THE LEWIS-MATHESON METHOD ON COMPUTER

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ABSTRACT

Title of Thesis: The Lewis Matheson Method On Computer

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Lewis and Matheson, in the early 1930's, developed a manual calculation technique for the solution of multicomponent distillation problems. The object of this study was to see if there would be any advantage to using the Lewis-Matheson method, once incorporated onto a computer, over current multicomponent distillation solution techniques. The immediate advantage of using the L-M technique is that it requires fewer preliminary calculations than other computer methods. It was found that the L-M technique uses about half the execution time of a typical Newton-Raphson program, while using only one tenth the computer core (memory). This was not intended to be a direct comparison, however, since the Newton-Raphson program used is a far more rigorous program that takes into account the column energy balance, side streams, multiple feeds, and many condenser types. It was concluded that the accuracy of the L-M technique was not improved in the transformation to a computer program the problem area still being the ability to achieve a converged solution. Another problem area was found to be conversion difficulties when the feed key ratio is close to the distillate or bottoms key ratio.

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INTRODUCTION

The object of this study was to develop a computer program to aid in the solution of multicomponent distillation problems. What sets this program apart from other currently avaliable programs is that this program is based on an old and relativily straight foward manual calculation technique. The reason for attempting this is to combine the advantages of both manual and computer calculation technique and at the same time eliminating some of the disadvantages of both.

The semirigorous solution method used was the Lewis-Matheson technique[1]. When using the Lewis-Matheson approch one proceeds by taking a material balance around the top, and bottom, of the tower:

Overall Top: $V=L+D=D(R+1)$ (1)

Component Top: $V_2 Y_{i,2}=L X_{i,1} + D X_{i,d}$ (2)

Overall Bottom: $B + V_b = L_b$ (3)

Component Bottom:

$B X_{i,b} + V_{bn-1} Y_{i,n-1} = L_{bn-2} X_{i,n-2}$ (4)

These equations can be combined and rearranged to yield:

$Y_{i,n+1}=(L/V)X_{i,n} + (D/V)X_{i,d}$ (5)

$X_{i,m-1}=(V_b/L_b)Y_{i,m} + (B/L_b)X_{i,b}$ (6)

Where:

V=molar flow of vapor up the column from feed stage.

L=molar flow of liquid down the column from top.

D=molar distillate rate.

R=reflux ratio=L/D

Yi,n=Vapor mole fraction of component i at stage n.

Xi,m=liquid mole fraction of component i at stage m.

Vb=molar flow of vapor up the column from reboiler.

Lb=molar flow of liquid down the column from feed stage.

B=bottoms molar flow rate.

Equation (5) is the material balance equation that relates the composition of the liquid on a stage to the composition of the vapor in the next lower stage in the enriching section of the column. Equation (6) relates the composition of the vapor in a stage to the liquid composition in the next higher stage in the stripping section. Both equations (5) and (6) are based on a material balance around the ends of the column. Both equations assume constant molar overflow, that is:

L1=L2=L3=L4=... =L

V2=V3=V4=V5=... =V

Lbn-2=Lbn-3=Lbn-4=... =Lb

Vbn-1=Vbn-2=Vbn-3=... =Vb

The vapor and liquid composition leaving a stage are related by the equlibrium relation:

Ki=Yi/Xi.

Using this Lewis-Matheson approach stage to stage calculations are carried out from the condenser, and the equilibrium stage reboiler, to the feed stage. The bottoms and distillate nonkey composition is adjusted, through the use of an algorithm, by trial and error until the feed composition matches. A more detailed discussion of the Lewis-Matheson approach follows in the main text.

There are many computer programs for distillation calculations avaliable today, but adapting the Lewis-Matheson method yields some advantages over these programs[2]. If one uses the Lewis-Matheson program one needs to specify the pressure change per stage, the initial feed, distillate, and bottoms composition and flow rate. Equlibrium data must also be supplied. If one wishes to use one of the other semirigorous computer programs one will also have to specify the feed stage location, and the number of equlibrium stages. The Lewis-Matheson technique gives the number of stages and feed plate location as part of the output. No enthalpy data is required also because constant molar overflow is assumed. This program also has an advantage in that it is small enough that it could probably be used in a hand held programable calculator.

Since this L-M program was written for the purpose of exploring any advantages of the L-M technique over current matrix methods it has many constraints. These constraints are: a total condenser, a single bubble point (or dew point) feed, an equilibrium stage reboiler, systems must be ideal, and there are no side streams.

The program was tested against many examples of Lewis-Matheson type calculations found in the literature. The program output was also compared to a rigorous distilation program (DISTL) using the Newton-Raphson approach.

The program was also tested to see if varying the operational (i.e. Reflux ratio) and convergence parameters would improve its accuracy. The effect of the operational parameters does not just apply to the results of the program but to the Lewis-Matheson method in general.

CHAPTER I

THEORY AND PROGRAMING LOGIC

Two common methods for solving multicomponent distillation problems, with computers, are the Linear-Algebra method and the Newton-Raphson method. Another common computer method is that of Thiele-Geddes, [3] which solves the material balance and energy balance in a completely decoupled manner, but since this is not a matrix method it is not within the scope of this paper. Both of the first two methods involve the use of matrices to recalculate the material and energy balances for each stage in the column simultaneously. These two matrix methods still involve iterative calculations since the original estimate of the composition throughout the column is only approximate. The problem must be solved many times, each time using the normalized solution for the composition on each stage from the previous iteration as the initial composition for the next .

The Linear-Algebra Method has been in use since 1966 when, Wang and Henke[4] published a paper on the technique as applied to multicomponent distillation. Like most matrix method programs the Linear-Algebra method requires preliminary hand calculations to estimate the number of stages, feed stage location, and the external reflux ratio. To establish the internal flow rates constant molar overflow is usually assumed, as it is in the Lewis-Matheson technique.

When seeking a solution using the Linear-Algebra method the first computational step is to write the material balance for a stage:

$$L_n X_{i,n} + V_n Y_{i,n} = L_{n-1} X_{i,n-1} + V_{n+1} Y_{i,n+1} + F_n X_{i,nf}$$

Then;

rearranging and eliminating $Y_{i,n}$ by using:

$$Y_{i,n} = K_{i,n} X_{i,n}$$

one gets:

$$(L_{n-1}) X_{i,n-1} - (L_n + V_n K_{i,n}) X_{i,n} + (V_{n+1} K_{i,n+1}) X_{i,n+1} = -F_n X_{i,nf}$$

Where n is incremented going down the column. The material balance equation is put into matrix form with the coefficients of X forming a tridiagonal matrix and $X_{i,n}$ forming the column vector. The product of the coefficient matrix and the X vector is equal to the column vector form of the left hand term of the material balance equation. This feed vector is zero everywhere except at the feed stage. Next a matrix equation is set up for each component.

The material balance matrix equation is then solved for the X vector by conventional techniques such as Gaussian elimination. Once the X vector is calculated for all components the mole fractions are adjusted, to compensate for any negative values, and normalized so that their sum is unity. From the compositions the temperature throughout the column is calculated. From the temperature profile the energy balance for the column is calculated, again by matrix methods, for the vapor flow rates attained. With the vapor flow rates the corresponding liquid flow rates are found; then the new liquid flow rates are used to update the original material balance matrix and the entire process is repeated. Iterations continue until the program converges to within preset tolerances. There are no guarantees that this method will converge because the equations are decoupled and no acceleration technique is used.

The Newton-Raphson method is similar to the Linear-Algebra method except that the design equations are used in discrepancy function form and are all solved simultaneously.

Component material balance:

$F1(i,n) = (1 + Sln/Ln)\ li,n + (1 + Svn/Vn)\ vi,n$

$- li,n-1 - vi,n+1 - fi,n = 0$

Where the feed rate is zero everywhere except the feed stage.

Equlibrium relationship, derived from the definition of the vapor phase Murphree stage efficiency:

$F2(i,n) = Nn\ (Vn/Ln)\ Ki,n\ li,n - vi,n + (1 - Nn)$

$(Vn/Vn+1)\ vi,n+1 = 0$

Energy balance:

$F3(n) = (Ln + Sln)\ hn + (Vn + Svn)\ Hn - Ln-1\ hn-1 +$

$Vn+1\ Hn+1 - Fn\ hfn - Qn = 0$

The next step is the key to the Newton-Raphson method. Each of the design equations is linearized by representing each equation by a two term Taylor's series. By making the design equations linear, convergence accelerates as a solution is approached. As will be seen later, convergence is one of the major problems when using the Lewis-Matheson method. It should be noted at this point that the resulting derivatives from the Taylor expansion must be evaluated numerically by the computer, which further complicates the problem. In the Newton-Raphson program used the derivatives of K with respect to T are evaluated analytically because the K values are regressed into a polynomial.

As in the Linear-Algebra method, the linearized design equations are put into matrix form. The matrix equations are then solved by conventional techniques for corrections that are used to revise the componential vapor, liquid, and temperature profiles within the column. The process is then repeated. Iteration continues until a coherent solution is reached[5].

At the other extreme from the very rigorous computer techniques for distillation solutions we have graphical techniques used by engineers since the early part of this century. The advantage of graphical methods, like McCabe-Thiele and Ponchon-Savarit, is that they are simple, fast and reasonably accurate. The Ponchon-Savarit method even works well with nonideal solutions since the equilibrium and enthalpy data are theoretically complete. The major problem with these techniques is that they are designed for binary systems.

The impetus behind this investigation was to seek a compromise between the extreme complexity of conventional computer techniques and the speed and simplicity of the graphical methods. The program developed has the advantages of the graphical techniques in that no preliminary calculations are required to use it, and it yields reasonably accurate solutions. The Lewis-Matheson program also has the advantages of the computer methods in that it is a semirigorous method and can handle ideal multicomponent problems.

As was stated in the introduction the Lewis-Matheson, on which the thesis program is founded, is basically a stage to stage equlibrium-material balance calculation. The major assumption in the Lewis-Matheson approach, which sets it apart from more rigorous computer techniques, is that of constant molar overflow. What this does is negate the need for enthalpy data and an energy balance. The result is greatly simplified calculations in the solution of a given problem.

The basis for the Lewis-Matheson approach is a stage to stage material balance:

$$V Y_{i,n+1} = L X_{i,n} + D X_{i,d}$$

for the portion of the column above the feed. For the lower portion of the column the stage to stage material balence is:

$$L_b X_{i,n} = V_b Y_{i,n+1} + B X_{i,b}$$

Both of these equations can be rearranged into the operational design equations:

$$Yi,n = (L/V)\ Xi,n-1 + (D/V)\ Xi,d$$

and:

$$Xi,n = (Vb/Lb)\ Yi,n+1 + (B/Lb)\ Xi,b$$

In verbal form, what the first of the two design equations does is allow one to calculate the vapor compositions from the liquid compositions in the stage above in the enriching section. The last design equation permits the calculation of the liquid composition from the vapor composition of the stage below in the stripping section.

One should note that in the two design equations only Xi,n-1, Yi,n+1, Yi,n, and Xi,n are variables the rest of the terms are constant for a single pass. Xi,d and Xi,b are determined by the covergence routine in the L-M program in such a way that the output compositions result in a viable solution. D and B are given. L is equal to the product of R and D. Lb equals L plus F since the feed is assumed to be at its bubble point. V equals Vb for the same reason. Vb equals Lb minus B.

What remains to be calculated is the liquid composition from the vapor composition on a stage in the enriching section. In the stripping section the vapor composition on a stage must be calculated from the liquid make up. Both of these task are accomplished by employing the equilibrium relationship:

$$Ki,n = Yi,n\ /\ Xi,n$$

where K is the equlibrium constant[6]. The next problem is that K is a temperature dependent function but at this point the temperature on each stage is unknown. The temperature and composition on each stage are found by assuming that the liquid and vapor on a stage are in equilibrium with each other. That is to say that, in the enriching section a dew point calculation is used to compute the stage composition. In the stripping section a bubble point calculation is used to find the stage vapor make up. The design equations are:

$$\sum X_i = \sum Y_i / K_i = 1$$

$$\sum Y_i = \sum K_i X_i = 1$$

The temperatures (K=f(T)) are found by trial and error.

To accelerate convergence a different form of the bubble point and dew point equations were used in the L-M program[7] to take advantage of the equation representing the V-L equilibrium data:

$$\ln K = A + B/T .$$

The determination of A and B will be discussed later. The principal difference lies in the following definition:

$$\alpha_{ir} = K_i / K_r$$

α is the relative volitality and Kr is the equilibrium constant of the compound chosen as reference. The light key component in the L-M program is the reference compound. Using the relative volatility the design equations become:

$$\sum X_i = (1/K_r) \sum (Y_i / \alpha_{ir}) = 1.0$$

and:

$$\sum Y_i = K_r \sum \alpha_{ir} X_i = 1.0$$

which becomes:

$$K_r = \sum Y_i / \alpha_{ir}$$

$Kr = 1/\sum \alpha ir\ Xi$

In all of the equilibrium equations the system is assumed to be ideal so the activity coefficent is one. By redefining the bubble and dew point equations in this way an initial estimate of the stage temperature can be used to generate a new value for the refrerence equlibrium constant. This new value is used to generate a better estimination of the stage bubble or dew point temperature. This improved temperature approximation is again used to generate K values. The process is iterated until the reference equlibrium constant does not change appreciably. Once the stage temperature is determined the equlibrium composition can then be calculated. By using this method to determine equlibrium composition only a few trials are necessary if the initial temperature estimate is reasonably accurate. In the L-M program, except for the condenser and reboiler the initial temperature estimate is taken to be the temperature of the stage calculated before it. Since temperature rarely varies significantly between adjacent stages all of the initial temperature estimates are reasonably close so the number of calculations is further minimized.

Since distillation columns are not truly isobaric the equlibrium constants used in the program had to be determined at various stage pressures. If a K value is known at a reference pressure it is not difficult to find the K value (at the same temperature) at another pressure. Recalling the definition of K for ideal systems using

Raoult's and Dalton's laws:

$$K = Po/P$$

Where Po is the vapor pressure and P is the pressure at which K is taken. In the L-M program, the pressure at which all of the K values are known is called the reference pressure, or:

$$Pr = P$$

To find the equlibrium constant at another pressure one simply multiplies the known K value by the reference pressure and then divides by the unknown pressure as follows:

$$K(\text{at new } P,\ P=P1) = K\ Pr/P1 = (Po/Pr)\ (Pr/P1) = Po/P1$$

Where P1 is the pressure at which K is desired. The result is the K value at any desired pressure providing all of the pressures are in the same units.

A set of five K values at five different temperatures and one pressure for each component are fed to the program as given data. The necessary intermediate K values are interpolated; the interpolation is not linear however. K values are regressed into an equation of the form:

$$\ln K = \text{Alpha} + \text{Beta}\ (1/T)$$

Since this equation is of linear form, with respect to ln K, Alpha is the intercept and Beta is the slope. The standard linear regression equations used are:

$$\text{BETA} = \frac{\sum \ln(K)(1/T) - (\sum \ln K \sum (1/T))/N}{\sum (1/T)^2 - ((\sum 1/T)^2)/N}$$

$$\text{ALPHA} = \ln Kb - \text{Beta}\ (1/T)b$$

$$Kb = (\sum \ln K)/N$$

$$(1/T)b = (\sum 1/T)/N$$

$$r^2 = \frac{\left[\sum(1/T)\ \ln K - (\sum(1/T)\sum \ln K)/N\right]^2}{\left[\sum(1/T)^2 - ((\sum 1/T)^2)/N\right]\left[\sum(\ln K)^2 - ((\sum \ln K)^2)/N\right]}$$

The value r squared is the correlation coefficient for the regressed K values vs T. The correlation coefficient expresses the confidence in, and linearity of, the regressed data. The correlation coefficients are the first thing calculated and given as output in the L-M program. That way the program may be terminated if the K's do not regress.

The single most difficult problem encountered in the creation of the L-M program was a problem that is common to many distillation programs: overall convergence of the material balances. In order to understand the problems encountered one must first understand the computational logic used. The logic used in the L-M progran is based on the concept of key components. By the nature of multicomponent distillation problems only the feed composition, amount of distillate and bottoms, the reflux ratio, and the split between the same two components in the distillate and bottoms may be fixed. The other variables, the nonkey components in the distillate and bottoms, the number of stages, and the feed stage location are calculated by the program. It should be noted at this point, that other programs fix the number of stages, and feed location, but do not fix the distillate and bottoms composition at all. The key components are usually the two major constituents which one is trying to separate in a mixture. For the purposes of the L-M program the two key components must be successive in relative volitilty in the given feed.

The way in which the program works is that the ratio of the mole fractions, of the two keys, in the distillate, and in the bottoms is held constant, but the mole fraction may vary. Thus the split is fixed. Initially the mole fractions in the distillate and bottoms are given. The calculation begins by doing a stage-wise equlibrium-material balance computation, as indicated earlier, from the condenser until the feed stage is reached. The feed stage is said to have been reached when the ratio of the key components is equal to the ratio of the keys in the feed. The calculation is repeated from the reboiler up until, the feed stage is again reached.

With a two component system the calculation would be complete at this point. With a multicomponent system one has to account for the nonkey components at this point. If the initial estimate of the distillate and bottoms composition was correct the composition from the condenser and from the reboiler, at the feed stage, should match the feed. If there is a mismatch, one has to go back and adjust the nonkey components in the distillate and bottoms. The stage-wise calculation is then started again. This entire process is repeated until the composition matches at the feed stage.

In the program, one of the first problems encountered was that of diverging key components. That is to say that normally the ratio of the keys in the stripping section of the column (and enriching section) would become closer to the key ratio in the feed as the calculations progressed. The problem lies in the fact that sometimes before the key ratio matched the key ratio in the feed the ratio would cease converging on the feed key ratio. The keys would actually start to separate as the feed stage was approached from the ends of the column. To evaluate this problem a routine was introduced to monitor the key ratios. Instead of the stage-wise computation stopping just if the key ratio matches the feed it will also stop if the key ratio begins to diverge. If the calculation were to proceed otherwise it would never stop. The intrinsic assumption here is that as the nonkeys are adjusted divergence will stop. It should be noted here that divergence is a common problem with the Lewis-Matheson technique and is not unique to the L-M program.

The next problem that arose was how to adjust the nonkeys in the distillate and bottoms to attain the most efficient and guaranteed convergence. Due to overall material balance considerations setting the amount of a nonkey component in the distillate automatically determiness it quantity in the bottoms and vice versa. Because of this fact, it was decided to adjust the light nonkeys in the bottoms and the heavy nonkeys in the distillate. By adjusting the nonkeys which should be present in small amounts it is possible to change a components mole fraction by a significant percentage and change its corresponding percentage in the distillate or bottoms by very little. What this means is that the composition at the feed stage is very sensitive to the trace components in the distillate and bottoms.

The problem was to find the best algorithm for adjusting the nonkey components. It was found, after much trial and error, that the simplest algorithm worked the best. Following a logical course the secant method was the first method tried. The computation flucuated wildly and the program never converged. It was reasoned that there were too many independent variables for the secant method to work. A simpler algorithm was chosen that would only make small changes at one time so that the variables would behave as psudo-constants.

The algorithm decided upon simply uses the difference between the two calculated feed stage mole fractions, for a component, and divides that by the sum of the two mole fractions. This yields a correction factor that when added to 1 can be multiplied with the nonkey mole fraction in the distillate or bottoms to obtain an adjusted product composition. Simply stated:

Correction factor distillate =

$$[(Xbf - Xdf)/(Xbf + Xdf)] + 1$$

Correction factor bottoms =

$$[(Xdf - Xbf)/(Xdf + Xbf)] + 1$$

Even though this simple algorithm was found to work best, it also has a problem. As the compositions at the feed near matching the correction factor becomes extremly small. The program converges on a solution after many trials with with small corrections. To force faster convergence an adjustment factor was added. The adjustment factor, like the correction factor, is rather simple but was found to work well. The adjustment factor is simply a doubling of the correction factor once the correction factor drops below a ten percent correction. On the surface this may seem rather arbitrary but many combinations of doubling, tripling, and quadrupling of the correction factor over five, ten, fifteen, twenty, twenty five, and thirty percentiles were tried. The doubling at ten percent was found to work the best, as the other combinitions either didn't accelerate convergence, or caused extreme oscillations.

The last major problem encountered was that of overall instability in the program. On the first pass, the program would determine a number of stages for a column. On successive passes the number of stages would remain the same while the feed stage composition would begin to converge. The problem arose when, because of the changing composition in the distillate and bottoms, the number of stages would change. When this happens the composition of the nonkeys at the feed changes substantily. This was because the components would go through one stage more, or less, of separation. When the composition at the feed stage changes dramatically, the correction of the nonkeys in the distillate and bottoms would change considerably. When the distillate and bottoms composition changed, often the number of stages would also change. The program would continue to oscillate and fail to converge.

The solution to this problem was simply to force convergence by not allowing the number of stages to decrease on successive passes. That is to say that if N stages were required on the first pass and later N-1 stages were required the calculation would continue through to N stages. If N+k stages were later required then the calculation was continued through N+k stages, but N+k would then be the new minimum. The logic behind this is that if N stages were required for separation as the calculation converges the only reason fewer stages would be calculated would be because of oscillation. The usual trend is for one or two more stages to be required as the calculation converges.

As suggested earlier, distillation calculations are usually not isobaric. The L-M program also had to account for changing pressure in the column. The problem of changing pressure is particularly difficult, in the Lewis-Matheson type calculations, because the number of stages is unknown at the start of the calculation. The complication lies in the fact that one must know the pressure in the reboiler and in the condenser to do the problem. Without knowing the number of stages the reboiler pressure can only be assumed, since what is fixed is the pressure change per stage.

The L-M program tackled the problem of changing pressure by first solving the distillation problem isobarically at the known condenser pressure. This was done to determine the approximate number of stages in the column. This yields a good estimation because a normal column and an isobaric column, usually differ by only a few stages. With the number of stages estimated the pressure in the reboiler is then calculated. This is done by letting the reboiler pressure equal the number of stages times the pressure change per stage plus the condenser pressure. If at the completion of the calculation of the distillation problem the pressure does not match at the feed stage the new number of stages is used to again estimate the reboiler pressure. The calculation is repeated until the pressure at the feed, from the top and bottom, matches. This method seems to work because the pressure usually matches at the feed after two or three trials.

CHAPTER II

THE PROGRAM

Up to this point the description has been of the computational logic used. The following will be a description of how the logic is linked together in the program.

The initial portion of the program, as one would expect, is the entry of the data. The quantities of feed, distillate, bottoms, the key components, reflux ratio, number of components (up to ten), and the component mole fractions are all read in at this point. All components listed as being present with zero mole fraction are changed to 0.00001 mole fraction, because all components are required to be present on each stage. The section of the program that follows reads in the K values, their corresponding temperatures, and regresses them into an equation of the form:

$$\ln K = A + B/T.$$

The final input consist of: the temperature and pressure of the condenser, temperature of the reboiler, pressure drop per stage, pressure change in the condenser, and the equilibrium data reference pressure. The correlation coefficients for the K values are next printed out so that if they are unacceptable the program can be terminated.

With the initialization section of the program finished the Lewis-Matheson calculations are begun. The constants for the stage-wise computations are now calculated and the initial pressure drop through the column set at zero. In order to determine the temperature in the condenser the first bubble point of the program is calculated. The pressure drop through the condenser, if any, is accounted for and the stage-wise calculation is carried out as described earlier. After each stage calculation the program tests to see if it is at the feed and has gone beyond the minimum number of stages as determined by the previous trial, if any. Once past the feed test the calculation for the enriching section is finished for that pass.

The temperature in the reboiler is next determined by doing yet another bubble point calculation. Once again a stage-wise calculation is carried out, only this time it is from the bottom up. At the end of each stage calculation the feed stage is tested for and so is the minimum number of stages in the stripping section. Once the calculation for the stripping section is completed the Lewis-Matheson segment of the program is finished, for a given pass.

The program, next compares the compositions at the feed stage. If they match the pressure correction portion of the program is branched to. If not, the nonkey mole fractions are adjusted at the bottoms and distillate. With the compositions changed an overall column material balance is next calculated. The entire calculation is then repeated and continues until the compositions matches at the feed.

Once the feed compositions, from the top down and bottom up, does match the program branches to the feed pressure matching section. Here the approximate number of stages and pressure change per stage are used to estimate the reboiler pressure. Providing the column is not isobaric the calculation is started all over again, only this time with a pressure drop through the column.

After one or two passes through the feed pressure matching section the pressure at the feed will indeed match and the problem will finally be solved. The last portion of the program is simply the print out. The pressure, temperature, and composition are printed for each stage in the column including the condenser (stage 1) and the reboiler. It should be noted that the condenser used is a total condenser but it is called a stage for convenience. The number of stages (including the condenser) and the total number of passes through the Lewis-Matheson portion of the program are also printed.

CHAPTER III

RESULTS and CONCLUSIONS

The results of this study can be broken up into three categories. First, verification that the L-M program works correctly. This was done by comparison with a couple of Lewis-Matheson examples found in the literature. Second, a side example to test the effect of reflux ratio on program accuracy. This was done to see if a possible conversion scheme could be worked out based on varying reflux ratio. Third, and last, the L-M program was contrasted with a Newton-Raphson program (called DISTL)[11]. Input data, runs, and graphs of all output can be found in the appendix.

To check that the program was working correctly it had to be verified against already completed Lewis-Matheson calculations. Fortunately two examples of Lewis-Matheson calculations were found in the literature. For the first case agreement with the program results was excellent. The first case was a butane pentane splitter[8]. In this example the number of stages was the same for the program and the literature, twenty four. The mismatch between the key components at the feed was also reasonable, only 0.0168 mole fraction. For the second case, an example taken from Hengstebeck[9], the number of stages also agreed; 9 stages for the program and 8.3 stages for the example. The mismatch between the keys at the feed was more significant than the first case, 0.1084 mole fraction. Even though agreement between calculated and published results was not perfect, the agreement was close enough to conclude that the program works correctly.

A third example of a Lewis-Matheson type calculation was found in the literature but an interesting problem arose when this example was considered. The example, from Robinson and Gilliland[10], has a feed and bottoms composition with almost the same key component ratio. Because of this the program would only calculate one stage for the stripping section. Because the stripping section had only one stage, the nonkey elements were not adjusted, and the program failed to converge. The unconverged example is included in the appendix. The conclusion one can draw from this is that the Lewis-Matheson method has one theoretical short coming. A problem cannot be solved if the key ratio in the distillate or bottoms is the same as the feed.

Next the butane pentane splitter was run at six different reflux ratios. This was done to see the effect of reflux ratio on the key mismatch error at the feed stage. The reflux ratio was varied between 1.0 and 1.5. The error ranged from 0.0 to 0.0906 but in a random fashion.

Last of all, the case of a debutanizer was run on the L-M program and the Newton-Raphson program DISTL. As expected DISTL took more than twice as long to run as the L-M program, 19 seconds as apposed to 6.1 seconds. Because a compiled version of DISTL was used, 19 seconds. was the absolute minimum run time obtainable. Agreement between the two programs was not complete. The L-M program required 18 stages where DISTL required 25. This is not truly indictive of actual performance because DISTL is a rating program. DISTL does not calculate the number of stages. The number of stages is estimated for DISTL by hand calculations which are based on ideal solutions and enthalpys. It should be noted that both programs did converge. An attempt was made to run DISTL with 18 stages but it failed to converge. The reason for this is unknown but warrants further investigation.

The L-M program has the advantage of lending itself to 'quick and dirty' solutions. The L-M program will fit and run one on most small computers and could probably be modified to run on a programable calculater. DISTL by contrast requires a more sophisticated computer for storage and execution. This is not intended to be a direct comparison because DISTL is a much more sophisticated program configured for 20 components, 502 stages, side streams, feed flashes, and enthalpy considerations.

To summarize, the Lewis-Matheson method was adapted to the computer to see if there could be any advantage over current computer techniques. The method works well on a computer but the accuracy is limited by the method itself. The accuracy of the calculation is the same as when done by hand, but the program is infinitly easier to use.

FOOTNOTES

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[6] De Priester, C.L., Chem. Eng. Prog. Symp. Ser., 49(7), 1, (1953).

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[8] Schweitzer, op. cit. pp. 53-145.

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[10] Robinson, C.S., and Gilliland, E.R., 'Elements of Fractional Distillation,' 4th ed., Mc Graw-Hill, New York, (1958).

[11] Roche, E.C., Jr., 'DISTL,' N.J.I.T., Newark, N.J., (1971).

APPENDIX A

DATA INPUT FORMAT

Input Format

Line	Column	Format	Data
1	1	F10.5	Feed
1	11	F10.5	Reflux Ratio
1	21	F10.5	Distillate
1	31	F10.5	Bottoms
1	50	I10	Number of Components
1	60	I10	Number of Key 1
1	70	I10	Number of Key 2
2	1	F10.8	Mole Fraction Component 1 Distillate
2	11	F10.8	Mole Fraction Component 1 Bottoms
2	21	F10.8	Mole Fraction Component 1 Feed
3	1	F10.8	Mole Fraction Component 2 Distillate
3	11	F10.8	Mole Fraction Comoponent 2 Bottoms
3	21	F10.8	Mole Fraction Component 2 Feed
.			
.			
.			
N+1	1	F10.5	Temperature One
N+2	1	F10.5	K 1 At Temperature One
N+3	1	f10.5	K 2 At Temperature One
N+3	1	F10.5	K 3 At Temperature One
N+4	1	F10.5	K 4 At Temperature One
.			
.			
.			

Input Format cont.

Line	Column	Format	Data
2N+1	1	F10.5	Temperature Two
2N+2	1	F10.5	K 1 At Temperature Two
.			
.			
.			
Last	1	F10.5	Temperature Condenser
Last	11	F10.5	Temperature Boiler
Last	21	F10.5	Pressure Condenser
Last	31	F10.5	Condenser Pressure Drop
Last	41	F10.5	Pressure Drop Perstage
Last	51	F10.5	Reference Pressure

APPENDIX B

VERIFICATION OF DATA, RESULTS

BUTANE PROPANE SPLITTER DATA

```
   1.0000   65.716     1.355    34.369    31.347             5          3
       4
   2.0000 .1385     .00004    .07246
   3.0000 .3149     .00068    .16486
   4.0000 .5146     .01239    .2750
   5.0000 .02355    .34588    .17729
   6.0000 .0085     .64108    .31024
   7.0000 148.0
   8.0000 2.41
   9.0000 1.18
  10.0000 0.88
  11.0000 0.422
  12.0000 0.342
  13.0000 176.0
  14.0000 3.0
  15.0000 1.54
  16.0000 1.18
  17.0000 0.57
  18.0000 0.475
  19.0000 200.0
  20.0000 3.51
  21.0000 1.87
  22.0000 1.43
  23.0000 0.715
  24.0000 0.63
  25.0000 220.0
  26.0000 4.01
  27.0000 2.21
  28.0000 1.73
  29.0000 0.90
  30.0000 0.78
  31.0000 243.0
  32.0000 4.6
  33.0000 2.61
  34.0000 2.10
  35.0000 1.1
  36.0000 0.96
  37.0000 148.0     243.0     120.0     2.5       0.217     120.0

  38.
```

Figure 1
C4-C5 Splitter, L-M Program

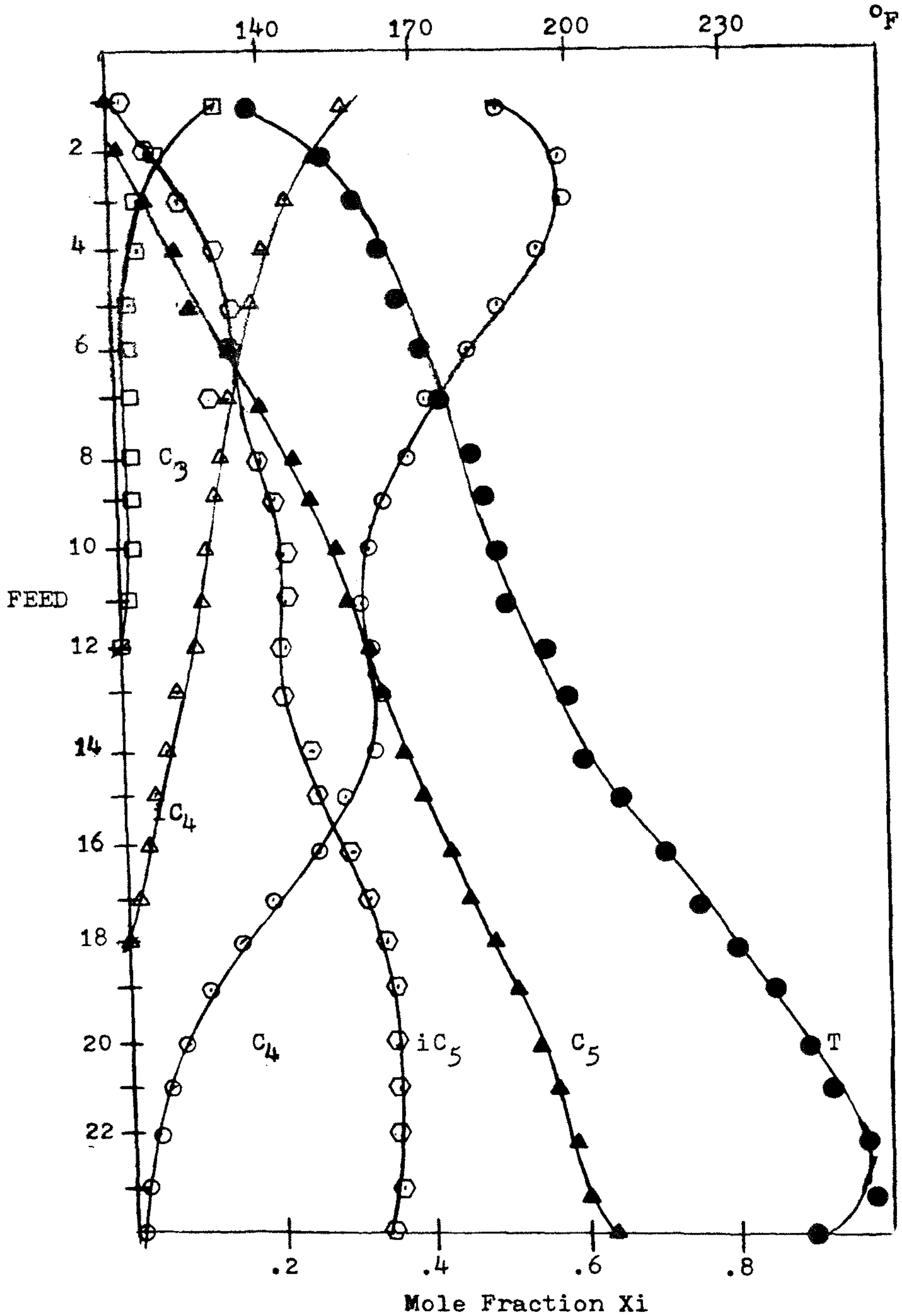
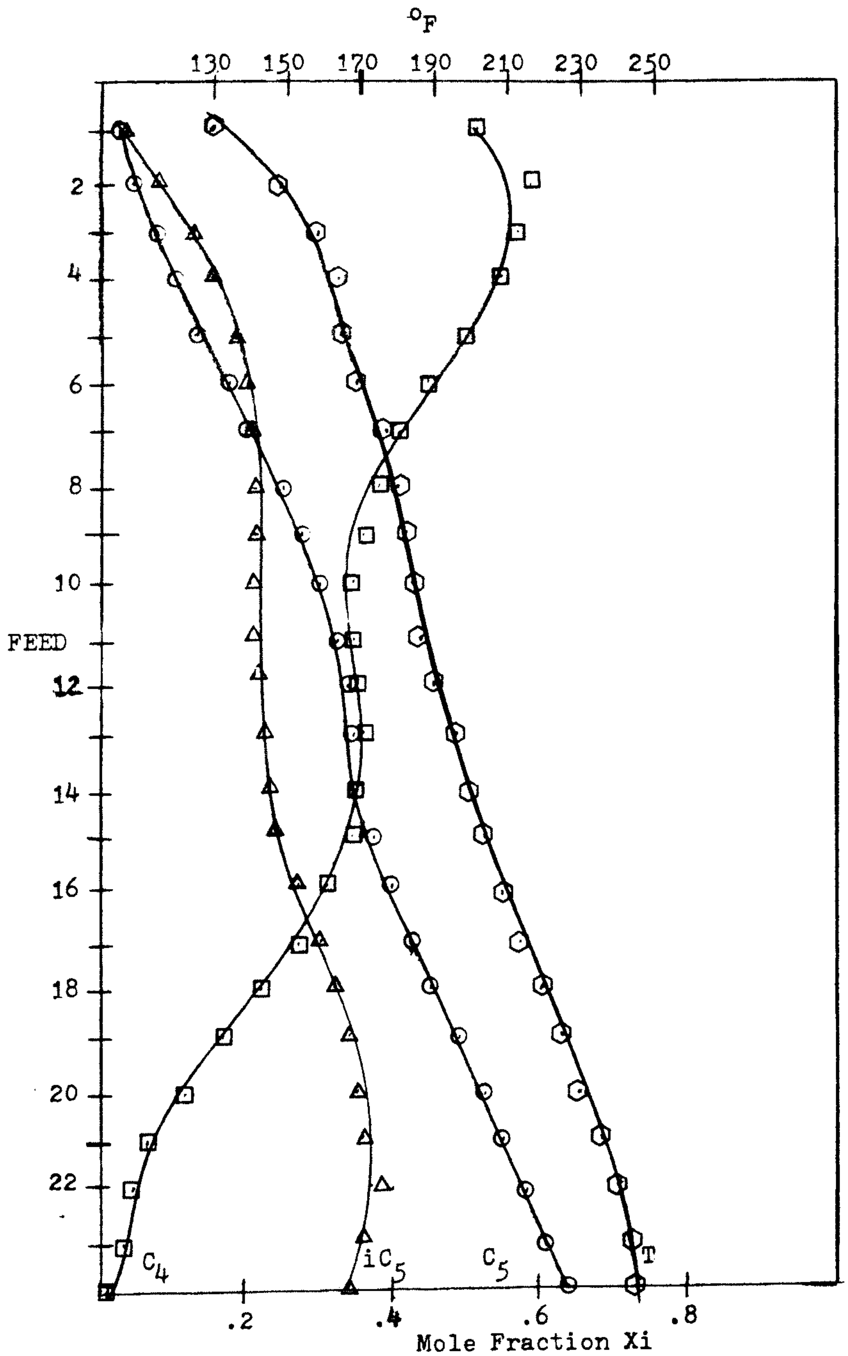


Figure 2

C4-C5 Splitter, Literature



BUTANE PROPANE SPLITTER: RESULTS

FASTFOR (CONVERSATIONAL, VER 9)

1	0.9903304
2	0.9898047
3	0.9859442
4	0.9821548
5	0.9892838

F= 65.71600	D= 34.37918	B= 31.33682
R= 1.35500	N= 5	
KEY1= 3	KEY2= 4	

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.92	156.98	161.72	166.32
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2695	0.2293	0.1999	0.1782
X 3	0.5144	0.5905	0.5908	0.5573	0.5101
X 4	0.0236	0.0568	0.0941	0.1324	0.1676
X 5	0.0087	0.0257	0.0494	0.0802	0.1164

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.86	175.07	178.74	181.74	184.11
X 1	0.0262	0.0251	0.0242	0.0235	0.0230
X 2	0.1617	0.1491	0.1396	0.1327	0.1277
X 3	0.4609	0.4167	0.3809	0.3536	0.3339
X 4	0.1958	0.2148	0.2248	0.2271	0.2239
X 5	0.1555	0.1943	0.2306	0.2630	0.2914

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.94	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1242	******	******	******	******
X 3	0.3198	******	******	******	******
X 4	0.2172	******	******	******	******
X 5	0.3160	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	184.82	191.00	196.47	202.15
X 1	******	0.0227	0.0096	0.0039	0.0016
X 2	******	0.1242	0.0991	0.0759	0.0557
X 3	******	0.3366	0.3445	0.3370	0.3152
X 4	******	0.2004	0.2145	0.2315	0.2521
X 5	******	0.3160	0.3323	0.3517	0.3755

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	208.47	215.48	222.87	230.17	236.87
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0392	0.0264	0.0169	0.0104	0.0062
X 3	0.2812	0.2386	0.1925	0.1480	0.1090
X 4	0.2756	0.3006	0.3246	0.3452	0.3607
X 5	0.4035	0.4344	0.4661	0.4965	0.5241

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.63	247.36	251.35	254.36	245.14
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0036	0.0020	0.0011	0.0005	0.0003
X 3	0.0772	0.0527	0.0345	0.0215	0.0124
X 4	0.3704	0.3739	0.3707	0.3616	0.3460
X 5	0.5489	0.5714	0.5924	0.6150	0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 35

329.

PETROLEUM FRACTION DATA

```
 1.0000 100.0     3.0       55.0      45.0                          6         3
    4
 2.0000 0.1818    0.0       0.10
 3.0000 0.2727    0.0       0.15
 4.0000 0.5091    0.0444    0.30
 5.0000 0.0364    0.5111    0.25
 6.0000 0.0       0.3333    0.15
 7.0000 0.0       0.1111    0.05
 8.0000 100.0
 9.0000 3.4
10.0000 1.71
11.0000 0.847
12.0000 0.425
13.0000 0.213
14.0000 0.127
15.0000 120.0
16.0000 5.6
17.0000 2.8
18.0000 1.4
19.0000 0.7
20.0000 0.35
21.0000 0.21
22.0000 140.0
23.0000 8.0
24.0000 4.0
25.0000 2.0
26.0000 1.0
27.0000 0.5
28.0000 0.3
29.0000 160.0
30.0000 10.46
31.0000 5.25
32.0000 2.61
33.0000 1.31
34.0000 0.655
35.0000 0.392
36.0000 180.0
37.0000 12.88
38.0000 6.46
39.0000 3.21
40.0000 1.61
41.0000 0.807
42.0000 0.483
43.0000 110.0     170.0     760.0     0.0       0.0       760.0

44.
```

Figure 3
Hengstebeck, L-M Program

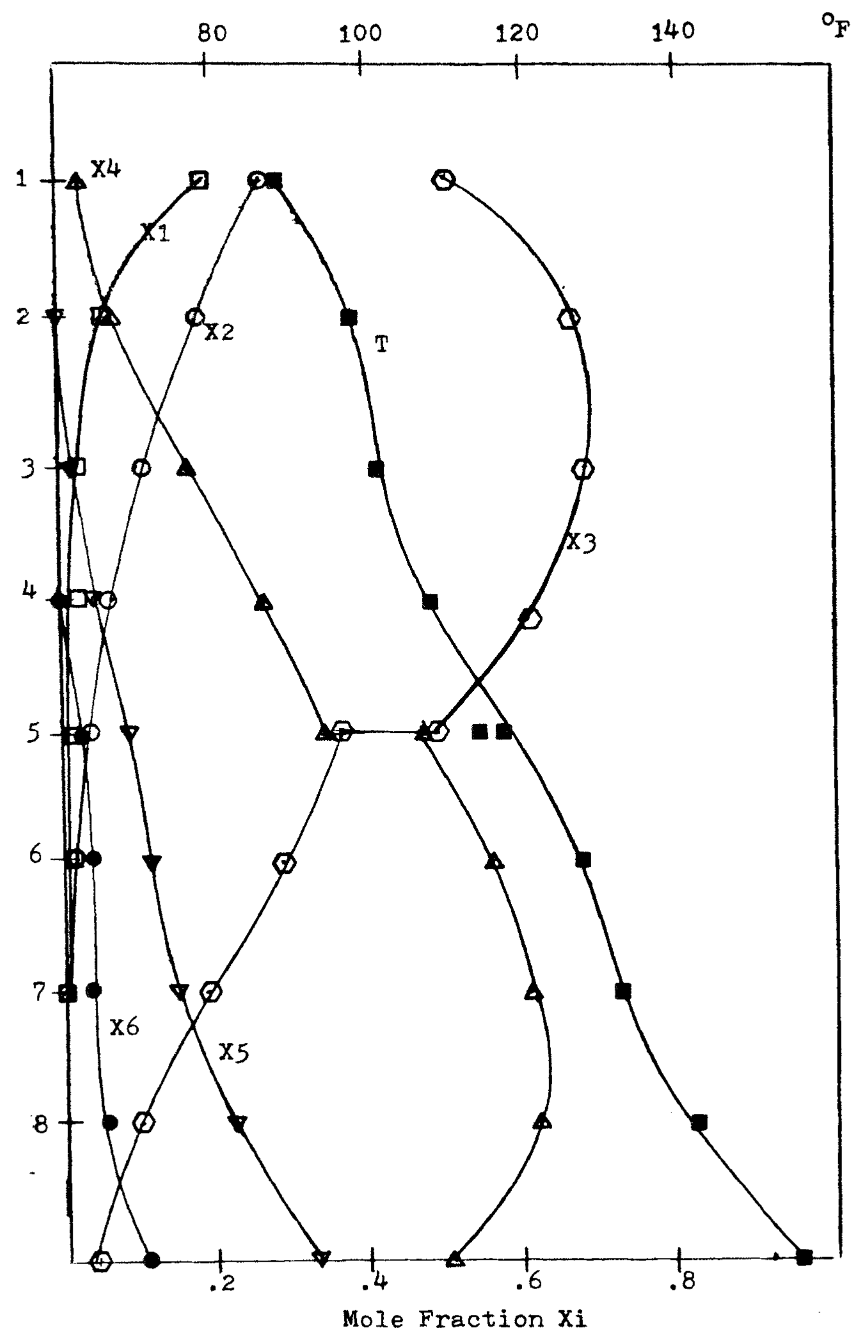
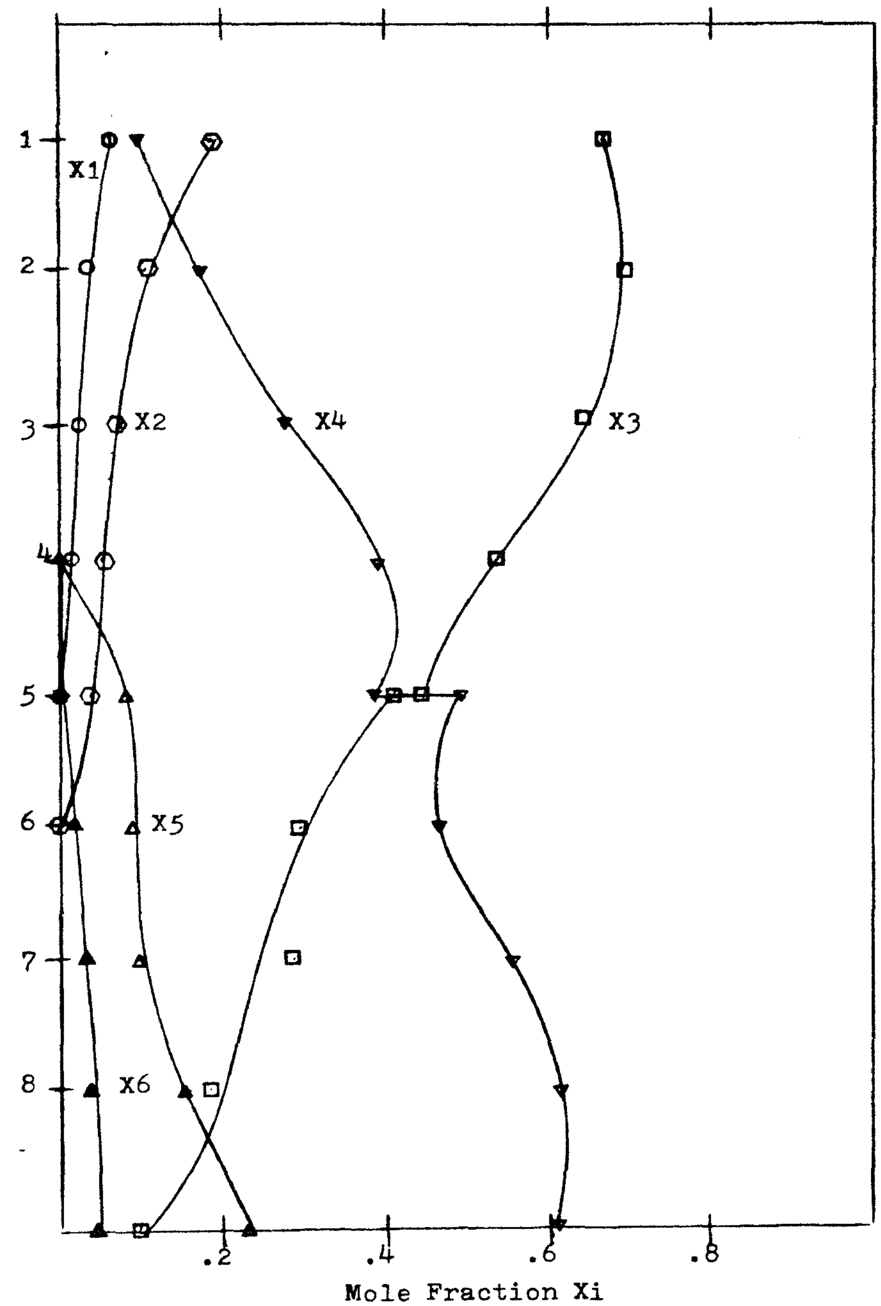


Figure 4
Hengstebeck, Literature



PETROLEUM FRACTIONS

FASTFOR (CONVERSATIONAL, VER 9)

1	0.9999928
2	0.9999855
3	1.0000030
4	1.0000080
5	1.0000100
6	1.0000110

F= 100.00000 D= 55.02902 B= 44.97098
R= 3.00000 N= 6
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	760.000	760.000	760.000	760.000	760.000
T(F)	87.58	96.69	102.85	107.71	113.58
X 1	0.1817	0.0592	0.0243	0.0151	0.0117
X 2	0.2722	0.1769	0.1083	0.0707	0.0496
X 3	0.5089	0.6649	0.6791	0.6055	0.4789
X 4	0.0364	0.0950	0.1740	0.2650	0.3418
X 5	0.0007	0.0038	0.0131	0.0379	0.0940
X 6	0.0000	0.0002	0.0012	0.0058	0.0240

FEED STAGE= 5

STAGE	5	6	7	8	9
P(PSIA)	760.000	760.000	760.000	760.000	760.000
T(F)	116.58	125.71	133.99	143.17	156.07
X 1	0.0117	0.0022	0.0004	0.0001	0.0000
X 2	0.0496	0.0190	0.0062	0.0018	0.0004
X 3	0.3705	0.2792	0.1803	0.0993	0.0444
X 4	0.4501	0.5579	0.6240	0.6166	0.5114
X 5	0.0941	0.1155	0.1563	0.2289	0.3327
X 6	0.0240	0.0263	0.0328	0.0534	0.1112

NUMBER OF STAGES= 9
NUMBER OF TRIALS= 13

329.

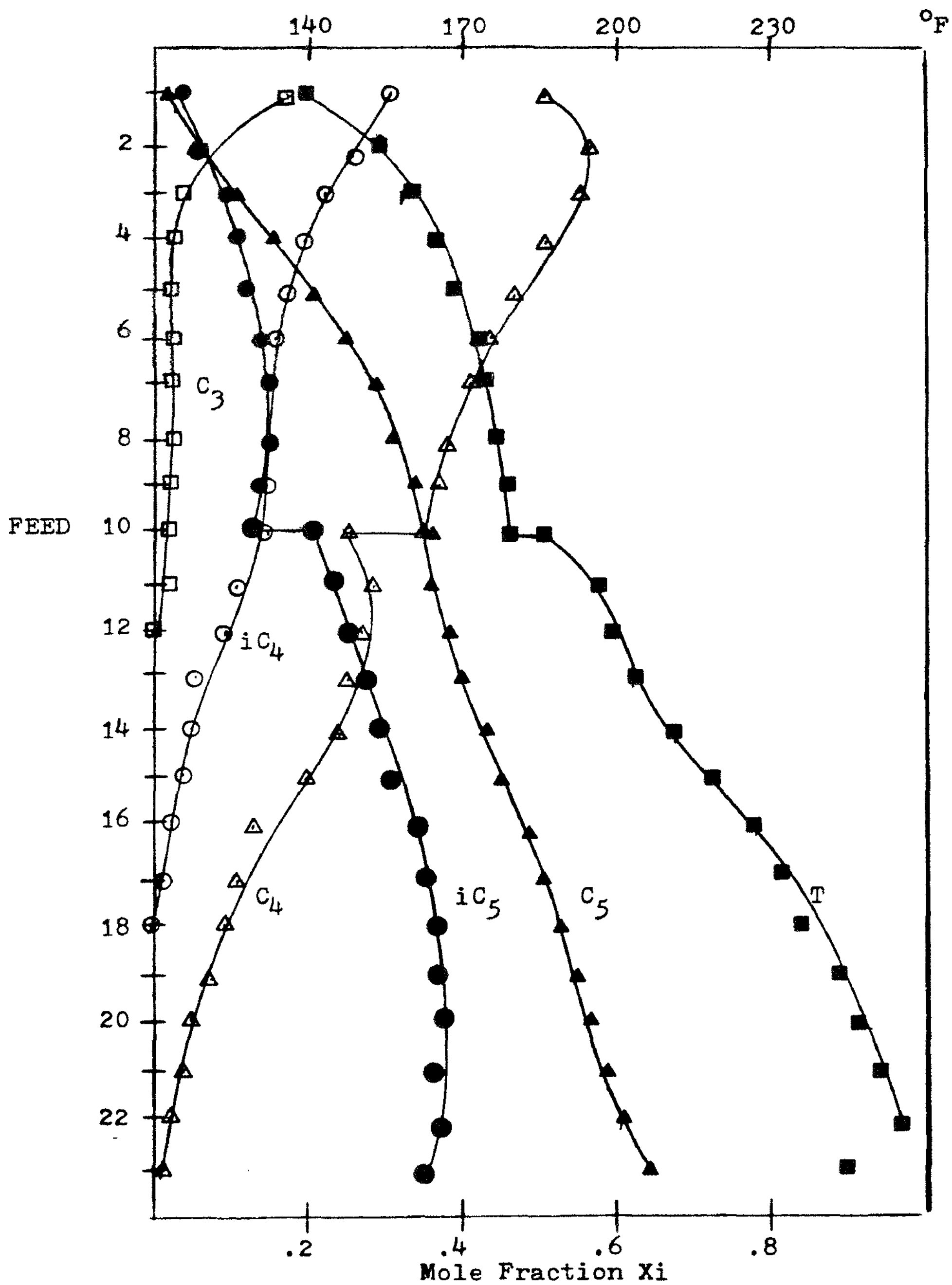
APPENDIX C

CHANGE OF REFLUX DATA, RESULTS

BUTANE PROPANE SPLITTER DATA: R=1.0

```
 1.0000   65.716    1.000    34.369    31.347        5        3
    4
 2.0000 .1385     .00004    .07246
 3.0000 .3149     .00068    .16486
 4.0000 .5146     .01239    .2750
 5.0000 .02355    .34588    .17729
 6.0000 .0085     .64108    .31024
 7.0000 148.0
 8.0000 2.41
 9.0000 1.18
10.0000 0.88
11.0000 0.422
12.0000 0.342
13.0000 176.0
14.0000 3.0
15.0000 1.54
16.0000 1.18
17.0000 0.57
18.0000 0.475
19.0000 200.0
20.0000 3.51
21.0000 1.87
22.0000 1.43
23.0000 0.715
24.0000 0.63
25.0000 220.0
26.0000 4.01
27.0000 2.21
28.0000 1.73
29.0000 0.90
30.0000 0.78
31.0000 243.0
32.0000 4.6
33.0000 2.61
34.0000 2.10
35.0000 1.1
36.0000 0.96
37.0000 148.0'   243.0    120.0    2.5      0.217    120.0

38.
```

Figure 5
C4-C5 Splitter, R=1.0



BUTANE PROPANE SPLITTER: R=1.0

FASTFOR (CONVERSATIONAL, VER 9)

1	0.9903304
2	0.9898047
3	0.9859442
4	0.9821548
5	0.9892838

F= 65.71600 D= 34.87724 B= 30.83876
R= 1.00000 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	139.50	152.90	159.61	164.61	168.89
X 1	0.1365	0.0561	0.0371	0.0320	0.0299
X 2	0.3103	0.2588	0.2190	0.1928	0.1754
X 3	0.5072	0.5663	0.5491	0.5091	0.4668
X 4	0.0236	0.0551	0.0835	0.1062	0.1221
X 5	0.0224	0.0642	0.1113	0.1600	0.2057

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	172.48	175.36	177.58	179.23	180.46
X 1	0.0288	0.0280	0.0274	0.0270	0.0268
X 2	0.1635	0.1553	0.1497	0.1459	0.1433
X 3	0.4307	0.4029	0.3827	0.3687	0.3591
X 4	0.1313	0.1352	0.1353	0.1331	0.1297
X 5	0.2457	0.2787	0.3049	0.3253	0.3412

FEED STAGE= 10

STAGE	9	10	11	12	13
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	186.36	193.46	199.59	205.63
X 1	******	0.0267	0.0115	0.0048	0.0019
X 2	******	0.1433	0.1163	0.0902	0.0671
X 3	******	0.2685	0.2780	0.2741	0.2580
X 4	******	0.2199	0.2349	0.2519	0.2712
X 5	******	0.3414	0.3592	0.3790	0.4018

STAGE	14	15	16	17	18
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	211.99	218.68	225.47	232.01	237.96
X 1	0.0008	0.0003	0.0001	0.0000	0.0000
X 2	0.0478	0.0326	0.0214	0.0135	0.0083
X 3	0.2319	0.1990	0.1631	0.1281	0.0967
X 4	0.2924	0.3141	0.3345	0.3520	0.3654
X 5	0.4272	0.4542	0.4810	0.5065	0.5298

STAGE	19	20	21	22	23
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	243.10	247.39	251.08	253.95	245.05
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0049	0.0028	0.0016	0.0008	0.0004
X 3	0.0703	0.0493	0.0332	0.0212	0.0124
X 4	0.3739	0.3773	0.3746	0.3663	0.3512
X 5	0.5509	0.5706	0.5894	0.6105	0.6357

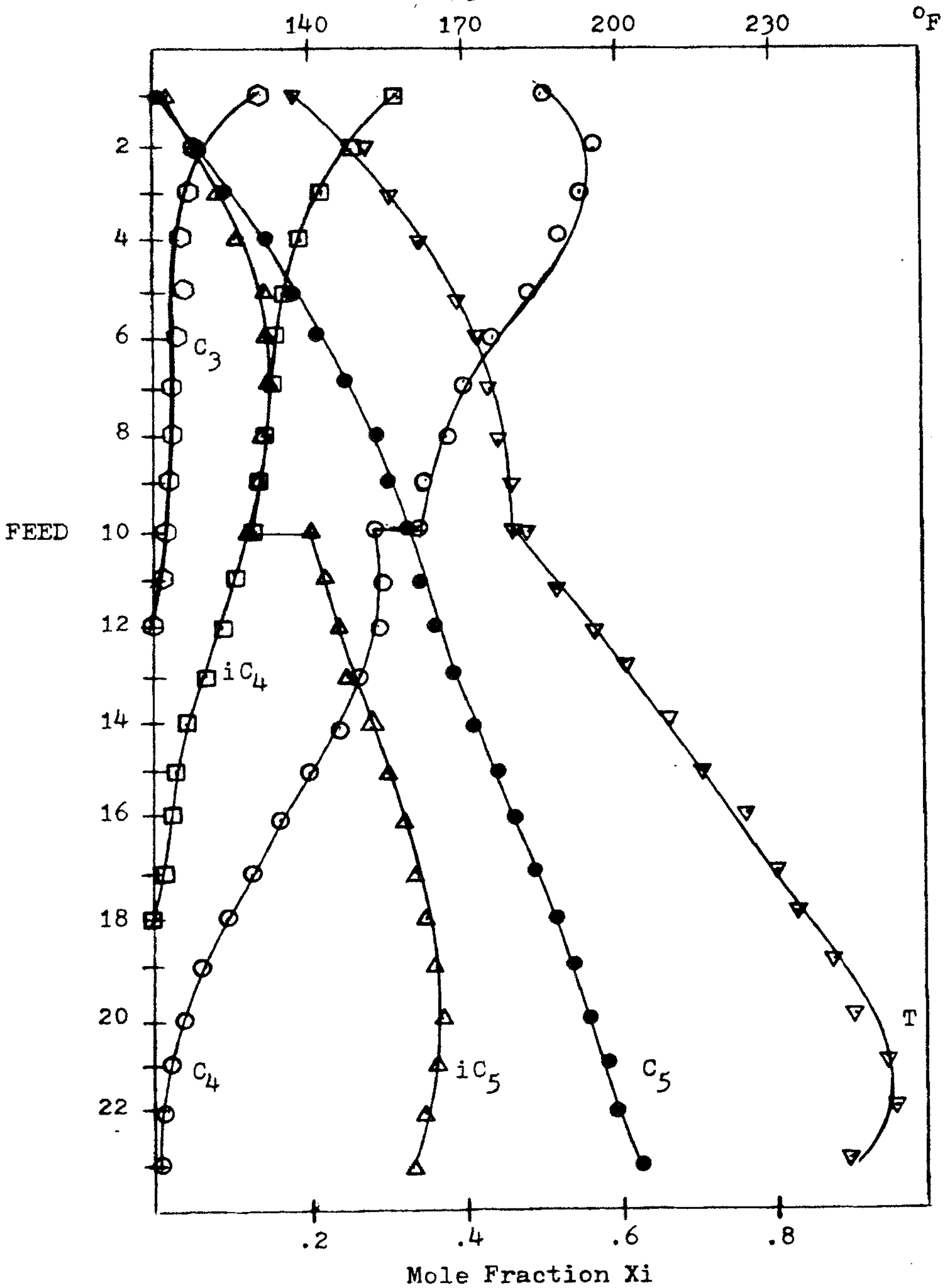
```
NUMBER OF STAGES=23
NUMBER OF TRIALS= 29

329.
```

BUTANE PROPANE SPLITTER DATA: R=1.1

1.0000	65.716	1.100	34.369	31.347	5	3	4
2.0000	.1385	.00004	.07246				
3.0000	.3149	.00068	.16486				
4.0000	.5146	.01239	.2750				
5.0000	.02355	.34588	.17729				
6.0000	.0085	.64108	.31024				
7.0000	148.0						
8.0000	2.41						
9.0000	1.18						
10.0000	0.88						
11.0000	0.422						
12.0000	0.342						
13.0000	176.0						
14.0000	3.0						
15.0000	1.54						
16.0000	1.18						
17.0000	0.57						
18.0000	0.475						
19.0000	200.0						
20.0000	3.51						
21.0000	1.87						
22.0000	1.43						
23.0000	0.715						
24.0000	0.63						
25.0000	220.0						
26.0000	4.01						
27.0000	2.21						
28.0000	1.73						
29.0000	0.90						
30.0000	0.78						
31.0000	243.0						
32.0000	4.6						
33.0000	2.61						
34.0000	2.10						
35.0000	1.1						
36.0000	0.96						
37.0000	148.0	243.0	120.0	2.5	0.217	120.0	
38.							

Figure 6

C4-C5 Splitter, R=1.1



BUTANE PROPANE SPLITTER: R=1.1

FASTFOR (CONVERSATIONAL, VER 9)

1	0.9903304
2	0.9898047
3	0.9859442
4	0.9821548
5	0.9892838

F= 65.71600 D= 34.69183 B= 31.02417
R= 1.10000 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	139.24	152.18	158.67	163.64	168.10
X 1	0.1373	0.0568	0.0369	0.0315	0.0293
X 2	0.3120	0.2626	0.2226	0.1953	0.1763
X 3	0.5098	0.5750	0.5632	0.5244	0.4797
X 4	0.0236	0.0557	0.0869	0.1141	0.1349
X 5	0.0174	0.0503	0.0903	0.1347	0.1798

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	172.07	175.41	178.08	180.13	181.68
X 1	0.0280	0.0271	0.0264	0.0259	0.0256
X 2	0.1629	0.1533	0.1465	0.1417	0.1384
X 3	0.4389	0.4059	0.3811	0.3633	0.3508
X 4	0.1484	0.1552	0.1568	0.1549	0.1509
X 5	0.2218	0.2586	0.2893	0.3142	0.3343

FEED STAGE= 10

STAGE	9	10	11	12	13
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	185.85	192.69	198.64	204.59
X 1	******	0.0256	0.0110	0.0045	0.0018
X 2	******	0.1384	0.1118	0.0863	0.0639
X 3	******	0.2873	0.2965	0.2916	0.2739
X 4	******	0.2141	0.2288	0.2458	0.2655
X 5	******	0.3345	0.3519	0.3717	0.3948

STAGE	14	15	16	17	18
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	210.94	217.73	224.70	231.45	237.60
X 1	0.0007	0.0003	0.0001	0.0000	0.0000
X 2	0.0454	0.0308	0.0201	0.0126	0.0076
X 3	0.2456	0.2099	0.1712	0.1336	0.1001
X 4	0.2874	0.3100	0.3313	0.3497	0.3636
X 5	0.4210	0.4491	0.4774	0.5042	0.5287

STAGE	19	20	21	22	23
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.91	247.32	251.09	253.99	245.10
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0045	0.0026	0.0014	0.0007	0.0004
X 3	0.0723	0.0503	0.0335	0.0213	0.0124
X 4	0.3725	0.3759	0.3730	0.3645	0.3492
X 5	0.5508	0.5713	0.5907	0.6123	0.6377

NUMBER OF STAGES=23
NUMBER OF TRIALS= 28

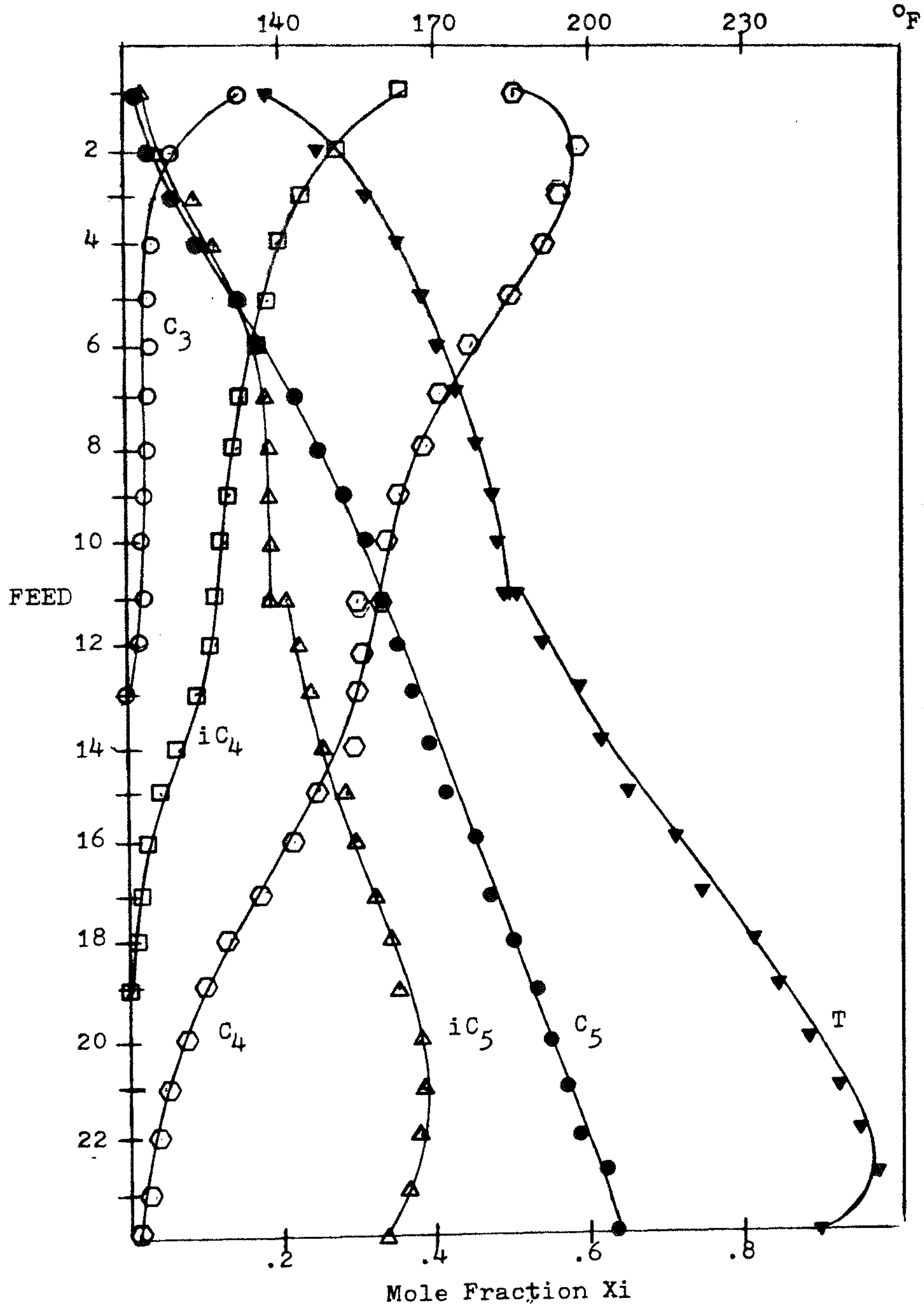
329.

BUTANE PROPANE SPLITTER DATA: R=1.2

-

1.0000	65.716	1.200	34.369	31.347		5	3
4							
2.0000	.1385	.00004	.07246				
3.0000	.3149	.00068	.16486				
4.0000	.5146	.01239	.2750				
5.0000	.02355	.34588	.17729				
6.0000	.0085	.64108	.31024				
7.0000	148.0						
8.0000	2.41						
9.0000	1.18						
10.0000	0.88						
11.0000	0.422						
12.0000	0.342						
13.0000	176.0						
14.0000	3.0						
15.0000	1.54						
16.0000	1.18						
17.0000	0.57						
18.0000	0.475						
19.0000	200.0						
20.0000	3.51						
21.0000	1.87						
22.0000	1.43						
23.0000	0.715						
24.0000	0.63						
25.0000	220.0						
26.0000	4.01						
27.0000	2.21						
28.0000	1.73						
29.0000	0.90						
30.0000	0.78						
31.0000	243.0						
32.0000	4.6						
33.0000	2.61						
34.0000	2.10						
35.0000	1.1						
36.0000	0.96						
37.0000	148.0	243.0	120.0	2.5	0.217	120.0	
38.							

Figure 7
C4-C5 Splitter, R=1.2



BUTANE PROPANE SPLITTER: R=1.2

FASTFOR (CONVERSATIONAL. VER 9)

1	0.9903304
2	0.9898047
3	0.9859442
4	0.9821548
5	0.9892838

F= 65.71600 D= 34.49902 B= 31.21698
R= 1.20000 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.98	151.41	157.56	162.30	166.73
X 1	0.1380	0.0576	0.0370	0.0312	0.0289
X 2	0.3138	0.2668	0.2272	0.1992	0.1792
X 3	0.5126	0.5844	0.5796	0.5443	0.4990
X 4	0.0236	0.0564	0.0906	0.1232	0.1506
X 5	0.0120	0.0353	0.0657	0.1021	0.1422

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.89	174.60	177.71	180.20	182.13
X 1	0.0275	0.0265	0.0257	0.0251	0.0247
X 2	0.1645	0.1534	0.1453	0.1395	0.1353
X 3	0.4546	0.4166	0.3866	0.3642	0.3482
X 4	0.1708	0.1829	0.1880	0.1878	0.1839
X 5	0.1827	0.2206	0.2544	0.2834	0.3078

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	183.61	******	******	******	******
X 1	0.0244	******	******	******	******
X 2	0.1324	******	******	******	******
X 3	0.3368	******	******	******	******
X 4	0.1780	******	******	******	******
X 5	0.3283	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	185.69	192.28	198.06	203.91
X 1	******	0.0244	0.0104	0.0043	0.0017
X 2	******	0.1324	0.1064	0.0818	0.0604
X 3	******	0.3058	0.3144	0.3083	0.2890
X 4	******	0.2088	0.2233	0.2403	0.2603
X 5	******	0.3285	0.3455	0.3653	0.3887

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	210.26	217.13	224.25	231.20	237.55
X 1	0.0007	0.0002	0.0001	0.0000	0.0000
X 2	0.0427	0.0289	0.0187	0.0117	0.0070
X 3	0.2585	0.2202	0.1789	0.1388	0.1033
X 4	0.2827	0.3060	0.3283	0.3473	0.3618
X 5	0.4156	0.4447	0.4742	0.5023	0.5279

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	243.02	247.54	251.40	254.34	245.10
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0041	0.0023	0.0013	0.0007	0.0003
X 3	0.0741	0.0511	0.0339	0.0214	0.0124
X 4	0.3709	0.3743	0.3713	0.3626	0.3472
X 5	0.5510	0.5722	0.5922	0.6141	0.6398

NUMBER OF STAGES=24
NUMBER OF TRIALS= 26

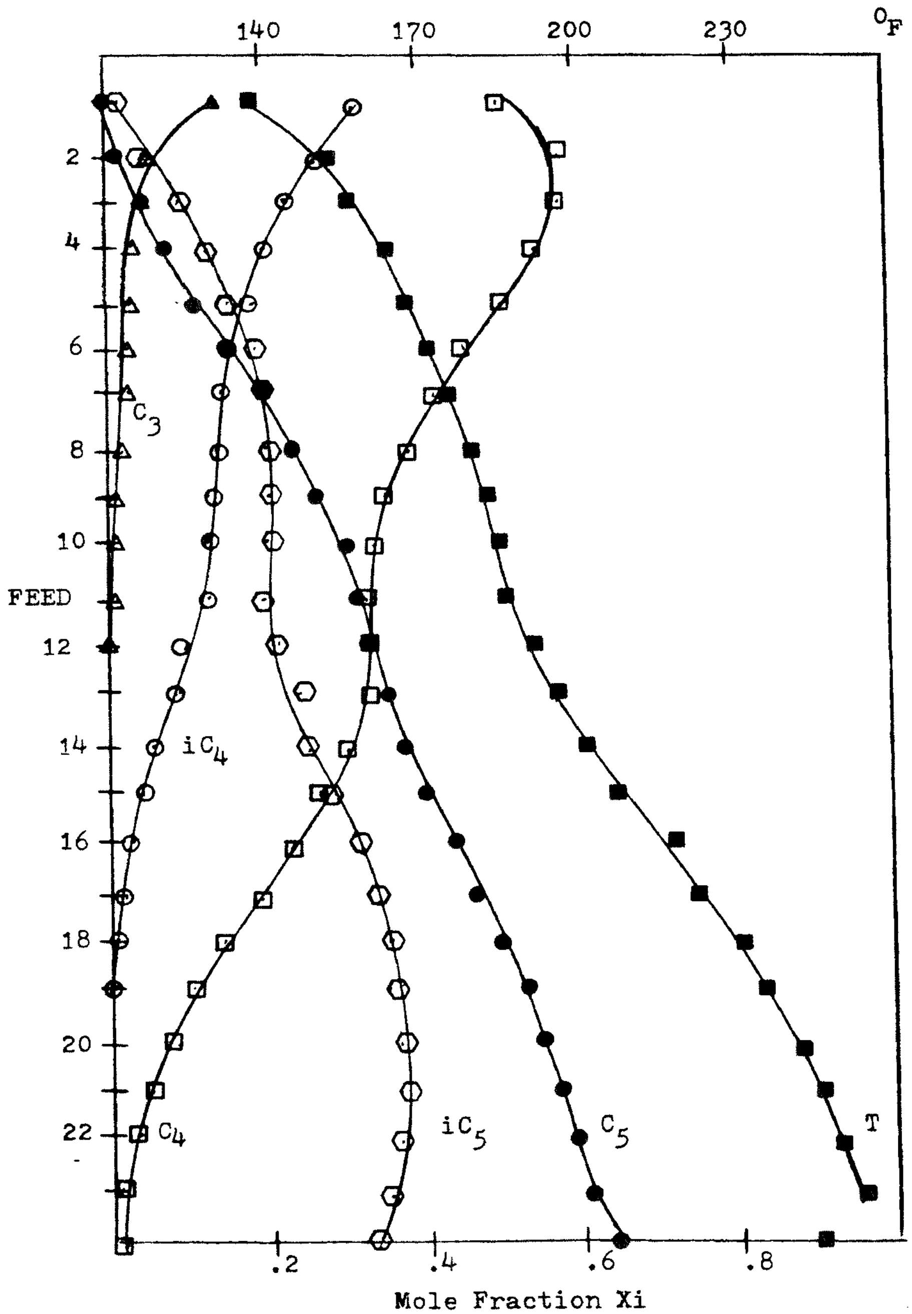
329.

BUTANE PROPANE SPLITTER DATA: R=1.3

1.0000	65.716	1.300	34.369	31.347		5	3
4							
2.0000	.1385	.00004	.07246				
3.0000	.3149	.00068	.16486				
4.0000	.5146	.01239	.2750				
5.0000	.02355	.34588	.17729				
6.0000	.0085	.64108	.31024				
7.0000	148.0						
8.0000	2.41						
9.0000	1.18						
10.0000	0.88						
11.0000	0.422						
12.0000	0.342						
13.0000	176.0						
14.0000	3.0						
15.0000	1.54						
16.0000	1.18						
17.0000	0.57						
18.0000	0.475						
19.0000	200.0						
20.0000	3.51						
21.0000	1.87						
22.0000	1.43						
23.0000	0.715						
24.0000	0.63						
25.0000	220.0						
26.0000	4.01						
27.0000	2.21						
28.0000	1.73						
29.0000	0.90						
30.0000	0.78						
31.0000	243.0						
32.0000	4.6						
33.0000	2.61						
34.0000	2.10						
35.0000	1.1						
36.0000	0.96						
37.0000	148.0	243.0	120.0	2.5	0.217	120.0	

38.

Figure 8
C4-C5 Splitter, R=1.3



BUTANE PROPANE SPLITTER: R=1.3

FASTFOR (CONVERSATIONAL, VER 9)

1	0.9903304
2	0.9898047
3	0.9859442
4	0.9821548
5	0.9892838

F=	65.71600	D=	34.41406	B=	31.30194
R=	1.30000	N=	5		
KEY1=	3	KEY2=	4		

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.86	151.06	157.14	161.87	166.41
X 1	0.1384	0.0579	0.0366	0.0305	0.0281
X 2	0.3146	0.2687	0.2287	0.1998	0.1787
X 3	0.5139	0.5887	0.5874	0.5534	0.5068
X 4	0.0236	0.0567	0.0930	0.1294	0.1619
X 5	0.0097	0.0285	0.0543	0.0868	0.1244

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.82	174.86	178.34	181.17	183.39
X 1	0.0266	0.0256	0.0247	0.0241	0.0236
X 2	0.1628	0.1507	0.1417	0.1351	0.1304
X 3	0.4593	0.4172	0.3833	0.3577	0.3391
X 4	0.1873	0.2038	0.2120	0.2134	0.2099
X 5	0.1640	0.2027	0.2383	0.2698	0.2970

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.10	******	******	******	******
X 1	0.0233	******	******	******	******
X 2	0.1271	******	******	******	******
X 3	0.3259	******	******	******	******
X 4	0.2033	******	******	******	******
X 5	0.3203	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	185.13	191.45	197.03	202.77
X 1	******	0.0233	0.0099	0.0040	0.0016
X 2	******	0.1271	0.1017	0.0779	0.0573
X 3	******	0.3257	0.3338	0.3268	0.3059
X 4	******	0.2033	0.2176	0.2346	0.2549
X 5	******	0.3204	0.3370	0.3566	0.3803

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	209.11	216.07	223.37	230.54	237.11
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0404	0.0272	0.0175	0.0108	0.0065
X 3	0.2731	0.2320	0.1876	0.1448	0.1070
X 4	0.2781	0.3025	0.3258	0.3459	0.3611
X 5	0.4079	0.4382	0.4691	0.4986	0.5256

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.77	247.43	251.37	254.36	245.13
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0037	0.0021	0.0011	0.0006	0.0003
X 3	0.0761	0.0521	0.0343	0.0215	0.0124
X 4	0.3705	0.3740	0.3708	0.3619	0.3463
X 5	0.5497	0.5718	0.5924	0.6148	0.6407

NUMBER OF STAGES=24
NUMBER OF TRIALS= 25

329.

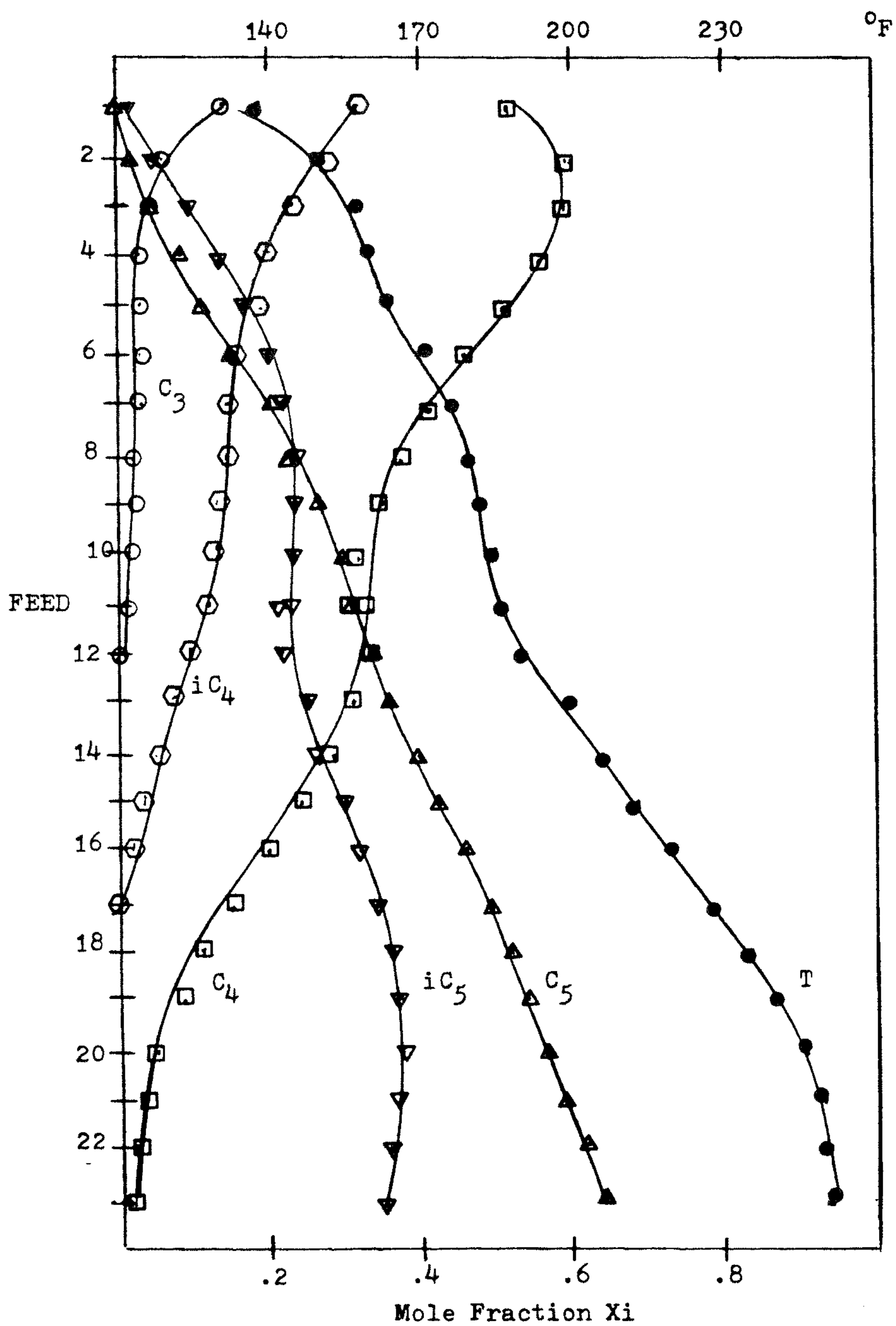
BUTANE PROPANE SPLITTER DATA: R=1.4

1.0000	65.716	1.400	34.369	31.347	5	3
4						
2.0000	.1385	.00004	.07246			
3.0000	.3149	.00068	.16486			
4.0000	.5146	.01239	.2750			
5.0000	.02355	.34588	.17729			
6.0000	.0085	.64108	.31024			
7.0000	148.0					
8.0000	2.41					
9.0000	1.18					
10.0000	0.88					
11.0000	0.422					
12.0000	0.342					
13.0000	176.0					
14.0000	3.0					
15.0000	1.54					
16.0000	1.18					
17.0000	0.57					
18.0000	0.475					
19.0000	200.0					
20.0000	3.51					
21.0000	1.87					
22.0000	1.43					
23.0000	0.715					
24.0000	0.63					
25.0000	220.0					
26.0000	4.01					
27.0000	2.21					
28.0000	1.73					
29.0000	0.90					
30.0000	0.78					
31.0000	243.0					
32.0000	4.6					
33.0000	2.61					
34.0000	2.10					
35.0000	1.1					
36.0000	0.96					
37.0000	148.0	243.0	120.0	2.5	0.217	120.0

38.

Figure 9

C4-C5 Splitter, R=1.4



BUTANE PROPANE SPLITTER: R=1.4

FASTFOR (CONVERSATIONAL, VER 9)

1	0.9903304
2	0.9898047
3	0.9859442
4	0.9821548
5	0.9892838

F= 65.71600 D= 34.37050 B= 31.34550
R= 1.40000 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.80	150.90	157.01	161.84	166.58
X 1	0.1385	0.0581	0.0362	0.0298	0.0272
X 2	0.3149	0.2696	0.2290	0.1990	0.1767
X 3	0.5145	0.5909	0.5914	0.5575	0.5091
X 4	0.0236	0.0569	0.0947	0.1341	0.1706
X 5	0.0085	0.0251	0.0488	0.0797	0.1165

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	171.28	175.67	179.48	182.61	185.06
X 1	0.0257	0.0245	0.0237	0.0230	0.0225
X 2	0.1596	0.1467	0.1369	0.1298	0.1248
X 3	0.4582	0.4125	0.3754	0.3473	0.3270
X 4	0.2000	0.2200	0.2305	0.2330	0.2297
X 5	0.1564	0.1963	0.2335	0.2669	0.2960

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	186.95	******	******	******	******
X 1	0.0222	******	******	******	******
X 2	0.1213	******	******	******	******
X 3	0.3127	******	******	******	******
X 4	0.2226	******	******	******	******
X 5	0.3213	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	124.453	124.670	124.887
T(F)	******	******	185.84	192.82	199.32
X 1	******	******	0.0222	0.0092	0.0037
X 2	******	******	0.1213	0.0949	0.0707
X 3	******	******	0.3289	0.3295	0.3131
X 4	******	******	0.2065	0.2245	0.2460
X 5	******	******	0.3211	0.3418	0.3666

STAGE	14	15	16	17	18
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	206.15	213.55	221.32	228.96	235.96
X 1	0.0014	0.0005	0.0002	0.0001	0.0000
X 2	0.0502	0.0339	0.0219	0.0135	0.0080
X 3	0.2823	0.2412	0.1953	0.1504	0.1107
X 4	0.2706	0.2967	0.3219	0.3436	0.3600
X 5	0.3957	0.4278	0.4610	0.4927	0.5215

STAGE	19	20	21	22	23
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	241.96	246.87	250.71	252.60	255.97
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0046	0.0025	0.0014	0.0007	0.0003
X 3	0.0782	0.0532	0.0348	0.0217	0.0124
X 4	0.3701	0.3739	0.3713	0.3644	0.3459
X 5	0.5471	0.5703	0.5926	0.6199	0.6411

NUMBER OF STAGES=23
NUMBER OF TRIALS= 40

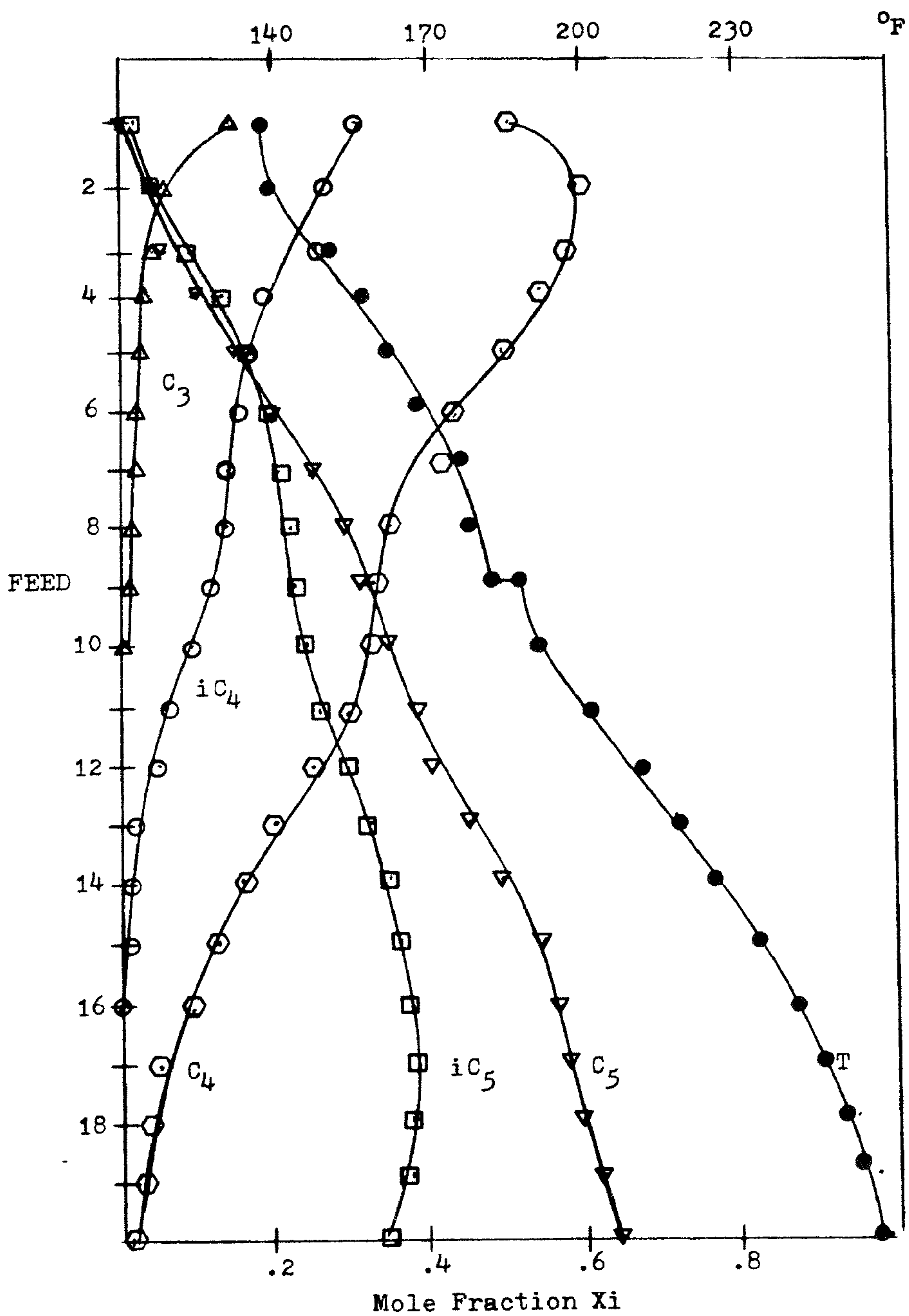
329.

BUTANE PROPANE SPLITTER DATA: R=1.5

```
 1.0000   65.716     1.500    34.369    31.347          5         3
   4
 2.0000 .1385     .00004    .07246
 3.0000 .3149     .00068    .16486
 4.0000 .5146     .01239    .2750
 5.0000 .02355    .34588    .17729
 6.0000 .0085     .64108    .31024
 7.0000 148.0
 8.0000 2.41
 9.0000 1.18
10.0000 0.88
11.0000 0.422
12.0000 0.342
13.0000 176.0
14.0000 3.0
15.0000 1.54
16.0000 1.19
17.0000 0.57
18.0000 0.475
19.0000 200.0
20.0000 3.51
21.0000 1.87
22.0000 1.43
23.0000 0.715
24.0000 0.63
25.0000 220.0
26.0000 4.01
27.0000 2.21
28.0000 1.73
29.0000 0.90
30.0000 0.78
31.0000 243.0
32.0000 4.6
33.0000 2.61
34.0000 2.10
35.0000 1.1
36.0000 0.96
37.0000 148.0     243.0     120.0     2.5       0.217     120.0

38.
```

Figure 10

C4-C5 Splitter, R=1.5



BUTANE PROPANE SPLITTER: R=1.5

FASTFOR (CONVERSATIONAL, VER 9)

1	0.9903304
2	0.9898047
3	0.9859442
4	0.9821548
5	0.9892838

F= 65.71600 D= 34.46036 B= 31.25565
R= 1.50000 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.93	151.27	157.89	163.36	168.83
X 1	0.1382	0.0577	0.0352	0.0284	0.0257
X 2	0.3140	0.2675	0.2247	0.1924	0.1682
X 3	0.5132	0.5863	0.5826	0.5428	0.4882
X 4	0.0236	0.0565	0.0943	0.1332	0.1682
X 5	0.0111	0.0325	0.0632	0.1032	0.1497

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	********
T(F)	174.20	179.11	183.25	186.51	******
X 1	0.0241	0.0229	0.0221	0.0214	******
X 2	0.1499	0.1364	0.1267	0.1199	******
X 3	0.4325	0.3843	0.3466	0.3192	******
X 4	0.1950	0.2114	0.2181	0.2175	******
X 5	0.1985	0.2451	0.2867	0.3222	******

FEED STAGE= 9

STAGE	6	7	8	9	10
P(PSIA)	********	********	********	124.019	124.236
T(F)	******	******	******	186.13	194.07
X 1	******	******	******	0.0214	0.0087
X 2	******	******	******	0.1199	0.0914
X 3	******	******	******	0.3245	0.3166
X 4	******	******	******	0.2122	0.2352
X 5	******	******	******	0.3220	0.3482

STAGE	11	12	13	14	15
P(PSIA)	124.453	124.670	124.887	125.104	125.321
T(F)	201.75	209.80	218.18	226.43	233.97
X 1	0.0034	0.0013	0.0004	0.0002	0.0001
X 2	0.0658	0.0448	0.0289	0.0178	0.0105
X 3	0.2903	0.2505	0.2037	0.1568	0.1148
X 4	0.2617	0.2901	0.3178	0.3418	0.3599
X 5	0.3790	0.4135	0.4493	0.4837	0.5149

STAGE	16	17	18	19	20
P(PSIA)	125.538	125.755	125.972	126.189	126.406
T(F)	240.40	245.61	249.64	251.73	255.06
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0059	0.0033	0.0017	0.0009	0.0004
X 3	0.0806	0.0544	0.0352	0.0218	0.0124
X 4	0.3711	0.3752	0.3727	0.3654	0.3468
X 5	0.5425	0.5670	0.5904	0.6180	0.6401

```
NUMBER OF STAGES=20
NUMBER OF TRIALS= 25

329.
```

APPENDIX D

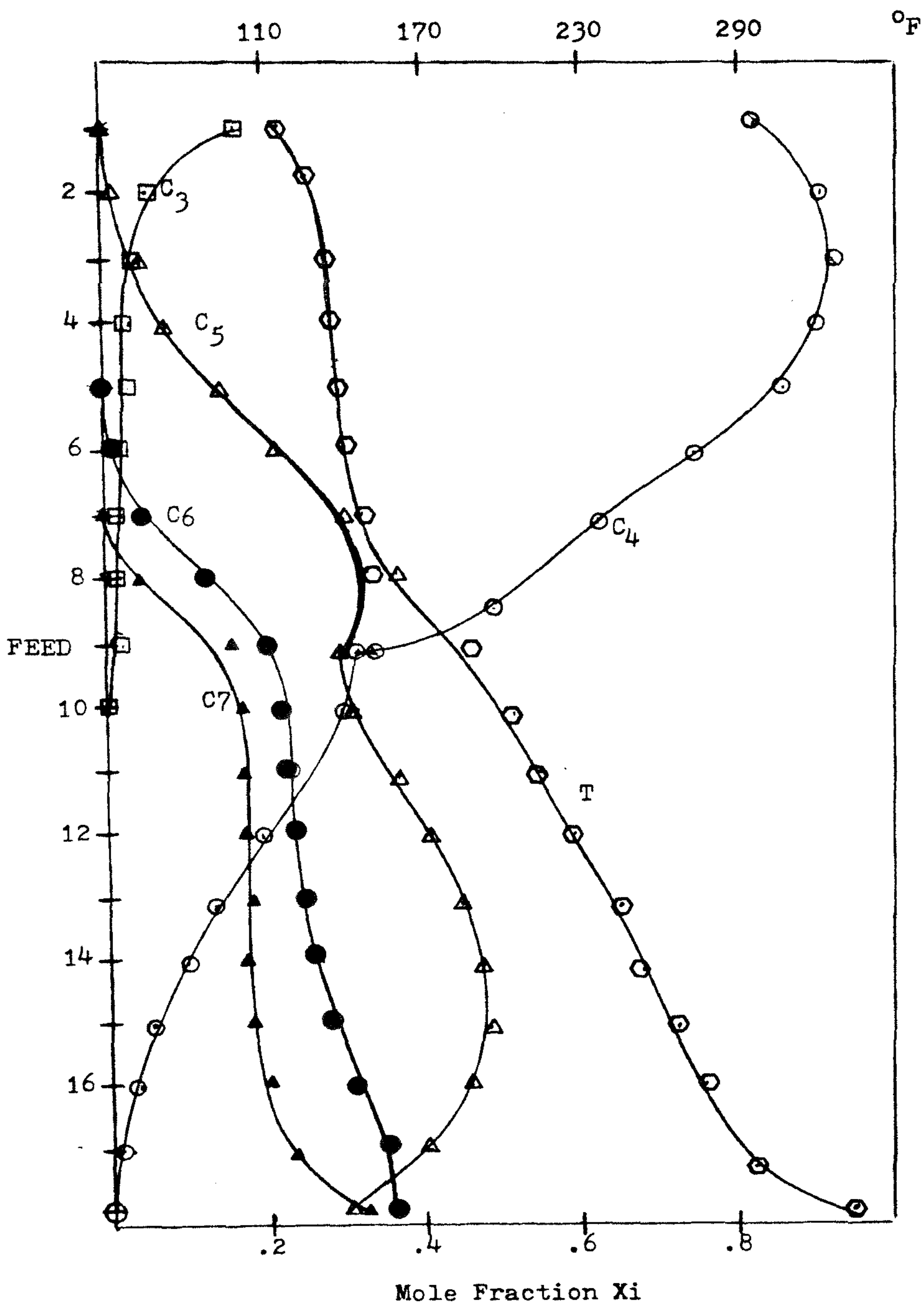
DISTL COMPARISON

DEBUTANIZER DATA

1.0000	1000.0	2.0	297.1	702.9		5	2
3							
2.0000	0.16829	0.0	0.05				
3.0000	0.82464	0.00711	0.25				
4.0000	0.00707	0.29577	0.21				
5.0000	0.0	0.36990	0.26				
6.0000	0.0	0.32722	0.230				
7.0000	100.0						
8.0000	1.8						
9.0000	0.57						
10.0000	0.198						
11.0000	0.074						
12.0000	0.0285						
13.0000	150.0						
14.0000	2.93						
15.0000	1.07						
16.0000	0.41						
17.0000	0.179						
18.0000	0.076						
19.0000	200.0						
20.0000	4.21						
21.0000	1.76						
22.0000	0.75						
23.0000	0.348						
24.0000	0.161						
25.0000	250.0						
26.0000	5.78						
27.0000	2.68						
28.0000	1.21						
29.0000	0.62						
30.0000	0.318						
31.0000	300.0						
32.0000	7.45						
33.0000	3.8						
34.0000	1.9						
35.0000	1.03						
36.0000	0.55						
37.0000	120.0	292.0	100.0	2.0	0.2	100.0	

38.

Figure 11
Debutanizer, L-M Program



DEBUTANIZER

FASTFOR (CONVERSATIONAL. VER 9)

1	0.9626661
2	0.9589094
3	0.9545148
4	0.9580695
5	0.9564800

F=1000.00000 D= 297.10490 B= 702.89500
R= 2.00000 N= 5
KEY1= 2 KEY2= 3

STAGE	1	2	3	4	5
P(PSIA)	100.000	102.000	102.200	102.400	102.600
T(F)	116.90	127.69	131.70	134.28	137.46
X 1	0.1683	0.0662	0.0376	0.0296	0.0268
X 2	0.8246	0.9132	0.9180	0.8866	0.8272
X 3	0.0071	0.0208	0.0441	0.0826	0.1413
X 4	0.0000	0.0001	0.0003	0.0012	0.0046
X 5	0.0000	0.0000	0.0000	0.0000	0.0001

STAGE	6	7	8	9	10
P(PSIA)	102.800	103.000	103.200	103.400	********
T(F)	142.33	150.26	164.38	192.78	******
X 1	0.0248	0.0226	0.0198	0.0162	******
X 2	0.7384	0.6203	0.4774	0.3256	******
X 3	0.2196	0.3005	0.3411	0.2930	******
X 4	0.0161	0.0491	0.1211	0.2162	******
X 5	0.0012	0.0080	0.0433	0.1632	******

FEED STAGE= 9

STAGE	9	10	11	12	13
P(PSIA)	103.400	103.600	103.800	104.000	104.200
T(F)	193.31	204.00	215.35	227.98	241.35
X 1	0.0162	0.0063	0.0023	0.0008	0.0003
X 2	0.3158	0.2802	0.2315	0.1780	0.1277
X 3	0.2890	0.3244	0.3652	0.4070	0.4436
X 4	0.2162	0.2239	0.2330	0.2432	0.2545
X 5	0.1632	0.1657	0.1687	0.1718	0.1750

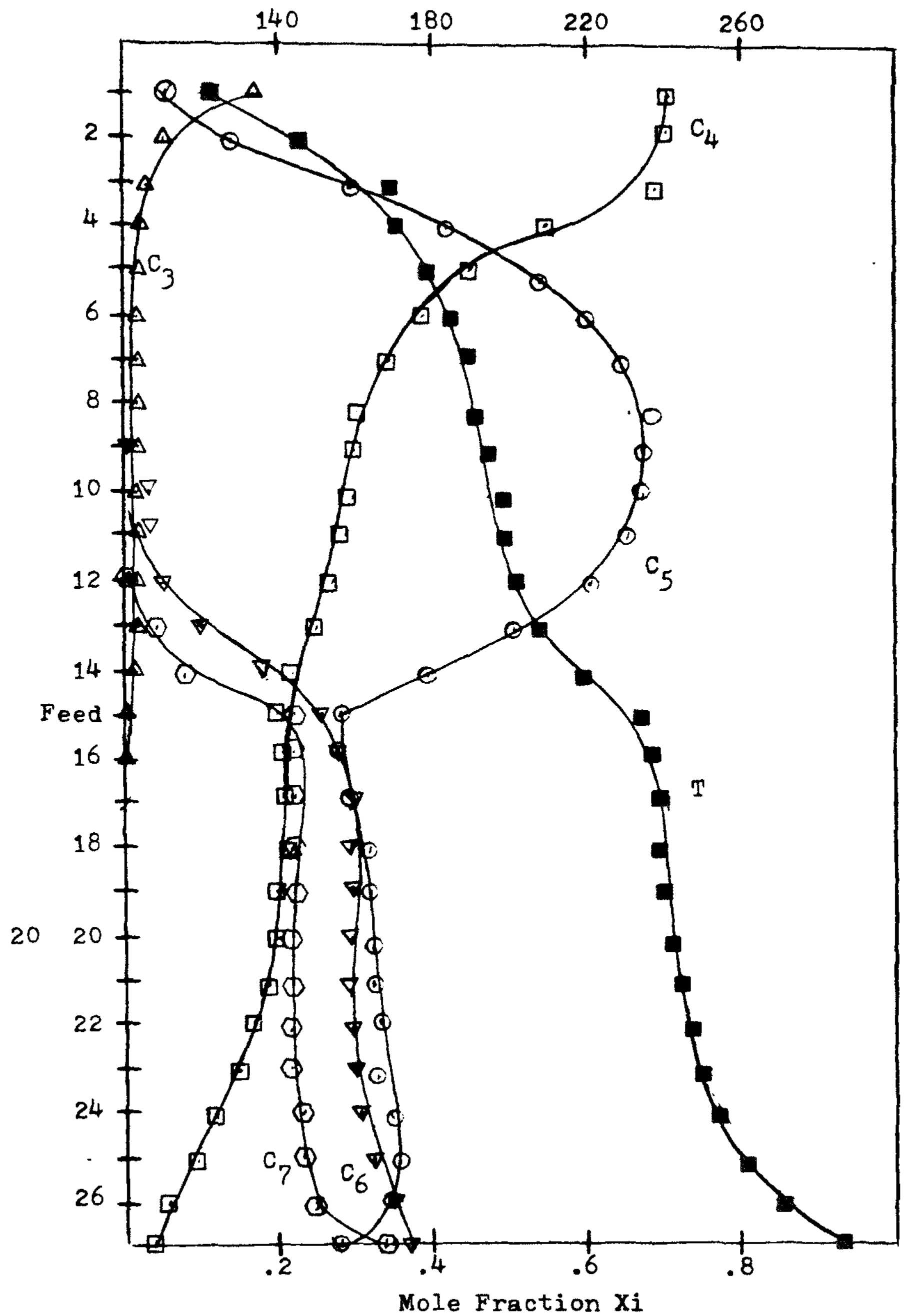
STAGE	14	15	16	17	18
P(PSIA)	104.400	104.600	104.800	105.000	105.200
T(F)	254.51	267.10	280.64	303.18	345.34
X 1	0.0001	0.0000	0.0000	0.0000	0.0000
X 2	0.0859	0.0543	0.0319	0.0167	0.0071
X 3	0.4690	0.4780	0.4622	0.4032	0.2958
X 4	0.2678	0.2863	0.3143	0.3472	0.3699
X 5	0.1785	0.1839	0.1966	0.2306	0.3272

NUMBER OF STAGES=18
NUMBER OF TRIALS= 35

329.

```
%  TSN PRI TYPE  TERM     USER-ID    CPU-TIME REMARK
% 1325  8    3  MN 147   JC927112       6.1
/
```

Figure 12
Debutanizer, DISTL



```
FORTRAN IV PROGRAM DISTL   STARTED --- 07/01/83

**FORTRAN ** STOP
/STEP
/SYSFILE SYSDTA=(PRIMARY)
/ERASE DISTL.SCR
/LOGOFF
  E420 LOGOFF AT 15:16 ON 07/01/83, FOR TSN 1768.
  E421 CPU TIME USED : 19.09 SECONDS.
```

BILL CASINER RUN 011

NUMBER OF TRAYS	25
NUMBER OF COMPONENTS	5
NUMBER OF FEEDS	1
SIDESTREAM AND/OR HEAT TRAYS	0
NUMBER OF K-DATA POINTS	5
NUMBER OF H-DATA POINTS	3
NUMBER OF ITERATIONS	20
DISTILLATE CODE	3
QC-QR-RR-BU CODE	3
DISTILLATE K-DATA CODE	1
DOCUMENTATION LEVEL	7
EXTERNAL REFLUX RATIO	2.0000
OVERHEAD VAPOR PRODUCT, MOLS/HR	0.00000
OVERHEAD LIQUID PRODUCT, MOLS/HR	297.10009
DISTILLATE SUBCOOLING, DEG F	0.0

INPUT TEMPERATURES, DEG F

ACCUMULATOR	120.0
TOP TRAY	136.0
BOTTOM TRAY	292.0

INPUT PRESSURES, PSIA

ACCUMULATOR	100.0000
CONDENSER DELTA P	2.0000
TOWER DELTA P	5.0000
TOWER TOP	102.0000
TOWER BOTTOM	106.9999

DATA ON COMPONENTS

	NAME	MOL WT	LBS/GAL
1	PROPANE	44.100	4.2200
2	BUTANE	58.100	4.8700
3	PENTANE	72.100	5.2500
4	HEXANE	86.200	5.5300
5	HEPTANE	100.200	5.7300

JTC COMP. FORM 7001

NO SEPARATE K-TABLE HAS BEEN PROVIDED FOR THE ACCUMULATOR --- MAIN COLUMN K-TABLE WILL BE USED

MAIN COLUMN K-TABLE

TEMPERATURE, F	100.00	150.00	200.00	250.00	300.00
PRESSURE, PSIA	100.000	100.000	100.000	100.000	100.000
PROPANE	1.80000	2.93000	4.21000	5.78000	7.45000
BUTANE	0.57000	1.07000	1.76000	2.66000	3.80000
PENTANE	0.19800	0.41000	0.75000	1.21000	1.90000
HEXANE	0.07400	0.17900	0.34800	0.62000	1.03000
HEPTANE	0.02850	0.07600	0.16100	0.31800	0.55000

K-DATA WILL BE PRESSURE CORRECTED TO THE TRAY PRESSURE USING THE K-DATA REFERENCE PRESSURE AS THE DATUM

ENTHALPY TABLE

TEMPERATURE, F	100.00	200.00	300.00
PRESSURE, PSIA	100.000	100.000	100.000
VAPOR, BTU/MOLE			
PROPANE	13671.0	15831.9	18125.1
BUTANE	17139.5	19812.1	22833.3
PENTANE	20648.5	23937.2	27686.4
HEXANE	23801.6	27564.0	32238.9
HEPTANE	26052.0	30961.8	36272.4
LIQUID, BTU/MOLE			
PROPANE	7832.4	10231.2	13406.4
BUTANE	8889.3	12433.4	16384.7
PENTANE	10454.5	14780.5	19539.1
HEXANE	11981.8	16981.4	22584.4
HEPTANE	13826.4	19138.2	25150.2

JTC CORP. FORM 7001

```
INPUT FEED DATA
  FEED NO                                 1
  FEED NAME                            FEED
  ENTERING AT TRAY NO                    14
  COMPOSITION,MOLS/HR
   PROPANE                         50.00000
   BUTANE                         250.00000
   PENTANE                        210.00000
   HEXANE                         260.00000
   HEPTANE                        230.00000
  TOTAL                          1000.00000

  TEMPERATURE, F                      100.0
  PRESSURE, PSIA                   104.6800

  HEAT CONTENT, BTUS (CALC)             0.0

  HEAT CONTENT, BTUS (GIVEN)  10937000.0

  ADDITIONAL HEAT, BTUS          9060000.0

  HEAT CONTENT, BTUS (INLET)  19996992.0
  TEMPERATURE, F (INLET)        240.720

  VAPOR, MOLS (INLET)           297.92919
  LIQUID, MOLS (INLET)          702.06982


SUMMARY OF RESULTING FEED FLASH

FEED NO              1
  FEED NAME        FEED
  FEED TRAY NO      14

COMPONENT AND V-L EQUILIBRIUM DATA TABULATION
```

#	NAME	FEED	VAPOR	LIQUID	K-DATA
1	PROPANE	50.00000	34.46094	15.53906	5.22599
2	BUTANE	250.00000	125.61348	124.38657	2.37974
3	PENTANE	210.00000	65.75310	144.24698	1.07418
4	HEXANE	260.00000	48.52348	211.47643	0.54070
5	HEPTANE	230.00000	23.57860	206.42126	0.26917
	TOTAL	1000.00000	297.92919	702.06982	

CALCULATED VAPOR RATES

0.000	891.300	891.300	891.300	891.300	891.300	891.300	891.300	891.300	891.300
891.300	891.300	891.300	891.300	742.336	391.301	391.301	391.301	391.301	391.301
391.301	391.301	391.301	391.301	391.301	391.301	391.301			

CORRESPONDING LIQUID RATES

594.200	594.200	594.200	594.200	594.200	594.200	594.200	594.200	594.200	594.200
594.200	594.200	594.200	743.165	1094.200	1094.200	1094.200	1094.200	1094.200	1094.200
1094.200	1094.200	1094.200	1094.200	1094.200	1094.200	702.900			

CALCULATED TEMPERATURES

120.000	136.000	142.240	148.480	154.720	160.960	167.200	173.440	179.680	185.920
192.160	198.400	204.640	210.880	217.120	223.350	229.600	235.840	242.080	248.320
254.560	260.800	267.040	273.280	279.520	285.760	292.000			

CONDENSER DUTY, BTUS	0.0
REBOILER DUTY, BTUS	0.0
REFLUX RATIO	2.0000
BOILUP RATIO	0.5567

DLVMAX = 0.10000D-02 DTMAX = 0.10000

#	SUM DT SQUARED	DT MAX	MAX DF/F
1	3825.8	23.165	
1	2047.3	18.868	
1	1113.0	15.243	
1	647.13	12.249	
1	417.26	9.8130	0.88510
2	253.88	6.6646	
2	253.37	6.6487	
2	254.09	6.8105	0.39348
3	587.94	8.2234	
3	469.92	8.2095	
3	386.53	8.0321	
3	322.51	7.6697	
3	269.00	7.1862	0.33296
4	1270.2	12.521	
4	1054.4	11.102	
4	853.16	9.7760	
4	671.43	8.5375	
4	514.28	7.1753	0.21332
5	817.08	10.605	
5	519.65	6.9853	
5	365.30	6.5141	
5	275.23	6.0490	
5	211.60	5.4781	0.20820
6	491.63	9.1343	
6	303.78	7.2164	
6	183.08	5.7005	
6	107.64	4.4020	
6	61.977	3.3203	0.10464

P	SUM DT SQUARED	DT MAX	MAX DF/F
7	47.598	2.3422	
7	32.557	2.0999	
7	23.280	1.9176	
7	18.227	1.7057	
7	14.284	1.4753	0.50774E-01
8	17.733	1.9640	
8	10.345	1.4982	
8	5.6933	1.1335	
8	3.3391	0.84392	
8	1.9463	0.60544	0.12795E-01
9	1.1994	0.44215	
9	0.91613	0.37581	
9	0.68566	0.31206	
9	0.49968	0.25970	
9	0.35122	0.21510	0.82334E-02
10	0.29826	0.25255	
10	0.17513	0.19357	
10	0.10458	0.14604	
10	0.64680E-01	0.10962	
10	0.42956E-01	0.80566E-01	0.17509E-02

CALCULATED VAPOR RATES

0.000	891.750	893.193	865.153	849.822	840.692	836.211	833.930	832.153	829.699
825.244	816.594	800.020	771.097	433.077	441.137	449.187	454.165	457.679	460.866
464.395	468.908	475.070	483.339	493.596	504.249	510.564			

CORRESPONDING LIQUID RATES

574.200	556.097	568.050	552.722	543.592	539.111	536.830	535.052	532.599	528.144
519.494	502.940	473.997	433.906	1144.006	1152.086	1157.063	1160.598	1163.765	1167.294
1171.602	1177.969	1186.238	1196.495	1207.146	1213.463	702.900			

CALCULATED TEMPERATURES

123.628	146.805	158.929	169.462	178.237	184.741	189.097	191.912	193.870	195.601
197.781	201.871	207.946	219.673	235.232	237.051	238.287	239.339	240.482	241.942
243.730	246.868	250.364	255.250	261.753	271.194	287.367			

CONDENSER DUTY, BTUS 7549422.0
REBOILER DUTY, BTUS 5834405.0
REFLUX RATIO 2.0000
BOILUP RATIO 0.7264

DLVMAX = 0.50000E-03 DTMAX = 0.50000E-01

#		SUM DT SQUARED	DT MAX	MAX DF/F	MAX DX
1	1	0.25238E-01	0.62337E-01	0.83156E-03	0.55278E-03
2	0	0.74805E-05	0.11372E-02	0.15891E-04	0.14181E+04

CALCULATED VAPOR RATES

0.000	891.299	883.191	865.120	849.726	840.511	835.960	833.641	831.855	829.412
824.932	916.362	799.815	771.928	432.923	441.186	449.083	453.981	457.459	460.639
464.158	468.671	474.781	482.964	493.180	503.874	510.286			

CORRESPONDING LIQUID RATES

574.230	536.807	568.021	552.626	543.412	538.861	536.542	534.756	532.313	527.883
519.262	502.716	473.529	433.753	1144.086	1151.983	1156.881	1160.389	1163.539	1167.058
1171.571	1177.660	1185.664	1196.080	1206.774	1213.186	702.900			

CALCULATED TEMPERATURES

123.628	146.089	158.901	169.427	178.202	184.713	189.079	191.904	193.869	195.605
197.787	201.377	207.951	219.677	235.238	237.042	238.268	239.312	240.448	241.898
243.878	246.608	250.302	255.195	261.717	271.169	287.355			

CONDENSER DUTY, BTUS	7649380.0
REBOILER DUTY, BTUS	5634356.0
REFLUX RATIO	2.0000
BOILUP RATIO	0.7260

FEED AND PRODUCT SUMMARY:

	FEED NO 1 TRAY NO 14	OVERHEAD LIQUID PRODUCT	BOTTOMS PRODUCT
COMPONENT	MOLS	MOLS	MOLS
PROPANE	50.00000	49.99974	0.00043
BUTANE	250.00000	228.47610	21.52583
PENTANE	210.00000	18.62315	191.37723
HEXANE	260.00000	0.00110	259.99853
HEPTANE	230.00000	0.00000	229.99982
TOTAL	1000.00000	297.10009	702.89990
POUNDS	77328.977	16882.270	60506.816
GALLONS	14463.84	3504.05	10959.82
Q, MBTU	19996.988	2823.450	15257.000
TEMP, F	240.72	123.63	287.36

****** ****** ****** ****** NET LIQUID & VAPOR LEAVING EACH STAGE ****** ****** ****** ******

ACCUMULATOR TEMP, F 123.63 PRESS, PSIA 100.000

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	0.00000	0.00	0.00000	0.00000	99.99948	4409.98	1045.018	16.82927	13.10755	14.91160	2.28377
2	BUTANE	0.00000	0.00	0.00000	0.00000	456.95214	26549.92	5451.523	76.90215	78.91003	77.78903	0.77756
3	PENTANE	0.00000	0.00	0.00000	0.00000	37.24631	2665.46	511.516	6.26832	7.98186	7.29894	0.28390
4	HEXANE	0.00000	0.00	0.00000	0.00000	0.00219	0.19	0.034	0.00037	0.00056	0.00049	0.11368
5	HEPTANE	0.00000	0.00	0.00000	0.00000	0.00000	0.00	0.000	0.00000	0.00000	0.00000	0.04601
TOTAL		0.00000	0.00	0.00000	0.00000	594.19946	33644.54	7008.086	100.00000	100.00000	100.00000	

VAPOR MW = 0.000 VAPOR ENTHALPY = 0. BTUS
LIQUID MW = 56.622 LIQUID LB/GAL = 4.801 LIQUID ENTHALPY = 5646900. BTUS

TRAY NO 1 TEMP, F 146.09 PRESS, PSIA 102.000

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	149.99690	6614.95	16.82922	13.10753	36.00110	1587.65	376.220	6.14268	4.54864	5.28883	2.73972
2	BUTANE	685.42773	39823.36	76.90205	78.91003	453.20092	26330.98	5406.770	77.32729	75.43864	76.00728	0.99450
3	PENTANE	55.86946	4028.19	6.26831	7.98186	96.86612	6984.05	1330.294	16.52776	20.00940	18.70100	0.37926
4	HEXANE	0.00329	0.28	0.00037	0.00056	0.01345	1.16	0.210	0.00230	0.00332	0.00295	0.16070
5	HEPTANE	0.00000	0.00	0.00000	0.00000	0.00000	0.00	0.000	0.00000	0.00000	0.00000	0.06815
TOTAL		891.29907	50466.77	100.00000	100.00000	586.08129	34903.83	7113.488	100.00000	100.00000	100.00000	

VAPOR MW = 56.622 VAPOR ENTHALPY = 16019005. BTUS
LIQUID MW = 59.555 LIQUID LB/GAL = 4.907 LIQUID ENTHALPY = 6277615. BTUS

TRAY NO 2 TEMP, F 158.90 PRESS, PSIA 102.200

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	86.00044	3792.62	9.73758	7.33212	18.17903	801.70	189.975	3.20042	2.28550	2.69477	3.04260
2	BUTANE	681.67675	39605.42	77.18425	76.56761	383.46484	22279.31	4574.805	67.50905	63.51468	64.89302	1.14332
3	PENTANE	115.48927	8326.77	13.07651	16.09782	166.32825	11992.27	2284.241	29.28210	34.18799	32.40168	0.44657
4	HEXANE	0.01455	1.25	0.00165	0.00242	0.04804	4.14	0.749	0.00846	0.01180	0.01062	0.19479
5	HEPTANE	0.00000	0.00	0.00000	0.00000	0.00000	0.00	0.000	0.00000	0.00000	0.00000	0.08473
TOTAL		883.18066	51726.07	100.00000	100.00000	568.01977	35077.41	7049.762	100.00000	100.00000	100.00000	

VAPOR MW = 58.568 VAPOR ENTHALPY = 16649695. BTUS
LIQUID MW = 61.754 LIQUID LB/GAL = 4.976 LIQUID ENTHALPY = 6539007. BTUS

TRAY NO 3 TEMP, F 169.43 PRESS, PSIA 102.400

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	68.17847	3006.67	7.88081	5.79324	13.19241	581.79	137.864	2.38722	1.65352	1.971.1	3.30125
2	BUTANE	611.94067	35553.75	70.73479	68.50481	306.58764	17812.74	3657.647	55.47830	50.62639	52.30051	1.27500
3	PENTANE	184.95129	13334.99	21.37866	25.69379	232.70764	16778.22	3195.851	42.10941	47.68613	45.69731	0.50769
4	HEXANE	0.04913	4.24	0.00568	0.00816	0.13860	11.95	2.160	0.02508	0.03396	0.03089	0.22644
5	HEPTANE	0.00000	0.00	0.00000	0.00000	0.00003	0.00	0.000	0.00001	0.00001	0.00001	0.10049
TOTAL		865.11936	51899.64	100.00000	100.00000	552.62597	35184.69	6993.520	100.00000	100.00000	100.00000	

VAPOR MW = 59.991 VAPOR ENTHALPY = 16911104. BTUS
LIQUID MW = 63.668 LIQUID LB/GAL = 5.031 LIQUID ENTHALPY = 6748907. BTUS

****** ****** ****** ****** NET LIQUID & VAPOR LEAVING EACH STAGE ****** ****** ****** ******

TRAY NO 4 TEMP, F 178.20 PRESS, PSIA 102.600

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	63.19183	2786.76	7.43674	5.35844	11.47175	505.90	119.883	2.11106	1.42830	1.71695	3.52275
2	BUTANE	535.06747	31087.79	62.96948	59.77510	245.75134	14291.54	2934.608	45.26627	40.34888	42.02933	1.39108
3	PENTANE	251.33041	18120.92	29.57734	34.84329	285.60766	20592.31	3922.345	52.55833	58.13765	56.17564	0.56276
4	HEXANE	0.13970	12.04	0.01644	0.02315	0.34972	30.15	5.451	0.06436	0.08511	0.07807	0.25545
5	HEPTANE	0.00003	0.00	0.00000	0.00001	0.00016	0.02	0.003	0.00003	0.00004	0.00004	0.11520
TOTAL		849.72509	52066.91	100.00000	100.00000	543.41064	35419.92	6982.285	100.00000	100.00000	100.00000	

VAPOR MW = 61.204 VAPOR ENTHALPY = 17120976. BTUS
LIQUID MW = 65.181 LIQUID LB/GAL = 5.073 LIQUID ENTHALPY = 6957090. BTUS

TRAY NO 5 TEMP, F 184.71 PRESS, PSIA 102.800

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	61.47124	2710.88	7.31356	5.18907	10.69275	471.11	111.637	1.98247	1.32019	1.59566	3.68912
2	BUTANE	474.45800	27566.01	56.44879	52.76534	205.46964	11937.79	2451.291	38.13039	33.45082	35.03703	1.48041
3	PENTANE	304.23022	21935.00	36.19589	41.98717	321.89990	23208.98	4420.758	59.73715	65.03380	63.18724	0.60592
4	HEXANE	0.35082	30.24	0.04174	0.05789	0.80759	69.61	12.588	0.14987	0.19507	0.17993	0.27850
5	HEPTANE	0.00016	0.02	0.00002	0.00003	0.00080	0.08	0.014	0.00015	0.00022	0.00020	0.12706
TOTAL		840.51000	52242.14	100.00000	100.00000	538.85035	35687.57	6996.281	100.00000	100.00000	100.00000	

VAPOR MW = 62.155 VAPOR ENTHALPY = 17329168. BTUS
LIQUID MW = 66.228 LIQUID LB/GAL = 5.101 LIQUID ENTHALPY = 7134114. BTUS

TRAY NO 6 TEMP, F 189.08 PRESS, PSIA 103.000

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	60.68219	2676.08	7.25898	5.09635	10.24957	452.01	107.110	1.91030	1.25933	1.52747	3.79992
2	BUTANE	433.94580	25212.25	51.90987	48.01437	180.72021	10499.84	2156.025	33.68243	29.25356	30.74651	1.54116
3	PENTANE	340.52246	24551.67	40.73430	46.75636	343.80390	24788.41	4721.598	64.07819	69.06287	67.33347	0.63570
4	HEXANE	0.80869	69.71	0.09674	0.13275	1.76204	151.89	27.466	0.32841	0.42317	0.39169	0.29457
5	HEPTANE	0.00080	0.08	0.00010	0.00015	0.00379	0.38	0.066	0.00071	0.00106	0.00095	0.13541
TOTAL		835.95971	52509.79	100.00000	100.00000	536.54125	35892.52	7012.258	100.00000	100.00000	100.00000	

VAPOR MW = 62.814 VAPOR ENTHALPY = 17506176. BTUS
LIQUID MW = 66.896 LIQUID LB/GAL = 5.119 LIQUID ENTHALPY = 7260054. BTUS

TRAY NO 7 TEMP, F 191.90 PRESS, PSIA 103.200

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	60.24905	2656.98	7.22721	5.04030	9.98767	440.46	104.373	1.86771	1.22338	1.48710	3.86957
2	BUTANE	409.19677	23774.53	49.08546	45.09993	166.11984	9651.56	1981.840	31.06465	26.80745	28.23708	1.58011
3	PENTANE	362.42871	26131.11	43.47537	49.57072	354.92333	25589.97	4874.277	66.37120	71.07680	69.44827	0.65503
4	HEXANE	1.76313	151.98	0.21150	0.28831	3.70706	319.55	57.785	0.69323	0.88756	0.82331	0.30509
5	HEPTANE	0.00379	0.33	0.00046	0.00072	0.01727	1.73	0.302	0.00323	0.00481	0.00430	0.14093
TOTAL		833.64111	52714.78	100.00000	100.00000	534.75488	36003.27	7018.570	100.00000	100.00000	100.00000	

VAPOR MW = 63.234 VAPOR ENTHALPY = 17632096. BTUS
LIQUID MW = 67.327 LIQUID LB/GAL = 5.130 LIQUID ENTHALPY = 7337596. BTUS

****** ****** ****** ****** NET LIQUID & VAPOR LEAVING EACH STAGE ****** ****** ****** ******

TRAY NO 8 TEMP, F 193.87 PRESS, PSIA 103.400

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	59.98717	2645.43	7.21126	5.00787	9.83260	432.29	102.439	1.84152	1.20035	1.46150	3.91594
2	BUTANE	394.59570	22936.01	47.43568	43.39952	157.17107	9131.64	1875.079	29.52614	25.35574	26.75171	1.60657
3	PENTANE	373.54614	26932.68	44.90524	50.98424	357.56577	25787.70	4911.941	67.19104	71.60452	70.07855	0.66832
4	HEXANE	3.70816	319.64	0.44577	0.60509	7.59610	654.78	118.406	1.42700	1.81813	1.68929	0.31238
5	HEPTANE	0.01727	1.73	0.00208	0.00328	0.07634	7.65	1.335	0.01434	0.02124	0.01905	0.14478
TOTAL		831.85400	52825.49	100.00000	100.00000	532.31152	36014.06	7009.191	100.00000	100.00000	100.00000	

VAPOR MW = 63.503 VAPOR ENTHALPY = 17709648. BTUS
LIQUID MW = 67.656 LIQUID LB/GAL = 5.138 LIQUID ENTHALPY = 7377239. BTUS

TRAY NO 9 TEMP, F 195.60 PRESS, PSIA 103.600

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	59.80209	2637.27	7.21019	4.99140	9.62086	424.28	100.540	1.82254	1.18166	1.44128	3.95613
2	BUTANE	385.64672	22406.07	46.49646	42.40659	150.60283	8750.02	1796.719	28.52963	24.36958	25.75653	1.62976
3	PENTANE	376.28881	27130.43	45.36819	51.34808	352.16577	25391.15	4836.406	66.71298	70.71660	69.33142	0.68005
4	HEXANE	7.59720	654.88	0.91598	1.23945	15.16484	1307.21	236.385	2.87277	3.64069	3.38865	0.31885
5	HEPTANE	0.07634	7.65	0.00920	0.01448	0.32782	32.85	5.733	0.06210	0.09148	0.08218	0.14821
TOTAL		829.41088	52836.29	100.00000	100.00000	527.88183	35905.50	6975.777	100.00000	100.00000	100.00000	

VAPOR MW = 63.703 VAPOR ENTHALPY = 17749280. BTUS
LIQUID MW = 68.018 LIQUID LB/GAL = 5.147 LIQUID ENTHALPY = 7385876. BTUS

TRAY NO 10 TEMP, F 197.79 PRESS, PSIA 103.800

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	59.62133	2629.26	7.22687	4.98647	9.36110	412.82	97.826	1.80277	1.15918	1.41767	4.00876
2	BUTANE	379.07910	22024.50	45.95000	41.77019	143.73730	8351.14	1714.813	27.68108	23.44928	24.85077	1.65998
3	PENTANE	370.78906	26733.89	44.94511	50.70171	335.64379	24199.92	4609.508	64.63863	67.95134	66.80022	0.69533
4	HEXANE	15.16592	1307.30	1.83833	2.47934	29.16830	2514.31	454.667	5.61726	7.05997	6.58895	0.32727
5	HEPTANE	0.32782	32.85	0.03974	0.06230	1.35141	135.41	23.632	0.26026	0.38022	0.34247	0.15268
TOTAL		824.98166	52727.79	100.00000	100.00000	519.26171	35613.59	6900.438	100.00000	100.00000	100.00000	

VAPOR MW = 63.914 VAPOR ENTHALPY = 17757872. BTUS
LIQUID MW = 68.585 LIQUID LB/GAL = 5.161 LIQUID ENTHALPY = 7361153. BTUS

TRAY NO 11 TEMP, F 201.38 PRESS, PSIA 104.000

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	59.36063	2617.80	7.27137	4.99239	8.91393	393.10	93.153	1.77316	1.12287	1.37999	4.10081
2	BUTANE	372.21289	21625.57	45.59612	41.24196	133.84990	7776.68	1596.854	26.62537	22.21341	23.65622	1.71243
3	PENTANE	354.26708	25542.66	43.39586	48.71220	302.22265	21790.25	41°0.523	60.11800	62.24197	61.48698	0.72185
4	HEXANE	29.16934	2514.40	3.57309	4.79519	52.54271	4529.18	819.020	10.45177	12.93721	12.13318	0.34186
5	HEPTANE	1.35141	135.41	0.16554	0.25824	5.18583	519.72	90.702	1.03176	1.48454	1.34368	0.16044
TOTAL		816.36108	52435.83	100.00000	100.00000	502.71557	35008.93	6750.246	100.00000	100.00000	100.00000	

VAPOR MW = 64.231 VAPOR ENTHALPY = 17733168. BTUS
LIQUID MW = 69.640 LIQUID LB/GAL = 5.186 LIQUID ENTHALPY = 7290040. BTUS

****** ****** ****** ****** NET LIQUID & VAPOR LEAVING EACH STAGE ****** ****** ****** ******

TRAY NO 12 TEMP, F 207.95 PRESS, PSIA 104.200

		VAPOR				LIQUID						
NO	COMP	MOLS	LBS	MOL %	WT %	MOLS	LBS	GALS	MOL %	WT %	VOL %	K-DATA
1	PROPANE	58.91344	2598.06	7.36588	5.01259	8.15872	359.80	85.261	1.72187	1.05966	1.31401	4.27784
2	BUTANE	362.32566	21051.12	45.30118	40.61481	118.35184	6876.24	1411.959	24.97778	20.25145	21.76071	1.81366
3	PENTANE	320.84545	23132.96	40.11494	44.63138	245.77527	17720.39	3375.313	51.87010	52.18893	52.01939	0.77338
4	HEXANE	52.54370	4529.77	6.56946	8.73850	84.05080	7245.18	1310.158	17.73865	21.33801	20.19179	0.37035
5	HEPTANE	5.18653	519.72	0.64850	1.00272	17.49200	1752.70	305.881	3.69163	5.16193	4.71415	0.17567
TOTAL		799.81494	51831.14	100.00000	100.00000	473.82836	38954.30	6488.566	100.00000	100.00000	100.00000	

VAPOR MW = 64.804 VAPOR ENTHALPY = 17662032. BTUS
LIQUID MW = 71.660 LIQUID LB/GAL = 5.233 LIQUID ENTHALPY = 7164157. BTUS

TRAY NO 13 TEMP, F 219.68 PRESS, PSIA 104.400

		VAPOR				LIQUID						
NO	COMP	MOLS	LBS	MOL %	WT %	MOLS	LBS	GALS	MOL %	WT %	VOL %	K-DATA
1	PROPANE	58.15831	2564.78	7.54393	5.05111	7.10294	313.24	74.227	1.63756	0.96020	1.20821	4.60683
2	BUTANE	346.82963	20150.69	44.98831	39.68500	97.31239	5653.85	1160.954	22.43498	17.33116	18.89703	2.00528
3	PENTANE	264.35643	19063.13	34.29611	37.54315	170.45174	12289.57	2340.870	39.29698	37.67215	38.10271	0.87274
4	HEXANE	84.05191	7245.27	10.90269	14.26893	111.04413	9572.00	1730.922	25.60078	29.34178	28.17468	0.42587
5	HEPTANE	17.49200	1752.70	2.26895	3.45179	47.84196	4793.76	836.608	11.02978	14.69468	13.61759	0.20571
TOTAL		770.92797	50776.57	100.00000	100.00000	433.75268	32622.42	6143.578	100.00000	100.00000	100.00000	

VAPOR MW = 65.864 VAPOR ENTHALPY = 17536112. BTUS
LIQUID MW = 75.210 LIQUID LB/GAL = 5.310 LIQUID ENTHALPY = 7046338. BTUS

TRAY NO 14 TEMP, F 235.24 PRESS, PSIA 104.600

		VAPOR				LIQUID						
NO	COMP	MOLS	LBS	MOL %	WT %	MOLS	LBS	GALS	MOL %	WT %	VOL %	K-DATA
1	PROPANE	22.64156	998.49	5.22993	3.40310	11.82612	521.53	123.586	1.03367	0.57529	0.73499	5.05956
2	BUTANE	200.17429	11630.13	46.23786	39.63820	232.25993	13494.30	2770.904	20.30089	14.88522	16.47916	2.27763
3	PENTANE	123.32188	8891.51	28.48589	30.30435	320.01879	23073.36	4394.922	27.97153	25.45163	26.13754	1.01839
4	HEXANE	62.52182	5389.78	14.44180	18.36827	324.83593	28000.86	5063.445	28.39258	30.88702	30.11340	0.50865
5	HEPTANE	24.26340	2431.19	5.60456	8.28607	255.14661	25565.69	4461.723	22.30132	28.20085	26.53482	0.25131
TOTAL		432.92260	29340.70	100.00000	100.00000	1144.03710	90655.69	16814.578	100.00000	100.00000	100.00000	

VAPOR MW = 67.774 VAPOR ENTHALPY = 10305659. BTUS
LIQUID MW = 79.238 LIQUID LB/GAL = 5.391 LIQUID ENTHALPY = 20230112. BTUS

TRAY NO 15 TEMP, F 237.04 PRESS, PSIA 104.800

		VAPOR				LIQUID						
NO	COMP	MOLS	LBS	MOL %	WT %	MOLS	LBS	GALS	MOL %	WT %	VOL %	K-DATA
1	PROPANE	11.82569	521.51	2.68043	1.72979	6.04939	266.78	63.218	0.52513	0.29205	0.37325	5.10433
2	BUTANE	210.73514	12243.71	47.76561	40.61075	238.56244	13860.48	2846.094	20.70882	15.17342	16.80394	2.30653
3	PENTANE	128.64180	9275.07	29.15819	30.76418	324.68505	23409.79	4459.008	28.18483	25.62730	26.32692	1.03453
4	HEXANE	64.83701	5588.95	14.69606	18.53778	326.79760	28169.95	5094.023	28.36823	30.83836	30.07619	0.51805
5	HEPTANE	25.14663	2519.70	5.69979	8.35750	255.88976	25640.15	4474.719	22.21294	28.06894	26.41968	0.25660
TOTAL		441.18579	30148.94	100.00000	100.00000	1151.98410	91347.06	16937.059	100.00000	100.00000	100.00000	

VAPOR MW = 68.336 VAPOR ENTHALPY = 10605375. BTUS
LIQUID MW = 79.295 LIQUID LB/GAL = 5.393 LIQUID ENTHALPY = 20485440. BTUS

****** ****** ****** ****** NET LIQUID & VAPOR LEAVING EACH STAGE ****** ****** ****** ******

TRAY NO 16 TEMP, F 228.27 PRESS, PSIA 105.000

		- - - VAPOR - - -				- - - LIQUID - - -						
NO	COMP	MOLS	LBS	MOL %	WT %	MOLS	LBS	GALS	MOL %	WT %	VOL %	K-DATA
1	PROPANE	6.04895	266.76	1.34696	0.86497	3.33656	133.91	31.733	0.26248	0.14588	0.18649	5.13169
2	BUTANE	217.03719	12609.56	48.33901	40.88756	240.49071	13972.51	2869.098	20.78781	15.22160	16.86162	2.32487
3	PENTANE	133.30829	9611.53	29.68457	31.16544	328.63549	23694.62	4513.258	28.40698	25.81282	26.52431	1.04497
4	HEXANE	66.79671	5758.05	14.87446	18.67050	328.28027	28297.76	5117.133	28.37627	30.82747	30.07326	0.52419
5	HEPTANE	25.88966	2594.14	5.76501	8.41153	256.43920	25695.21	4484.328	22.16640	27.99226	26.35428	0.26008
TOTAL		449.08251	30840.73	100.00000	100.00000	1156.88200	91793.94	17015.547	100.00000	100.00000	100.00000	

VAPOR MW = 68.674 VAPOR ENTHALPY = 10860684. BTUS
LIQUID MW = 79.346 LIQUID LB/GAL = 5.395 LIQUID ENTHALPY = 20654272. BTUS

TRAY NO 17 TEMP, F 239.31 PRESS, PSIA 105.200

		- - - VAPOR - - -				- - - LIQUID - - -						
NO	COMP	MOLS	LBS	MOL %	WT %	MOLS	LBS	GALS	MOL %	WT %	VOL %	K-DATA
1	PROPANE	3.03612	133.89	0.66876	0.42795	1.50556	66.41	15.737	0.12977	0.07207	0.09216	5.15350
2	BUTANE	218.96559	12721.90	48.23238	40.66168	239.19588	13897.28	2853.651	20.61337	15.08225	16.71169	2.33985
3	PENTANE	137.25854	9896.34	30.23445	31.63065	332.98706	24008.37	4573.020	28.69609	26.05547	26.78073	1.05361
4	HEXANE	68.28131	5885.85	15.04058	18.81232	329.73754	28423.38	5139.848	28.41606	30.84692	30.10022	0.52930
5	HEPTANE	26.43918	2649.21	5.82386	8.46738	256.96484	25747.88	4498.520	22.14467	27.94330	26.31517	0.26299
TOTAL		453.98046	31287.18	100.00000	100.00000	1160.39110	92143.25	17075.773	100.00000	100.00000	100.00000	

VAPOR MW = 68.917 VAPOR ENTHALPY = 11029528. BTUS
LIQUID MW = 79.407 LIQUID LB/GAL = 5.396 LIQUID ENTHALPY = 20790752. BTUS

TRAY NO 18 TEMP, F 240.45 PRESS, PSIA 105.400

		- - - VAPOR - - -				- - - LIQUID - - -						
NO	COMP	MOLS	LBS	MOL %	WT %	MOLS	LBS	GALS	MOL %	WT %	VOL %	K-DATA
1	PROPANE	1.50542	66.39	0.32906	0.20985	0.73942	32.61	7.727	0.06355	0.03525	0.04510	5.17806
2	BUTANE	217.67050	12646.66	47.57941	39.97496	234.91917	13648.80	2802.629	20.19002	14.75628	16.35617	2.35657
3	PENTANE	141.60976	10210.06	30.95370	32.27310	338.74267	24423.35	4652.083	29.11310	26.40508	27.14949	1.06322
4	HEXANE	69.73857	6011.46	15.24378	19.00169	331.53906	28578.66	5167.930	28.49399	30.89755	30.16010	0.53498
5	HEPTANE	26.96478	2701.87	5.89409	8.54038	257.60009	25811.53	4504.629	22.13933	27.90590	26.28906	0.26623
TOTAL		457.48876	31636.44	100.00000	100.00000	1163.54020	92494.88	17134.977	100.00000	100.00000	100.00000	

VAPOR MW = 69.152 VAPOR ENTHALPY = 11165997. BTUS
LIQUID MW = 79.494 LIQUID LB/GAL = 5.398 LIQUID ENTHALPY = 20932400. BTUS

TRAY NO 19 TEMP, F 241.90 PRESS, PSIA 105.600

		- - - VAPOR - - -				- - - LIQUID - - -						
NO	COMP	MOLS	LBS	MOL %	WT %	MOLS	LBS	GALS	MOL %	WT %	VOL %	K-DATA
1	PROPANE	0.73899	32.59	0.16043	0.10188	0.35921	15.84	3.754	0.03078	0.01715	0.02182	5.21217
2	BUTANE	213.39378	12398.18	46.32562	38.75867	227.23405	13202.30	2710.944	19.47061	14.20719	15.75547	2.37925
3	PENTANE	147.36568	10625.06	31.99159	33.21562	346.94213	25014.53	4764.672	29.72784	26.91850	27.69133	1.07615
4	HEXANE	71.54030	6166.77	15.53067	19.27831	334.05395	28795.45	5207.133	28.62350	30.98720	30.26282	0.54258
5	HEPTANE	27.60019	2765.54	5.99172	8.64551	258.47119	25898.81	4519.859	22.14717	27.87009	26.26852	0.27054
TOTAL		460.63867	31988.14	100.00000	100.00000	1167.06050	92926.88	17206.359	100.00000	100.00000	100.00000	

VAPOR MW = 69.443 VAPOR ENTHALPY = 11307643. BTUS
LIQUID MW = 79.625 LIQUID LB/GAL = 5.401 LIQUID ENTHALPY = 21009312. BTUS

****** ****** ****** ****** NET LIQUID & VAPOR LEAVING EACH STAGE ****** ****** ****** ******

TRAY NO 20 TEMP, F 243.89 PRESS, PSIA 105.800

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	0.35878	15.82	0.07730	0.04880	0.17209	7.59	1.798	0.01469	0.00812	0.01039	5.26238
2	BUTANE	205.70254	11951.65	44.31860	36.86502	215.26469	12506.98	2568.147	18.37398	13.37463	14.84303	2.41202
3	PENTANE	155.56482	11816.22	33.51546	34.59654	358.53652	25861.30	4925.961	30.61578	27.65559	28.47040	1.09471
4	HEXANE	74.05505	6383.54	15.95470	19.69009	337.73168	29112.47	5264.461	28.82718	31.13234	30.42682	0.55346
5	HEPTANE	28.47121	2852.81	6.13394	8.79953	259.71826	26023.77	4541.668	22.16832	27.82933	26.24931	0.27670
TOTAL		464.15820	32420.06	100.00000	100.00000	1171.57320	93511.96	17302.035	100.00000	100.00000	100.00000	

VAPOR MW = 69.847 VAPOR ENTHALPY = 11484556. BTUS
LIQUID MW = 79.817 LIQUID LB/GAL = 5.405 LIQUID ENTHALPY = 21350368. BTUS

TRAY NO 21 TEMP, F 246.61 PRESS, PSIA 106.000

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	0.17166	7.57	0.03663	0.02294	0.08084	3.57	0.845	0.00686	0.00378	0.00485	5.33546
2	BUTANE	193.73509	11256.24	41.33797	34.10449	197.95648	11501.27	2361.657	16.80898	12.19316	13.54595	2.45927
3	PENTANE	167.31545	12067.01	35.69870	36.54836	374.89379	27029.84	5148.539	31.83318	28.65590	29.53088	1.12143
4	HEXANE	77.73270	6700.55	16.58577	20.30153	343.22933	29586.21	5350.123	29.14432	31.36604	30.68713	0.56909
5	HEPTANE	29.71834	2977.78	6.34098	9.02216	261.52392	26204.70	4573.242	22.20665	27.78110	26.23111	0.28554
TOTAL		468.67089	33005.15	100.00000	100.00000	1177.68230	94325.56	17434.406	100.00000	100.00000	100.00000	

VAPOR MW = 70.423 VAPOR ENTHALPY = 11725610. BTUS
LIQUID MW = 80.094 LIQUID LB/GAL = 5.410 LIQUID ENTHALPY = 21686032. BTUS

TRAY NO 22 TEMP, F 250.30 PRESS, PSIA 106.200

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	0.08041	3.55	0.01694	0.01049	0.03693	1.63	0.386	0.00311	0.00171	0.00219	5.43831
2	BUTANE	176.43068	10250.62	37.16048	30.31047	174.45257	10137.44	2081.609	14.71352	10.62183	11.81728	2.52560
3	PENTANE	183.51878	13231.56	38.65298	39.12496	395.47509	28513.75	5431.188	33.34904	29.87621	30.83279	1.15904
4	HEXANE	83.22865	7874.31	17.52992	21.21400	351.67456	30314.34	5481.797	29.65550	31.76283	31.12012	0.59112
5	HEPTANE	31.52397	3158.70	6.63970	9.34009	264.19677	26472.52	4619.984	22.27879	27.73743	26.22762	0.29803
TOTAL		474.78027	33818.73	100.00000	100.00000	1185.86570	95439.63	17614.961	100.00000	100.00000	100.00000	

VAPOR MW = 71.230 VAPOR ENTHALPY = 12061266. BTUS
LIQUID MW = 80.481 LIQUID LB/GAL = 5.418 LIQUID ENTHALPY = 22146868. BTUS

TRAY NO 23 TEMP, F 255.19 PRESS, PSIA 106.400

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	0.03650	1.61	0.00756	0.00461	0.01620	0.71	0.169	0.00135	0.00074	0.00095	5.57855
2	BUTANE	152.95691	8886.80	31.67046	25.43966	144.78322	8411.90	1727.290	12.10479	8.68036	9.67640	2.07035
3	PENTANE	204.09732	14715.45	42.25943	42.12494	417.43286	30096.91	5732.742	34.90001	31.05740	32.11523	1.21087
4	HEXANE	91.67601	7902.47	18.98195	22.62186	365.27368	31486.59	5693.777	30.53917	32.49144	31.89694	0.62156
5	HEPTANE	34.19708	3426.55	7.08067	9.80895	268.57543	26911.26	4696.555	22.45459	27.77010	26.31044	0.31533
TOTAL		482.96336	34932.88	100.00000	100.00000	1196.08120	96907.31	17850.531	100.00000	100.00000	100.00000	

VAPOR MW = 72.330 VAPOR ENTHALPY = 12522082. BTUS
LIQUID MW = 81.021 LIQUID LB/GAL = 5.429 LIQUID ENTHALPY = 22760832. BTUS

****** ****** ****** ****** NET LIQUID & VAPOR LEAVING EACH STAGE ****** ****** ****** ******

TRAY NO 24 TEMP, F 261.72 PRESS, PSIA 106.600

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	0.01577	0.70	0.00320	0.00191	0.00669	0.29	0.070	0.00055	0.00030	0.00039	5.77049
2	BUTANE	123.25732	7161.75	24.99239	19.67346	110.01135	6391.66	1312.456	9.11614	6.47293	7.23642	2.74154
3	PENTANE	226.05592	16298.63	45.83643	44.77576	431.07470	31080.49	5920.090	35.72121	31.47569	32.64130	1.28317
4	HEXANE	105.27501	9074.70	21.34619	24.93011	387.81689	33429.81	6045.172	32.13663	33.85489	33.33095	0.66423
5	HEPTANE	38.57558	3865.27	7.82181	10.61872	277.86372	27842.14	4859.012	23.02547	28.19617	26.79088	0.33970
TOTAL		493.17919	36400.54	100.00000	100.00000	1206.77510	98744.38	18136.797	100.00000	100.00000	100.00000	

VAPOR MW = 73.808 VAPOR ENTHALPY = 13136066. BTUS
LIQUID MW = 81.325 LIQUID LB/GAL = 5.444 LIQUID ENTHALPY = 23557488. BTUS

TRAY NO 25 TEMP, F 271.17 PRESS, PSIA 106.800

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	0.00626	0.28	0.00124	0.00072	0.00249	0.11	0.026	0.00021	0.00011	0.00014	6.05684
2	BUTANE	88.48550	5141.01	17.56105	13.44491	72.69371	4223.50	867.249	5.99196	4.18293	4.69878	2.93076
3	PENTANE	239.69746	17282.19	47.57097	45.19685	413.92260	29843.82	5684.535	34.11858	29.55714	30.79895	1.39428
4	HEXANE	127.81834	11017.94	25.36714	28.81441	421.41040	36325.57	6568.816	34.73578	35.97664	35.59000	0.73029
5	HEPTANE	47.86610	4796.18	9.49963	12.54310	305.15869	30576.90	5336.281	25.15344	30.28317	28.91209	0.37767
TOTAL		503.87329	38237.59	100.00000	100.00000	1213.18770	100969.88	18456.906	100.00000	100.00000	100.00000	

VAPOR MW = 75.887 VAPOR ENTHALPY = 13932714. BTUS
LIQUID MW = 83.227 LIQUID LB/GAL = 5.471 LIQUID ENTHALPY = 24610224. BTUS

REBOILER TEMP, F 287.36 PRESS, PSIA 107.000

NO	COMP	VAPOR MOLS	VAPOR LBS	VAPOR MOL %	VAPOR WT %	LIQUID MOLS	LIQUID LBS	LIQUID GALS	LIQUID MOL %	LIQUID WT %	LIQUID VOL %	K-DATA
1	PROPANE	0.00206	0.09	0.00040	0.00022	0.00043	0.02	0.005	0.00006	0.00003	0.00004	6.56484
2	BUTANE	51.16783	2972.85	10.02729	7.34707	21.52583	1250.65	256.807	3.06242	2.06696	2.34317	3.27428
3	PENTANE	222.54579	16045.55	43.61197	39.65477	191.37723	13798.30	2628.247	27.22673	22.80452	23.98073	1.60180
4	HEXANE	161.41167	13913.68	31.63161	34.38611	259.99853	22411.87	4052.780	36.98930	37.04024	36.97850	0.85515
5	HEPTANE	75.15884	7530.91	14.72877	18.61180	229.99982	23045.98	4021.986	32.72147	38.08823	36.69754	0.45012
TOTAL		510.28583	40463.09	100.00000	100.00000	702.90161	60506.82	10959.820	100.00000	100.00000	100.00000	

VAPOR MW = 79.295 VAPOR ENTHALPY = 14985382. BTUS
LIQUID MW = 86.081 LIQUID LB/GAL = 5.521 LIQUID ENTHALPY = 15257002. BTUS

APPENDIX E

ILLUSTRATIVE TRIALS

F= 65.71600 D= 34.36900 B= 31.34700
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.81	149.43	155.24	159.79	164.19
X 1	0.1385	0.0578	0.0362	0.0299	0.0274
X 2	0.3149	0.2691	0.2288	0.1993	0.1775
X 3	0.5146	0.5910	0.5915	0.5578	0.5101
X 4	0.0236	0.0570	0.0946	0.1334	0.1691
X 5	0.0085	0.0253	0.0489	0.0795	0.1159

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	********	********
T(F)	168.52	172.53	175.99	******	******
X 1	0.0259	0.0248	0.0239	******	******
X 2	0.1608	0.1481	0.1385	******	******
X 3	0.4603	0.4156	0.3793	******	******
X 4	0.1976	0.2169	0.2268	******	******
X 5	0.1554	0.1947	0.2316	******	******

FEED STAGE= 8

STAGE	7	8	9	10	11
P(PSIA)	********	120.000	120.000	120.000	120.000
T(F)	******	149.75	178.92	204.10	220.65
X 1	******	0.2557	0.1133	0.0425	0.0146
X 2	******	0.0450	0.0382	0.0265	0.0164
X 3	******	0.1474	0.1606	0.1403	0.1084
X 4	******	0.2211	0.2812	0.3251	0.3525
X 5	******	0.3309	0.4069	0.4662	0.5087

STAGE	12	13	14	15	16
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	230.72	237.06	241.28	243.86	246.40
X 1	0.0048	0.0015	0.0005	0.0001	0.0000
X 2	0.0095	0.0053	0.0028	0.0014	0.0007
X 3	0.0781	0.0534	0.0350	0.0217	0.0124
X 4	0.3676	0.3734	0.3716	0.3634	0.3459
X 5	0.5405	0.5666	0.5904	0.6160	0.6411

NUMBER OF STAGES=16
NUMBER OF TRIALS= 1

```
 F=  65.71600      D=  34.40147      B=  31.31453
R=   1.35500      N=          5
KEY1=       3     KEY2=       4
```

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.87	149.64	155.64	160.41	165.02
X 1	0.1384	0.0576	0.0360	0.0297	0.0272
X 2	0.3140	0.2676	0.2267	0.1967	0.1745
X 3	0.5140	0.5885	0.5846	0.5505	0.5009
X 4	0.0236	0.0568	0.0938	0.1313	0.1649
X 5	0.0100	0.0296	0.0569	0.0919	0.1326

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	********
T(F)	169.51	173.60	177.06	179.82	******
X 1	0.0256	0.0245	0.0236	0.0230	******
X 2	0.1578	0.1452	0.1358	0.1291	******
X 3	0.4503	0.4058	0.3703	0.3438	******
X 4	0.1908	0.2073	0.2149	0.2153	******
X 5	0.1756	0.2173	0.2555	0.2889	******

FEED STAGE=   9

STAGE	9	10	11	12	13
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	165.21	185.79	202.25	214.77	224.33
X 1	0.1317	0.0555	0.0211	0.0074	0.0025
X 2	0.1136	0.0910	0.0639	0.0411	0.0249
X 3	0.1960	0.2008	0.1787	0.1445	0.1091
X 4	0.2234	0.2658	0.3028	0.3325	0.3542
X 5	0.3352	0.3870	0.4340	0.4749	0.5097

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	231.62	237.10	241.15	244.24	246.49
X 1	0.0008	0.0003	0.0001	0.0000	0.0000
X 2	0.0144	0.0080	0.0043	0.0022	0.0010
X 3	0.0781	0.0534	0.0349	0.0217	0.0124
X 4	0.3677	0.3734	0.3717	0.3626	0.3462
X 5	0.5393	0.5652	0.5891	0.6131	0.6401

NUMBER OF STAGES=18
NUMBER OF TRIALS= 2

F= 65.71600 D= 34.45097 B= 31.26503
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.94	149.85	156.04	161.01	165.81
X 1	0.1382	0.0574	0.0357	0.0294	0.0269
X 2	0.3134	0.2663	0.2249	0.1944	0.1719
X 3	0.5133	0.5859	0.5816	0.5432	0.4921
X 4	0.0236	0.0566	0.0930	0.1293	0.1609
X 5	0.0115	0.0339	0.0648	0.1037	0.1482

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	170.43	174.57	178.02	180.72	182.74
X 1	0.0254	0.0242	0.0234	0.0228	0.0223
X 2	0.1551	0.1427	0.1336	0.1271	0.1226
X 3	0.4410	0.3968	0.3623	0.3369	0.3190
X 4	0.1846	0.1988	0.2045	0.2037	0.1985
X 5	0.1940	0.2376	0.2764	0.3097	0.3378

FEED STAGE= 10

STAGE	6	7	8	9	10
P(PSIA)	********	********	********	********	120.000
T(F)	******	******	******	******	166.40
X 1	******	******	******	******	0.0991
X 2	******	******	******	******	0.1729
X 3	******	******	******	******	0.2072
X 4	******	******	******	******	0.2058
X 5	******	******	******	******	0.3149

STAGE	11	12	13	14	15
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	181.78	194.73	205.98	215.92	224.49
X 1	0.0430	0.0170	0.0063	0.0022	0.0007
X 2	0.1434	0.1065	0.0728	0.0464	0.0281
X 3	0.2207	0.2090	0.1806	0.1448	0.1091
X 4	0.2389	0.2727	0.3050	0.3329	0.3542
X 5	0.3542	0.3949	0.4357	0.4741	0.5083

STAGE	16	17	18	19	20
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	231.49	236.95	241.04	244.07	246.43
X 1	0.0002	0.0001	0.0000	0.0000	0.0000
X 2	0.0162	0.0090	0.0048	0.0025	0.0012
X 3	0.0781	0.0534	0.0350	0.0217	0.0124
X 4	0.3678	0.3737	0.3721	0.3633	0.3467
X 5	0.5380	0.5640	0.5882	0.6127	0.6394

NUMBER OF STAGES=20
NUMBER OF TRIALS= 3

F= 65.71600 D= 34.42836 B= 31.28764
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.91	149.74	155.82	160.68	165.38
X 1	0.1383	0.0575	0.0359	0.0296	0.0270
X 2	0.3138	0.2671	0.2259	0.1957	0.1734
X 3	0.5137	0.5872	0.5842	0.5471	0.4968
X 4	0.0236	0.0567	0.0934	0.1303	0.1630
X 5	0.0107	0.0316	0.0605	0.0974	0.1398

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	169.93	174.05	177.51	180.24	182.31
X 1	0.0255	0.0244	0.0235	0.0229	0.0224
X 2	0.1566	0.1440	0.1348	0.1282	0.1236
X 3	0.4459	0.4016	0.3665	0.3405	0.3220
X 4	0.1879	0.2033	0.2100	0.2098	0.2049
X 5	0.1842	0.2268	0.2653	0.2988	0.3272

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	183.83	******	******	******	******
X 1	0.0221	******	******	******	******
X 2	0.1203	******	******	******	******
X 3	0.3092	******	******	******	******
X 4	0.1973	******	******	******	******
X 5	0.3512	******	******	******	******

FEED STAGE= 11

STAGE	8	9	10	11	12
P(PSIA)	********	********	********	120.000	120.000
T(F)	******	******	******	165.52	178.58
X 1	******	******	******	0.0920	0.0409
X 2	******	******	******	0.1935	0.1653
X 3	******	******	******	0.2187	0.2407
X 4	******	******	******	0.1936	0.2199
X 5	******	******	******	0.3021	0.3331

STAGE	13	14	15	16	17
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	189.50	199.37	208.78	217.65	225.55
X 1	0.0168	0.0065	0.0024	0.0008	0.0003
X 2	0.1283	0.0921	0.0617	0.0390	0.0234
X 3	0.2391	0.2182	0.1848	0.1465	0.1098
X 4	0.2488	0.2795	0.3095	0.3357	0.3558
X 5	0.3671	0.4040	0.4420	0.4784	0.5112

STAGE	18	19	20	21	22
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	232.14	237.32	241.25	244.26	246.50
X 1	0.0001	0.0000	0.0000	0.0000	0.0000
X 2	0.0135	0.0075	0.0040	0.0020	0.0010
X 3	0.0783	0.0535	0.0350	0.0217	0.0124
X 4	0.3686	0.3740	0.3721	0.3629	0.3465
X 5	0.5398	0.5653	0.5891	0.6130	0.6399

NUMBER OF STAGES=22
NUMBER OF TRIALS= 4

F= 65.71600 D= 34.37785 B= 31.33815
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.84	149.51	155.39	160.03	164.51
X 1	0.1385	0.0578	0.0361	0.0298	0.0273
X 2	0.3145	0.2684	0.2280	0.1982	0.1763
X 3	0.5144	0.5900	0.5896	0.5550	0.5065
X 4	0.0236	0.0569	0.0943	0.1326	0.1674
X 5	0.0091	0.0269	0.0520	0.0843	0.1225

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.91	172.95	176.42	179.20	181.35
X 1	0.0258	0.0247	0.0238	0.0231	0.0226
X 2	0.1596	0.1469	0.1374	0.1305	0.1256
X 3	0.4564	0.4117	0.3757	0.3486	0.3290
X 4	0.1950	0.2131	0.2221	0.2235	0.2196
X 5	0.1633	0.2037	0.2411	0.2744	0.3033

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.95	******	******	******	******
X 1	0.0223	******	******	******	******
X 2	0.1221	******	******	******	******
X 3	0.3151	******	******	******	******
X 4	0.2123	******	******	******	******
X 5	0.3283	******	******	******	******

FEED STAGE= 11

STAGE	8	9	10	11	12
P(PSIA)	********	********	********	120.000	120.000
T(F)	******	******	******	176.52	185.92
X 1	******	******	******	0.0405	0.0171
X 2	******	******	******	0.1743	0.1396
X 3	******	******	******	0.2593	0.2667
X 4	******	******	******	0.2065	0.2300
X 5	******	******	******	0.3193	0.3466

STAGE	13	14	15	16	17
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	194.36	202.71	211.14	219.29	226.65
X 1	0.0068	0.0026	0.0009	0.0003	0.0001
X 2	0.1043	0.0731	0.0483	0.0302	0.0180
X 3	0.2544	0.2264	0.1888	0.1482	0.1103
X 4	0.2568	0.2855	0.3137	0.3384	0.3572
X 5	0.3779	0.4126	0.4487	0.4833	0.5146

STAGE	18	19	20	21	22
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	232.83	237.74	241.49	244.39	246.57
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0104	0.0057	0.0031	0.0016	0.0007
X 3	0.0785	0.0535	0.0350	0.0217	0.0124
X 4	0.3692	0.3740	0.3718	0.3625	0.3459
X 5	0.5423	0.5670	0.5903	0.6139	0.6406

NUMBER OF STAGES=22
NUMBER OF TRIALS= 5

F= 65.71600 D= 34.37303 B= 31.34297
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.82	149.47	155.33	159.92	164.37
X 1	0.1385	0.0578	0.0361	0.0299	0.0274
X 2	0.3146	0.2687	0.2283	0.1987	0.1768
X 3	0.5145	0.5904	0.5905	0.5562	0.5081
X 4	0.0236	0.0570	0.0944	0.1329	0.1681
X 5	0.0088	0.0262	0.0506	0.0823	0.1196

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.74	172.77	176.23	179.03	181.18
X 1	0.0259	0.0247	0.0238	0.0232	0.0227
X 2	0.1601	0.1474	0.1379	0.1310	0.1260
X 3	0.4581	0.4134	0.3773	0.3499	0.3301
X 4	0.1961	0.2147	0.2241	0.2259	0.2221
X 5	0.1599	0.1998	0.2370	0.2702	0.2992

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.80	******	******	******	******
X 1	0.0223	******	******	******	******
X 2	0.1225	******	******	******	******
X 3	0.3161	******	******	******	******
X 4	0.2149	******	******	******	******
X 5	0.3243	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	169.40	179.94	188.46
X 1	******	******	0.0691	0.0304	0.0126
X 2	******	******	0.1818	0.1537	0.1205
X 3	******	******	0.2556	0.2784	0.2799
X 4	******	******	0.1914	0.2116	0.2346
X 5	******	******	0.3020	0.3258	0.3524

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	196.32	204.25	212.32	220.15	227.24
X 1	0.0050	0.0019	0.0007	0.0002	0.0001
X 2	0.0886	0.0614	0.0403	0.0251	0.0149
X 3	0.2628	0.2313	0.1912	0.1493	0.1108
X 4	0.2608	0.2888	0.3162	0.3401	0.3583
X 5	0.3830	0.4169	0.4520	0.4857	0.5163

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	233.21	237.97	241.62	244.44	246.60
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0085	0.0047	0.0025	0.0013	0.0006
X 3	0.0786	0.0536	0.0350	0.0217	0.0124
X 4	0.3697	0.3743	0.3719	0.3625	0.3459
X 5	0.5433	0.5676	0.5907	0.6143	0.6408

NUMBER OF STAGES=23
NUMBER OF TRIALS= 6

F= 65.71600 D= 34.35435 B= 31.36165
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.79	149.38	155.16	159.66	164.02
X 1	0.1386	0.0579	0.0362	0.0300	0.0275
X 2	0.3149	0.2693	0.2292	0.1998	0.1780
X 3	0.5147	0.5915	0.5926	0.5594	0.5121
X 4	0.0236	0.0570	0.0948	0.1338	0.1700
X 5	0.0082	0.0244	0.0472	0.0770	0.1125

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.31	172.31	175.76	178.57	180.76
X 1	0.0260	0.0249	0.0240	0.0233	0.0228
X 2	0.1614	0.1487	0.1391	0.1320	0.1269
X 3	0.4625	0.4178	0.3813	0.3535	0.3332
X 4	0.1991	0.2190	0.2294	0.2320	0.2288
X 5	0.1511	0.1899	0.2264	0.2593	0.2884

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.41	******	******	******	******
X 1	0.0224	******	******	******	******
X 2	0.1233	******	******	******	******
X 3	0.3188	******	******	******	******
X 4	0.2218	******	******	******	******
X 5	0.3138	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	176.64	184.63	191.57
X 1	******	******	0.0369	0.0157	0.0064
X 2	******	******	0.1637	0.1327	0.1014
X 3	******	******	0.2877	0.3000	0.2937
X 4	******	******	0.1992	0.2178	0.2396
X 5	******	******	0.3124	0.3338	0.3589

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	198.50	205.85	213.50	220.99	227.80
X 1	0.0025	0.0009	0.0003	0.0001	0.0000
X 2	0.0734	0.0503	0.0327	0.0203	0.0120
X 3	0.2710	0.2357	0.1934	0.1503	0.1112
X 4	0.2649	0.2920	0.3185	0.3416	0.3591
X 5	0.3884	0.4213	0.4554	0.4882	0.5180

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	233.57	238.18	241.74	244.51	246.64
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0069	0.0038	0.0020	0.0010	0.0005
X 3	0.0787	0.0536	0.0350	0.0217	0.0124
X 4	0.3701	0.3744	0.3719	0.3624	0.3457
X 5	0.5445	0.5684	0.5913	0.6147	0.6411

NUMBER OF STAGES=23
NUMBER OF TRIALS= 7

F= 65.71600 D= 34.35532 B= 31.36069
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.79	149.37	155.15	159.64	164.00
X 1	0.1386	0.0579	0.0362	0.0300	0.0275
X 2	0.3150	0.2693	0.2292	0.1998	0.1781
X 3	0.5147	0.5916	0.5927	0.5596	0.5123
X 4	0.0236	0.0570	0.0948	0.1339	0.1701
X 5	0.0082	0.0243	0.0470	0.0767	0.1121

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.29	172.28	175.74	178.55	180.73
X 1	0.0260	0.0249	0.0240	0.0233	0.0228
X 2	0.1615	0.1488	0.1391	0.1321	0.1270
X 3	0.4627	0.4180	0.3815	0.3537	0.3334
X 4	0.1993	0.2192	0.2298	0.2324	0.2292
X 5	0.1506	0.1893	0.2258	0.2587	0.2878

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.39	******	******	******	******
X 1	0.0224	******	******	******	******
X 2	0.1233	******	******	******	******
X 3	0.3189	******	******	******	******
X 4	0.2222	******	******	******	******
X 5	0.3132	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	179.16	186.43	192.92
X 1	******	******	0.0291	0.0122	0.0049
X 2	******	******	0.1480	0.1181	0.0893
X 3	******	******	0.3036	0.3114	0.3014
X 4	******	******	0.2026	0.2207	0.2423
X 5	******	******	0.3167	0.3375	0.3621

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	199.56	206.69	214.14	221.46	228.12
X 1	0.0019	0.0007	0.0002	0.0001	0.0000
X 2	0.0642	0.0437	0.0283	0.0175	0.0104
X 3	0.2759	0.2384	0.1948	0.1509	0.1114
X 4	0.2671	0.2939	0.3199	0.3425	0.3597
X 5	0.3911	0.4235	0.4571	0.4894	0.518[illegible]

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	233.77	238.31	241.81	244.53	246.65
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0059	0.0033	0.0018	0.0009	0.0004
X 3	0.0788	0.0536	0.0350	0.0217	0.0124
X 4	0.3705	0.3746	0.3720	0.3625	0.3457
X 5	0.5450	0.5687	0.5914	0.6148	0.6412

NUMBER OF STAGES=23
NUMBER OF TRIALS= 8

```
 F=  65.71600      D=  34.36110      B=  31.35490
R=   1.35500      N=          5
KEY1=        3     KEY2=       4
```

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.79	149.39	155.17	159.68	164.05
X 1	0.1386	0.0579	0.0362	0.0300	0.0275
X 2	0.3150	0.2693	0.2292	0.1997	0.1779
X 3	0.5146	0.5914	0.5923	0.5591	0.5117
X 4	0.0236	0.0570	0.0948	0.1338	0.1698
X 5	0.0083	0.0245	0.0475	0.0775	0.1131

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.35	172.35	175.81	178.62	180.80
X 1	0.0260	0.0248	0.0239	0.0233	0.0228
X 2	0.1613	0.1486	0.1390	0.1319	0.1269
X 3	0.4620	0.4173	0.3809	0.3531	0.3329
X 4	0.1988	0.2186	0.2290	0.2315	0.2282
X 5	0.1519	0.1908	0.2273	0.2603	0.2894

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.45	******	******	******	******
X 1	0.0224	******	******	******	******
X 2	0.1232	******	******	******	******
X 3	0.3185	******	******	******	******
X 4	0.2212	******	******	******	******
X 5	0.3147	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	180.94	187.95	194.22
X 1	******	******	0.0264	0.0110	0.0044
X 2	******	******	0.1273	0.1003	0.0751
X 3	******	******	0.3200	0.3238	0.3101
X 4	******	******	0.2057	0.2238	0.2451
X 5	******	******	0.3205	0.3411	0.3655

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	200.66	207.58	214.84	221.96	228.46
X 1	0.0017	0.0006	0.0002	0.0001	0.0000
X 2	0.0535	0.0362	0.0234	0.0144	0.0085
X 3	0.2813	0.2416	0.1964	0.1516	0.1117
X 4	0.2696	0.2959	0.3214	0.3436	0.3604
X 5	0.3941	0.4260	0.4589	0.4907	0.5197

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	233.99	238.44	241.89	244.58	246.67
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0049	0.0027	0.0014	0.0007	0.0003
X 3	0.0790	0.0537	0.0350	0.0217	0.0124
X 4	0.3709	0.3748	0.3721	0.3625	0.3458
X 5	0.5455	0.5690	0.5916	0.6149	0.6412

NUMBER OF STAGES=23
NUMBER OF TRIALS= 9

F= 65.71600 D= 34.36684 B= 31.34917
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.80	149.41	155.21	159.74	164.13
X 1	0.1386	0.0578	0.0362	0.0299	0.0275
X 2	0.3149	0.2692	0.2290	0.1995	0.1777
X 3	0.5145	0.5911	0.5918	0.5583	0.5107
X 4	0.0236	0.0570	0.0947	0.1336	0.1694
X 5	0.0084	0.0250	0.0483	0.0787	0.1148

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.45	172.46	175.92	178.72	180.90
X 1	0.0259	0.0248	0.0239	0.0232	0.0227
X 2	0.1610	0.1483	0.1387	0.1317	0.1266
X 3	0.4609	0.4163	0.3799	0.3522	0.3321
X 4	0.1981	0.2176	0.2277	0.2300	0.2266
X 5	0.1540	0.1932	0.2299	0.2630	0.2920

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.54	******	******	******	******
X 1	0.0224	******	******	******	******
X 2	0.1231	******	******	******	******
X 3	0.3179	******	******	******	******
X 4	0.2195	******	******	******	******
X 5	0.3173	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	181.98	188.54	194.57
X 1	******	******	0.0223	0.0092	0.0037
X 2	******	******	0.1248	0.0978	0.0730
X 3	******	******	0.3244	0.3266	0.3118
X 4	******	******	0.2067	0.2245	0.2456
X 5	******	******	0.3217	0.3419	0.3660

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	200.88	207.74	214.94	222.04	228.51
X 1	0.0014	0.0005	0.0002	0.0001	0.0000
X 2	0.0519	0.0351	0.0226	0.0139	0.0082
X 3	0.2823	0.2421	0.1967	0.1518	0.1118
X 4	0.2701	0.2963	0.3217	0.3438	0.3606
X 5	0.3945	0.4263	0.4591	0.4908	0.5197

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	234.02	238.45	241.90	244.57	246.67
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0047	0.0026	0.0014	0.0007	0.0003
X 3	0.0790	0.0537	0.0350	0.0217	0.0124
X 4	0.3710	0.3749	0.3722	0.3626	0.3458
X 5	0.5455	0.5690	0.5916	0.6149	0.6411

NUMBER OF STAGES=23
NUMBER OF TRIALS= 10

```
 F=  65.71600      D=  34.37115      B=  31.34485
R=   1.35500      N=          5
KEY1=       3     KEY2=       4

STAGE          1         2         3         4         5
P(PSIA)     120.000   120.000   120.000   120.000   120.000
T(F)        138.80    149.42    155.24    159.79    164.20
X 1         0.1385    0.0578    0.0362    0.0299    0.0274
X 2         0.3149    0.2691    0.2289    0.1993    0.1775
X 3         0.5145    0.5909    0.5914    0.5577    0.5099
X 4         0.0236    0.0570    0.0946    0.1334    0.1690
X 5         0.0085    0.0253    0.0490    0.0797    0.1162

STAGE          6         7         8         9        10
P(PSIA)     120.000   120.000   120.000   120.000   120.000
T(F)        168.53    172.55    176.01    178.81    180.98
X 1         0.0259    0.0248    0.0239    0.0232    0.0227
X 2         0.1608    0.1481    0.1385    0.1315    0.1265
X 3         0.4601    0.4154    0.3791    0.3516    0.3315
X 4         0.1976    0.2168    0.2267    0.2288    0.2254
X 5         0.1556    0.1950    0.2319    0.2650    0.2940

STAGE         11        12        13        14        15
P(PSIA)     120.000  ********  ********  ********  ********
T(F)        182.61    ******    ******    ******    ******
X 1         0.0224    ******    ******    ******    ******
X 2         0.1229    ******    ******    ******    ******
X 3         0.3174    ******    ******    ******    ******
X 4         0.2182    ******    ******    ******    ******
X 5         0.3192    ******    ******    ******    ******

FEED STAGE=  11

STAGE          9        10        11        12        13
P(PSIA)    ********  ********  120.000   120.000   120.000
T(F)        ******    ******    182.03    188.60    194.63
X 1         ******    ******    0.0224    0.0093    0.0037
X 2         ******    ******    0.1234    0.0967    0.0721
X 3         ******    ******    0.3254    0.3274    0.3124
X 4         ******    ******    0.2069    0.2246    0.2458
X 5         ******    ******    0.3218    0.3420    0.3661

STAGE         14        15        16        17        18
P(PSIA)     120.000   120.000   120.000   120.000   120.000
T(F)        200.94    207.78    214.98    222.06    228.53
X 1         0.0014    0.0005    0.0002    0.0001    0.0000
X 2         0.0512    0.0347    0.0223    0.0137    0.0081
X 3         0.2827    0.2424    0.1969    0.1519    0.1118
X 4         0.2702    0.2964    0.3218    0.3439    0.3606
X 5         0.3946    0.4263    0.4592    0.4908    0.5197

STAGE         19        20        21        22        23
P(PSIA)     120.000   120.000   120.000   120.000   120.000
T(F)        234.03    238.46    241.90    244.57    246.67
X 1         0.0000    0.0000    0.0000    0.0000    0.0000
X 2         0.0046    0.0026    0.0014    0.0007    0.0003
X 3         0.0790    0.0537    0.0350    0.0217    0.0124
X 4         0.3711    0.3750    0.3722    0.3627    0.3459
X 5         0.5455    0.5690    0.5915    0.6148    0.6411

NUMBER OF STAGES=23
NUMBER OF TRIALS= 11
```

F= 65.71600 D= 34.37364 B= 31.34236
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.81	149.43	155.26	159.82	164.24
X 1	0.1385	0.0578	0.0362	0.0299	0.0274
X 2	0.3149	0.2691	0.2288	0.1992	0.1773
X 3	0.5145	0.5907	0.5912	0.5573	0.5095
X 4	0.0236	0.0570	0.0946	0.1333	0.1688
X 5	0.0086	0.0255	0.0493	0.0803	0.1169

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.58	172.60	176.06	178.86	181.02
X 1	0.0259	0.0248	0.0239	0.0232	0.0227
X 2	0.1607	0.1480	0.1384	0.1314	0.1264
X 3	0.4596	0.4150	0.3787	0.3512	0.3312
X 4	0.1973	0.2163	0.2261	0.2282	0.2246
X 5	0.1566	0.1961	0.2330	0.2662	0.2952

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.66	******	******	******	******
X 1	0.0224	******	******	******	******
X 2	0.1228	******	******	******	******
X 3	0.3171	******	******	******	******
X 4	0.2175	******	******	******	******
X 5	0.3204	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	182.06	188.62	194.65
X 1	******	******	0.0224	0.0093	0.0037
X 2	******	******	0.1230	0.0964	0.0719
X 3	******	******	0.3258	0.3277	0.3126
X 4	******	******	0.2069	0.2247	0.2458
X 5	******	******	0.3218	0.3420	0.3662

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	200.95	207.79	214.99	222.07	228.53
X 1	0.0014	0.0005	0.0002	0.0001	0.0000
X 2	0.0511	0.0345	0.0222	0.0137	0.0081
X 3	0.2829	0.2425	0.1969	0.1519	0.1119
X 4	0.2703	0.2964	0.3219	0.3439	0.3607
X 5	0.3946	0.4263	0.4592	0.4908	0.5197

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	234.03	238.46	241.90	244.57	246.67
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0046	0.0025	0.0014	0.0007	0.0003
X 3	0.0790	0.0537	0.0350	0.0217	0.0124
X 4	0.3711	0.3750	0.3723	0.3627	0.3459
X 5	0.5455	0.5689	0.5915	0.6148	0.6411

NUMBER OF STAGES=23
NUMBER OF TRIALS= 12

```
F=   65.71600      D=   34.37506      B=   31.34094
R=   1.35500       N=              5
KEY1=        3     KEY2=           4
```

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.81	149.44	155.27	159.84	164.26
X 1	0.1385	0.0578	0.0362	0.0299	0.0274
X 2	0.3149	0.2690	0.2287	0.1991	0.1773
X 3	0.5144	0.5907	0.5910	0.5571	0.5092
X 4	0.0236	0.0570	0.0946	0.1332	0.1687
X 5	0.0086	0.0256	0.0495	0.0806	0.1174

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.60	172.62	176.09	178.89	181.05
X 1	0.0259	0.0248	0.0239	0.0232	0.0227
X 2	0.1606	0.1479	0.1383	0.1313	0.1263
X 3	0.4594	0.4147	0.3784	0.3510	0.3310
X 4	0.1971	0.2161	0.2258	0.2278	0.2242
X 5	0.1571	0.1967	0.2337	0.2668	0.2958

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.68	******	******	******	******
X 1	0.0224	******	******	******	******
X 2	0.1228	******	******	******	******
X 3	0.3169	******	******	******	******
X 4	0.2171	******	******	******	******
X 5	0.3210	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	182.07	188.63	194.66
X 1	******	******	0.0224	0.0093	0.0037
X 2	******	******	0.1229	0.0962	0.0718
X 3	******	******	0.3259	0.3278	0.3127
X 4	******	******	0.2070	0.2247	0.2459
X 5	******	******	0.3218	0.3420	0.3661

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	200.96	207.80	214.99	222.07	228.53
X 1	0.0014	0.0005	0.0002	0.0001	0.0000
X 2	0.0510	0.0345	0.0222	0.0137	0.0081
X 3	0.2829	0.2425	0.1969	0.1519	0.1119
X 4	0.2703	0.2965	0.3219	0.3439	0.3607
X 5	0.3946	0.4263	0.4591	0.4908	0.5197

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	234.03	238.46	241.90	244.57	246.67
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0046	0.0025	0.0014	0.0007	0.0003
X 3	0.0790	0.0537	0.0350	0.0217	0.0124
X 4	0.3712	0.3750	0.3723	0.3627	0.3459
X 5	0.5455	0.5689	0.5915	0.6148	0.6411

NUMBER OF STAGES=23
NUMBER OF TRIALS= 13

```
F=  65.71600     D=  34.37585      B=  31.34015
R=   1.35500     N=           5
KEY1=       3    KEY2=        4
```

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.81	149.44	155.28	159.85	164.27
X 1	0.1385	0.0578	0.0362	0.0299	0.0274
X 2	0.3149	0.2690	0.2287	0.1991	0.1772
X 3	0.5144	0.5906	0.5910	0.5570	0.5091
X 4	0.0236	0.0570	0.0945	0.1332	0.1687
X 5	0.0086	0.0257	0.0497	0.0808	0.1176

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.62	172.64	176.10	178.90	181.06
X 1	0.0259	0.0248	0.0239	0.0232	0.0227
X 2	0.1606	0.1478	0.1383	0.1313	0.1263
X 3	0.4592	0.4145	0.3783	0.3508	0.3309
X 4	0.1970	0.2159	0.2256	0.2276	0.2240
X 5	0.1574	0.1970	0.2340	0.2672	0.2962

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.69	******	******	******	******
X 1	0.0223	******	******	******	******
X 2	0.1227	******	******	******	******
X 3	0.3168	******	******	******	******
X 4	0.2168	******	******	******	******
X 5	0.3214	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	182.08	188.64	194.66
X 1	******	******	0.0224	0.0092	0.0037
X 2	******	******	0.1228	0.0962	0.0717
X 3	******	******	0.3260	0.3279	0.3127
X 4	******	******	0.2070	0.2247	0.2459
X 5	******	******	0.3218	0.3420	0.3661

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	200.96	207.80	214.99	222.07	228.53
X 1	0.0014	0.0005	0.0002	0.0001	0.0000
X 2	0.0509	0.0344	0.0222	0.0137	0.0081
X 3	0.2830	0.2426	0.1970	0.1519	0.1119
X 4	0.2703	0.2965	0.3219	0.3439	0.3607
X 5	0.3946	0.4263	0.4591	0.4908	0.5197

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	234.03	238.46	241.90	244.57	246.67
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0046	0.0025	0.0014	0.0007	0.0003
X 3	0.0790	0.0537	0.0350	0.0217	0.0124
X 4	0.3712	0.3750	0.3723	0.3627	0.3459
X 5	0.5455	0.5689	0.5915	0.6148	0.6410

NUMBER OF STAGES=23
NUMBER OF TRIALS= 14

F= 65.71600 D= 34.37630 B= 31.33971
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	138.81	149.44	155.28	159.85	164.28
X 1	0.1385	0.0578	0.0362	0.0299	0.0274
X 2	0.3149	0.2690	0.2287	0.1991	0.1772
X 3	0.5144	0.5906	0.5909	0.5570	0.5090
X 4	0.0236	0.0570	0.0945	0.1332	0.1686
X 5	0.0087	0.0257	0.0497	0.0809	0.1178

STAGE	6	7	8	9	10
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	168.63	172.65	176.11	178.91	181.07
X 1	0.0259	0.0248	0.0239	0.0232	0.0227
X 2	0.1605	0.1478	0.1383	0.1313	0.1263
X 3	0.4591	0.4145	0.3782	0.3508	0.3309
X 4	0.1969	0.2159	0.2255	0.2275	0.2239
X 5	0.1576	0.1972	0.2342	0.2674	0.2964

STAGE	11	12	13	14	15
P(PSIA)	120.000	********	********	********	********
T(F)	182.70	******	******	******	******
X 1	0.0223	******	******	******	******
X 2	0.1227	******	******	******	******
X 3	0.3167	******	******	******	******
X 4	0.2167	******	******	******	******
X 5	0.3216	******	******	******	******

FEED STAGE= 11

STAGE	9	10	11	12	13
P(PSIA)	********	********	120.000	120.000	120.000
T(F)	******	******	182.08	188.64	194.66
X 1	******	******	0.0224	0.0092	0.0037
X 2	******	******	0.1228	0.0961	0.0717
X 3	******	******	0.3261	0.3279	0.3127
X 4	******	******	0.2070	0.2247	0.2459
X 5	******	******	0.3218	0.3420	0.3661

STAGE	14	15	16	17	18
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	200.96	207.80	214.99	222.07	228.53
X 1	0.0014	0.0005	0.0002	0.0001	0.0000
X 2	0.0509	0.0344	0.0222	0.0136	0.0081
X 3	0.2830	0.2426	0.1970	0.1519	0.1119
X 4	0.2703	0.2965	0.3219	0.3439	0.3607
X 5	0.3946	0.4263	0.4591	0.4908	0.5196

STAGE	19	20	21	22	23
P(PSIA)	120.000	120.000	120.000	120.000	120.000
T(F)	234.03	238.46	241.90	244.57	246.67
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0046	0.0025	0.0014	0.0007	0.0003
X 3	0.0790	0.0537	0.0350	0.0217	0.0124
X 4	0.3712	0.3750	0.3723	0.3627	0.3459
X 5	0.5455	0.5689	0.5915	0.6148	0.6410

NUMBER OF STAGES=23
NUMBER OF TRIALS= 15

F= 65.71600 D= 34.37630 B= 31.33971
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.92	156.97	161.71	166.31
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2694	0.2293	0.1999	0.1782
X 3	0.5144	0.5906	0.5909	0.5575	0.5103
X 4	0.0236	0.0568	0.0941	0.1325	0.1677
X 5	0.0087	0.0256	0.0493	0.0800	0.1162

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	********
T(F)	170.84	175.06	178.72	181.72	******
X 1	0.0262	0.0251	0.0242	0.0235	******
X 2	0.1617	0.1491	0.1396	0.1327	******
X 3	0.4610	0.4169	0.3810	0.3538	******
X 4	0.1959	0.2150	0.2249	0.2273	******
X 5	0.1552	0.1940	0.2302	0.2627	******

FEED STAGE= 9

STAGE	6	7	8	9	10
P(PSIA)	********	********	********	124.670	124.887
T(F)	******	******	******	194.00	200.35
X 1	******	******	******	0.0080	0.0032
X 2	******	******	******	0.0914	0.0679
X 3	******	******	******	0.3251	0.3078
X 4	******	******	******	0.2281	0.2492
X 5	******	******	******	0.3474	0.3719

STAGE	11	12	13	14	15
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	207.06	214.34	221.96	229.43	236.27
X 1	0.0012	0.0005	0.0002	0.0001	0.0000
X 2	0.0481	0.0325	0.0210	0.0130	0.0077
X 3	0.2770	0.2364	0.1915	0.1477	0.1090
X 4	0.2733	0.2987	0.3232	0.3443	0.3602
X 5	0.4005	0.4320	0.4643	0.4952	0.5232

STAGE	16	17	18	19	20
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.15	246.97	250.75	252.59	255.96
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0044	0.0025	0.0013	0.0007	0.0003
X 3	0.0773	0.0527	0.0346	0.0217	0.0124
X 4	0.3701	0.3737	0.3712	0.3645	0.3459
X 5	0.5483	0.5710	0.5930	0.6200	0.6410

NUMBER OF STAGES=20
NUMBER OF TRIALS= 16

F= 65.71600 D= 34.41766 B= 31.29834
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.86	151.09	157.30	162.21	166.98
X 1	0.1384	0.0579	0.0362	0.0300	0.0275
X 2	0.3144	0.2684	0.2278	0.1980	0.1760
X 3	0.5138	0.5884	0.5868	0.5515	0.5028
X 4	0.0236	0.0567	0.0935	0.1308	0.1644
X 5	0.0099	0.0291	0.0557	0.0898	0.1294

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	********
T(F)	171.64	175.92	179.59	182.56	******
X 1	0.0259	0.0248	0.0240	0.0233	******
X 2	0.1594	0.1469	0.1376	0.1309	******
X 3	0.4529	0.4089	0.3737	0.3473	******
X 4	0.1905	0.2075	0.2156	0.2165	******
X 5	0.1712	0.2119	0.2492	0.2819	******

FEED STAGE= 9

STAGE	8	9	10	11	12
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	174.41	184.30	191.97	198.88
X 1	******	0.0630	0.0278	0.0117	0.0047
X 2	******	0.1578	0.1329	0.1051	0.0789
X 3	******	0.2870	0.3110	0.3151	0.3016
X 4	******	0.1901	0.2066	0.2251	0.2467
X 5	******	0.3019	0.3215	0.3429	0.3680

STAGE	13	14	15	16	17
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	205.95	213.48	221.31	228.97	235.96
X 1	0.0018	0.0007	0.0002	0.0001	0.0000
X 2	0.0564	0.0383	0.0248	0.0153	0.0091
X 3	0.2734	0.2346	0.1908	0.1474	0.1089
X 4	0.2713	0.2973	0.3223	0.3438	0.3601
X 5	0.3972	0.4292	0.4621	0.4935	0.5220

STAGE	18	19	20	21	22
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	241.95	246.83	250.91	253.97	245.14
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0052	0.0029	0.0016	0.0008	0.0004
X 3	0.0772	0.0527	0.0345	0.0215	0.0124
X 4	0.3703	0.3740	0.3710	0.3621	0.3464
X 5	0.5473	0.5703	0.5915	0.6144	0.6406

NUMBER OF STAGES=22
NUMBER OF TRIALS= 17

F= 65.71600 D= 34.44440 B= 31.27161
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.90	151.19	157.48	162.49	167.35
X 1	0.1382	0.0578	0.0361	0.0298	0.0273
X 2	0.3142	0.2680	0.2270	0.1970	0.1749
X 3	0.5134	0.5872	0.5845	0.5481	0.4987
X 4	0.0236	0.0566	0.0931	0.1299	0.1626
X 5	0.0105	0.0310	0.0593	0.0952	0.1365

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	172.07	176.39	180.05	183.00	185.28
X 1	0.0258	0.0247	0.0238	0.0232	0.0228
X 2	0.1582	0.1457	0.1365	0.1300	0.1253
X 3	0.4486	0.4047	0.3699	0.3440	0.3255
X 4	0.1877	0.2035	0.2107	0.2110	0.2066
X 5	0.1797	0.2214	0.2591	0.2916	0.3197

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	187.01	******	******	******	******
X 1	0.0225	******	******	******	******
X 2	0.1221	******	******	******	******
X 3	0.3127	******	******	******	******
X 4	0.1994	******	******	******	******
X 5	0.3433	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	180.51	188.13	194.41	200.53
X 1	******	0.0369	0.0158	0.0065	0.0026
X 2	******	0.1411	0.1150	0.0892	0.0661
X 3	******	0.3167	0.3314	0.3288	0.3106
X 4	******	0.1960	0.2110	0.2286	0.2496
X 5	******	0.3092	0.3267	0.3468	0.3711

STAGE	15	16	17	18	19
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	207.14	214.36	221.95	229.42	236.26
X 1	0.0010	0.0004	0.0001	0.0000	0.0000
X 2	0.0468	0.0316	0.0204	0.0126	0.0075
X 3	0.2790	0.2379	0.1926	0.1484	0.1094
X 4	0.2737	0.2992	0.3238	0.3450	0.3609
X 5	0.3996	0.4310	0.4633	0.4942	0.5223

STAGE	20	21	22	23	24
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.14	246.96	250.74	252.61	255.96
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0043	0.0024	0.0013	0.0007	0.0003
X 3	0.0775	0.0528	0.0346	0.0217	0.0124
X 4	0.3709	0.3745	0.3719	0.3652	0.3466
X 5	0.5474	0.5702	0.5922	0.6192	0.6404

NUMBER OF STAGES=24
NUMBER OF TRIALS= 18

F= 65.71600 D = 34.40607 B= 31.30994
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.85	151.03	157.18	162.03	166.75
X 1	0.1384	0.0580	0.0363	0.0300	0.0275
X 2	0.3146	0.2688	0.2284	0.1987	0.1768
X 3	0.5140	0.5892	0.5882	0.5535	0.5054
X 4	0.0236	0.0567	0.0937	0.1314	0.1655
X 5	0.0094	0.0278	0.0535	0.0863	0.1247

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	171.36	175.62	179.29	182.27	184.60
X 1	0.0260	0.0249	0.0240	0.0234	0.0229
X 2	0.1602	0.1477	0.1383	0.1315	0.1267
X 3	0.4557	0.4117	0.3762	0.3495	0.3303
X 4	0.1924	0.2101	0.2188	0.2202	0.2165
X 5	0.1656	0.2057	0.2427	0.2753	0.3036

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	186.39	******	******	******	******
X 1	0.0226	******	******	******	******
X 2	0.1233	******	******	******	******
X 3	0.3168	******	******	******	******
X 4	0.2095	******	******	******	******
X 5	0.3279	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	183.12	189.95	195.76	201.59
X 1	******	0.0288	0.0123	0.0050	0.0020
X 2	******	0.1261	0.1013	0.0778	0.0572
X 3	******	0.3321	0.3422	0.3360	0.3150
X 4	******	0.1991	0.2136	0.2308	0.2515
X 5	******	0.3138	0.3306	0.3503	0.3743

STAGE	15	16	17	18	19
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	207.99	215.05	222.48	229.81	236.53
X 1	0.0008	0.0003	0.0001	0.0000	0.0000
X 2	0.0403	0.0271	0.0174	0.0107	0.0064
X 3	0.2814	0.2389	0.1928	0.1484	0.1092
X 4	0.2753	0.3004	0.3245	0.3453	0.3610
X 5	0.4024	0.4334	0.4653	0.4958	0.5235

STAGE	20	21	22	23	24
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.31	247.05	251.04	254.07	245.18
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0037	0.0020	0.0011	0.0006	0.0003
X 3	0.0773	0.0528	0.0345	0.0215	0.0124
X 4	0.3707	0.3742	0.3710	0.3619	0.3462
X 5	0.5484	0.5710	0.5920	0.6147	0.6408

NUMBER OF STAGES=24
NUMBER OF TRIALS= 19

```
 F=  65.71600       D=  34.39142       B=  31.32458
R=   1.35500       N=          5
KEY1=       3      KEY2=       4

STAGE         1        2        3        4        5
P(PSIA)     120.000  122.500  122.717  122.934  123.151
T(F)        138.83   150.97   157.07   161.86   166.52
X 1         0.1385   0.0580   0.0364   0.0301   0.0276
X 2         0.3148   0.2692   0.2289   0.1993   0.1776
X 3         0.5142   0.5899   0.5896   0.5556   0.5079
X 4         0.0236   0.0568   0.0939   0.1320   0.1667
X 5         0.0090   0.0266   0.0513   0.0830   0.1202

STAGE         6        7        8        9        10
P(PSIA)     123.368  123.585  123.802  124.019  124.236
T(F)        171.09   175.32   178.99   181.99   184.34
X 1         0.0261   0.0250   0.0241   0.0235   0.0230
X 2         0.1610   0.1484   0.1390   0.1322   0.1273
X 3         0.4585   0.4144   0.3787   0.3517   0.3322
X 4         0.1942   0.2126   0.2220   0.2239   0.2205
X 5         0.1601   0.1996   0.2362   0.2687   0.2970

STAGE        11       12       13       14       15
P(PSIA)     124.453 ******** ******** ******** ********
T(F)        186.15   ******   ******   ******   ******
X 1         0.0227   ******   ******   ******   ******
X 2         0.1238   ******   ******   ******   ******
X 3         0.3184   ******   ******   ******   ******
X 4         0.2136   ******   ******   ******   ******
X 5         0.3215   ******   ******   ******   ******

FEED STAGE=  11

STAGE        10       11       12       13       14
P(PSIA)    ********  124.236  124.453  124.670  124.887
T(F)        ******   183.97   190.44   196.05   201.79
X 1         ******   0.0255   0.0108   0.0044   0.0018
X 2         ******   0.1244   0.0995   0.0763   0.0561
X 3         ******   0.3352   0.3441   0.3371   0.3156
X 4         ******   0.1998   0.2141   0.2312   0.2518
X 5         ******   0.3150   0.3315   0.3511   0.3749

STAGE        15       16       17       18       19
P(PSIA)     125.104  125.321  125.538  125.755  125.972
T(F)        208.13   215.15   222.55   229.85   236.56
X 1        -0.0007   0.0002   0.0001   0.0000   0.0000
X 2         0.0394   0.0265   0.0170   0.0105   0.0062
X 3         0.2817   0.2391   0.1929   0.1484   0.1093
X 4         0.2754   0.3005   0.3245   0.3452   0.3608
X 5         0.4029   0.4339   0.4656   0.4960   0.5238

STAGE        20       21       22       23       24
P(PSIA)     126.189  126.406  126.623  126.840  127.057
T(F)        242.33   247.08   250.81   252.65   255.98
X 1         0.0000   0.0000   0.0000   0.0000   0.0000
X 2         0.0036   0.0020   0.0011   0.0006   0.0003
X 3         0.0774   0.0528   0.0346   0.0217   0.0124
X 4         0.3706   0.3740   0.3714   0.3646   0.3461
X 5         0.5485   0.5711   0.5930   0.6199   0.6410

NUMBER OF STAGES=24
NUMBER OF TRIALS= 20
```

F= 65.71600 D= 34.38484 B= 31.33116
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.82	150.94	157.02	161.78	166.41
X 1	0.1385	0.0581	0.0364	0.0301	0.0276
X 2	0.3148	0.2693	0.2291	0.1996	0.1779
X 3	0.5143	0.5902	0.5902	0.5565	0.5091
X 4	0.0236	0.0568	0.0940	0.1322	0.1672
X 5	0.0088	0.0261	0.0503	0.0815	0.1182

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.96	175.19	178.86	181.85	184.21
X 1	0.0261	0.0250	0.0242	0.0235	0.0230
X 2	0.1614	0.1488	0.1393	0.1324	0.1275
X 3	0.4598	0.4157	0.3799	0.3528	0.3331
X 4	0.1951	0.2138	0.2235	0.2256	0.2223
X 5	0.1576	0.1968	0.2332	0.2657	0.2940

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	186.03	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1240	******	******	******	******
X 3	0.3192	******	******	******	******
X 4	0.2155	******	******	******	******
X 5	0.3185	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	184.64	190.79	196.24	201.90
X 1	******	0.0225	0.0095	0.0039	0.0015
X 2	******	0.1243	0.0992	0.0759	0.0558
X 3	******	0.3370	0.3448	0.3373	0.3156
X 4	******	0.2003	0.2144	0.2314	0.2519
X 5	******	0.3158	0.3320	0.3514	0.3752

STAGE	15	16	17	18	19
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	208.21	215.21	222.60	229.89	236.59
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0392	0.0264	0.0169	0.0104	0.0062
X 3	0.2815	0.2389	0.1927	0.1482	0.1092
X 4	0.2756	0.3006	0.3246	0.3452	0.3608
X 5	0.4032	0.4341	0.4659	0.4963	0.5239

STAGE	20	21	22	23	24
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.35	247.07	251.06	254.06	245.18
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0036	0.0020	0.0011	0.0005	0.0003
X 3	0.0773	0.0527	0.0345	0.0215	0.0124
X 4	0.3705	0.3740	0.3708	0.3617	0.3460
X 5	0.5487	0.5713	0.5923	0.6150	0.6410

NUMBER OF STAGES=24
NUMBER OF TRIALS= 21

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F=  65.
       71600      D=  34.38206      B=  31.33394
R=   1.35500      N=          5
KEY1=       3     KEY2=       4
```

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.82	150.93	157.00	161.75	166.37
X 1	0.1385	0.0581	0.0364	0.0301	0.0277
X 2	0.3149	0.2694	0.2292	0.1998	0.1780
X 3	0.5143	0.5904	0.5905	0.5569	0.5096
X 4	0.0236	0.0568	0.0941	0.1323	0.1674
X 5	0.0088	0.0259	0.0499	0.0808	0.1173

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.91	175.13	178.80	181.80	184.16
X 1	0.0262	0.0250	0.0242	0.0235	0.0230
X 2	0.1615	0.1489	0.1395	0.1326	0.1276
X 3	0.4603	0.4162	0.3804	0.3532	0.3335
X 4	0.1954	0.2143	0.2241	0.2264	0.2231
X 5	0.1566	0.1956	0.2319	0.2644	0.2927

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.99	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1241	******	******	******	******
X 3	0.3195	******	******	******	******
X 4	0.2163	******	******	******	******
X 5	0.3173	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	184.62	190.79	196.24	201.90
X 1	******	0.0227	0.0096	0.0039	0.0016
X 2	******	0.1241	0.0990	0.0758	0.0557
X 3	******	0.3370	0.3449	0.3374	0.3157
X 4	******	0.2003	0.2144	0.2314	0.2519
X 5	******	0.3158	0.3320	0.3515	0.3752

STAGE	15	16	17	18	19
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	208.21	215.20	222.59	229.88	236.58
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0392	0.0263	0.0169	0.0104	0.0062
X 3	0.2816	0.2390	0.1928	0.1483	0.1092
X 4	0.2755	0.3005	0.3245	0.3452	0.3608
X 5	0.4032	0.4341	0.4658	0.4962	0.5239

STAGE	20	21	22	23	24
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.34	247.09	250.82	252.66	255.98
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0035	0.0020	0.0011	0.0006	0.0003
X 3	0.0774	0.0528	0.0346	0.0217	0.0124
X 4	0.3705	0.3739	0.3713	0.3645	0.3460
X 5	0.5487	0.5712	0.5931	0.6200	0.6410

NUMBER OF STAGES=24
NUMBER OF TRIALS= 22

F= 65.71600 D= 34.38058 B= 31.33542
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.93	156.99	161.73	166.35
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2694	0.2292	0.1998	0.1781
X 3	0.5143	0.5905	0.5906	0.5572	0.5098
X 4	0.0236	0.0568	0.0941	0.1324	0.1675
X 5	0.0087	0.0258	0.0496	0.0805	0.1168

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.88	175.10	178.77	181.77	184.13
X 1	0.0262	0.0250	0.0242	0.0235	0.0230
X 2	0.1616	0.1490	0.1395	0.1326	0.1277
X 3	0.4606	0.4165	0.3806	0.3534	0.3337
X 4	0.1956	0.2146	0.2245	0.2267	0.2235
X 5	0.1560	0.1949	0.2312	0.2637	0.2921

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.96	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1242	******	******	******	******
X 3	0.3197	******	******	******	******
X 4	0.2168	******	******	******	******
X 5	0.3166	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	184.64	190.80	196.26	201.92
X 1	******	0.0227	0.0096	0.0039	0.0015
X 2	******	0.1241	0.0990	0.0757	0.0556
X 3	******	0.3370	0.3448	0.3373	0.3156
X 4	******	0.2003	0.2144	0.2314	0.2520
X 5	******	0.3159	0.3321	0.3516	0.3753

STAGE	15	16	17	18	19
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	208.23	215.22	222.61	229.90	236.59
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0391	0.0263	0.0169	0.0104	0.0062
X 3	0.2815	0.2388	0.1927	0.1482	0.1091
X 4	0.2756	0.3006	0.3246	0.3452	0.3608
X 5	0.4033	0.4342	0.4660	0.4963	0.5240

STAGE	20	21	22	23	24
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.35	247.08	251.06	254.06	245.18
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0035	0.0020	0.0011	0.0005	0.0003
X 3	0.0773	0.0527	0.0345	0.0215	0.0124
X 4	0.3705	0.3739	0.3708	0.3617	0.3460
X 5	0.5488	0.5714	0.5923	0.6150	0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 23

F= 65.71600 D= 34.37981 B= 31.33620
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.92	156.98	161.72	166.33
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2694	0.2293	0.1999	0.1781
X 3	0.5144	0.5905	0.5907	0.5573	0.5100
X 4	0.0236	0.0568	0.0941	0.1324	0.1676
X 5	0.0087	0.0257	0.0495	0.0803	0.1166

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.87	175.09	178.75	181.75	184.12
X 1	0.0262	0.0250	0.0242	0.0235	0.0230
X 2	0.1616	0.1490	0.1396	0.1327	0.1277
X 3	0.4607	0.4166	0.3808	0.3535	0.3338
X 4	0.1957	0.2147	0.2246	0.2269	0.2238
X 5	0.1557	0.1946	0.2309	0.2633	0.2917

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.95	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1242	******	******	******	******
X 3	0.3198	******	******	******	******
X 4	0.2170	******	******	******	******
X 5	0.3163	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	184.62	190.78	196.24	201.90
X 1	******	0.0227	0.0096	0.0039	0.0016
X 2	******	0.1242	0.0991	0.0758	0.0557
X 3	******	0.3369	0.3448	0.3373	0.3156
X 4	******	0.2003	0.2144	0.2314	0.2519
X 5	******	0.3158	0.3321	0.3515	0.3753

STAGE	15	16	17	18	19
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	208.21	215.20	222.59	229.88	236.58
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0392	0.0264	0.0169	0.0104	0.0062
X 3	0.2816	0.2389	0.1928	0.1483	0.1092
X 4	0.2755	0.3005	0.3245	0.3451	0.3607
X 5	0.4032	0.4342	0.4659	0.4963	0.5239

STAGE	20	21	22	23	24
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.34	247.09	250.82	252.66	255.98
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0036	0.0020	0.0011	0.0006	0.0003
X 3	0.0774	0.0528	0.0346	0.0217	0.0124
X 4	0.3704	0.3739	0.3713	0.3645	0.3460
X 5	0.5487	0.5712	0.5931	0.6200	0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 24

F= 65.71600 D= 34.37936 B= 31.33664
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.92	156.98	161.72	166.33
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2694	0.2293	0.1999	0.1782
X 3	0.5144	0.5905	0.5908	0.5573	0.5101
X 4	0.0236	0.0568	0.0941	0.1324	0.1676
X 5	0.0087	0.0257	0.0495	0.0802	0.1165

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.86	175.08	178.74	181.74	184.11
X 1	0.0262	0.0251	0.0242	0.0235	0.0230
X 2	0.1617	0.1491	0.1396	0.1327	0.1277
X 3	0.4608	0.4167	0.3808	0.3536	0.3338
X 4	0.1958	0.2148	0.2247	0.2271	0.2239
X 5	0.1556	0.1944	0.2307	0.2631	0.2915

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.94	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1242	******	******	******	******
X 3	0.3198	******	******	******	******
X 4	0.2171	******	******	******	******
X 5	0.3161	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.236	124.453	124.670	124.887
T(F)	******	184.63	190.79	196.25	201.92
X 1	******	0.0227	0.0096	0.0039	0.0016
X 2	******	0.1242	0.0991	0.0758	0.0557
X 3	******	0.3369	0.3448	0.3373	0.3155
X 4	******	0.2003	0.2144	0.2314	0.2520
X 5	******	0.3159	0.3321	0.3516	0.3753

STAGE	15	16	17	18	19
P(PSIA)	125.104	125.321	125.538	125.755	125.972
T(F)	208.23	215.22	222.61	229.90	236.59
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0392	0.0263	0.0169	0.0104	0.0062
X 3	0.2815	0.2388	0.1927	0.1482	0.1091
X 4	0.2756	0.3005	0.3245	0.3452	0.3608
X 5	0.4033	0.4343	0.4660	0.4963	0.5240

STAGE	20	21	22	23	24
P(PSIA)	126.189	126.406	126.623	126.840	127.057
T(F)	242.35	247.08	251.06	254.06	245.18
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0035	0.0020	0.0011	0.0005	0.0003
X 3	0.0773	0.0527	0.0345	0.0215	0.0124
X 4	0.3704	0.3739	0.3707	0.3617	0.3460
X 5	0.5488	0.5714	0.5923	0.6150	0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 25

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 F=  65.71600       D=  34.37915       B=  31.33685
R=   1.35500      N=          5
KEY1=        3     KEY2=       4

STAGE          1         2         3         4         5
P(PSIA)      120.000   122.500   122.717   122.934   123.151
T(F)         138.81    150.92    156.98    161.71    166.32
X 1          0.1385    0.0581    0.0364    0.0302    0.0277
X 2          0.3149    0.2695    0.2293    0.1999    0.1782
X 3          0.5144    0.5905    0.5908    0.5574    0.5101
X 4          0.0236    0.0568    0.0941    0.1324    0.1676
X 5          0.0087    0.0257    0.0494    0.0801    0.1164

STAGE          6         7         8         9         10
P(PSIA)      123.368   123.585   123.802   124.019   124.236
T(F)         170.86    175.07    178.74    181.74    184.11
X 1          0.0262    0.0251    0.0242    0.0235    0.0231
X 2          0.1617    0.1491    0.1396    0.1327    0.1277
X 3          0.4609    0.4167    0.3809    0.3536    0.3339
X 4          0.1958    0.2148    0.2248    0.2271    0.2239
X 5          0.1555    0.1943    0.2306    0.2630    0.2914

STAGE          11        12        13        14        15
P(PSIA)      124.453 ******** ******** ******** ********
T(F)         185.93    ******    ******    ******    ******
X 1          0.0227    ******    ******    ******    ******
X 2          0.1242    ******    ******    ******    ******
X 3          0.3198    ******    ******    ******    ******
X 4          0.2172    ******    ******    ******    ******
X 5          0.3160    ******    ******    ******    ******

FEED STAGE=  11

STAGE          10        11        12        13        14
P(PSIA)     ********   124.236   124.453   124.670   124.887
T(F)         ******    184.61    190.78    196.24    201.90
X 1          ******    0.0227    0.0096    0.0039    0.0016
X 2          ******    0.1242    0.0992    0.0759    0.0557
X 3          ******    0.3368    0.3447    0.3373    0.3156
X 4          ******    0.2003    0.2144    0.2314    0.2519
X 5          ******    0.3158    0.3321    0.3515    0.3753

STAGE          15        16        17        18        19
P(PSIA)      125.104   125.321   125.538   125.755   125.972
T(F)         208.21    215.20    222.59    229.88    236.58
X 1          0.0006    0.0002    0.0001    0.0000    0.0000
X 2          0.0392    0.0264    0.0169    0.0104    0.0062
X 3          0.2816    0.2389    0.1928    0.1483    0.1092
X 4          0.2755    0.3005    0.3245    0.3451    0.3607
X 5          0.4032    0.4342    0.4659    0.4963    0.5240

STAGE          20        21        22        23        24
P(PSIA)      126.189   126.406   126.623   126.840   127.057
T(F)         242.34    247.09    250.82    252.66    255.98
X 1          0.0000    0.0000    0.0000    0.0000    0.0000
X 2          0.0036    0.0020    0.0011    0.0006    0.0003
X 3          0.0774    0.0528    0.0346    0.0217    0.0124
X 4          0.3704    0.3739    0.3713    0.3645    0.3460
X 5          0.5487    0.5712    0.5931    0.6200    0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 26
```

F= 65.71600 D= 34.37915 B= 31.33685
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.92	156.98	161.71	166.32
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2695	0.2293	0.1999	0.1782
X 3	0.5144	0.5905	0.5908	0.5574	0.5101
X 4	0.0236	0.0568	0.0941	0.1324	0.1676
X 5	0.0087	0.0257	0.0494	0.0801	0.1164

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	********
T(F)	170.86	175.07	178.74	181.74	******
X 1	0.0262	0.0251	0.0242	0.0235	******
X 2	0.1617	0.1491	0.1396	0.1327	******
X 3	0.4609	0.4167	0.3809	0.3536	******
X 4	0.1958	0.2148	0.2248	0.2271	******
X 5	0.1555	0.1943	0.2306	0.2630	******

FEED STAGE= 9

STAGE	6	7	8	9	10
P(PSIA)	********	********	********	124.887	125.104
T(F)	******	******	******	196.49	202.16
X 1	******	******	******	0.0039	0.0015
X 2	******	******	******	0.0757	0.0556
X 3	******	******	******	0.3371	0.3153
X 4	******	******	******	0.2315	0.2521
X 5	******	******	******	0.3518	0.3755

STAGE	11	12	13	14	15
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	208.48	215.49	222.88	230.18	236.88
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0391	0.0263	0.0169	0.0104	0.0062
X 3	0.2812	0.2386	0.1925	0.1480	0.1090
X 4	0.2757	0.3006	0.3246	0.3452	0.3608
X 5	0.4035	0.4345	0.4662	0.4965	0.5242

STAGE	16	17	18	19	20
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.64	247.36	251.36	254.57	245.18
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0035	0.0020	0.0011	0.0005	0.0003
X 3	0.0772	0.0527	0.0345	0.0215	0.0124
X 4	0.3704	0.3739	0.3707	0.3612	0.3460
X 5	0.5489	0.5715	0.5924	0.6143	0.6411

NUMBER OF STAGES=20
NUMBER OF TRIALS= 27

F= 65.71600 D= 34.42197 B= 31.29404
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.87	151.10	157.32	162.24	167.02
X 1	0.1383	0.0579	0.0362	0.0299	0.0274
X 2	0.3144	0.2684	0.2277	0.1979	0.1759
X 3	0.5137	0.5883	0.5865	0.5511	0.5023
X 4	0.0236	0.0567	0.0934	0.1307	0.1642
X 5	0.0099	0.0293	0.0561	0.0904	0.1301

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	********
T(F)	171.69	175.97	179.64	182.61	******
X 1	0.0259	0.0248	0.0239	0.0233	******
X 2	0.1593	0.1468	0.1375	0.1308	******
X 3	0.4525	0.4085	0.3733	0.3470	******
X 4	0.1902	0.2070	0.2150	0.2159	******
X 5	0.1721	0.2129	0.2503	0.2830	******

FEED STAGE= 9

STAGE	6	7	8	9	10
P(PSIA)	********	********	********	124.887	125.104
T(F)	******	******	******	194.35	200.52
X 1	******	******	******	0.0065	0.0026
X 2	******	******	******	0.0934	0.0694
X 3	******	******	******	0.3254	0.3080
X 4	******	******	******	0.2280	0.2491
X 5	******	******	******	0.3466	0.3710

STAGE	11	12	13	14	15
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	207.17	214.45	222.09	229.60	236.48
X 1	0.0010	0.0004	0.0001	0.0000	0.0000
X 2	0.0492	0.0333	0.0215	0.0133	0.0079
X 3	0.2772	0.2367	0.1918	0.1479	0.1091
X 4	0.2732	0.2988	0.3234	0.3445	0.3606
X 5	0.3995	0.4311	0.4635	0.4944	0.5226

STAGE	16	17	18	19	20
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.38	247.23	251.02	252.86	256.24
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0045	0.0025	0.0014	0.0007	0.0003
X 3	0.0773	0.0528	0.0346	0.0217	0.0124
X 4	0.3705	0.3742	0.3716	0.3650	0.3464
X 5	0.5477	0.5704	0.5925	0.6196	0.6406

NUMBER OF STAGES=20
NUMBER OF TRIALS= 28

F= 65.71600 D= 34.45641 B= 31.25960
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.92	151.25	157.59	162.65	167.56
X 1	0.1382	0.0578	0.0361	0.0298	0.0273
X 2	0.3141	0.2676	0.2265	0.1963	0.1741
X 3	0.5132	0.5865	0.5831	0.5462	0.4964
X 4	0.0236	0.0565	0.0929	0.1293	0.1616
X 5	0.0109	0.0322	0.0614	0.0983	0.1407

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	172.32	176.65	180.32	183.25	185.50
X 1	0.0257	0.0246	0.0238	0.0232	0.0227
X 2	0.1575	0.1450	0.1359	0.1294	0.1248
X 3	0.4461	0.4023	0.3677	0.3421	0.3239
X 4	0.1860	0.2013	0.2079	0.2079	0.2033
X 5	0.1847	0.2268	0.2647	0.2974	0.3252

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	187.22	******	******	******	******
X 1	0.0224	******	******	******	******
X 2	0.1217	******	******	******	******
X 3	0.3113	******	******	******	******
X 4	0.1960	******	******	******	******
X 5	0.3485	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	176.08	185.24	192.47	199.17
X 1	******	0.0543	0.0239	0.0100	0.0040
X 2	******	0.1607	0.1345	0.1060	0.0795
X 3	******	0.2910	0.3130	0.3161	0.3022
X 4	******	0.1911	0.2071	0.2253	0.2468
X 5	******	0.3027	0.3215	0.3426	0.3675

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	206.15	213.66	221.50	229.18	236.20
X 1	0.0016	0.0006	0.0002	0.0001	0.0000
X 2	0.0568	0.0386	0.0250	0.0154	0.0092
X 3	0.2739	0.2350	0.1910	0.1476	0.1090
X 4	0.2714	0.2974	0.3225	0.3441	0.3605
X 5	0.3965	0.4286	0.4615	0.4929	0.5215

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.20	247.10	251.20	254.26	245.09
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0053	0.0029	0.0016	0.0008	0.0004
X 3	0.0773	0.0527	0.0345	0.0215	0.0124
X 4	0.3706	0.3744	0.3714	0.3625	0.3468
X 5	0.5469	0.5699	0.5911	0.6140	0.6402

NUMBER OF STAGES=24
NUMBER OF TRIALS= 29

F= 65.71600 D= 34.40256 B= 31.31345
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.85	151.03	157.17	162.01	166.73
X 1	0.1384	0.0580	0.0363	0.0300	0.0275
X 2	0.3146	0.2688	0.2284	0.1987	0.1769
X 3	0.5140	0.5893	0.5883	0.5538	0.5056
X 4	0.0236	0.0567	0.0937	0.1314	0.1656
X 5	0.0094	0.0277	0.0533	0.0860	0.1243

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	171.34	175.59	179.26	182.25	184.58
X 1	0.0260	0.0249	0.0240	0.0234	0.0229
X 2	0.1603	0.1477	0.1384	0.1316	0.1267
X 3	0.4560	0.4119	0.3765	0.3497	0.3305
X 4	0.1926	0.2103	0.2191	0.2206	0.2168
X 5	0.1651	0.2052	0.2421	0.2747	0.3030

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	186.37	******	******	******	******
X 1	0.0226	******	******	******	******
X 2	0.1233	******	******	******	******
X 3	0.3169	******	******	******	******
X 4	0.2099	******	******	******	******
X 5	0.3272	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	181.10	188.38	194.52	200.60
X 1	******	0.0334	0.0144	0.0060	0.0024
X 2	******	0.1481	0.1207	0.0937	0.0696
X 3	******	0.3127	0.3272	0.3250	0.3076
X 4	******	0.1959	0.2107	0.2281	0.2491
X 5	******	0.3098	0.3270	0.3471	0.3714

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	207.22	214.48	222.11	229.62	236.49
X 1	0.0009	0.0003	0.0001	0.0000	0.0000
X 2	0.0494	0.0334	0.0215	0.0133	0.0079
X 3	0.2768	0.2363	0.1915	0.1477	0.1090
X 4	0.2732	0.2987	0.3232	0.3444	0.3604
X 5	0.3999	0.4314	0.4638	0.4947	0.5229

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.39	247.23	251.03	252.87	256.25
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0045	0.0025	0.0014	0.0007	0.0003
X 3	0.0773	0.0527	0.0346	0.0217	0.0124
X 4	0.3703	0.3739	0.3714	0.3647	0.3462
X 5	0.5479	0.5707	0.5927	0.6198	0.6408

NUMBER OF STAGES=24
NUMBER OF TRIALS= 30

F= 65.71600 D= 34.38608 B= 31.32993
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.82	150.95	157.03	161.80	166.44
X 1	0.1385	0.0581	0.0364	0.0301	0.0276
X 2	0.3148	0.2693	0.2290	0.1996	0.1778
X 3	0.5143	0.5902	0.5901	0.5563	0.5088
X 4	0.0236	0.0568	0.0940	0.1322	0.1671
X 5	0.0089	0.0262	0.0505	0.0818	0.1187

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.99	175.22	178.89	181.89	184.24
X 1	0.0261	0.0250	0.0241	0.0235	0.0230
X 2	0.1613	0.1487	0.1393	0.1324	0.1274
X 3	0.4595	0.4153	0.3796	0.3525	0.3329
X 4	0.1949	0.2135	0.2231	0.2252	0.2219
X 5	0.1583	0.1975	0.2339	0.2664	0.2948

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	186.06	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1240	******	******	******	******
X 3	0.3190	******	******	******	******
X 4	0.2151	******	******	******	******
X 5	0.3193	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	183.42	190.18	195.97	201.81
X 1	******	0.0281	0.0120	0.0049	0.0019
X 2	******	0.1277	0.1025	0.0788	0.0580
X 3	******	0.3308	0.3408	0.3347	0.3139
X 4	******	0.1991	0.2136	0.2308	0.2515
X 5	******	0.3142	0.3310	0.3508	0.3747

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	208.23	215.30	222.74	230.08	236.81
X 1	0.0007	0.0003	0.0001	0.0000	0.0000
X 2	0.0409	0.0275	0.0177	0.0109	0.0065
X 3	0.2804	0.2382	0.1923	0.1480	0.1090
X 4	0.2752	0.3003	0.3244	0.3451	0.3607
X 5	0.4028	0.4339	0.4657	0.4962	0.5239

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.59	247.34	251.34	254.37	245.14
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0037	0.0021	0.0011	0.0006	0.0003
X 3	0.0772	0.0527	0.0345	0.0215	0.0124
X 4	0.3704	0.3739	0.3707	0.3617	0.3460
X 5	0.5487	0.5713	0.5922	0.6149	0.6410

NUMBER OF STAGES=24
NUMBER OF TRIALS= 31

```
F=  65.71600      D=  34.38123      B=  31.33478
R=   1.35500      N=          5
KEY1=       3     KEY2=       4

STAGE        1         2         3         4         5
P(PSIA)    120.000   122.500   122.717   122.934   123.151
T(F)       138.82    150.93    157.00    161.74    166.36
X 1        0.1385    0.0581    0.0364    0.0301    0.0277
X 2        0.3149    0.2694    0.2292    0.1998    0.1781
X 3        0.5143    0.5904    0.5906    0.5570    0.5097
X 4        0.0236    0.0568    0.0941    0.1324    0.1675
X 5        0.0087    0.0258    0.0498    0.0807    0.1171

STAGE        6         7         8         9         10
P(PSIA)    123.368   123.585   123.802   124.019   124.236
T(F)       170.90    175.12    178.78    181.78    184.15
X 1        0.0262    0.0250    0.0242    0.0235    0.0230
X 2        0.1616    0.1490    0.1395    0.1326    0.1276
X 3        0.4604    0.4163    0.3805    0.3533    0.3336
X 4        0.1955    0.2144    0.2243    0.2265    0.2233
X 5        0.1563    0.1953    0.2316    0.2641    0.2924

STAGE        11        12        13        14        15
P(PSIA)    124.453  ********  ********  ********  ********
T(F)       185.97    ******    ******    ******    ******
X 1        0.0227    ******    ******    ******    ******
X 2        0.1241    ******    ******    ******    ******
X 3        0.3196    ******    ******    ******    ******
X 4        0.2165    ******    ******    ******    ******
X 5        0.3170    ******    ******    ******    ******

FEED STAGE=  11

STAGE        10        11        12        13        14
P(PSIA)   ********   124.453   124.670   124.887   125.104
T(F)       ******    184.18    190.64    196.26    202.01
X 1        ******    0.0253    0.0107    0.0044    0.0017
X 2        ******    0.1252    0.1002    0.0768    0.0565
X 3        ******    0.3343    0.3432    0.3362    0.3148
X 4        ******    0.1999    0.2141    0.2312    0.2518
X 5        ******    0.3152    0.3317    0.3513    0.3752

STAGE        15        16        17        18        19
P(PSIA)    125.321   125.538   125.755   125.972   126.189
T(F)       208.37    215.40    222.81    230.12    236.83
X 1        0.0007    0.0002    0.0001    0.0000    0.0000
X 2        0.0398    0.0267    0.0172    0.0106    0.0063
X 3        0.2810    0.2386    0.1926    0.1482    0.1091
X 4        0.2754    0.3004    0.3244    0.3451    0.3607
X 5        0.4032    0.4342    0.4659    0.4963    0.5240

STAGE        20        21        22        23        24
P(PSIA)    126.406   126.623   126.840   127.057   127.274
T(F)       242.61    247.37    251.10    252.91    256.27
X 1        0.0000    0.0000    0.0000    0.0000    0.0000
X 2        0.0036    0.0020    0.0011    0.0006    0.0003
X 3        0.0773    0.0527    0.0346    0.0217    0.0124
X 4        0.3704    0.3739    0.3713    0.3645    0.3460
X 5        0.5488    0.5712    0.5931    0.6201    0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 32
```

F= 65.71600 D= 34.37955 B= 31.33646
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.92	156.98	161.72	166.33
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2694	0.2293	0.1999	0.1782
X 3	0.5144	0.5905	0.5907	0.5573	0.5100
X 4	0.0236	0.0568	0.0941	0.1324	0.1676
X 5	0.0087	0.0257	0.0495	0.0803	0.1166

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.87	175.08	178.75	181.75	184.12
X 1	0.0262	0.0251	0.0242	0.0235	0.0230
X 2	0.1617	0.1490	0.1396	0.1327	0.1277
X 3	0.4608	0.4166	0.3808	0.3536	0.3338
X 4	0.1957	0.2148	0.2247	0.2270	0.2238
X 5	0.1557	0.1945	0.2308	0.2632	0.2916

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.94	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1242	******	******	******	******
X 3	0.3198	******	******	******	******
X 4	0.2171	******	******	******	******
X 5	0.3162	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	184.80	190.97	196.44	202.12
X 1	******	0.0226	0.0096	0.0039	0.0016
X 2	******	0.1248	0.0996	0.0762	0.0560
X 3	******	0.3363	0.3442	0.3367	0.3151
X 4	******	0.2003	0.2144	0.2314	0.2520
X 5	******	0.3159	0.3322	0.3516	0.3754

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	208.44	215.46	222.86	230.16	236.86
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0394	0.0265	0.0170	0.0105	0.0062
X 3	0.2811	0.2385	0.1925	0.1480	0.1090
X 4	0.2756	0.3006	0.3245	0.3452	0.3607
X 5	0.4034	0.4344	0.4661	0.4965	0.5241

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.63	247.36	251.35	254.36	245.14
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0036	0.0020	0.0011	0.0006	0.0003
X 3	0.0772	0.0527	0.0345	0.0215	0.0124
X 4	0.3704	0.3739	0.3707	0.3616	0.3460
X 5	0.5489	0.5714	0.5923	0.6150	0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 33

```
F=   65.71600     D=   34.37930      B=   31.33670
R=    1.35500     N=           5
KEY1=       3     KEY2=        4
```

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.92	156.98	161.72	166.33
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2694	0.2293	0.1999	0.1782
X 3	0.5144	0.5905	0.5908	0.5573	0.5101
X 4	0.0236	0.0568	0.0941	0.1324	0.1676
X 5	0.0087	0.0257	0.0495	0.0802	0.1165

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.86	175.08	178.74	181.74	184.11
X 1	0.0262	0.0251	0.0242	0.0235	0.0230
X 2	0.1617	0.1491	0.1396	0.1327	0.1277
X 3	0.4608	0.4167	0.3808	0.3536	0.3338
X 4	0.1958	0.2148	0.2247	0.2271	0.2239
X 5	0.1556	0.1944	0.2307	0.2631	0.2915

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.94	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1242	******	******	******	******
X 3	0.3198	******	******	******	******
X 4	0.2172	******	******	******	******
X 5	0.3161	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	184.80	190.98	196.45	202.13
X 1	******	0.0227	0.0096	0.0039	0.0016
X 2	******	0.1244	0.0993	0.0760	0.0558
X 3	******	0.3365	0.3444	0.3370	0.3153
X 4	******	0.2004	0.2144	0.2314	0.2520
X 5	******	0.3159	0.3322	0.3517	0.3754

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	208.45	215.45	222.85	230.15	236.85
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0393	0.0264	0.0170	0.0105	0.0062
X 3	0.2813	0.2387	0.1926	0.1482	0.1091
X 4	0.2756	0.3005	0.3245	0.3451	0.3607
X 5	0.4034	0.4343	0.4660	0.4964	0.5241

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.62	247.37	251.11	252.91	256.27
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0036	0.0020	0.0011	0.0006	0.0003
X 3	0.0773	0.0527	0.0346	0.0217	0.0124
X 4	0.3704	0.3739	0.3712	0.3645	0.3460
X 5	0.5488	0.5713	0.5931	0.6202	0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 34

F= 65.71600 D= 34.37918 B= 31.33682
R= 1.35500 N= 5
KEY1= 3 KEY2= 4

STAGE	1	2	3	4	5
P(PSIA)	120.000	122.500	122.717	122.934	123.151
T(F)	138.81	150.92	156.98	161.72	166.32
X 1	0.1385	0.0581	0.0364	0.0302	0.0277
X 2	0.3149	0.2695	0.2293	0.1999	0.1782
X 3	0.5144	0.5905	0.5908	0.5573	0.5101
X 4	0.0236	0.0568	0.0941	0.1324	0.1676
X 5	0.0087	0.0257	0.0494	0.0802	0.1164

STAGE	6	7	8	9	10
P(PSIA)	123.368	123.585	123.802	124.019	124.236
T(F)	170.86	175.07	178.74	181.74	184.11
X 1	0.0262	0.0251	0.0242	0.0235	0.0230
X 2	0.1617	0.1491	0.1396	0.1327	0.1277
X 3	0.4609	0.4167	0.3809	0.3536	0.3339
X 4	0.1958	0.2148	0.2248	0.2271	0.2239
X 5	0.1555	0.1943	0.2306	0.2630	0.2914

STAGE	11	12	13	14	15
P(PSIA)	124.453	********	********	********	********
T(F)	185.94	******	******	******	******
X 1	0.0227	******	******	******	******
X 2	0.1242	******	******	******	******
X 3	0.3198	******	******	******	******
X 4	0.2172	******	******	******	******
X 5	0.3160	******	******	******	******

FEED STAGE= 11

STAGE	10	11	12	13	14
P(PSIA)	********	124.453	124.670	124.887	125.104
T(F)	******	184.82	191.00	196.47	202.15
X 1	******	0.0227	0.0096	0.0039	0.0016
X 2	******	0.1242	0.0991	0.0759	0.0557
X 3	******	0.3366	0.3445	0.3370	0.3152
X 4	******	0.2004	0.2145	0.2315	0.2521
X 5	******	0.3160	0.3323	0.3517	0.3755

STAGE	15	16	17	18	19
P(PSIA)	125.321	125.538	125.755	125.972	126.189
T(F)	208.47	215.48	222.87	230.17	236.87
X 1	0.0006	0.0002	0.0001	0.0000	0.0000
X 2	0.0392	0.0264	0.0169	0.0104	0.0062
X 3	0.2812	0.2386	0.1925	0.1480	0.1090
X 4	0.2756	0.3006	0.3246	0.3452	0.3607
X 5	0.4035	0.4344	0.4661	0.4965	0.5241

STAGE	20	21	22	23	24
P(PSIA)	126.406	126.623	126.840	127.057	127.274
T(F)	242.63	247.36	251.35	254.36	245.14
X 1	0.0000	0.0000	0.0000	0.0000	0.0000
X 2	0.0036	0.0020	0.0011	0.0005	0.0003
X 3	0.0772	0.0527	0.0345	0.0215	0.0124
X 4	0.3704	0.3739	0.3707	0.3616	0.3460
X 5	0.5489	0.5714	0.5924	0.6150	0.6411

NUMBER OF STAGES=24
NUMBER OF TRIALS= 35

APPENDIX F

ROBINSON RUN

1.0000	100.0	10.0	33.05	66.95		5	2
3							
2.0000	0.935	0.0524	0.350				
3.0000	0.0455	0.2020	0.150				
4.0000	0.0015	0.4470	0.300				
5.0000	0.0	0.2240	0.150				
6.0000	0.0	0.0750	0.050				
7.0000	100.0						
8.0000	0.1664						
9.0000	0.1280						
10.0000	0.0781						
11.0000	0.0397						
12.0000	0.0109						
13.0000	120.0						
14.0000	0.3640						
15.0000	0.2800						
16.0000	0.1792						
17.0000	0.1064						
18.0000	0.0238						
19.0000	140.0						
20.0000	0.7800						
21.0000	0.6000						
22.0000	0.3960						
23.0000	0.2520						
24.0000	0.0510						
25.0000	160.0						
26.0000	1.560						
27.0000	1.200						
28.0000	0.8280						
29.0000	0.5400						
30.0000	0.1020						
31.0000	180.0						
32.0000	2.860						
33.0000	2.200						
34.0000	1.540						
35.0000	1.056						
36.0000	0.1870						
37.0000	133.0	165.0	150.0	4.0	4.0	250.0	

38.

```
 F= 100.00000      D=   33.05000      B=   66.95000
R=  10.00000      N=          5
KEY1=       2     KEY2=       3
```

STAGE	1	2	3	4	5
P(PSIA)	150.000	150.000	150.000	150.000	150.000
T(F)	129.49	128.64	129.19	129.36	129.57
X 1	0.9350	0.9377	0.9203	0.8992	0.8731
X 2	0.0455	0.0593	0.0741	0.0907	0.1089
X 3	0.0015	0.0030	0.0056	0.0101	0.0180
X 4	0.0000	0.0000	0.0000	0.0000	0.0000
X 5	0.0000	0.0000	0.0000	0.0000	0.0000

STAGE	6	7	8	9	10
P(PSIA)	150.000	150.000	150.000	150.000	150.000
T(F)	129.88	130.31	130.94	131.82	133.04
X 1	0.8405	0.7989	0.7458	0.6789	0.5976
X 2	0.1282	0.1477	0.1654	0.1787	0.1843
X 3	0.0313	0.0534	0.0888	0.1425	0.2181
X 4	0.0000	0.0000	0.0000	0.0000	0.0000
X 5	0.0000	0.0000	0.0000	0.0000	0.0000

STAGE	11	12	13	14	15
P(PSIA)	150.000	********	********	********	********
T(F)	134.61	******	******	******	******
X 1	0.5058	******	******	******	******
X 2	0.1796	******	******	******	******
X 3	0.3146	******	******	******	******
X 4	0.0000	******	******	******	******
X 5	0.0000	******	******	******	******

FEED STAGE= 11

STAGE	7	8	9	10	11
P(PSIA)	********	********	********	********	150.000
T(F)	******	******	******	******	148.36
X 1	******	******	******	******	0.0524
X 2	******	******	******	******	0.2020
X 3	******	******	******	******	0.4470
X 4	******	******	******	******	0.2240
X 5	******	******	******	******	0.0750

NUMBER OF STAGES=11
NUMBER OF TRIALS= 1

```
 F= 100.00000      D=   28.94191      B=   71.05809
R=  10.00000      N=          5
KEY1=       2     KEY2=       3
```

STAGE	1	2	3	4	5
P(PSIA)	150.000	150.000	150.000	150.000	150.000
T(F)	128.86	128.92	129.00	129.12	129.28
X 1	0.9762	0.9682	0.9582	0.9450	0.9273
X 2	0.0223	0.0288	0.0363	0.0448	0.0544
X 3	0.0015	0.0030	0.0056	0.0102	0.0183
X 4	0.0000	0.0000	0.0000	0.0000	0.0000
X 5	0.0000	0.0000	0.0000	0.0000	0.0000

STAGE	6	7	8	9	10
P(PSIA)	150.000	150.000	150.000	150.000	150.000
T(F)	129.53	129.93	130.53	131.45	132.76
X 1	0.9029	0.8684	0.8196	0.7522	0.6643
X 2	0.0648	0.0757	0.0859	0.0940	0.0978
X 3	0.0323	0.0560	0.0945	0.1538	0.2380
X 4	0.0000	0.0000	0.0000	0.0000	0.0000
X 5	0.0000	0.0000	0.0000	0.0000	0.0000

STAGE	11	12	13	14	15
P(PSIA)	150.000	********	********	********	********
T(F)	134.50	******	******	******	******
X 1	0.5598	******	******	******	******
X 2	0.0955	******	******	******	******
X 3	0.3447	******	******	******	******
X 4	0.0000	******	******	******	******
X 5	0.0000	******	******	******	******

FEED STAGE= 11

STAGE	7	8	9	10	11
P(PSIA)	********	********	********	********	150.000
T(F)	******	******	******	******	146.83
X 1	******	******	******	******	0.0950
X 2	******	******	******	******	0.2020
X 3	******	******	******	******	0.4216
X 4	******	******	******	******	0.2111
X 5	******	******	******	******	0.0704

NUMBER OF STAGES=11
NUMBER OF TRIALS= 2

```
 F= 100.00000      D=  21.38756      B=  78.61244
R=  10.00000      N=          5
KEY1=       2     KEY2=       3

STAGE         1         2         3         4         5
P(PSIA)     150.000   150.000   150.000   150.000   150.000
T(F)        128.48    128.43    128.37    128.33    128.31
X 1         1.0396    1.0510    1.0638    1.0775    1.0906
X 2         ******    ******    ******    ******    ******
X 3         0.0015    0.0030    0.0058    0.0110    0.0205
X 4         0.0000    0.0000    0.0000    0.0000    0.0000
X 5         0.0000    0.0000    0.0000    0.0000    0.0000

STAGE         6         7         8    .    9         10
P(PSIA)     150.000   150.000   150.000   150.000   150.000
T(F)        128.38    128.59    129.11    130.12    131.85
X 1         1.1001    1.0995    1.0776    1.0182    0.9069
X 2         ******    ******    ******    ******    ******
X 3         0.0379    0.0692    0.1235    0.2117    0.3390
X 4         0.0000    0.0000    0.0000    0.0000    0.0000
X 5         0.0000    0.0000    0.0000    0.0000    0.0000

STAGE         11        12        13        14        15
P(PSIA)     150.000 ******** ******** ******** ********
T(F)        134.36    ******    ******    ******    ******
X 1         0.7464    ******    ******    ******    ******
X 2         ******    ******    ******    ******    ******
X 3         0.4936    ******    ******    ******    ******
X 4         0.0000    ******    ******    ******    ******
X 5         0.0000    ******    ******    ******    ******

FEED STAGE=  11

STAGE         7         8         9         10        11
P(PSIA)    ******** ******** ******** ********  150.000
T(F)        ******    ******    ******    ******    144.57
X 1         ******    ******    ******    ******    0.1624
X 2         ******    ******    ******    ******    0.2020
X 3         ******    ******    ******    ******    0.3812
X 4         ******    ******    ******    ******    0.1908
X 5         ******    ******    ******    ******    0.0636

NUMBER OF STAGES=11
NUMBER OF TRIALS=  3
ALOG -- X=<0
***ERROR***     LI-J
PROGRAM WAS ON LINE   96.0000  IN ROUTINE *MAIN*.

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```

APPENDIX G

PROGRAM LISTING

```
C       DISSP3
        DIMENSION X(25,10),XB(25,10),RK(5,10),T(5),TC(25),TB(25)
        DIMENSION ALPHA(10),BETA(10),R2(10)
        DIMENSION XF(10),Y(10),CONI(10),CONII(10),SLK(10),SLKT(1
0)
        DIMENSION SLK2(10),PC(25),PB(25)
        REAL LBAR
        READ(1,3100)F,R,D,B,N,KEY1,KEY2
        DO 3200 I=1,N
  3200  READ(1,3300)X(1,I),XB(1,I),XF(I)
        MX=0
C       ADD TRACE COMPONENTS
        J=KEY1-1
        DO 2100 I=1,J
  2100  IF (XB(1,I).EQ.0.0) XB(1,I)=0.00001
        J=KEY2+1
        DO 2200 I=J,N
  2200  IF (X(1,I).EQ.0.0) X(1,I)=0.00001
C       READ AND REGRESS SECTION
        SRT=0
        SRT2=0
        DO 3350 I=1,N
        SLK(I)=0
        SLKT(I)=0
  3350  SLK2(I)=0
        DO 3400 I=1,5
        READ(1,3500)T(I)
        SRT=SRT+(1.0/T(I))
        SRT2=SRT2+(1.0/T(I))*(1.0/T(I))
        DO 3600 J=1,N
        READ(1,3700) RK(I,J)
        SLK(J)=SLK(J)+ALOG(RK(I,J))
        SLKT(J)=SLKT(J)+(ALOG(RK(I,J))*(1.0/T(I)))
  3600  SLK2(J)=SLK2(J)+(ALOG(RK(I,J))*ALOG(RK(I,J)))
  3400  CONTINUE
        READ(1,3800) TC(1),TB(1),PC(1),RDPC,RDP,PR
        DO 3450 I=1,N
        BETA(I)=(SLKT(I)-(SLK(I)*SRT/5.0))/(SRT2-(SRT*SRT/5.0))
        ALPHA(I)=(SLK(I)/5.0)-(BETA(I)*SRT/5.0)
        R2(I)=(SLKT(I)-SRT*SLK(I)/5.0)**2
        R2(I)=R2(I)/((SRT2-SRT*SRT/5.0)*(SLK2(I)-SLK(I)*SLK(I)/5
.0))
  3450  WRITE(2,4025)I,R2(I)
        IF (N.EQ.10) GOTO 6060
        NP1=N+1
        DO 6050 I=NP1,10
        X(1,I)=0
        XB(1,I)=0
  6050  XF(I)=0
  6060  MMAXB=0
        MMAXC=0
        DPC=0
```

```
      DP=0
      PB(1)=PC(1)
C     ESTABILISH CONSTANTS FOR MATERIAL BALENCE
6000  VBAR=D*(R+1)
      LBAR=VBAR+B
      CON1=R/(R+1)
      CON2=VBAR/LBAR
      DO 100 I=1,N
      CONI(I)=X(1,I)/(R+1)
100   CONII(I)=XB(1,I)*B/LBAR
C     CALCULATE FEED KEY RATIO CONSTANT
      FR=XF(KEY1)/XF(KEY2)
C     SET INITAL STAGE NUMBER
      GOTO 130
7500  MMAXB=0
      MMAXC=0
130   M=1
C     FIND TEMPERATURE IN CONDENSER
      REFK=EXP(ALPHA(KEY1)+BETA(KEY1)*(1.0/TC(1)))*PR/PC(1)
125   SUMK=0
      SUMY=0
C     DO BP
      DO 150 I=1,N
      DY=X(1,I)*(EXP(ALPHA(I)+BETA(I)*(1.0/TC(1))))*PR/PC(1)
      SUMY=SUMY+DY
150   SUMK=SUMK+(DY/REFK)
      REFK=1.0/SUMK
      TC(1)=(ALOG(REFK)-ALPHA(KEY1))/BETA(KEY1)
      TC(1)=1.0/TC(1)
      IF(SUMY.LT.0.99) GOTO 125
      IF(SUMY.GT.1.01) GOTO 125
C     ADD PRESSURE LOSS ACROSS CONDENSER PIPING
      PC(2)=PC(1)+DPC
C     COLUM TOP STAGE TO STAGE CALCULATION
1000  MM1=M
      M=M+1
C     INITAL TRIAL IS TEMPERATURE OF LAST STAGE
      TC(M)=TC(MM1)
C     CORRECT REFERENCE KEY FOR PRESSURE CHANGE
      REFK=REFK*PC(MM1)/PC(M)
C     MATERAL BALENCE EQUATIONS
      DO 600 I=1,N
600   Y(I)=CON1*X(MM1,I)+CONI(I)
C     EQULIBRIUM EQUATIONS
      DO 900 J=1,3
      SUMK=0
C     DO DP
      DO 400 I=1,N
      X(M,I)=Y(I)/(EXP(ALPHA(I)+BETA(I)*(1.0/TC(M)))*PR/PC(M))
400   SUMK=SUMK+(REFK*X(M,I))
```

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```
      REFK=SUMK
C     FIND CORRECTED TEMPERATURE
      TC(M)=(ALOG(REFK)-ALPHA(KEY1))/BETA(KEY1)
900   TC(M)=1.0/TC(M)
C     ADD STAGE PRESSURE DROP
      PC(M+1)=PC(M)+DP
C     TEST IF KEYS DIVERGE
      IF((X(M,KEY1)/X(M,KEY2)).GT.(X(MM1,KEY1)/X(MM1,KEY2))) G
OTO 20
C     TEST IF AT FEED STAGE
      IF ((X(M,KEY1)/X(M,KEY2)).GT.FR) GOTO 1000
C     TEST IF NUMBER OF STAGES DECREASED
20    IF(M.LT.MMAXC) GOTO 1000
      MFSD=M-1
      MMAXC=M
C     END COLUMN TOP CALCULATION
      MX=MX+1
C     ***********************************************************
C     BOILER CALCULATIONS
C     FIND EQULIBRIUM COMPOSITION IN BOILER
C     DO BP
      M=1
      REFK=EXP(ALPHA(KEY1)+BETA(KEY1)*(1.0/TB(1)))*PR/PB(1)
1100  SUMK=0
      SUMY=0
      DO 1200 I=1,N
      Y(I)=XB(1,I)*(EXP(ALPHA(I)+BETA(I)*(1.0/TB(1))))*PR/PB(1)
      SUMY=SUMY+Y(I)
1200  SUMK=SUMK+(Y(I)/REFK)
      REFK=1.0/SUMK
      TB(1)=(ALOG(REFK)-ALPHA(KEY1))/BETA(KEY1)
      TB(1)=1.0/TB(1)
      IF(SUMY.LT.0.99) GOTO 1100
      IF (SUMY.GT.1.01) GOTO 1100
C     GOTO NEXT STAGE
2000  M=M+1
      MM1=M-1
C     CALCULATE MATERIAL BALENCE
      DO 1400 I=1,N
1400  XB(M,I)=CON2*Y(I)+CONII(I)
C     INITAL TEMPERATURE OF NEXT STAGE IS TEMPERATURE OF LAST
STAGE
      TB(M)=TB(MM1)
C     ACCOUNT FOR PRESSURE DROP
      PB(M)=PB(MM1)-DP
C     CORRECT REFERENCE KEY FOR PRESSURE CHANGE
      REFK=REFK*PB(MM1)/PB(M)
C     FIND EQULIBRIUM COMPOSITION
      DO 1500 J=1,3
      SUMK=0
C     DO BP
      DO 1600 I=1,N
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```
          Y(I)=XB(M,I)*(EXP(ALPHA(I)+BETA(I)*(1.0/TB(M))))*PR/PB(M)
1600      SUMK=SUMK+(Y(I)/REFK)
          REFK=1.0/SUMK
          TB(M)=(ALOG(REFK)-ALPHA(KEY1))/BETA(KEY1)
1500      TB(M)=1.0/TB(M)
C         TEST IF KEYS DIVERGE
          IF((XB(M,KEY1)/XB(M,KEY2)).LT.(XB(MM1,KEY1)/XB(MM1,KEY2)
)) GOTO 10
C         TEST IF AT FEED STAGE
          IF ((XB(M,KEY1)/XB(M,KEY2)).LT.FR) GOTO 2000
C         TEST IF NUMBER OF STAGES DECREASED
10        IF (M.LT.MMAXB) GOTO 2000
          MFSB=M-1
          MMAXB=M
C         END OF BOTTONS CALCULATION
C         ****************************************************
C         TEST IF FEED COMPOSITION MATCHES
          J=KEY1-1
          DO 6350 I=1,J
          IF(ABS((X(MFSD,I)-XB(MFSB,I))*2./(X(MFSD,I)+XB(MFSB,I)))
.GT.0.0009
         1)GOTO 6450
6350      CONTINUE
          J=KEY2+1
          DO 6400 I=J,N
          IF(ABS((X(MFSD,I)-XB(MFSB,I))*2./(X(MFSD,I)+XB(MFSB,I)))
.GT.0.0009
         1) GOTO 6450
6400      CONTINUE
          GOTO 7000
C         CONVERSION-CORECTION SECTION
C         CORECT LIGHT NON KEYS IN BOTTOMS
6450      IF (KEY1.EQ.1) GOTO 6100
          J=KEY1-1
          DO 6150 I=1,J
          PCR=(X(MFSD,I)-XB(MFSB,I))/(X(MFSD,I)+XB(MFSB,I))
          IF(ABS(PCR).LT.0.10) PCR=PCR*2.
6150      XB(1,I)=XB(1,I)*(PCR+1)
C         CORECT HEAVY NON KEYS IN DISTILATE
          IF(KEY2.EQ.N) GOTO 6250
6100      J=KEY2+1
          DO  6300 I=J,N
          PCR=(XB(MFSB,I)-X(MFSD,I))/(X(MFSD,I)+XB(MFSB,I))
          IF(ABS(PCR).LT.0.10) PCR=PCR*2.
6300      X(1,I)=X(1,I)*(PCR+1)
C         MATERIAL BALANCE SECTION
6250      IF(KEY1.EQ.1) GOTO 5050
          IF(KEY1.EQ.2) GOTO 5100
          IF(KEY1.EQ.3) GOTO 5150
          IF(KEY1.EQ.4) GOTO 5200
          IF(KEY1.EQ.5) GOTO 5250
          IF(KEY1.EQ.6) GOTO 5300
          IF(KEY1.EQ.7) GOTO 5350
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```
      IF(KEY1.EQ.8) GOTO 5400
      B=F*(XF(10)-X(1,10))
      B=B/(1-XB(1,1)-XB(1,2)-XB(1,3)-XB(1,4)-XB(1,5)-XB(1,6)-X
B(1,7)-XB(
     11,8)-XB(1,9)-X(1,10))
      D=F-B
      GOTO 5500
 5050 D=F*(XF(1)-XB(1,1))
      D=D/(1-XB(1,1)-X(1,2)-X(1,3)-X(1,4)-X(1,5)-X(1,6)-X(1,7)
-X(1,8)-X(
     11,9)-X(1,10))
      B=F-D
      GOTO 5500
 5100 D=F*(XF(1)-XB(1,1)+XF(2)-XB(1,2))
      D=D/(1-XB(1,1)-XB(1,2)-X(1,3)-X(1,4)-X(1,5)-X(1,6)-X(1,7
)-X(1,8)-X
     1(1,9)-X(1,10))
      B=F-D
      GOTO 5500
 5150 D=F*(XF(1)-XB(1,1)+XF(2)-XB(1,2)+XF(3)-XB(1,3))
      D=D/(1-XB(1,1)-XB(1,2)-XB(1,3)-X(1,4)-X(1,5)-X(1,6)-X(1,
7)-X(1,8)-
     1X(1,9)-X(1,10))
      B=F-D
      GOTO 5500
 5200 D=F*(XF(1)-XB(1,1)+XF(2)-XB(1,2)+XF(3)-XB(1,3)+XF(4)-XB(
1,4))
      D=D/(1-XB(1,1)-XB(1,2)-XB(1,3)-XB(1,4)-X(1,5)-X(1,6)-X(1
,7)-X(1,8)
     1-X(1,9)-X(1,10))
      B=F-D
      GOTO 5500
 5250 B=F*(XF(10)-X(1,10)+XF(9)-X(1,9)+XF(8)-X(1,8)+XF(7)-X(1,
7)+XF(6)-X
     1(1,6))
      B=B/(1-XB(1,1)-XB(1,2)-XB(1,3)-XB(1,4)-XB(1,5)-X(1,6)-X(
1,7)-X(1,8
     1)-X(1,9)-X(1,10))
      D=F-B
      GOTO 5500
 5300 B=F*(XF(10)-X(1,10)+XF(9)-X(1,9)+XF(8)-X(1,8)+XF(7)-X(1,
7))
      B=B/(1-XB(1,1)-XB(1,2)-XB(1,3)-XB(1,4)-XB(1,5)-XB(1,6)-X
(1,7)-X(1,
     18)-X(1,9)-X(1,10))
      D=F-B
      GOTO 5500
 5350 B=F*(XF(10)-X(1,10)+XF(9)-X(1,9)+XF(8)-X(1,8))
      B=B/(1-XB(1,1)-XB(1,2)-XB(1,3)-XB(1,4)-XB(1,5)-XB(1,6)-X
B(1,7)-X(1
     1,8)-X(1,9)-X(1,10))
      D=F-B
      GOTO 5500
 5400 B=F*(XF(10)-X(1,10)+XF(9)-X(1,9))
      B=B/(1-XB(1,1)-XB(1,2)-XB(1,3)-XB(1,4)-XB(1,5)-XB(1,6)-X
B(1,7)-XB(
     11,8)-X(1,9)-X(1,10))
      D=F-B
 5500 DO 5550 I=1,KEY1
 5550 X(1,I)=(XF(I)*F-XB(1,I)*B)/D
      DO 5600 I=KEY2,N
 5600 XB(1,I)=(XF(I)*F-X(1,I)*D)/B
```

```
C      END MATERIAL BALANCE SECTION
       GOTO 6000
C      FEED PRESSURE MATCHING SECTION
7000   IF(DP.NE.0.0) GO TO 7350
       IF(RDP.EQ.0.0) GO TO 8000
       DPC=RDPC
       DP=RDP
       GO TO 7400
7350   IF((PC(MFSD)-PB(MFSB)).LT.(DP/10.)) GOTO 8000
7400   PB(1)=PC(1)+DPC+DP*(MFSD+MFSB-3)
       GOTO 7500
C      ENDING SECTION (WILL BE FINAL PRINT OUT)
8000   MI=MFSD+1
       DO 8910 I=MI,25
       PC(I)=99999.9
       TC(I)=99999.9
       DO 8920 J=1,N
8920   X(I,J)=99999.9
8910   CONTINUE
       MI=MFSB+1
       DO 8930 I=MI,25
       PB(I)=99999.9
       TB(I)=99999.9
       DO 8940 J=1,N
8940   XB(I,J)=99999.9
8930   CONTINUE
       WRITE(2,8800) F,D,B
8800   FORMAT(/,' F=',F10.5,5X,'D=',F10.5,5X,'B=',F10.5)
       WRITE(2,8850) R,N
8850   FORMAT (1X,'R=',F10.5,5X,'N=',I10)
       WRITE(2,8900) KEY1,KEY2
8900   FORMAT (1X,'KEY1=',I7,5X,'KEY2=',I7)
       M=1
8050   WRITE(2,8100)M,M+1,M+2,M+3,M+4
8100   FORMAT(/,' STAGE',5X,I3,6X,I3,6X,I3,6X,I3,6X,I3)
       WRITE(2,8150)PC(M),PC(M+1),PC(M+2),PC(M+3),PC(M+4)
8150   FORMAT(1X,'P(PSIA)',3X,F8.3,1X,F8.3,1X,F8.3,1X,F8.3,1X,F
8.3)
       WRITE(2,8200)TC(M),TC(M+1),TC(M+2),TC(M+3),TC(M+4)
8200   FORMAT(1X,'T(F)',7X,F6.2,3X,F6.2,3X,F6.2,3X,F6.2,3X,F6.2)
       DO 8250 I=1,N
8250   WRITE(2,8300) I,X(M,I),X(M+1,I),X(M+2,I),X(M+3,I),X(M+4,
I)
8300   FORMAT(1X,'X',I2,8X,F6.4,3X,F6.4,3X,F6.4,3X,F6.4,3X,F6.4)
       MP4=M+4
       M=M+5
       IF(MFSD.GT.MP4) GOTO 8050
       WRITE(2,8350)MFSD
8350   FORMAT(/,' FEED STAGE= ',I3)
       M=MFSB
       IF((M/5.).EQ.INT(M/5.)) GOTO 8400
8450   M=M+1
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      IF((M/5.).NE.INT(M/5.)) GOTO 8450
8400  MD=MFSD-(M-MFSB)
8500  WRITE(2,8550)MD,MD+1,MD+2,MD+3,MD+4
8550  FORMAT(/,' STAGE',5X,I3,6X,I3,6X,I3,6X,I3,6X,I3)
      WRITE(2,8600)PB(M),PB(M-1),PB(M-2),PB(M-3),PB(M-4)
8600  FORMAT(1X,'P(PSIA)',3X,F8.3,1X,F8.3,1X,F8.3,1X,F8.3,1X,F
8.3)
      WRITE(2,8650) TB(M),TB(M-1),TB(M-2),TB(M-3),TB(M-4)
8650  FORMAT(1X,'T(F)',7X,F6.2,3X,F6.2,3X,F6.2,3X,F6.2,3X,F6.2)
      DO 8700 I=1,N
8700  WRITE(2,8750) I,XB(M,I),XB(M-1,I),XB(M-2,I),XB(M-3,I),XB
(M-4,I)
8750  FORMAT(1X,'X',I2,8X,F6.4,3X,F6.4,3X,F6.4,3X,F6.4,3X,F6.4)
      M=M-5
      MD=MD+5
      IF(M.GT.0) GOTO 8500
      MS=MFSD+MFSB-1
      WRITE(2,8950) MS
8950  FORMAT (/,' NUMBER OF STAGES=',I2)
      WRITE(2,8960)MX
8960  FORMAT(' NUMBER OF TRIALS=',I3)
C     END PRINT OUT
      STOP
4025  FORMAT(10X,I2,10X,F10.7)
3100  FORMAT(4F10.5,3I10)
3300  FORMAT(3F10.8)
3500  FORMAT(F10.5)
3700  FORMAT(F10.5)
3800  FORMAT(6F10.5)
      END
```

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