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Hexane	1.45	1.56	2.07	1.13	0.33	0.11	0.05	0.02	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Heptane	0.56	1.09	1.47	1.76	1.89	1.22	0.96	0.48	0.26	0.11	0.06	0.04	0.03	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00
n-Octane	0.26	0.52	0.53	0.98	1.67	1.35	1.78	1.65	1.69	1.01	0.87	0.77	0.75	0.32	0.25	0.18	0.10	0.07	0.00	0.00	0.00
n-Nonane	0.12	0.24	0.17	0.49	0.94	0.78	1.13	1.22	1.45	1.02	1.17	1.39	2.22	1.50	1.83	4.74	0.00	0.00	0.00	0.00	0.00
n-Decane	0.06	0.12	0.06	0.25	0.52	0.43	0.65	0.74	0.87	0.63	0.76	0.89	1.35	0.91	1.06	2.12	0.00	0.00	0.00	0.00	0.00
n-Pentadecane	0.04	0.01	0.00	0.01	0.02	0.02	0.05	0.06	0.07	0.04	0.07	0.08	0.11	0.08	0.11	0.19	0.53	0.87	0.69	0.08	0.00

TABLE B.4-CONTINUED

x(i)

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60	300.00	309.60
n-Pentane	0.2175	0.0980	0.0149	0.0031	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1599	0.1362	0.1054	0.0971	0.1116	0.1213	0.1410	0.1622	0.1836	0.1996	0.2176	0.2360	0.2603	0.2749	0.2904	0.3143	0.3729	0.4353	0.4835	0.4889
n-Heptane	0.1566	0.1743	0.1656	0.1415	0.1175	0.0879	0.0781	0.0720	0.0730	0.0782	0.0824	0.0882	0.0946	0.1035	0.1089	0.1147	0.1238	0.1469	0.1706	0.1895	0.1916
n-Octane	0.1374	0.1683	0.1865	0.1905	0.1800	0.1414	0.1230	0.0956	0.0743	0.0564	0.0472	0.0404	0.0355	0.0313	0.0299	0.0291	0.0295	0.0333	0.0375	0.0416	0.0421
n-Nonane	0.1223	0.1571	0.1890	0.2087	0.2161	0.2051	0.1961	0.1740	0.1479	0.1178	0.0982	0.0782	0.0594	0.0378	0.0269	0.0174	0.0067	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1448	0.1814	0.2055	0.2231	0.2408	0.2458	0.2435	0.2314	0.2109	0.1931	0.1700	0.1449	0.1104	0.0899	0.0696	0.0418	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0976	0.1264	0.1451	0.1658	0.2132	0.2357	0.2740	0.3113	0.3530	0.3795	0.4056	0.4296	0.4567	0.4695	0.4789	0.4838	0.4469	0.3566	0.2854	0.2774

y(i)

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7000	14.7000	14.7000
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.6000	300.0000	309.6000
n-Pentane	0.2175	0.0980	0.0149	0.0031	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1599	0.1362	0.1054	0.0971	0.1116	0.1213	0.1410	0.1622	0.1836	0.1996	0.2176	0.2360	0.2603	0.2749	0.2904	0.3143	0.3729	0.7936	0.8593	0.8672
n-Heptane	0.1566	0.1743	0.1656	0.1415	0.1175	0.0879	0.0781	0.0720	0.0730	0.0782	0.0824	0.0882	0.0946	0.1035	0.1089	0.1147	0.1238	0.1469	0.2924	0.3152	0.3179
n-Octane	0.1374	0.1683	0.1865	0.1905	0.1800	0.1414	0.1230	0.0956	0.0743	0.0564	0.0472	0.0404	0.0355	0.0313	0.0299	0.0291	0.0295	0.0333	0.0600	0.0644	0.0649
n-Nonane	0.1223	0.1571	0.1890	0.2087	0.2161	0.2051	0.1961	0.1740	0.1479	0.1178	0.0982	0.0782	0.0594	0.0378	0.0269	0.0174	0.0067	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1448	0.1814	0.2055	0.2231	0.2408	0.2458	0.2435	0.2314	0.2109	0.1931	0.1700	0.1449	0.1104	0.0899	0.0696	0.0418	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0976	0.1264	0.1451	0.1658	0.2132	0.2357	0.2740	0.3113	0.3530	0.3795	0.4056	0.4296	0.4567	0.4695	0.4789	0.4838	0.4469	0.3465	0.2582	0.2490

Liq. Fug. Coeff.

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.7000
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60	300.00	309.6000
n-Pentane	1.0219	1.0314	1.0394	1.0432	1.0458	1.0496	1.0510	1.0530	1.0545	1.0559	1.0565	1.0568	1.0571	1.0572	1.0570	1.0566	1.0558	1.0521	2.0705	2.0164	2.0119
n-Hexane	0.9956	1.0064	1.0158	1.0206	1.0244	1.0290	1.0313	1.0339	1.0360	1.0381	1.0394	1.0404	1.0412	1.0419	1.0422	1.0423	1.0419	1.0386	1.9228	1.8646	1.8602
n-Heptane	0.9665	0.9789	0.9900	0.9958	1.0009	1.0065	1.0098	1.0132	1.0162	1.0191	1.0212	1.0231	1.0247	1.0260	1.0269	1.0276	1.0278	1.0249	1.7845	1.7237	1.7195
n-Octane	0.9451	0.9583	0.9701	0.9763	0.9820	0.9880	0.9917	0.9954	0.9988	1.0020	1.0045	1.0067	1.0087	1.0103	1.0115	1.0125	1.0129	1.0103	1.6456	1.5820	1.5775
n-Nonane	0.9214	0.9356	0.9484	0.9552	0.9617	0.9683	0.9726	0.9768	0.9807	0.9844	0.9875	0.9902	0.9926	0.9946	0.9963	0.9977	0.9985	0.9961	1.5192	1.4538	1.4492
n-Decane	0.8962	0.9116	0.9253	0.9329	0.9401	0.9473	0.9523	0.9569	0.9614	0.9657	0.9693	0.9725	0.9754	0.9779	0.9800	0.9818	0.9829	0.9808	1.3898	1.3230	1.3184
n-Pentadecane	0.7834	0.8031	0.8211	0.8315	0.8421	0.8519	0.8596	0.8663	0.8732	0.8797	0.8857	0.8912	0.8962	0.9006	0.9045	0.9081	0.9107	0.9098	0.9011	0.8360	0.8315

Vap.Fug. Coeff.

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60	300.00	309.60
n-Pentane	1.0219	1.0314	1.0394	1.0432	1.0458	1.0496	1.0510	1.0530	1.0545	1.0559	1.0565	1.0568	1.0571	1.0572	1.0570	1.0566	1.0558	1.0521	1.0681	1.0622	1.0614
n-Hexane	0.9956	1.0064	1.0158	1.0206	1.0244	1.0290	1.0313	1.0339	1.0360	1.0381	1.0394	1.0404	1.0412	1.0419	1.0422	1.0423	1.0419	1.0386	1.0548	1.0492	1.0487
n-Heptane	0.9665	0.9789	0.9900	0.9958	1.0009	1.0065	1.0098	1.0132	1.0162	1.0191	1.0212	1.0231	1.0247	1.0260	1.0269	1.0276	1.0278	1.0249	1.0413	1.0362	1.0361
n-Octane	0.9451	0.9583	0.9701	0.9763	0.9820	0.9880	0.9917	0.9954	0.9988	1.0020	1.0045	1.0067	1.0087	1.0103	1.0115	1.0125	1.0129	1.0103	1.0268	1.0219	1.0220
n-Nonane	0.9214	0.9356	0.9484	0.9552	0.9617	0.9683	0.9726	0.9768	0.9807	0.9844	0.9875	0.9902	0.9926	0.9946	0.9963	0.9977	0.9985	0.9961	1.0127	1.0081	1.0085
n-Decane	0.8962	0.9116	0.9253	0.9329	0.9401	0.9473	0.9523	0.9569	0.9614	0.9657	0.9693	0.9725	0.9754	0.9779	0.9800	0.9818	0.9829	0.9808	0.9976	0.9932	0.9939
n-Pentadecane	0.7834	0.8031	0.8211	0.8315	0.8421	0.8519	0.8596	0.8663	0.8732	0.8797	0.8857	0.8912	0.8962	0.9006	0.9045	0.9081	0.9107	0.9098	0.9275	0.9243	0.9263

TABLE B.4-CONTINUED

Cut	z(i) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60
n-Pentane	0.2175	0.0980	0.0149	0.0031	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1599	0.1362	0.1054	0.0971	0.1116	0.1213	0.1410	0.1622	0.1836	0.1996	0.2176	0.2360	0.2603	0.2749	0.2904	0.3143	0.3729	0.4353
n-Heptane	0.1566	0.1743	0.1656	0.1415	0.1175	0.0879	0.0781	0.0720	0.0730	0.0782	0.0824	0.0882	0.0946	0.1035	0.1089	0.1147	0.1238	0.1469	0.1706
n-Octane	0.1374	0.1683	0.1865	0.1905	0.1800	0.1414	0.1230	0.0956	0.0743	0.0564	0.0472	0.0404	0.0355	0.0313	0.0299	0.0291	0.0295	0.0333	0.0375
n-Nonane	0.1223	0.1571	0.1890	0.2087	0.2161	0.2051	0.1961	0.1740	0.1479	0.1178	0.0982	0.0782	0.0594	0.0378	0.0269	0.0174	0.0067	0.0000	0.0000
n-Decane	0.1103	0.1448	0.1814	0.2055	0.2231	0.2408	0.2458	0.2435	0.2314	0.2109	0.1931	0.1700	0.1449	0.1104	0.0899	0.0696	0.0418	0.0000	0.0000
n-Pentadecane	0.0739	0.0976	0.1264	0.1451	0.1658	0.2132	0.2357	0.2740	0.3113	0.3530	0.3795	0.4056	0.4296	0.4567	0.4695	0.4789	0.4838	0.4469	0.3566

Cut	Coefficient Activity 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60
n-Pentane	6.19	4.58	3.47	2.95	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
n-Hexane	110.25	68.64	44.65	34.75	26.22	21.01	17.03	14.46	12.08	6.42	5.38	4.55	3.87	3.36	2.91	2.52	2.20	1.88	3.15
n-Heptane	49.15	29.98	19.16	14.76	11.03	8.77	7.06	5.97	4.96	4.18	3.49	2.94	2.50	1.23	1.08	0.94	0.83	0.71	1.13
n-Octane	86.44	51.66	32.37	24.66	18.18	14.31	11.41	9.57	7.88	6.58	5.44	4.55	3.83	3.30	2.83	1.36	1.20	1.03	1.51
n-Nonane	187.36	105.94	63.18	46.77	33.41	25.64	19.96	16.44	13.28	10.88	8.83	7.25	6.00	5.08	4.29	3.64	3.11	3.11	3.11
n-Decane	401.22	214.44	121.62	87.48	60.51	45.29	34.45	27.85	22.05	17.74	14.12	11.39	9.26	7.72	6.42	5.37	4.52	4.52	4.52
n-Pentadecane	17111.23	6785.18	2964.12	1838.57	1080.88	712.28	481.53	355.23	254.63	186.78	135.05	99.54	74.24	57.39	44.16	34.30	26.93	20.39	16.83

Cut	Excess Gibbs Energy 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pressure (psia)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
T(ºC)	98.90	115.00	131.10	141.20	153.20	163.30	173.30	181.50	190.90	200.10	210.20	220.20	230.30	239.60	249.50	259.50	269.50	281.40	289.60
G^excess(kJoules/gmol)	4.78	5.96	7.29	8.06	8.80	10.89	11.58	13.04	14.26	15.57	16.03	16.40	16.59	16.89	16.55	16.06	15.40	13.31	10.09

TABLE B.5-ANALYSIS RESULTS FOR STEAM DIST. RUN NO. 1

	Liquid Fugacity (psia)										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181	190	200.00	209.10
n-Pentane	3.2667	2.1765	6.9255	11.0955	17.1587	30.8831	39.9195	50.5512	62.5369	76.5486	91.9184
n-Hexane	2.6638	2.4848	5.9815	9.3267	14.2098	23.0866	29.3975	36.8661	45.4980	55.3632	66.6275
n-Heptane	2.2233	2.3421	2.0492	2.3501	2.8552	3.2866	4.1142	5.1626	6.3854	7.8317	9.6026
n-Octane	1.9070	2.1896	0.3757	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	1.6555	1.9992	1.5004	0.4883	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4512	1.7958	3.0131	3.2836	0.9461	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8491	1.0429	3.2687	4.8807	6.7932	0.3410	0.4513	0.6554	0.8141	1.0282	1.2100

	Vapor Fugacity (psia)										
Cut	1	2	3	4	5	6	7	8	9	10	11.00
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	3.2667	2.1765	6.9255	11.0955	17.1587	30.8832	39.9197	50.5512	62.5370	76.5488	91.9185
n-Hexane	2.6638	2.4848	5.9815	9.3267	14.2098	23.0866	29.3976	36.8661	45.4980	55.3633	66.6276
n-Heptane	2.2233	2.3421	2.0492	2.3501	2.8552	3.2866	4.1143	5.1626	6.3854	7.8317	9.6026
n-Octane	1.9070	2.1896	0.3757	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	1.6556	1.9992	1.5004	0.4883	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4512	1.7958	3.0131	3.2836	0.9461	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8491	1.0429	3.2687	4.8807	6.7932	0.3410	0.4513	0.6554	0.8141	1.0282	1.2100

	K's Calculated										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	1.0000	1.0000	1.0000	1.0000	1.0000	3.7262	3.1796	2.8079	2.4717	2.1846	1.9323
n-Hexane	1.0000	1.0000	1.0000	1.0000	1.0000	2.0567	1.8341	1.7058	1.5424	1.4260	1.3171
n-Heptane	1.0000	1.0000	1.0000	1.0000	1.0000	0.9369	0.8915	0.8945	0.8455	0.8331	0.8171
n-Octane	1.0000	1.0000	1.0000	1.0000	1.0000	0.6255	0.6024	0.6133	0.5801	0.5826	0.5842
n-Nonane	1.0000	1.0000	1.0000	1.0000	1.0000	0.3623	0.3601	0.3807	0.3660	0.3810	0.3961
n-Decane	1.0000	1.0000	1.0000	1.0000	1.0000	0.2097	0.2152	0.2362	0.2306	0.2488	0.2683
n-Pentadecane	1.0000	1.0000	1.0000	1.0000	1.0000	0.0152	0.0182	0.0240	0.0253	0.0324	0.0417

	K's Experimental										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Hexane	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Heptane	0.06	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Octane	0.04	0.01	0.02	0.01	0.02	0.02	0.04	0.03	0.06	0.00	0.00
n-Nonane	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Decane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Pentadecane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE B.5-CONTINUED

x(i)

Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	0.2175	0.1440	0.2723	0.3170	0.3657	0.1401	0.1648	0.1864	0.2128	0.2397	0.2683
n-Hexane	0.1821	0.1684	0.2427	0.2766	0.3164	0.1983	0.2213	0.2368	0.2610	0.2821	0.3067
n-Heptane	0.1566	0.1632	0.0862	0.0728	0.0669	0.0651	0.0674	0.0675	0.0709	0.0732	0.0774
n-Octane	0.1374	0.1558	0.0162	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1457	0.0669	0.0162	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1343	0.1388	0.1134	0.0252	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0885	0.1769	0.2041	0.2258	0.5965	0.5465	0.5093	0.4553	0.4050	0.3477

y(i)

Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	0.2175	0.1440	0.2723	0.3170	0.3657	0.5222	0.5241	0.5234	0.5260	0.5236	0.5184
n-Hexane	0.1821	0.1684	0.2427	0.2766	0.3164	0.4078	0.4058	0.4040	0.4025	0.4023	0.4039
n-Heptane	0.1566	0.1632	0.0862	0.0728	0.0669	0.0610	0.0601	0.0603	0.0599	0.0610	0.0632
n-Octane	0.1374	0.1558	0.0162	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1457	0.0669	0.0162	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1343	0.1388	0.1134	0.0252	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0885	0.1769	0.2041	0.2258	0.0091	0.0100	0.0122	0.0115	0.0131	0.0145

Liq. Fug. Coeff.

Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	1.0218	1.0284	1.0239	1.0173	1.0063	3.5568	2.9914	2.6024	2.2203	1.9236	1.6628
n-Hexane	0.9952	1.0036	0.9922	0.9799	0.9634	1.8793	1.6411	1.4936	1.3173	1.1820	1.0543
n-Heptane	0.9659	0.9765	0.9570	0.9382	0.9158	0.8149	0.7536	0.7343	0.6809	0.6441	0.6021
n-Octane	0.9444	0.9559	0.9315	0.9085	0.8818	0.5229	0.4865	0.4778	0.4463	0.4258	0.4018
n-Nonane	0.9206	0.9333	0.9033	0.8757	0.8446	0.2898	0.2765	0.2799	0.2676	0.2618	0.2529
n-Decane	0.8953	0.9093	0.8739	0.8418	0.8066	0.1600	0.1565	0.1634	0.1598	0.1603	0.1584
n-Pentadecane	0.7819	0.8012	0.7439	0.6951	0.6452	0.0092	0.0102	0.0123	0.0135	0.0153	0.0169

Vap.Fug. Coeff.

Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	1.0218	1.0284	1.0239	1.0173	1.0063	0.9545	0.9408	0.9268	0.8983	0.8805	0.8605
n-Hexane	0.9952	1.0036	0.9922	0.9799	0.9634	0.9138	0.8948	0.8756	0.8540	0.8289	0.8005
n-Heptane	0.9659	0.9765	0.9570	0.9382	0.9158	0.8697	0.8453	0.8209	0.8054	0.7732	0.7369
n-Octane	0.9444	0.9559	0.9315	0.9085	0.8818	0.8359	0.8075	0.7789	0.7693	0.7309	0.6878
n-Nonane	0.9206	0.9333	0.9033	0.8757	0.8446	0.8001	0.7679	0.7354	0.7311	0.6872	0.6383
n-Decane	0.8953	0.9093	0.8739	0.8418	0.8066	0.7632	0.7275	0.6916	0.6929	0.6441	0.5902
n-Pentadecane	0.7819	0.8012	0.7439	0.6951	0.6452	0.6071	0.5598	0.5136	0.5348	0.4712	0.4046

TABLE B.5-CONTINUED

	z(i)										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	0.2175	0.1440	0.2723	0.3170	0.3657	0.3863	0.3913	0.3940	0.4014	0.4112	0.4272
n-Hexane	0.1821	0.1684	0.2427	0.2766	0.3164	0.3332	0.3376	0.3398	0.3462	0.3547	0.3684
n-Heptane	0.1566	0.1632	0.0862	0.0728	0.0669	0.0624	0.0628	0.0631	0.0643	0.0658	0.0684
n-Octane	0.1374	0.1558	0.0162	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1457	0.0669	0.0162	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1343	0.1388	0.1134	0.0252	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0885	0.1769	0.2041	0.2258	0.2181	0.2083	0.2031	0.1881	0.1683	0.1360

	Coefficient Activity										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
n-Pentane	6.3990	4.5639	5.8811	6.8987	7.7567	18.5099	17.9983	17.3271	16.8262	16.2786	15.7866
n-Hexane	115.9645	68.4509	76.6738	82.6782	84.7203	183.0322	173.4190	161.4277	154.0472	85.9917	81.5964
n-Heptane	51.8096	29.9078	32.1759	33.7737	33.6943	32.6361	32.1920	31.5535	31.1570	30.6989	30.3491
n-Octane	91.3091	51.5218	54.1117	54.1117	54.1117	54.1117	54.1117	54.1117	54.1117	54.1117	54.1117
n-Nonane	199.0660	105.6704	105.1234	104.8943	104.8943	104.8943	104.8943	104.8943	104.8943	104.8943	104.8943
n-Decane	428.8500	213.9118	201.4090	194.1117	176.4215	176.4215	176.4215	176.4215	176.4215	176.4215	176.4215
n-Pentadecane	18885.4577	6769.6317	4831.2052	3914.8535	2947.1222	39.0457	39.0663	38.8680	39.2661	39.7652	40.7757

	Excess Gibbs Energy										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	97.30	115.00	130.20	140.00	151.40	160.00	169.20	181.00	190.00	200.00	209.10
G^excess(kJoules/gmol)	4.80	5.40	10.79	12.42	13.64	16.86	15.78	15.08	13.79	12.57	11.08

TABLE B.6-ANALYSIS RESULTS FOR STEAM DIST. RUN NO. 2

	Liquid Fugacity (psia)									
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180	190	200.00	210.00
n-Pentane	3.2684	1.9396	5.1072	7.6998	13.9416	34.0437	44.0115	55.6454	68.3419	82.8228	98.8736
n-Hexane	2.6674	2.3752	4.3359	6.2395	10.4155	20.9433	26.6469	33.4389	41.6659	51.2668	62.2351
n-Heptane	2.2287	2.4253	2.4698	3.0200	3.2430	2.3723	2.9481	3.7117	4.7368	6.0664	7.6706
n-Octane	1.9124	2.2666	1.7302	1.7210	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	1.6613	2.0607	2.7013	3.2689	1.8330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4573	1.8475	3.5410	4.6964	4.4595	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8555	1.0967	3.0349	4.3061	7.0429	0.3537	0.4881	0.6537	0.8507	1.0732	1.3166

	Vapor Fugacity (psia)										
Cut	1	2	3	4	5	6	7	8	9	10	11.00
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	3.2684	1.9396	5.1072	7.6998	13.9416	34.0437	44.0117	55.6454	68.3420	82.8230	98.8737
n-Hexane	2.6674	2.3752	4.3359	6.2395	10.4155	20.9433	26.6470	33.4389	41.6659	51.2669	62.2351
n-Heptane	2.2287	2.4253	2.4698	3.0200	3.2430	2.3723	2.9481	3.7117	4.7368	6.0664	7.6706
n-Octane	1.9124	2.2666	1.7302	1.7210	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	1.6613	2.0607	2.7013	3.2689	1.8330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4573	1.8475	3.5410	4.6964	4.4595	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8555	1.0967	3.0349	4.3061	7.0429	0.3537	0.4881	0.6537	0.8507	1.0731	1.3166

	K's Calculated										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	1.0000	1.0000	1.0000	1.0000	1.0000	3.7314	3.2091	2.7886	2.4749	2.1880	1.9480
n-Hexane	1.0000	1.0000	1.0000	1.0000	1.0000	2.0612	1.8576	1.6895	1.5444	1.4279	1.3298
n-Heptane	1.0000	1.0000	1.0000	1.0000	1.0000	0.9388	0.9065	0.8812	0.8458	0.8333	0.8264
n-Octane	1.0000	1.0000	1.0000	1.0000	1.0000	0.6260	0.6118	0.6031	0.5792	0.5816	0.5897
n-Nonane	1.0000	1.0000	1.0000	1.0000	1.0000	0.3625	0.3662	0.3733	0.3651	0.3799	0.3998
n-Decane	1.0000	1.0000	1.0000	1.0000	1.0000	0.2097	0.2191	0.2310	0.2298	0.2478	0.2708
n-Pentadecane	1.0000	1.0000	1.0000	1.0000	1.0000	0.0152	0.0187	0.0232	0.0250	0.0321	0.0421

	K's Experimental										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	Ki	Ki	0.00	Ki	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Hexane	0.36	0.00	0.01	0.00	Ki	Ki	Ki	0.00	0.00	0.00	0.00
n-Heptane	0.14	0.02	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Octane	0.06	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Nonane	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Decane	0.01	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Pentadecane	0.01	0.17	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE B.6-CONTINUED

Cut	x(i) 1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	0.2175	0.1281	0.1997	0.2180	0.2925	0.1544	0.1802	0.2070	0.2324	0.2591	0.2862
n-Hexane	0.1821	0.1608	0.1751	0.1836	0.2291	0.1796	0.1981	0.2173	0.2386	0.2608	0.2832
n-Heptane	0.1566	0.1688	0.1035	0.0930	0.0754	0.0469	0.0475	0.0493	0.0525	0.0566	0.0609
n-Octane	0.1374	0.1611	0.0745	0.0548	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1500	0.1200	0.1081	0.0464	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1381	0.1628	0.1618	0.1187	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0930	0.1643	0.1808	0.2380	0.6190	0.5742	0.5264	0.4765	0.4235	0.3697

Cut	y(i) 1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	0.2175	0.1281	0.1997	0.2180	0.2925	0.5763	0.5783	0.5772	0.5752	0.5668	0.5575
n-Hexane	0.1821	0.1608	0.1751	0.1836	0.2291	0.3703	0.3679	0.3671	0.3685	0.3724	0.3766
n-Heptane	0.1566	0.1688	0.1035	0.0930	0.0754	0.0440	0.0431	0.0435	0.0444	0.0472	0.0503
n-Octane	0.1374	0.1611	0.0745	0.0548	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1500	0.1200	0.1081	0.0464	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1381	0.1628	0.1618	0.1187	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0930	0.1643	0.1808	0.2380	0.0094	0.0107	0.0122	0.0119	0.0136	0.0156

Cut	Liq. Fug. Coeff. 1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	1.0224	1.0297	1.0294	1.0266	1.0223	3.5575	3.0166	2.5796	2.2221	1.9254	1.6766
n-Hexane	0.9966	1.0048	0.9968	0.9874	0.9753	1.8817	1.6618	1.4768	1.3194	1.1840	1.0663
n-Heptane	0.9682	0.9775	0.9606	0.9437	0.9232	0.8161	0.7667	0.7224	0.6821	0.6452	0.6112
n-Octane	0.9471	0.9569	0.9347	0.9129	0.8867	0.5230	0.4944	0.4691	0.4464	0.4259	0.4074
n-Nonane	0.9238	0.9343	0.9059	0.8788	0.8467	0.2899	0.2815	0.2742	0.2676	0.2618	0.2567
n-Decane	0.8990	0.9103	0.8758	0.8437	0.8060	0.1600	0.1597	0.1596	0.1597	0.1602	0.1610
n-Pentadecane	0.7878	0.8020	0.7435	0.6923	0.6349	0.0092	0.0105	0.0119	0.0135	0.0153	0.0173

Cut	Vap.Fug. Coeff. 1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	1.0224	1.0297	1.0294	1.0266	1.0223	0.9534	0.9400	0.9251	0.8979	0.8800	0.8607
n-Hexane	0.9966	1.0048	0.9968	0.9874	0.9753	0.9129	0.8946	0.8741	0.8543	0.8292	0.8019
n-Heptane	0.9682	0.9775	0.9606	0.9437	0.9232	0.8693	0.8458	0.8197	0.8064	0.7743	0.7396
n-Octane	0.9471	0.9569	0.9347	0.9129	0.8867	0.8354	0.8081	0.7777	0.7706	0.7323	0.6908
n-Nonane	0.9238	0.9343	0.9059	0.8788	0.8467	0.7998	0.7687	0.7344	0.7329	0.6891	0.6421
n-Decane	0.8990	0.9103	0.8758	0.8437	0.8060	0.7630	0.7286	0.6907	0.6951	0.6464	0.5945
n-Pentadecane	0.7878	0.8020	0.7435	0.6923	0.6349	0.6074	0.5619	0.5132	0.5385	0.4748	0.4104

TABLE B.6-CONTINUED

	z(i)										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	0.2175	0.1281	0.1997	0.2180	0.2925	0.3867	0.3928	0.4040	0.4227	0.4478	0.4725
n-Hexane	0.1821	0.1608	0.1751	0.1836	0.2291	0.2846	0.2888	0.2970	0.3107	0.3292	0.3474
n-Heptane	0.1566	0.1688	0.1035	0.0930	0.0754	0.0453	0.0451	0.0462	0.0480	0.0508	0.0536
n-Octane	0.1374	0.1611	0.0745	0.0548	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1500	0.1200	0.1081	0.0464	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1381	0.1628	0.1618	0.1187	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0930	0.1643	0.1808	0.2380	0.2834	0.2733	0.2529	0.2186	0.1721	0.1265

	Activity coefficent										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
n-Pentane	5.6293	4.5695	5.9327	6.9619	8.0496	18.5136	17.9593	17.3942	16.8395	16.2943	15.7592
n-Hexane	95.0158	68.5308	77.4385	83.3132	88.6771	183.2623	172.5651	162.9531	154.2985	86.1317	81.2239
n-Heptane	42.1043	29.9400	32.4743	33.9712	35.1426	32.6828	32.1809	31.6900	31.2113	30.7503	30.3137
n-Octane	73.5753	51.5782	54.6066	56.1474	56.1474	56.1474	56.1474	56.1474	56.1474	56.1474	56.1474
n-Nonane	156.7699	105.7838	106.0895	105.2715	103.2360	103.2360	103.2360	103.2360	103.2360	103.2360	103.2360
n-Decane	329.9107	214.1385	203.2713	194.5564	184.0932	184.0932	184.0932	184.0932	184.0932	184.0932	184.0932
n-Pentadecane	12815.1020	6776.4051	4878.3835	3899.3175	3088.7140	39.0234	38.9202	38.9717	39.2079	39.6893	40.4993

	Exc.Gibbs Energy										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	103.70	115.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00
G^excess(kJoules/gmol)	4.69	5.68	10.03	11.00	14.41	17.50	16.59	15.56	14.42	13.14	11.78

TABLE B.7-ANALYSIS RESULTS FOR STEAM DIST. RUN NO. 3

	Liquid Fugacity (psia)										
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.5	193.3	200.20	210.50	220.00
n-Pentane	3.2669	1.8431	5.2243	7.4724	11.4572	17.4165	32.6640	41.4830	50.7902	62.2201	74.8864	89.0841
n-Hexane	2.6643	2.4059	5.8207	8.2258	12.2650	18.1712	29.2045	36.6380	45.3573	54.9554	65.7265	77.5632
n-Heptane	2.2241	2.4531	3.9769	5.4493	7.4670	10.1326	11.1205	13.7594	17.6819	21.3836	25.6036	30.3697
n-Octane	1.9078	2.2924	1.6957	2.0705	1.7425	0.4967	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	1.6564	2.0753	1.2554	1.4042	0.3921	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4521	1.8558	2.0539	2.5954	2.2937	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8500	1.0991	3.0810	4.1678	5.8825	7.9274	0.4056	0.5409	0.7876	0.8336	1.0255	1.1655

	Vapor Fugacity (psia)											
Cut	1	2	3	4	5	6	7	8	9	10	11.00	12.00
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50	220.00
n-Pentane	3.2669	1.8431	5.2243	7.4724	11.4572	17.4166	32.6641	41.4831	50.7902	62.2204	74.8864	89.0844
n-Hexane	2.6643	2.4059	5.8207	8.2258	12.2650	18.1713	29.2046	36.6380	45.3573	54.9556	65.7265	77.5634
n-Heptane	2.2241	2.4531	3.9769	5.4493	7.4670	10.1326	11.1205	13.7594	17.6819	21.3836	25.6036	30.3697
n-Octane	1.9078	2.2924	1.6957	2.0705	1.7425	0.4967	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	1.6564	2.0753	1.2554	1.4042	0.3921	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4521	1.8558	2.0539	2.5954	2.2937	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8500	1.0991	3.0810	4.1678	5.8824	7.9273	0.4056	0.5409	0.7876	0.8336	1.0255	1.1655

	K's Calculated											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50	220.00
n-Pentane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	3.2035	2.7850	2.4923	2.1459	1.9376	1.7239
n-Hexane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.8445	1.6807	1.5873	1.4172	1.3232	1.2344
n-Heptane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9067	0.8845	0.9027	0.8489	0.8336	0.8288
n-Octane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.6141	0.6079	0.6315	0.6051	0.5998	0.6134
n-Nonane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.3685	0.3776	0.4083	0.4036	0.4099	0.4369
n-Decane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.2210	0.2345	0.2640	0.2692	0.2799	0.3110
n-Pentadecane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0191	0.0240	0.0328	0.0389	0.0452	0.0614

	K's Experimental											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	0.00
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50	220.00
n-Pentane	0.21	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Hexane	0.07	0.07	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
n-Heptane	0.03	0.23	0.01	0.04	0.03	0.04	0.01	0.00	0.00	0.00	0.00	0.00
n-Octane	0.01	0.81	0.05	0.27	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Nonane	0.01	1.04	0.09	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Decane	0.00	0.45	0.04	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Pentadecane	0.00	0.01	0.00	0.00	0.01	0.04	0.03	0.04	0.06	0.02	0.05	0.00

TABLE B.7-CONTINUED

	x(i)											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50	220.00
n-Pentane	0.2175	0.1217	0.2055	0.2132	0.2430	0.2807	0.1333	0.1537	0.1681	0.1949	0.2169	0.2416
n-Hexane	0.1821	0.1628	0.2363	0.2435	0.2721	0.3088	0.2179	0.2385	0.2520	0.2819	0.3009	0.3218
n-Heptane	0.1566	0.1705	0.1674	0.1684	0.1746	0.1830	0.1788	0.1819	0.1861	0.1999	0.2027	0.2077
n-Octane	0.1374	0.1628	0.0733	0.0660	0.0423	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1509	0.0560	0.0464	0.0100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1384	0.0947	0.0893	0.0611	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0929	0.1669	0.1732	0.1970	0.2181	0.4700	0.4259	0.3937	0.3233	0.2795	0.2288

	y(i)											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50	220.00
n-Pentane	0.2175	0.1217	0.2055	0.2132	0.2430	0.2808	0.4270	0.4280	0.4191	0.4183	0.4203	0.4166
n-Hexane	0.1821	0.1628	0.2363	0.2435	0.2721	0.3088	0.4019	0.4009	0.4000	0.3995	0.3981	0.3972
n-Heptane	0.1566	0.1705	0.1674	0.1684	0.1746	0.1830	0.1621	0.1609	0.1680	0.1697	0.1690	0.1722
n-Octane	0.1374	0.1628	0.0733	0.0660	0.0423	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1509	0.0560	0.0464	0.0100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1384	0.0947	0.0893	0.0611	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0929	0.1669	0.1732	0.1970	0.2181	0.0090	0.0102	0.0129	0.0126	0.0126	0.0140

	Liq. Fug. Coeff.											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50	220.00
n-Pentane	1.0219	1.0300	1.0235	1.0187	1.0115	1.0012	3.0266	2.5901	2.2826	1.9224	1.6753	1.4559
n-Hexane	0.9954	1.0055	0.9917	0.9816	0.9667	0.9497	1.6556	1.4739	1.3601	1.1742	1.0602	0.9518
n-Heptane	0.9662	0.9786	0.9565	0.9406	0.9176	0.8937	0.7683	0.7260	0.7179	0.6444	0.6130	0.5774
n-Octane	0.9448	0.9582	0.9310	0.9111	0.8828	0.8538	0.4969	0.4730	0.4722	0.4271	0.4106	0.3914
n-Nonane	0.9210	0.9357	0.9028	0.8786	0.8446	0.8106	0.2834	0.2771	0.2855	0.2631	0.2596	0.2538
n-Decane	0.8958	0.9120	0.8734	0.8450	0.8056	0.7670	0.1609	0.1616	0.1719	0.1614	0.1634	0.1637
n-Pentadecane	0.7828	0.8047	0.7434	0.6994	0.6406	0.5867	0.0107	0.0122	0.0151	0.0155	0.0178	0.0201

	Vap.Fug. Coeff.											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50	220.00
n-Pentane	1.0219	1.0300	1.0235	1.0187	1.0115	1.0012	0.9448	0.9300	0.9158	0.8959	0.8646	0.8445
n-Hexane	0.9954	1.0055	0.9917	0.9816	0.9667	0.9497	0.8976	0.8769	0.8568	0.8285	0.8012	0.7711
n-Heptane	0.9662	0.9786	0.9565	0.9406	0.9176	0.8937	0.8473	0.8208	0.7952	0.7591	0.7353	0.6966
n-Octane	0.9448	0.9582	0.9310	0.9111	0.8828	0.8538	0.8093	0.7782	0.7477	0.7058	0.6845	0.6381
n-Nonane	0.9210	0.9357	0.9028	0.8786	0.8446	0.8106	0.7690	0.7338	0.6991	0.6520	0.6333	0.5809
n-Decane	0.8958	0.9120	0.8734	0.8450	0.8056	0.7670	0.7282	0.6891	0.6509	0.5995	0.5836	0.5265
n-Pentadecane	0.7828	0.8047	0.7434	0.6994	0.6406	0.5867	0.5588	0.5085	0.4606	0.3996	0.3938	0.3277

TABLE B.7-CONTINUED

	z(i)										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50
n-Pentane	0.2175	0.1217	0.2055	0.2132	0.2430	0.2807	0.3007	0.3089	0.3186	0.3300	0.3333
n-Hexane	0.1821	0.1628	0.2363	0.2435	0.2721	0.3088	0.3227	0.3304	0.3407	0.3530	0.3565
n-Heptane	0.1566	0.1705	0.1674	0.1684	0.1746	0.1830	0.1693	0.1700	0.1753	0.1816	0.1834
n-Octane	0.1374	0.1628	0.0733	0.0660	0.0423	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1509	0.0560	0.0464	0.0100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1384	0.0947	0.0893	0.0611	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0929	0.1669	0.1732	0.1970	0.2181	0.2073	0.1907	0.1654	0.1353	0.1268

	Coefficient Activity										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50
n-Pentane	6.2829	4.3266	5.8787	6.5330	7.9037	5.0505	17.9472	17.3547	16.6246	16.2308	15.6605
n-Hexane	112.7045	62.9822	76.6298	75.9222	86.8521	87.7996	170.8054	160.9495	88.5029	85.1088	80.0466
n-Heptane	50.2945	27.4208	32.1588	30.9605	34.5050	33.9518	32.0384	31.5233	30.7945	30.5954	30.1327
n-Octane	88.5313	47.0644	54.0838	51.0253	56.0613	54.0871	54.0871	54.0871	54.0871	54.0871	54.0871
n-Nonane	192.3772	95.6011	105.0672	94.8856	101.5289	101.5289	101.5289	101.5289	101.5289	101.5289	101.5289
n-Decane	413.0491	191.6422	201.2963	173.9163	181.1611	181.1611	181.1611	181.1611	181.1611	181.1611	181.1611
n-Pentadecane	17863.3893	5762.0980	4827.9044	3337.2194	3047.1124	2251.5197	39.0286	39.1037	38.9834	40.1043	41.0352

	Excess Gibbs Energy										
Cut	1	2	3	4	5	6	7	8	9	10	11
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07
T(ºC)	98.20	118.00	130.20	143.50	150.50	162.30	170.30	180.50	193.30	200.20	210.50
G^excess(kJoules/gmol)	4.79	5.61	10.17	10.43	11.92	13.05	13.61	12.62	11.99	10.07	8.95

TABLE B.8-ANALYSIS RESULTS FOR STEAM-C_3 DIST. RUN NO. 1

	x(i)													
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	0.2175	0.1333	0.2672	0.2695	0.2700	0.2722	0.2756	0.1282	0.1459	0.1664	0.1840	0.2094	0.2328	0.2821
n-Hexane	0.1821	0.1699	0.3300	0.3329	0.3334	0.3361	0.3403	0.2397	0.2605	0.2828	0.3010	0.3229	0.3400	0.3219
n-Heptane	0.1566	0.1713	0.2359	0.2353	0.2357	0.2376	0.2404	0.2666	0.2743	0.2810	0.2854	0.2863	0.2845	0.2575
n-Octane	0.1374	0.1590	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0882	0.1669	0.1623	0.1546	0.1482	0.1383	0.3617	0.3161	0.2678	0.2277	0.1800	0.1421	0.1384

	y(i)													
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	0.2175	0.1333	0.2672	0.2695	0.2700	0.2722	0.2756	0.3549	0.3537	0.3542	0.3542	0.3568	0.3554	0.3930
n-Hexane	0.1821	0.1699	0.3300	0.3329	0.3334	0.3361	0.3403	0.3985	0.3972	0.3963	0.3953	0.3940	0.3925	0.3562
n-Heptane	0.1566	0.1713	0.2359	0.2353	0.2357	0.2376	0.2404	0.2342	0.2363	0.2369	0.2380	0.2363	0.2382	0.2193
n-Octane	0.1374	0.1590	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0882	0.1669	0.1623	0.1546	0.1482	0.1383	0.0087	0.0097	0.0105	0.0106	0.0114	0.0133	0.0183

	Liq. Fug. Coeff.													
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	1.0217	1.0287	1.0138	1.0067	0.9966	0.9873	0.9739	2.5809	2.2207	1.9121	1.6686	1.4431	1.2631	1.1184
n-Hexane	0.9949	1.0041	0.9837	0.9715	0.9552	0.9403	0.9177	1.4593	1.3035	1.1615	1.0517	0.9395	0.8530	0.7816
n-Heptane	0.9652	0.9772	0.9508	0.9332	0.9102	0.8897	0.8579	0.7209	0.6815	0.6393	0.6111	0.5720	0.5465	0.5238
n-Octane	0.9437	0.9566	0.9262	0.9049	0.8775	0.8525	0.8147	0.4703	0.4484	0.4245	0.4103	0.3889	0.3775	0.3667
n-Nonane	0.9197	0.9342	0.8992	0.8740	0.8418	0.8125	0.7685	0.2755	0.2697	0.2617	0.2599	0.2526	0.2525	0.2517
n-Decane	0.8943	0.9103	0.8709	0.8419	0.8052	0.7718	0.7222	0.1607	0.1614	0.1606	0.1638	0.1632	0.1678	0.1718
n-Pentadecane	0.7804	0.8027	0.7455	0.7019	0.6489	0.6018	0.5347	0.0121	0.0138	0.0155	0.0180	0.0202	0.0238	0.0276

	Vap.Fug. Coeff.													
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	1.0217	1.0287	1.0138	1.0067	0.9966	0.9873	0.9739	0.9322	0.9161	0.8982	0.8668	0.8466	0.8275	0.8028
n-Hexane	0.9949	1.0041	0.9837	0.9715	0.9552	0.9403	0.9177	0.8778	0.8548	0.8289	0.8007	0.7699	0.7389	0.7065
n-Heptane	0.9652	0.9772	0.9508	0.9332	0.9102	0.8897	0.8579	0.8208	0.7912	0.7581	0.7330	0.6931	0.6527	0.6150
n-Octane	0.9437	0.9566	0.9262	0.9049	0.8775	0.8525	0.8147	0.7778	0.7430	0.7041	0.6810	0.6331	0.5841	0.5400
n-Nonane	0.9197	0.9342	0.8992	0.8740	0.8418	0.8125	0.7685	0.7328	0.6933	0.6495	0.6285	0.5745	0.5195	0.4719
n-Decane	0.8943	0.9103	0.8709	0.8419	0.8052	0.7718	0.7222	0.6876	0.6442	0.5963	0.5778	0.5189	0.4594	0.4100
n-Pentadecane	0.7804	0.8027	0.7455	0.7019	0.6489	0.6018	0.5347	0.5053	0.4514	0.3945	0.3850	0.3176	0.2544	0.2085

TABLE B.8-CONTINUED

Liquid Fugacity (psia)

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.2	190.3	199.80	210.40	219.40	229.70	240.00
n-Pentane	3.2662	2.0164	6.7292	9.3363	12.5435	16.6500	21.7273	34.4758	42.8791	52.8282	63.2713	76.5014	90.6848	117.4793
n-Hexane	2.6628	2.5081	8.0636	11.1277	14.8473	19.5812	25.2827	36.4531	44.9318	54.5399	65.2343	76.8095	89.4176	93.7020
n-Heptane	2.2219	2.4605	5.5722	7.5564	10.0016	13.0949	16.6991	20.0314	24.7422	29.8240	35.9441	41.4690	47.9374	50.2235
n-Octane	1.9056	2.2362	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	1.6541	1.9911	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4497	1.7831	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8474	1.0407	3.0900	3.9197	4.6776	5.5269	5.9885	0.4570	0.5782	0.6882	0.8435	0.9191	1.0427	1.4231
				0.0302		0.3310		1.3677	17.9983	18.1343	14.4920	13.9174	9.9985	10.1396

Vapor Fugacity (psia)

Cut	1	2	3	4	5	6	7	8	9	10	11.00	12.00	13.00	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	3.2662	2.0164	6.7292	9.3363	12.5435	16.6500	21.7273	34.4758	42.8792	52.8284	63.2713	76.5016	90.6850	117.4792
n-Hexane	2.6628	2.5081	8.0637	11.1278	14.8473	19.5813	25.2827	36.4531	44.9318	54.5401	65.2344	76.8097	89.4177	93.7020
n-Heptane	2.2219	2.4605	5.5722	7.5564	10.0016	13.0950	16.6991	20.0314	24.7422	29.8240	35.9441	41.4690	47.9374	50.2235
n-Octane	1.9056	2.2362	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	1.6541	1.9911	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	1.4497	1.7831	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.8474	1.0407	3.0900	3.9197	4.6776	5.5269	5.9885	0.4570	0.5782	0.6882	0.8435	0.9191	1.0427	1.4231
				0.0302		0.3310		1.3677	17.9983	18.1343	14.492017	13.9174	9.99847	10.139573

K's Calculated

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	2.7686	2.4240	2.1290	1.9250	1.7045	1.5264	1.3931
n-Hexane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.6624	1.5249	1.4013	1.3134	1.2203	1.1544	1.1064
n-Heptane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.8783	0.8614	0.8433	0.8337	0.8253	0.8373	0.8518
n-Octane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.6047	0.6034	0.6029	0.6025	0.6142	0.6463	0.6791
n-Nonane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.3760	0.3889	0.4029	0.4135	0.4397	0.4861	0.5334
n-Decane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.2338	0.2506	0.2693	0.2835	0.3145	0.3653	0.4189
n-Pentadecane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0240	0.0306	0.0392	0.0467	0.0635	0.0935	0.1324

K's Experimental

Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	46.62	61.96	80.96	104.21	132.34	166.04	0.00
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Hexane	0.25	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Heptane	0.09	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Octane	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Nonane	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Decane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Pentadecane	0.01	0.01	0.02	0.03	0.03	0.06	0.07	0.07	0.06	0.07	0.06	0.07	0.05	0.00

TABLE B.8-CONTINUED

	z(i)													
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	0.2175	0.1333	0.2672	0.2695	0.2700	0.2722	0.2756	0.2807	0.2853	0.2892	0.2926	0.2950	0.2980	0.2821
n-Hexane	0.1821	0.1699	0.3300	0.3329	0.3334	0.3361	0.3403	0.3465	0.3522	0.3570	0.3612	0.3642	0.3679	0.3219
n-Heptane	0.1566	0.1713	0.2359	0.2353	0.2357	0.2376	0.2404	0.2448	0.2488	0.2522	0.2552	0.2573	0.2599	0.2575
n-Octane	0.1374	0.1590	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Nonane	0.1223	0.1450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.1103	0.1333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Pentadecane	0.0739	0.0882	0.1669	0.1623	0.1546	0.1482	0.1383	0.1242	0.1105	0.0996	0.0893	0.0821	0.0736	0.1384

	Activity Coeff.													
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
n-Pentane	6.61	4.42	5.48	6.39	7.66	4.78	5.77	17.36	16.77	16.22	15.61	15.09	14.49	14.04
n-Hexane	122.04	65.25	69.19	73.87	83.60	81.12	94.68	160.35	151.53	84.81	79.55	75.56	71.24	67.77
n-Heptane	54.64	28.45	29.00	30.18	33.33	31.51	35.77	31.49	31.00	30.58	30.09	29.81	29.46	16.15
n-Octane	96.51	48.91	48.91	48.91	48.91	48.91	48.91	48.91	48.91	48.91	48.91	48.91	48.91	48.91
n-Nonane	211.64	99.76	99.76	99.76	99.76	99.76	99.76	99.76	99.76	99.76	99.76	99.76	99.76	99.76
n-Decane	458.70	200.83	200.83	200.83	200.83	200.83	200.83	200.83	200.83	200.83	200.83	200.83	200.83	200.83
n-Pentadecane	20868.36	6172.97	4042.08	3241.09	2937.45	2028.68	1958.06	39.35	39.73	40.53	41.57	43.68	46.61	49.24

	Excess Gibbs Energy													
Cut	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22	308.35	372.39
T(ºC)	95.70	116.70	133.80	144.20	151.60	165.40	170.30	180.20	190.30	199.80	210.40	219.40	229.70	240.00
G^excess(kJoules/gmol)	4.83	5.35	10.05	9.76	9.35	8.83	8.29	10.74	9.62	8.37	7.32	5.98	4.90	4.94

TABLE B.9-ANALYSIS RESULTS FOR STEAM-C_3 DIST. RUN NO. 2

	Liquid Fugacity (psia)											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.5	190.5	200.80	211.10	220.00
n-Pentane	3.2696	2.0133	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	2.6697	2.3067	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Heptane	2.2322	2.3877	0.8549	1.1977	1.7126	2.3115	2.5857	3.1846	3.9028	4.7670	5.7378	6.7320
n-Octane	1.9158	2.2655	4.0507	5.5912	7.9180	10.5431	8.0745	9.9448	12.2734	15.1077	18.3360	21.6832
n-Nonane	1.6650	2.0725	6.2541	8.4110	11.4285	14.9091	6.9614	8.8583	11.2037	14.1304	17.5563	21.1779
n-Decane	1.4611	1.8608	6.8564	8.9932	11.1242	13.7220	3.8646	5.0282	6.5097	8.4047	10.6854	13.1386
n-Pentadecane	0.8596	1.1032	3.8634	4.9553	5.6296	6.0652	0.1457	0.1893	0.2398	0.2914	0.3539	0.3898

	Vapor Fugacity (psia)											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	3.2696	2.0133	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	2.6697	2.3067	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Heptane	2.2322	2.3877	0.8548	1.1977	1.7126	2.3115	2.5857	3.1846	3.9028	4.7670	5.7378	6.7320
n-Octane	1.9158	2.2655	4.0507	5.5912	7.9180	10.5431	8.0745	9.9448	12.2734	15.1077	18.3359	21.6832
n-Nonane	1.6650	2.0725	6.2541	8.4110	11.4285	14.9091	6.9614	8.8583	11.2036	14.1303	17.5562	21.1779
n-Decane	1.4611	1.8608	6.8564	8.9932	11.1242	13.7220	3.8646	5.0282	6.5097	8.4047	10.6853	13.1386
n-Pentadecane	0.8596	1.1032	3.8634	4.9553	5.6296	6.0652	0.1457	0.1893	0.2398	0.2914	0.3539	0.3898

	K's Calculated											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	3.2040	2.7663	2.4197	2.1420	1.9125	1.7041
n-Hexane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.7906	1.6076	1.4615	1.3442	1.2448	1.1440
n-Heptane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.8414	0.8007	0.7707	0.7495	0.7318	0.7027
n-Octane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.5479	0.5259	0.5111	0.5026	0.4968	0.4828
n-Nonane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.3163	0.3119	0.3116	0.3150	0.3200	0.3185
n-Decane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.1821	0.1845	0.1894	0.1970	0.2057	0.2097
n-Pentadecane	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0129	0.0149	0.0175	0.0208	0.0249	0.0285

	K's Experimental											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	0.00
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Hexane	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Heptane	0.07	2.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Octane	0.03	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Nonane	0.02	0.12	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Decane	0.01	0.06	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Pentadecane	0.01	0.06	0.00	0.03	0.02	0.03	0.03	0.03	0.04	0.03	0.05	0.00

TABLE B.9-CONTINUED

	x(i)											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	0.2175	0.1330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1562	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Heptane	0.1566	0.1662	0.0350	0.0359	0.0385	0.0399	0.0410	0.0419	0.0427	0.0437	0.0445	0.0453
n-Octane	0.1374	0.1611	0.1709	0.1739	0.1868	0.1932	0.1988	0.2016	0.2058	0.2105	0.2141	0.2182
n-Nonane	0.1223	0.1509	0.2732	0.2732	0.2846	0.2930	0.3005	0.3072	0.3136	0.3207	0.3262	0.3325
n-Decane	0.1103	0.1391	0.3109	0.3060	0.2935	0.2904	0.2935	0.2993	0.3051	0.3117	0.3170	0.3227
n-Pentadecane	0.0739	0.0936	0.2099	0.2110	0.1965	0.1835	0.1662	0.1500	0.1327	0.1134	0.0982	0.0813

	y(i)											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	0.2175	0.1330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1562	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Heptane	0.1566	0.1662	0.0350	0.0359	0.0385	0.0399	0.0345	0.0335	0.0329	0.0328	0.0325	0.0318
n-Octane	0.1374	0.1611	0.1709	0.1739	0.1868	0.1932	0.1089	0.1060	0.1052	0.1058	0.1064	0.1053
n-Nonane	0.1223	0.1509	0.2732	0.2732	0.2846	0.2930	0.0950	0.0958	0.0977	0.1010	0.1044	0.1059
n-Decane	0.1103	0.1391	0.3109	0.3060	0.2935	0.2904	0.0534	0.0552	0.0578	0.0614	0.0652	0.0677
n-Pentadecane	0.0739	0.0936	0.2099	0.2110	0.1965	0.1835	0.0021	0.0022	0.0023	0.0024	0.0024	0.0023

	Liq. Fug. Coeff.											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	1.0227	1.0297	1.0629	1.0694	1.0764	1.0926	3.0469	2.6037	2.2498	1.9628	1.7240	1.5098
n-Hexane	0.9974	1.0048	1.0254	1.0226	1.0181	1.0177	1.6817	1.4911	1.3355	1.2066	1.0954	0.9860
n-Heptane	0.9697	0.9775	0.9829	0.9700	0.9532	0.9355	0.7786	0.7299	0.6900	0.6568	0.6262	0.5867
n-Octane	0.9488	0.9569	0.9540	0.9344	0.9094	0.8805	0.5017	0.4733	0.4506	0.4323	0.4156	0.3925
n-Nonane	0.9258	0.9342	0.9214	0.8947	0.8613	0.8212	0.2861	0.2767	0.2700	0.2654	0.2611	0.2516
n-Decane	0.9014	0.9102	0.8877	0.8542	0.8129	0.7627	0.1627	0.1612	0.1612	0.1624	0.1636	0.1608
n-Pentadecane	0.7916	0.8018	0.7410	0.6824	0.6144	0.5335	0.0108	0.0121	0.0136	0.0155	0.0175	0.0189

	Vap.Fug. Coeff.											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	1.0227	1.0297	1.0629	1.0694	1.0764	1.0926	0.9510	0.9412	0.9298	0.9163	0.9014	0.8860
n-Hexane	0.9974	1.0048	1.0254	1.0226	1.0181	1.0177	0.9392	0.9275	0.9138	0.8977	0.8800	0.8619
n-Heptane	0.9697	0.9775	0.9829	0.9700	0.9532	0.9355	0.9253	0.9115	0.8953	0.8764	0.8558	0.8350
n-Octane	0.9488	0.9569	0.9540	0.9344	0.9094	0.8805	0.9157	0.9001	0.8817	0.8601	0.8365	0.8129
n-Nonane	0.9258	0.9342	0.9214	0.8947	0.8613	0.8212	0.9047	0.8871	0.8665	0.8423	0.8160	0.7898
n-Decane	0.9014	0.9102	0.8877	0.8542	0.8129	0.7627	0.8933	0.8738	0.8510	0.8242	0.7952	0.7666
n-Pentadecane	0.7916	0.8018	0.7410	0.6824	0.6144	0.5335	0.8402	0.8123	0.7800	0.7424	0.7025	0.6640

TABLE B.9-CONTINUED

	z(i)											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	0.2175	0.1330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Hexane	0.1821	0.1562	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-Heptane	0.1566	0.1662	0.0350	0.0359	0.0385	0.0399	0.0410	0.0419	0.0427	0.0437	0.0445	0.0453
n-Octane	0.1374	0.1611	0.1709	0.1739	0.1868	0.1932	0.1988	0.2016	0.2058	0.2105	0.2141	0.2182
n-Nonane	0.1223	0.1509	0.2732	0.2732	0.2846	0.2930	0.3005	0.3072	0.3136	0.3207	0.3262	0.3325
n-Decane	0.1103	0.1391	0.3109	0.3060	0.2935	0.2904	0.2935	0.2993	0.3051	0.3117	0.3170	0.3227
n-Pentadecane	0.0739	0.0936	0.2099	0.2110	0.1965	0.1835	0.1662	0.1500	0.1327	0.1134	0.0982	0.0813

	Activity Coeff.											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
n-Pentane	5.1788	4.5950	4.5950	4.5950	4.5950	4.5950	4.5950	4.5950	4.5950	4.5950	4.5950	4.5950
n-Hexane	83.4832	69.1225	69.1225	69.1225	69.1225	69.1225	69.1225	69.1225	69.1225	69.1225	69.1225	69.1225
n-Heptane	36.7964	30.2091	33.1376	33.7682	34.9848	37.0360	32.1133	31.6887	31.2630	30.8386	30.4555	30.2655
n-Octane	63.9425	52.0610	55.5787	55.4926	56.3052	58.2495	34.2142	33.6514	33.1130	32.6026	32.1644	31.9686
n-Nonane	134.2377	106.8780	107.5709	103.0966	100.6613	100.2345	35.1217	34.6358	34.1814	33.7634	33.4249	33.3403
n-Decane	278.2496	216.5677	205.3237	188.7683	177.2460	169.7574	35.5110	35.1156	34.7599	34.4502	34.2283	34.2717
n-Pentadecane	9973.9441	6888.9433	4837.1809	3612.0038	2793.8368	2209.8639	38.8472	38.8528	38.9505	39.1550	39.5121	40.2499

	Excess Gibbs Energy											
Cut	1	2	3	4	5	6	7	8	9	10	11	12
Pressure (psia)	14.70	14.70	24.84	34.41	46.62	61.96	80.96	104.21	132.34	166.04	206.07	253.22
T(ºC)	108.00	114.70	130.10	141.30	151.50	160.50	170.80	180.50	190.50	200.80	211.10	220.00
G^excess(kJoules/gmol)	4.62	5.72	12.80	12.78	11.81	10.93	4.82	4.45	4.03	3.52	3.13	2.65

APPENDIX C

Equilibrium Evaluation Program

This Appendix shows the program developed in Visual Basic to calculate thermodynamic properties of the mixture in every cut for each kind of distillation.

```
  ' EQUILIBRIUM EVALUATION PROGRAM

'Variables Declaration


'Input Data

Private count As Integer           ' Number of iterations
Private T, Tcel As Double           ' Temperature
Private Psys                        ' System Pressure
Private R As Double                 ' Gases Constant
Private Parachor(ck) As Double      ' Parachor for each component
Private Psat(ck) As Double          'Saturation Pressure for each component

'Composition and Properties of the Components

Private Const ck As Integer = 100   ' Maximum Number of components
Private AprimaL(ck) As Double
Private AprimaV(ck) As Double
Private BprimaL(ck) As Double
Private BprimaV(ck) As Double
Private Nc As Integer               ' Number of componentes
Private Ncut As Integer             ' Number of cuts
Private Z(ck) As Double             ' Overall composition for each component
Private Zc(ck) As Double            ' Z Critical each component
```

```
Private Tc(ck) As Double            ' Critical temperature of each component
Private Asat(ck) As Double          ' Antoine A constant
Private AAsat(ck) As Double         ' Constant at saturation conditions
Private Bsat(ck) As Double          ' Antoine B constant
Private BBsat(ck) As Double         ' Constant at saturation conditions
Private Csat(ck) As Double          ' Antoine C constant
Private Pisat(ck) As Double         ' Saturation pressure of each component
Private Pc(ck) As Double            ' Critical pressure of each component
Private w(ck) As Double             ' Acentric factor of each component
Private Mw(ck) As Double            ' Molecular weight of each component
Private delta(ck, ck) As Double     ' Binary intereaction parameters


'Calculated Variables

Private Tr(ck) As Double            ' Reduced temperature of each component
Private Trsat(ck) As Double         ' Reduced temperature of each component at saturation conditions
Private Pr(ck) As Double            ' Reduced pressure of each component
Private Prsat(ck) As Double         ' Reduced pressure of each component at saturation conditions
Private FV As Double                ' Vapor Fraction
Private FL As Double                ' Liquid Fraction
Private VL(ck) As Double            ' Volume of Liquid (sln. from cubic EOS)
Private VV(ck) As Double            ' Volume of Gas (Sln. from cubic EOS)
Private ZL As Double                ' Liquid Compressibility Factor
Private ZV As Double                ' Vapor Compressibility Factor
Private ZLsat(ck) As Double         ' Liquid Compressibility Factor at saturation conditions
Private DL As Double                ' Liquid Density (lb/ft3)
Private DV As Double                ' Vapor Density (lb/ft3)
Private D As Double                 ' System Density (lb/ft3)
```

'EOS Variables

Private ac(ck) As Double ' PR EOS's ac parameter for each component

Private acsat(ck) As Double ' PR EOS's ac parameter for each component at saturation conditions

Private A(ck) As Double ' PR EOS's A parameter for each component

Private b(ck) As Double ' PR EOS's B parameter for each component

Private m(ck) As Double ' PR EOS's M parameter for each component

Private msat(ck) As Double ' PR EOS's M parameter for each component at saturation conditions

Private alpha(ck) As Double ' PR EOS's Alpha parameter for each component

Private alphasat(ck) As Double ' PR EOS's Alpha parameter for each component at saturation conditions

Private aT(ck) As Double ' PR EOS's A * Alpha parameter for each component at saturation conditions

Private aTsat(ck) As Double ' PR EOS's A * Alpha parameter for each component

Private aTL As Double ' PR EOS's A-Alpha for liquid composition

Private aTV As Double ' PR EOS's A-Alpha for vapor composition

Private aTLf As Double ' A-Alpha final for liquid phase from quadratic mixing rule

Private aTVf As Double ' A-Alpha final for vapor phase from quadratic mixing rule

Private a1, a2, a3 As Double ' variables transformed for resolution of cubic equation in liquid phase

Private a11, a22, a33 As Double ' variables transformed for resolution of cubic equation in vapor phase

Private a1sat(ck), a2sat(ck), a3sat(ck) As Double 'variables for resolution of EoS at saturation conditions

Private bL As Double ' B parameter for liquid composition

Private bV As Double ' B parameter for vapor composition

Private bLf As Double ' B final for liquid phase from linear mixing rule

Private bVf As Double ' B final for vapor phase from linear mixing rule

Private CoefFugL(ck) As Double ' Fugacity coefficient for each component in liquid phase

Private CoefFugV(ck) As Double ' Fugacity coefficient for each component in vapor phase

Private CoefFugsat(ck) As Double ' Fugacity coefficient for each component in liquid phase at saturation conditions

Private DD, DDD As Double ' Discriminant of cubic equation for liquid and vapor phase

Private DDsat(ck) As Double ' Discriminant of cubic equation for liquid phase at saturation conditions

Private epsilontol As Double ' Fugacity coefficient for each component in liquid phase

Private Ki(ck) As Double ' Initial K value for each component

Private K(ck) As Double ' K value from iteration for each component

Private x(ck) As Double ' Liquid composition for each component

Private y(ck) As Double ' Vapor composition for each component

Private Kf(ck) As Double ' Final K's values for each component

Private QQ, RR, SS, TT As Double ' Terms of cubic equation evaluation in liquid phase

Private QQQ, RRR, SSS, TTT As Double ' Terms of cubic equation evaluation in vapor phase

Private QQsat(ck), RRsat(ck) As Double ' Terms of cubic equation evaluation in liquid phase at saturation conditions

'FugacityCoefCalculation

Dim i, j As Integer

```
Dim alpbL(ck, ck) As Double
Dim alpbV(ck, ck), U(ck) As Double
Dim CAL, CBL As Double        'A and B variables for P-R equation in liquid phase
Dim CAV, CBV As Double        'A and B variables for P-R equation in vapor phase
Dim CbiL(ck) As Double
Dim CbiV(ck) As Double
Dim FugL(ck), FugV(ck) As Double    'Fugacity per component in liquid and vapor phases
Dim FugSatLiq(ck) As Double    'Fugacity per component in liquid phase at saturation condition
Dim GL, GV, H(ck), L(ck) As Double   'Variables included in the evaluation for fugacity coefficient of each component
Dim MmL, MmV, p As Double
Dim sumauxL, sumauxV As Double
Dim Gexcess As Double       'Excess Gibss Energy for each cut

' Subroutine OUTPUT
Private epsilon(ck) As Double  'Function of error of the difference of fugacities for each component in both phases
Private epsilonaux As Double     'Auxiliar function to compare the function of error epsilon
Dim DensityL, DensityV, PML, PMV As Double    'Density and Molecular Weight of liquid and vapor phases
Dim DensityLi(ck), DensityVi(ck) As Double    'Density per component in liquid and vapor phases
Dim DensityLiSat(ck)          'Density per component in liquid phase at saturation condition
Dim SpecificVL, SpecificVV As Double     'Specific volume of liquid and vapor phases
Dim SpecificVLi(ck), SpecificVVi(ck) As Double  'Specific volume for each component in vapor and liquid phases
```

```
Dim SpecificVLiSat(ck) As Double          'Specific volume for each component in liquid phase at saturation condition
Dim PoyntingFact(ck)                      'Poynting factor
Dim PHI(ck) As Double                     'Ratio of coefficient fugacities
Dim Gamma(ck) As Double                   'Activity coeffient of each component
Dim VML, VMV As Double                    'Molar volume of hte mixture in vapor and liquid phases

Sub EquilibriumProgram()

  Call Inputdata              ' Read input data from worksheet

  Call InitialKi              'Initial Ki calculation based on correlation

  Call Flash                  'Calculates trial compositions of equilibrium gas-liquid

  Call EoSsolution            'Peng-Robinson EoS Solution

  Call FugacityCoefCalculation        'Fugacity Coefficient Calculation from Peng-Robinson EoS

  Call EquilibriumCondition     'Calculate and compare fugacities for every component in every phase

  Call InitialDataFugCoefSat    'Coefficient Fugacity at Saturation Conditions

  Call EoSsolutionFugCoefSat    'Peng-Robinson EoS Solution for i pure component

  Call FugacityCoefCalculSat    'Coefficient Fugacity at Saturation conditions

  Call ActivityGibbsEnergy      'Coefficient Activity and Excess Gibbs Energy
```

```
  Call Output                    'Determine finally the properties of the mixture calculated

End Sub
Sub Inputdata()

'Variables Declaration

Dim i, j As Integer
  Nc = Worksheets("Inputdata").Cells(7, 3).Value     'number of components
  Ncut = Worksheets("Inputdata").Cells(8, 3).Value    'Cut number
  Tcel = Worksheets("Inputdata").Cells(10, 3).Value   'Temperature of the system in
Centigrades degrees
  T = Worksheets("Inputdata").Cells(12, 3).Value     'Temperature of the system
  R = Worksheets("Inputdata").Cells(13, 3).Value     'General Constant of Gases
  Psys = Worksheets("Inputdata").Cells(14, 3).Value   'System pressure

  ' Read properties for each component

  For i = 1 To Nc
    Tc(i) = Worksheets("Inputdata").Cells(19, 2 + i).Value  'Critical Temperature for each
component
      Pc(i) = Worksheets("Inputdata").Cells(20, 2 + i).Value   'Critical Pressure for each
component
     Mw(i) = Worksheets("Inputdata").Cells(21, 2 + i).Value  'Molecular Weight for each
component
    Zc(i) = Worksheets("Inputdata").Cells(22, 2 + i).Value    'Critical Compressibility for
each component
     Z(i) = Worksheets("Inputdata").Cells(23, 2 + i).Value   'Overall composition for each
component
```

```
    w(i) = Worksheets("Inputdata").Cells(24, 2 + i).Value 'Acentric factor for each component
      Parachor(i) = Worksheets("Inputdata").Cells(25, 2 + i).Value  'Parachor for each component
    Asat(i) = Worksheets("Inputdata").Cells(38, 2 + i).Value 'A Antoine's constant
    Bsat(i) = Worksheets("Inputdata").Cells(39, 2 + i).Value 'B Antoine's constant
    Csat(i) = Worksheets("Inputdata").Cells(40, 2 + i).Value 'C Antoine's constant

  Next i

   For i = 1 To Nc
      For j = 1 To Nc
      delta(i, j) = Worksheets("Inputdata").Cells(27 + i, 2 + j).Value 'Binary interaction parameters
      Next j
   Next i

   For i = 1 To Nc
      For j = 1 To Nc
         delta(j, i) = delta(i, j)
      Next j
   Next i

   For j = 1 To Nc
      delta(j, j) = 0
   Next j

' Calculus of properties for pure components using Peng-Robinson EoS

   For i = 1 To Nc
      b(i) = 0.0778 * R * Tc(i) / Pc(i)  'b(j)
```

```
  Next i

  For i = 1 To Nc
    ac(i) = 0.45724 * R ^ 2# * Tc(i) ^ 2 / Pc(i)  'ac(j)
    Tr(i) = T / Tc(i)
    Pr(i) = Psys / Pc(i)
    m(i) = 0.379642 + 1.48503 * w(i) - 0.1644 * w(i) ^ 2 + 0.016667 * w(i) ^ 3
    'm(i) = 0.37464 + 1.54226 * w(i) - 0.26992 * w(i) ^ 2
    alpha(i) = (1 + m(i) * (1 - Tr(i) ^ 0.5)) ^ 2  'alpha(j)
    aT(i) = ac(i) * alpha(i)  'aT(j)
  Next i
End Sub

Sub InitialKi()                    'Initial Ki calculation using Wilson's expression

Dim i As Integer

    For i = 1 To Nc
      K(i) = Exp(5.3727 * (1 + w(i)) * (1 - Tc(i) / T)) / Pr(i)
    Next i

End Sub

Sub Flash()                        ' Flash Calculation using Newton-Raphson for Rachford-
Rice
 Dim i  As Integer
 Dim FBeta, sumFbeta1, sumFbeta2, betac, beta As Double
 Dim sumazk, sumazk2 As Double

  beta = 1
  betac = 0
```

```
sumFbeta1 = 0
sumFbeta2 = 0
sumazk = 0
sumazk2 = 0

For i = 1 To Nc
        sumazk = sumazk + Z(i) * K(i)
        sumazk2 = sumazk2 + Z(i) / K(i)
    Next i
If (sumazk > 1) And (sumazk2 > 1) Then

For i = 1 To Nc
        sumFbeta1 = sumFbeta1 + ((K(i) - 1) * Z(i)) / (1 + beta * (K(i) - 1))
    Next i

    For i = 1 To Nc
        sumFbeta2 = sumFbeta2 + (((K(i) - 1) / (1 + beta * (K(i) - 1))) ^ 2) * Z(i)
    Next i

        betac = beta + sumFbeta1 / sumFbeta2

Do While Abs(beta - betac) > 0.000001

    beta = betac
    sumFbeta1 = 0
    sumFbeta2 = 0

    For i = 1 To Nc
        sumFbeta1 = sumFbeta1 + ((K(i) - 1) * Z(i)) / (1 + beta * (K(i) - 1))
    Next i
```

```
      For i = 1 To Nc
         sumFbeta2 = sumFbeta2 + (((K(i) - 1) / (1 + beta * (K(i) - 1))) ^ 2) * Z(i)
      Next i

         betac = beta + sumFbeta1 / sumFbeta2

   Loop
  End If

      FV = betac

      For i = 1 To Nc
            x(i) = Z(i) / (1 + FV * (K(i) - 1))
            y(i) = K(i) * x(i)
      Next i


End Sub

Sub EoSsolution()                    ' Cubic EoS Solution
  Dim i, j  As Integer
  Dim AA, AAA, BB, BBB As Double
  Dim a1, a2, a3 As Double
  Dim a11, a22, a33 As Double
  Dim QQ, RR, SS, TT, DD As Double
  Dim QQQ, RRR, SSS, TTT, DDD, tetha1, tetha2 As Double

'Mixing Rules for Peng-Robinson EoS
  aTLf = 0   'aTL final
  aTVf = 0 'aTV final
  aTL = 0    'aTL temporal
```

```
aTV = 0    'aTV temporal

For i = 1 To Nc
  For j = 1 To Nc

      aTL = x(i) * x(j) * (aT(i) * aT(j)) ^ 0.5 * (1 - delta(i, j)) 'aT Liquid phase
      aTLf = aTLf + aTL
      aTV = y(i) * y(j) * (aT(i) * aT(j)) ^ 0.5 * (1 - delta(i, j)) 'aT Vapor phase
      aTVf = aTVf + aTV

  Next j

Next i
bL = 0     'bL temporal
bV = 0     'bV temporal
bLf = 0    'bL final
bVf = 0    'bV final

For i = 1 To Nc
  bL = x(i) * b(i)
  bLf = bLf + bL  'b Liquid phase
  bV = y(i) * b(i)
  bVf = bVf + bV  'b Vapor phase
Next i

'Cubic Equation Solution: z^3-(1-B)z^2+(A-3*B^2-2*B)z-(AB-B^2-B^3)=0
'x^3+a1*x^2+a2*x+a3 = 0
'a1=(B-1)
'a2=(A-3*B^2-2*B)
'a3=-(A*B-B^2-B^3)
'A=aT*P/(R^2*T^2)
```

```
'B=b*P/R*T
'Q=(3*a2-a1^2)/9
'R=(9*a1*a2-27*a3-2*a1^3)/54
'S=(R+(Q^3+RT^2)^0.5)^(1/3)
'T=(R-(Q^3+R^2)^0.5))^(1/3)
'x1=S+T-(1/3)*a1
'x2=-0.5*(S+T)-(1/3)*a1+0.5*i*(3^0.5)*(S-T)
'x3=-0.5*(S+T)-(1/3)*a1-0.5*i*(3^0.5)*(S-T)
'If a1,a2,a3 are real and if D=Q^3+R^2 is the discriminant then
' 1. One root real and 2 complex conjugate if D>0
' 2. All roots real and at least 2 are equal if D=0
' 3. All roots are real and unequal if D<0
' If D<0 the:
'    x1=2*(-Q)^0.5*cos((1/3)*theta)-(1/3)*a1
'    x2=2*(-Q)^0.5*cos((1/3)*theta + 120º)-(1/3)*a1
'    x3=2*(-Q)^0.5*cos((1/3)*theta + 240º)-(1/3)*a1
' where  cos theta = R/(-Q^3)^0.5
' x1+x2+x3 = -a1
' x1*x2 + x2*x3 + x3*x1 = a2
' x1*x2*x3 = -a3
' where x1,x2,x3 are the roots
'Then applying to this case we have then

'Cubic EOS Solution for Volume of Liquid Phase
 AA = aTLf * Psys / (R * T) ^ 2
 BB = bLf * Psys / (R * T)
 a1 = BB - 1   'a1=(B-1)
 a2 = AA - 3 * BB ^ 2 - 2 * BB 'a2=(A-3*B^2-2*B)
 a3 = -(AA * BB - BB ^ 2 - BB ^ 3) 'a3=-(A*B-B^2-B^3)
 QQ = (3 * a2 - a1 ^ 2) / 9   'Q=(3*a2-a1^2)/9
 RR = (9 * a1 * a2 - 27 * a3 - 2 * a1 ^ 3) / 54    'R=(9*a1*a2-27*a3-2*a1^3)/54
```

```
'Discriminant D=Q^3+R^2

DD = QQ ^ 3 + RR ^ 2

If DD > 0 Then 'One real and two complex and means single phase

   If (RR + DD ^ 0.5) < 0 Then
       VL(1) = -(Abs(RR + DD ^ 0.5)) ^ (1 / 3) - (Abs(RR - DD ^ 0.5)) ^ (1 / 3) - a1 / 3
       Else
           VL(1) = (RR + DD ^ 0.5) ^ (1 / 3) - (Abs(RR - DD ^ 0.5)) ^ (1 / 3) - a1 / 3

   'SS = (RR + DD ^ 0.5) ^ (1 / 3)    'S=(R+(Q^3+RT^2)^0.5)^(1/3)
   'TT = (RR - DD ^ 0.5) ^ (1 / 3)    'T=(R-(Q^3+R^2)^0.5))^(1/3)
   'VL(1) = SS + TT - (1 / 3) * a1
   'If (R + Sqr(D)) < 0 Then
       'VL(1) = -(Abs(R + Sqr(D)) ^ (1 / 3)) - (Abs(R - Sqr(D))) ^ (1 / 3) - a1 / 3
   'Else
       'VL(1) = (R + Sqr(D)) ^ (1 / 3) - (Abs(R - Sqr(D))) ^ (1 / 3) - a1 / 3

   End If

  Else

  If DD = 0 Then 'All roots real and at least two are equal and lowest root is z-factor
liquid
                'and highest root is z-factor gas


       VL(1) = 2 * (RR) ^ (1 / 3) - a1 / 3 'This root is positive
```

```
    'VL(2) = -(RR) ^ (1 / 3) - a1 / 3
    'VL(3) = VL(2)



  Else 'All roots are real and unequal and lowest root is z-factor liquid
    'and highest root is z-factor gas

     tetha1 = Application.Acos(RR / ((-QQ) ^ (3 / 2)) * 2 * 3.141592 / 360)

     For i = 1 To 3
         VL(i) = 2 * Sqr(-QQ) * Cos((tetha1 / 3) + (i - 1) * 120) - (a1 / 3)
     Next i
  End If

 End If

'Cubic EOS solution for Volume of vapor phase
 AAA = aTVf * Psys / (R * T) ^ 2
 BBB = bVf * Psys / (R * T)
 a11 = BBB - 1   'a1=(B-1)
 a22 = AAA - 3 * BBB ^ 2 - 2 * BBB 'a2=(A-3*B^2-2*B)
 a33 = -(AAA * BBB - BBB ^ 2 - BBB ^ 3) 'a3=-(A*B-B^2-B^3)
 QQQ = (3 * a22 - a11 ^ 2) / 9
 RRR = (9 * a11 * a22 - 27 * a33 - 2 * a11 ^ 3) / 54


 'Discriminant D

 DDD = QQQ ^ 3 + RRR ^ 2
```

```
 If DDD > 0 Then   'One real and two complex and means single phase

   If (RRR + DDD ^ 0.5) < 0 Then

       VV(1) = -(Abs(RRR + DDD ^ 0.5)) ^ (1 / 3) - (Abs(RRR - DDD ^ 0.5)) ^ (1 / 3) -
a11 / 3
       Else
           VV(1) = (RRR + DDD ^ 0.5) ^ (1 / 3) + (Abs(RRR - DDD ^ 0.5)) ^ (1 / 3) - a11 /
3

   'SSS = (RRR + DDD ^ 0.5) ^ (1 / 3)
   'TTT = (RRR - DDD ^ 0.5) ^ (1 / 3)
   'VV(1) = SSS + TTT - (1 / 3) * a11
   'If (R + Sqr(D)) < 0 Then
     'VL(1) = -(Abs(RRR + Sqr(DDD)) ^ (1 / 3)) - (Abs(RRR - Sqr(DDD))) ^ (1 / 3) - a11
/ 3
   'Else
       'VV(1) = (RRR + Sqr(DDD)) ^ (1 / 3) + (Abs(RRR - Sqr(DDD))) ^ (1 / 3) - a11 / 3
   End If

 Else

   If DDD = 0 Then  'All roots real and at least two are equal and highest root is z-factor
gas

       VV(1) = 2 * (RRR) ^ (1 / 3) - a11 / 3
       'VV(2) = -(RRR) ^ (1 / 3) - a11 / 3
       'VV(3) = VV(2)

 Else  'All roots are real and unequal and highest root is z-factor gas
```

```
    'and lowest root is z-factor liquid

   tetha2 = Application.Acos(RRR / ((-QQQ) ^ (3 / 2)) * 2 * 3.141592 / 360)
   For i = 1 To 3
      VV(i) = 2 * Sqr(-QQQ) * Cos((tetha2 / 3) + (i - 1) * 120) - (a11 / 3)
   Next i
  End If
 End If
End Sub

Sub FugacityCoefCalculation()

Dim i, j As Integer
Dim CAL, CBL, CAV, CBV As Double
Dim CbiL(ck) As Double
Dim alpbL(ck, ck) As Double
Dim CbiV(ck) As Double
Dim alpbV(ck, ck), U(ck) As Double
Dim GL, GV, H(ck), L(ck) As Double
Dim MmL, MmV, p As Double
Dim sumauxL, sumauxV As Double
Dim AprimaL(ck), BprimaL(ck) As Double


'Compressibility factors Calculation

ZL = VL(1)   'ZL
ZV = VV(1)   'ZV

'Fugacity Coefficients Calculation for each component in Liquid Phase
```

```
CAL = aTLf * Psys / (R * T) ^ 2  'A for liquid
CBL = bLf * Psys / (R * T)       'B for liquid
MmL = Log((ZL + (2 ^ 0.5 + 1) * CBL) / (ZL - (2 ^ 0.5 - 1) * CBL)) '
ln((z+(2^0.5+1)B)/(z-(2^0.5-1)B)
GL = CAL / ((2 ^ 1.5) * CBL) 'A/(2^1.5*B)
sumauxL = 0

For j = 1 To Nc

    BprimaL(j) = b(j) / bLf '  B'j=bj/b

    U(j) = -Log(ZL - CBL) + (ZL - 1) * BprimaL(j) '-ln(z-B)+(z-1)B'j

   For i = 1 To Nc

       sumauxL = x(i) * (aT(i)) ^ 0.5 * (1 - delta(i, j)) + sumauxL   'Sigma
xi*aTi^0.5*(1-delta(i,j))

   Next i

    AprimaL(j) = (2 / aTLf) * (aT(j) ^ 0.5) * sumauxL  'A'j=(1/aTL)*2*aTj^0.5*Sigma
xi*aTi^0.5*(1-delta(i,j))

    H(j) = AprimaL(j) - BprimaL(j)  'H(j)=A'j - B'j

    CoefFugL(j) = Exp(U(j) - GL * H(j) * MmL) 'PHI(j) of liquid

    sumauxL = 0

Next j
```

```
'Fugacity Coefficients Calculation for each component in Vapor Phase

   CAV = aTVf * Psys / (R * T) ^ 2  'A for vapor
   CBV = bVf * Psys / (R * T)  'B for vapor
   MmV = Log((ZV + (Sqr(2) + 1) * CBV) / (ZV - (Sqr(2) - 1) * CBV))  ' ln((z+(2^0.5+1)B)/(z-(2^0.5-1)B)
   GV = CAV / (2 ^ 1.5 * CBV)  'A/(2^1.5*B)
   sumauxV = 0

   For j = 1 To Nc
       BprimaV(j) = b(j) / bVf  'B'j=bj/b
       U(j) = -Log(ZV - CBV) + (ZV - 1) * BprimaV(j)  '-ln(z-B)+(z-1)B'j

       For i = 1 To Nc
           sumauxV = y(i) * (aT(i)) ^ 0.5 * (1 - delta(i, j)) + sumauxV  'Sigma yi*aTi^0.5*(1-delta(i,j))

       Next i
       AprimaV(j) = (2 / aTVf) * (aT(j) ^ 0.5) * sumauxV  'A'j=(1/aTV)*2*aTj^0.5*Sigma xi*aTi^0.5*(1-delta(i,j))

       H(j) = AprimaV(j) - BprimaV(j)  'H(j)=A'j - B'j

       CoefFugV(j) = Exp(U(j) - GV * (H(j) * MmV))  'PHI(j) of vapor

       sumauxV = 0

   Next j

   'New Values for K's based on fugacity calculation
```

```
  For i = 1 To Nc
   FugL(i) = x(i) * Psys * CoefFugL(i)  'fLj
   FugV(i) = y(i) * Psys * CoefFugV(i)  'fVj
   Kf(i) = CoefFugL(i) / CoefFugV(i)
  Next i

End Sub

Sub EquilibriumCondition()

Dim i As Integer
epsilontol = 0.0000000001

epsilonaux = 0

For i = 1 To Nc
      epsilon(i) = (K(i) - Kf(i)) ^ 2 / (K(i) * Kf(i))
      epsilonaux = epsilonaux + epsilon(i)
Next i

Do While epsilonaux > epsilontol
   epsilonaux = 0

   For i = 1 To Nc
      K(i) = Kf(i)
   Next i

   Call Flash
   Call EoSsolution
   Call FugacityCoefCalculation
```

```
    For i = 1 To Nc
        epsilon(i) = (K(i) - Kf(i)) ^ 2 / (K(i) * Kf(i))
        epsilonaux = epsilonaux + epsilon(i)
    Next i

 Loop

    For i = 1 To Nc
        K(i) = Kf(i)
    Next i

End Sub

Sub InitialDataFugCoefSat()

    Dim i As Integer

' Calculus of properties for pure components using Peng-Robinson EoS

    For i = 1 To Nc
        Psat(i) = Exp(Asat(i) - (Bsat(i) / (Tcel + Csat(i))))  'Psat del i component as pure at
psi
        Bsat(i) = 0.0778 * R * Tc(i) / Pc(i)  'b(j)
        acsat(i) = 0.45724 * R ^ 2 * Tc(i) ^ 2 / Pc(i)  'ac(j)
        Trsat(i) = T / Tc(i)
        Prsat(i) = Psat(i) / Pc(i)
        msat(i) = 0.379642 + 1.48503 * w(i) - 0.1644 * w(i) ^ 2 + 0.016667 * w(i) ^ 3
        'm(i) = 0.37464 + 1.54226 * w(i) - 0.26992 * w(i) ^ 2
        alphasat(i) = (1 + m(i) * (1 - Tr(i) ^ 0.5)) ^ 2  'alpha(j)
        aTsat(i) = ac(i) * alpha(i)  'aT(j)
```

```
    Next i

End Sub

Sub EoSsolutionFugCoefSat()

    Dim i As Integer
    Dim tetha1sat(ck) As Double
'Cubic EOS Solution for Volume of Liquid Phase

 For i = 1 To Nc
    AAsat(i) = aTsat(i) * Psat(i) / (R * T) ^ 2
    BBsat(i) = Bsat(i) * Psat(i) / (R * T)
    a1sat(i) = BBsat(i) - 1   'a1=(B-1)
    a2sat(i) = AAsat(i) - 3 * BBsat(i) ^ 2 - 2 * BBsat(i) 'a2=(A-3*B^2-2*B)
    a3sat(i) = -(AAsat(i) * BBsat(i) - BBsat(i) ^ 2 - BBsat(i) ^ 3) 'a3=-(A*B-B^2-B^3)
    QQsat(i) = (3 * a2sat(i) - a1sat(i) ^ 2) / 9   'Q=(3*a2-a1^2)/9
    RRsat(i) = (9 * a1sat(i) * a2sat(i) - 27 * a3sat(i) - 2 * a1sat(i) ^ 3) / 54    'R=(9*a1*a2-
27*a3-2*a1^3)/54


 'Discriminant D=Q^3+R^2

 DDsat(i) = QQsat(i) ^ 3 + RRsat(i) ^ 2

 If DDsat(i) > 0 Then 'One real and two complex and means single phase

    If (RRsat(i) + DDsat(i) ^ 0.5) < 0 Then
        ZLsat(i) = -(Abs(RRsat(i) + DDsat(i) ^ 0.5)) ^ (1 / 3) - (Abs(RRsat(i) - DDsat(i) ^
0.5)) ^ (1 / 3) - a1sat(i) / 3
```

```
    Else
        ZLsat(i) = (RRsat(i) + DDsat(i) ^ 0.5) ^ (1 / 3) - (Abs(RRsat(i) - DDsat(i) ^ 0.5)) ^
(1 / 3) - a1sat(i) / 3

    'SS = (RR + DD ^ 0.5) ^ (1 / 3)    'S=(R+(Q^3+RT^2)^0.5)^(1/3)
    'TT = (RR - DD ^ 0.5) ^ (1 / 3)    'T=(R-(Q^3+R^2)^0.5))^(1/3)
    'VL(1) = SS + TT - (1 / 3) * a1
    'If (R + Sqr(D)) < 0 Then
       'VL(1) = -(Abs(R + Sqr(D)) ^ (1 / 3)) - (Abs(R - Sqr(D))) ^ (1 / 3) - a1 / 3
    'Else
       'VL(1) = (R + Sqr(D)) ^ (1 / 3) - (Abs(R - Sqr(D))) ^ (1 / 3) - a1 / 3

    End If

   Else

  If DDsat(i) = 0 Then 'All roots real and at least two are equal and lowest root is z-factor
liquid
             'and highest root is z-factor gas


       ZLsat(i) = 2 * (RRsat(i)) ^ (1 / 3) - a1sat(i) / 3 'This root is positive
       'VL(2) = -(RR) ^ (1 / 3) - a1 / 3
       'VL(3) = VL(2)



   Else 'All roots are real and unequal and lowest root is z-factor liquid
       'and highest root is z-factor gas
```

```
         tetha1sat(i) = Application.Acos(RRsat(i) / ((-QQsat(i)) ^ (3 / 2)) * 2 * 3.141592 /
360)
        ZLsat(i) = 2 * Sqr(-QQsat(i)) * Cos((tetha1sat(i) / 3)) - (a1sat(i) / 3)

   End If

   End If
  Next i

End Sub

Sub FugacityCoefCalculSat()

Dim i As Integer
Dim numsat(ck), densat(ck) As Double


'Fugacity Coefficients Calculation for each component in Liquid Phase

   CAL = aTLf * Psys / (R * T) ^ 2  'A for liquid
   CBL = bLf * Psys / (R * T)       'B for liquid
   MmL = Log((ZL + (2 ^ 0.5 + 1) * CBL) / (ZL - (2 ^ 0.5 - 1) * CBL)) '
ln((z+(2^0.5+1)B)/(z-(2^0.5-1)B)
   GL = CAL / ((2 ^ 1.5) * CBL) 'A/(2^1.5*B)
   sumauxL = 0

   For i = 1 To Nc

        numsat(i) = ZLsat(i) + (2 ^ 0.5 + 1) * BBsat(i)
        densat(i) = ZLsat(i) - (2 ^ 0.5 - 1) * BBsat(i)
```

```
        CoefFugsat(i) = ZLsat(i) - 1 - Log(ZLsat(i) - BBsat(i)) - (AAsat(i) / (2 ^ 1.5 *
BBsat(i)) * (densat(i) / numsat(i)))
        CoefFugsat(i) = Exp(CoefFugsat(i))
        FugSatLiq(i) = CoefFugsat(i) * Psat(i)
   Next i

End Sub

Sub ActivityGibbsEnergy()

Dim i As Integer

Gexcess = 0

 For i = 1 To Nc
    DensityLiSat(i) = Psat(i) * Mw(i) / (ZLsat(i) * R * T)
    SpecificVLiSat(i) = 1 / DensityLiSat(i)
    PoyntingFact(i) = Exp(-(SpecificVLiSat(i) * (Psys - Psat(i)) / (R * T)))
    'PHI(i) = (CoefFugL(i) / CoefFugsat(i)) * PoyntingFact(i)
    If Z(i) = 0 Then

        SpecificVLi(i) = 0
        SpecificVVi(i) = 0
        DensityLi(i) = 0
        DensityVi(i) = 0
        'Kf(i) = 0
        'CoefFugV(i) = 0
        'CoefFugL(i) = 0

       Else
```

```
      Gamma(i) = y(i) * CoefFugV(i) * Psys / (x(i) * CoefFugsat(i) * Psat(i) *
PoyntingFact(i))
      'Gamma(i) = Gamma(i) / (x(i) * Psat(i))
         Gexcess = (x(i) * Log(Gamma(i)) + Gexcess) * 144 * 1.36 / (1000 * Mw(i))
'kJoules/gmol
      End If
 Next i
      Gexcess = Gexcess * R * T
End Sub

Sub Output()

  Dim i, j As Integer
  Dim DensityL, DensityV, PML, PMV As Double
  Dim DensityLi(ck), DensityVi(ck) As Double
  Dim SpecificVL, SpecificVV As Double
  Dim SpecificVLi(ck), SpecificVVi(ck) As Double
  Dim SurfaceTen As Double
  Dim VML, VMV As Double

    PML = 0
    PMV = 0
    VML = ZL * R * T / Psys
    VMV = ZV * R * T / Psys
    SurfaceTen = 0




    For i = 1 To Nc

      If Z(i) = 0 Then
```

```
SpecificVLi(i) = 0
SpecificVVi(i) = 0
DensityLi(i) = 0
DensityVi(i) = 0
'Kf(i) = 0
'CoefFugV(i) = 0
'CoefFugL(i) = 0

Else

PML = PML + Mw(i) * x(i)
PMV = PMV + Mw(i) * y(i)
DensityLi(i) = x(i) * Psys * Mw(i) / (ZL * R * T)
DensityVi(i) = y(i) * Psys * Mw(i) / (ZV * R * T)
SpecificVLi(i) = 1 / DensityLi(i)
SpecificVVi(i) = 1 / DensityVi(i)

End If

Next i

DensityL = Psys * PML / (ZL * R * T)
DensityV = Psys * PMV / (ZV * R * T)
SpecificVL = 1 / DensityL
SpecificVV = 1 / DensityV

For i = 1 To Nc
    SurfaceTen = (SurfaceTen + Parachor(i) * (454 / 30.48 ^ 3) * (x(i) * (DensityL / PML) - y(i) * (DensityV / PMV))) ^ 4
Next i
```

```
'Write results into Input data sheet of workbook
 With Worksheets("Inputdata")
   For i = 1 To Nc
      .Cells(43, i + 2).Value = x(i)
      .Cells(44, i + 2).Value = y(i)
      .Cells(45, i + 2).Value = FugL(i)        'Liquid Fugacity
      .Cells(46, i + 2).Value = FugV(i)        'Vapor Fugacity
      .Cells(68 + i, Ncut + 2).Value = FugL(i)  'Liquid Fugacity
      .Cells(47, i + 2).Value = CoefFugL(i)     'Liquid Fugacity coefficients
      .Cells(48, i + 2).Value = CoefFugV(i)     'Vapor Fugacity coefficients
      .Cells(81 + i, Ncut + 2).Value = FugV(i)  'Vapor Fugacity
      .Cells(49, i + 2).Value = Kf(i)          'Final K's values
      .Cells(93 + i, Ncut + 2).Value = Kf(i)    'Final K's values
      .Cells(145 + i, Ncut + 2).Value = CoefFugL(i) 'Liquid Fugacity coefficients
      .Cells(158 + i, Ncut + 2).Value = CoefFugV(i) 'Vapor Fugacity coefficients
      .Cells(119 + i, Ncut + 2).Value = x(i)    'Final x(i) values
      .Cells(132 + i, Ncut + 2).Value = y(i)    'Final y(i) values
      .Cells(50, i + 2).Value = DensityLi(i)    'Liquid Density of i
      .Cells(51, i + 2).Value = DensityVi(i)    'Vapor Density of i
      .Cells(52, i + 2).Value = SpecificVLi(i)  'Specific Volume Liquid of i
      .Cells(53, i + 2).Value = SpecificVVi(i)  'Specific Volume Vapor of i
      .Cells(63, i + 2).Value = Z(i)           'Initial composition
      .Cells(178 + i, Ncut + 2).Value = Z(i)    'Initial composition
      .Cells(192 + i, Ncut + 2).Value = Gamma(i)     'Initial composition

   Next i

      .Cells(54, 3).Value = ZL                'Z Liquid
      .Cells(55, 3).Value = ZV                'Z Vapor
      .Cells(56, 3).Value = VML                 'Molar Volume of Liquid
```

```
.Cells(57, 3).Value = VMV              'Molar Volume of Vapor
.Cells(58, 3).Value = DensityL         'Liquid Density of mixture
.Cells(59, 3).Value = DensityV         'Vapor Density of mixture
.Cells(60, 3).Value = SpecificVL       'Specific Volume Liquid
.Cells(61, 3).Value = SpecificVV       'Specific Volume Vapor
.Cells(62, 3).Value = SurfaceTen       'Surface Tension of mixture
.Cells(172, 2 + Ncut).Value = SurfaceTen  'Surface Tension of mixture
.Cells(207, 2 + Ncut).Value = Gexcess     'Excess Gibss Energy
.Cells(68, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9   'Temperature of the system
.Cells(67, 2 + Ncut).Value = Psys       'Pressure of the system
.Cells(80, 2 + Ncut).Value = Psys       'Pressure of the system
.Cells(92, 2 + Ncut).Value = Psys       'Pressure of the system
.Cells(105, 2 + Ncut).Value = Psys      'Pressure of the system
.Cells(118, 2 + Ncut).Value = Psys      'Pressure of the system
.Cells(131, 2 + Ncut).Value = Psys      'Pressure of the system
.Cells(144, 2 + Ncut).Value = Psys      'Pressure of the system
.Cells(157, 2 + Ncut).Value = Psys      'Pressure of the system
.Cells(170, 2 + Ncut).Value = Psys      'Pressure of the system
.Cells(177, 2 + Ncut).Value = Psys      'Pressure of the system
.Cells(191, 2 + Ncut).Value = Psys      'Pressure of the system
.Cells(205, 2 + Ncut).Value = Psys      'Pressure of the system


.Cells(81, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9   'Temperature of the system
.Cells(93, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9   'Temperature of the system
.Cells(106, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the system
```

```
        .Cells(119, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the
system
        .Cells(132, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the
system
       .Cells(145, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the
system
        .Cells(158, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the
system
        .Cells(171, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the
system
        .Cells(178, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the
system
        .Cells(192, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the
system
        .Cells(206, 2 + Ncut).Value = ((T - 459.67) - 32) * 5 / 9 'Temperature of the
system

       .Cells(66, 2 + Ncut).Value = Ncut      'Cut number
       .Cells(79, 2 + Ncut).Value = Ncut      'Cut number
       .Cells(91, 2 + Ncut).Value = Ncut      'Cut number
       .Cells(104, 2 + Ncut).Value = Ncut     'Cut number
       .Cells(117, 2 + Ncut).Value = Ncut     'Cut number
       .Cells(130, 2 + Ncut).Value = Ncut     'Cut number
       .Cells(143, 2 + Ncut).Value = Ncut     'Cut number
       .Cells(156, 2 + Ncut).Value = Ncut     'Cut number
       .Cells(169, 2 + Ncut).Value = Ncut     'Cut number
       .Cells(176, 2 + Ncut).Value = Ncut     'Cut number
       .Cells(190, 2 + Ncut).Value = Ncut     'Cut number
       .Cells(204, 2 + Ncut).Value = Ncut     'Cut number
   End With
End Sub
```

APPENDIX D

Chromatograms

This Appendix shows a chromatogram of the original synthetic oil and a set of 15 chromatograms for steam distillation run no. 1 (as an example).

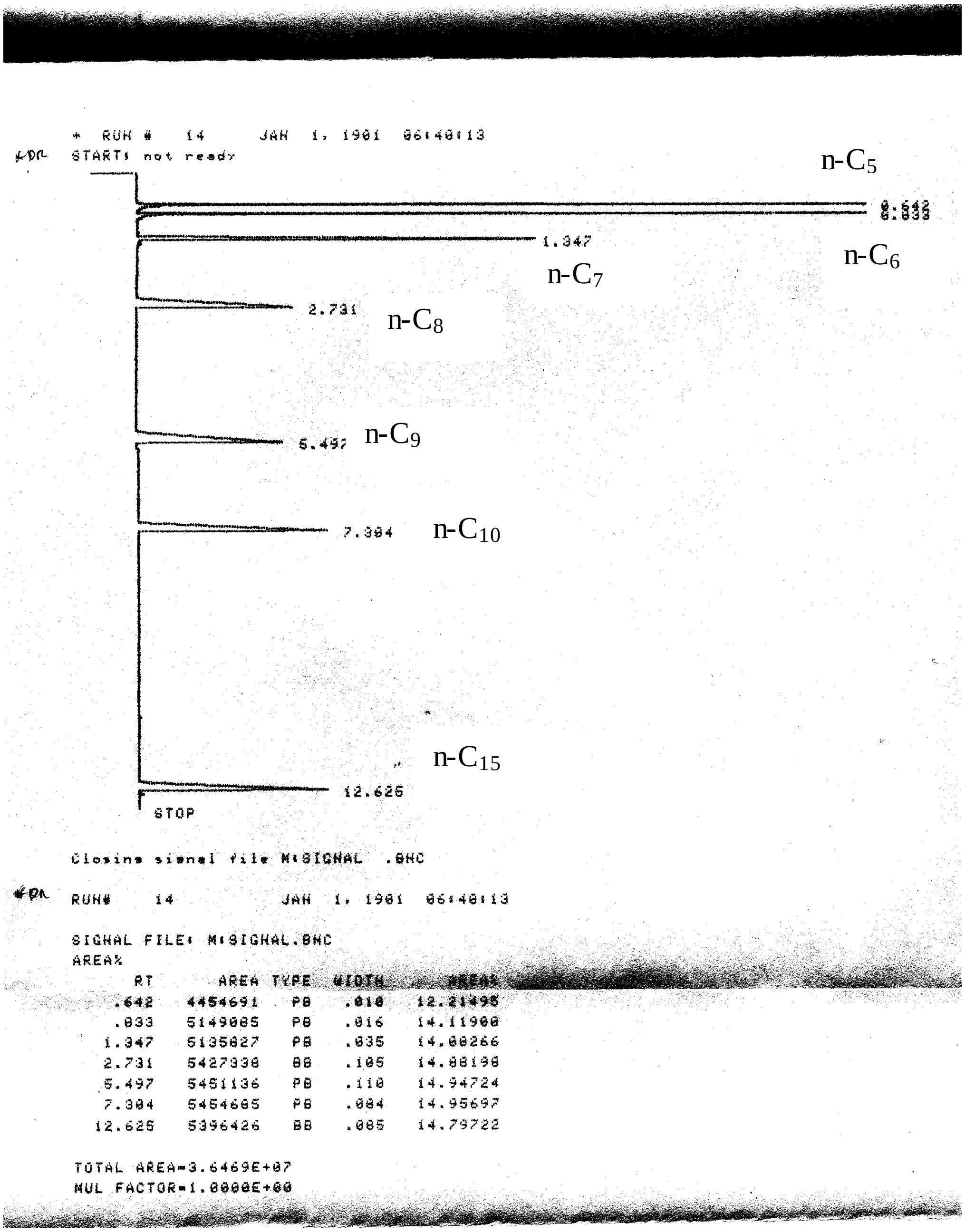
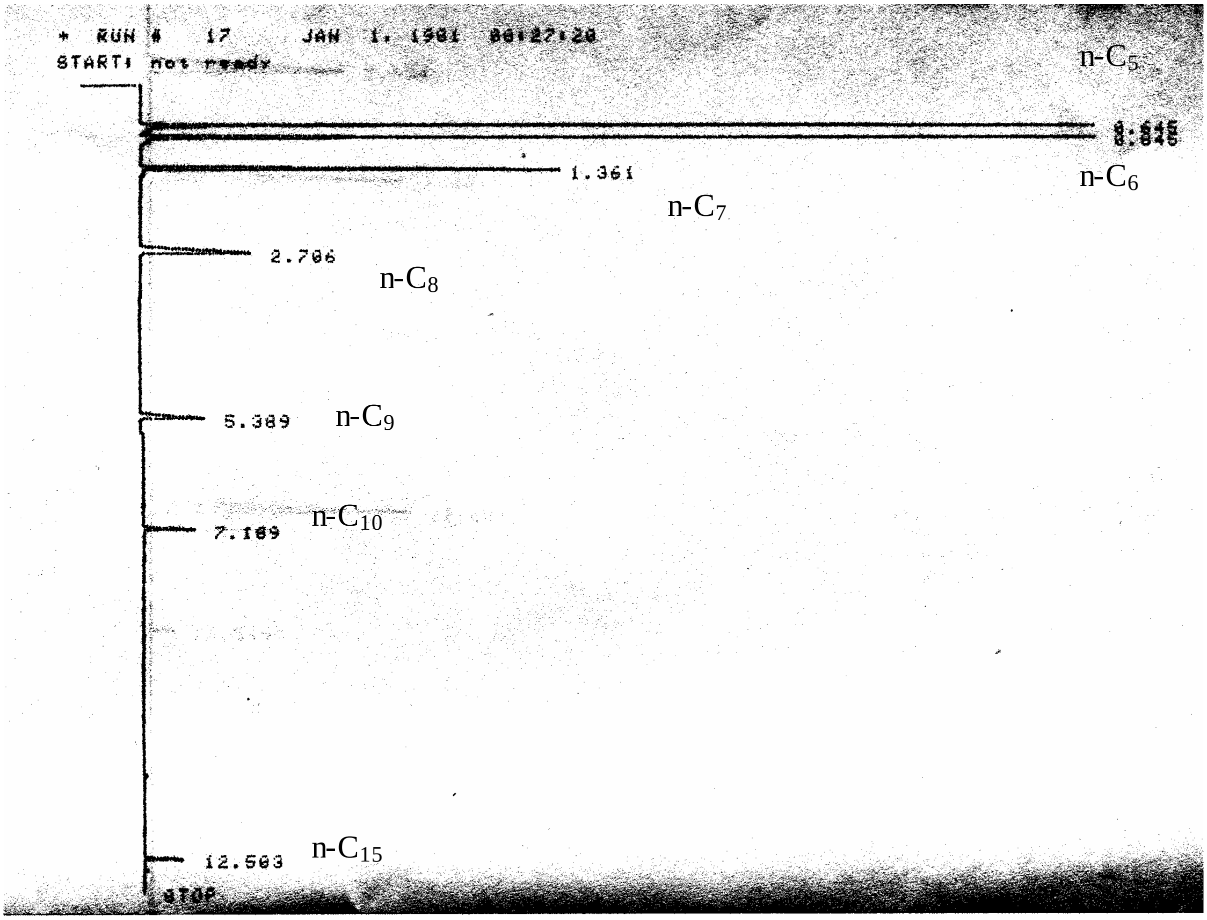


Fig. D-1-Original hydrocarbon chromatogram.



Closing signal file M:SIGNAL .BHC

RUN# 17 JAN 1, 1981 08:27:20

SIGNAL FILE: M:SIGNAL.BHC

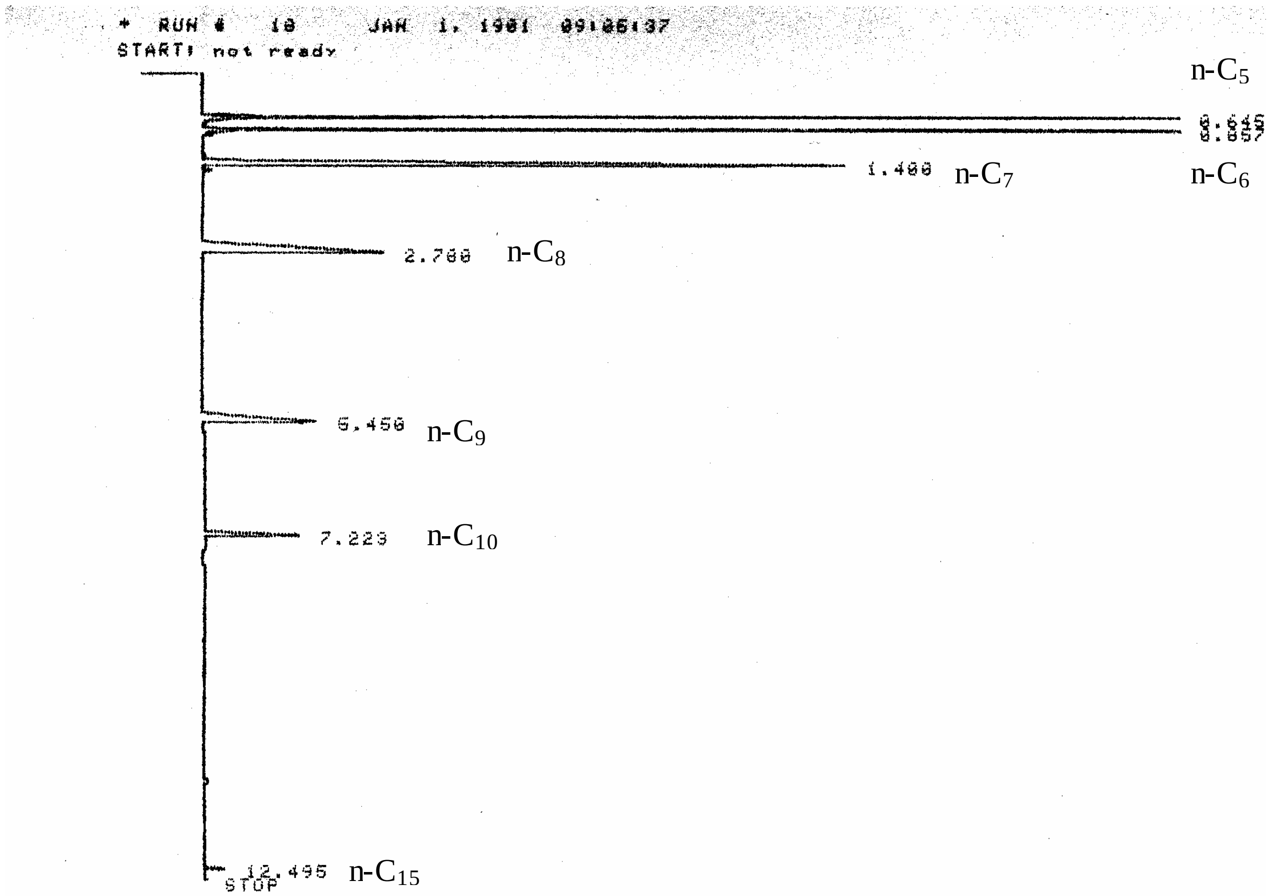
AREA%

RT	AREA	TYPE	WIDTH	AREA%
.645	11591560	SBB	.011	46.60371
.845	6634845	PB	.015	26.67531
1.361	3351254	PB	.030	13.47367
2.706	1745715	BB	.060	7.01862
5.389	844752	PB	.051	3.39632
7.189	411878	PB	.031	1.65595
12.583	292618	BB	.027	1.17647

TOTAL AREA=2.4873E+07

MUL FACTOR=1.0000E+00

Fig. D-2-Steam distillation chromatogram cut no. 1.



Closing signal file M:SIGNAL .BNC

RUN# 10 JAN 1, 1901 09:05:37

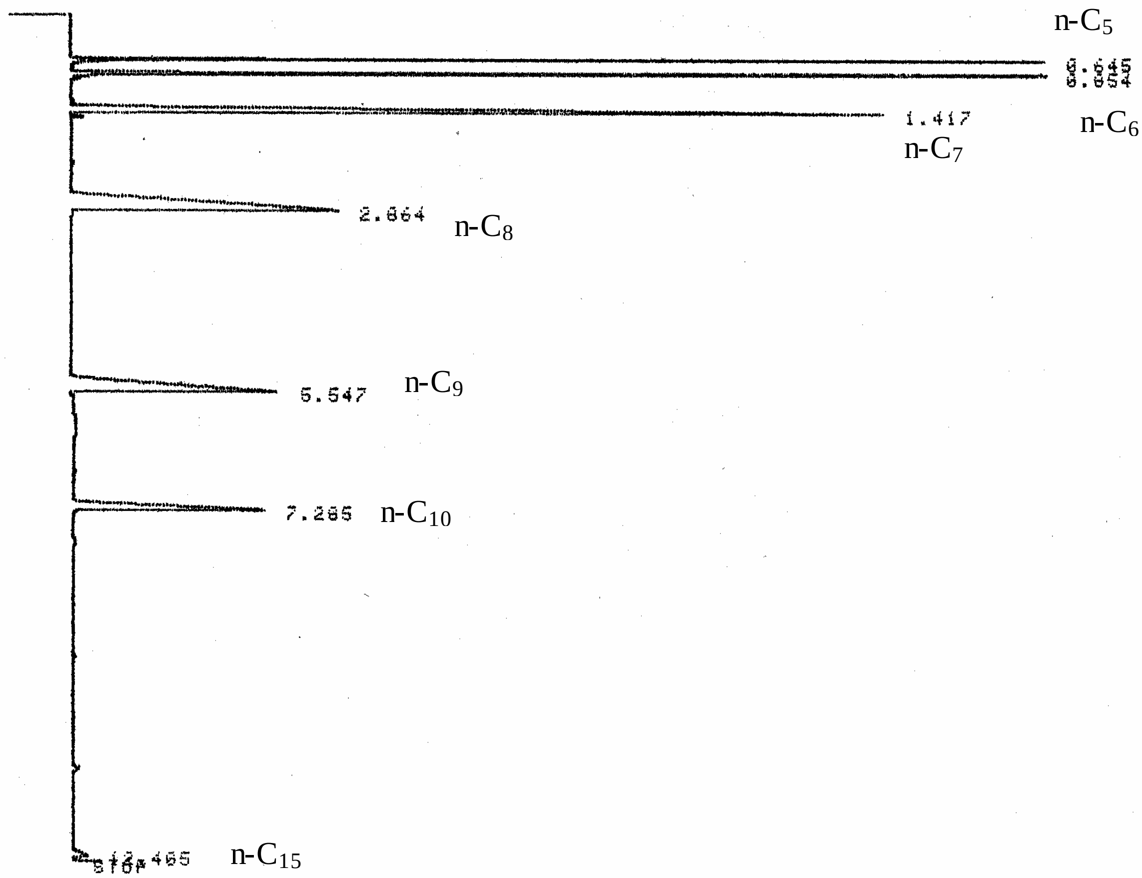
SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
.645	14067168	SBB	.011	34.62957
.857	11844456	PB	.017	29.15706
1.400	7352944	PB	.045	18.10096
2.700	4117274	BB	.090	10.13562
5.450	2083244	PB	.070	5.12838
7.223	1009458	PB	.043	2.48501
12.495	147315	PB	.027	.36265

TOTAL AREA=4.0622E+07
MUL FACTOR=1.0000E+00

Fig. D-3-Steam distillation chromatogram cut no. 2.

* RUN # 20 JAN 1, 1981 09:59:33
START: not ready



Closing signal file M:SIGNAL .BNC

RUN# 20 JAN 1, 1981 09:59:33

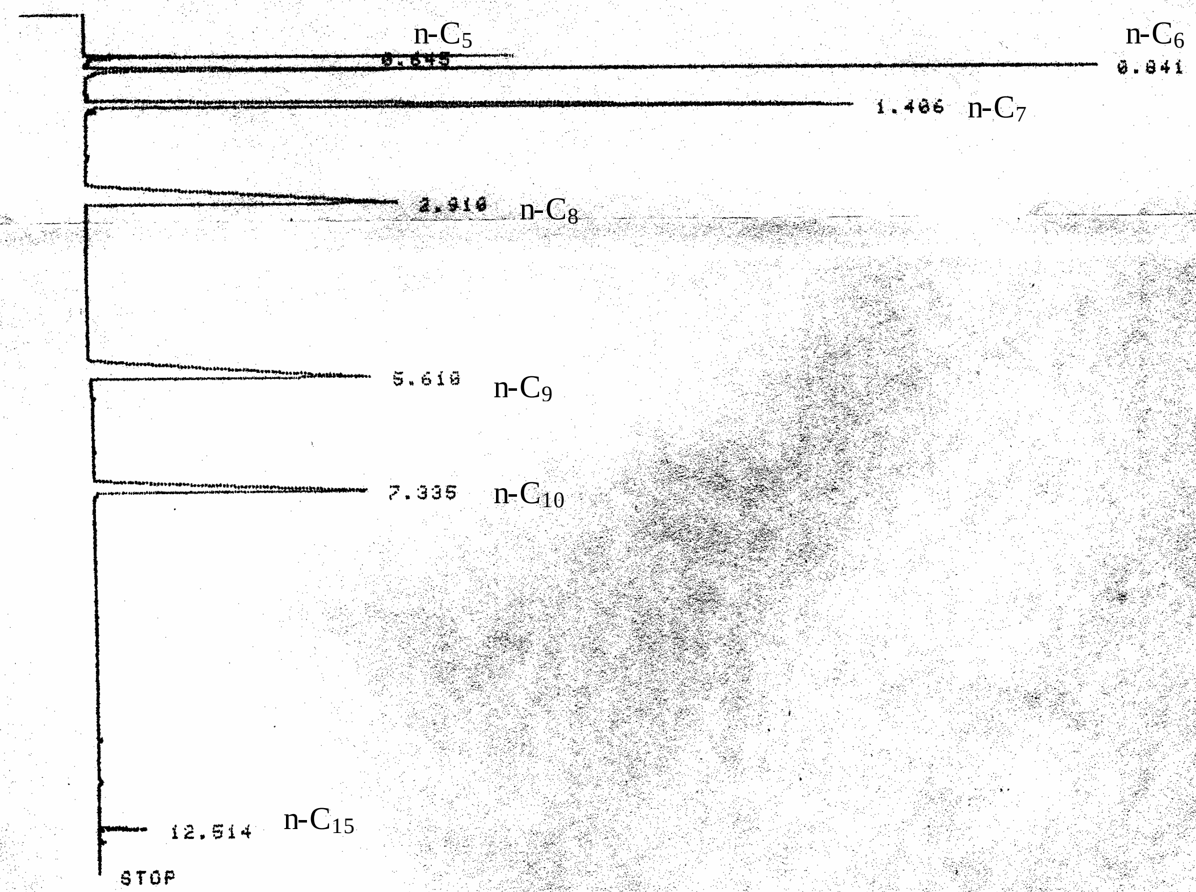
SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
.645	4157456	PB	.010	9.43773
.854	9917440	PB	.016	22.51330
1.417	11365016	PB	.055	25.79941
2.864	9162430	PB	.139	20.79941
5.547	5830749	PB	.109	13.23622
7.285	3300522	PB	.070	7.49243
12.405	317845	PV	.077	.72153

TOTAL AREA=4.4051E+07
MUL FACTOR=1.0000E+00

Fig. D-4-Steam distillation chromatogram cut no. 3.

* RUN # 21 JAN 1, 1901 10:19:55
START: not ready



Closing signal file M:SIGNAL .BNC

RUN# 21 JAN 1, 1901 10:19:55

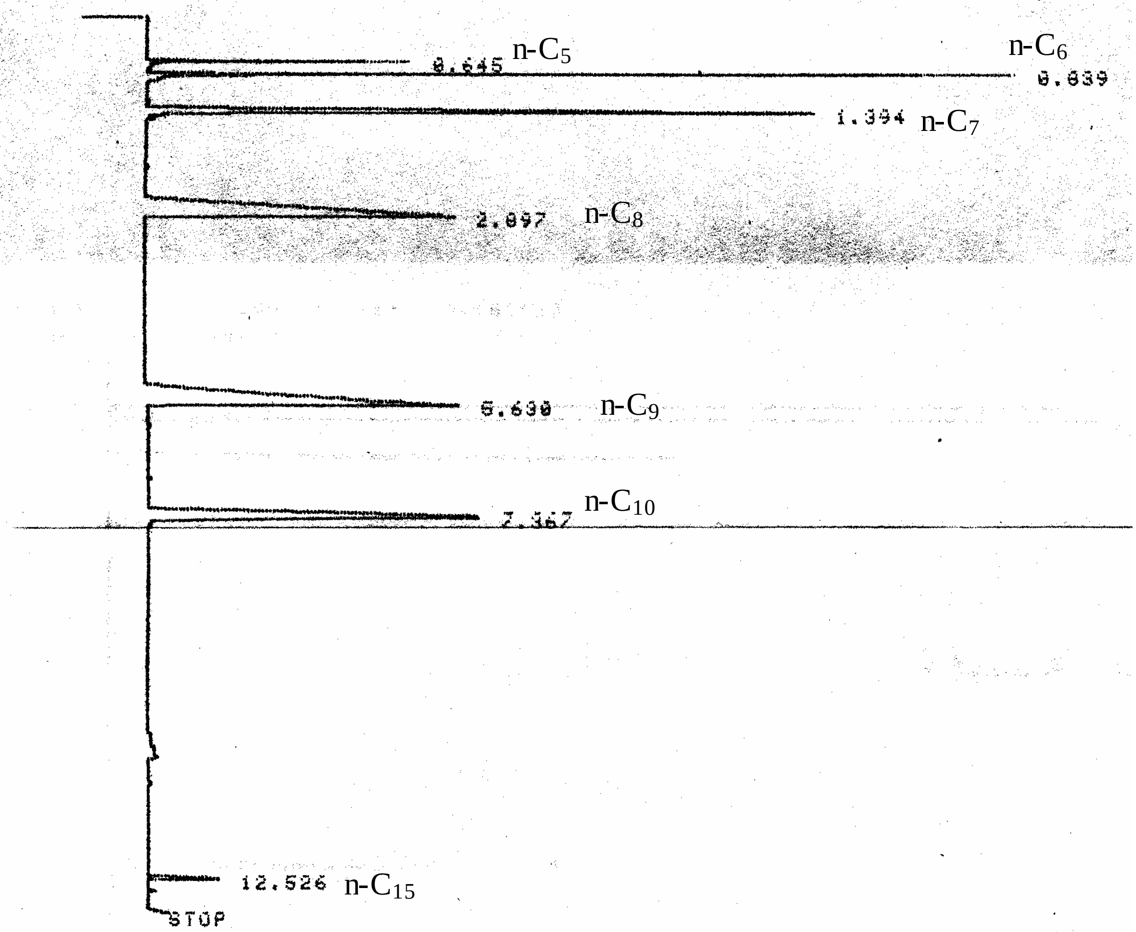
SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
.645	1079477	PB	.010	2.52300
.841	4743795	PB	.015	11.08742
1.406	9653024	PB	.050	22.56150
2.910	11838000	PB	.151	27.66635
5.610	9257650	PB	.130	21.63742
7.335	5877936	PB	.089	13.73818
12.514	335500	BB	.027	.78415

TOTAL AREA=4.2785E+07
MUL FACTOR=1.0000E+00

Fig. D-5-Steam distillation chromatogram cut no. 4.

* RUN # 22 JAN 1, 1901 10:41:50
START: not ready



Closing signal file M:SIGNAL .BNC

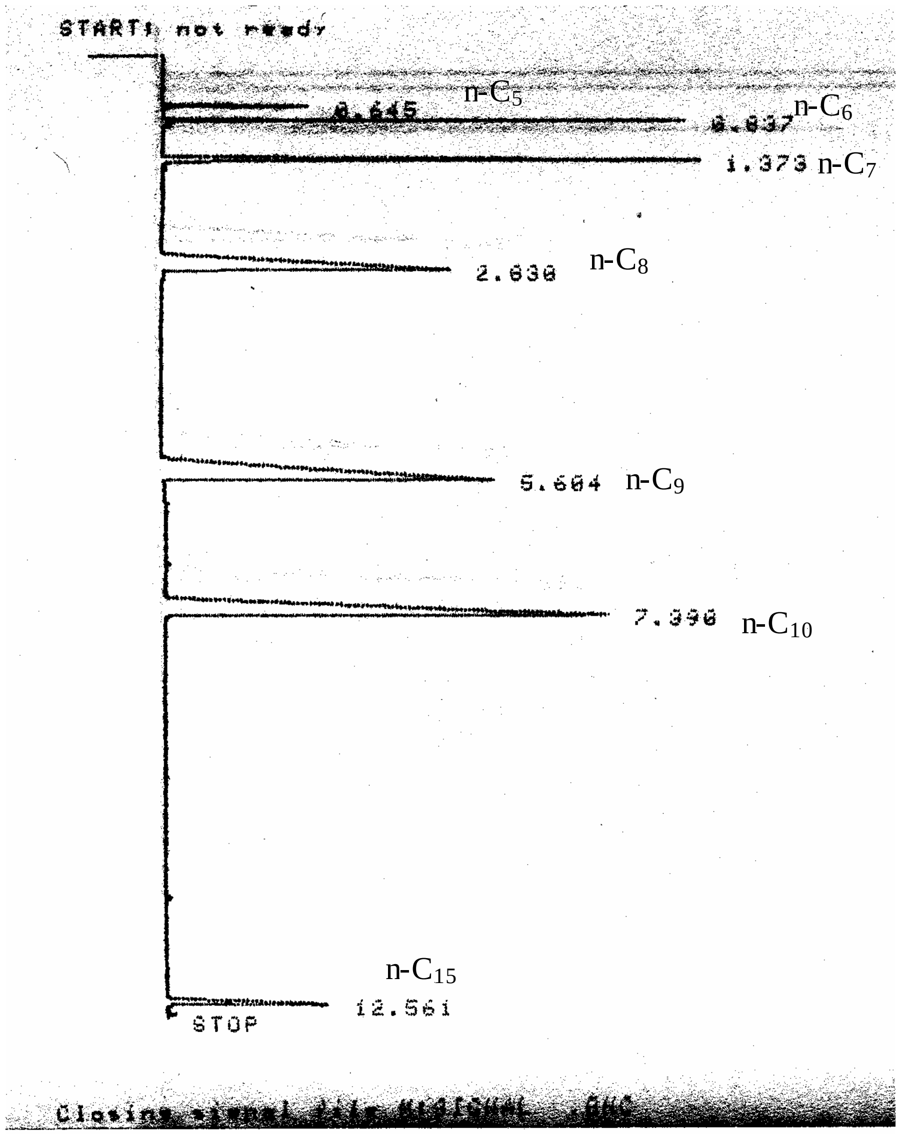
RUN# 22 JAN 1, 1901 10:41:50

SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
.645	666385	PB	.011	1.57784
.839	2919789	PB	.014	6.91334
1.394	7408125	PV	.044	17.54061
2.897	10901792	PB	.139	25.81276
5.630	10896928	PV	.146	25.80124
7.367	8891008	VB	.112	21.05361
12.526	549310	BB	.031	1.30063

TOTAL AREA=4.2234E+07
MUL FACTOR=1.0000E+00

Fig. D-6-Steam distillation chromatogram cut no. 5.



RUN# 24 JAN 1, 1901 11:29:05

SIGNAL FILE: M:SIGNAL.BHC

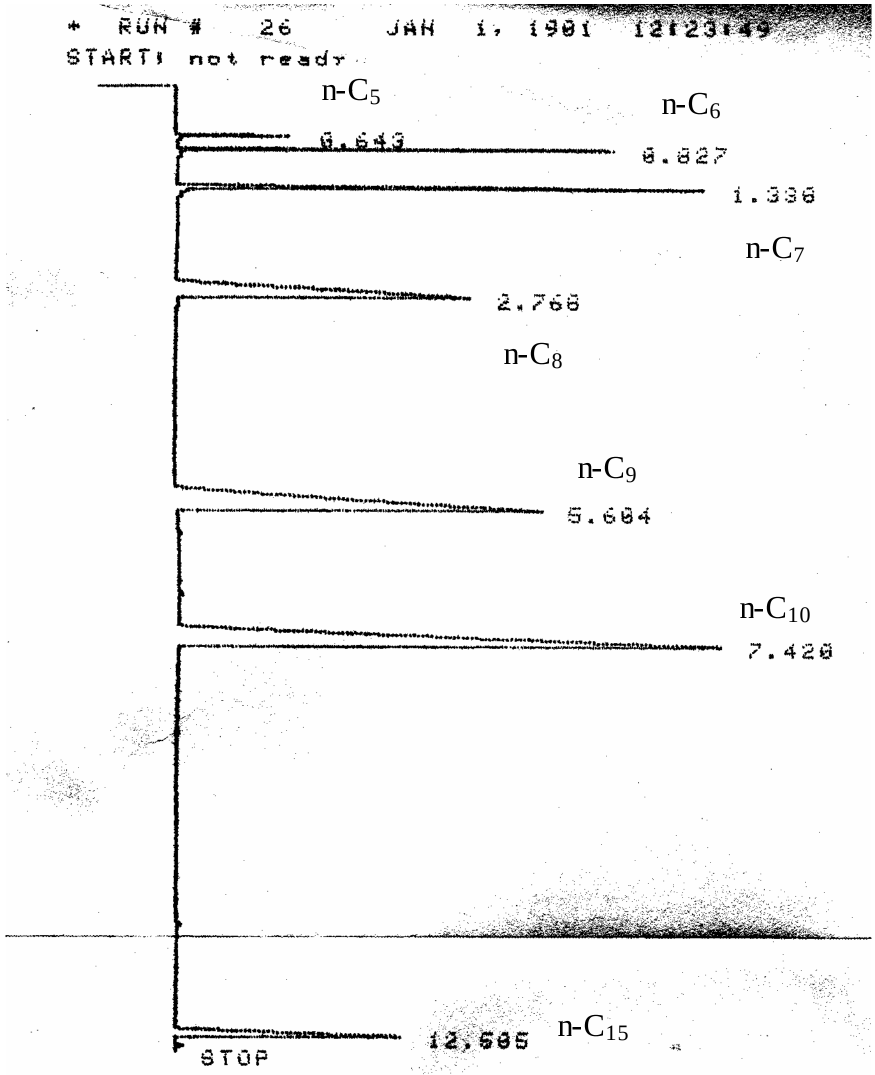
AREA%

RT	AREA	TYPE	WIDTH	AREA%
.645	325362	BB	.011	.95018
.837	1420224	BV	.013	4.14750
1.373	3806234	PB	.031	11.11562
2.030	6982506	BB	.113	20.39174
5.604	9509952	PB	.137	27.77260
7.390	10686864	PB	.114	31.20962
12.561	1510996	PB	.047	4.41267

TOTAL AREA=3.4242E+07

MUL FACTOR=1.0000E+00

Fig. D-7-Steam distillation chromatogram cut no. 6.



Closing signal file M:SIGNAL .BNC

RUN# 26 JAN 1, 1901 12:23:49

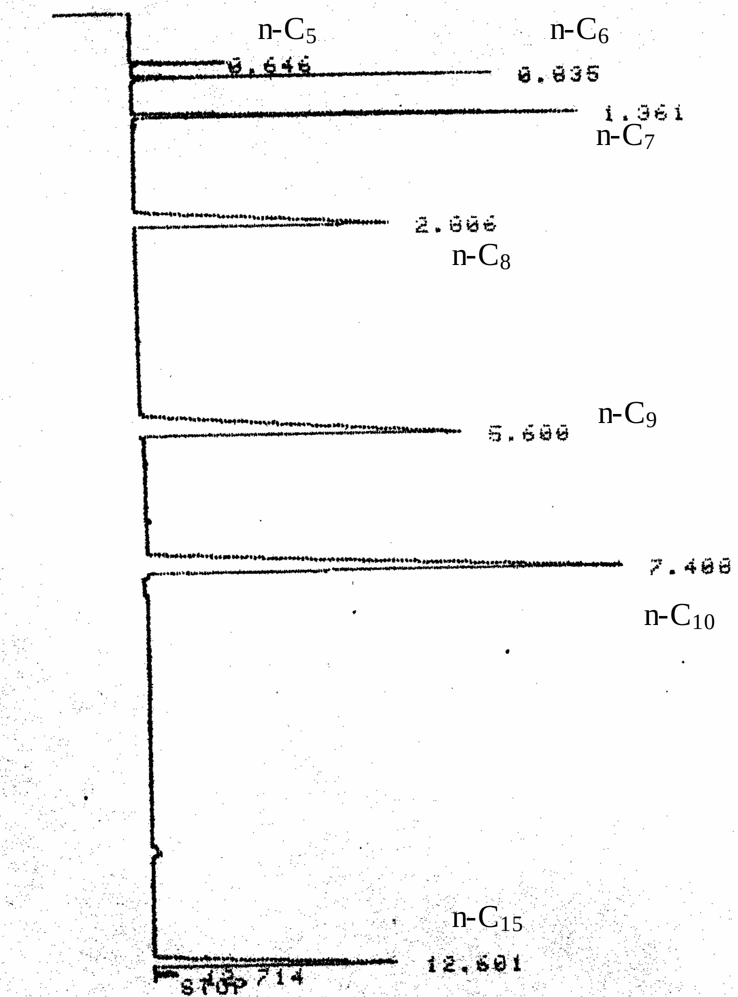
SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
.643	210803	PB	.009	.54081
.827	1023104	PB	.011	2.62395
1.338	2906824	PB	.028	7.45453
2.768	6664627	BB	.111	17.09138
5.604	11095736	PP	.156	28.45493
7.420	14473960	PB	.134	37.11837
12.585	2618869	BB	.059	6.71607

TOTAL AREA=3.8994E+07
MUL FACTOR=1.0000E+00

Fig. D-8-Steam distillation chromatogram cut no. 7.

* RUN # 27 JAN 1, 1981 13:13:32
START: not ready



Closing signal file M:SIGNAL .BNC

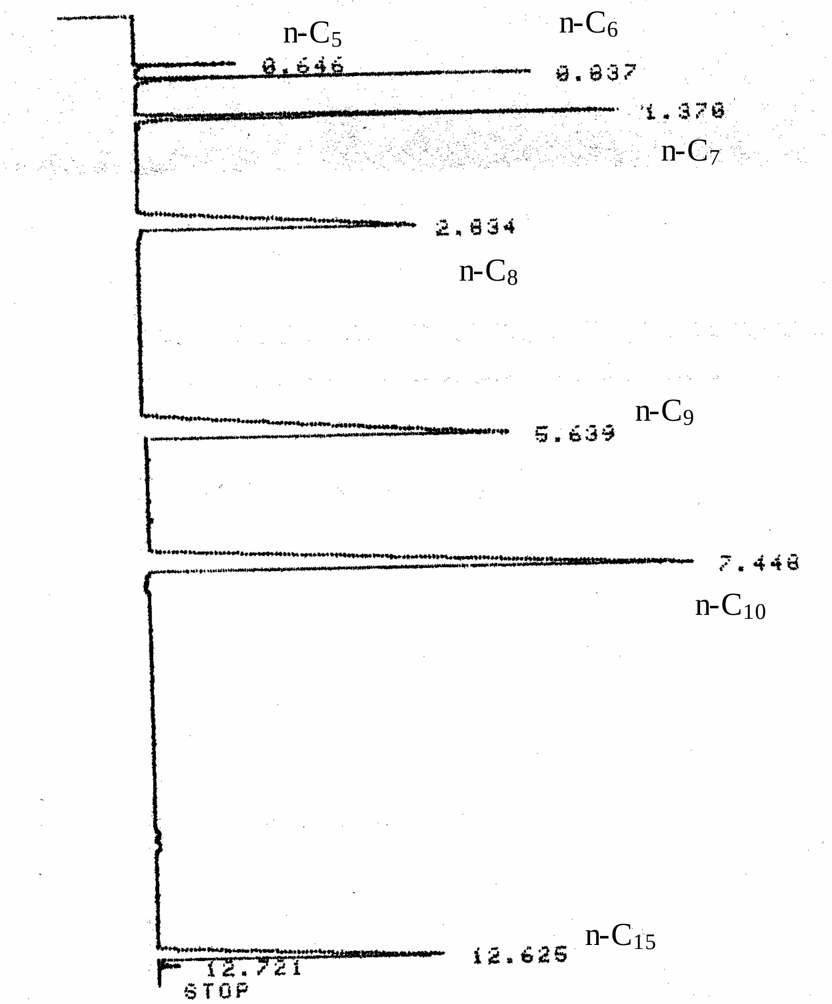
RUN# 27 JAN 1, 1981 13:13:32

SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
.646	194144	BB	.011	.58889
.835	860124	PB	.012	2.59749
1.361	2445224	PB	.027	7.31628
2.806	5304208	BB	.099	15.87056
5.600	8845811	BV	.139	26.46489
7.400	12403464	VB	.128	37.11283
12.601	3221880	BB	.065	9.64809

Fig. D-9-Steam distillation chromatogram cut no. 8.

* RUN # 28 JAN 1, 1901 13:56:56
START: not ready



Closing signal file M:SIGNAL .BHC

RUN# 28 JAN 1, 1901 13:56:56

SIGNAL FILE: M:SIGNAL.BHC
AREA%

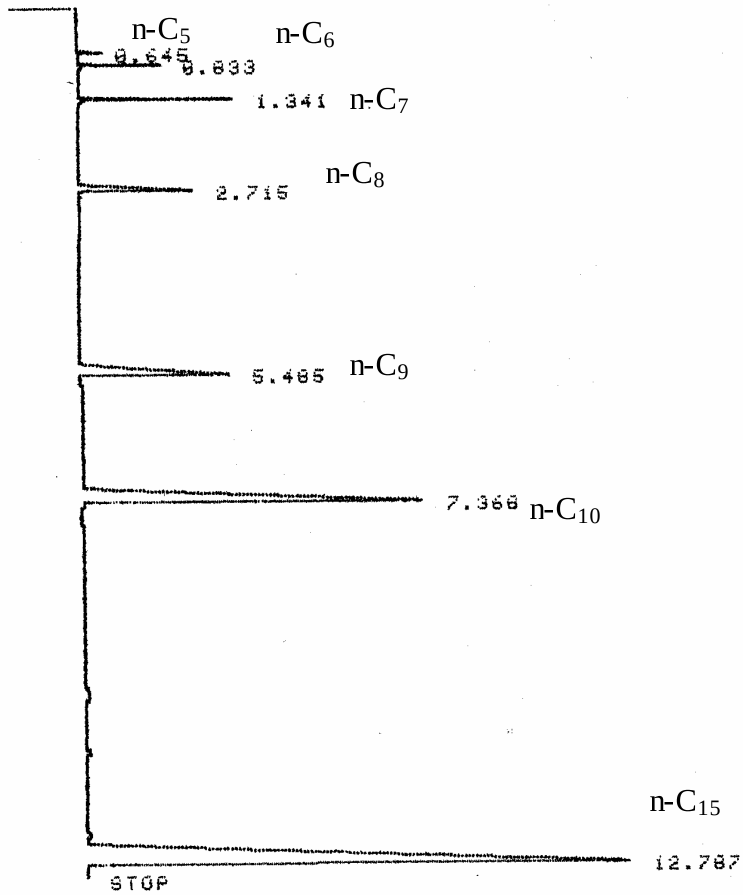
RT	AREA	TYPE	WIDTH	AREA%
.646	212620	PB	.010	.50499
.837	1010683	PB	.012	2.40046
1.370	3085469	BB	.029	7.32826
2.034	6699683	BB	.100	15.91234
5.639	11117400	PB	.148	26.40503
7.448	15485104	BB	.137	36.77870
12.625	4382256	BB	.075	10.40825
12.721	110306	BB	.023	.26199

TOTAL AREA=4.2104E+07
MUL FACTOR=1.0000E+00

Fig. D-10-Steam distillation chromatogram cut no. 9.

TOTAL AREA=4.2104E+07
MUL FACTOR=1.0000E+00

* RUN # 29 JAN 1, 1981 14:35:59
START: not ready



Closing signal file M:SIGNAL .BNC

RUN# 29 JAN 1, 1981 14:35:59

SIGNAL FILE: M:SIGNAL.BNC
AREA%

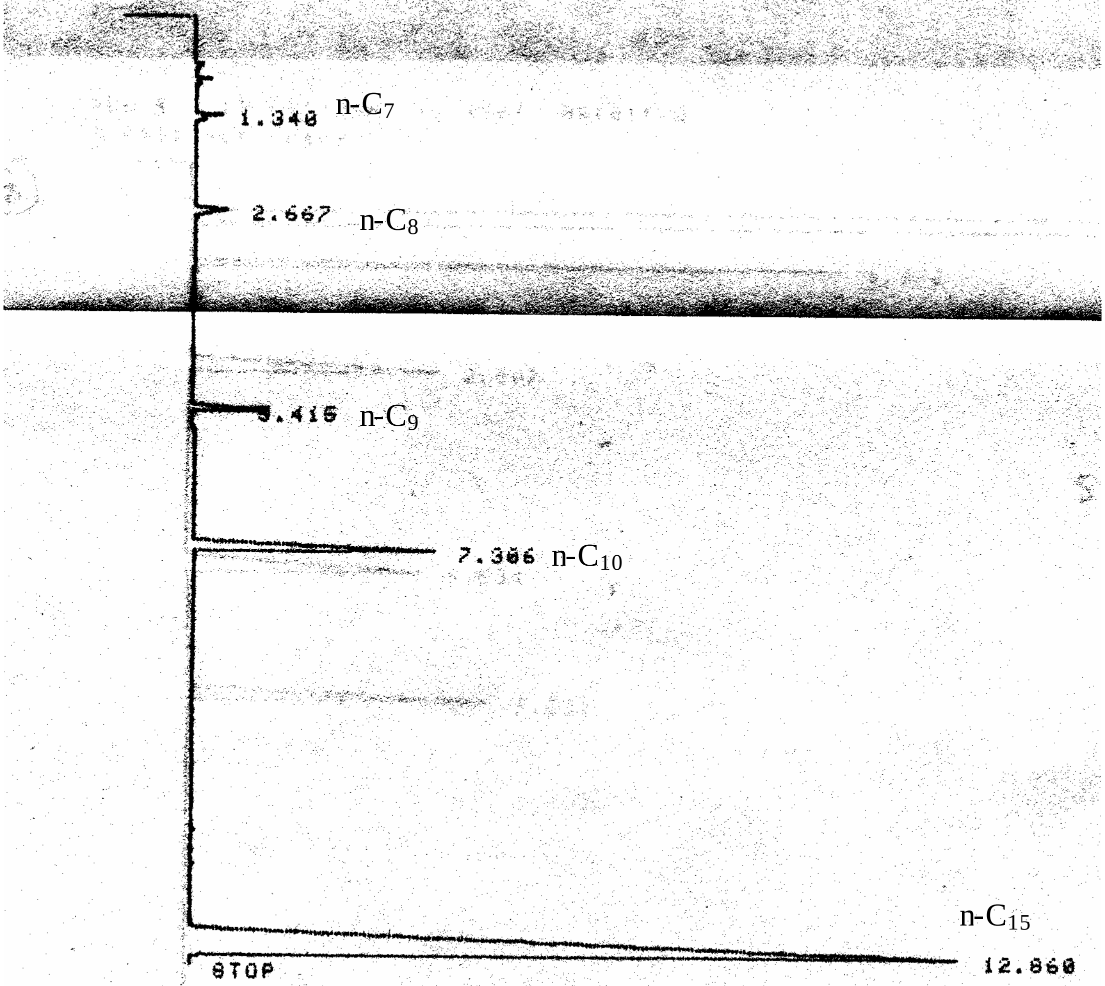
RT	AREA	TYPE	WIDTH	AREA%
.645	55254	PB	.009	.16734
.833	211491	PB	.011	.64052
1.341	596143	PB	.018	1.80548
2.715	1514500	BB	.058	4.58682
5.485	2921080	PB	.086	8.84678
7.368	8114525	PB	.103	24.57565
12.787	19605568	BB	.154	59.37741

TOTAL AREA=3.3019E+07
MUL FACTOR=1.0000E+00

Fig. D-11-Steam distillation chromatogram cut no. 10.

* RUN # 31 JAN 1, 1901 15:22:27

START: not ready



Closing signal file M:SIGNAL .BNC

RUN# 31 JAN 1, 1901 15:22:27

SIGNAL FILE: M:SIGNAL.BNC

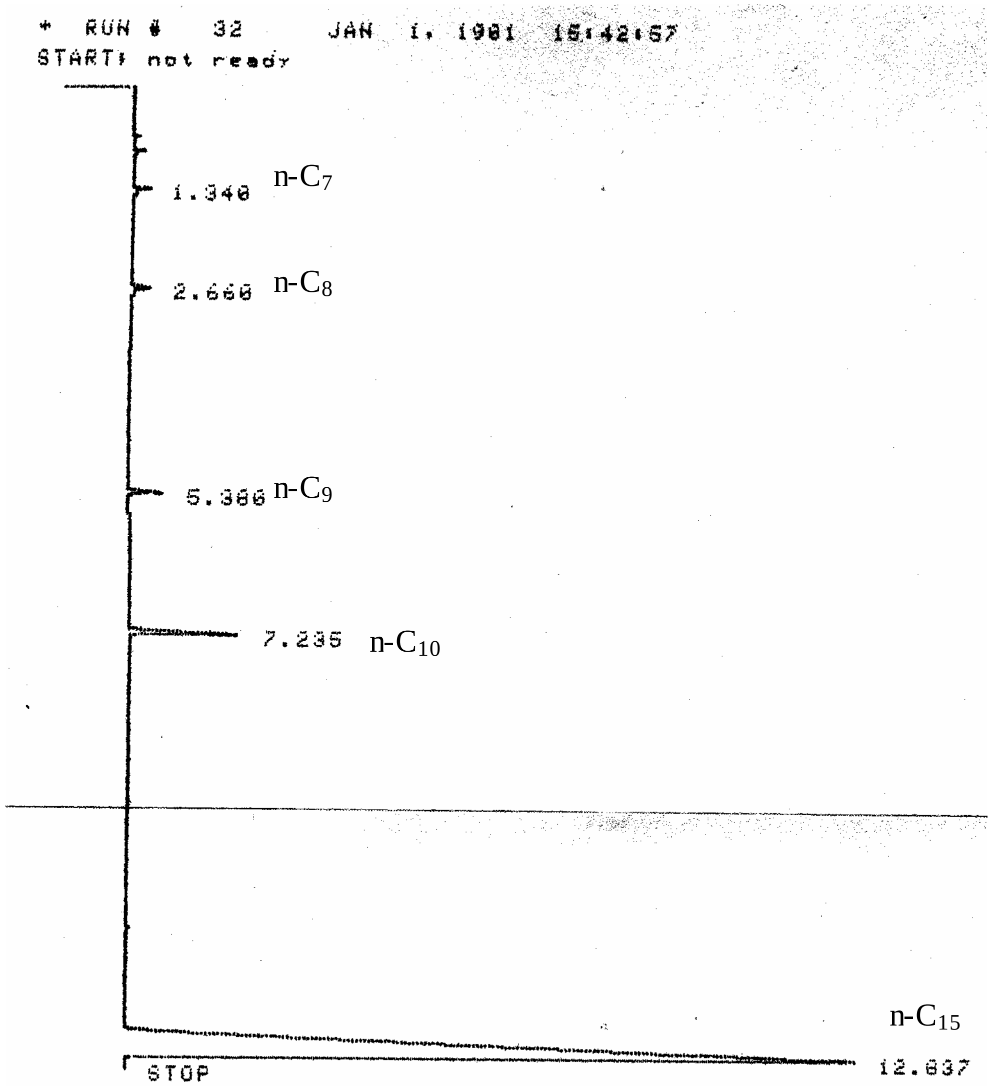
AREA%

RT	AREA	TYPE	WIDTH	AREA%
1.340	111752	PV	.019	.30866
2.667	420623	PB	.050	1.16182
5.415	859876	PB	.050	2.37510
7.306	3885194	PB	.072	10.73146
12.860	30926336	BB	.104	85.42294

TOTAL AREA=3.6204E+07

MUL FACTOR=1.0000E+00

Fig. D-12-Steam distillation chromatogram cut no. 11.



Closing signal file M:SIGNAL .BNC

RUN# 32 JAN 1, 1981 15:42:57

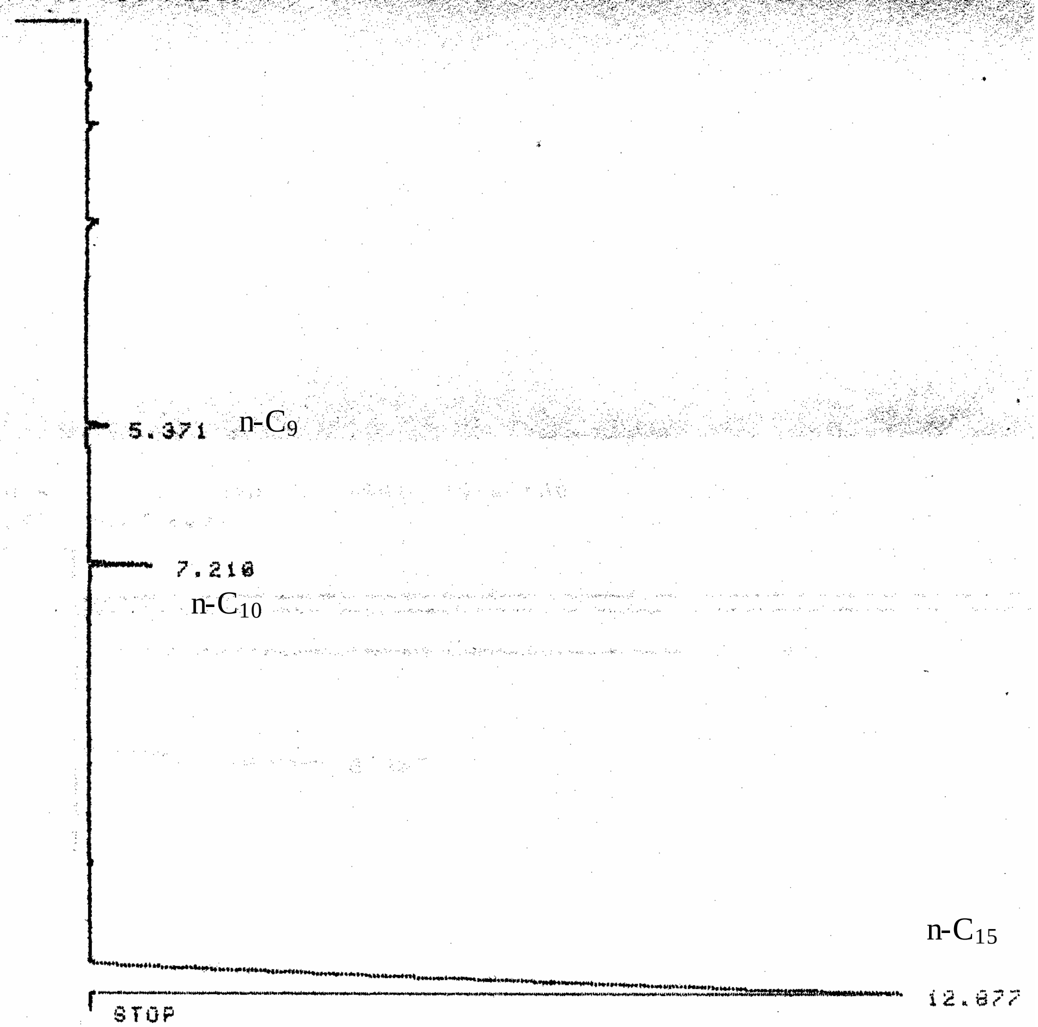
SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
1.340	97736	PB	.024	.33760
2.660	179341	PB	.043	.61947
5.380	302291	PB	.039	1.04416
7.235	992060	PB	.043	3.42673
12.837	27379200	BB	.172	94.57206

TOTAL AREA=2.8951E+07
MUL FACTOR=1.0000E+00

Fig. D-13-Steam distillation chromatogram cut no. 12.

RUN # 33 JAN 1, 1981 16:04:17
START: not ready



Closing signal file M:SIGNAL .BNC

RUN# 33 JAN 1, 1981 16:04:17

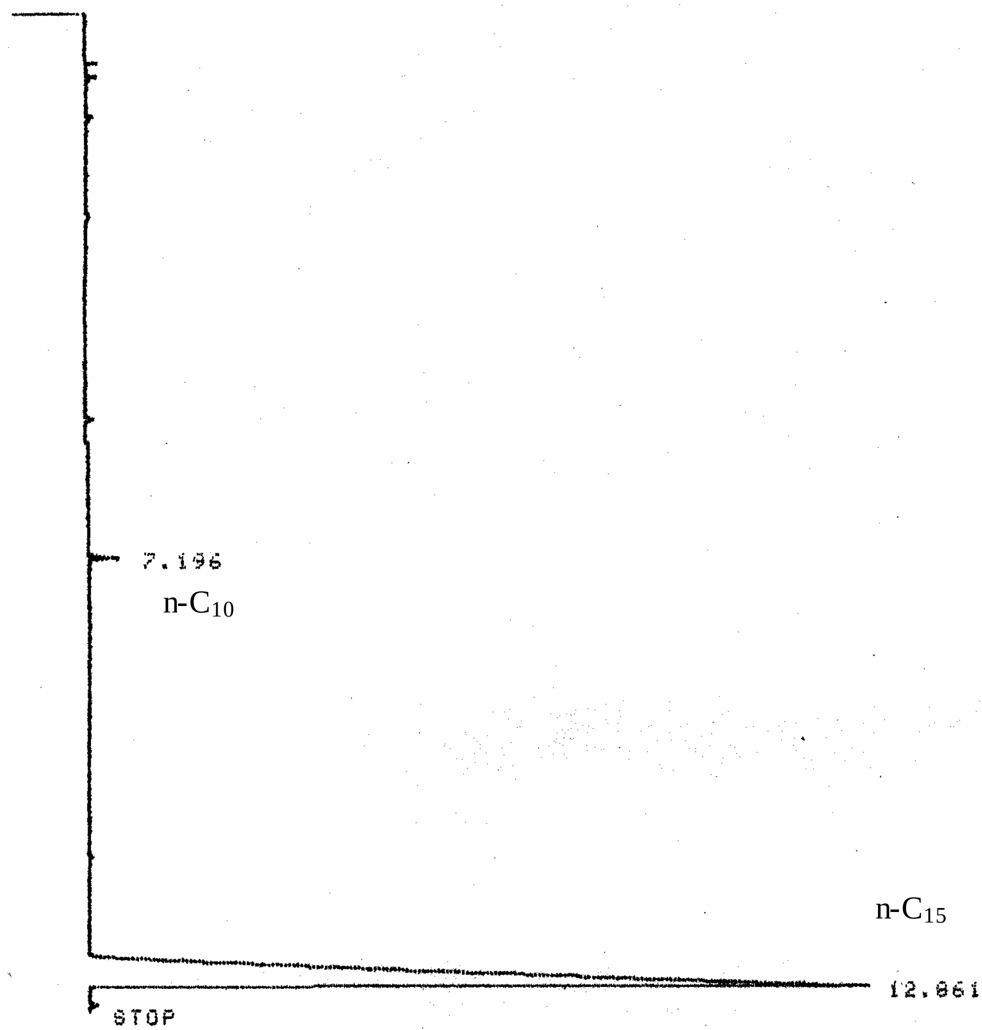
SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
5.371	200866	PB	.040	.58756
7.210	428915	PB	.031	1.25464
12.877	33556672	BB	.184	98.15782

TOTAL AREA=3.4186E+07
MUL FACTOR=1.0000E+00

Fig. D-14-Steam distillation chromatogram cut no. 13.

* RUN # 34 JAN 1, 1981 16:24:57
START: not ready



Closing signal file M:SIGNAL .BNC

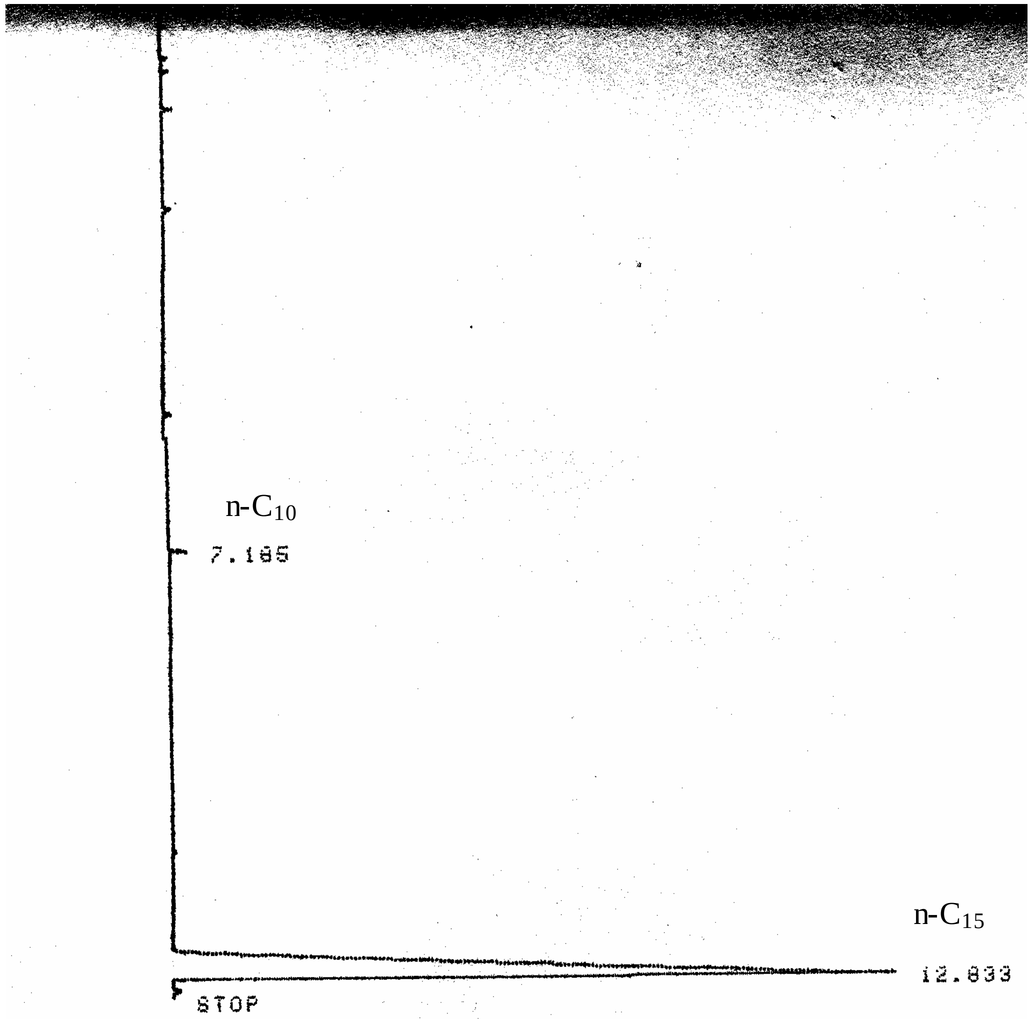
RUN# 34 JAN 1, 1981 16:24:57

SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
7.196	177253	PB	.026	.56992
12.861	30923984	PB	.171	99.43008

TOTAL AREA=3.1101E+07
MUL FACTOR=1.0000E+00

Fig. D-15-Steam distillation chromatogram cut no. 14.



Closing signal file M:SIGNAL .BNC

RUN# 35 JAN 1, 1901 16:47:10

SIGNAL FILE: M:SIGNAL.BNC
AREA%

RT	AREA	TYPE	WIDTH	AREA%
7.185	106405	PB	.026	.39034
12.833	27153440	PV	.173	99.60970

TOTAL AREA=2.7260E+07
MUL FACTOR=1.0000E+00

Fig. D-16-Steam distillation chromatogram cut no. 15.

VITA

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