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MINIMUM REFLUX IN FRACTIONATING COLUMNS

A NEW AND IMPROVED SHORT-CUT METHOD

BY

ELIZABETH GARCIA

A THESIS

PRESENTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE IN CHEMICAL ENGINEERING

AT

NEWARK COLLEGE OF ENGINEERING

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ABSTRACT

A short-cut method is presented for calculating the minimum reflux rate for multicomponent systems. This new method is best suited for use on the computer and gives a very accurate estimate of this important factor in the design of fractionating columns. It does so without going to the tedious and time-consuming calculations of the rigorous methods.

The calculation approach is based on a simplification of the Thiele and Geddes method for fractionating columns under minimum reflux conditions.

The program is written in Fortran IV language and was used on an IBM 370 computer. Input specifications include the split of the light and heavy key components and feed conditions and composition. The liquid rate at the rectifying pinch zone, which represents the constant internal minimum reflux, is then calculated.

This method is an iterative procedure and the program assumes constant molal overflow between the rectifying and stripping pinch zones. The overall material balance for every trial is based on temperatures calculated from the composition of the previous trial. However, the liquid rate at the rectifying pinch zone temporarily remains constant until convergence is obtained on the distillate composition and pinch zone temperatures. The liquid rate is then changed in the direction of convergence on the key component specifications and the calculations are repeated until converged. The true minimum reflux was calculated on a rigorous plate-toplate program by a parameter study of the actual required reflux for a series of column designs with increasing stages and with each design making the same separation for the key components. These values were asymtotically extrapolated to the case for infinite stages, and the minimum reflux value obtained was compared with the results given by the new procedure. The results demonstrated the reliability and usefulness of this new short-cut method.

APPROVAL OF THESIS

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ВҮ

ELIZABETH GARCIA

FOR

DEPARTMENT OF CHEMICAL ENGINEERING

NEWARK COLLEGE OF ENGINEERING

BY

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APPROVED:

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NOMENCLATURE

- A Component absorption factor for the specific stage or section of the column. A_{R^*} = component absorption factor at the rectifying pinch.
- ${\rm A}_{\rm A}$ Average component absorption factor in the specific section.
- b Component molar flow rate in the bottoms.
- B Bottom molar flow rate.
- C Total number of components; the least volatile component.
- d Component molar flow rate in the distillate.
- D Distillate molar flow rate.
- f Feed stage.
- f_F Total component molar flow rate in the feed.
- F Total molar flow rate of feed.
- h Enthalpy of one mole of the liquid leaving the specific stage or section of the column.
- H Enthalpy of one mole of the vapor leaving the specific stage or section of the column.
- HK Heavy key component.
- IHS First component separated from the distillate.
- ILS First component separated from the bottoms.
- K Component vapor-liquid equilibrium constant (y = Kx), in the specific stage or section of the column.
- ℓ Component liquid molar flow rate leaving the specific stage.
- $\ell_{\rm fl}$ Component liquid molar flow rate onto stage f.
- $\ell_{_{\rm F}}$ Component molar flow rate in liquid feed.
- L Total liquid molar flow rate in the specific section.
- L_F Total liquid molar flow rate of feed.
- L_R External reflux.

L _{Rm}	External minimum reflux.
L _{R*}	Internal minimum reflux; liquid rate at the rectifying pinch.
LK	Light key component.
М	Number of stages between the stripping pinch and stage f.
N	Number of stages between the rectifying pinch and stage f+1.
N _m	Minimum number of stages of a column.
۹ _۲	Condenser duty.
Q _R	Reboiler duty.
R*	Rectifying pinch.
S	Component stripping factor for the specific stage or section of the column. $S_{\underline{S}^*}$ = component stripping factor at the stripping pinch.
SA	Average component stripping factor in the specific section.
<u>S</u> *	Stripping pinch.
Т	Temperature in °F.
v	Component vapor molar flow rate leaving the specific stage.
$\mathbf{\bar{v}}_{\mathtt{f}}$	Component vapor molar flow rate as it enters stage f+1.
v _F	Component molar flow rate in vapor feed.
v	Total vapor molar flow rate in the specific section.
v ₁	Total molar flow rate of the vapor from the top stage of the column.
v _F	Total vapor molar flow rate of feed.
x	Component mole fraction in the liquid phase.
У	Component mole fraction in the vapor phase.
α	Relative volatility.
θ	Multiplier used to correct the (b/d) ratios.

xi

Subscripts

- A Average value.
- c Total number of components.
- F Feed.
- f+1 Stage above the feed stage.
- f Feed stage.
- HK Heavy key.
- i Component number. Components are numbered in the order of decreasing volatility.
- L Liquid part of a stream.
- LK Light key.
- R* Rectifying pinch.
- <u>S</u>* Stripping pinch.
- V Vapor part of a stream.

CHAPTER I

INTRODUCTION

The minimum reflux ratio is the lowest reflux which can give a specified separation for two key components from a fixed feed to a fractionating column. To obtain that separation, an infinite number of equilibrium stages is required in both the rectifying section and the stripping section of the column.

This imaginary operation, that cannot be duplicated in practice, is of interest as a limiting case since it provides an effective variable for the selection of an economic operating reflux in the real design of the fractionating column.

A small increase in the value of the reflux ratio at values near the minimum gives a marked reduction in the number of stages, but as the value of this reflux ratio increases further, the effect on the number of stages becomes much less.

A large reflux ratio increases the operating costs, since large quantities of liquid are recirculated to the column resulting in higher cooling and heating duties. A low reflux ratio requires a greater number of stages and the investment cost increases. The most economic reflux ratio usually lies between 1.2 and 1.5 times the minimum reflux ratio.

Many methods have been presented for calculating the minimum reflux value for multicomponent distillation separations.

1

The purpose of this work was to develop a method for calculating the minimum reflux ratio for multicomponent fractionating columns, which will give a more accurate estimate of the minimum reflux without going to the tedious and time-consuming rigorous methods. This new method consists of a simplification of the Thiele and Geddes (30) plate-to-plate procedure applied to the calculation for infinite stages and, therefore, minimum reflux.

To obtain the rigorous solution of the minimum reflux a parameter study was made by calculating the reflux required for a series of column designs with increasing stages and with each design making the same separation for the key components. These values were asymptotically extrapolated to the case for infinite stages and, then, the true minimum reflux value obtained was compared with the results given by the new simplified procedure and with the traditional Underwood method.

The programs used have been written in Fortran IV language and are listed in the Appendix B. The calculations were carried out on an IBM 370 computer.

2 .

CHAPTER II

A FRACTIONATING COLUMN

The purpose of a fractionating column is the separation of two or more components which are present in a feed stream to give an overhead product (D) and a bottom product (B) meeting certain specifications. Figure 2-1 illustrates a fractionating column having one feed.

The components upon which the specifications are made are commonly referred to as the light and the heavy keys.

The split, light and heavy key components will appear in both, the distillate and the bottoms products and therefore, these are, by definition, distributed components. Components lighter than the light key which appear in the distillate and heavier than heavy key which appear in the bottoms are also, distributed components. Components which appear only in one product are called separated components.

The conventional procedure for the design of a fractionating column frequently involves the calculation of two limits. One is the minimum number of stages required for the separation if practically no product is withdrawn from the column. This condition is called total reflux. The other is the requirement of an infinite height column and this leads to the calculation of the minimum reflux. Therefore, a practical operation lies in between these two conditions.

3

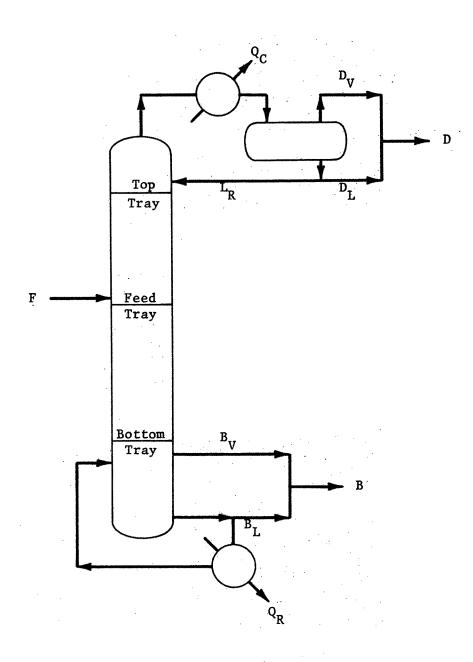


FIGURE 2-1. A fractionating column having one feed.

CHAPTER III

BEHAVIOR OF A COLUMN AT MINIMUM REFLUX

A fractionating column in the state of minimum reflux presents a maximum of six distinct column sections. This type of infinite column is represented in Figure 3-1 and corresponds to separations where some of the components of the feed are completely separated from the top product and some others are completely separated from the bottom product.

At minimum reflux no separation occurs at some point in the column. This point will originate what is called a "pinch" zone.

Sections II and V, where the "pinch" zones occur, are the uniform sections. The temperatures, stream compositions and molal overflow remain constant throughout these sections.

The points of infinitude or pinches of the type of column shown in Figure 3-1 occur away from the feed stage. Hence, two other sections are to be distinguished between the pinch zones in the rectifying and stripping sections and the feed stage: Section III, which is an intermediate section between the feed and the stripping pinch, and Section IV, which is an intermediate section between the feed and the rectifying pinch. Stream compositions, as well as temperatures and molal overflow may change considerably over the intermediate trays between the feed and the constant composition zones. The compositions of the liquid and vapor phases of the feed differ from the liquid and vapor stream compositions in the pinch zones for all feed conditions.

5

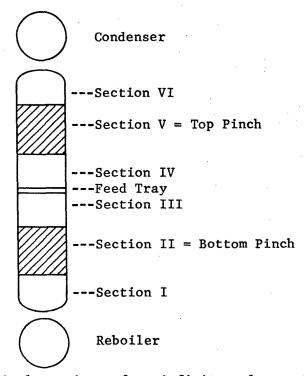


FIGURE 3-1. The six typical sections of an infinite column. Both pinch zones occur away from the feed tray.

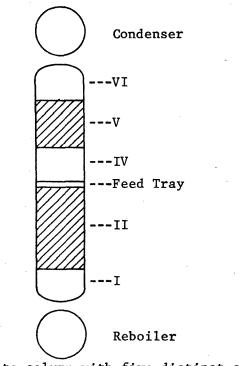


FIGURE 3-2. An infinite column with five distinct sections. The rectifying pinch occurs away from the feed tray.

Stripping and absorption occur again near the reboiler (Section I) and near the condenser (Section VI) respectively.

If the bottom product contains all the light components of the feed but some of the heavy components are separated from the top product, the pinch zone in the rectifying section will still be at an intermediate point away from the feed stage, similar to that section of the column in Figure 3-1. However, the pinch zone in the stripping section terminates in the feed stage. This type of column is schematically represented in Figure 3-2.

A similar statement can be applied to the case where all the heavy components of the feed are present in the distillate but some of the light components are separated from the bottoms product. In this case, the pinch zone occurs away from the feed plate in the stripping section, while the rectifying section pinch zone terminates at the feed stage. This type of column is schematically represented in Figure 3-3.

The paragraphs above describe three different types of fractionating columns at minimum reflux in which at least one of the pinch zones occurs away from the feed stage. Separations of these types fall under the Class II category such that, with infinite stages, some of the components are separated completely from the top product, or completely from the bottom product, or from both products.

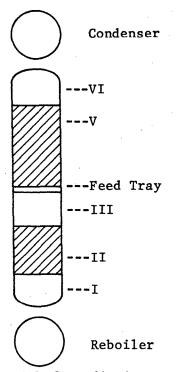


FIGURE 3-3. An infinite column with five distinct sections. The stripping pinch occurs away from the feed tray.

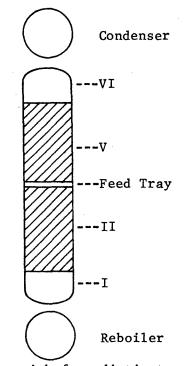


FIGURE 3-4. An infinite column with four distinct sections. Typical case of a bynary mixture.

If all the components in the feed are distributed to both the top and bottom products, both pinch zones terminate in the feed stage and only four sections are present in this column (Figure 3-4). This system is analogous to that of a bynary mixture and is classified under the Class I separations. The composition of the liquid and vapor phases of the feed are respectively identical with the liquid and vapor compositions in the constant composition zones except for superheated-vapor and subcooled-liquid feeds.

Since three different types of fractionating columns at minimum reflux are classified under Class II separations, it is possible to subclassify them according to the pinch zone occurrence at the rectifying and stripping sections of the column, as shown in Table 1.

CLASS OF SEPARATION	COMPONENT DISTRIBUTION	TYPE OF COLUMN SECTION
I	All Distributed	Rectifying-Type I Stripping-Type I
II-A	Lightest Separated Others Distributed	Rectifying-Type I Stripping-Type II
II-B	Heaviest Separated Others Distributed	Rectifying-Type II Stripping-Type I
II-C	Lightest Separated Heaviest Separated Others Distributed	Rectifying-Type II Stripping-Type II

TABLE 1. TYPES OF COLUMN SECTIONS AT MINIMUM REFLUX

The compositions of the pinch zones at the rectifying section and the stripping section are given by the familiar relationships (5):

$$\left(\frac{\underline{\ell}}{d}\right)_{R^{*}} = \frac{\left(\frac{\underline{L}}{VK}\right)_{R^{*}}}{1 - \left(\frac{\underline{L}}{VK}\right)_{R^{*}}} = \frac{A_{R^{*}}}{1 - A_{R^{*}}}$$
(3-1)
$$\left(\frac{\underline{v}}{b}\right)_{\underline{S}^{*}} = \frac{\left(\frac{\underline{VK}}{\underline{L}}\right)_{\underline{S}^{*}}}{1 - \left(\frac{\underline{VK}}{\underline{L}}\right)_{\underline{S}^{*}}} = \frac{S_{\underline{S}^{*}}}{1 - S_{\underline{S}^{*}}}$$
(3-2)

where ℓ = component liquid molar rate;

v = component vapor molar rate; d = component molar rate in the distillate; b = component molar rate in the bottoms; L = liquid molar rate in the specific section; V = vapor molar rate in the specific section; K = component equilibrium constant in the specific section; R* = bottom stage of the rectifying pinch zone; \underline{S}^* = top stage of the stripping pinch zone; A_{R*} = component absorption factor for the rectifying pinch zone; S_{S*} = component stripping factor for the stripping pinch zone.

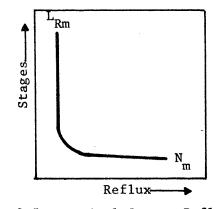
In these equations and the following ones, the subscript "i" is understood for all terms.

These equations easily explain the existence of four types of fractionating columns when minimum reflux $(N = \infty)$ is approached: A component present in the feed stream is distributed to both the top and bottom products (or constant composition zones), only if the

factors A_{R^*} and $S_{\underline{S^*}}$ are both less than unity. A separated heavy component (d_i = 0) is one for which $A_{R^*} \ge 1.0$. Similarly for a separated light component (b_i = 0), the factor $S_{\underline{S^*}} \ge 1.0$. It is obvious that A_{R^*} for the heavy key and $S_{\underline{S^*}}$ for the light key must be less than 1.0 in order to meet the required specifications for these two components.

In binaries or narrow cut multicomponent systems, where all components are distributed, the absorption factor at the rectifying pinch, A_{R*} , and the stripping factor at the stripping pinch, $S_{\underline{S}*}$, of the column for all components are less than unity. However, this is not true for wide boiling feeds and Class II minimum reflux situations result for such systems.

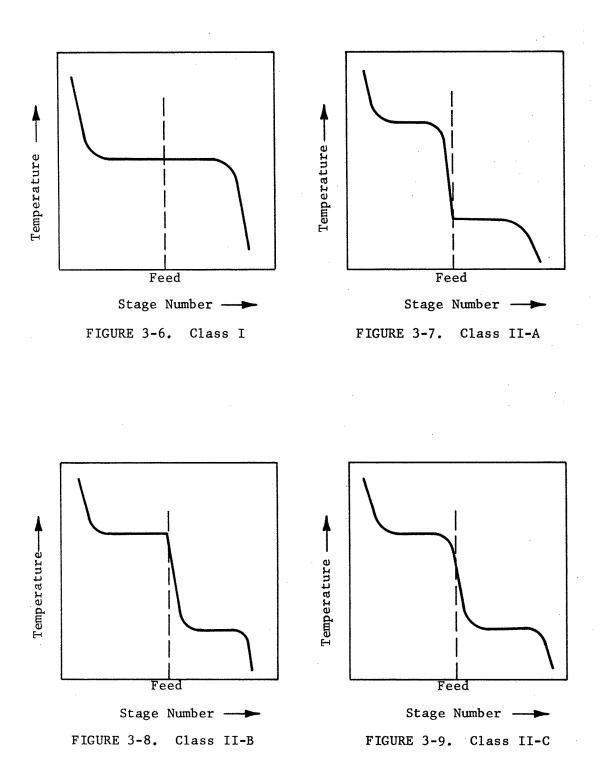
For rigorous calculations, the minimum reflux can be approximated as an asymptote of the stages-reflux curve which results of a parameter study of the actual reflux required for a series of column designs with increasing stages for the same given separation of the key components. Such a curve is shown in Figure 3-5.



Typical Stages-Reflux curve. FIGURE 3-5.

11

If a parameter study is made and the column design case which represents the minimum reflux is chosen, a plot of temperature vs stage number will explain the behavior of the four different types of fractionating columns discussed above. These temperature plots are shown in Figure 3-6 through Figure 3-9. Similar curves can be obtained from plots of stream compositions or total molal overflow vs stage number.



CHAPTER IV

LITERATURE SURVEY

There exist in the literature several methods for determining the minimum reflux ratio for a multicomponent system. Many of these methods are very complex. The estimation of the feed plate composition is essential in order to compute the minimum reflux required for the separation between distillate and feed plate, and between feed plate and bottoms.

Underwood (31) and Fenske (13) independently developed an equation for the minimum reflux required to attain a certain composition of the key components in the rectifying section. This equation is not accurate unless the compositions of the key components are known on the plate where the equation is applied. Underwood's equation (31) is applicable to binary mixtures or to completely distributed systems only, since it assumes that the composition on the stages immediately above and below the feed stage are approximately equal. This is true only if the liquid feed composition is the same as the liquid on the feed stage.

A false assumption that the ratio of the fractions of the key components in the liquid on the feed plate is the same as that of the same components in the liquid feed at minimum reflux has been presented in other methods (5,12,15).

Many of the methods developed (1,6,9,14,17,19) involve tedious trial and error.

Later, Underwood (32) developed equations for the determination of the minimum reflux for a multicomponent system based on constant volatility and constant molal overflow. These assumptions used by some investigators (14,22,32) are some of the most common ones made for short-cut techniques. These short-cut methods involve some loss of accuracy, but are used widely in preliminary design calculations.

Scheibel and Montross (27) have presented an empirical equation which eliminates the trial and error procedures. The procedure was modified by Bailey and Coates (3) to be applied to systems with varying volatility, but tedious trial and error is used.

Empirical correlations of the minimum and operating reflux ratios and equilibrium stages have been proposed as a short-cut design procedure by Brown and Martin (5), Gilliland (14), Erbar and Maddox (12), Maxwell (21), Colburn (6), and Gray (16).

Mayfield and May (23) assume a complete separation and no components lighter than the light key or heavier than the heavy key are present.

Many articles (10,11,12,26,28,29) have dealt with minor modifications or rearrangements of a second Underwood's minimum reflux method (33). Much of the work is of little consequence in advancing the techniques used to find minimum reflux.

An exact calculation of the minimum reflux for the Class II separations for which the simplifying assumptions of constant volatility and constant molal overflow are not valid has been carried out by Brown and Holcomb (4). Their method is an adaptation to minimum reflux of the Lewis and Matheson (20) plate-to-plate procedure for calculation of finite plates and reflux. The method assumes distribution of the key components only. If several components other than the key components are distributing, the operations are time consuming.

Shiras, Hanson and Gibson (28) presented methods which distinguish between systems with all components of the feed being distributed (Class I Separations) and systems on which some components have been separated (Class II Separations). This latter method is a rigorous plate-to-plate calculation.

Another plate-to-plate procedure which does not require preestimation of component distribution, but still is too time-consuming, is the method of Thiele and Geddes (30), adapted to the calculation of minimum reflux. Some authors (1,2,28) have suggested the use of this method which is outlined by Holland (18) including convergence methods proposed by McDonough (24) and McDonough and Holland (25).

Edmister (7,8) calculated the fractionation in each section of the column by short-cut equations based on a simplification of the rigorous Thiele and Geddes series solutions.

CHAPTER V

THEORY AND DEVELOPMENT OF EQUATIONS

The proposed method presented in this paper was guided by Dr. Ralph Cecchetti. In this work, his development of the simplified Thiele and Geddes procedure for the design of fractionating columns has been extended to the calculation of minimum reflux conditions. Some of the equations of the proposed new method have been presented by Edmister (7,8) for the calculation of theoretical stages and component distribution for multi-component fractionation. Holland (18) uses the general plate-to-plate calculational procedure of Thiele and Geddes for the calculation of minimum reflux and applies the Θ Method of Convergence (24,25) to the specified working conditions of the column.

The following sections contain the derivation of the short-cut equations that relate the component rates at the pinches and the component rates at the feed stage with the distillate composition and the number of stages between these sections of the column. The procedure employed in this new method will also calculate the number of stages between the pinches for each section, i.e., rectifying and stripping, and the feed stage.

Material Balances for the Rectifying Section

Distributed and light separated components. As discussed in Chapter III, the Equation (3-1) relating the rectifying pinch zone composition for distributed and light separated components is given by:

$$\left(\frac{\underline{\ell}}{d}\right)_{R^{\star}} = \frac{A_{R^{\star}}}{1 - A_{R^{\star}}}$$

17

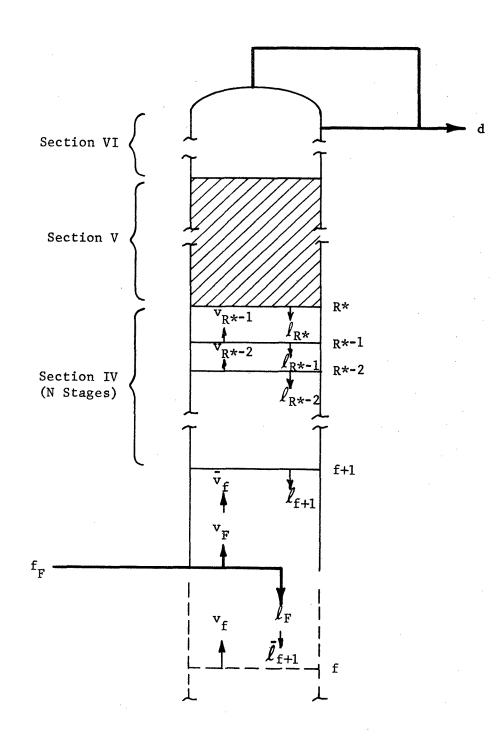


FIGURE 5-1. Component rates in the rectifying section of a fractionating column at minimum reflux conditions.

For the stages, N, between the feed and the rectifying pinch zones, an equation can be developed for the composition on the bottom stage of the rectifying section, f+1, by material balances enclosing the top of the column, the bottom stage of the rectifying pinch, R*, through to the bottom stage of the rectifying section.

By an inspection of Figure 5-1, the component liquid rate leaving stage R^* of the top infinite section of the column is given by:

$$\ell_{R^*} = v_{R^{*-1}} - d$$
 (5-1)

Since $v_{R^{*-1}} = \frac{\ell_{R^{*-1}}}{A_{R^{*-1}}}$, Equation (5-1) may be expressed as follows:

$$\left(\frac{\ell}{d}\right)_{R^{\star-1}} = A_{R^{\star-1}}\left[\left(\frac{\ell}{d}\right)_{R^{\star}} + 1\right]$$
(5-2)

or

$$\left(\frac{\ell}{d}\right)_{R^{\star}-1} = A_{R^{\star}-1} \left(\frac{\ell}{d}\right)_{R^{\star}} + A_{R^{\star}-1}$$
(5-3)

Similarly, for the R*-2 stage:

$$\left(\frac{\underline{\ell}}{d}\right)_{R^{\star-2}} = A_{R^{\star-2}}\left[\left(\frac{\underline{\ell}}{d}\right)_{R^{\star-1}} + 1\right]$$

Substituting for $(\ell/d)_{R^{*-1}}$ with Equation (5-2) gives:

$$\left(\frac{\ell}{d}\right)_{R^{\star-2}} = A_{R^{\star-2}} \left\{ A_{R^{\star-1}} \left[\left(\frac{\ell}{d}\right)_{R^{\star}} + 1 \right] + 1 \right\} (5-4) \right\}$$

or

$$\left(\frac{\ell}{d}\right)_{R^{\star-2}} = A_{R^{\star-2}} A_{R^{\star-1}} \left(\frac{\ell}{d}\right)_{R^{\star}} + A_{R^{\star-2}} A_{R^{\star-1}} + A_{R^{\star-2}} (5-5)$$

This procedure can continue until stage f+1 is reached, which gives the general expression:

$$\left(\frac{\ell}{d}\right)_{f+1} = A_{f+1} \cdots A_{R^{*-1}} \left(\frac{\ell}{d}\right)_{R^{*}} + A_{f+1} \cdots A_{R^{*-1}} + A_{f+1} \cdots A_{R^{*-2}} + \cdots + A_{f+1}$$
(5-6)

where A = absorption factors subscripted for each stage.

This equation is completely rigorous and requires the component absorption factor, A, on each stage of that section of the column for its solution.

If an average component absorption factor can be determined, such that it gives the identical solution as the rigorous equation, Equation (5-6) simplifies as follows:

$$\left(\frac{\underline{\ell}}{d}\right)_{f+1} = A_A^N \left(\frac{\underline{\ell}}{d}\right)_{R^*} + A_A^N + A_A^{N-1} + \dots + A_A$$
(5-7)

where N = number of stages between stage R* of the top infinite

section and stage f+1;

 A_A = average absorption factor for the component in the N-stage section.

Simplifying further,

$$\left(\frac{\ell}{d}\right)_{f+1} = A_A^N \left(\frac{\ell}{d}\right)_{R^*} + \frac{A_A^{N+1} - A_A}{A_A - 1}$$
(5-8)

By utilizing Equation (3-1), $(\ell/d)_{R^*}$ is substituted in Equations (5-6), (5-7) or (5-8), and the value of $(\ell/d)_{f+1}$ can be found. The use of Equation (3-1) requires that the absorption factor at the rectifying pinch, A_{R^*} , be less than 1, which is true only for distributed components and light separated components. The liquid rates, ℓ_{R^*} , of the heavy separated components at the rectifying pinch can be determined by Equations (5-14) or (5-15). The derivation of these equations follows.

Heavy separated components. A material balance enclosing the bottom of the column and the feed stage, f, (Figure 5-2) gives:

$$v_{f} + b = \bar{l}_{f+1} = l_{f+1} + l_{F}$$
 (5-9)
 $f_{F} = l_{F} + v_{F}$ (5-10)

since

Therefore,

$$v_{f} + b + v_{F} = l_{f+1} + f_{F}$$
 (5-11)

where $f_F = total$ component molar rate in feed;

 l_F = component molar rate in liquid feed; v_F = component molar rate in vapor feed;

Since $b=f_{F}$ for a heavy separated component, Equation (5-11) becomes:

$$\ell_{f+1} = v_f + v_F \tag{5-12}$$

Equation (5-6) can be modified to give:

$$\ell_{f+1} = \Lambda_{f+1} \cdots \Lambda_{R^{\star}-1} \left(\ell_{R^{\star}} \right) + \Lambda_{f+1} \cdots \Lambda_{R^{\star}-1} (d) + \Lambda_{f+1} \cdots \Lambda_{R^{\star}-2} (d) + \cdots + \Lambda_{f+1} (d)$$

Since d=o, the above expression becomes:

$$\ell_{f+1} = \Lambda_{f+1} \cdots \Lambda_{R^{\star}-1} \left(\ell_{R^{\star}} \right)$$
(5-13)

Substitution of Equation (5-13) into Equation (5-12), gives:

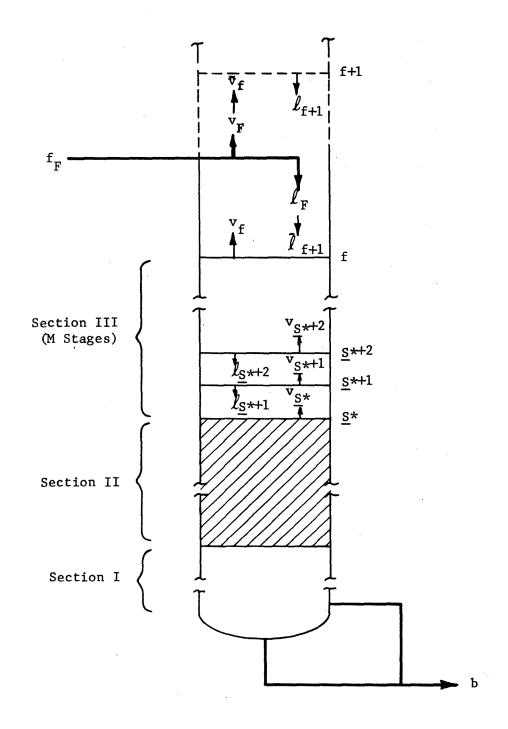


FIGURE 5-2. Component rates in the stripping section of a fractionating column at minimum reflux conditions.

$$\ell_{R^*} = \frac{1}{A_{f+1}} \cdots \frac{1}{A_{R^{*-1}}} (v_f + v_F)$$

or

$$\ell_{R^*} = s_{f+1} \dots s_{R^{*-1}} (v_f + v_F)$$
 (5-14)

If an average stripping (or absorption) factor is used, Equation (5-14) may be written as:

$$l_{R^{\star}} = S_{A}^{N}(v_{f} + v_{F})$$
 (5-15)

These equations are applicable to a heavy separated component to give the liquid rate from the bottom stage of the rectifying section, ℓ_{f+1} , and the liquid rate from the pinch of that section, ℓ_{R*} , provided the vapor rate of that component from the feed stage, v_f , is known.

The development of Equations (5-19), (5-20) and (5-21) to determine v_f , or $(v/b)_f$, similar to equations (5-6), (5-7) and (5-8) respectively, for distributed and heavy separated components will be given on the following section.

Material Balances for the Stripping Section

Distributed and heavy separated components. As discussed in Chapter III, the Equation (3-2) relating the stripping pinch zone composition for distributed and heavy separated components is given by:

$$\left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\underline{\mathbf{S}}^{\star}} = \frac{\mathbf{S}_{\underline{\mathbf{S}}^{\star}}}{1 - \mathbf{S}_{\underline{\mathbf{S}}^{\star}}}$$

In the event that M stages exist between the feed and the stripping pinch zones, an equation similar to Equation (5-6),

relating the component vapor rates in these two sections of the column, is necessary.

By a material balance around the bottom of the column and the top stage of the stripping pinch, <u>S</u>*, through the feed stage, f, the component vapor rate leaving stage <u>S</u>* of the bottom infinite section of the column (Figure 5-2) is:

$$\mathbf{v}_{\underline{\mathbf{S}}^{\star}} = \boldsymbol{\ell}_{\underline{\mathbf{S}}^{\star+1}} - \mathbf{b}$$
 (5-16)

Since
$$\ell_{\underline{S}^{\star+1}} = \frac{v_{\underline{S}^{\star+1}}}{s_{\underline{S}^{\star+1}}}$$
, Equation (5-16) becomes:

$$\left(\frac{v}{b}\right)_{\underline{S}^{\star+1}} = s_{\underline{S}^{\star+1}} \left[\left(\frac{v}{b}\right)_{\underline{S}^{\star}} + 1\right]$$

or

$$\left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\underline{\mathbf{S}}^{\star+1}} = \mathbf{s}_{\underline{\mathbf{S}}^{\star+1}} \left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\underline{\mathbf{S}}^{\star}} + \mathbf{s}_{\underline{\mathbf{S}}^{\star+1}}$$
(5-17)

For the S^{+2} stage:

$$\left(\frac{\underline{v}}{b}\right)_{\underline{S}^{\star+2}} = s_{\underline{S}^{\star+2}} \left\{ s_{\underline{S}^{\star+1}} \left[\left(\frac{\underline{v}}{b}\right)_{\underline{S}^{\star}} + 1 \right] + 1 \right\}$$

or

$$\left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\underline{\mathbf{S}}^{*+2}} = \mathbf{s}_{\underline{\mathbf{S}}^{*+2}} \mathbf{s}_{\underline{\mathbf{S}}^{*+1}} \left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\underline{\mathbf{S}}^{*}} + \mathbf{s}_{\underline{\mathbf{S}}^{*+2}} \mathbf{s}_{\underline{\mathbf{S}}^{*+1}} + \mathbf{s}_{\underline{\mathbf{S}}^{*+2}}$$
(5-18)

Similarly, for the successive stages up to stage f, the general expression is obtained:

$$\left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\mathbf{f}} = \mathbf{s}_{\mathbf{f}} \cdots \mathbf{s}_{\underline{\mathbf{S}}^{*+1}} \left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\underline{\mathbf{S}}^{*}} + \mathbf{s}_{\mathbf{f}} \cdots \mathbf{s}_{\underline{\mathbf{S}}^{*+1}} + \mathbf{s}_{\mathbf{f}} \cdots \mathbf{s}_{\underline{\mathbf{S}}^{*+2}} + \dots + \mathbf{s}_{\mathbf{f}}$$

$$\dots + \mathbf{s}_{\mathbf{f}}$$

$$(5-19)$$

where S = stripping factors subscripted for each stage.

Component stripping factors, S, are required on each stage of that section of the column to solve the above rigorous equation. The following equation results when an average component stripping factor is used:

$$\left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\mathbf{f}} = \mathbf{s}_{\mathbf{A}}^{\mathbf{M}}\left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\underline{\mathbf{S}}^{\star}} + \mathbf{s}_{\mathbf{A}}^{\mathbf{M}} + \mathbf{s}_{\mathbf{A}}^{\mathbf{M}-1} + \dots + \mathbf{s}_{\mathbf{A}}$$
(5-20)

where M = number of stages between <u>S</u>* of the bottom infinite section and stage f;

 S_A = average stripping factor for the component in the M-stage section.

Simplifying further,

$$\left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{f} = S_{A}^{M}\left(\frac{\mathbf{v}}{\mathbf{b}}\right)_{\underline{S}^{\star}} + \frac{S_{A}^{M+1} - S_{A}}{S_{A} - 1}$$
(5-21)

To solve these equations, $(v/b)_{\underline{S}^*}$ must be determined by Equation (3-2), which applies for distributed components and heavy separated components. The derivation of the equations for the determination of $v_{\underline{S}^*}$ for the light separated components follows.

Light separated components. Since b = 0, Equation (5-9) gives:

$$v_{f} = l_{f+1} + l_{F}$$
 (5-22)

Equation (5-19 can be modified to give:

$$v_{f} = s_{f} \dots s_{\underline{S}^{*+1}} \left(v_{\underline{S}^{*}} \right) + s_{f} \dots s_{\underline{S}^{*+1}} (b) + s_{f} \dots s_{\underline{S}^{*+2}} (b) + \dots + s_{f} (b)$$

Since b = o, the above expression becomes:

$$v_{f} = S_{f} \dots S_{\underline{S}^{\star+1}} \left(v_{\underline{S}^{\star}} \right)$$
 (5-23)

If Equation (5-23) is substituted into Equation (5-22), it yields:

$$\mathbf{v}_{\underline{\mathbf{S}}^{\star}} = \frac{1}{\mathbf{S}_{f}} \cdots \frac{1}{\mathbf{S}_{f+1}} \left(\boldsymbol{\ell}_{f+1} + \boldsymbol{\ell}_{F} \right)$$

or

$$\mathbf{v}_{\underline{\mathbf{S}^{\star}}} = \mathbf{A}_{\mathbf{f}} \cdots \mathbf{A}_{\mathbf{f}+1} \left(\boldsymbol{\ell}_{\mathbf{f}+1} + \boldsymbol{\ell}_{\mathbf{F}} \right)$$
(5-24)

If an average absorption (or stripping) factor is used, Equation (5-24) becomes:

$$\mathbf{v}_{\underline{\mathbf{S}}^{\star}} = \mathbf{A}_{\mathbf{A}}^{\mathbf{M}} \left(\boldsymbol{\ell}_{\mathbf{f}+1} + \boldsymbol{\ell}_{\mathbf{F}} \right)$$
(5-25)

The liquid rate from the bottom stage of the rectifying section, l_{f+1} , is determined by Equations (5-6), (5-7) or (5-8) for the light separated components.

Feed Plate Match

The feed plate match equation for the short-cut procedure is identical to that used in the rigorous Thiele and Geddes method.

This equation is obtained from Equation (5-9) which can be expressed as follows:

$$v_{f} + b = \ell_{f+1} + \ell_{F} \left(\frac{b+d}{f_{F}} \right)$$

and

$$\mathbf{v}_{\mathbf{f}} + \mathbf{b} - \frac{\boldsymbol{\ell}_{\mathbf{F}} \mathbf{b}}{\mathbf{f}_{\mathbf{F}}} = \boldsymbol{\ell}_{\mathbf{f}+1} + \frac{\boldsymbol{\ell}_{\mathbf{F}} \mathbf{d}}{\mathbf{f}_{\mathbf{F}}}$$
$$\mathbf{b} \left[\frac{\mathbf{v}_{\mathbf{f}}}{\mathbf{b}} + 1 - \frac{\boldsymbol{\ell}_{\mathbf{F}}}{\mathbf{f}_{\mathbf{F}}} \right] = \mathbf{d} \left[\frac{\boldsymbol{\ell}_{\mathbf{f}+1}}{\mathbf{d}} + \frac{\boldsymbol{\ell}_{\mathbf{F}}}{\mathbf{f}_{\mathbf{F}}} \right]$$

which can be solved for (b/d) to give:

$$\frac{b}{d} = \frac{\left(\frac{\ell}{d}\right)_{f+1} + \frac{\ell_F}{f_F}}{\left(\frac{v}{b}\right)_f + \frac{v_F}{f_F}}$$

For all liquid feed $(\ell_F / f_F) = 1$ and $(v_F / f_F) = 0$, and Equation (5-26) becomes:

$$\frac{b}{d} = \frac{\left(\frac{\ell}{d}\right)_{f+1} + 1}{\left(\frac{v}{b}\right)_{f}}$$
(5-27)

For all vapor feed, $(v_F/f_F) = 1$ and $(\ell_F/f_F) = 0$, and Equation (5-26) gives:

$$\frac{b}{d} = \frac{\left(\frac{\ell}{d}\right)_{f}}{\left(\frac{v}{b}\right)_{f} + 1}$$
(5-28)

(5-26)

CHAPTER VI

METHOD OF CALCULATION

This chapter describes the calculational procedure used to calculate the minimum reflux for the four different types of column that can occur as a result of component distributions.

The primary interest of this work is the determination of the liquid rate at the rectifying pinch zone, L_{R*} , which represents the constant internal minimum reflux of the column.

The external reflux, L_R , can then be obtained by overall heat balance calculations as will be seen later on this chapter.

The proposed method uses the rectifying pinch and the stripping pinch sections of the column to obtain the material balance which will give the component distribution.

This method is a trial and error procedure, and in order to initiate the calculations, values for the liquid rate at the rectifying pinch, L_{R*} , and the total distillate rate, D, are assumed. The other internal loadings in the column are then determined by overall material balance and the assumption of constant molal overflow between the rectifying and stripping pinch stages:

$$V_{R*} = L_{R*} + D$$
 (6-1)

$$L_{S*} = L_{R*} + L_{F}$$
 (6-2)

$$v_{\underline{S}^{\star}} = v_{R^{\star}} - v_{F} \qquad (6-3)$$

and the bottom rate is:

$$B = F - D \tag{6-4}$$

where L_{R^*} = liquid molar rate at the rectifying pinch; V_{R^*} = vapor molar rate at the rectifying pinch; $L_{\underline{S}^*}$ = liquid molar rate at the stripping pinch; $V_{\underline{S}^*}$ = vapor molar rate at the stripping pinch; L_{F} = liquid molar flow rate of feed; V_{F} = vapor molar flow rate of feed.

In the next step, values are assumed for temperatures at the feed locations, T_f and T_{f+1} , and at the pinch locations, T_{R*} and $T_{\underline{S}*}$. The K values at these temperatures combined with the respective L/V's give the component absorption factors or stripping factors at these points of the column.

The component distribution and the type of column section is then determined by inspection of the absorption factors at the rectifying pinch, A_{R*} , and the stripping factors at the stripping pinch, $S_{\underline{S}*}$: light separated components are those with values of $S_{\underline{S}*}$ greater than 1.0, while heavy separated components are those with values of A_{R*} greater than 1.0. This is shown on the following diagram:

	Component	Rectifying Section	Stripping Section	
	Number	Distribution	Distribution	
Light Separated From Bottoms First Component where $S_{\underline{S}^*} > 1.0$	1 : ILS		b _i =o	
Distributed Components	ILS + 1 · V · V · V · V · V · V · V · V	(l/d) _{R*} (l/d) Increasing	(v/b) <u>s</u> *	
First Component where A _{R*} > 1.0	IHS	d _i =o		
Heavy Separated from Distillate	C	↓		

Therefore, the four different types of column occur under the following circumstances:

- If ILS = 0 and IHS = C + 1
 - All components are distributed

- Rectifying and Stripping sections are Type I

• If ILS = 0 and IHS $\langle C + 1$

- All light components are distributed

- Some heavy components are separated from the distillate

- Rectifying section is Type II and Stripping section is Type I
- If ILS > 0 and IHS = C + 1
 - Some light components are separated from the bottoms.
 - All heavy components are distributed
 - Rectifying section is Type I and Stripping section is Type II

• If ILS > 0 and IHS $\langle C + 1$

- Some light components are separated from bottoms
- Some heavy components are separated from distillate
- Rectifying and Stripping sections are Type II

Type I in Both Column Sections

In systems with type I in both sections, the minimum reflux can be calculated directly by Underwood's Equations (31). If these equations are applied to the two key components whose specified distributions (b/d), define the separation, they give an exact solution for the minimum reflux for Class I separations.

These equations are presented here for convenient reference.

For a partially vaporized feed:

$$L_{R^{\star}} = \frac{L_{F}\left[\left(\frac{d}{\ell_{F}}\right)_{A} - \left(\frac{d}{\ell_{F}}\right)_{B} - \alpha_{AB}\right]}{\alpha_{AB} - 1}$$

where A,B = specific components

 α_{AB}^{α} = relative volatility for the key components at the feed stage conditions.

For all liquid feed:

$$L_{R^{*}} = \frac{F\left[\left(\frac{d}{f_{F}}\right)_{A} - \left(\frac{d}{f_{F}}\right)_{B} \alpha_{AB}\right]}{\alpha_{AB} - 1}$$
(6-6)

since $L_F = F$ and $\ell_F = f_F$.

For all vapor feed:

$$L_{R^{\star}} = \frac{F\left[\begin{array}{c} \alpha_{AB}\left(\frac{d}{f_{F}}\right)_{A} - \left(\frac{d}{f_{F}}\right)_{B}\right]}{\alpha_{AB}} - 1 \qquad (6-7)$$

The traditional approach has been to use the feed temperature for the values of K_f or α_{AB} . However, the preferred solution is to calculate the component distributions (b/d), with the assumed temperatures at the feed location ($T_f = T_{f+1}$) to give K values and solve by the following:

$$\frac{b}{d} = \frac{L_{R^{*}}(1-K_{f}) + F - DK_{f}}{L_{R^{*}}(K_{f}-1) + DK_{f}}$$
(6-8)

for a liquid feed.

And for a vapor feed:

$$\frac{b}{d} = \frac{L_{R^{*}}(1-K_{f}) + FK_{f} - DK_{f}}{L_{R^{*}}(K_{f}-1) + DK_{f}}$$
(6-9)

(6-5)

The values of (b/d) can then be used to determine the individual component distillate rate, d, by:

$$d = \frac{f_F}{1 + \left(\frac{b}{d}\right)}$$
(6-10)

Since the rectifying pinch occurs at the feed stage, $T_{f+1} = T_{R^*}$, and the liquid rate at the stage above the feed stage, f+1, can be calculated by Equation (3-1) which becomes:

$$\left(\frac{\ell}{d}\right)_{f+1} = \frac{A_{f+1}}{1 - A_{f+1}}$$
(6-11)

The values of ℓ_{f+1} are determined and normalized to give reflux compositions at the feed stage. The bubble point is calculated and the resulting K values or α values used for the next trial to determine $L_{R\star}$. Convergence results when $T_{R\star}$ reaches a constant value.

Type II in Rectifying Section, Type I in Stripping Section

The objective for this type of system is to calculate the number of stages N, between the rectifying pinch, R*, and the stage above the feed stage, f+1. This is done by applying Equation (5-6) or Equation (5-8) to the heavy key component.

If the calculations are done by hand, a good approximation results by using Equation (5-8). If a computer program is used, as the one presented in this paper, Equation (5-6) can be used for better results, assuming a linear profile of the absorption factors between the calculated values at the f+1 and R* locations. The ratios $(\ell/d)_{R^*_{SHK}}$, and $(v/b)_{\underline{S^*_{SHK}}}$ are calculated by Equation (3-1) and Equation (3-2) respectively as discussed in Chapter V. Note that $(v/b)_f = (v/b)_{S^*}$ in this case.

The Feed Plate Match Equation (5-26) is then used to determine $(b/d)_{HK}$ for the heavy key component.

Starting with N = 0, the value of N is varied until the specified $(b/d)_{HK}$ is calculated. Interpolation can be used between trials to find N.

Type I in Rectifying Section, Type II in Stripping Section

The objective in this case is to calculate the number of stages M, between the stripping pinch, \underline{S}^* , and the feed stage, f.

Equations (5-19) or (5-21) are applied to the light key component. Again, Equation (5-19) can be used for better results with a linear profile between the calculated stripping factors at the <u>S</u>* and f locations.

The ratios $(v/b)_{\underline{S}^*_{LK}}$, and $(\ell/d)_{R^*_{LK}}$ are calculated by Equation (3-2) and Equation (3-1) respectively as discussed in Chapter V. Note that $(\ell/d)_{f+1} = (\ell/d)_{R^*}$.

The Feed Plate Match Equation (5-26) is again used here, to determine $(b/d)_{I,K}$ for the light key component.

Starting with M = 0, the value of M is varied until the specified $(b/d)_{LK}$ is calculated. Interpolation can be used between trials to find M.

Type II in Both Sections

This case is actually the general one. The discussed previous cases are special situations where N, M or both were zero.

The objective is to calculate N and M. The calculation of $(\ell/d)_{R^*}$ and $(v/b)_{\underline{S^*}}$ is the same as discussed in the previous sections except that these values are determined for both the key components. The solution of N and M is the simultaneous solution of Equation (5-6) and Equation (5-19) for both key components.

This in effect, gives two (b/d) equations, one for the light key and one for the heavy key in the two unknowns N and M.

Material Balances Calculation Procedure

The following stepwise procedure is self-explanatory:

- 1. Evaluate Equation (3-1) to obtain $(2/d)_{R^*}$ for the distributed and light separated components.
- 2. Calculate $(\frac{p}{L}/d)_{f+1}$:
 - a. If N = 0, the rectifying section is Type I and IHS = C+1 (see diagram on page 30). It results in this case that $(\ell/d)_{f+1} = (\ell/d)_{R*}$.
 - b. If N > 0, IHS < C+1 and the rectifying section is Type II. In this case, $(\ell/d)_{f+1}$ is calculated by Equation (5-6).
- 3. Determine $(v/b)_{\underline{S}^*}$ for the distributed and heavy separated components by Equation (3-2).

- 4. Calculate (v/b)_f:
 - a. If M = 0, the stripping section is Type I and ILS = 0 (see diagram on page 30). Therefore, $(v/b)_{S*} = (v/b)_{f}$.
 - b. If M > 0, ILS > 0 and the stripping section is Type II. Here, $(v/b)_f$ is calculated by Equation (5-19).
- 5. Calculate (b/d) for the distributed components by Equation (5-26). Correct (b/d)_{LK} and (b/d)_{HK} to be consistent with the specifications. This is done by using the multiplier Θ , such that,

$$(b/d)_{LK}$$
, spec. = Θ_{LK} $(b/d)_{LK}$, calc.

and

$$(b/d)_{HK}$$
, spec. = Θ_{HK} $(b/d)_{HK}$, calc.

6. Determine the distillate rate $D_{calc.} = \sum_{c} d$. For the light separated components, $d = f_F$. For the separated heavies, d = o. The flow rates for all distributed components are evaluated by an overall material balance which yields,

$$d = \frac{f_F}{1 + \left(\frac{b}{d}\right)}$$

The specified values of (b/d) are used for the light and heavy key components.

- 7. Calculate the liquid rate at the rectifying pinch zone,
 - L_{R*, calc}. This is done as follows:
 - a. For the distributed and light separated components, determine $\ell_{\rm R\star}$ by,

$$\ell_{R^*} = \left(\frac{\ell}{d}\right)_{R^*} d$$

b. For the heavy separated components, \mathcal{L}_{R^*} is determined by Equation (5-14).

c. Determine
$$L_{R^*}$$
, calc. = $\sum_{c} \ell_{R^*}$.

- If L_{R*} , calc. = L_{R*} , spec., "converge" = 1 - If L_{R*} , calc. $\neq L_{R*}$, spec., "converge" = 0
- 8. Calculate liquid rates on f+1, and vapor rates on S_f and <u>S</u>* by the following procedure:
 - a. For the distributed and light separated components,

$$\ell_{f+1} = \left(\frac{\ell}{d}\right)_{f+1} d$$

 $v_{f}^{}$ is determined by Equation (5-22) and $v_{\underline{S}^{\star}}^{}$ by Equation (5-24).

b. For the separated heavies, ℓ_{f+1} is determined by Equation (5-12). Here also,

$$v_{f} = \left(\frac{v}{b}\right)_{f} b$$

and

$$v_{\underline{S}^{\star}} = \left(\frac{v}{b}\right)_{\underline{S}^{\star}} b$$

c. Then, the sum of the calculated component flow rates gives

$$L_{f+1} = \sum_{c} \ell_{f+1}$$

$$V_{f} = \sum_{c} v_{f}$$

$$V_{\underline{S}^{*}} = \sum_{c} v_{\underline{S}^{*}}$$

- 9. Mole fraction compositions on stages R*, f+1, f and <u>S</u>* are calculated by normalizing the component molar rates with the total molar rates calculated in step 8-c.
- 10. T_{f+1} and T_{R*} are determined by bubble point calculations. T_f and T_{S*} are found by dew point calculations.
- 11. Check convergence.
 - If the calculated temperatures are different from the values used in the trial, the new values are used to calculate absorption and stripping factors, determine the type of column sections and then repeat the stepwise procedure just outlined. The value of $D_{calc.}$ from this trial is used for the next trial, but L_{R*} must not be changed. New values of V_{R*} , L_{S*} and B are also determined.
 - If the calculated temperatures are the same as the values used in the trial, check "converge" (see step 7). The trial should be repeated if "converge" = 0.
 - If the calculated temperatures are the same and "converge" = 1, this is a converged case for the specified value of L_{R*}
- 12. When the calculations are converged for the value of L_{R*} , the value of θ_{LK} and θ_{HK} are a measure of the deviation from convergence to the specified (b/d) for the key components. For the second iteration on L_{R*} an arbitrary change is made in the direction of convergence, i.e., bringing the θ values to 1.0. After the second iteration, interpolation on $\Delta \theta$ and ΔL_{R*} can be used to estimate the next iteration on L_{R*} . This procedure converges all systems with Type I in either or both sections of the column.

For Type II systems in both sections, the Θ values become equal to 1.0 when the value of L_{R*} is in the vicinity of the true minimum reflux. However, this is not necessarily the final answer. The number of stages N and M can adjust the key component compositions, so that the specified separation is made at a reflux higher than the minimum. Successively, lower values of L_{R*} are then assumed and this results in lower values of N and M. The total calculation is converged when the values of N and M reach a minimum, i.e., lower values of L_{R*} give non-convergence on the specified key components split.

Enthalpy Balance

column;

The external minimum reflux was calculated by use of the following enthalpy balance. Enclosing the rectifying pinch and the top plate of the column, it gives:

$$V_{R*}H_{R*} + L_{Rm}h_{Rm} = V_{1}H_{1} + L_{R*}h_{R*}$$
 (6-12)
where V_{1} = molar flow rate of the vapor from the top stage of the

- H = enthalpy of one mole of the vapor leaving the specific stage or section of the column;
- h = enthalpy of one mole of the liquid leaving the specific stage or section of the column.

Since:

 $V_1 = L_{Rm} + D$

and

$$V_{R*} = L_{R*} + D$$

Equation (6-12) reduces to:

L_{Rm} =
$$\frac{L_{R*} (H_{R*} - h_{R*}) + D (H_{R*} - H_{1})}{(H_{1} - h_{Rm})}$$
 (6-13)

CHAPTER VII

DISCUSSION OF ILLUSTRATIVE EXAMPLES

The minimum reflux was calculated for four hydrocarbons mixtures which at minimum reflux conditions fall into each possible combination of Class I or Class II separations.

The true minimum reflux was determined by a plot of the actual reflux required to make the specified separation of the key components vs the number of stages specified. Such a plot approaches the minimum reflux at a value of stages that is 10-20 times the minimum number of stages required for the specified separation. An example of such a plot is shown in Figure A-1.

The actual reflux required to make the separation for various stages from 8 to 100 was determined by a plate-to-plate procedure available to the author through Esso Research and Engineering Company. This program uses a Newton-Raphson algorithim. One option in the program allows the user to specify stages and key component split and the program then calculate the required reflux.

The internal minimum reflux was then calculated by the short-cut method outlined in this work, through a computer program as listed in Appendix B. The values obtained by this method were then compared with the rigorous plate-to-plate minimum reflux at the constant composition zone. These results are shown in Table A-10. The results obtained by the short-cut method are in agreement with those obtained by the plate-to-plate procedure. Only in the case for a Type II

situation in both sections of the column, the values are off by 7.6% as compared with the plate-to-plate values.

The external minimum reflux calculated by an enthalpy balance was also in agreement with the one obtained by the plate-to-plate procedure (see Table A-10). Enthalpies were calculated using a composition independent procedure available to the author through Esso Research and Engineering Company. This procedure is the same one used by the plate-to-plate program.

The short-cut method for minimum reflux that is most commonly used is the method of Underwood. This procedure gives the value of the reflux at the stage above the feed. However, the Underwood value is frequently taken as the external minimum reflux. This can lead to a significant error when the actual external reflux is specified as a ratio to the Underwood minimum reflux for the design of a fractionating column. Underwood's values for the four examples are also given in Table A-10.

Specifications for Examples 1, 2, 3, and 4 are presented in Table A-1. The key components split is the same for all four examples.

Example 1 is a typical case of Class II separations which presents a Type I rectifying section and a Type II stripping section. In this example, light components are separated in the distillate while the keys and heavier are distributed to both products. This is shown in Table A-2. Temperature profiles from the various plate-toplate cases are plotted in Figure A-2. These temperature profiles illustrate the typical behavior of this type of column as minimum reflux conditions are approached.

Example 2 and 3 are also Class II separations, and although the rectifying section is Type II for both cases, the stripping section is Type I for Example 2 and Type II for Example 3. Tables A-4 and A-6 respectively, show the distribution of the components for these two cases. Example 2 is similar to Example 1 except that in this case, a heavy component is separated in the bottoms. In Example 3, only the key components are distributed.

Example 4 is the typical case of Class I separations, and therefore, both sections of the column are Type I. Table A-8 shows all components distributed in both products.

Temperature profiles for Examples 2, 3, and 4 are shown in Figures A-3, A-4, and A-5. These plots were obtained from plate-toplate cases with 100 stages each, since this number of stages was high enough to develop the plateaus and approximate the rigorous value of the minimum reflux. Cases with 200 stages were obtained and no change in the minimum reflux value was observed.

Tables A-3, A-5, A-7, and A-9 tabulate the flow rates and temperatures at the key locations of the column as they were obtained by the short-cut procedure and by the plate-to-plate program. By an inspection of these Tables, the values of the internal flow rate, obtained for Examples 1, 2, and 4 are in agreement with the values obtained by the plate-to-plate procedure. Small differences are due to the pinches for the intermediate trials. The internal flow rates calculated for Type II systems in both column sections show some disagreement with the values obtained by the plate-to-plate procedure. (See Table A-7). Enthalpy balances to establish L_{f+1} and $L_{\underline{S}}$ * rather than using constant molal overflow would probably eliminate most if not all of this error. This case, with only two distributed components was the most difficult to converge.

The same vapor-liquid equilibrium ratio (K) values were used for the rigorous plate-to-plate solution as for the short-cut procedures. Five values for each component at five different temperatures and the column pressure were taken from the plate-to-plate results and read in the input cards to the computer program used. A polynomial curvefit was used to obtain K values at other temperatures. This is done by a sub-routine program listed in Appendix B.

Other sub-routine programs were written for the calculation of bubble point, dew point and to solve the linear series Equations (5-6), (5-14), (5-19), and (5-24). All these programs are listed in Appendix B.

CHAPTER VIII

CONCLUSIONS

The new minimum reflux method presented in this paper is very accurate for computing the minimum reflux when the split of two components is specified. In the examples presented here these two components, the light key and the heavy key, are adjacent, but the method is not limited to this case.

The values from the plate-to-plate procedure were chosen as the correct minimum reflux because they are based on a rigorous solution of a column with a large number of stages. The Underwood minimum reflux is probably the most widely used method today. It is also presented here for the sake of comparison and the minimum reflux values are not as accurate as the proposed procedure.

The assumption made by some authors that all components lighter than the light key and heavier than the heavy key are separated from the products at minimum reflux conditions is not valid as it can be seen in Examples 1, 2, and 4. In these cases some lighter and heavier components are distributed along with the keys. Example 3, with only the two keys distributed was found to be the most difficult to converge. Class I separations are the easiest to converge with very good results as illustrated by Example 4, Tables A-8 and A-9. In this case the Underwood method is also very reliable.

The minor discrepancies found in some of the results are mainly due to the assumption of constant molal overflow between the pinch zones. The method does calculate the liquid rate from the stage above

the feed, and the vapor from the feed stage, as well as the liquid and vapor in the pinches by material balance. However, these values were not used in successive iterations since they were not restricted by enthalpy balance considerations. The material balances were only used to obtain normalized compositions and these were then used for temperature determination.

CHAPTER IX

RECOMMENDATIONS

The primary contribution of this work is the short-cut calculation of the minimum reflux for systems under the Class II separations category. Underwood's method gives good results for the Class I separations systems.

Improvements in the accuracy of the program would result from the addition of enthalpy balances to calculate the internal loadings in the column for the successive trials. It was expected that the calculation procedure would become very sensitive and the rate of convergence decrease if the internal loadings calculated by material balance in one trail were used in the next one.

More work should be done to demonstrate the accuracy of the method with feeds of more than five components, with totally and partially vaporized feeds and with non-ideal systems. APPENDIX A

	Example 1		Exam	Example 2		Example 3		Example 4	
Component	Comp. No.	Feed Rate	Comp. No.	Feed Rate	Comp. No.	Feed Rate	Comp. No.	Feed Rate	
С ₃ Н ₈ EX34 (*)	1	5	1	20	1	5	1	20	
$i-C_4H_{10}$ $n-C_4H_{10}$ (LK) $i-C_5H_{12}$ (HK)	2 3 4	15 25 20	2	25 20	2 3 4	15 25 20	2	25 20	
$n-C_{5H_{12}}$ (int) EX23 (*)	5	35	4	35	5	35	4	35	
emperature °F		181.73		204.46		191.25		193.27	

TABLE A-1. SPECIFICATIONS FOR EXAMPLES 1, 2, 3, AND 4

Total Feed Rate = 100 Moles/Hr Feed Condition = Boiling Point Liquid Column Pressure = 120 Lb/Sq.In.Abs. Distillate Condition = Boiling Point Liquid LK Specification, (b/d) = 0.1933 HK Specification, (b/d) = 5.7340

(*) Hypothetical components with K values that give the desired type of separation.

Component	Short-cut in This Work		Plate-to-Plate		
Number	Distillate	Bottoms	Distillate	Bottoms	
1 2 3 - LK 4 - HK 5 Total	5.00 15.00 20.95 2.97 <u>0.98</u> 44.90	- 4.05 17.03 <u>34.02</u> 55.10	5.00 15.00 20.95 2.97 <u>0.97</u> 44.89	- 4.05 17.03 <u>34.03</u> 55.11	
Temperature, °F	141.27	226.50	141.26	226.47	

TABLE A-2.MOLAR FLOW RATES AND CONDITIONSOF PRODUCTS FOR EXAMPLE 1

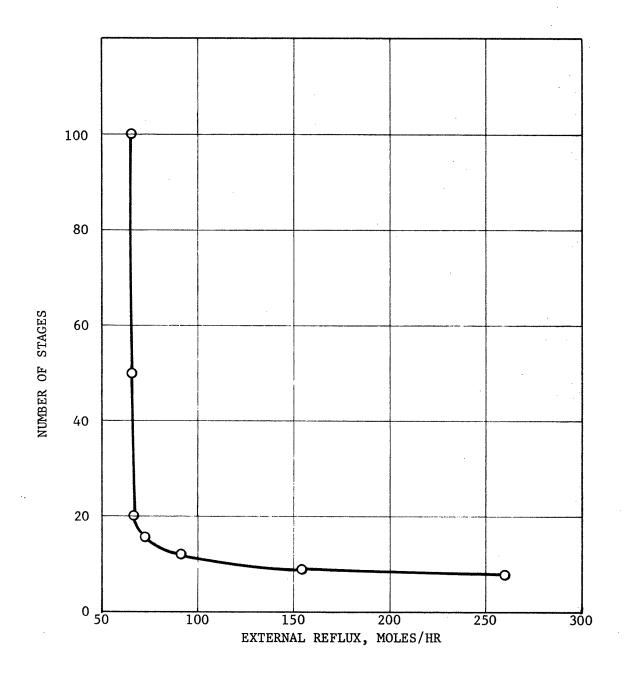


FIGURE A-1. Typical stages - reflux curve for Example 1

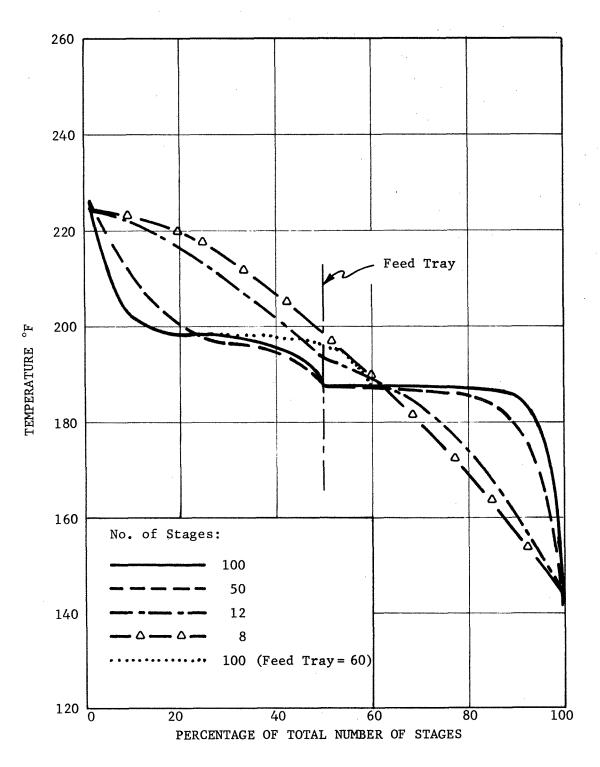


FIGURE A-2. Temperature profiles for Example 1.

Component		Short-cut in This Work				Plate-to-Plate			
Number	L _{R*}	L _{f+1}	Vf	۷ <u>s</u> *	L _{R*}	^L f+1	v _f	₹ <u>S</u> *	
1	1.25	1.25	6.25	0.03	1.25	1.25	6.25	0.00	
2	8.45	8.45	23.45	12.78	8.46	8.46	23.45	4.06	
3 - LK	16.40	16.40	37.35	51.18	16.43	16.42	37.37	58.00	
4 - HK	12.12	12.12	15.09	18.19	12.18	12.16	15.12	18.3	
5	21.12	21.12	22.10	26.48	21.11	21.14	22.11	26,60	
Total	59.34	59.34	104.24	108.66	59.43	59.43	104.30	106.98	
nperature °F	187.53	187.53	187.53	195.63	187.54	187.55	187.55	197.28	

TABLE A-3. MOLAR FLOW RATES AND CONDITIONS AT KEY COLUMN LOCATIONS FOR EXAMPLE 1

Component Numbe r	Short-c This		Plate-to-P	late
	Distillate	Bottoms	Distillate	Bottoms
1 2 3 4	17.88 20.95 2.97 	2.12 4.05 17.03 <u>35.00</u>	17.61 20.95 2.97	2.39 4.05 17.03 <u>35.00</u>
Total	41.80	58.20	41.53	58.47
Temperature °F	161.79	248.81	161.82	248.23

TABLE A-4. MOLAR FLOW RATES AND CONDITIONS OF PRODUCTS FOR EXAMPLE 2

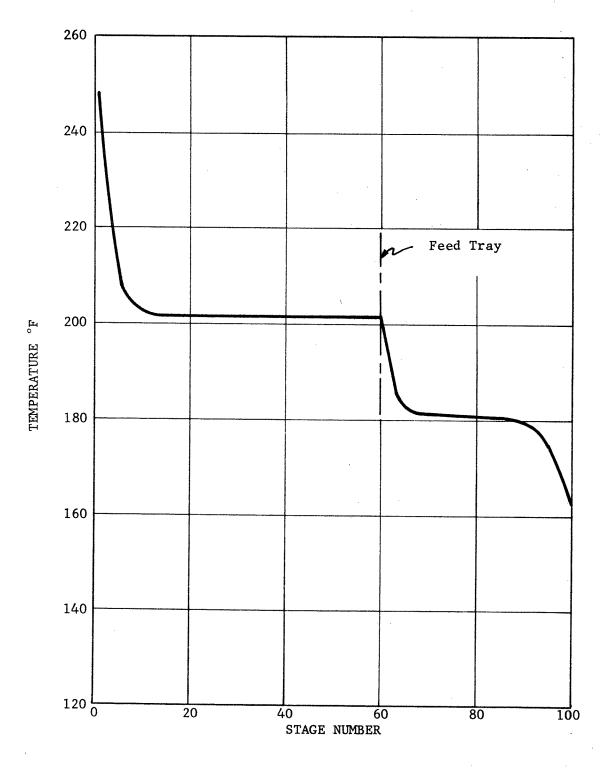


FIGURE A-3. Temperature profile for Example 2.

Short-cut in Thi			in This Wo:	s Work Plate-to-Plate				
Component Number	L _{R*}	L _{f+1}	Vf	v <u>s</u> *	L _{R*}	L _{f+1}	V _f	۷ <u>s</u> *
1 2 3 4	15.61 19.34 23.96 0.06	12.95 15.99 14.57 12.07	30.83 40.10 17.54 12.07	30.83 40.10 17.54 12.07	15.41 19.39 24.13 0.01	11.63 14.57 14.29 12.01	29.24 35.52 17.26 12.01	29.21 35.50 17.24 12.00
Total	58.97	55.57	100.54	100.54	58.94	52.50	94.03	93.95
ſemperature °F	180.58	193.58	199.51	199.51	180.68	195.59	201.37	201.38

TABLE A-5. MOLAR FLOW RATES AND CONDITIONS AT KEY COLUMN LOCATIONS FOR EXAMPLE 2

Component Number	Short-cut This Wor	i i	Plate-to-	Plate
	Distillate	Bottoms	Distillate	Bottoms
1 2 3 4 5	5.00 15.00 20.95 2.97 	- 4.05 7.03 5.00	5.00 15.00 20.95 2.97	4.05 17.03 <u>35.00</u>
Total	43.92	56.08	43.92	56.08
emperature °F	139.73	253.95	139.73	253.97

TABLE A-6. MOLAR FLOW RATES AND CONDITIONS OF PRODUCTS FOR EXAMPLE 3

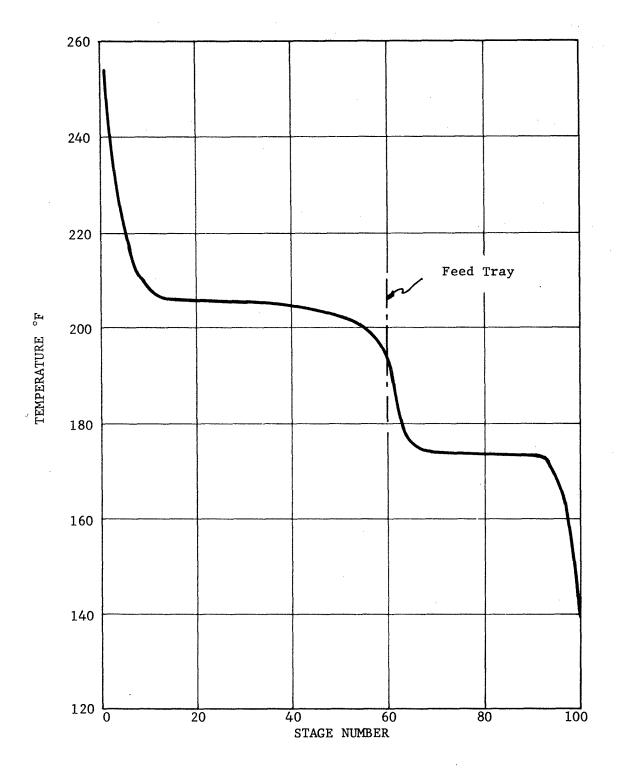


FIGURE A-4. Temperature profile for Example 3.

Component Number		Short-cut in This Work				Plate-to-Plate			
	L _{R*}	L _{f+1}	v _f	۷ <u>s</u> *	L _{R*}	L _{f+1}	v _f	۷ <u>s</u> *	
1	1.25	1.12	6.11	0.35	1.30	1.06	6.06	0.00	
2 3	8.74	7.44	22.45	17.03	9.12	6,98	21.98	0.43	
3	17.52	14.44	35.39	40.80	18.38	13.49	34.44	59.24	
4 5	17.85	12.75	15.72	17.77	21.46	12.16	15.13	19.08	
5	1.06	10.90	10.90	12.30	0.00	10.60	10.60	13.00	
Total	46.42	46.65	90.57	88.25	50.26	44.29	88.21	91.75	
emperature °	F 172.80	187.97	194.47	202.65	173.51	188.78	194.30	205.80	

TABLE A-7. MOLAR FLOW RATES AND CONDITIONS AT KEY COLUMN LOCATIONS FOR EXAMPLE 3

Component	Short-cut This Wor		Plate-to-Pl	late
Number	Distillate	Bottoms	Distillate	Bottoms
1 2 3 4 Total	18.24 20.95 2.97 <u>0.60</u> 42.76	$ \begin{array}{r} 1.76 \\ 4.05 \\ 17.03 \\ \underline{34.40} \\ 57.24 \end{array} $	18.23 20.95 2.97 <u>0.64</u> 42.79	1.77 4.05 17.03 <u>34.36</u> 57.21
Temperature °F	161.39	223.75	161.45	223.73

TABLE A-8. MOLAR FLOW RATES AND CONDITIONS OF PRODUCTS FOR EXAMPLE 4

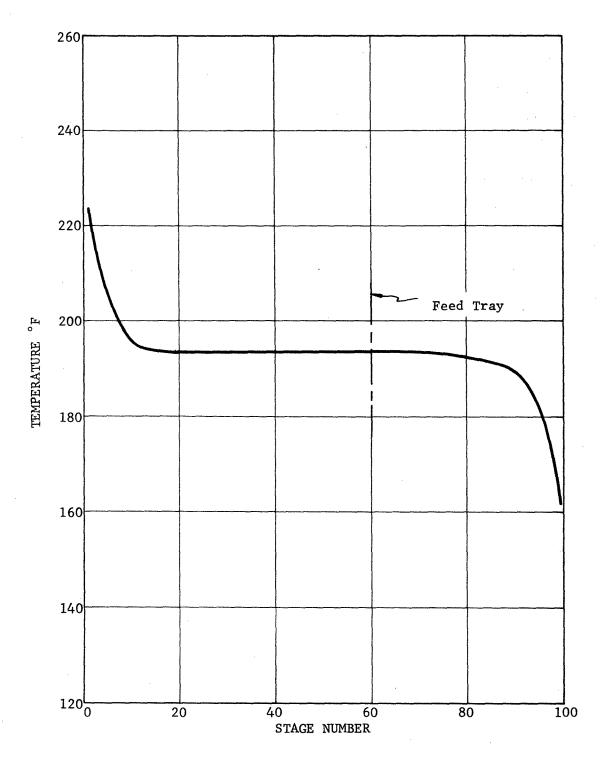


FIGURE A-5. Temperature profile for Example 4.

_		Short-cut	in This Wo	rk		Plate-	to-Plate	
Component Number	L _{R*}	L _{f+1}	v _f	۷ <u>s</u> *	L _{R*}	L _{f+1}	v _f	۷ <u>s</u> *
1 2 3 4 Total	14.02 17.53 13.93 <u>24.54</u> 70.02	14.02 17.53 13.93 24.54 70.02	32.25 38.33 17.03 25.13	32.25 38.33 17.03 25.13	14.01 17.53 14.09 24.41	$ \begin{array}{r} 14.01 \\ 17.53 \\ 14.06 \\ \underline{24.45} \\ \hline \end{array} $	32.24 38.48 17.03 25.10	32.24 38.50 17.04 25.10
Temperature °F		193.31	112.74 193.39	112.74 193.39	70.04	70.05	112.85 193.34	112.88 193.34

TABLE A-9. MOLAR FLOW RATES AND CONDITIONS AT KEY COLUMN LOCATIONS FOR EXAMPLE 4

Case	Short- This N		Plate-to	-Plate	Underwood
	L _{R*}	L _{Rm}	L _{R*}	L _{Rm}	L _{R*}
Example 1	59.34	66.12	59.43	66.09	55.80
Example 2	58.97	63.50	58.94	63.32	55.30
Example 3	46.42	50.45	50.26	54.05	46.90
Example 4	70.02	79.35	70.04	79.28	70.00

TABLE A-10. MINIMUM REFLUX RESULTS FOREXAMPLES 1, 2, 3, AND 4

APPENDIX B

PROGRAM 1. MAIN EXECUTOR

.

С	MMON / SHRTC	т /				MNR 00100
Α	AA(100),	AB(100),	AC	(100),	AD(100),	MNR 00120
B	B(50),	BDI(50),	BFLC	JW.	BN(50),	MNR 00140
С	D(50),	DCALC,	DCOM	٧,	DELBAR(100),	MNR 00160
D	DELF(100),	DL,	DLS	5(50),	DLST,	MNR 00180
E F	DN(50),	DSPEC,	DV	,	DVS,	MNR 00200
F	DVX(50),	DVXT,	ENT	ΓΗ,	ER,	MNR00220
G	FACT(100),	FEND(50,6)	, FFI	_OW,	FL(50),	MNR 00240
Н	FLTOT,	FMAXA,	EMA)	(S,	FMINA,	MNR 00260
I	FMINS,	FP,	FRV	ΑΡ ,	FT,	MNR CO280
J	FTOT(50),	FV(50),	FVT	ЭΤ,	ICON,	MNR 00300
κ	ID,	IP,	ISEC	,	MTRY,	MNR00320
L	ISTAGE,	KODE(10),	KSEC	•	LFD(50),	MNR 00340
М	LFFX(50),	LV(6),	. NAE	3SR,	NCOMP,	MNR 00360
N	NFSTG,	NITER +	NS	(5),	NSTRP,	MNR 00380
0	P(6),	R,	S2 ((50),	\$3(50),	MNR 00400
P	S4(50),	S5(50),	т (е	5),	THETA,	MNR 00420
Q	VFB(50),	VFFX(50),	NTRY,	IHK,	ILK	MNR 0044 0
	NTEGER ER					MNR 00460
C	ALL WIPE (AA(1), ILK)				MNR 00480
					-	4NR 00500
	ALL RELOC					MNR 00520
C,	ALL INPUT					MNR 00540
						MNR 00560
El	ND					MNR 00580

С

С

.

OPTIONS IN EFFECT ID,EBCDIC,SOURCE,NULIST,NODECK,LOAD,NOMAP *OPTIONS IN EFFECT* NAME = MAIN , LINECNT = 55 *STATISTICS* SOURCE STATEMENTS = 6,PROGRAM SIZE = 332 *STATISTICS* NO DIAGNOSTICS GENERATED PROGRAM 2. BUBBLE POINT CALCULATIONS

	SUBROUTINE BUB(PBP, TBP, L)	MNR 00600
С		MNR 00620
С	SUBROUTINE TO PERFORM BUBBLE POINT CALCULATIONS	MNR00640
С	LIQUID COMPONENT RATES	MNR 00660
С	RATE TOTAL LIQUID RATE	MNR 00680
С		MNR 00700
	COMMON /KVALUE/ AK(50), DK(50), DDK(50)	MNR 00720
	COMMON / SHRTCT /	MNR 00740
	A = AA(100), AB(100), AC(100), AD(100),	MNR 00760
	B B(50), BDI(50), BFLOW, BN(50),	MNR00780
	C D(50), DCALC, DCON, DELBAR(100),	MNR 00800
	D DELF(100), DL, DLS(50), DLST,	MNR 00820
	E DN(50), DSPEC, DV, DVS,	MNR 00840
	F DVX(50), DVXT, ENTH, ER,	MNR 00860
,	G FACT(100), FEND(50,6), FFLOW, FL(50),	MNR 00880
	H FLTOT, FMAXA, FMAXS, FMINA,	MNR 00900
	I FMINS, FP, FRVAP, FT,	MNR 00920
	J FTOT(50), FV(50), FVTOT, ICON,	MNR 00940
	K ID, IP, ISEC, MTRY,	MNR 00960
	L ISTAGE, KODE(10), KSEC, LFD(50),	MNR 00980
	M LFFX(50), LV(6), NABSR, NCOMP,	MNR 01 000 MNR 01 020
	N NFSTG, NITER, NS(5), NSTRP,	MNR 01020
	0 P(6), R, S2(50), S3(50), P S4(50), S5(50), T(6), THETA,	MNR 01 060
		MNR 01080
		MNR 01 100
	REAL L(50)	MNR 01120
r	INTEGER ER	MNR 01140
с с	SUM LIQUID COMPONENT RATES	MNR 01160
U	RATE = 0.0	MNR 01180
	DO 100 I=1,NCOMP	MNR 01200
	RATE = RATE + L(I)	MNR01220
	100 CONTINUE	MNR 01240
С	IOU CONTINUE	MNR 01260
ř	START BUBBLE POINT CALCULATIONS	MNR 01280
C C	START BOULL FOR ORLOGATIONS	MNR 01300
v	DO 500 ITER=1,50	MNR 01320
С		MNR 01340
C C	CALCULATE THE SUMS OF LK, LDK, AND LDDK	MNR 01 360
Č		MNR 01 380
	SKL = 0.0	MNR 01400
	DF = 0.0	MNR 01420
	DDF = 0.0	MNR 01 440
	CALL KVAL(PBP, TBP, IER)	MNR 01460
	DD 200 $I=1, NCOMP$	MNR 01480
	SKL = SKL + L(I) * AK(I)	MNR 01500
	DF = DF + L(I) * DK(I)	MNR 01520
	DDF = DDF + L(I) * DDK(I)	MNR 01540
	200 CONTINUE	MNR 01560
	F = -1.0 + SKL / RATE	MNR 01 580
	IF (ABS(F) .LT.0.00001) GO TO 600	MNR 01600
С		MNR 01620
С	CALCULATE CORRECTED TEMPERATURE USING RICHMOND METHOD	MNR 01640

C C C C C C

B UB

C	MNR 01660
TBP = TBP - 1.0 / ((DF/(F * RATE))- (0.5 * DDF / DF))	MNR 01680
500 CONTINUE	MNR 01700
C SOLUTION NOT CUNVERGING	MNR 01720
ER = 1	MNR 01740
CALL ERROR	MNR 01760
C	MNR 01 780
600 RETURN	MNR 01800
C	MNR 01820
END	MNR 01840

OPTIONS IN EFFECT ID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP *OPTIONS IN EFFECT* NAME = BUB , LINECNT = 55 *STATISTICS* SOURCE STATEMENTS = 27,PRUGRAM SIZE = 756 *STATISTICS* NO DIAGNOSTICS GENERATED

PROGRAM 3. DEW POINT CALCULATIONS

		SUBROUTINE DEWL	PDW, TDW, V)			MNR 01860
С						MNR 01890
С		SUBROUTINE TO PI	ERFORM DEW POI	NT CALCULATIONS		MNR 01900
С		V VAPOR (COMPONENT RATE	S		MNR 01920
С						MNR 01940
		COMMON /KVALUE/	AK(50).	DK(50),	DDK (50)	MNR 01960
		COMMON / SHRTO				MNR 01 980
	А	AA(100),	AB(100),	AC(100),	AD(100),	MNR 02000
	B		BDI(50),	BFLOW,	BN(50),	MNR 02020
	Č	•	DCALC,	DC UN.	DELBAR(100),	MNR 02040
	Ď	· · · ·	DL,	DLS(50),	DLST.	MNR 02060
	E		D SPEC,	DV,	DVS,	MNR 02080
	F		DVXT,	ENTH,	ER,	MNR 02100
	G		FEND(50,6)	•	FL(50),	MNR 02120
	н		FMAXA,	FMAXS,	FMINA,	MNR 02120
	I		FP,	FRVAP,	FT,	MNR 02160
	J	· · · •	FV(50),	EVIOT,	ICON,	MNR 02180
	K		IP,	ISEC,	MTRY,	
	Ĺ		KODE(10),	KSEC,	LFD(50),	MNR 02200
	M	•	LV(6),			MNR 02220
				NABSR, NS(5),	NCOMP,	MNR 02240
	N		NITER,		NSTRP,	MNR 02260
	0	· · · ·	R,	S2(50),	\$3(50),	MNR 02280
	P		\$5(50),	T(6),	THETA,	MNR 02300
~	Q) VFB(50),	VFFX(50),	NTRY, IHK,	ILK	MNR 02320
С		A THENE TON MEDAL				MNR 02340
		DIMENSION V(50)				MNR 02360
~		INTEGER ER				4NR 02380
C						MNR 02400
C						MNR 02420
С		SUM VAPOR COMPO	NENT RATES			MNR 02440
		RATE = 0.0	-			MNR 02460
		DD 100 I=1,NCOM				MNR 02480
		RATE = RATE + V	(1)			MNR 02500
	100	CONTINUE				MNR 02520
С						MNR 02540
С				•		MNR 02560
		DU 500 ITER=1,5	0			MNR 02580
С					·	MNR 02600
С		CALCULATE THE S	UMS OF F,DFYD	T,D2F/DT2		MNR 02620
C			н. -			MNR 02640
		SKV = 0.0				MNR 02660
		DF = 0.0				MNR 02680
		ODF = 0.0				MNR 02700
		CALL KVAL(PDW,T	DW,IER)			MNR02720
		DO 200 I=1,NCOM				MNR 02740
		AK2 = AK(1)**	2			MNR 02760
		SKV = SKV + V(I) / AK(I)			MNR 02780
			(I)*DK(I)/AK2			MNR 02800
				2 - 2.*DK(I)**2	/ AK2*AK(1))	MNR 02820
		CONTINUE				MNR 02820
		F = -1.0 + SKV	/ RATE			MNR 02860
		IF (ABS(F) '.LT		0 600		MNR 02880
С						MNR 02900
-						1000 VZ 7VU

DEW

С	CALCULATE CORRECTED TEMPERATURE USING RICHMOND METHOD	4NR 02920
С		MNP 02940
	TDW = TDW - 1.0 / ((DF / (F * RATE)) - (0.5 * DDF / DF))	MNR 02960
50	O CONTINUE	MNR 02980
С	SOLUTION NOT CONVERGING	MNR 03000
	ER = 2	MNR 33620
	CALL ERROR	MNR 03040
С		MNR 03060
60	O RETURN	MNR 03080
Ċ		MNR 03100
	END	MNR 03120

OPTIONS IN EFFECT ID, EBCDIC, SOURCE, NOLIST, NODECK, LOAD, NOMAP *OPTIONS IN EFFECT* NAME = DEW , LINECNT = 55 *STATISTICS* SUURCE STATEMENTS = 28, PROGRAM SIZE = 812 *STATISTICS* NO DIAGNOSTICS GENERATED

PROGRAM 4. ROUTINE TO READ ALL INPUT

SUBROUTINE INPUT				MNR 03140 MNR 03160
				MNR 03180
INPUT ROUTINE - 1	KEAD, STUKE, &	PRINT INPUT DA	1 A	MNR.03200
	MONAN(2 EO)			MNR 03220
COMMON /COMPNM/	MPNAMUS DUI			4NR 03240
COMMON / FNSKOP	/ IREF,	REFRCL,	FNM,	MNR 03260
	DEST,	Net Noty	1 1 1 1 7 7 3	MNR 03280
-	FNAME(3),	DUMDUM(100)		MNR 03300
2 LRSTAR,	E MARCE ())	00000000000	· · · · · · · · · · · · · · · · · · ·	MNR 03320
COMMON / SHRTC	T /			MNR 03340
	AB(100),	AC(100),	AD(100),	MNR 03360
A AA(100), B B(50),	BDI(50),	BFLOW,	BN (50).	MNR 03380
D(50),		DC ON,	DELBAR(100),	MNR03400
DELF(100),	DL,	DLS(5)),	DLST,	MNR 03420
E DN(50),	D SPEC	DV,	DVS +	MNR 03440
= DVX(50),	DVXT,	ENTH,	ER,	MNR 03460
G FACT(100),	FEND(50,6),	FFLOW,	FL(50),	MNR 03480
+ FLTOT,	FMAXA,	FMAXS,	FMINA,	MNR 03500
I FMINS,	FP.	FRVAP.	FT,	MNR 03520
	FV(50),	FVTOT,	ICON,	MNR 03540
J FTOT(50), (ID,	IP,	ISEC,	MTRY,	MNR 03560
ISTAGE,	KODE(10),	KSEC,	LFD(50),	MNR 03580
<u>LFFX(50)</u>	LV(6),	NABSR.	NCOMP,	MNR 03600
N NESTG.	NITER,	NS(5),	NSTRP,	MNR 03620
) P(6),	R,	S2(50),	\$3(50),	MNR 03640
P \$4(50),	\$5(50),	T(6),	THETA,	MNR 03660
Q VFB(50),		TRY, IHK,	ILK	MNR 03680
41919014				MNR 03700
COMMON /SYSTEM/	IREAD. IWRITE			MNR 03720
	INCRUT INNIIC			MNR 03740
COMMON /WHILE/ P	FRC.THTAL.THTA2	.TT1 .TT2. CLV	(5),DELPC,DELP	MNR 03760
Conton / Antzer /				MNR 03780
COMMON /ZALPHA/	KZ(160)			MNR 03800
				MNR 03820
DIMENSION NAME(3	.8), DATA(10)			MNR 03840
DIMENSION		, RNAME(2,50)		MNR 03860
	• • • •			MNR 03880
	5), W(5), DUMY(5), XK(5)		MNR 03900
DIMENSION COEF				MNR 03920
	5), PCF(5), CF	KV(30,5)		PHNKUSYZU
	5), PCF(5), CF	KV(30,5)		MNR 03940
DIMENSION TOF		KV(30,5)		
DIMENSION TCF (DATA NAME / !*30		KV(30,5)		MNR 03940
DIMENSION TCF DATA NAME / **36 1 **CN	50*, *1 *, * {P*, * *, *	1 , 2 ,		MNR 03940 MNR 03960
DIMENSION TCF DATA NAME / **36 1 *CM 2 **K	0, 1, 1, 1, 1 p, 1, 1, 1, 1 0, 1EF 1, 1	t , t , t ,		MNR 03940 MNR 03960 MNR 03980
DIMENSION TCF DATA NAME / '*36 1 '*CN 2 '*KC 3 '*KC	00', '1 ', ' p', ' ', ' 0', 'EF ', ' A', 'TA ', '	1 , 2 ,		MNR 03940 MNR 03960 MNR 03980 MNR 04000
DIMENSION TCF DATA NAME / **36 1 **CN 2 **K0 3 **K0 4 **FE	00', '1 ', ' 1P', ' ', ' 0', 'EF ', ' 0A', 'TA ', ' E', 'D ', '	1 , 1 , 1 , 1 , 1 ,		MNR 03940 MNR 03960 MNR 03980 MNR 04000 MNR 04020
DIMENSION TCF DATA NAME / **36 1 **CN 2 **K0 3 **K0 4 **FE 5 **BA	00', '1 ', ' 10', 'EF ', ' 04', 'TA ', ' E', 'D ', ' AS', 'E CA', 'SE	f , f , f , f , f , f , f ,		MNR 03940 MNR 03960 MNR 03980 MNR 04000 MNR 04020 MNR 04040
DIMENSION TCF DATA NAME 1 **36 1 **CN **CN 2 **K0 **K0 3 **K0 **K0 4 **FE **K0 5 **K0 **K0 6 **C0 **C0	00', '1 ', ' 10', 'EF ', ' 04', 'TA ', ' E', 'D ', ' S', 'E CA', 'SE 0M', 'PR ', '	1 , 1 , 1 , 1 , 1 ,		MNR 03940 MNR 03960 MNR 03980 MNR 04000 MNR 04020 MNR 04040 MNR 04060
DIMENSION TCF DATA NAME **30 1 **CN 2 **K0 3 **K0 4 **FE 5 **80 6 **C0	00', '1 ', ' 10', 'EF ', ' 04', 'TA ', ' E', 'D ', ' S', 'E CA', 'SE 0M', 'PR ', '	f , f , f , f , f , f , f , f , f ,		MNR 03940 MNR 03960 MNR 03980 MNR 04000 MNR 04020 MNR 04040 MNR 04060 MNR 04080
DIMENSION TCF DATA NAME / **30 1 **CN 2 **K0 3 **K0 4 **FE 5 **BA 6 **C0 7 **DE	50', '1 ', ' 10', 'EF ', ' 10', 'TA ', ' 10', 'TA ', ' 10', 'TA ', ' 10', 'EF ', ' 10', '	f , f , f , f , f , f , f , f , f ,		MNR 03940 MNR 03960 MNR 03980 MNR 04000 MNR 04020 MNR 04040 MNR 04060 MNR 04080 MNR 04080 MNR 04100
DIMENSION TCF DATA NAME 1 **36 1 **CN **CN 2 **K0 **K0 3 **K0 **K0 4 **FE **K0 5 **K0 **K0 6 **C0 **C0	50', '1 ', ' 10', 'EF ', ' 10', 'TA ', ' 10', 'TA ', ' 10', 'TA ', ' 10', 'EF ', ' 10', '	f , f , f , f , f , f , f , f , f ,		MNR 03940 MNR 03960 MNR 03980 MNR 04000 MNR 04020 MNR 04040 MNR 04060 MNR 04080 MNR 04100 MNR 04120

. 73 С С INITIALIZE С С VAR TABLES С ENTH = 0.FFLOW = 0.FLTOT = 0.FVTOT = 0.FTF = 0.0ID = 0IP = 0IREAD = 5IWRITE = 6NCOMP = 0С С INPUT CARD CHECKING COUNTERS С ICDEF = 0IDATA = 0IFD = 0IK = 0IR = 0KERROR = 0KVC = 0TTC = 0.С С DD 5 J=1,50 D(J) = 0.DLS(J) = 0.DVX(J) = 0.05 CONTINUE С 10 CALL ZCAPD (Z, 850) С С ERROR MSG - * CARD SEQUENCE ERROR С PRINT 20 С KERROR = KERROR + 1STOP С С PACK FIRST 12 WORDS INTO 3 С 50 DUMMY = ZPACK (KZ(1), KZ(81), 12) С С CHECK FOR TYPE OF CARD FOUND С $DO \ 100 \ I = 1.10$ IT = IIF (KZ(81) - NAME(1,I))100, 150, 100 **100 CONTINUE**

INPUT

MNR 04200 MNR 04220 MNR 04240 MNR 04250 MNR 04280 MNR 04300 MNR 04320 MNR 04340 MNR 04360 MNR 04380 MNR 04400 MNR 04420 MNR 04440 MNR 04460 MNR 04480 MNR.04500 MNR 04520 MNR 04540 MNR 04560 MNR 04580 MNR 04600 MNR 04620 MNR 04640 MNR 04660 MNR 04680 MNR 04700 MNR 04720 MNR 04740 MNR04760 MNR 04780 MNR 04800 MNR 04820 MNR 04840 MNR 04860 MNR 04880 MNR 04900 MNR 04920 MNR 04940 MNR 04960 MNR 04980 MNR 05000 MNR 05020 MNR 05040 MNR 05060 MNR 05080 MNR 05100 MNR 05120 MNR 05140 MNR 05160 MNR 05180 MNR 05200 MNR 05220 MNR 05240

```
С
                                                                               MNR 05260
С
      NO MATCH FOUND
                                                                                MNR 05280
С
                                                                                MNR 05300
      WRITE (IWRITE, 120) (KZ(I), I=1,80)
                                                                                MNR 05320
С
                                                                                MNR 05340
      KERROR = KERROR + 1
                                                                               MNR 05360
      STOP
                                                                                MNR 05380
С
                                                                                MNR 05400
С
      MATCH FOUND - GU TO PROPER STATEMENT FOR PROCESSING
                                                                                MNR 05420
С
                                                                                MNR 05440
             TITL CMP KCF KDA FD BC CPR DES
С
                                                                                MNR 05460
  150 GO TO (200,250,300,350,400,450,500,550 ),IT
                                                                                MNR 05480
С
                                                                                MNR 05500
С
      *3601 TITLE CARD FOUND
                                                                                MNR 05520
С
                                                                                MNR 05540
  200 \text{ TTC} = \text{TTC} + 1
                                                                                MNR 05560
      IF ( TTC .EQ. 1 ) GO TO 210
                                                                                MNR 05580
С
                                                                                MNR C5600
      WRITE (IWRITE,2000)(KZ(I), I=1,80)
                                                                                MNR 05620
С
                                                                                MNR 05640
      GO TO 220
                                                                                MNR 05660
С
                                                                                MNR 05680
  210 WRITE (IWRITE, 2010) (KZ(I), I=1,80)
                                                                                MNR 05700
С
                                                                                MNR 05720
  220 CALL ZCARD ( Z, 850 )
                                                                                MNR 05740
С
                                                                                MNR 05760
С
                                                                                MNR 05780
      GO TO 220
                                                                                MNR 05800
С
                                                                                MNR 05820
С
      *CMP COMPONENT CARD FOUND
                                                                                MNR 05840
С
                                                                                MNR 05860
  250 PRINT 2020
                                                                                MNR 05880
С
                                                                                MNR 05900
  260 CALL ZCARD ( Z, &270 )
                                                                                MNR 05920
С
                                                                                MNR 05940
      GO TO 280
                                                                                 MNR 05960
С
                                                                                MNR 05980
С
      EITHER NO CD OR UNRECOGNIZABLE CD CARD FOUND - PRINT MESSAGE
                                                                                MNR 06000
С
                                                                                MNR 06020
  270 WRITE (IWRITE, 2030)
                                                                                MNR 06040
С
                                                                                MNR 06060
      KERROR = KERROR + 1
                                                                                MNR 06080
С
                                                                                MNR 06100
   GO TO 50
                                                                                MNR 06120
С
                                                                                MNR 06140
С
      CHECK FOR CD CARDS
                                                                                MNR 06160
С
                                                                                MNR 06180
  280 IF( TEST( 2, KZ(81),1, 1, 'CD ', 1, 1 ).EQ.0.0 ) GO TO 290
                                                                                MNR 06200
С
                                                                                MNR 06220
      GO TO 270
                                                                                MNR 06240
С
                                                                                MNR 06260
  290 \text{ NCDMP} = \text{NCOMP} + 1
                                                                                MNR 06280
      DUMMY = ZPACK ( KZ(5), CMPNAM(1, NCOMP), 12)
                                                                                MNR 06300
```

```
С
                                                                             MNR 06320
      WRITE (IWRITE,2000)(KZ(I), I=1,80)
                                                                              MNR 06340
                                                                              MNR 06360
      CALL ZCARD ( Z, &50 )
                                                                              MNR 06380
      GO TO 280
С
                                                                              MNR 06400
С
      *KCDEF CARD FOUND
                                                                              MNR 06420
                                                                              MNR 06440
С
      GENERATE DATA TYPE IDENTIFIER, IK
                                                                              MNR 06460
C
Ċ
                                                                              MNR 06480
                                                                              MNR 06500
  300 \text{ IK} = 1
С
                                                                              MNR06520
      X = ZINTGR (KZ(13), KSEC, 12)
                                                                              MNR 06540
С
                                                                              MNR06560
      DETERMINE WHICH SECTION BEING PROCESSED
                                                                              MNR 06580
C
                                                                              MNR 06600
С
      KVC = KVC + 1
                                                                              MNR 06620
      IF ( KSEC .EQ. O .AND. KVC .EQ. 1 ) KSEC = 1
                                                                              MNR 06640
      IF ( KSEC .EQ. O .AND. KVC .EQ. 2 ) KSEC = 2
                                                                              MNR 06660
                                                                              MNR 06680
С
                                                                              MNR06700
С
      CHECK FOR KV CARDS
                                                                              MNR 06720
С
  310 CALL ZCARD ( Z, &320)
                                                                              MNR 06740
С
                                                                              MNR 06760
      GD TO 330
                                                                              MNR 06780
С
                                                                              MNR 06800
      EITHER NO KC OR UNRECOGNIZABLE KC CARD FOUND - PRINT MESSAGE
С
                                                                              MNR 06820
С
                                                                              MNR 06840
  320 WRITE (IWRITE, 2040)
                                                                              MNR 06860
С
                                                                              MNR 06880
      KERROR = KERROR + 1
                                                                              MNR C6900
С
                                                                              MNR 06920
      GO TO 50
                                                                              MNR 06940
С
                                                                              MNR 06960
      CHECK FOR KC CARDS
С
                                                                              MNR 06980
С
                                                                              MNR 07000
  330 IF( TEST( 2, KZ(81),1, 1, 'KC ', 1, 1 ).EQ.0.0 ) GO TO 340
                                                                              MNR 07020
С
                                                                              MNR 07040
      GO TO 320
                                                                              MNR 07060
С
                                                                              MNR 07080
  340 \text{ ICUEF} = \text{ICUEF} + 1
                                                                              MNR 07100
С
                                                                              MNR 07120
      DD 342 K = 1,4
                                                                              MNR 07140
      X = ALFA ( DATA(K), KZ(7+(K-1)*18), 18, 1, 8)
                                                                              MNR 07160
  342 CONTINUE
                                                                              MNR 07180
С
                                                                              MNR 07200
      ISLOT = (KSEC-1) * 50 + ICUEF
                                                                              MNR 07220
С
                                                                              MNR 07240
      AA(ISLOT) = DATA(1)
                                                                              MNR 07260
      AB(ISLOT) = DATA(2)
                                                                              MNR07280
      AC(ISLOT) = DATA(3)
                                                                              MNR07300
      AD(ISL)T) = DATA(4)
                                                                              MNR 07320
С
                                                                              MNR 07340
                                                                            MNR 07360
      CALL ZCARD ( Z, &50 )
```

. 76 LNPUT

с			MNR 07380
C		GD TO 330	MNR 07400
С			MNR 07420
С		*KDATA CARD FOUND	MNR 07440
С			MNR07460
С		GENERATE DATA TYPE IDENTIFIER, IK	MNR 07480
С			MNR 07500
	350	IK = 2	MNR 07520
С			MNR 07540
С		CHECK FOR * CARD	MNR 07560
		CALL ZCARD (Z, &370)	MNR 07580
С			MNR 07600
		GO TO 372	MNR 07620
С			MNR 07640
	370	WRITE (IWRITE,2055)	MNR 07660
С			MNR 07680
-		KERROR = KERROR + 1	MNR 07700
С			MNR 07720
~		GD TO 50	MNR 07740
C		STORE TENDEDATION DATA TEE	MNR 07760
C C		STORE TEMPERATURE DATA, TCF	MNR 07780 MNR 07800
C		DO 374 K = $1,5$	MNR 07820
	516	X = 2REAL (KZ(13+(K-1)*12), TCF(K), IU, 12)	MNR 07840
	271	CONTINUE	MNR 07860
С	214	CONTINUE	MNR 07880
C		CALL ZCARD (Z, &370)	MNR 07900
С			MNR 07920
č		STORE PRESSURE DATA, PCF	MNR 07940
č			MNR 07960
-		DO 376 K = 1,5	MNR 07980
		X = ZREAL (KZ(13+(K-1)*12), PCF(K), UI, 12)	MNR 08000
	376	CONTINUE	MNR 08020
С			MNR 08040
		CALL ZCARD (Z, &370)	MNR 08060
С			MNR 08 080
С		CHECK FOR KV CARDS	MNR 08100
С			MNR 08120
	380	IF(TEST(2, KZ(81),1, 1, 'KV ', 1, 1).EQ.0.0) GO TO 390	MNR 08140
С			MNR 08160
		GO TO 370	MNR 08180
С			MNR 08200
	390	IDATA = IDATA + 1	MNR 08220
C		CTODE COMPONENT TRAV & MALUES	MNR 08240
ç		STORE COMPONENT-TRAY K-VALUES	MNR 08260
С		20.202 K = 1.5	MNR 08280
		DO 392 K = 1,5 x = ZREAL { KZ(13+(K-1)*12),CFKV(IDATA,K),IU, 12 }	MNR 08300
	202	x = 2REAL (RZ(13+(R-1)*12))CRV(1DATA,R), 10, 12) CONTINUE	MNR 08320
с	276		MNR 08340 MNR 08360
C		CALL ZCARD (Z, 850)	MNR 08380
С		ONEE EDAND (EY UDD)	MNR 08 400
U		GD TO 380	MNR 08420

```
MNR 08440
С
                                                                               MNR 08460
С
      *FEED CARD FOUND
                                                                               MNR 08480
С
  400 DUMMY = ZPACK ( KZ(13), FNAME(1),12)
                                                                               MNR 08500
С
                                                                               MNR 08520
                                                                               MNR 08540
      DO 402 K = 1.4
                                                                               MNR 08560
      X = ZREAL ( KZ(25+(K-1)*12), DATA(K), IU, 12)
                                                                               MNR 08580
  402 CONTINUE
С
                                                                               MNR 08600
                                                                               MNR 08620
      FFLOW = DATA(1)
      NESTG = DATA(2)
                                                                               MNR 08640
      FT = DATA(3)
                                                                               MNR 08660
                                                                               MNR 08680
      FRVAP = DATA(4)
                                                                               MNR 08700
С
                                                                               MNR 08720
      CALL ZCARD (Z, &420 )
С
                                                                               MNR 08740
      GO TO 430
                                                                               MNR 08760
                                                                               MNR 08780
С
  420 WRITE (IWRITE,2050)
                                                                               MNR 08800
                                                                               MNP. 08820
С
      KERROR = KERROR + 1
                                                                               MNR 08840
                                                                               MNR 08860
С
                                                                               MNR 09880
      GD TO 50
                                                                               MNR 08900
С
  430 IF( TEST( 2, KZ(81),1, 1, 'COMP', 1, 1 ).EQ.0.0 ) GO TO 440
                                                                               MNR 08920
С
                                                                               MNR 08940
                                                                               MNR 08960
      GO TO 420
                                                                               MNR 08980
С
  440 IFD = IFD + 1
                                                                               MNR 09000
                                                                               MNR 09020
С
                                                                               MNR 09040
       DO 442 K = 1.2
       X = ZREAL ( KZ(13+(K-1)*12), DATA(K), IU, 12)
                                                                               MNR 09060
                                                                               MNR 09080
  442 CONTINUE
С
                                                                               MNR 09100
                                                                               MNR 09120
       FTOT(IFD) = DATA(1)
                                                                               MNR 09140
      FV(IFD) = DATA(2)
       FL(IFD) = FTOT(IFD) - FV(IFD)
                                                                               MNR 09160
       FVTOT = FVTOT + FV(IFD)
                                                                               MNR 09180
       FLTOT = FLTOT + FL(IFD)
                                                                               MNR 09200
       FTF = FTF + FTOT(IFD)
                                                                               MNR 09220
С
                                                                               MNR 09240
       CALL ZCARD ( Z, 650)
                                                                                MNR 09260
С
                                                                                MNR 09280
       GO TO 430
                                                                                MNR 09300
С
       *COMPR CARD FOUND
                                                                                MNR 09320
С
                                                                                MNR 09340
С
       CHECK FOR * CARD
                                                                                MNR 09360
                                                                                MNR 09380
   500 CALL ZCARD( Z, &520 )
С
                                                                                MNR 09400
       GO TO 530
                                                                                MNR 09420
С
                                                                                MNK 09440
   520 WRITE ( IWRITE, 2070 )
                                                                                MNR 09460
С
                                                                                MNR 09480
```

```
INPUT
```

```
KERROR = KERROR + 1
                                                                              MNR 09500
      GO TO 50
                                                                              MNR 09520
                                                                              MNR 09540
С
  530 IF( TEST( 2, KZ(81),1, 1, "RATI", 1, 1 ).EQ.0.0 ) GO TO 540
                                                                              MNR 09560
С
                                                                              MNR 09580
                                                                              MNR 09600
      GO TO 520
С
                                                                              MNR 09620
  540 \text{ IR} = \text{IR} + 1
                                                                              MNR 09640
      00542 \text{ K} = 1.2
                                                                              MNR 09660
                                                                            MNR 09680
      X = ZREAL ( KZ(13+(K-1)*12), DATA(K), IU, 12)
  542 CONTINUE
                                                                              MNR 09700
С
                                                                              MNR 09720
С
      TRANSFER L(F+1)/D AND V(F)/B COMPONENT RATIO INFURMATION
                                                                              MNR 09740
С
                                                                              MNR 09760
      LFD(IR) = DATA(1)
                                                                              MNR 09780
      VFB(IR) = DATA(2)
                                                                              MNR 09800
С
                                                                              MNR 09820
      CALL ZCARD ( Z, &50 )
                                                                              MNR 09840
С
                                                                              MNR 09860
      GO TO 530
                                                                              MNR 09880
С
                                                                               MNR 09900
      *BASE CASE CARD FOUND
С
                                                                              MNR 09920
С
                                                                               MNR 09940
С
      READ SPECIAL OPERATING CODES
                                                                               MNR 09960
С
                                                                               MNR 09980
  450 DD 452 K = 1,10
                                                                               MNR 10000
      X = ZINTGR ( KZ(13+(K-1)*4), KODE(K), 4 )
                                                                              MNR10020
  452 CONTINUE
                                                                               MNR 10040
С
                                                                               MNR10060
С
      CHECK FOR * CARD
                                                                               MNR 10080
С
                                                                               MNR 10100
      CALL ZCARD(Z, &470)
                                                                               MNR10120
С
                                                                               MNR 10140
      GO TO 480
                                                                               MNR10160
С
                                                                               MNR10180
  470 WRITE ( IWRITE, 2060)
                                                                               MNR 10200
С
                                                                               MNR 10220
      KERROR = KERROR + 1
                                                                               MNR 10240
      GO TO 50
                                                                               MNR 10260
С
                                                                               MNR10280
  480 IF( TEST( 2, KZ(81),1, 1, 'B1 ', 1, 1 ).EQ.0.0 ) GO TO 490
                                                                               MNR 10300
С
                                                                               MNR 10320
      GO TO 470
                                                                               MNR10340
С
                                                                               MNR10360
  490 \text{ DO } 492 \text{ K} = 1.5
                                                                               MNR 10380
      X = ZREAL ( KZ(9+(K-1)*12), DATA(K), IU, 12)
                                                                               MNR10400
  492 CONTINUE
                                                                               MNR10420
С
                                                                               MNR 10440
С
      TRANSFER GENERAL INFORMATION FROM B1 CARD
                                                                               MNR10460
С
                                                                               MNR10480
      ISTAGE = DATA(1)
                                                                               MNR 10500
      ISEC = DATA(2)
                                                                               MNR10520
      R = DATA(3)
                                                                               MNR10540
```

```
INPUT
      P(5) = DATA(4)
                                                                            MNR 10560
                                                                            MNR10580
      DELP = DATA(5)
С
                                                                            MNR10600
С
      CHECK FOR *CARD
                                                                            MNR 10620
                                                                            MNR10640
С
                                                                            MNR 10660
      CALL ZCARD( Z, &470)
                                                                             MNR 10680
С
      IF( TEST( 2, KZ(81),1, 1, 'B2 ', 1, 1 ).EQ.0.0 ) GD TO 493
                                                                             MNR 10700
                                                                            MNR10720
С
      GO TO 470
                                                                             MNR10740
                                                                             MNR10760
С
  493 DD 494 K = 1,5
                                                                             MNR 10780
      X = ZREAL ( KZ(9+(K-1)*12), DATA(K), 10, 12)
                                                                             MNR 10800
  494 CONTINUE
                                                                             MNR 10820
С
                                                                             MNR 10840
      TRANSFER CONDENSER INFORMATION FROM B2 CARD
                                                                             MNR10860
С
      DSPEC = DATA(1)
                                                                             MNR10880
                                                                             MNR 10900
      DELPC = DATA(2)
                                                                             MNR10920
      ICON = DATA(3)
      DL = DATA(4)
                                                                             MNR 10940
      DV = DATA(5)
                                                                             MNR10960
С
                                                                             MNR10980
С
      CHECK FOR * CARD
                                                                             MNR 11000
                                                                             MNR11020
С
                                                                             MNR11040
      CALL ZCARD ( 2, 8470 )
С
                                                                             MNR 11060
      IF( TEST( 2, KZ(81),1, 1, 'B3 ', 1, 1 ).EQ.0.0 ) GO TO 495
                                                                             MNR11080
                                                                             MNR11100
С
      GO TO 470
                                                                             MNR 11120
С
                                                                             MNR11140
      READ LIQUID/VAPOR MOLAR RATIOS FROM B3 CARD
С
                                                                             MNR11160
                                                                             MNR11190
C
  495 00 496 K = 1.5
                                                                             MNR 11 200
      X = ZREAL ( KZ(9+(K-1)*12), LV(K), IU, 12)
                                                                             MNR11220
  496 CONTINUE
                                                                             MNR11240
С
                                                                             MNR11260
      CHECK FOR * CARD
С
                                                                             MNR 11280
С
                                                                             MNR11300
      CALL ZCARD ( Z, &470)
                                                                             MNR11320
С
                                                                             MNR 11340
      IF( TEST( 2, KZ(81),1, 1, 'B4 ', 1, 1 ).EQ.0.0 ) GD TO 497
                                                                             MNR11360
С
                                                                             MNR 11380
      GO TO 470
                                                                             MNR 11400
С
                                                                             MNR11420
С
      READ STAGE TEMPERATURES FROM B4 CARD
                                                                             MNR 11440
С
                                                                             MNR11460
  497 \text{ DD } 498 \text{ K} = 1.6
                                                                             MNR11480
      X = ZREAL ( KZ(9+(K-1)*12), T(K), IU, 12)
                                                                             MNR11500
  498 CONTINUE
                                                                             MNR11520
С
                                                                             MNR 11540
      GO TO 600
                                                                             MNR 11560
С
                                                                             MNR11580
      *DESIGN CARD FOUND
С
                                                                             MNR11600
```

```
MNR11620
С
                                                                          MNR11640
  550 ID = 1
                                                                          MNR11660
С
                                                                          MNR11680
      DO 552 K = 1,10
      X = ZINTGR ( KZ(13+(K-1)*4), KODE(K), 4)
                                                                          MNR11700
  552 CONTINUE
                                                                          MNR11720
                                                                          MNR 11740
С
С
      CHECK FOR * CARD
                                                                          MNR11760
                                                                          MNR11780
С
      CALL ZCARD ( Z, &570 )
                                                                          MNR11800
С
                                                                          MNR 11820
                                                                          MNR11840
      GO TO 580
                                                                          MNR11860
С
  570 WRITE ( IWRITE, 2080)
                                                                          MNR11880
С
                                                                           MNR11900
      KERROR = KERROR + 1
                                                                          MNR11920
                                                                          MNR11940
      GO TO 50
С
                                                                           MNR11960
  580 IF( TEST( 2, KZ(81),1, 1, 'D1 ', 1, 1 ).EQ.0.0 ) GO TO 590
                                                                           MNR11980
С
                                                                           MNR12000
      GO TO 570
                                                                           MNR12020
                                                                          MNR12040
С
  590 DO 592 K = 1,6
                                                                           MNR 12060
      X = ZREAL ( KZ(9+(K-1)*12), DATA(K), IU, 12)
                                                                           MNR12080
  592 CONTINUE
                                                                           MNR12100
С
                                                                           MNR12120
C
      TRANSFER GENERAL INFORMATION FROM D1 CARD
                                                                           MNR12140
С
                                                                           MNR12160
                                                                           MNR12180
      ISTAGE = DATA(1)
                                                                           MNR12200
      ISEC = DATA(2)
      R = DATA(3)
                                                                           MNR12220
      P(5) = DATA(4)
                                                                          .MNR 12240
      DELP = DATA(5)
                                                                           MNR12260
      NTRY = DATA(6)
                                                                           MNR12280
С
      CHECK FDR *CARD
                                                                           MNR12300
С
                                                                           MNR12320
      CALL ZCARD ( Z, 6570)
                                                                           MNR12340
С
                                                                           MNR12360
      IF( TEST( 2, KZ(81),1, 1, 'D2 ', 1, 1).EQ.0.0 ) GO TO 593
                                                                           MNR12380
С
                                                                           MNR12400
      GO TO 570
                                                                           MNR12420
С
                                                                           MNR12440
                                                                           MNR12460
  593 D0 594 K = 1.6
      X = ZREAL ( KZ(9+(K-1)+12), DATA(K), IU, 12)
                                                                           MNR12480
  594 CONTINUE
                                                                           MNR12500
С
                                                                           MNR12520
С
      TRANSFER CONDENSER INFORMATION FROM D2 CARD
                                                                           MNR12540
С
                                                                           MNR12560
      DSPEC = DATA(1)
                                                                           MNR12580
      DELPC = DATA(2)
                                                                           MNR12600
      ICON = DATA(3)
                                                                           MNR 12620
      DL = DATA(4)
                                                                           MNR12640
      DV = DATA(5)
                                                                           MNR12660
```

MNR12680 FACMAX = DATA(6)С MNR12700 CHECK FOR *CARD MNR 12720 C CALL ZCARD (Z, &570) MNR12740 MNR12760 С IF(TEST(2, KZ(81),1, 1, 'D3 ', 1, 1).EQ.0.0) GO TO 595 MNR 12780 MNR 12800 С GO TO 570 MNR 12820 MNR12840 С READ LIQUID/VAPOR MOLAR RATIOS FROM D3 CARD MNR 12860 С MNR12880 С MNR12900 595 DO 596 K = 1,5MNR12920 X = ZREAL (KZ(9+(K-1)*12), LV(K), IU, 12)596 CONTINUE MNR 12940 С MNR12960 MNR12980 CHECK FOR *CARD С MNR13000 С MNR 13020 CALL ZCARD (Z, 8570) MNR13040 С IF(TEST(2, KZ(81),1, 1, 'D4 ', 1, 1).EQ.0.0) GO TO 597 MNR13060 MNR13080 Ċ GO TO 570 MNR13100 С MNR13120 READ STAGE TEMPERATURES FROM D4 CARD MNR13140 С MNR13160 С 597 DO 598 K = 1,6MNR13180 X = ZREAL (KZ(9+(K-1)*12), T(K), IU, 12)MNR13200 598 CONTINUE MNR13220 MNR13240 С CHECK FOR *CARD MNR 13260 С С MNR13280 CALL ZCARD (Z, &570) MNR 13300 С MNR13320 IF(TEST(2, KZ(81),1, 1, 'D5 ', 1, 1).EQ.0.0) GO TO 587 MNR13340 С MNR13360 GO TO 570 MNR13380 С MNR13400 С READ OPTIONAL DESIGN INFORMATION MNR13420 С MNR13440 587 DO 588 K = 1,9MNR13460 X = ZREAL (KZ(9+(K-1)*8), DATA(K), IU, 8)MNR13480 588 CONTINUE MNR13500 С MNR 13520 IREF = DATA(1)MNR 13540 REFRCL = DATA(2)MNR13560 FNM = DATA(3)MNR 13580 REFRCH = DATA(4)MNR13600 DEST = DATA(5)MNR13620 MNR13640 = DATA(6) ILK = DATA(7) MNR13660 THK LRSTAR = DATA(8)MNR13680 MTRY = DATA(9)MNR 13700 С INPUT INFORMATION FORMATS MNR13720

INPUT

С MNR13740 20 FORMAT (/5X, **** ERROR *** REQUIRED **** CARD NUT FOUND - RUN THNR13760 1ERMINATED - CHECK DATA. !) MNR13780 120 FORMAT (/5X, **** ERROR *** NO RECOGNIZABLE INPUT DATA FOUND. FIRMNR13800 1ST CARD ENCOUNTERED IS: ', /5X, 80A1, ' RUN TERMINATED.') MNR13820 2000 FURMAT (/25X, 80A1) **MNR 13840** 2010 FORMAT (1H1,//25X, 80A1) MNR13860 2020 FORMAT (1H1, 60X, 'COMPONENTS', /61X, 10('-'), //) MNR 13880 2030 FORMAT (/5X, **** ERRUR MESSAGE *** EITHER NO CD OR UNRECOGNIZABLANR13900 1E CD CARD FOUND, EXECUTION WILL TERMINATE AFTER INPUT PROCESSING. 1) MNR 13920 2040 FORMAT (/5X, **** ERROR MESSAGE *** EITHER NO KC OR UNRECOGNIZABLANR 13940 1E KC CARD FOUND, EXECUTION WILL TERMINATE AFTER INPUT PROCESSING. *)MNR 13960 2050 FORMAT (/5X, **** ERROR *** NO FEED FLOW CARDS SUBMITTED -MNR 13980 1EXECUTION WILL TERMINATE AFTER INPUT PROCESSING. *) MNR 14000 2055 FORMAT (/5X, **** ERROR MESSAGE *** UNRECOGNIZABLE CARD FOUND UNDANR14020 1ER *KDATA, EXECUTION WILL TERMINATE AFTER INPUT PROCESSING. () MNR 14040 2060 FORMAT (/5X, **** ERROR MESSAGE *** INCORRECT NUMBER OF BASE CASEMNR14060 1 CARDS. EXECUTION WILL TERMINATE AFTER INPUT PROCESSING.") MNR 14080 2070 FORMAT (/5X, !*** ERROR MESSAGE *** UNRECOGNIZABLE CARD FOUND UNDMNR14100 1ER *COMPR. EXECUTION WILL TERMINATE AFTER INPUT PROCESSING.*) MNR14120 2080 FORMAT (/5X, **** ERROR MESSAGE *** INCORRECT NUMBER OF *DESIGN 14NR14140 1 CARDS. EXECUTION WILL TERMINATE AFTER INPUT PROCESSING. () MNR 14160 С MNR14180 600 CONTINUE MNR 14200 С MNR 14220 С CHECK INPUT COUNTERS AND ERROR GENERATION MNR 14240 С MNR14260 С CHECK NUMBER OF EQUILIBRIUM COEFFICIENT CARDS MNR14280 С MNR 14300 IF (IK.NE.1) GO TO 604 MNR14320 С MNR14340 IF (NCOMP.EQ.ICOEF) GO TO 604 MNR 14360 WRITE (IWRITE, 2100) ICOEF, NCOMP MNR14380 KERROR = KERROR + 1MNR 14400 С MNR 14420 604 IF (IK.NE.2) GO TO 606 MNR14440 С MNR14460 С CHECK THE NUMBER OF EQUILIBRIUM K-VALUE CARDS MNR14480 С MNR14500 IF (NCOMP.EQ.IDATA) GO TO 606 MNR14520 WRITE (IWRITE, 2110) IDATA, NCOMP MNR14540 KERROR = KERROR + 1MNR 14560 С MNR 14580 BE SURE THAT EQUILIBRIUM DATA IS AVAILABLE С MNR14600 С MNR 14620 606 IF (IK.GE.1.AND.IK.LE.3) GO TO 608 MNR14640 WRITE (IWRITE, 2120) MNR14660 KERROR = KERROR + 1MNR14680 С MNR14700 CHECK THE NUMBER OF FEED CARDS С MNR 14720 С MNR 14740 608 IF (NCOMP.EQ.IFD) GO TO 610 MNR14760 WRITE (IWRITE, 2130) IFD, NCOMP MNR14780

KERROR = KERROR + 1MNR 14800 С MNR 14820 610 IF (ID.EQ.1) GD TO 612 MNR14840 MNR14860 C IF (NCOMP.EQ.IR) GO TO 612 MNR 14880 WRITE (IWRITE, 2135) IR, NCOMP MNR14900 612 IF (KERROR.EQ.0) GO TO 620 MNR14920 MNR14940 % PRINT 2140, KERROR MNR14960 STOP С 4NR 14980 FORMATS FOR ERRORS IN NO. OF INPUT CARDS MNR15000 С 2100 FORMAT (///5X, **** ERROR MESSAGE *** PLEASE CHECK INPUT DECK. THANR15020 1E NUMBER OF KC EQUILIBRIUM COEFFICIENT CARDS, ', 13, ', DUES NOT MAMNR15040 2TCH THE NUMBER OF COMPONENT CARDS, ', I3, '.') 2110 FORMAT (///5X, '*** ERROR MESSAGE *** PLEASE CHECK INPUT DECK. THWNR15080 1E NUMBER OF KV EQUILIBRIUM CONSTANT CARDS, ", I3, ", DOES NOT MATCHMNR15100 2 THE NUMBER OF COMPONENT CARDS, ', I3, '.') MNR 15120 2120 FORMAT (///5X, **** ERROR MESSAGE *** PLEASE CHECK INPUT DECK. YOMNR15140 10 HAVE FAILED TO SUBMIT OR ACCESS VAPOR/LIQUID EQUILIBRIUM DATA. JMNR15160 2130 FORMAT (///5X, **** ERROR MESSAGE *** PLEASE CHECK INPUT DECK. TH4NR15180 1E NUMBER OF COMP FEED CARDS, ', 13, ', DOES NOT MATCH THE NUMBER OFMNR15200 2 COMPONENT CARDS, ', I3, '.') MNR 15220 2135 FORMAT (///5X, **** ERROR MESSAGE *** PLEASE CHECK INPUT DECK. THINR 15240 1E NUMBER OF COMPONENT RATIO CARDS, 1, 13, 1, DOES NOT MATCH THE NUMMAR15260 2BER OF COMPONENT CARDS, ', I3, '.') MNR 15280 2140 FORMAT (//5X, "INPUT PROCESSING COMPLETED - EXECUTION TERMINATED WNR15300 1DUE TO, ', 14, ', INPUT ERROR(S).') MNR 15320 2150 FORMAT (///5X, **** ERROR MESSAGE *** THE DISTILLATE LIQUID AND/DMNR15340 IR THE DISTILLATE VAPOR RATES WERE NOT SPECIFIED FOR A PARTIAL CONDWNR15360 2ENSER. / /27X, 'PLEASE CORRECT INPUT CARDS AND RESUBMIT. /) MNR15380 2160 FORMAT (///5X, **** ERROR MESSAGE *** BOTH FEED TEMPERATURE *. MNR 15400 F7.2, ' AND FRACTION VAPORIZED ', F7.4, ' WERE GIVEN.' 1 MNR15420 /27X, 'RESUBMIT CASE WITH ONLY ONE GIVEN ON THE *FEED CARD." **JMNR15440** 2 С MNR 15460 620 CONTINUE MNR 15480 С MNR15500 ISEC = 2MNR 15520 С MNR15540 IF (IK.NE.1) GO TO 634 MNR15560 С MNR 15580 PRINT 910 MNR15600 С MNR 15620 С MNR15640 CHECK IF KVAL SECTION 2 FILLED IN С MNR15660 С MNR 15680 IF (KVC .EQ. 2) GD TO 633 MNR 15700 С MNR15720 DO 632 J=1.NCOMP MNR 15740 С MNR15760 AA(J+50) = AA(J)MNR 15780 AB(J+50) = AB(J)MNR 15800

INPUT

AB(J+50) = AB(J) AC(J+50) = AC(J)AD(J+50) = AD(J)

MNR15820

MNR15840

```
MNR15860
С
                                                                          MNR 15880
  632 CONTINUE
                                                                          MNR15900
С
  633 CONTINUE
                                                                          MNR 15920
                                                                          MNR15940
С
                                                        .
                                                                          MNR15960
С
  ,
      PHYSICAL PROPERTIES
                                                                          MNR 15980
С
      PRINT SECTION HEADING
                                                                          MNR16000
С
                                                                          MNR16020
      DO 950 I= 1, ISEC
                                                                          MNR 16040
      PRINT 920, I
С
                                                                          MNR16060
                                                                          MNR16080
      PRINT K-VALUE COEFFICIENTS PER SECTION
С
                                                                           MNR 16100
С
      00 940 J=1,NCOMP
                                                                           MNR16120
                                                                           MNR16140
      ISLOT = (I-1)*50+J
С
                                                                           MNR16160
      PRINT 930, J, AA(ISLOT), AB(ISLOT), AC(ISLOT), AD(ISLOT)
                                                                           MNR16180
                                                                           MNR 16200
  940 CONTINUE
                                                                           MNR16220
С
                                                                           MNR 16240
С
                                                  .
                                                                           MNR 16260
  950 CONTINUE
                                                                           MNR16280
С
                                                                           MNR16300
  634 IF ( IK.NE.2 ) GO TO 846
                                                                           MNR 16320
С
                                                                           MNR16340
С
      CURVE-FIT K-DATA
С
                                                                           MNR16360
С
      INITIALIZE
                                                                           MNR16380
                                                                           MNR16400
С
      TLOW = TCF(1) - (TCF(1) * .1)
                                                                           MNR16420
      THIGH = TCF(5) + (TCF(5) * .1)
                                                                           MNR16440
С
                                                                           MNR16460
С
      PRINT HEADING
                                                                           MNR16480
                                                                           MNR16500
С
  830 PRINT 831
                                                                           MNR16520
                                                                           MNR16540
С
      PRINT 832, P(5)
                                                                           MNR16560
                                                                           MNR16580
С
                                                                           MNR 16600
      DO 845 I = 1,NCOMP
                                                                           MNR16620
      DO 840 J = 1.5
      DUMY(J) = (( CFKV(I,J) * PCF(J) ) / (( TCF(J)+460. ) * P(5) ) )
                                                                           MNR16640
     1
                 ** ( 1./3. )
                                                                           MNR 16660
  840 CONTINUE
                                                                           MNR 16680
С
                                                                           MNR16700
      SE = FITIT( TCF, DUMY, 5, 3, COEF, 1, 1, W )
                                                                           MNR16720
С
                                                                           MNR16740
      AA(I) = COEF(2)
                                                                           MNR16760
      AB(I) = COEF(3)
                                                                           MNR16780
      AC(I) = COEF(4)
                                                                           MNR 16800
                                                                           MNR16820
      AD(I) = COEF(5)
      AA(I+50) = AA(I)
                                                                           MNR16840
      AB(I+50) = AB(I)
                                                                           MNR 16860
      AC(I+50) = AC(I)
                                                                           MNR16880
      AD(I+50) = AD(I)
                                                                           MNR16900
```

	XKLOW = (TLOW + 460.) * (AA(I) + TLOW * (AB(I) + TLOW * (MNR16
1	AC(I) + TLOW * AD(I)))) ** 3		MNR16
	XKHIGH = (THIGH + 460.) * (AA(I) + THIGH * (AB(I) + THIGH		MNR16
1	* { AC(I) + THIGH * AD(I))) ** 3		MNR 16
	DO = 843 LL = 1,5		MNR17
	XK(LL) = (TCF(LL) + 460.) * (AA(I) + TCF(LL) * (AB(I) +		MNR 17
1	TCF(LL) * (AC(I) + TCF(LL) * AD(I)))) ** 3		MNR 17
843	CONTINUE		MNR17
			MNR 1
	PRINT 842, I, AA(I), AB(I), AC(I), AD(I), SE, TLOW, XKLOW,		MNR1
1	(TCF(KK), XK(KK), KK = 1,5), THIGH, XKHIGH		MNR17
			MNR 1
845	CONTINUE .		MNR1
	KSEC = 1		MNR1
846	CONTINUE		MNR1
2 A			MNR1
640	CONTINUE		MNRI
			MNR1
	CALCULATE STAGE PRESSURES		MNR1
			MNR1
	P(1) = P(5) + (ISTAGE-1) + DELP		MNR 1
	P(2) = P(5) + (ISTAGE-2) * DELP		MNR1
	P(3) = P(5) + (ISTAGE-NFSTG) + DELP		MNR 1
	P(4) = P(5) + (ISTAGE- (NFSTG+1)) * DELP		MNR1
	P(6) = P(5) - DELPC		MNR 1
	FP = P(3)		MNR1
			MNR1
	DEFAULTS		MNR 1
			MNR1
	NITER = KODE(1)		MNR1
	IF (NITER.EQ.0) NITER = 10	÷.,	MNR 1
	IF (KODE(3).EQ.0) KODE(3) = 20		MNR 1
			MNR1
	CONDENSER FLOWS AND DSPEC		MNR 1
			MNR1
	IF ($ICON_{\bullet}EQ_{\bullet}O$) $ICON = 1$		MNR1
	CD TD ((50 (70 (60)))))		MNR1
	GO TO (650,670,660), ICON		MNR1
•	LIQUID DISTILLATE		MNR1
	LIQUID DISTILLATE		MNR1
	DL = DSPEC		MNR1
000	DV = 0.0		MNR1
	GO TO 680		MNR1
			MNR 1
•	VAPOR DISTILLATE		MNR1
	TAFUN DIJILLAIL		MNRI
	DL = 0.0		MNR1
000	DV = DSPEC		MNR1
	GO TO 680		- MNR1
		e el	MNRI
•			

			r,
		v INPUT	,
67		DL.NE.0.0.AND.DV.NE.0.0) GO TO 675	MNR17980
сŬ			MNR18000
č	INPUT	ERROR	MNR 18020
C C			MNR 18040
-	PRINT	2150	MNR18060
	KERRO	R = KERROR + 1	MNR 18080
	GO TO	612	MNR18100
С			MNR18120
6	75 DVD =	DL + DV	MNR18140
	DL = 1	DL * DSPEC / DVD	MNR18160
	DV = I	DV * DSPEC / DVD	MNR18180
С			MNR 18200
68	BO CONTI	NUE	MNR18220
	BFLOW	= FFLOW - DSPEC	MNR 18240
	DO 68	1 I = 1, NCOMP	MNR 18260
	FTOTI	I) = (FTOT(I)/FTF)*FFLOW	MNR 18280
	31 CONTI		MNR 18300
61	B6 FRVAP	= FVTOT / (FVTOT + FLTOT)	MNR18320
С			MNR 18340
С		· · · · · · · · · · · · · · · · · · ·	MNR 18360
	DO 68	7 I=1,NCOMP	MNR 18380
С			MNR 18400
		FVTOT .EQ. 0.0) GO TO 1380	MNR 18420
		= (FV(I)/FTF)*FFLOW	MNR18440
138		FLTOT .EQ. 0.0) GO TO 687	MNR 18460
		= (FL(I)/FTF)*FFLOW	MNR18480
		I) = FL(I)/FTOT(I)	MNR 18500
_	VFFX(I) = FV(I)/FTOT(I)	MNR 18520
с с			MNR18540
С		·	MNR 18560
C			MNR18580
	B7 CONTI	NUE	MNR18600
С			MNR18620
-	GO TO		MNR18640

```
С
  687 CONTINUE
С
      GO TO 689
      CALL TO FFLASH REPLACED BY A CONTINUE. USE LATER IF NEEDED.
С
  688 CONTINUE
С
С
  689 IF ( ID.EQ.1 ) GO TO 690
С
      PRINT SUMMARY OF INPUT
С
С
      PRINT 1000
С
      PRINT 1010, ISTAGE, ISEC, R
```

С

С С

С

С

С

С

С

С

С

```
С
                                                                            MNR18880
      PRINT 1020, (FNAME(I), I=1,3), NFSTG
                                                                            MNR18900
С
                                                                             MNR18920
      PRINT 1030
                                                                             MNR18940
С
                                                                             MNR18960
      IS = 1
                                                                             MNR18980
      PRINT 1040, DSPEC, IS, BFLOW
                                                                             MNR19000
С
                                                                             MNR 19020
```

87

MNR18660

MNR 18680

MNR18700

MNR18720

MNR 18740

MNR18760

MNR18780

MNR18800

MNR18820

MNR18840

MNR18860

INPUT INPUT PRINT 1050, P(5), DELPC, DELP, DELP MNR 19040 . MNR19060 С С MNR 19080 PRINT 1070 () NS(1) = 110 NS(2) = 2 MNR 19100 С MNR19120 MNR19140 MNR 19160 NS(3) = NFSTGMNR19180 NS(4) = (NF.STG, + (1 + 1)) MNR 19200 NS(5) = ISTAGE MNR19220 **C** ::: MNR 19240 00 1100 I=1,5 MNR19260 PRINT 1080, NS(I), T(I), P(I), LV(I) MNR19280 1100 CONTINUE MNR 19300 PRINT 1105, T(6), P(6) as a f MNR19320 PRINT 1120, (K, VFB(K), LFD(K), K = 1, NCOMP) MNR 19340 PRINT 1120, (K, VFB(K), LFD(K), K = 1,NCOMP) 1120 FORMAT (//5X, COMPOSITION RATIOS -', //10X, COMPONENT NO. SECUNR19360 1TION ND.1 SECTION NO.2', 50(/12X, 14, 7X, 2(2X, E15.8))) MNR 19380 C MNR 19400 С MNR19420 PRINT SUMMARY OF FEED STREAMS С MNR19440 C MNR 19460 690 PRINT 1240 WE BY TO PREM MNR19480 С MNR19500 PRINT STREAM DATA С MNR 19520 С MNR 19540 PRINT 1270, (FNAME(I), I=1,3), FFLOW, FP MNR 19560 С MNR 19580 PRINT 1280, FT, ENTH, FRVAP MNR19600 С MNR 19620 С MNR 19640 **PRINT 1370** MNR19660 **PRINT 1310** MNR 19680 DO 1400 I=1,NCOMP MNR 19700 С MNR 19720 PRINT 1330, I, (CMPNAM(J,I), J=1,3), FTOT(1), FV(I), FL(I) MNR19740 C MNR 19760 1400 CONTINUE CALL MINR MNR 19780 MNR 19800 STOP - Constraints of the second second MNR19820 С MNR19840 1500 RETURN MNR 19860 С MNR19880 BASE CASE INPUT FORMATS С MNR 19900 С MNR19920 831 FORMAT (1H1, 4X, 'PHYSICAL PROPERTIES', /, 5X, 19('-'), MNR19940 /,/, 5X, 'K-VALUE COEFFICIENTS (K/T)**1/3',' = A + BT + ', 1 MNR 19960 !CT**2 + DT**3!, /) 2 MNR 19980 832 FORMAT & 5X, CURVE-FIT K-DATA FOR BOTH SECTIONS AT TOP STAGE REFEMENZOODO IRENCE PRESSURE OF ', F6.1, ' PSIA', /, MNR 20020 10X, "ASSUME P*K = CONSTANT', //, 2 MNR 20040 10X, 'K-VALUES ARE TABULATED AT REFERENCE PRESSURE',/////MNR 20060 3 842 FORMAT (////10X, 'COMPONENT NO.', I3, //, MNR 20080

	INPUT	
1	15X, 'CURVE-FIT COEFFICIENTS', /, 20X, 'A = ', E15.8, /,	MNR 20100
2	20X, 'B = ', E15.8, /,20X, 'C = ', E15.8, /,20X, 'D = ',	MNR 20120
3	E15.8, /,20X, 'STANDARD ERROR OF THE COEFFICIENTS = ',	MNR 20140
4	E10.4, //,15X, 'TEMP (DEG.F) K (CALC)', //, 30(17X,	MNR 20160
5	F7.2, 9X, F9.4, /) , ////)	MNR 20180
910 FORMAT	(1H1, 4X, 'PHYSICAL PROPERTIES', /5X, 19('-'),//5X,	MNR 20200
	LUE COEFFICIENTS (K/T) **1/3 = A + BT + CT**2 + DT**3', /	
920 FORMAT	(/10X, 'SECTION = ', I4, //15X, 'COMPONENT NO.',10X, 'A ',	
1	18X, 'B ', 18X, 'C ', 18X, 'D ', /)	MNR 20260
	(17X, 14, 2X, 4(2X,E18.8))	MNR 20280
	(1H1, 4X, 'SUMMARY OF BASE CASE INPUT', /5X, 26('-'))	MNR 20300
	(//5X, 'GENERAL -', //10X, 'NUMBER OF STAGES = ', I5	
1	/10X, 'NUMBER OF SECTIONS = ', I5, /10X,	MNR 20340
2	<pre>'REFLUX RATIO = ', F10.5)</pre>	MNR 20360
		MNR 20380
1	/13X, 4(1-1), 9X, 12(1-1), //10X, 3A4, 6X, 15)	MNR 20400
	<pre>(//5X, 'PRODUCTS -', //13X, 'NAME', 9X, 'STAGE NUMBER', 9X, 'RATE (MPH)', /13X, 4('-'), 9X, 12('-'), 9X, 10('-')</pre>	
1 1040 EDDMAT	/29X, 'CUND', 13X, F10.5, /, 29X, 14, 13X, F10.5)	MNR 20440
	(//5X, 'PRESSURE DROPS -', //10X,	MNR 20480
1000 T UKMAT	'PRESSURE OF THE TOP STAGE = ', F12.5, ' PSIA',/10X	- MNR 20500
2	'PRESSURE DROP ACROSS CONDENSER = ', F12.5, ' PSI', /10X	MNR 20520
3	'PRESSURE DROP ACROSS EACH TRAY = ', F12.5, ' PSI', /10X	
4	'PRESSURE DROP ACROSS REBOILER = ', F12.5, ' PSI')	
1070 FURMAT		MNR 20580
1	'PROFILES -', //10X, 'STAGE NUMBER TEMPERATURE', 7X,	MNR 20600
2	PRESSURE L/V', /)	MNR 20620
1080 FORMAT	<pre>(/12X, I4, 4X, 3(4X,F12.5))</pre>	MNR 20640
	(/12X, 'COND', 4X, 2(4X,F12.5))	MNR20660
1240 FORMAT	(1H1, 4X, 'SUMMARY OF FEED STREAMS', /5X, 23('-	MNR 20680
1),		MNR 20700
	(10X, 'STREAM NAME', 20X, 3A4, //10X, 'FLOW RATE', 20X,	MNR 20720
1	F12.4, //10X, 'PRESSURE (PSIA)', 14X, F12.4)	MNR 20740
	(/10X, 'TEMPERATURE (DEG.F)', 10X, F12.4, //10X,	MNR 20760
1	'ENTHALPY (MBTU/MOL)', 10X, F12.4, //10X,	MNR 20780
2	'FRACTION VAPORIZED', 11X, F12.4)	MNR 20800
	//10X, 'UNNORMALIZED COMPOSITIONS :')	MNR 20820
1510 FURMAT	<pre>(/10X, 'NO. NAME', 22X, 'TOTAL', 17X, 'VAPOR', 17X, 'LIQUID', /)</pre>	MNR 20840 MNR 20860
_	(8X, I4, 4X, 3A4, 3X, 3(2X,F20.4))	MNR 20880
	(//IOX, 'NORMALIZED COMPOSITIONS :', /)	MNR 20900
C	t from toneteed compositons t y y	MNR 20920
END		MNR 20940

OPTIONS IN EFFECT ID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP *OPTIONS IN EFFECT* NAME = INPUT , LINECNT = 55 *STATISTICS* SOURCE STATEMENTS = 440,PROGRAM SIZE = 17468 *STATISTICS* NO DIAGNOSTICS GENERATED PROGRAM 5. EVALUATION OF THE POLYNOMIAL TO CALCULATE K VALUES

50	BROUTINE KVAL				MNR 209
c o	MMON /KVALUE/	ΔΚ(50).	DK(50),	UDK (50)	MNR 210
			0	000000	MNR 210
C O	MMON / SHRT				MNR 21 C
A	AA(100).	AB(100),	AC(100).	AD(100).	MNR 210
В	8(50).	BDI(50),	BFLOW.	BN(50).	MNR 210
č	D(50).	DCALC.	DC ON.	DELBAR(100),	MNR 211
Ð	DELF(100),	DL,	DLS(50),	DLST,	MNR 211
E	DN(50),	DSPEC,	DV,	DVS,	MNR 211
F	DVX(50),	DVXT,	ENTH,	ER,	4NR 211
G	FACT(100),	FEND(50,6),	FFLOW,	FL(50),	MNR 21 1
Ĥ	FLTOT,	FMAXA,	FMAXS.	FMINA,	MNR 21 2
I	FMINS,	FP,	FRVAP,	FT,	MNR 212
Ĵ	FTOT(50),	FV(50),	FVTOT,	ICON,	MNR 212
ĸ	TD,	IP,	ISEC,	MTRY,	MNR212
Ĺ	ISTAGE,	KODE(10),	KSEC,	LFD(50),	
M	LFFX(50),	LV(6),	NABSR,	NCOMP,	MNR212
N	NFSTG.	NITER,	NS(5)	· · · ·	MNR 21
	P(6),	R.	S2(50),	NSTRP, S3(50),	MNR 213
P	S4(50),	\$5(50),			MNR 213
Г Q	VFB(50),		T(6),	THETA,	4NR 213
-			ITRY, IHK,	ĨLK	MNR 21 2
PC	= P(5) / PK	•			MNR 214
) + 50			MNR 214
l l	= (KSEC - 1	1 * 50			MNR214
ТА	- TK + 440	0			MNR 214
1 4	= TK + 460.	0			MNR21
DO	500 I = 1	NCOMP			MNR 21
		, NCOMP			MNR 21
КК	= JJ + I				MNR21
	AL HATE DOL VNO		1.050		MNR 21
ΕV	ALUATE PULTNU	MIAL AND DERIVAT	IVES		MNR 21
		TUATECTURE - TUA			MNR 21
		TK*(AB(KK) + TK*	· · · · · · · ·	[KK] * [K] }	MNR 21
		TK*(2.*AC(KK)+ T	K#3.#AU(KK))		MNR 21
່ຍປ	F = 2.*AU(KK)	+ 6.0*AD(KK)*TK			MNR21
					MNR 21
EV	ALUATE K (AT	CORRECT PRESSURE	AND DERIVAT	IVES	MNR 21
		· · · · · · · · · · · · · · · · · · ·			MNR21
	$(I) = TA \neq F$				MNR21
		()*(FCN + 3.0*TA*			MNR21
DD	K(I) = 3.0 * FCN	I*(FCN*(DFN + TA*	DDF) + 2.0*T/	*(DFN**2)) * PC	MNR21
					MNR 21
00 CC	NTINUE				MNR21
					MNR 21
RE	TURN				MNR 21
					MNR21
	D				MNR 21

.

KVAL

OPTIONS IN EFFECT ID, EBCDIC, SOURCE, NOLIST, NODECK, LOAD, NOMAP *OPTIONS IN EFFECT* NAME = KVAL , LINECNT = 55 *STATISTICS* SOURCE STATEMENTS = 17, PROGRAM SIZE = 720 *STATISTICS* NO DIAGNOSTICS GENERATED

					93
		RAM 6. EVALUATION ATIONS (5-6), (5-14			
	SUBROUTINE LINEAR	(XNM. LOCA. TO	AMP 1		MNR 21920
С	JUN JOINT CHIER	MNR21940			
č	ADAPTED FROM DELF	MNR 21960			
č	KSEC = 1, STRIPPI	MNR 21980			
č	KSEC= 2, RECTIFYI	MNR22000			
С					MNR 22020
С					MNR 22040
	COMMON / LINMIN /	SLFD, SVFB			MNR 22060
С			MNR 22080		
	DIMENSION SLFD(5	MNR 22100			
С					MNR 22120
	COMMON / SHRTCT				MNR 22140
	Α ΑΑ(100),	AB(100),	AC(100),	AD(100),	MNR 22160
	B B(50),	BDI(50),	BFLOW,	BN(50),	MNR 22180
	C D(50),	DCALC,	DCON,	DELBAR(100),	MNR 22200
	D DELF(100),	DL,	DLS(50),	DLST,	MNR 22220 MNR 22240
	E DN(50), F DVX(50),	D SPEC , D V XT ,	DV, ENTH,	DVS, ER,	MNR 22240
	F DVX(50), G FACT(100),	FEND(50,6),	FFLOW,	FL(50),	MNR 22280
	H FLTOT,	FMAXA,	FMAXS,	FMINA.	MNR 22300
	I FMINS,	FP,	FRVAP,	FT.	MNR 22320
	J FTOT(50),	FV(50),	FVTOT,	ICON,	MNR 22340
	K ID.	IP,	ISEC,	MTRY,	MNR 22360
	L ISTAGE,	KODE(10),	KSEC,	LFD(50),	MNR22380
	M LFFX(50),	LV(6),	NABSR,	NCOMP,	MNR 22400
	N NESTG,	NITER,	NS(5),	NSTRP,	MNR 22420
	D P(6),	R,	S2(50),	\$3(50),	MNR 22440
	P \$4(50),	S5(50),	Τ(6),	THET A,	MNR 22460
	Q VFB(50),	VFFX(50), N	TRY, IHK,	ILK	MNR22480
С					MNR 22500
	REAL LFD				MNR 22520
С		MNR22540			
С	KSEC = 1 STRIPP	MNR 22560			
C	KSEC = 2 RECTIF	MNR 22580			
С. С.		MNR 22600 MNR 22620			
U	GO TO (10, 20),	MNR 22640			
С	90 10 (1 0) 20 77	NJC0	·		MNR 22660
č	STRIPPING SECTION	1			MNR 22680
č		*			MNR 22700
•	10 LU = 2				MNR 22720
	LL = 3			•	MNR 22740
С					MNR22760
	GO TO 30				MNR 22780
С		MNR 22800			
С	RECTIFYING SECTIO	IN			MNR 22820
С					MNR 22840
	20 LU = 5				MNR 22860 MNR 22880
~	LL = 4				MNR 22880 MNR 22900
C	TEST FOR COMPONEN	MNR 22900 MNR 22920			
С С	IESI FUK CUMPUNEN	MNR 22940			
ι L	30 IF (ICOMP.EQ.0)	GO TO 32			MNR 22960
	20 II 1 10000 80 40 1				

LINEAR

```
MNR22980
С
      GD TO ( 101, 102, 103, 104 ), LOCA
                                                                             MNR 23000
                                                                             MNR23020
С
  101 II = ICOMP
                                                                             MNR23040
                                                                             MNR 23060
      I2 = ICDMP
                                                                             MNR23080
      GO TO 34
                                                                             MNR 23100
С
                                                                             MNR 23120
  102 GO TO 101
                                                                             MNR23140
С
                                                                             MNR 23160
  103 I1 = 1
      I2 = ICOMP
                                                                             MNR 23180
                                                                             MNR23200
      GO TO 34
                                                                             MNR 23220
С
                                                       .
                                                                             MNR23240
  104 II = ICOMP
                                                                             MNR 23260
      I2 = NCOMP
      GO TO 34
                                                                             MNR 23280
С
                                                                             MNR 23300
                                                                             MNR 23320
   32 I1 = 1
                                                                             MNR 23340
       I2 = NCDMP
С
                                                                             MNR 23360
                                                                             MNR 23380
   34 \text{ DO } 100 \text{ I} = \text{I1},\text{I2}
                                                                             MNR23400
С
       INITIALIZE LINEAR MODEL
                                                                              MNR23420
С
                                                                              MNR 23440
С
       IF([ LOCA .EQ. 3 ] .OR. ( LOCA .EQ. 4 )) GO TO 35
                                                                              MNR23460
                                                                              MNR 23480
С
       INITIALIZE FOR LOCA = 1 OR 2. THIS IS USED FOR THE DISTRIBUTED
С
                                                                              MNR 23500
       COMPONENTS AND GENERATES THE SERIES FROM THE COMPONENT FACTORS
                                                                              MNR23520
С
                                                                              MNR 23540
С
                                                                              MNR23560
С
       ASA = FEND(I.LL)
                                                                              MNR23580
       DEL = (FEND(I,LU) - ASA) / XNM
                                                                              MNR 23600
       GO TO 36
                                                                              MNR23620
                                                                              MNR 23640
С
       INITIALIZE FOR LOCA = 3 OR 4. THIS IS USED FOR THE SEPARATED
                                                                              MNR 23660
С
       COMPONENTS AND REQUIRES THE RECIPROCAL OF THE COMPONENT FACTORS
С
                                                                              MNR23680
                                                                              MNR 23700
С
С
                                                                              MNR 23720
    35 ASA = 1. / FEND(I,LL)
                                                                              MNR23740
       DEL = ((1. / FEND(I,LU)) - ASA) / XNM
                                                                              MNR 23760
С
                                                                              MNR23780
       INITIALIZE FOR LOCA = 1 OR 2 OR 3 OR 4
C
                                                                              MNR23800
                                                                              MNR23820
С
    36 CSA = ASA
                                                                              MNR23840
       FLSA = ASA
                                                                              MNR 23860
                                                                              MNR 23880
       IDO = IFIX (XNM)
                                                                              MNR23900
С
       CALCULATE FACTORS, PRODUCTS, AND SUMS FOR TRUNCATED INTERGER
С
                                                                              MNR 23920
       NUMBER OF TRAYS
                                                                              MNR 23940
C
С
                                                                             MNR 23960
       IF ( IDO .LE. 0 ) GO TO 42
                                                                              MNR 23980
                                                                            1 MNR 24000
С
       DO \ 40 \ J = 1, IDO
                                                                              MNR 24020
```

```
FLSA = FLSA + DEL
                                                                               MNR 24040
      ASA = ASA * FLSA
                                                                                MNR 24060
      CSA = CSA + ASA
                                                                                MNR 24080
   40 CONTINUE
                                                                                MNR 24100
С
                                                                                MNR 24120
С
                                                                                MNR 24140
С
      CALCULATED FACTURS, PRODUCTS, AND SUMS FOR NEXT INTERGER
                                                                                MNR24160
C.
      NUMBER OF TRAYS
                                                                                MNR 24180
С
                                                                                MNR24200
   42 FLSA = FLSA + DEL
                                                                                MNR 24220
      ASA1 = ASA * FLSA
                                                                                MNR 24240
      CSA1 = CSA + ASA1
                                                                                MNR 24260
С
                                                                                MNR 24280
   44 CONTINUE
                                                                                MNR24300
С
                                                                                MNR 24320
С
                                                                                MNR24340
C
      BRANCH PER LOCA
                                                                                MNR24360
С
                                                                                MNR 24380
      GO TO ( 1000, 2000, 3000, 4000 ), LOCA
                                                                                MNR24400
С
                                                                                MNR24420
      CALCULATE. RATIOS ON FEED TRAY FROM RATIOS AT STRIPPING PINCH ZONE MNR 24440
С
C
                                                                                MNR24460
 1000 IF ( 100 ) 1010, 1010, 1020
                                                                                MNR24480
C
                                                                                MNR 24500
 1010 \text{ FN} = \text{SVFB(I)}
                                                                                MNR24520
      GO TO 1030
                                                                                MNR 24540
 1020 \text{ FN} = \text{ASA} * \text{SVFB(I)} + \text{CSA}
                                                                                MNR 24560
 1030 F1 = ASA1 \neq SVEB(I) + CSA1
                                                                                MNR24580
      RI00 = ID0
                                                                                MNR 24600
       VFB(I) = FN + (FI - FN) * (XNM - RIDO)
                                                                                MNR24620
С
                                                                                MNR 24640
С
                                                                                MNR 24660
      GO TO 100
                                                                                MNR24680
С
                                                                                MNR 24700
      CALCULATE RATIOS ON TRAY ABOVE FEED FROM RATIOS AT RECTIFYING
С
                                                                                MNR 24720
С
      PINCH ZONE
                                                                                MNR 24740
С
                                                                                MNR 24760
 2000 IF ( 100 ) 2010, 2010, 2020
                                                                                MNR24780
 2010 \text{ FN} = \text{SLFD}(I)
                                                                                MNR 24800
      GO TO 2030
                                                                                MNR 24820
 2020 \text{ FN} = \text{ASA} \times \text{SLFD(I)} + \text{CSA}
                                                                                MNR24840
 2030 = 1 = ASA1 * SLED(I) + CSA1
                                                                                MNR 24860
      RIDO = IDO
                                                                                MNR 24880
      LFD(I) = FN + (F1 - FN) * (XNM - RIDO)
                                                                                MNR24900
С
                                                                                MNR 24920
С
                                                                                MNR24940
      GO TO 100
                                                                                MNR24960
С
                                                                                MNR 24980
      CALCULATE FLOW OF LIGHT SEPARATED COMPONENTS AT STRIPPING PINCH
С
                                                                                MNR25000
С
                                                                                MNR 25020
 3000 IF ( IDD ) 3010, 3010, 3020
                                                                                MNR 25040
С
                                                                                MNR25060
 3010 \text{ FN} = S3(I)
                                                                                MNR 25080
```

	LINEAR	
	GO TO 3030	MNR 25100
3020	FN = ASA * S3(I)	MNR 25120
	F1 = ASA1 * S3(I)	MNR 25140
	RIDO = IDO	MNR 25160
	S2(I) = FN + (F1 - FN) * (XNM - RIDO)	MNR 25180
С		MNR 25200
С		MNR 25220
	GO TO 100	MNR 25240
С		MNR 25260
С	CALCULATE FLOW OF HEAVY SEPARATED COMPONENTS AT RECTIFYING PINCH	MNR 25280
С		MNR 25300
4000	IF (IDD) 4010, 4010, 4020	MNR 25320
С		MNR 25340
4010	FN = S4(I)	MNR 25360
	GO TO 4030	MNR 25380
4020		MNR 25400
4030	F1 = ASA1 + S4(I)	MNR 25420
	RIDO = IDO	MNR 25440
	S5(I) = FN + (F1 - FN) * (XNM - RIDD)	MNR25460
c		MNR 25480
С		MNR 25500
	CONTINUE	MNR 25520
С		MNR 25540
<u> </u>	RETURN	MNR 25560
C		MNR 25580
С		MNR 25600
	END	MNR 25620

LINEAR

OPTIONS IN EFFECT ID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP *OPTIONS IN EFFECT* NAME = LINEAR , LINECNT = 55 *STATISTICS* SDURCE STATEMENTS = 80,PROGRAM SIZE = 1906 *STATISTICS* NO DIAGNOSTICS GENERATED

PROGRAM 7. MINIMUM REFLUX CALCULATIONS

	SUB	ROUTINE MINR				MNR 25640
С	6.01			,		MNR 25660 MNR 25680
~	U™	MON / LINMIN /	SLFD, SVFB			MNR 25700
C	COM	IMON / FNSKOP /	IREF,	REFRCL,		MNR25720
	1	REFRCH,	DEST,	REFRULY		MNR 25740
	2	LRSTAR,	FNAME (3),	DUMDUM(100)		MNR 25760
С	2	LNDIANI	I AMALIJIY	0000000000		MNR 25780
L	COV	MON /KVALUE/ A	K(50).	DK(50),	DDK (50)	MNR-25800
С	CU.	MUN / NALUL/ 4		01(1)011		MNR 25820
C	COM	MON / SHRTCT	1			MNR 25840
	A	AA(100).	AB(100).	AC(100),	AD(100),	MNR 25860
	в	B(50),	BDI(50),	BFLOW,	BN(50),	MNR 25880
	Ĉ	D(50),	DCALC.	DCON,	DEL BAR (100),	MNR 25900
	D	DELF(100),	DL,	DLS(50),	DLST,	MNR 25920
	E	DN(50),	DSPEC,	DV,	DVS,	MNR25940
	F	DVX(50),	DVXT,	ENTH,	ER,	MNR 25960
	G	FACT(100),	FEND(50,6),	FFLOW,	FL(50),	MNR 25980
	Н	FLTOT,	FMAXA,	FMAXS,	FMINA,	MNR 26000
	I	FMINS,	FP,	FRVAP,	FT,	MNR 26020
	J	FTOT(50),	FV(50),	FVTOT,	ICON,	MNR 26040
	ĸ	ID,	IP,	ISEC,	MTRY +	MNR 26060
	L	ISTAGE,	KODE(10),	KSEC,	LFD(50),	MNR 26080
	M	LFFX(50),	LV(6),	NABSR,	NCOMP.	MNR 26100
	N	NFSTG,	NITER,	NS(5),	NSTRP,	MNR 26120
	0	P(6),	R,	S2(50),	S3(50),	MNR 26140
	Р	S4(50),	S5(50),	T(6),	THETA,	MNR 26160
	Q	VFB(50),	VFFX(50),	NTRY, IHK,	ILK	MNP 26180
С						MNR26200
					AAHK(50),SALK(50)	MNR 26220
	RE4			,KSSTAR,KSTAR,	LFD,LFFX,LV,MULT,	MNR26240
	1	LEDTRY, LESTR	1,LRSTR2			MNR 26260
С						MNR26280
	77 CO!	NTINUE				MNR 26300
С						MNR 26320
С						MNR 26340
С		ITIALIZE TEMPER	ATURES			MNR 26360
		10 I = 1.6				MNR 26380
-	10 TE	$MP(\mathbf{I}) = T(\mathbf{I})$				MNR 2h 400
C						MNR 26420
C				IND BID'S FUR L	IGHT AND HEAVY KEY	MNR 26440
		CL = REFRCL / 1				MNR 20460
		CH = REFRCH /]				MNR 26480
	80	I(ILK) = (1.0)		·L		MNR 26500
~	80	I(IHK) = FRCH	11.0 - rRCH	3		MNR 26520
C	с. с.	T COUNTED C EDD	NUMBER OF ITCO	ATTONE TTOV T	S FOR ITERATIONS AT	MNR 26540
C C					TERATIONS ON LESTAR.	
C			LEGIAN. JLK U	NUM TO TOK T	TERHILUNG DA LESTAR.	
	-	RY = 0 $RY = 1$				MNR 26600 MNR 26620
		K = 0				MNR 26640
		K = 0				MNR 26660
С	3 11					MNR 26680
U						ONE ZOUGU

MNR27740

MNR 26700 STGM = 5. MNR26720 STGN = 5. MNR 26740 С MNR 26760 IF (DEST) 110,110,120 MNR26780 С CALCULATE DEFAULT ESTIMATE ON DISTILLATE ASSUMING IDEAL SPLIT OF MNR 26800 С LIGHTER THAN LIGHT KEY AND SPECIFIED SPLIT OF LIGHT AND HEAVY KEY MNR 26820 С MNR26840 C MNR 26860 110 ID0 = ILK - 1MNR26880 DEST = 0.0MNR 26900 00 115 I=1,ID0 MNR 26920 DEST = DEST + FTOT(I)MNR 26940 115 CONTINUE MNR 26960 IDO = IHK - 1MNR26980 DO 116 I=ILK,IDO MNR27000 116 DEST = DEST + (FTOT(I) * FRCL) DEST = DEST + FTOT(IHK) * (1.0 - FRCH) MNR 27020 MNR 27040 120 IF (LRSTAR .GT. 0.) GO TO 200 MNR27060 С INITIAL DEFAULT ESTIMATE ON LESTAR IS TO ASSUME A TYPE ONE SYSTEM MNR27080 С IN TOP AND BOTTOM AND USE UNDERWOOD EQUATION METHOD NOT PRESENTLY MNR27100 С MNR 27120 PROGRAMMED С MNR 27140 С MNR 27160 STOP MNR 27180 200 CONTINUE THIS IS RETURN POINT FOR MAJOR EXTERNAL LOOP. MNR 27200 C MNR27220 ITRY = ITRY + 1MNR 27240 ICONV = 0MNR 27260 С MNR 27280 С CALCULATE INTERNAL FLOW RATES AND L/V RATIOS FOR LOCATIONS 2 TO 5 MNR 27300 С MNR 27320 С MNR 27340 С MNR 27360 VRSTAR = LRSTAR + DESTMNR 27380 LSSTAR = LRSTAR + FLTOTVSSTAR = VRSTAR - FVTOT MNR 27400 BEST = FFLOW - DEST MNR 27420 MNR 27440 С С MNR 27460 MNR27480 LVRAT(5) = LRSTAR / VRSTARMNR 27500 LVRAT(4) = LVRAT(5)LVRAT(2) = LSSTAR / VSSTARMNR 27520 MNR27540 LVRAT(3) = LVRAT(2)MNR 27560 С INITIAL DEFAULT ESTIMATE ON STAR TEMPERATURES BY ASSUMING FACTORS MNR27580 С MNR27600 C. EQUAL 0.9 FOR LIGHT AND HEAVY KEY. 300 IF (TEMP(2) .NE. 0. .AND. TEMP(5) .NE. 0.) GO TO 400 MNR27620 310 KRSTAR = LVRAT(5) / 0.9MNR27640 KSSTAR = LVRAT(2) * 0.9MNR 27660 MNR 27680 TSTART = FTMNR27700 KKEY = 1KSTAR = KSSTARMNR 27720

MINR

IK = ILK

.

MINR

2		EVALUATE POLYNOMIAL AND DERIVATIVES	MNR 2776
5			MNR 2778
	320	DD 330 I=1,50	MNR 2780
		FCN = AA(IK) + TSTART * (AB(IK) + TSTART * (AC(IK) + AD(IK) *	MNR2782
		TSTART))	MNR 2784
		DFN = AB(IK) + TSTART * (2.*AC(IK) + TSTART * 3. * AD(IK))	MNR2786
		FFT = ((TSTART + 460.) * FCN **3) - KSTAR	MNR 2788
		DFFT = (FCN ** 2) * (FCN + 3.0 * (TSTART + 460.) * DFN)	MNR 2790
		IF (ABS (FFT) .LT. 1.0 E-04) GO TO 340	MNR 2792
		TSTART = TSTART - (FFT / DFFT)	MNR 2794
	220	CONTINUE	MNR 2796
	550	PRINT 335	MNR2798
	225	FORMAT ('0',5X, **** NEWTON''S METHOD FAILED TO GENERATE A NEW TE	
		PERATURE IN 50 ITERATIONS. *****)	4NR 2802
	1	STOP	4NR 2804
	240		MNR 2806
		GO TO (350,360), KKEY TEMP(2) = TSTART	MNR2808
		TSTART = FT	MNR 2810
			MNR 2812
		KKEY = 2	
		KSTAR = KRSTAR	MNR 2814
		IK = IHK	MNR 281
			MNR 281
~	360	TEMP(5) = TSTART	MNR 282
Ç			MNR 282
C			MNR282
C		CALCULATE ABSORPTION AND STRIPPING FACTORS FOR ALL COMPONENTS AT	
C		KEY LOCATIONS	MNR282
С			MNR 283
	400	J_0 410 J=2,5	MNR 283
		00 409 I=1,NCOMP	MNR 283
		FCN = AA(I) + TEMP(J) * (AB(I) + TEMP(J) * (AC(I) + AD(I) *	MNR 283
	1	TEMP(J))	MNR 283
		$A = \{FCN ** 3\} * (TEMP(J) + 460.\}$	MNR 284
		$IF(J \in Q \cdot 2 \cdot DR \cdot J \in Q \cdot 3) FEND(I,J) = A / LVRAT(J)$	MNR 284
		$IF(J \cdot EQ \cdot 4 \cdot OR \cdot J \cdot EQ \cdot 5) FEND(I \cdot J) = LVRAT(J) / A$	MNR 284
С			MNR 284
С			MNR 284
С			MNR 285
	409	CONTINUE	MNR 285
	410	CONTINUE	MNR285
С			MNR 285
C		CALCULATE TYPE OF SEPARATION IN TOP AND BOTTOM SECTIONS	MNR 285
Ċ			MNR286
С			MNR 286
С		START WITH FIRST COMPONENT HEAVIER THAN HEAVY KEY AND CHECK IF	MNR 286
С		ABSORPTION FACTOR AT TOP PINCH IS GREATER THAN ONE.IF NOT CONTINU	
C		THROUGH HEAVY COMPONENTS. FIRST COMPONENT WITH ABSORPTION FACTOR	MNR 286
Ċ		GREATER THAN ONE SETS INDEX FOR HEAVY SEPARATED COMPONENTS AND	MNR287
Ĉ		SETS TOP SECTION AS TYPE TWO. IF ALL COMPONENTS HAVE ABSORPTION	MNR 287
č		FACTORS LESS THAN ONE THE TOP IS TYPE ONE.	MNR 287
-		IDD = IHK + 1	MNR 287
		DO 440 I=IDO,NCOMP	MNR 287
		IF (FEND(I,5) .LE. 1.0) GO TO 440	MNR 288
		and a construction of all the statements and and the statement of the statements o	

		MINR		
		ITR = 2		MNR 28820
		IHS = I		MNR 28 840
~		1113 ~ 1		MNR 28860
С		IF (STGN) 432, 432, 450		MNR 28880
	1.22	2 STGN = 5.0		MNR 28900
	4 22	$\frac{1}{60}$		MNR 28920
		D CONTINUE		MNR 28940
	440	STGN = 0.0		MNR 28960
	1.1.7	2 ITR = 1		MNR28980
	446	IHS = NCOMP + 1		MNR 29000
		D CONTINUE		MNR 29020
с	490	START WITH FIRST COMPONENT LIGHTER THAN LIGHT KEY A		MNR 29040
ĉ		STRIPPING FACTOR AT BOTTOM PINCH IS GREATER THAN ON	TE NOT	MNR 29060
č		CONTINUE UP THROUGH LIGHT COMPONENTS, FIRST COMPONEN	NT WITH	MNR29080
c		STRIPPING FACTOR GREATER THAN ONE SETS INDEX FOR LIG		MNR 29100
c		COMPONENTS AND SETS BOTTOM SECTION AS TYPE TWO. IF	ALL COMPONENTS	
č		HAVE STRIPPING FACTORS LESS THAN ONE THE BOTTOM IS	TYPE ONE.	MNR 29140
C		IDB = ILK - 1		MNR 29160
		J = I00		MNR 29180
		$00 460 I = 1 \cdot I 00$		MNR 29200
		J = J + 1 - I		MNR 29220
		IF (FEND(J,2) .LE. 1.0) GO TO 460		MNR29240
		ITS = 2		MNR 29260
		IIS = J		MNR 29280
		IF (STGM) 452, 452, 464		MNR29300
	1.52	2 STGM = 5.0		MNR 29320
	τJ2.	GO TO 464		MNR 29340
	460	O CONTINUE		MNR 29360
		STGM = 0.0	•	MNR 29380
		2 ITS = 1		MNR 29400
		ILS = 0		MNR 29420
	464	4 CONTINUE		MNR 29440
С		BRANCH FOR CALCULATION ON N AND M DEPENDING ON TYPE	OF SYSTEM	MNR 29460
Č				MNR 29480
•		IF (ITR .EQ. 1) GO TO 550		MNR 29500
		IF (ITS .EQ. 2) GO TO 580		MNR29520
С		CONTINUE FOR TYPE TWO TOP AND TYPE ONE BOTTOM.		MNR 29540
č				MNR 29560
č		CALCULATE NUMBER OF STAGES (N)		MNR 29580
C		LOCA=2 IS FOR DISTRIBUTED COMPS IN THE RECTIFYING S	ECTION	MNR 29600
Ċ		KSEC=2 IS FOR THE RECTIFYING SECTION		MNR 29620
		LOCA = 2		MNR 29640
		KSEC = 2		MNR 29660
С				MNR 29680
-		4 SLFD(IHK) = FEND(IHK,5) / (1.0 - FEND(IHK,5))		MNR 29700
		VFB(IHK) = FEND(IHK,2) / (1.0 - FEND(IHK,2))		MNR 29720
		DIV = VFB(IHK) + VFFX(IHK)		MNR 29740
С				MNR 29760
č		INITIALIZE FOR N = 0. TRANSFER OUT IF B/D EQUALS OF	EXCEEDS SPEC.	MNR29780
č		HOWEVER RECOGNIZE INCONSISTANCY OF N = 0 AND TYPE T	WO TOP.	MNR 29800
č				MNR 29820
č				MNR29840
5		BDHK= (SLFD(IHK) + LFFX(IHK)) / DIV		MNR 29860

MNR 29880 С MNR 29900 DELBD1 = BDI(IHK) - BDHK MNR 29920 IF (DELBD1 .LT. 0.0) GO TO 505 MNR 29940 С MNR 29960 STGN = 0.0MNR 29980 GO TO 530 MNR 30000 С MNR 30020 505 CONTINUE CONVERGE ON N BY LINEAR INTERPOLATION WITH B/D CALC. AND B/D SPEC.MNR 30040 С MNR 30060 STGN1 = 0.0MNR 30080 STGN2 = STGNMNR 30100 С MNR30120 $00\ 520\ I = 1,25$ MNR 30140 CALL LINEAR (STGN, LOCA, IHK) BDHK= (LFD(IHK) + LFFX(IHK)) / DIV MNR 30160 DELBD2 = BDI(IHK) - BDHK MNR 30180 IF (ABS (DELBD2) .LT. .00001) GO TO 530 MNR 30200 STGN = (STGN1 * DELBD2 - STGN2 * DELBD1) / (DELBD2 - DELBD1) MNR 30220 MNR 30240 С IF STGN HAS EXCEEDED 50, PROGRAM WILL USE 50. FOR THIS TRIAL MNR 30260 С MNR 30280 С MNR 30300 С MNR 30320 IF (STGN .GT. 50.) GO TO 522 MNR 30340 IF (STGN .LE. 0.0) GO TO 526 MNR 30360 STGN1 = STGN2MNR 30380 STGN2 = STGNMNR 30400 DELBD1 = DELBD2MNR 30420 DELBD1 = DELBD2MNR 30440 520 CONTINUE MNR 30460 С MNR 30480 PRINT 525 525 FORMAT ('0', 5X, '**** HEAVY KEY B/D SPEC AND B/D CALC HAVE NOT CONVMNR 30500 1ERGED IN 25 ITERATIONS. *****) MNR 30520 MNR 30540 GO TO 530 MNR 30560 522 STGN = 50.MNR30580 PRINT 523 523 FORMAT ('0', 5X, '**** N EXCEEDS 50. PROGRAM WILL USE 50. FOR', MNR 30600 1 * THIS TRIAL. *****) MNR 30620 MNR 30640 C MNR 30660 GO TO 530 MNR 30680 526 STGN = 0.0001MNR 30700 С MNR 30720 **530 CONTINUE** MNR 30740 С MNR 30760 550 IF (ITS.EQ.1) GO TO 600 MNR30780 С CONTINUE FOR TYPE ONE TOP AND TYPE TWO BOTTOM. MNR 30800 С CALCULATE NUMBER OF STAGES (M) MNR 30820 С MNR 30840 С LOCA = 1 IS FOR DISTRIBUTED COMPS IN THE STRIPPING SECTION MNR 30860 С KSEC = 1 IS FOR THE STRIPPING SECTION MNR 30880 С MNR 30900 LOCA = 1KSEC = 1MNR 30920

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MINR
554 SVFB(IREF) = FEND(IREF,2) / (1.0 - FEND(IREF,2))
LFD(IREF) = FEND(IREF,5) / (1.0 - FEND(IREF,5))
                                                                           MNR 30940
                                                                           MNR 30960
    MULT = LFD(IREF) + LFFX(IREF)
                                                                           MNR 30980
                                                                           MNR 31000
    INITIALIZE FOR M = 0. TRANSFER OUT IF B/D EQUALS OR EXCEEDS SPEC. MNR 31020
    HOWEVER RECOGNIZE INCONSISTANCY OF M = 0 AND TYPE TWO BOTTOM.
                                                                           MNR 31040
                                                                           MNR 31060
    BDLK= MULT/ (SVFB(ILK) + VFFX(ILK))
    DELBD1 = BDI(ILK) - BDLK
                                                                           MNR 31080
    IF ( DELBD1 .GT. 0.0 ) GO TO 565
                                                                           MNR 31100
                                                                            MNR 31120
                                                                            MNR 31140
    STGM = 0.0
                                                                            MNR 31160
    GO TO 574
                                                                            MNR 31180
565 CONTINUE
                                                                            MNR 31200
    CONVERGE ON M BY LINEAR INTERPOLATION WITH B/D CALC. AND B/D SPEC.MNR31220
                                                                            MNR 31240
    STGM1 = 0.0
                                                                            MNR 31260
    STGM2 = STGM
    DO 570 I = 1,25
                                                                            MNR 31280
    CALL LINEAR ( STGM, LOCA, ILK )
                                                                            MNR 31 300
                                                                            MNR 31320
    BDLK= MULT / ( VFB(ILK)+VFFX(ILK))
                                                                            MNR 31340
    DELBD2 = BDI(ILK) - BDLK
    IF (ABS(DELBD2).LT. .00001 ) GO TO 578
                                                                            MNR 31 360
    STGM = ( STGM1*DELBD2 - STGM2*DELBD1) / ( DELBD2 - DELBD1 )
                                                                            MNR 31380
                                                                            MNR 31400
    IF STGM HAS EXCEEDED 50, PROGRAM WILL USE 50. FOR THIS TRIAL
                                                                            MNR 31420
                                                                            MNR 31440
                                                                            MNR 31460
    IF ( STGM .GT. 50. ) GO TO 572
                                                                            MNR 31480
    IF ( STGM .LE. 0.0 ) GO TO 574
                                                                            MNR 31 500
                                                                            MNR 31520
    STGM1 = STGM2
                                                                            MNR 31540
    STGM2 = STGM
    DELBD1 = DELBD2
                                                                            MNR31560
                                                                            MNR 31580
570 CONTINUE
                                                                            MNR31600
    PRINT 575
575 FORMAT ( 101,5X, 1**** LIGHT KEY B/D SPEC AND B/D CALC HAVE NOT CONVMNR 31620
    lerged in 25 iterations. ***** )
                                                                            MNR 31640
                                                                            MNR 31660
    GO TO 574
                                                                            MNR 31680
572 \text{ STGM} = 50.
    PRINT 573
                                                                            MNR 31700
573 FORMAT ( '0', 5X, '**** M EXCEEDS 50. PROGRAM WILL USE 50. FOR', MNR 31720
   1 ' THIS TRIAL' )
                                                                            MNR 31740
    GO TO 578
                                                                            MNR 31760
                                                                            MNR31780
574 \text{ STGM} = 0.0001
578 CONTINUE
                                                                            MNR 31800
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CALCULATE NUMBER OF STAGES FOR TYPE TWO BOTTOM AND TYPE TWO TOP

SVFB(ILK) = FEND(ILK,2) / (1.0 - FEND(ILK,2))

SLFD(ILK) = FEND(ILK,5) / (1.0 - FEND(ILK,5))

SVFB(IHK) = FEND(IHK,2) / (1.0 - FEND(IHK,2))

C C GO TO 600

580 CONTINUE

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С

С

С

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с С

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MNR31820

MNR 31840

MNR 31860

MNR 31880

MNR 31900 MNR 31920

MNR 31940

MNR 31960

MNR31980

SLFD(1HK) = FEND[1HK,5] / (1.0 - FEND[1HK,5]) WNR32020 C INTIALIZE FOR N AND M = 0 WNR32020 C TRANSFER DUT LF B/DI'S EQUAL DF EXCEED SPEC. HDWEVER RECONIZE WNR32020 C INCONSISTANCY OF M00 AND NOD FOR TWP TAU TO A AL- OTTOW WNR32020 DDHK = (SLFD(1HK) + LFFX(1HK)) / (SVFB(1HK) + VFFX(1HK)) WNR32100 DBDHK = (SLFD(1LK) + LFFX(1HK)) / (SVFB(1LK) + VFFX(1LK)) WNR32100 DBDHK = BD1(1LK) - BDLK WNR32100 DBDHK = BDI(1LK) - DDLK WNR32100 DBDHK = GSLFOR WNR32100 STGN = 0.0 STGN = 0.0 STGN = 0.0 MNR32200 STGN = 0.0 STGN = 0.0 STGN = 0.0 STGN = 0.0 STGN = 0.0 STGN = 0.0 STGN = 0.0 MNR32200 STGN = STGN MNR32200 STGN = STGN MNR32400 MR32340<			
C INITIALIZE FOR N AND M = 0 MAR 2023 C TRANSER OUT IF B/D'S EUGAL OF EXCEED SPEC. HOWEVER KECOGNIZE C TRANSER OUT IF B/D'S EUGAL OF EXCEED SPEC. HOWEVER KECOGNIZE C INCONSISTANCY UF M=0 AND N=0 FOR TYPE TAU TOP A/A ==CTTCM MN 823240 DOBLK = (SICFOILK) + LFFX(ILK)) / (SVFG(ILK) + VFFX(ILK)) MN 832100 DBOLK = (SICFOILK) + LFFX(ILK)) / (SVFG(ILK) + VFFX(ILK)) MN 83210 DBOLK = B0I(ILK) - BOLK MN 83210 DBOLK = B0I(ILK) - BOLK MN 83210 STGM = 0.0 C OVYERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MN 822200 S1GM = 0.0 C OVYERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MN 822200 S1GM = 0.0 STGM = 0.0 C OVYERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MN 822200 S1GM = 0.0 S1GM = 0.0		SLFD(IHK) = FEND(IHK,5) / (1.0 - FEND(IHK,5))	MNR 32 000
C TRANSFER DUT IF B/D/S EUGL OF EXCEED SPEC. HOMEVER RECORNIZE WH 32340 DOBMS = (SLFD(IHK) + LFFX(IHK)) / (SVFB(IHK) + VFFX(IHK)) WH 32300 BOLK = (SLFD(IHK) + LFFX(ILK)) / (SVFB(ILK) + VFFX(IHK)) WH 32100 DBOHK1 = BDI(IHK) - BOHK NH 23210 DBOHK1 = BDI(IHK) - BOHK IF (DBOHK1.LT.0.).OR.(DBDLK1.GT.0.)) GO TO 582 WH 322140 TF (DBOHK1.LT.0.).OR.(DBDLK1.GT.0.)) GO TO 582 WH 322200 STGM = 0.0 STGM = (STGM, LOCA, IHK) C ALL LINEAR (STGM, LOCA, ILK) MN 832500 DBOHK = 1LFD(IHK) + LFFX(IHK) / (VFB(IHK) + VFFX(IHK)) MN 832500 STGM = (STGM +0.0) STGM = 0.0 STGM = (STGM +0.0) STGM = 0.0 STGM = (STGM +0.0) STGM = 0.0 STGM = STGM -0.0 STGM = STGM -0 DBOLK1 = DBOHK2 STGM = STGM -0 STGM = STGM	С	INITIALIZE FOR N AND $M = 0$	
C INCONSISTANCY OF M=O AND N=O FOR TYPE TAU TOP ATA- METTY BOHK = (SLEFOLIKK) + LEFX(ILK)) / (SVFB(ILK) + VFFX(IHX)) MAR 32100 BOBUK1 = BOIT(IKK) + DFX(IHK)) / (SVFB(ILK) + VFFX(ILK)) MAR 32120 BOBUK1 = BOIT(IKK) - BOHK MAR 32120 TF (LOBDHK1.LT.O.).OR.(DBDLK1.GT.O.)) GO TO 582 G COVYERGE DN N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MAR 32160 STGM = 0.0 C COVYERGE DN N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MAR 32260 STGM1 = 0.0 STGM1 = 0.0 STGM1 = 0.0 STGM1 = 0.0 STGM1 = 0.0 STGM1 = 0.0 STGM2 = STGN MAR 32300 STGM2 = STGN MAR 32300 DO 584 I = 1.25 C COVYERGE DN N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MAR 32300 STGM2 = STGN MAR 3240 MAR 32400 MAR 32400 MAR 32400 MAR 32400 MAR 32400 STGM2 = STGN MAR 32400 C CALL LINEAR (STGN, LOCA, ILK) MAR 32400 D DBHK = (LEP0(IHK) + LEFX(ILK)) / (VEB(IHK) + VFFX(IHK)) MAR 32400 MAR 32500 C CALL LINEAR (STGN, LOCA, ILK) MAR 32400 D DBHK = (LEP0(IHK) + LEFX(ILK)) / (VEB(IHK) + VFFX(IHK)) MAR 32600 D STGN = (STGN1*DBHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MAR 32700 STGN = STGN2 STGN = STGN2 STGN3 STGN2 STGN3 STGN2 STGN2 STGN2 STGN2 STGN2 STGN2 STGN3 STGN2 STGN2 STGN2 STGN3 STGN2 STGN3 STGN2 STGN3 STGN2 STGN3 STGN2 STGN3 STGN2 STGN3 STGN2 STGN2 STGN3 STGN3 STGN2 ST		TRANSFER DUT LE BZD'S EQUAL OR EXCEED SPEC. HOWEVER RECOGNIZE	
BOLK = (SLF)(ILK) + DHK VFFX(ILK)) WAR 32100 0BDLK1 = BDI(ILK) - BDLK WAR 32120 0BDLK1 = BDI(ILK) - BDLK WAR 32140 1F (IOBDHK1.LT.0.).OR.(DBDLK1.GT.0.)) GO TD 582 WAR 32160 STGM = 0.0 WAR 32160 0 TO 585 WAR 32200 92 CONTINUE WAR 32200 C COVERGE DN N AND M BY LINEAR INTERPOLATION WITH B/D CALC. WAR 32200 STGM1 = 0.0 WAR 32300 STGM1 = 0.0 WAR 32300 STGM1 = 0.0 WAR 32300 STGM2 = STGN WAR 32300 STGM2 = STGM WAR 32300 D0 584 I = 1, 25 WAR 32300 D0 584 I = 1, 25 WAR 3240 CALL LINEAR (STGN, LOCA, ILK) WAR 32400 CALL LINEAR (STGN, LOCA, ILK) WAR 32500 DBMK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) WAR 32600 NDK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) WAR 32600 STGN2 = STGN STGN2 = STG	C	INCONSISTANCY OF M=O AND N=O FOR TYPE TWO TOP AND HOTTOM	
DBDHK1 = BDI(11K) - BDHK WNR 32120 DBDLK1 = BDI(11K) - BDLK WNR 32140 IF ((DBDHK1.LT.O.).GR.(DBDLK1.GT.O.)) GO TO 582 WNR 32180 STGM = 0.0 WNR 32180 STGM = 0.0 WNR 32270 SD O TO 585 WNR 32280 STGM = 0.0 WNR 32280 C COVVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. WNR 32280 STGM1 = 0.0 WNR 32280 STGM2 = STGN WNR 32280 STGM2 = STGM WNR 32280 DO 584 I = 1.25 WNR 32280 DO 584 I = 1.25 WNR 32300 DO 584 I = 1.25 WNR 32400 DO 584 I = 1.25 WNR 32400 DO 584 I = 1.25 WNR 32400 LOCA = 2 WNR 32400 CALL LINEAR (STGN, LOCA, TIK) WNR 32800 CALL LINEAR (STGM, LOCA, TIK) WNR 32500 CALL LINEAR (STGM, LOCA, TIK) WNR 32500 DALK = (LEDITIK) + LEFX(ILK) / (VFB(IHK) + VFFX(IHK)) WNR 32600 BDHK = (LEDITIK) + LEFX(ILK) / (VFB(ILK) + VFFX(ILK)) WNR 32600 DALK = ULDILKA + BOLK WNR 32700 BDHK = (LEDITIK) + BOLK		BDHK = {SLFD(IHK) + LFFX(IHK)} / (SVFB(IHK) + VFFX(IHK))	
DBDRK1 = BD111LK1 = BD1K WR 22140 DBDRK1 = BD111LK1 = BD1K WR 32160 IF ((DBDHK1.LT.0.).0R.(DBDLK1.GT.0.)) GO TO 582 WR 32160 STGM = 0.0 WR 32200 GG TO 585 WR 32220 522 CONTINUE WR 32220 C CONVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. WR 32240 STGM1 = 0.0 WR 32280 STGM1 = 0.0 WR 32280 STGM1 = 0.0 WR 32300 STGM1 = 0.0 WR 32320 STGM2 = STGN WR 32340 DO 584 I = 1, 25 WR 32460 UCC A = 2 WR 32400 CALL LINEAR (STGN, LOCA, ILK) WR 32460 VSEC = 1 WR 32460 CALL LINEAR (STGN, LOCA, ILK) WR 32500 CALL LINEAR (STGM, LOCA, ILK) WR 32500 CALL LINEAR (STGM, LOCA, ILK) WR 32500 BDLK = (LED11HK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) WR 32500 BDLK = LED1(HK) + LFFX(ILK) / (VFB(ILK) + VFFX(ILK)) WR 32500 STGN = STGN WR 32500 STGN = CTO.0001, AND.(ABS(DBDLK2)-LT-0.00001) WR 32600 STGN = STGN			
DDDLK1.tr.0.).OR.(DBDLK1.GT.0.)) GO TO 582 MNR 32160 STGN = 0.0 MNR 32180 STGN = 0.0 MNR 32200 GO TO 585 MNR 32200 STGN = 0.0 MNR 32200 GO TO 585 MNR 32200 C CONVERGE DN N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MNR 32260 C MNR 32260 MNR 32280 STGN1 = 0.0 MNR 32320 MNR 32320 STGM1 = 0.0 MNR 32300 MNR 32340 STGM2 = STGN MNR 3240 MNR 32400 DO 584 I = 1, 25 MNR 32400 MNR 32440 KSEC = 2 MNR 32440 MNR 32440 CALL LINEAR (STGN, LOCA, ILK) MNR 32460 MNR 32520 CALL LINEAR (STGM, LOCA, ILK) MNR 32520 MNR 32540 MSSEC = 1 MNR 32520 MNR 32520 CALL LINEAR (STGM, LOCA, ILK) / VFB(ILK) + VFFX(ILK) MNR 32600 DBDK2 = BDI(1HK) + BDHK / VFB(ILK) + VFFX(ILK) MNR 32600 DBDK2 = BDI(1HK) - BDHK / MNR 32600 MNR 32600 JF (STGN.EE,0.0) STGN = 0.0001 MNR 32760 MNR 32760 STGN1 = STGN MNR 32760 MNR 32760		DBDHK1 = BDI(IHK) - BDHK	
STGN = 0.0 MAR 32140 STGN = 0.0 MAR 32210 GO TO 585 MAR 32220 SB2 CONTINUE MAR 32220 C CUVVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MAR 32260 STGM1 = 0.0 MAR 32230 STGM1 = 0.0 MAR 32320 STGM1 = 0.0 MAR 32320 STGM2 = STGN MAR 32340 DD 584 I = 1, 25 MAR 3240 CALL LINEAR (STGN, LOCA, IHK) MAR 32400 CALL LINEAR (STGN, LOCA, ILK) MAR 32400 CALL LINEAR (STGN, LOCA, ILK) MAR 32440 CALL LINEAR (STGM, LOCA, ILK) MAR 32400 MAR 32400 MAR 32400 CALL LINEAR (STGM, LOCA, ILK) MAR 32400 MAR 32400 MAR 32400 CALL LINEAR (STGM, LOCA, ILK) MAR 32520 MAL = (LFD(IHK) + LFFXIIK) / (VFB(IHK) + VFFX(IH		OBDLK1 = BDI(ILK) - BDLK	
3150 = 0.0 MR 32200 GQ TO 585 MR 32200 582 CONTINUE MR 32200 C COVVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MR 32260 C COVVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MR 32280 C COVVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MR 32280 C COVVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MR 32280 C MR 32300 MR 32300 STGN1 = 0.0 MR 32340 MR 32340 MR 32340 DO 584 I = 1, 25 MR 32420 KSEC = 2 MR 32420 CALL LINEAR (STGN, LOCA, IHK) MR 32460 LOCA = 1 MR 32460 MR 32460 MR 32460 MR 32460 MR 32460 MR 32460 MR 32460 MR 4 (LINEAR (STGM, LOCA, IHK) MR 32500 C BDHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MR 32560 MR 32560 MR 32560 MR 32560 DBOHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MR 32600 DBOHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MR 32600 DBOHK = (STGM		IF ((DBDHK1.LT.0.).OR.(DBDLK1.GT.0.)) GO TO 582	
Sign 10 585 MNR 32220 582 CONTINUE MNR 32240 C COVVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MNR 32240 C AND 8/D SPEC. MNR 32280 STGM1 = 0.0 MNR 322300 STGM1 = 0.0 MNR 32320 STGM1 = 10.0 MNR 32320 STGM1 = 10.0 MNR 32320 STGM2 = STGM MNR 32360 D0 584 I = 1, 25 MNR 32240 CALL LINEAR (STGN, LOCA, IHK) MNR 32400 KSEC = 2 MNR 32400 CALL LINEAR (STGN, LOCA, IHK) MNR 32400 CALL LINEAR (STGM, LOCA, ILK) MNR 32400 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 CALL LINEAR (STGM, LOCA, IHK) MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 DBDK = (LFD(ILK) + LFFX(ILK)) / (VFB(IHK) + VFFX(IHK)) MNR 32500 DBDK = SUT(ILK) - BDHK MNR 32600 DBDK = SUT(ILK) - BDHK MNR 32260 MR 322600 MR 322600 IF (TABSUBDHK2).LT.O.00001.AND.(ABS(DBDLK2).LT.0.00001)) MR 32600 IF (STGN.GT. 50.) STGN = 50. MR 32700 STGM1 = STGN2 MR 327800 MR 32780		STGN = 0.0	
582 CONTINUE MR 32240 C COVVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. MR 32260 C AND B/D SPFC. MR 32280 STGN1 = 0.0 MR 32300 STGN2 = STGN MR 32300 DD 584 I = 1, 25 MR 32360 LOCA = 2 MR 32360 CALL LINEAR (STGN, LOCA, ILK) MR 32400 CALL LINEAR (STGN, LOCA, ILK) MR 32460 MR 32460 MR 32480 KSEC = 1 MR 32460 CALL LINEAR (STGM, LOCA, ILK) MR 32460 MR 32460 MR 32480 KSEC = 1 MR 32460 CALL LINEAR (STGM, LOCA, ILK) MR 32500 DBHK = (LFD(ILK) + LFFX(ILK)) / (VFB(IHK) + VFFX(ILK)) MR 32500 DBHK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MR 32600 DBHK = SUTINK - BDLK MR 32760 MR 32760 MR 32760 MR 32760 MR 32760 MR 32760 MR 32760 STGN = (STGM:SDBHK2 - STGN2+DBDHK1) / (DBDLK2 -		STGM = 0.0	
C DOVVENGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC. C AND B/D SPEC. STOM = 0.0 STOM = 1, 25 CALL LINEAR (STGN, LOCA, ILK) C ALL LINEAR (STGM, LOCA, ILK) STOM = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32540 MNR 32540 STOM = (LFD(IHK) + LFFX(ILK)) / (VFB(IHK) + VFFX(ILK)) MNR 32540 DBDHK = (LFD(IHK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32540 STOM = (STON INDBOHK2 - STOM2*DBOHK1) / (DBOHK2 - DBDHK1) IF (STOM IE.0.0) STGM = 0.0001 STOM = STOM STOM = 50. STOM = STOM STOM = 0.0001 MNR 32760 MNR 3276		GO TO 585	
C AND B/D SPEC. MNR 32280 STGN1 = 0.0 MNR 32320 STGN2 = STGN MNR 32340 D0 584 I = 1, 25 MNR 32360 L0CA = 2 MNR 32420 KSEC = 2 MNR 3240 CALL LINEAR (STGN, LOCA, IHK) MNR 32420 CALL LINEAR (STGN, LOCA, ILK) MNR 32420 L0CA = 1 MNR 32420 CALL LINEAR (STGN, LOCA, ILK) MNR 32420 CALL LINEAR (STGM, LOCA, ILK) MNR 32420 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 DBHK = (LFO(IHK) + LFFX(ILK)) / (VFB(ILK) + VFFX(IHK)) MNR 32500 MNR 32500 MNR 32600 DBDHK = BDI(IHK) - BDHK MNR 32600 DBDHK2 = BDI(IHK) - BDHK MNR 32600 MNR 32660 MNR 32660 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32720 IF (STGN.EE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.EE.0.0) STGN = 0.0001 MNR 32780 STGM = (STGM1*DBDHK2 - STGM2*DBDLK1) / (DBDLK2 - DBDHK1) MNR 32720 STGM = STGM MNR 32780 DBHK1 = DBDHK2 STGM = 50. MNR 32780 </td <td></td> <td>582 CONTINUE</td> <td></td>		582 CONTINUE	
C NRC 00 0.0 MNR 32300 STGM1 = 0.0 MNR 32320 STGM1 = 0.0 MNR 32320 STGM1 = 0.0 MNR 32320 STGM2 = STGN MNR 32360 D0 584 I = 1, 25 MNR 32400 L0CA = 2 MNR 32420 CALL LINEAR (STGN, LOCA, IHK) MNR 32420 CALL LINEAR (STGN, LOCA, ILK) MNR 32460 L0CA = 1 MNR 32460 KSEC = 1 MNR 32500 CALL LINEAR (STGM, LOCA, IHK) MNR 32560 CALL LINEAR (STGM, LOCA, ILK) MNR 32560 BDHK = (LFD(1HK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32580 BDLK = (LFD(1HK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32640 MR 32640 MNR 32640 MNR 32640 DBDHK = BDI(ILK) - BDLK MNR 32640 MNR 32640 MR 0 TD 590 STGM = 0.0001 MNR 32700 MR 32700 MNR 32700 MNR 32700 MR 32760 MNR 32740 MNR 32760 STGM = STGN2 STGM2 = STGN MNR 32760 MBDHK = DBDHK2 STGM2 = STGN MNR 32760 MBDHK1 = DBDHK2 STGM2 = STGN MNR 32760 <t< td=""><td>С</td><td>CONVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC.</td><td></td></t<>	С	CONVERGE ON N AND M BY LINEAR INTERPOLATION WITH B/D CALC.	
STGM1 = 0.0 MNR 32320 STGM2 = STGM MNR 32340 STGM2 = STGM MNR 32340 D0 584 I = 1, 25 MNR 32380 L0CA = 2 MNR 32420 KSEC = 2 MNR 32420 CALL LINEAR (STGN, L0CA, IHK) MNR 32440 CALL LINEAR (STGM, L0CA, ILK) MNR 32440 KSEC = 1 MNR 32460 CALL LINEAR (STGM, L0CA, ILK) MNR 32500 CALL LINEAR (STGM, L0CA, ILK) MNR 32560 CALL LINEAR (STGM, L0CA, ILK) MNR 32560 BDHK = (LFD(IHK) + LFFX(ILK)) / (VFB(IHK) + VFFX(ILK)) MNR 32560 BDHK = (LFD(IHK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32660 MNR 32640 MNR 32640 DBDHK = BDI(ILK) - BDLK MNR 32640 MNR 2660 MNR 32660 STGN = (STGN1*DBDHK2)-LT-0.00001).AND.(ABS(DBDLK2).LT-0.00001)) MNR 32600 IF (IGABS(DBDHK2).LT-0.00001).AND.(ABS(DBDLK2).LT-0.00001)) MNR 32760 MNR 32760 MNR 32760 STGN2 = STGN MNR 32760 MNR 32780 MNR 32760 MS2740 MNR 32760 STGM2 = STGN MNR 32760 STGM2 = STGN MNR 32760	С	AND B/D SPEC.	
STGN 2 = STGN MNR 32340 STGM 2 = STGM MNR 32360 D0 584 I = 1, 25 MNR 32380 LCCA = 2 MNR 32420 KSEC = 2 MNR 32440 CALL LINEAR (STGN, LOCA, ILK) MNR 32440 LOCA = 1 MNR 32440 CALL LINEAR (STGM, LOCA, ILK) MNR 32460 LOCA = 1 MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32560 CALL LINEAR (STGM, LOCA, ILK) MNR 32560 CALL LINEAR (STGM, LOCA, ILK) MNR 32560 BDHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32560 BDBLK = LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32660 BDBLK = BD1(ILK) - BDHK MNR 32660 IF (IABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32660 STGN = CISGN:*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32760 STGN2 = STGN MNR 32780 DBHK1 = STGN2 MNR 32800 STGM = (STGM1*DBDHK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = STGM2 MNR 32800 STGM = STGM2 MNR 32800 STGM = STGM2 MNR 3280		STGN1 = 0.0	
STGM2 = STGM MNR32360 D0 584 I = 1, 25 MNR32380 LOCA = 2 MNR32400 KSEC = 2 MNR32420 CALL LINEAR (STGN, LOCA, IHK) MNR32440 LOCA = 1 MNR32460 KSEC = 1 MNR32460 CALL LINEAR (STGN, LOCA, ILK) MNR32460 CALL LINEAR (STGM, LOCA, ILK) MNR32500 CALL LINEAR (STGM, LOCA, ILK) MNR32500 DBHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR32560 BDHK = 8DI(ILK) - BDLK MNR32640 DBDHK = 8DI(ILK) - BDLK MNR32600 DBDHK = 8DI(ILK) - BDLK MNR32660 MNR32660 MNR32700 MNR32700 MNR32700 MNR32800 MNR32700 MNR32800 MNR32700 MNR32800		STGM1 = 0.0	
D0 584 I = 1, 25 MNR 32380 D0 584 I = 1, 25 MNR 32400 KSEC = 2 MNR 32420 CALL LINEAR (STGN, LOCA, IHK) MNR 32440 CALL LINEAR (STGN, LOCA, ILK) MNR 32440 LOCA = 1 MNR 32440 KSEC = 1 MNR 32440 CALL LINEAR (STGN, LOCA, ILK) MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32540 MNR 32540 MNR 32540 MNR 32540 MNR 32540 DBDK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32500 BDLK = (LFD(ILK) + LFFX(IKL)) / (VFB(ILK) + VFFX(IHK)) MNR 32600 DBDK = 80I(IHK) - BDHK MNR 32640 DBDK = 80I(IHK) - BDHK MNR 32640 DBDK = 80I(IHK) - BDHK MNR 32600 MNR 32260 MNR 32700 MNR 32700 MNR 32700 MNR 32720 MNR 32720 MR 500 MR2).LT.0.00001).AND. (ABS(DBDHK2 - DBDHK1) MNR 32700 MNR 327200 MNR 32760 MNR 327200 MNR 32760 MNR 327200 MNR 327200 MS 1 = STGN2 MNR 32780			
LOCA = 2 MNR 32400 KSEC = 2 MNR 32420 CALL LINEAR (STGN, LOCA, IHK) MNR 32420 CALL LINEAR (STGN, LOCA, ILK) MNR 32440 LOCA = 1 MNR 32480 KSEC = 1 MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 DBDK = (LFD(IIK) + LFFX(IKK)) / (VFB(IHK) + VFFX(ILK)) MNR 32560 BDK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32600 DBDHK 2 = BD1(ILK) - BDHK MNR 32660 DBDK 2 = BD1(ILK) - BOHK MNR 32660 JBOLK 2 = BD1(ILK) - BOHK MNR 32660 JBOLK 2 = BD1(ILK) - BOHK MNR 32600 JBOLK 2 = BD1(ILK) - BOHK MNR 32600 JBOLK 2 = BD1(ILK) - BOHK MNR 32700 JBOLK 2 = STGN MNR 32700 JF (STGN.LE.0.0) STGN = 0.0001 MNR 32760 STGN = STGN2 MNR 32760 JBOHK1 = DBDHK2 STGM = 50. JF (STGM.LE.0.0) STGM = 50. MNR 32760 JF (STGM.LE.0.0) STGM = 50. MNR 32800 <t< td=""><td></td><td></td><td></td></t<>			
KSEC = 2 MNR 32420 CALL LINEAR (STGN, LOCA, IHK) MNR 32440 CALL LINEAR (STGN, LOCA, ILK) MNR 32460 LOCA = 1 MNR 32480 KSEC = 1 MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 BDHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32500 BDBK = BDI(IHK) - BDHK MNR 32500 DBDK = BDI(IHK) - BDHK MNR 32600 DBDK = BDI(IHK) - BDHK MNR 32640 IF ((ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32640 MNR 32640 MNR 32700 MNR 32700 MNR 32700 MNR 32700 MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32760 MNR 32760 MNR 32760 STGN = STGN2 MNR 32760 MNR 32760 MNR 32760 STGN = STGN2 MNR 32760 MNR 32760 MNR 32760 STGN = STGN2 MNR 32760 MNR 32760 MNR 32760 STGN = STG		DO 584 I = 1, 25	
CALL LINEAR (STGN, LOCA, IHK) MNR 32440 CALL LINEAR (STGN, LOCA, ILK) MNR 32460 LOCA = 1 MNR 32500 CALL LINEAR (STGM, LOCA, IHK) MNR 32500 CALL LINEAR (STGM, LOCA, IHK) MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32500 DADK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32540 MNR 32500 MNR 32500 DBDK = BDI(IHK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32500 DBDK = BDI(IHK) - BDHK MNR 32600 MSCASCHORDHZ2.LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32600 MNR 32600 MSCASCHORDHZ2.LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32600 MSCASCHORDHZ2.LT.0.00001).AND.(ABS(DBDLK2 - DBDHK1) MNR 32700 MNR 32700 MR (STGN.E0.0) STGN = 0.0001 MNR 32760 MNR 32760 MSCASCH = STGN MNR 32760 MNR 32760 MSCASCH = STGN MNR 32700 MNR 32760 MSCASCH = STGN MNR 32760 MNR 32780 MBDHK1 = DBDHK2 STGM = 50. MNR 32780 MSCM = STGM MNR 32800		LOCA = 2	
CALL LINEAR (STGN, LOCA, ILK) MNR 32460 LOCA = 1 MNR 32480 KSFC = 1 MNR 32500 CALL LINEAR (STGM, LOCA, ILK) MNR 32520 CALL LINEAR (STGM, LOCA, ILK) MNR 32520 CALL LINEAR (STGM, LOCA, ILK) MNR 32540 BDHK = (LFD(IHK) + LFFX(ILK)) / (VFB(IHK) + VFFX(ILK)) MNR 32540 BDBHK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32560 DBDHK = BDI(IHK) - BDHK MNR 32620 DBDK2 = BDI(IHK) - BDHK MNR 32620 DBDK2 = BDI(IKL) - BDLK MNR 32640 IF ((ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32620 MR 32600 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 MNR 32740 STGN1 = STGN2 MNR 32740 MNR 32700 DBDHK1 = DBDHK2 STGM = 50. MNR 32780 DBDHK1 = BDBHK2 STGM = 50. MNR 32840 IF (STGM.GT.50.) STGM = 50. MNR 32840 MNR 32840 IF (STGM.GT.50.) STGM = 0.0001 MNR 32840 MNR 32840 IF (STGM.GT.50.) STGM = 0.0001 MNR 32840 MNR 32840 IF (STGM.GT.50.) STGM = 0.0001			
LOCA = 1 MNR 32480 KSEC = 1 MNR 32500 CALL LINEAR (STGM, LOCA, IHK) MNR 32520 CALL LINEAR (STGM, LOCA, ILK) MNR 32540 BDHK = (LED(IHK) + LEFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32540 BDHK = (LED(IHK) + LEFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32540 BDHK = LEPO(IHK) + LEFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32540 BDHK = DEVX MNR 32540 BDHK = SDI(IHK) - BDHK MNR 32540 DBDHK = BDI(IHK) - BDHK MNR 32640 JBD G TD 590 MNR 32640 JC GD TD 590 MNR 32640 JF (IABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32640 JF (STGN:CT. 50.) STGN = 0.0001 MNR 32700 JF (STGN:CT. 50.) STGN = 0.0001 MNR 32720 JF (STGN:CT. 50.) STGN = 50. MNR 32740 MNR 32760 MNR 32760 DBDHK1 = DBDHK2 STGM = 50. STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = STGM2 MNR 32800 MNR 32840 JF (STGM.EQ.00) STGM = 50. MNR 32800 MNR 328290 STGM			
KSEC = 1 MNR 32500 CALL LINEAR (STGM, LOCA, IHK) MNR 32520 CALL LINEAR (STGM, LOCA, ILK) MNR 32540 C MNR 32540 BDHK = (LED(IHK) + LEFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32540 DBDHK = (LED(ILK) + LEFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32540 DBDHK = BDI(IHK) - BDHK MNR 32540 DBDK2 = BDI(ILK) - BDHK MNR 32540 DBDK2 = BDI(ILK) - BDHK MNR 32640 IF ((ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32660 I GU TD 590 MNR 32700 I F (STGN.LE.0.0) STGN = 0.0001 MNR 32710 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGM.STGN2 MNR 32740 MNR 32720 MNR 32720 IF (STGN.EE.0.0) STGN = 50. MNR 32740 STGN2 STGN2 MNR 32740 MNR 32780 MNR 32780 DBDHK1 = DBDHK2 STGM = 50. MNR 32780 STGM = (STGM.EDDEDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 328200 STGM = STGM2 MNR 32800 MNR 32880 STGM1 = STGM2 MNR 32800 MNR 322800			
CALL LINEAR (STGM, LOCA, IHK) MNR 32520 CALL LINEAR (STGM, LOCA, ILK) MNR 32540 BDHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32580 BDLK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32620 DBDHK2 = BDI(IHK) - BDHK MNR 32640 DBDLK2 = BDI(IHK) - BDLK MNR 32640 IF ((ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32660 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32660 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.GT. 50.) STGN = 0.0001 MNR 32740 STGN1 = STGN2 MNR 32780 DBDHK1 = DBDHK2 STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = STGM2 MNR 32800 STGM = STGM2 MNR 32800 STGM = STGM2 MSTGM1 = STGM2 MNR 32800 STGM1 = STGM2 MNR 32800 MSTGM2 = STGM MNR 32800 MSTGM2 = STGM MNR 32800			
CALL LINEAR (STGM, LOCA, ILK) MNR 32540 C MNR 32560 BDHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32580 BDLK = LFD(IHK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32620 DBDHK2 = BDI(IHK) - BDHK MNR 32660 IF ((ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32660 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32740 IF (STGN.EE.0.0) STGN = 0.0001 MNR 32740 STGN = (STGN1*DBDHK2 - STGM2*DBDLK1) / (DBDLK2 - DBDHK1) MNR 32740 STGN = STGN2 MNR 32740 MNR 32780 MNR 32780 DBDHK1 = DBDHK2 STGM = 50. IF (STGM.GT. 50.) STGM = 50. MNR 32820 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32840 STGM1 = STGM2 MNR 32840 STGM1 = STGM2 MNR 32900 DBDLK1 = DBDLK2 MNR 32900			
C MNR 32560 BDHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32590 BDLK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32600 DBDHK = BDI(IHK) - BDHK MNR 32640 DBDLK = BDI(ILK) - BDLK MNR 32660 IF (ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32640 MNR 32560 MNR 32660 IF (STGN.EE.0.0) STGN = 0.0001 MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32760 IF (STGN.GT.50.) STGN = 50. MNR 32760 STGN1 = STGN2 MNR 32760 STGN2 = STGN MNR 32760 DBDHK1 = DBDHK2 STGM = 50. STGM2 = STGN MNR 32760 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32780 MDBHK1 = DBDHK2 MNR 32780 MNR 32820 MNR 32820 STGM1 = STGM2 MNR 32800 STGM1 = STGM2 MNR 32900 DBDLK1 = DBDLK2 MNR 32900 DBDLK1 = DBDLK2 MNR 32900<		CALL LINEAR (SIGM, LUCA, INK)	
BDHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 32590 BDLK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 32600 DBDLK2 = BDI(IHK) - BDHK MNR 32620 DBDLK2 = BDI(ILK) - BDLK MNR 32640 IF (IABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32660 MR 32 580 MNR 32640 IF (IABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32660 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32760 STGN1 = STGN2 MNR 32760 STGN2 = STGN MNR 32760 DBDHK1 = DBDHK2 STGM = 50. STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32860 STGM1 = STGM2 MNR 32800 STGM2 = STGM MNR 32800 STGM2 = STGM MNR 32860 STGM2 = STGM MNR 32860 STGM2 = STGM MNR 32800 DBDLK1 = DBDLK2 MNR 32900 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) G	-	CALL LINEAR (SIGM, LUCA, ILK)	
BDLK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR32600 DBDHK2 = BDI(IHK) - BDHK MNR32620 DBDLK2 = BDI(ILK) - BDLK MNR32640 IF (IABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR32660 MR 32660 MNR32660 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR32760 IF (STGN.GT.50.) STGN = 50. MNR32760 STGN1 = STGN2 MNR32760 STGN2 = STGN MNR32780 DBDHK1 = DBDHK2 MNR32780 DBDHK1 = DBDHK2 STGM = 50. STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR32800 STGM1 = STGM2 MNR32800 STGM1 = STGM2 MNR32800 STGM1 = STGM2 MNR32800 STGM1 = STGM2 MNR32800 STGM2 = STGM MNR32860 STGM2 = STGM MNR32880 STGM2 = STGM MNR32880 STGM2 = STGM MNR32900 DBDLK1 = DBDLK2 MNR32900 DBDLK1 = DBDLK2 MNR32900 IF(STGM.EQ.0.0001.AND.STGN.EQ.50.) GO TO 585 MNR32960 MRN32980 MNR3298	C		
DBDHK 2 = BDI(IHK) - BDHK MNR 32620 DBDLK 2 = BDI(ILK) - BDLK MNR 32640 IF ((ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32640 MR 32680 MNR 32680 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32740 STGN1 = STGN MNR 32760 STGN2 = STGN MNR 32780 DBDHK1 = DBDHK2 STGM2 = STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32780 MNR 32780 DBDHK1 = DBDHK2 STGM2 = STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = STGM2 STGM1 = STGM2 MNR 32800 STGM2 = STGM MNR 32800 STGM2 = STGM MNR 32800 DBDLK1 = DBDLK2 MNR 32900 DBDLK1 = DBDLK2 MNR 32900 MSTGM.EQ.00.0001.AND.STGN.EQ.00.0001) GO TO 590 MNR 32940 IF(STGM.EQ.00.0001.AND.STGN.EQ.00.0001) GO TO 590 MNR 32980 S84 CONTINUE MNR 33000 MNR 32980 PRINT 525 MNR 33020		$BUHK = \{LFD(IHK) + LFFA(IHK)\} / \{VFD(IHK) + VFFA(IDK)\}$	
DBDLK2 = BDI(ILK) - BDLK MNR 32640 JF ((ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32660 1 GU TD 590 MNR 32680 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.GT. 50.) STGN = 50. MNR 32740 STGN1 = STGN2 MNR 32760 DBDHK1 = STGN2 MNR 32760 DBDHK1 = STGN2 MNR 32760 MNR 32760 MNR 32760 MNR 32760 MNR 32760 STGN1 = STGN2 MNR 32760 DBDHK1 = DBDHK2 STGM = 50. STGM = (STGM1*BDBLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 STGM = (STGM.E0.00) STGM = 50. MNR 32840 IF (STGM.E0.00) STGM = 0.0001 MNR 32880 STGM2 = STGM MNR 32880 DBDLK1 = DBDLK2 MNR 32900 DBDLK1 = DBDLK2 MNR 32900 IF (STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32940 IF (STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32960 S84 CONTINUE MNR 32960 MNR 33000 PRINT 525 MN			
IF ((ABS(DBDHK2).LT.0.00001).AND.(ABS(DBDLK2).LT.0.00001)) MNR 32660 I GD T3 590 MNR 32680 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.GT. 50.) STGN = 50. MNR 32740 STGN2 = STGN MNR 32760 DBDHK1 = DBDHK2 MNR 32780 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGM.LE.0.0) STGM = 50. MNR 32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32840 STGM1 = STGM2 MNR 32880 STGM1 = STGM2 MNR 32840 STGM1 = STGM2 MNR 32840 STGM1 = STGM2 MNR 32840 STGM2 = STGM MNR 32880 STGM2 = STGM MNR 32840 STGM2 = STGM MNR 32940 STGM2 = STGM MNR 32940 STGM2 = STGM			
1 GD TB 590 MNR 32680 STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.GT.50.) STGN = 50. MNR 32740 STGN1 = STGN2 MNR 32760 DBDHK1 = DBDHK2 MNR 32780 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGM.GT.50.) STGM = 50. MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32800 STGM1 = STGM2 MNR 32800 STGM2 = STGM MNR 32880 STGM2 = STGM MNR 32800 DBDLK1 = DBDLK2 MNR 32900 DBDLK1 = DBDLK2 MNR 32900 IF(STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32940 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32940 S84 CONTINUE MNR 32960 PRINT 525 MNR 33000 PRINT 575 MNR 33020		f = (f A S (D B D H K 2) + T = 0.00001), AND, (ABS (D B D H K 2) + T = 0.00001))	
STGN = (STGN1*DBDHK2 - STGN2*DBDHK1) / (DBDHK2 - DBDHK1) MNR 32700 IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.GT.50.) STGN = 50. MNR 32740 STGN1 = STGN2 MNR 32760 STGN2 = STGN MNR 32760 DBDHK1 = DBDHK2 MNR 32780 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGM.GT. 50.) STGM = 50. MNR 32820 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32840 MNR 32800 MNR 32800 STGM1 = STGM2 MNR 32800 STGM2 = STGM MNR 32800 DBDLK1 = DBDLK2 MNR 32900 IF(STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32920 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32960 584 CONTINUE MNR 32980 PRINT 525 MNR 33020 PRINT 575 MNR 33020			
IF (STGN.LE.0.0) STGN = 0.0001 MNR 32720 IF (STGN.GT.50.) STGN = 50. MNR 32740 STGN1 = STGN2 MNR 32760 STGN2 = STGN MNR 32780 DBDHK1 = DBDHK2 STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MR 32800 MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGM.GT.50.) STGM = 50. MNR 32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32800 STGM1 = STGM2 MNR 32800 STGM2 = STGM MNR 32800 DBDLK1 = DBDLK2 MNR 32900 IF(STGM.EQ.50AND.STGN.EQ.50.) GO TO 585 MNR 32920 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32960 S84 CONTINUE MNR 32980 PRINT 525 MNR 33000 PRINT 575 MNR 33020			
IF (STGNGT50.) STGN = 50. MNR 32740 STGN1 = STGN2 MNR 32760 STGN2 = SIGN MNR 32780 DBDHK1 = DBDHK2 MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGME.0.0) STGM = 50. MNR 32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32860 STGM2 = STGM2 MNR 32860 MNR 32840 STGM1 = STGM2 MNR 32800 MNR 32840 STGM1 = STGM2 MNR 32800 MNR 32840 STGM2 = STGM MNR 32860 MNR 32840 DBDLK1 = DBDLK2 MNR 32900 MNR 32840 DBDLK1 = DBDLK2 MNR 32900 MNR 32900 DBLK1 = DBDLK2 MNR 32900 MNR 32920 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 585 MNR 32940 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32980 S84 CONTINUE MNR 33000 MNR 33020 PRINT 525 MNR 33020 MNR 33020			
STGN1 = STGN2 MNR 32760 STGN2 = STGN MNR 32780 DBDHK1 = DBDHK2 MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGM.EE.0.0) STGM = 50. MNR 32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32860 STGM1 = STGM2 MNR 32800 STGM2 = STGM MNR 32800 DBDLK1 = DBDLK2 MNR 32800 IF (STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32920 IF (STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32960 584 CONTINUE MNR 32980 PRINT 525 MNR 33000 PRINT 575 MNR 33020			
STGN 2 = STGN MNR 32780 DBDHK1 = DBDHK2 MNR 32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGM.EE.0.0) STGM = 50. MNR 32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32860 STGM1 = STGM2 MNR 32880 STGM2 = STGM MNR 32880 DBDLK1 = DBDLK2 MNR 32900 DBDLK1 = DBDLK2 MNR 32900 IF (STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32940 IF (STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32980 S84 CONTINUE MNR 3200 PRINT 525 MNR 33000 PRINT 575 MNR 33020			,
DBDHK1 = DBDHK2 MNR32800 STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR328220 IF (STGM.GT.50.) STGM = 50. MNR32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR32860 STGM1 = STGM2 MNR32880 STGM2 = STGM MNR32900 DBDLK1 = DBDLK2 MNR32900 IF(STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR32940 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR32980 S84 CONTINUE MNR3250 PRINT 525 MNR3200 PRINT 575 MNR3000			
STGM = (STGM1*DBDLK2 - STGM2*DBDLK1) / (DBDLK2 - DBDLK1) MNR 32820 IF (STGM.GT.50.) STGM = 50. MNR 32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32860 STGM1 = STGM2 MNR 32880 STGM2 = STGM MNR 32900 DBDLK1 = DBDLK2 MNR 32920 IF (STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32940 IF (STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32980 S84 CONTINUE MNR 32980 PRINT 525 MNR 33000 PRINT 575 MNR 33020			MNR32800
IF (STGM .GT. 50.) STGM = 50. MNR 32840 IF (STGM.LE.0.0) STGM = 0.0001 MNR 32860 STGM1 = STGM2 MNR 32880 STGM2 = STGM MNR 32900 DBDLK1 = DBDLK2 MNR 32920 IF(STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32940 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32960 584 CONTINUE MNR 32980 PRINT 525 MNR 33000 PRINT 575 MNR 33020			MNR 32820
IF (STGM.LE.0.0) STGM = 0.0001 MNR 32860 STGM1 = STGM2 MNR 32880 STGM2 = STGM MNR 32900 DBDLK1 = DBDLK2 MNR 32920 IF(STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32940 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32960 584 CONTINUE MNR 32980 PRINT 525 MNR 33000 PRINT 575 MNR 33020			MNR 32840
STGM1 = STGM2 MNR 32880 STGM2 = STGM MNR 32900 DBDLK1 = DBDLK2 MNR 32920 IF(STGM.EQ.50.AND.STGN.EQ.50.) GO TO 585 MNR 32940 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32960 584 CONTINUE MNR 32980 PRINT 525 MNR 33000 PRINT 575 MNR 33020		$IF (STGM_{\bullet}LE_{\bullet}O_{\bullet}O) STGM = 0.0001$	MNR 32860
STGM2 = STGM MNR 32900 DBDLK1 = DBDLK2 MNR 32920 IF{STGM.EQ.50.AND.STGN.EQ.50.} GD TD 585 MNR 32940 IF{STGM.EQ.0.0001.AND.STGN.EQ.0.0001} GD TD 590 MNR 32960 584 CONTINUE MNR 32980 PRINT 525 MNR 33020 PRINT 575 MNR 33020			
DBDLK1 = DBDLK2 MNR 32920 IF{STGM.EQ.50.AND.STGN.EQ.50.} GD TD 585 MNR 32940 IF{STGM.EQ.0.0001.AND.STGN.EQ.0.0001} GD TD 590 MNR 32960 584 CONTINUE MNR 32980 PRINT 525 MNR 33000 PRINT 575 MNR 33020			MNR 32900
IF(STGM.EQ.50AND.STGN.EQ.50.) GO TO 585 MNR 32940 IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) GO TO 590 MNR 32960 584 CONTINUE MNR 32980 PRINT 525 MNR 33000 PRINT 575 MNR 33020		DBDLK1 = DBDLK2	MNR 32920
IF(STGM.EQ.0.0001.AND.STGN.EQ.0.0001) G0 T0 590 MNR32960 584 CONTINUE MNR32980 PRINT 525 MNR33000 PRINT 575 MNR3201			MNR 32940
PRINT 525 PRINT 575 MNR 33000 MNR 33020			MNR 32960
PRINT 575 MNR 33020		584 CONTINUE	
		PRINT 525	
GO TO 590 MNR 33040		PRINT 575	
		GO TO 590	MNR 33040

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585 PRINT 523
      PRINT 573
  590 CONTINUE
  600 IF ( ITR.EQ.2 ) GO TO 620
С
С
      MATERIAL BALANCE FOR TYPE ONE RECTIFYING SECTION
С
      DO 610 I = 1, NCOMP
      LFD(I) = FEND(I,5) / (1.0 - FEND(I,5))
  609 \text{ SLFD(I)} = \text{LFD(I)}
  610 CONTINUE
С
      GO TO 640
С
С
      MATERIAL BALANCE FOR TYPE TWO RECTIFYING SECTION
С
  620 \text{ ID0} = \text{IHS} - 1
      KSEC = 2
      LOCA = 2
С
      DO 625 I = 1, IDO
  625 SLFD(I) = FEND(I,5) / ( 1.0 - FEND(I,5) )
      IF ( STGN ) 628, 628, 630
  628 DO 629 I = 1, IDO
  629 LFD(I) = SLFD(I)
      GD TO 640
С
  630 CALL LINEAR ( STGN, LOCA, 0 )
  640 CONTINUE
С
       IF ( ITS.EQ.2 ) GO TO 660
С
С
      MATERIAL BALANCE FOR TYPE ONE STRIPPING SCTION
C
       00 \ 650 \ I = 1, NCOMP
       VFB(I) = FEND(I,2) / (1.0 - FEND(I,2))
  649 \text{ SVFB(I)} = \text{VFB(I)}
  650 CONTINUE
С
       GO TO 680
С
С
      MATERIAL BALANCE FOR TYPE TWO STRIPPING SECTION
С
  660 IDD = ILS + 1
С
       KSEC = 1
      LOCA = 1
С
С
      DO 665 I = IDO, NCOMP
  665 \text{ SVFB(I)} = \text{FEND(I,2)} / (1.0 - \text{FEND(I,2)})
С
       IF ( STGM ) 668,668,670
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105

MNR 33060

MNR 33080 MNR 33100 MNR 33120 MNR33140 MNR33160 MNR 33180 MNR 33200 MNR 33220 MNR 33240 MNR 33260 MNR 33280 MNR33300 MNR 33320 MNR 33340 MNR33360 MNR 33380 MNR 33400 MNR33420 MNR 33440 MNR33460 MNR33480 MNR 33500 MNR 33520 MNR 33540 MNR 33560 MNR 33580 MNR 33600 MNR 33620 MNR 33640 MNR 33660 MNR33680 MNR33700 MNR 33720 MNR33740 MNR 33760 MNR 33780 MNR33800 MNR33820 MNR 33840 MNR 33860 MNR 33880 MNR33900 MNR 33920 MNR 33940 MNR 33960 MNR33980 MNR 34000 MNR34020 MNR 34040 MNR 34060 MNR 34080 MNR34100

~ MINR MNR 34120 668 DD 669 I= IDO,NCOMP 669 VFB(I) = SVFB(I)MNR 34140 MNR 34160 GO TO 680 MNR 34180 С . MNR 34200 670 CALL LINEAR (STGM, LOCA, 0) MNR 34220 680 CONTINUE OVERALL MATERIAL BALANCE AND DISTILLATE RATE MNR 34240 С MNR 34260 С MNR 34280 I1 = ILS + 1MNR 34300 I2 = IHS - 1MNR 34320 DTRIAL = 0.0MNR 34340 THETLK = 1.0THETHK = 1.0MNR 34360. MNR 34380 С BDHK = (LFD(IHK) + LFFX(IHK)) / (VFB(IHK) + VFFX(IHK)) MNR 34400 THETHK = BDI(IHK) / BDHK MNR 34420 MNR 34440 С 3DLK = (LFD(ILK) + LFFX(ILK)) / (VFB(ILK) + VFFX(ILK)) MNR 34460 THETLK = BDI(ILK) / BDLK **MNR 34480** MNR 34500 PRINT 6868, THETLK, THETHK 6868 FORMAT(/5X, 'THETA LIGHT KEY =', F9.3, /5X, 'THETA HEAVY KEY =', F9.3/)MNR 34520 IF (ITS .EQ. 1) GO TO 684 **MNR 34540** С MNR 34560 CALCULATE DISTILLATE RATE FOR LIGHT SEPARATED COMPONENTS MNR 34580 С MNR 34600 С $DO \ 682 \ I = 1, ILS$ MNR34620 MNR 34640 $\mathcal{D}(\mathbf{I}) = \mathsf{FTOT}(\mathbf{I})$ MNR 34660 B(1) = 0.0682 DTRIAL = DTRIAL + D(I)MNR 34680 CONTINUE MNR 34700 С MNR 34720 CALCULATE DISTILLATE RATE FOR DISTRIBUTED COMPONENTS С MNR 34740 С MNR 34760 684 DO 698 I = I1, I2MNR 34780 BDI(I) = (LFD(I) + LFFX(I)) / (VFB(I) + VFFX(I)) MNR 34800 IF (I .EQ. IHK) GO TO 686 MNR 34820 IF (I .EQ. ILK) GO TO 685 MNR 34840 GO TO 688 MNR 34860 685 BDI(I) = THETLK * BDI(I) MNR34880 GO TO 688 MNR 34900 686 BDI(I) = THETHK * BDI(I)MNR 34920 D(I) = FTOT(I) / (1. + BDI(I))MNR 34940 688 697 B(I) = BDI(I) * D(I)MNR 34960 DTRIAL = DTRIAL + D(I)MNR 34980 698 CONTINUE MNR35000 700 IF (ITR.EQ.1) GO TO 710 MNR 35020 С MNR35040 CALCULATE DISTILLATE RATE FOR HEAVY SEPARATED COMPONENTS С MNR 35060 С MNR 35080 MNR 35100 DO 702 I = IHS, NCOMP D(I) = 0.0MNR 35120 B(I) = FTOT(I)MNR35140 702 CONTINUE MNR35160

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107

MINR

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MNR 35180
  710 CONTINUE
                                                                               MNR 35200
С
      FIRST CONVERSION CHECK: CHANGE IN DISTILLATE RATE
                                                                               MNR 35220
С
                                                                               MNR 35240
С
                                                                               MNR 35260
      IF ( ABS(DTRIAL - DEST).LE.(0.001*DEST) ) ICONV = 1
                                                                               MNR 35280
      DEST = DTRIAL
                                                                               MNR 35300
      BEST = FFLOW - DEST
                                                                               MNR 35320
С
      CALC LR(STAR) FOR TRIAL.
                                                                               MNR 35340
C
                                                                                MNR 35360
      TRYLFS = 0.0
                                                                                MNR 35380
      TRYLRS = 0.0
                                                                                MNR 35400
       IDO = IHS - 1
                                                                                MNR 35420
С
                                                                                MNR 35440
      DO 720 I = 1, IDO
                                                                                MNR 35460
       S5(I) = SLFD(I) * D(I)
       TRYLRS = TRYLRS + S5(I)
                                                                                MNR35480
                                                                                MNR 35500
       S4(I) = LFD(I) * D(I)
                                                                                MNR 35520
       TRYLFS = TRYLFS + S4(I)
                                                                                MNR 35540
  720 CONTINUE
                                                                                MNR 35560
С
                                                                                MNR 35580
       IF ( ITR.EQ.1 ) GO TO 730
                                                                                MNR 35600
С
                                                                                MNR 35620
       DO 722 I = IHS, NCOMP
       S4(I) = VFB(I) * B(I) + FV(I)
                                                                                MNR35640
                                                                                MNR 35660
       TRYLFS = TRYLFS + S4(I)
                                                                                MNR 35680
  722 CONTINUE
       IF ( STGN ) 723, 723, 726
                                                                                MNR 35700
  723 DD 724 I = IHS, NCOMP
                                                                                MNR 35720
                                                                                MNR 35740
  724 S5(I) = S4(I)
                                                                                MNR 35760
       GO TO 727
                                                                                MNR 35780
  726 \text{ KSEC} = 2
                                                                                MNR 35800
       LOCA = 4
       CALL LINEAR ( STGN, LOCA, IHS)
                                                                                MNR 35820
                                                                                MNR 35840
   727 DO 728 I = IHS, NCOMP
                                                                                MNR 35860
   728 \text{ TRYLRS} = \text{TRYLRS} + \text{S5(I)}
                                                                                MNR 35880
С
                                                                                MNR35900
   730 CONTINUE
С
                                                                                MNR 35920
                                                                                MNR 35940
С
                                                                                MNR 35960
С
       CALC VS(STAR) FOR TRIAL
                                                                                MNR 35980
С
                                                                                MNR 36000
       TRYVSS = 0.0
                                                                                MNR36020
       TRYVFS = 0.0
                                                                                MNR 36040
       IDO = ILS + 1
                                                                                MNR 36060
С
       DO 740 I = IDO, NCOMP
                                                                                MNR 36080
                                                                                MNR 36100
       S3(I) = VFB(I) * B(I)
       S2(I) = SVFB(I) * B(I)
                                                                                MNR36120
       TRYVSS = TRYVSS + S2(I)
                                                                                MNR 36140
                                                                                MNR 36160
       TRYVFS = TRYVFS + S3(1)
                                                                                MNR36180
   740 CONTINUE
С
                                                                                MNR 36200
                                                                                MNR 36220
       IF ( [TS.EQ.1 ) GO TO 750
```

MNR 36240 С MNR 36260 DO 742 I = 1, ILSMNR 36280 S3(I) = S4(I) + FL(I)MNR 36300 TRYVFS = TRYVFS + S3(I)MNR 36320 742 CONTINUE MNR 36340 С MNR 36360 IF (STGM) 743,743,746 MNR 36380 743 DO 744 I = 1, ILSMNR 36400 744 S2(I) = S3(I)MNR 36420 GO TO 747 MNR 36440 С MNR 36460 746 KSEC = 1MNR 36480 LOCA = 3CALL LINEAR (STGM, LOCA, ILS) MNR 36500 MNR36520 747 DO 748 I = 1, ILSMNR 36540 748 TRYVSS = TRYVSS + S2(I)MNR 36560 С MNR 36580 750 KSEC = 2MNR 36600 С MNR 36620 С THE FOLLOWING IS INTENDED FOR TYPE ONE IN TOP AND BOTTOM SECTIONS. MNR 36640 С USES THE CALCULATED LRSTAR AS MINIMUM REFLUX ON THE NEXT TRIAL. MNR 36660 С MNR 36680 С IF ((ITR .EQ. 2) .OR. (ITS .EQ. 2)) GO TO 759 MNR 36700 MNR 36720 С MNR 36740 LRSTAR = TRYLRSMNR 36760 759 CONTINUE TEMPERATURE OF RECTIFYING PINCH ZONE. SECOND CONVERGENCE CHECK. MNR 36780 С USE AVERAGE TEMPERATURE FOR NEXT TRIAL IF OSCILLATION DEVELOPING. MNR 36800 С MNR36820 С MNR 36840 С MNR36860 TEMPERATURE OF RECTIFYING PINCH ZONE С MNR 36880 С TEMP5 = TEMP(5)MNR 36900 MNR 36920 CALL BUB (P(5), TEMP(5), S5) MNR 36940 C MNR36960 DELT = ABS (TEMP5 - TEMP(5))MNR 36980 IF (DELT - 0.1) 760, 760, 762 MNR 37000 760 ICDNV = ICDNV + 1MNR37020 GO TO 767 762 DELTR1 = TEMP(5) - TEMP5MNR 37040 IF (ITRY - 1) 768, 768, 764 MNR37060 MNR37080 764 IF (DELTR1 / DELTR2) 766, 766, 768 766 TEMP(5) = (((TEMP(5) + TEM5) / 2.) + TEMP5) / 2. MNR 37100 767 DELTR1 = TEMP(5) - TEMP5MNR 37120 MNR 37140 768 DELTR2 = DELTR1 MNR 37160 TEM5 = TEMP5TEMPERATURE OF STAGE ABOVE FEED С MNR 37180 MNR 37200 С MNR 37220 769 CALL BUB (P(4), TEMP(4), S4) MNR 37240 C TEMPERATURE OF DISTILLATE (LIQUID) MNR 37260 С

MINR

С

MNR 37280

MINR MNR 37300 CALL BUB (P(6), TEMP(6), D) MNR 37320 С MNR 37 340 С KSEC = 1MNR 37360 MNR 37380 С TEMPERATURE OF STRIPPING PINCH ZONE. THIRD CONVERGENCE CHECK. MNR 37400 C USE AVERAGE TEMPERATURE FOR NEXT TRIAL IF OSCILLATION DEVELOPING. MNR37420 С MNR 37440 TEMP2 = TEMP(2)MNR 37460 С CALL DEW (P(2), TEMP(2), S2) MNR 37480 MNR 37500 С DELT = ABS (TEMP2 - TEMP(2))MNR 37520 IF (DELT - 0.1) 770, 770, 772 MNR 37540 770 ICONV = ICONV + 1 MNR 37560 С MNR 37580 GO TO 777 MNR 37600 С MNR 37620 772 DELTS1 = TEMP(2) - TEMP2 MNR 37640 IF (ITRY - 1) 778, 778, 774 MNR 37660 774 IF (DELTS1 / DELTS2) 776, 776, 778 MNR37680 776 TEMP(2) = (((TEMP(2) + TEM2) / 2.) + TEMP2) / 2. MNR 37700 777 DELTS1 = TEMP(2) - TEMP2MNR 37720 778 DELTS2 = DELTS1 MNR 37740 MNR 37760 TEM2 = TEMP2TEMPERATURE OF FEED STAGE С MNR 37780 MNR 37800 С 779 CALL DEW (P(3), TEMP(3), S3) MNR 37820 С MNR37840 TEMPERATURE OF BOTTOMS MNR37860 С CALL BUB (P(1), TEMP(1), B) MNR 37880 С MNR 37900 С MNR 37920 IF (ICONV.EQ.3) GO TO 1010 MNR 37940 С MNR 37960 IF (ITRY - NTRY) 200,1010,1010 MNR37980 1000 CONTINUE MNR 38000 С MNR 38020 NO CONVERGENCE ON LESTAR FOR TYPE ONE IN TOP AND BOTTOM. С MNR38040 8888 CONTINUE MNR 38060 С MNR 38080 1010 IF ((ITR.EQ.1).AND.(ITS.EQ.1)) GO TO 1196 MNR38100 С USES THETA LK OR THETA HK FOR CONVERGENCE ADJUSTMENT ON LESTAR. MNR 38120 LRSTR1 = LRSTARMNR 38140 DTHL1 = THETLK - 1.0MNR 38160 $\mathsf{DTHH1} = \mathsf{THETHK} - 1.0$ MNR 38180 CHECK FOR TYPE TWO TOP AND TYPE ONE BOTTOM. CONTINUE FOR THIS С MNR 38200 CASE AND CONVERGE ON DEVIATION OF THETA LK FROM 1.0. IF THETA LK С MNR 38220 IS WITHIN TOLERANCE THE CALCULATION IS FINISHED. С MNR 38240 IF (ITS .EQ. 2) GO TO 1100 MNR 38260 ADTHLK = ABS (DTHL1 - 0.001)MNR 38280 IF (ADTHLK) 1200, 1200, 1020 MNR 38300 IF THIS IS SECOND TRIAL OR GREATER GO TO INTERPOLATION FOR LRSTAR.MNR38320

C IF THIS IS SECOND TRIAL OR GREATER GO TO INTERPOLATION FOR LRSTAR.MNR38320 C IF THIS IS FIRST TRIAL USE ARBITRARY FACTORS TO ADJUST LRSTAR BUT MNR38340

	MINR	
С	FIRST CHECK TO SEE IF JHK IS GREATER THAN ZERO. THIS WOULD MEAN	MNR 38360
С	TYPE SYSTEM HAS CHANGED AND CALCULATION IS STOPPED.	MNR 38380
	IF (JLK .GT. 0) GO TO 1080	MNR 38400
	IF (JHK .EQ. 0) GO TO 1050	MNR 38420
	PRINT 1045	MNR 38440
	FORMAT ('0', 5X, ***** CONVERGENCE PATH ON LESTAR HAS SWITCHED FRUM	
]	LTHETA HK TO THETA LK ****)	MNR 38480
	STOP	MNR 38500
	IF (DTHL1) 1060, 1200, 1070	MNR 38520
1060		MNR 38540
1070	GO TO 1090	MNR 38560
1070	LRSTAR = LRSTAR * 1.05	MNR 38580
1090	GO TO 1090 LRSTAR = (LRSTR1*DTHL2 - LRSTR2*DTHL1) / (DTHL2 - DTHL1)	MNR 38600 MNR 38620
	JLK = JLK + 1	MNR38640
1090	GO TO 1195	MNR 38660
С	CHECK FOR TYPE TWO TOP AND BOTTOM. TEMPOARY STOP FOR THIS CASE.	MNR 38680
	IF (ITR.EQ.2) GO TO 1200	MNR 38700
C	CONTINUE FOR TYPE ONE TOP AND TYPE TWO BUTTOM AND CONVERGE ON	MNR 38720
č		MNR38740
č	THE CALCULATION IS FINISHED.	MNR 38760
°,	ADTHHK = ABS(DTHH1 - 0.001)	MNR 38780
	IF (ADTHHK) 1200, 1200, 1120	MNR 38800
С	IF THIS IS SECOND TRIAL OR GREATER GO TO INTERPOLATION FOR LESTAR	MNR 38820
С	IF THIS IS FIRST TRIAL USE ARBITRARY FACTORS TO ADJUST LESTAR BUT	MNR 38840
С	FIRST CHECK TO SEE IF JLK IS GREATER THAN ZERO, THIS WOULD MEAN	MNR38860
С	TYPE SYSTEM HAS CHANGED AND CALCULATION IS STOPPED.	MNR 38880
С	INITALIZE N AND M AT FIVE.	MNR 38900
1120	IF (JHK .GT. 0) GO TO 1180	MNR 38920
	IF (JLK .EQ. 0) GO TO 1150	MNR 38940
	PRINT 1145	MNR 38960
	FORMAT ('0', 5X, '**** CONVERGENCE PATH ON LRSTAR HAS SWITCHED FROM	MNR 38980
	1THETA LK TO THETA HK #*##)	MNR 39000
	STOP	MNR 39020
	IF (DTHH1) 1160, 1200, 1170	MNR 39040
1160	LRSTAR = LRSTAR * 0.95	MNR 39060
1170	GO TO 1190	MNR 39080
1170	LRSTAR = LRSTAR * 1.05 GU TO 1190	MNR 39100
1190	LRSTAR = (LRSTR1*DTHH2 - LRSTR2*DTHH1) / (DTHH2 - DTHH1)	MNR 39120
	JHK = JHK + 1	MNR 39140 MNR 39160
	LRSTR2 = LRSTR1	MNR 39180
	DTHL2 = DTHL1	MNR 39200
	DTHH2= DTHH1	MNR 39220
	ITRY = 1	MNR 39240
1196	JTRY = JTRY + 1	MNR 39260
	IF (MTRY - JTRY) 1200, 1200, 200	MNR 39280
1200	STOP	MNR 39300
С		MNR39320
С		
С		
	END	

END

OPTIONS IN EFFECT ID, EBCDIC, SOURCE, NOLIST, NODECK, LOAD, NOMAP *OPTIONS IN EFFECT* NAME = MINR , LINECNT = 55 *STATISTICS* SOURCE STATEMENTS = 432, PROGRAM SIZE = 9836 *STATISTICS* NO DIAGNOSTICS GENERATED

STATISTICS NO DIAGNOSTICS THIS STEP 2

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