## ABSTRACT

Chemical process simulation programs have become an indispensable tool to chemical engineers in the preparation of heat and material balances, and energy conservation studies. Since the 1960's several dozen process simulators have been developed which are in use today within companies and through computer service bureaus. Due to advances in the areas of unit operation analysis and thermodynamic relations, these programs require periodic modification. This thesis describes the programming modifications made to the Chemical Engineering Simulation System (CHESS) version 2.0, computer program. This undertaking was considered warranted since no improvements have been made to CHESS since its release in 1971. The objective is to produce a version which is more useful to practicing engineers and students than version 2.0.

Many features of CHESS were found to be inferior to other simulators such as ChemShare's DESIGN II and SimSci's PROCESS which are considered by many as the industrial standards. The identified deficiencies are (1) lack of an extensive thermodynamics package, (2) simplified treatment of unit operations, (3) components restricted to hydrocarbons, (4) maximum of 20 components per stream, and (5) brief output.

The following improvements to CHESS have been made, Producing version 2.1:

- A new equipment module, COMP, has been added to simulate the operation of a single stage gas compressor. The outlet conditions and power requirement are determined to increase the pressure of a gas stream. The adiabatic and mechanical efficiencies are included in the calculation of power requirement. Multi-stage compressors must be handled as individual stages in series. This new module replaces the compression calculations in the PUMP module which was inflexible and gave incorrect results.

- PUMP module has been modified to strictly handle the simulation of liquid pumping. The outlet conditions and power requirement to increase the pressure of a liquid stream are determined. The mechanical efficiency of the pump is included in the power requirement. The energy requirement is added to the feed enthalpy to determine the outlet temperature.

- The Fahrenheit temperature scale is now used in input/output data, replacing Rankine.

- Petroleum fraction components may be defined by the user. CHESS will automatically calculate all the necessary physical constants from boiling point, density and molecular weight information supplied in the input data. The capability to define non-standard, user defined components has been retained.

- An additional summary of the mass rates (lbs/hr) of the components in each stream will be printed at the end of the simulation.

- A summary of seventeen properties including viscosity, thermal conductivity and density for each stream will be printed at the end of the simulation.

- Heat release curves (temperature v.s. enthalpy) for specified temperature and pressure limits can be calculated for a maximum of five streams in the simulation.

Use of version 2.1 of CHESS provides more useful and practical information about the process and additional simulation capabilities than version 2.0. Compressors and pumps may now be simulated in a more realistic manner using the new COMP and PUMP modules. The calculation of heating/cooling curves provides useful information for the design of heat exchangers (e.g., reboilers and condensers). The stream properties summary provides all the necessary physical properties for equipment design and specification. In addition, the specification of petroleum fraction components in the input data has been simplified.

It is recommended that further improvements be made to CHESS in the areas of unit operations and thermodynamics in future work.

# IMPROVING THE CAPABILITIES

# OF THE

# CHEMICAL ENGINEERING SIMULATION SYSTEM (CHESS) COMPUTER PROGRAM

BY

THOMAS J. ZVOLENSKY, JR.

A THESIS

PRESENTED IN PARTIAL FULFILLMENT OF

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APPROVAL OF THESIS

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FOR

DEPARTMENT OF CHEMICAL ENGINEERING AND CHEMISTRY

NEW JERSEY INSTITUTE OF TECHNOLOGY

BY

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## PREFACE AND ACKNOWLEDGEMENTS

Since the development of CHESS, significant advances in the areas of thermodynamics, properties prediction and unit operations have been made. If a flowsheet simulation program is to remain a useful tool, it must keep pace with these advances. It is therefore necessary to periodically improve and expand the capabilities of an existing program.

This thesis presents the successful development of a new, improved version of the CHESS process simulation program. The modifications and improvements made represent only a sample of what is necessary to upgrade the program to the level of technology available in other process simulators. Suggestions for further work are included in this report.

The writer wishes to thank Professor Edward C. Roche for his guidance and comments during the preparation of this thesis. The writer would also like to thank Foster Wheeler Energy Corporation for the use of their computer terminals and telephone lines during the programming phase of this work.

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May 1985 Thomas J. Zvolensky, Jr.

TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

# CHAPTER I

# INTRODUCTION

## Background and Objectives

The science of steady state computer chemical process simulation combines the expertise of chemical engineering, mathematics, and data processing into a single computer program. In the late 1950's, simulation programs were first written in machine language and were designed to simulate only a specific type of process. These programs were completely inflexible and were incapable of dealing with minor flowsheet changes which are always inevitable. In the 1960's, modular simulators written in FORTRAN were developed to provide flexibility and allow the user to describe the structure of the process flowsheet to the program at each computer run. Thus, only one program is needed to simulate a wide variety of processes.

Process simulation is the representation of a chemical process via a mathematical model which is solved to either design or evaluate the performance of the process. Most simulators have the capability to operate in the simulation/rating/performance mode or the design mode. In the rating mode, all of the operating characteristics (e.g. reflux ratio, condenser duty etc.) are specified for a particular unit module. The performance of the equipment is then determined based on these specifications. In the design mode, the desired performance of an equipment module is specified and the operating characteristics are determined. It is common to have some units operating in the rating mode and others in the design mode in the same simulation problem.

All modular flowsheet simulators, regardless of architecture, have essentially four common characteristics:

1. Input Interface - consists of routines which read problem data provided by the user to define the structure of the process flowsheet, establish equipment operating and design parameters, define the composition and thermal condition of the feed streams, and establish convergence tolerance limits.

2. Process Modules - a group of subroutines which perform the calculations of the various unit operations in the process.

3. Thermodynamics - a group of routines which provide enthalpy, entropy, density, and vapor-liquid equilibrium K-values to the process module routines.

4. Output Interface - gathers and displays the results of the simulation calculations for the user to review.

Items 2 and 3 above are considered the most vital components because the quality of the mathematical models and correlations provided, determine the type of processes and unit operations which may be simulated. Their accuracy is also an important consideration. Therefore, it is necessary that these components be as rigorous and flexible as possible.

There are several general-purposes simulators available today which can be accessed through service bureaus. The most widely used programs in the chemical and petroleum industries are PROCESS and DESIGN II. These programs are marketed and maintained by the Simulation Sciences and the CHEMSHARE companies which specialize in simulation technology. Both firms work continually at improving the capabilities of their programs to keep pace with the demands from industry.

The CHESS program, version 2.0 was developed at the University of Houston under the direction of R. L. Motard and H. M. Lee in 1971. Although this simulator contains all of the above mentioned components, its simplified treatment of unit operations and lack of a comprehensive thermodynamics package often restrict its use to trivial simulation problems. With these limitations, CHESS cannot compare with PROCESS or DESIGN II in power and flexibility. This can be attributed to the fact that it was written for academic use rather than for simulation of industrial processes.

The objective of this thesis with regard to the CHESS program is threefold:

1. Those aspects of CHESS which are obsolete and require improvement are identified. The features and capabilities provided in the PROCESS and DESIGN II programs were used as a basis for comparison.

2. Seven programming improvements were selected and implemented into CHESS to produce version 2.1. The changes made improved the usefulness of the program as a design tool by providing more information and capabilities than version 2.0. The CHESS USER'S GUIDE has also been re-written to reflect the changes made in this thesis.

3. A list of further improvements which should be made to CHESS is given for consideration in future work.

<u>Deficiencies of the CHESS Program</u>

Users of the PROCESS and DESIGN II simulation programs enjoy the benefits of advanced features such as a large chemical component library, extensive thermodynamic properties prediction methods, and the most advanced and flexible unit operations techniques. In addition, a complete output consisting of stream molal, weight and extensive physical properties are provided. The solutions of the individual unit simulations are also included. There are many other features and capabilities available which are too numerous to mention. Process engineers in industry require this degree of flexibility and power in a program because of the many different types of processes and chemical systems which must be simulated.

The CHESS program (version 2.0), which was written for academic use as a teaching tool, does not contain the degree of sophistication described above. All of the standard unit operations encountered in chemical and petroleum processes are provided but do not utilize rigorous calculation methods. The prediction of thermodynamic properties is limited to just one method for enthalpy departure and one method for vapor-liquid equilibrium K-values. In addition, the information provided in the output is brief and incomplete. In comparison to the capabilities of PROCESS and DESIGN II, CHESS is clearly inferior.

The specific short-comings of CHESS are described in detail below in Items 1. through 6.

1. <u>Distillation</u>

   CHESS contains two unit modules, DISC and MSEQ, which are used for simulating distillation columns. DISC is a short-cut distillation module which utilizes the Fenske-Underwood-Gilliland method for design and rating calculations. MSEQ simulates the performance of a column as a series of adiabatic flashes performed at each equilibrium stage. Both of these modules are very limited in capabilities and cannot handle complex configurations such as crude distillation or reboiled absorber/strippers. This simplified treatment of distillation is a great disadvantage to the user because simple, single feed columns are not always encountered. For this reason, a rigorous, Newton-Raphson distillation algorithm is a necessity in a process simulator.

2. <u>Compression/Pumping</u>

   The PUMP module in CHESS is used to simulate gas compression and liquid pumping. The combination of these two unit operations in the same module can cause some confusion to the user, but is done because of their simular nature.

Within the application of the isentropic compressor calculations, the following three flaws were noticed:

a) The actual discharge temperature of the compressed gas is not determined. Instead, the heat of compression is removed from the discharge stream which is cooled to the temperature level of the input stream.

b) The adiabatic/polytropic efficiency is not included in the calculation of power requirement.

c) The heat capacity ratio of the inlet gas is assumed to be 1.27.

Due to these deficiencies, the information obtained from this module could not be used to evaluate the performance of an existing compressor or for the specification of a new unit. Since the adiabatic or polytropic efficiency is not accounted for, the power requirement calculated is a theoretical value. The assumed value for the gas heat capacity ratio introduces an error in the power requirement because it is not constant for every gas mixture. This quantity should be determined dynamically for each stream that is compressed. Finally, since the actual (adiabatic) discharge temperature is not determined, the user must calculate it by hand to determine if it is within mechanical limits.

3. Flash Calculations

Equilibrium flash calculations are performed in the CHESS module ADBF. Only isothermal (T & P fixed) and adiabatic (P & H fixed) flashes can be performed on a single stream. Both of these options perform well, but may not always be sufficient to meet the needs of the user. In some instances, it may be necessary to determine the required temperature for a specific vapor fraction and pressure. Using CHESS, this would require trial-and-error resulting in several computer runs to obtain the desired value. CHESS is also not capable of performing three phase flashes which are encountered in many chemicals and petroleum processes.

4. Thermodynamics

The prediction of thermodynamic properties within CHESS is limited to the Redlich-Kwong equation of state for liquid and vapor enthalpy departure and the Grayson-Streed correlation for equilibrium k-values. Liquid density is calculated from the Yen-Woods correlation and vapor density from the Redlich-Kwong equation of state. Since the application of these methods is mainly restricted to non-polar hydrocarbons, they could not be used reliably on some chemicals or water.

Most simulators such as PROCESS and DESIGN II contain a very extensive set of methods which cover the full range of process conditions encountered in the hydrocarbon, chemical and synthetic fuels industries. They also allow the user to enter his/her own equilibrium, enthalpy and entropy data in tabular or equation form as functions of temperature and pressure. This level of flexibility is not available in CHESS.

5. Output

The output from the CHESS program includes the following information:

- Input data
- Calculational trace
- Results of intermediate recycle calculations
- Stream component molal rates
- Unit module solutions

There are two areas of the output printout which require improvement. More information about streams such as component mass rates and physical properties (density, viscosity, thermal conductivity, etc.) should be provided to aid in equipment sizing calculations and specifications. Since these calculations are complex and require large amounts of data, they are best suited for the computer. The information given in the unit operations solutions should also be expanded to decrease the amount of hand calculations by the user. Data such as distillation column tray loadings could be added for example.

6. General Drawbacks

The following are general drawbacks and disadvantages of CHESS:

- The maximum number of components per stream is 20
- The Rankine temperature scale is used in input/output of streams and unit module parameters.

- Water may only be a constituent of a gas stream. No provisions are made in ADBF (flash module) to handle water as a separate liquid phase.

- Dimensional units are restricted to the English system. No flexibility is provided for Metric or SI units.

## Comparison of the Capabilities of CHESS, DESIGN II and PROCESS

Given in Tables IA, IB and IC are brief comparisons of the general capabilities, unit operations and thermodynamic capabilities of the CHESS, DESIGN II and PROCESS simulation programs. They illustrate the many areas in which CHESS is deficient as well as what capabilities are desirable in a process simulation program.

Table IA
Comparison of General Program Features

| | | DESIGN II[3] | PROCESS[24] | CHESS[10] |
|---|---|---|---|---|
| 1. | Maximum Numbers of Components per stream | 50 | 50 | 20 |
| 2. | Dimensional units | English<br>Metric<br>SI | English<br>Metric<br>SI | English |
| 3. | Information included in Output | Unit Solutions, Stream Molal rates, composition, mass rates and properities | Unit Solutions, Stream Molal rates, compositions, mass rates and properties | Unit Solutions, Stream Molal rates |
| 4. | Recycle Convergence promotion | Direct Substitution, Wegstein | Direct sub-Substitution Wegstein | Direct Substitution Wegstein |
| 5. | Automatic determination of equipment in recycle loops | Yes | Yes | Yes |
| 6. | Flowsheet restart | Yes | Yes | Yes |
| 7. | Unit module calculation tracing | Yes | Yes | Yes |
| 8. | Case studies | Yes | Yes | Yes |

Table IB

Comparison of Unit Operations

| | | DESIGN II[3] | PROCESS[24] | CHESS[10] |
|---|---|---|---|---|
| 1. | Rigorous multicomponent distillation | Yes | Yes | No |
| 2. | Short-cut distillation | Yes | Yes | Yes |
| 3. | Liquid-liquid extraction | Yes | Yes | No |
| 4. | Controller Module | Yes | Yes | Yes |
| 5. | Compressor | Yes | Yes | Yes |
| 6. | Expander | Yes | Yes | No |
| 7. | Three phase flash | Yes | Yes | No |
| 8. | Reactor | Yes | Yes | Yes |
| 9. | Flowsheet Optimizer | No | Yes | No |
| 10. | Heating/Cooling property curves | Yes | Yes | No |
| 11. | User Added modules | Yes | Yes | Yes |

## Table IC

## Comparison of Thermodynamic capabilities

| | | DESIGN II[3] | PROCESS[24] | CHESS[10] |
|---|---|---|---|---|
| 1. | Size of pure component library | 857 | 900 | 98 |
| 2. | User-defined components | Yes | Yes | Yes |
| 3. | Petroleum fraction components | Yes | Yes | No |
| 4. | Number of generalized methods for equilibrium K prediction | 9 | 8 | 1 |
| 5. | Number of activity coefficient models | 4 | 9 | 0 |
| 6. | Number of generalized methods for enthalpy prediction | 9 | 8 | 1 |
| 7. | Simulation of electrolyte mixtures | No | Yes | No |
| 8. | User supplied thermodynamic data permitted | Yes | Yes | No |

# CHAPTER II

## DESCRIPTION OF PROGRAMMING CHANGES

### New Module for Gas Compression (COMP)

A new unit module COMP, has been added to CHESS to simulate a single stage isentropic compressor. The outlet conditions and power requirement are calculated using adiabatic and mechanical efficiencies. If an existing compressor is to be simulated, the brake horsepower of the driver may be specified in the input. If the required horsepower exceeds the driver limitation, the outlet conditions corresponding to the maximum horsepower available are determined.

The required horsepower to raise the pressure of a gas stream is calculated by the adiabatic (isentropic) formulas[7]:

$$H_{ad} = \frac{1545}{MW} \cdot \frac{Z\,T_1}{M}\left[\left(\frac{P_2}{P_1}\right)^{M} - 1\right]$$

$$\text{Gas horsepower} = \frac{(\text{lbs/MIN}) \cdot H_{ad}}{E_{ad} \cdot 33000}$$

$$\text{Brake horsepower} = \text{Gas horsepower}/E_{mech}$$

where;

$H_{ad}$ - adiabatic head, ft - lbs/lb of gas

MW - gas molecular weight

$Z$ - gas compressibility factor

$T_1$ - inlet temperature of gas, °R

$M$ - K-1/K, dimensionless

$K$ - gas heat capacity ratio, Cp/Cv

$E_{ad}$ - compressor adiabatic efficiency

$E_{mech}$ - Compressor mechanical efficiency

The discharge conditions are evaluated assuming no heat losses to the surroundings (adiabatic operation).

discharge enthalpy = Gas horsepower/2547 + inlet enthalpy

The actual discharge temperature is determined at the discharge pressure and enthalpy using CHESS subroutine TSUBH. If the required horsepower exceeds the driver capacity, the following calculations are performed:

$$WCAP = \text{Driver brake horsepower} * E_{mech}$$

$$H_{ad} = WCAP * E_{ad} * 33000/(\text{lbs/min})$$

$$\frac{P_2}{P_1} = \left[\frac{H_{ad} \cdot MW \cdot M}{1545 \cdot Z \cdot T_1} + 1\right]^{\frac{1}{M}}$$

$$P_2 = P_1 \left(\frac{P_2}{P_1}\right)$$

The discharge conditions are then evaluated as previously described. Default values for adiabatic efficiency (0.70) and mechanical efficiency (0.90) are used in the calculations if not specified in the input.

To avoid execution-time errors or unrealistic situations, the following conditions are checked for:

1. suction moles/hr < 1E-07

2. stream vapor fraction < 0.999

3. P2 < P1

Should any one of these exist, the input stream to the module is transferred to the output stream and the compression calculations are by-passed.

Within NAMELIST/EQLIST/,the compressor module (COMP) is specified as follows:

EQPJ = J, WCAP, P2, EA, EM, ACFM, BHP, 18*0,

where;

J - equipment node

WCAP - driver brake horsepower (optional)

P2 - discharge pressure, psia

EA - adiabatic efficiency (default = 0.70)

EM - mechanical efficiency (default = 0.90)

ACFM - inlet gas volume, actual $ft^3$/min (calculated by program)

BHP - driver shaft power required, horsepower (calculated by program)

PUMP Module Modified for Liquid Pumping

The PUMP module which was used for compression and pumping in version 2.0, has been modified to simulate exclusively liquid pumping. This change, along with the addition of the COMP subroutine, was done to separate the two unit operations into different unit modules. The accuracy of the two new modules is improved through the use of better calculational techniques. The information displayed in the program is also more useful to the user than version 2.0.

PUMP computes the outlet conditions and power requirement to increase the pressure of a liquid stream. The mechanical efficiency of the pump is included in the driver horsepower required. If an existing pump is simulated, the brake horsepower of the driver may be specified in the input. If the required horsepower exceeds the driver limitation, the outlet conditions corresponding to the available horsepower are determined.

The horsepower needed to raise the pressure of a liquid stream is calculated as follows:

$$\Delta P = P2 - P1$$

$$\text{Fluid Horsepower} = GPM * \Delta P/1715$$

$$\text{Brake Horsepower} = \text{Fluid Horsepower}/E_{mech}$$

where;

P1 - inlet pressure, psia

P2 - discharge pressure, psia

GPM - liquid volume, US gallons/minute

$E_{mech}$ - pump mechanical efficiency, fraction (default = 0.90)

The discharge conditions are evaluated assuming no heat loss to the surroundings (adiabatic operation).

$$\text{Discharge Enthalpy} = \text{Fluid Horsepower}/2547 + \text{Inlet Enthalpy}$$

The discharge temperature is determined at the discharge enthalpy using CHESS subroutine TSUBH.

If the required horsepower exceeds the driver capacity, the following calculations are performed:

$$WCAP = \text{Driver Horsepower} * E_{mech}$$

$$\Delta P = WCAP * 1715/GPM$$

$$P2 = P1 + \Delta P$$

The discharge conditions are then evaluated as previously described.

A default value of 0.90 is used for the pump mechanical efficiency if it is not specified in the input.

To avoid execution-time errors or unrealistic situations, the following conditions are checked for:

1. suction moles/hr $<$ 1E-07
2. stream vapor fraction $>$ 0.001
3. $P2 < P1$

Should any of these exist, the input stream is transferred to the output stream and the pump calculations are by-passed.

Within NAMELIST/EQLIST/, A PUMP module is specified as follows:

EQPJ = J, WCAP, P2, EM, GPM, BHP, 19 * 0,

where;

J - equipment node

WCAP - driver brake horsepower (optional)

P2 - discharge pressure, psia

EM - Pump mechanical efficiency (default = 0.90)

GPM - liquid volume, US gallons/min (calculated by program).

BHP - driver brake horsepower (calculated by program)

Faherenheit Temperature Scale Used for Input/Output

In CHESS version 2.0, the Rankine temperature scale is used for stream temperature and equipment module parameters. Use of an absolute temperature scale is an inconvenience since most engineers are accustomed to the Faherenheit or Celsius scales. The purpose of this modification to CHESS is to allow the user to work with stream temperatures and equipment parameters in degrees Faherenheit.

A new supporting subroutine named CONVRT, has been added to CHESS 2.1 to convert temperatures in the input data from degrees Farenheit to Rankine. After the simulation calculations are completed, CONVRT is called again to convert Rankine temperatures back to Faherenheit for printout of results.

Four existing CHESS subroutines (DREAD, EQFORM, EQPRINT and TPRINT) have been modified to accommodate this change. Subroutines DREAD, EQPRNT and TPRINT call CONVRT during the simulation. Format statements in EQFORM and TPRINT have been changed to print °F for equipment parameters and stream temperatures.

## New Way to Define Petroleum Fraction Components

In CHESS, components not included among the 98 standard components are defined in the input using NAMELIST/NSCOMP/. For each non-standard component, eleven physical constants must be provided to enable the prediction of a physical and thermodynamic properties.

In petroleum processes, engineers often utilize "petroleum" fraction components to characterize the behavior of heavy, high boiling streams such as diesel, gas oils or residues. Since these streams consist of several hundred components, it is not practical to attempt to identify each one. Petroleum fractions are created by breaking-up the TBP(true boiling point) vaporization curve of a stream into volumetric sections. The mid TBP temperature, API gravity and molecular weight of each section (or petroleum fraction) are then determined and are used to characterize the "average" properties of the fraction.

Since petroleum fractions are pseudo-components, their properties cannot be found in any publication and must be calculated from correlations found in the literature. Since these calculations are long and laborious, they are better suited for computer programs.

Because of their differences, non-standard and petroleum fractions components are specified differently within CHESS 2.1. A new input NAMELIST, PFCOMP has been added to CHESS 2.1 to allow the user to define petroleum fractions in a simple format. For each fraction, only mid TBP temperature (in °F), API gravity and molecular weight (optional) are required. From this information, all the necessary physical constants will be generated within CHESS. A new subroutine PROP, has been added to perform this task.

The procedure to generate the thermodynamic constants in PROP is as follows:

1. Compute the specific gravity @ 60°F,

$$SPGR = 141.5/(API + 131.5)$$

2. Compute the Characterization factor,

$$UOPK = \left[\frac{TBP + 459.7}{SPGR}\right]^{1/3}$$

3. Calculate density @ 25°C

$$D25 = 0.98907(SPGR),\ gm/cm^3$$

4. If not specified, calculate the molecular weight[11],

$$AMW = 1.435 \times 10^{-5}\ (TBP)^{2.3776}/(SPGR)^{0.9371}$$

5. Calculate the liquid molal volume @ 25°c,

$$V25 = AMW/D25,\ Cm^3/gm\text{-}mole$$

6. Calculate the pseudocritical temperature[2],

$$ATC(°R) = A_o + A_1\ (TBP) + A_2\ (TBP)^2 + A_3\ (API)\ (TBP) + A_4\ (TBP)^3 + A_5\ (API)\ (TBP)^2 + A_6\ (API)^2\ (TBP)^2$$

7. Calculate the pseudocritical pressure[2]

$$\log_{10} APC\ (psia) = b_o + b_1\ (TBP) + b_2\ (TBP)^2 + b_3\ (API)\ (TBP) + b_4\ (TBP)^3 + b_5\ (API)\ (TBP)^2 + b_6\ (API)^2\ (TBP) + b_7\ (API)^2\ (TBP)^2$$

8. Calculate the characteristic molar volume[5],

$$AW = \frac{V25}{5.7 + 3.0\left(\frac{536.69}{ATC}\right)},\ cm^3/gm\text{-}mole$$

9. Calculate the acentric factor[6]

$$\text{AOMEG} = \frac{(3/7)\log_{10}\left(\frac{APC}{14.7}\right)}{\frac{ATC}{TBP+459.7} - 1}$$

10. Calculate the heat of vaporization at the normal boiling point[8],

$$\Delta H_{vb} = [7.58 + 1.987 \ln(TBP+459.7)](TBP + 459.7)/1.8$$

11. Adjust the heat of vaporization to 25°C, [25],

$$\Delta H_{v25} = \Delta H_{vb}\left[\frac{ATC - 536.69}{ATC - (TBP+459.7)}\right]^{0.38}$$

12. Compute solubility parameter,

$$\text{ADEL} = \left[\frac{\Delta H_{v25} - 592.4439}{V25}\right]^{1/2} \quad ,(\text{Cal/cm}^3)^{1/2}$$

13. Compute the critical volume[9],

$$\text{ZC} = 1/(3.43 + 6.7 \times 10^{-9}\,\Delta H_{vb}^2)$$

$$\text{AVC} = \text{ZC} * \text{ATC} * 670.14/\text{APC}$$

14. Compute the constants for the ideal gas heat capacity equation[1],

$$\text{APH} = -0.35644 + 0.2972(\text{UOPK}) + A_4(0.29502 - 0.24846/\text{SPGR})$$

$$\text{BET} = (10^{-4})\,[2.9247 - (1.5524 - 0.05543\,\text{UOPK}) * \text{UOPK} + A_4\,(6.0283 - 5.0694/\text{SPGR})]$$

$$\text{GAM} = -(10^{-7})\,(1.6946 + 0.0844A_4)$$

$$A4 = \left[\left(\frac{12.8}{\text{UOPK}} - 1.0\right)\left(1.0 - \frac{10.0}{\text{UOPK}}\right)(\text{SPGR} - 0.885)(\text{SPGR} - 0.70)(10^4)\right]^4$$

$$10.0 < \text{UOPK} < 12.8 \text{ with } 0.70 < \text{SPGR} < 0.885$$

A4 = 0.0 outside this limit

DTA = 0.0

In CHESS 2.1, petroleum fractions are assigned component numbers greater than 200 in the COMPNT vector in NAMELIST/PMLIST/. Non-standard components are assigned component numbers from 100 - 199.

Petroleum fractions are specified in NAMELIST /PFCOMP/ as follows:

BP(I) = The mid TBP (true boiling point) temperature of the fraction, °F

API(I) = The API gravity of the fraction

ZMW(I) = The molecular weight of the fraction (optional - will be calculated from BP & API if a value is not specified)

Where I = position of the fraction in the COMPNT vector (1-20)

In the "INPUT DATA" section of the CHESS output, the eleven required physical constants for the non-standard and petroleum fraction components will be printed. This will allow the user to check that the component data was entered correctly.

If there are no petroleum fraction components, NAMELIST /PFCOMP/ is omitted from the input data for the problem.

Summary for Stream Componential Mass Rates

At the end of a converged problem, a new summary of the mass rates (lbs/hr) for the components in every stream will be printed. This information is useful for the determination of weight percents of a single component or group of components in a stream.

A new subroutine named WTRATE has been added to CHESS to calculate the lbs/hr of all components in the stream in the simulation. Subroutine TPRINT which calls WTRATE, has been modified to print out the stream mass summary directly following the printing of the stream molal summary. The stream mass summary will only be printed when "FINAL RESULTS" are obtained. The printout will be bypassed for input data and intermediate results.

Summary for Stream Properties

In addition to the summary for stream componential mass rates, a summary of seventeen properties for each stream in the simulation has been added to the CHESS output. The properties provided are useful to the engineer in equipment design calculations and specifications. Two new subroutines PRPCAL and PPRINT have been added to calculate and print the following stream properties:

1. Temperature, °F

2. Pressure, psia

3. lb-moles/hr

4. lbs/hr

5. Molecular weight

6. Pseudo Critical Temp., °F

7. Pseudo critical Pressure, psia

8. Acentric Factor

9. Compressibility Factor

10. Vapor Density, lbs/cu Ft

11. Vapor cu ft/min

12. Liquid Density, lbs/Cu FT

13. Liquid API @ 60°F

14. Liquid Gallons/min

15. Specific Heat, BTU/lb°F

16. Viscosity, centipoise

17. Thermal Conductivity, BTU/HR FT °F

The stream properties summary will be printed only when converged "FINAL RESULTS" are achieved for the problem. For vapor streams, properties 1 - 12 and 15 - 17 will be calculated. For liquid streams, properties 1 - 9 and 12 - 17 are calculated. Two-phase streams will only have properties 1 - 8 calculated.

Five new subroutines LPVIS, VISLIQ, GASVIS, LIQTK and GASTK have been added to compute stream viscosity and thermal conductivity. They utilize well known methods found in the literature. The procedure for calculating the stream properties is discussed below:

1. stream temperature - is retrieved from the SINTSV stream array, SINTSV(4,J)

2. stream pressure - is retrieved from the SINTSV stream array, SINTSV(5,J)

3. lb - mols/hr - is retrieved from the SEXTSV stream array, SEXTSV(3,J)

4. lbs/hr - is calculated from the stream molal rates and component molecular weights:

$$\text{lbs/hr} = \sum_{I=1}^{n} \text{SEXTSV(I,J)} * \text{AMW(I)}$$

5. molecular weight - is obtained from the division of property 4 by property 3.

6. Pseudocritical Temperature - is obtained from a molal average of the component critical temperatures (Kay's Rule):

$$\text{TC} = \sum_{I=1}^{n} \left[\text{mole fraction(I)} * \text{ATC(I)} - 459.7\right]$$

7. Pseudocritical Pressure - is calculated by a molal average of the component critical pressure (Kay's Rule):

$$\text{PC} = \sum_{I=1}^{n} \left[\text{mole fraction(I)} * \text{APC (I)}\right]$$

8. Acentric Factor - is calculated by a molal average of the component acentric factors:

$$\omega = \sum_{I=1}^{n} \text{mole Fraction (I)} * \text{AOMEG(I)}$$

9. Compressibility factor - CHESS subroutine ZDENS is called to perform the calculation.

10. Vapor density - subroutine ZDENS is called to calculate Z at the temperature and pressure of the stream. The gas law equation is then applied,

$$\rho_v = MW * P/(Z * R * T)$$

11. Vapor cu ft/min - calculated as follows:

$$ACFM = \text{vapor lb/hr}/(\rho_v * 60)$$

12. Liquid density, lbs/cu ft - subroutine ZDENS is first called to calculate the liquid compressibility ZL, then:

$$\rho_L = MW * P/(ZL * R * T)$$

13. Liquid API @ 60°F - Subroutine ZDENS is called to calculate the liquid compressibility @ 60°F, $ZL^{60}$, then:

$$\rho_{60} = MW * P/(ZL^{60} * R * T)$$

$$SPG60 = \rho_{60}/62.37$$

$$API = 141.5/SPG60 - 131.5$$

14. Liquid gallons/min - is calculated as follows:

$$GPM = (\text{lbs/hr})/(\rho_L/62.4 * 500)$$

15. Specific Heat, BTU/lb°F (for liquid and vapor streams) - is calculated by calling CHESS subroutine ENTH to obtain enthalpy values at the stream temperature and at 1°F higher, The following calculation is then done

$$cp = (lbs/hr)/abs\ (H_2 - H_1)$$

16. Viscosity, centipoise (for vapor and liquid streams).

A. Gas viscosity at low pressures ($\leq$ 1 atm).

i) Pure components - subroutine LPVIS, method of Thodos[12]

$$\eta \xi = 4.610\, T_r^{0.618} - 2.04\, e^{-0.449 T_r} + 1.94\, e^{-4.058 T_r} + 0.1$$

$$\xi = T_c^{1/6} / (MW^{1/2}\, P_c^{2/3})$$

$\eta$ = Viscosity, micropoise

ii) Mixtures - subroutine LPVIS, Wilke Method[13]

$$\eta_M = \sum_{i=1}^{n} \frac{y_i \eta_i}{\sum_{\substack{j=1 \\ j \neq i}}^{n} y_i \phi_{ij}}$$

$$\phi_{ij} = \frac{\left[1.0 + (\eta_i/\eta_j)^{1/2} (MW_i/MW_j)^{1/4}\right]^2}{8\left[1 + (MW_i/MW_j)^{1/2}\right]}$$

B. Gas viscosity at high pressure ( > 1 atm)

i) Pure components - subroutine GASVIS, Jossi, Stiel & Thodos method[14]

$$[(\eta-\eta^\circ)\xi + 1]^{0.25} = 1.023 + 0.23364\rho_r + 0.58533\rho_r^2 - 4.0758\rho_r^3 + 0.093324\rho_r^4$$

$\eta$ - viscosity, micropoise

$\eta^\circ$ - viscosity @ 1 atm

$\rho_r$ - $\rho/\rho_{critical}$

$\xi$ - $T_c^{1/6}/(MW^{1/2} P_c^{2/3})$

ii) Mixtures - Subroutine GASVIS, Dean & Stiel Method[15]

$$(\eta_M - \eta_M^\circ)\xi_M = 1.08\left[e^{1.439\rho_{rM}} - e^{-1.11\rho_{rM}^{1.858}}\right]$$

$\eta_M^\circ$ - mixture viscosity at 1 atm

$\rho_{rM}$ - $\rho_M/\rho_{critical\ (mixture)}$

$\xi_M$ - $T_{cM}^{1/6}/(MW^{1/2} P_{cM}^{2/3})$

(Mixture pseudocritical constants are used)

C. Liquid viscosity

i) Pure components - subroutine VISLIQ, Letsou & Stiel Method[16]

$$\eta\xi = (\eta\xi)^\circ + \omega(\eta\xi)^1$$

$$(\eta \mathcal{E})^{0} = 0.15174 - 0.02135T_r + 0.0075T_r^2$$

$$(\eta \mathcal{E})^{1} = 0.04552 - 0.0767\,T_r + 0.0340T_r^2$$

$\eta$ - viscosity, centipoise

$\mathcal{E}$ - $T_c^{1/6}/(MW^{1/2}\,P_c^{2/3})$

$\omega$ - acentric factor

Limitation: $0.76 \leq T_r \leq 0.98$

ii) ) Mixtures[17]

$$\ln(\eta_M) = \sum_{i=1}^{n} x_i \ln \eta_i$$

$x_i$ - mole fraction

$\eta_i$ - pure component viscosity, centipoise

17. Thermal conductivity, BTU/HR FT °F (liquid and vapor streams)

A. Gas thermal conductivity at low pressure ($\leq$ 1 atm)

i) Pure components - subroutine GASTK, Eucken Model[18]

$$\frac{\lambda\, MW}{\eta} = 4.47 + c_p/\gamma$$

$\lambda$ - thermal conductivity, cal/cm sec °K

$\eta$ - viscosity, poise

$c_p$ - heat capacity, cal/gm-mol

$\gamma$ - heat capacity ratio, $c_p/c_v$

ii) mixtures - subroutine GASTK, Riblett Method[4]

$$\lambda_M = \frac{\sum_{i=1}^{n} y_i \lambda_i Mw_i^{1/3}}{\sum_{i=1}^{n} y_i Mw_i^{1/3}}$$

$\lambda_M$ - mixture thermal conductivity, BTU/HR FT °F

$y_i$ - mole fraction of component i

B. Gas thermal conductivity at high pressure (> 1 atm)

i) Pure components - subroutine GASTK, Stiel & Thodos[20]

$$(\lambda-\lambda^\circ)\Gamma Z_c^5 = 14 \times 10^{-8} (e^{0.535 P_r} - 1) \qquad P_r < 0.5$$

$$(\lambda-\lambda^\circ)\Gamma Z_c^5 = 13.1 \times 10^{-8} (e^{0.67 P_r} - 1.069) \qquad 0.5 < P_r < 2.0$$

$$(\lambda-\lambda^\circ)\Gamma Z_c^5 = 2.976 \times 10^{-8} (e^{1.155 P_r} + 2.016) \qquad P_r > 2.0$$

$\lambda$ - thermal conductivity, cal/cm sec °K

$\lambda^\circ$ - thermal conductivity @ 1 atm, cal/cm/sec °K

$\Gamma$ - $T_c^{1/6} MW^{1/2} / P_c^{2/3}$

$Z_c$ - critical compressibility

ii) Mixtures - subroutine GASTK, Thodos Method[21]

The critical constants $T_c$, $P_c$, $Z_c$ and $P_r$ are computed for the mixture. The above equations for pure components are applied.

C. Liquid Thermal Conductivity

i) Pure components - subroutine LIQTK, Stiel & Thodos Method[22]

$\lambda^o$ for the pure component is calculated from subroutine GASTK.

$(\lambda - \lambda^o)$ is then calculated from the Stiel & Thodos equations using the properties of the liquid.

ii) Mixtures - subroutine LIQTK, Stiel & Thodos method[23]

$\lambda^o$ is calculated for the mixture from subroutine GASTK. $(\lambda - \lambda^o)$ is then calculated for the mixture from the Stiel & Thodos equations using the mixture liquid properties.

## Heating/Cooling Curve Generation

A new feature has been added to CHESS 2.1 which allows the user to generate tabular heating/cooling curves for a maximum of five streams in the simulation. These curves provide vaporization and enthalpy data for streams undergoing heat exchange (e.g.) condensers, reboilers. To utilize this feature, the user must identify the stream numbers, the temperature and pressure ranges, and the number of points to be evaluated.

A new subroutine named HEAT has been added to CHESS to perform the heat curve calculations. CHESS subroutine ADBF is utilized to perform isothermal flashes for each point on the curve. To avoid execution-time errors, the following conditions are checked before any calculations are performed:

1. Existence of the stream in the process matrix

2. Is the final temperature (T2) specified for the curve?

If one of the above conditions do not exist, the calculations for the particular stream is by-passed.

The following defaults have been incorporated into the HEAT subroutine:

1. The maximum number of streams for which heat curve data may be generated is five. If more than five are given in the input, only the first five will be evaluated.

2. The maximum number of points per curve is 15. If more are specified, only 15 will be calculated.

3. If less than 2 points for a curve is specified, 11 points will be calculated.

The input for this feature is specified in a new NAMELIST group called HCLIST, which is the last group in the problem data. The required information is as follows:

| Parameter | Description |
|---|---|
| CURVES | The total number of streams in the simulation which will have a heat curve calculated (1-5 allowed). |
| NAME1 - NAME5 | An 80 character description of the selected streams (enclosed in single quotes). |

| Parameter | Description |
|---|---|
| HCURV1- HCURV5 | Any array containing the control parameters for the curve calculations. |

HCURV1 through HCURV5 contain the following information;

HCURVN = J, T1, P1, T2, P2, NPOINT

N = The curve number (1-5).

J = The stream number in the process flowsheet.

T1 = The temperature of the stream at point 1 in °F. (If the user enters 0.0, the program defaults to the value in the stream vector).

P1 = The pressure of the stream at point 1 in psia. (If the user enters 0.0, the program defaults to the pressure of the stream in the stream vector).

T2 = The temperature of the stream at the last point in °F. This value is required.

P2 = The pressure of the stream at the last point in psia. (If the user enters 0.0, P2 = P1 is assigned by the program and all points are calculated at the same pressure)

NPOINT = The number of points to be calculated (15 max.).

The following example illustrates the format of the input. A heat curve for a single stream is to be generated.

```
&HCLIST
CURVES  =  1.,
NAME1   =  "REBOILER VAPORIZATION CURVE",
HCURVE1 =  1., 306.2, 154.56, 328.90, 154.56, 5.,
&END
```

The results of such a calculation will appear as follows:

REBOILER VAPORIZATION CURVE

STREAM - 1

| POINT | TEMPERATURE (DEGF) | PRESSURE (PSIA) | MOLE FRACTION VAPORIZED | ENTHALPY K BTU/HR |
|---|---|---|---|---|
| 1 | 306.20 | 154.56 | 0.0915 | 20128.910 |
| 2 | 311.87 | 154.56 | 0.2124 | 26020.734 |
| 3 | 317.55 | 154.56 | 0.3230 | 31562.461 |
| 4 | 323.22 | 154.56 | 0.4251 | 36821.613 |
| 5 | 328.90 | 154.56 | 0.5204 | 41857.902 |

If the user does not wish to utilize this feature, NAMELIST/HCLIST/ is left blank in the input data.

## CHESS USER'S GUIDE Updated

In conjunction with these programming changes, the CHESS USER'S GUIDE has been re-written to reflect the modifications and improvements made to the program. This will assist in the proper use of CHESS 2.1.

# CHAPTER III

## INCORPORATING PROGRAMMING CHANGES

### Compiling and Linking to the CHESS Load Module

All programming for this thesis was done on the New Jersey Educational Computer Network IBM 3033 computer system using the SUPERWYLBUR time-sharing application. Remote terminals at New Jersey Institute of Technology and Foster Wheeler Energy Corporation were used to access the system via telephone lines.

The Fortran IV source code for version 2.0 of CHESS was provided to the writer by Dr. E. C. Roche as a starting point. A test version of the CHESS load module (executable program) was created on the NJECN system by compiling the entire source program and linking into an existing partitioned dataset named NCE.JZ01099.RUNLIB. This load member was given the name TZCHESS. All programming changes were linked to this member to produce the load module for CHESS 2.1.

Incorporation of the modifications to the program involved compiling the changed or new CHESS subroutines and linking to the TZCHESS member. The job control statements to accomplish this are shown in FIGURE I. After the successful completion of the linkage-edit step, a test problem is executed in the same job submission to test the programming changes.

The overlay feature of the linkage editor was utilized to enable CHESS to be run on systems with limited memory. With the overlay, the load module requires a 130K Region size. The overlay structure of version 2.1 is shown in FIGURE II.

A list of subroutines which have been added or modified in this work is given in TABLE II.

```
//TONZ  JOB  (JA03010,NJIT,10000,99,0),'TONZ',
//            MSGLEVEL=(1,1),TIME=(0,30),REGION=256K,COND=(7,LT)
//*PASSWORD FIREB
//*FORMAT PR,DDNAME=,DEST=RMT20,FAILURE=RESTART
//*FORMAT PU,DDNAME=,DEST=RMT20
//PROCLIB  DD  DSN=NCE.JZ01099.PROCLIB,DISP=SHR
//STEP1  EXEC  COMPRESS,DSN='NCE.JZ01099.RUNLIB',DISP=SHR
//STEP2  EXEC  FORTGCL,
//       PARM.FORT=(NOLIST,SOURCE,NODECK,MAP,LOAD,EBCDIC,ID),
//       PARM.LKED=(MAP,LET,LIST,OVLY,XREF,XCAL)
//FORT.SYSIN  DD *
------------------------------------------------------------------------
*                                                                      *
*  F O R T R A N   S O U R C E   S T A T E M E N T S                   *
*                                                                      *
------------------------------------------------------------------------
/*
//LKED.SYSLMOD  DD  DSN='NCE.JZ01099.RUNLIB',
//    UNIT=OLS,DISP=(OLD,KEEP),SPACE=
//LKED.SYSIN  DD *
INCLUDE SYSLMOD(TZCHESS)
ENTRY MAIN
INSERT ZERO,ADBF,KHZT,TPRINT,TRANSF,CONVRT
 OVERLAY ALPHA
INSERT DREAD,CLEAN
 OVERLAY ALPHA
INSERT PPRINT,PRPCAL,LPVIS,VISLIQ,GASVIS,LIQTK,GASTK
 OVERLAY ALPHA
INSERT DEMETS
 OVERLAY ALPHA
INSERT HEAT
 OVERLAY ALPHA
INSERT COMPID,PROP
 OVERLAY ALPHA
INSERT INIT,DCHECK
 OVERLAY ALPHA
INSERT DPRINT
 OVERLAY ALPHA
INSERT UTRATE
 OVERLAY ALPHA
INSERT EQPRNT,EQFORM
 OVERLAY ALPHA
INSERT SUBSET,SCAN,RCYCLE,TEST,EQUIP,EQCALL
 OVERLAY BETA
INSERT CTRL,DISR,MIXR,ABSR
 OVERLAY BETA
INSERT DISC,DIST
 OVERLAY BETA
INSERT DVDR,FHTR,PUMP,REAC,VALV
 OVERLAY BETA
INSERT HXER,COMP
 OVERLAY BETA
INSERT MSEQ
 OVERLAY BETA
INSERT OVHD
 OVERLAY BETA
INSERT ADD1
NAME TZCHESS(R)
/*
//RUN  EXEC  PGM=TZCHESS,REGION=130K,
//STEPLIB  DD  DSN=NCE.JZ01099.RUNLIB,DISP=SHR
//FT06F001  DD  SYSOUT=A
//FT05F001  DD  *
------------------------------------------------------------------------
*                                                                      *
*  C H E S S   P R O B L E M   D A T A                                 *
*                                                                      *
------------------------------------------------------------------------
/*
//
```

FIGURE I

JCL for CHESS Compile & Link

FIGURE II

CHESS Overlay Structure

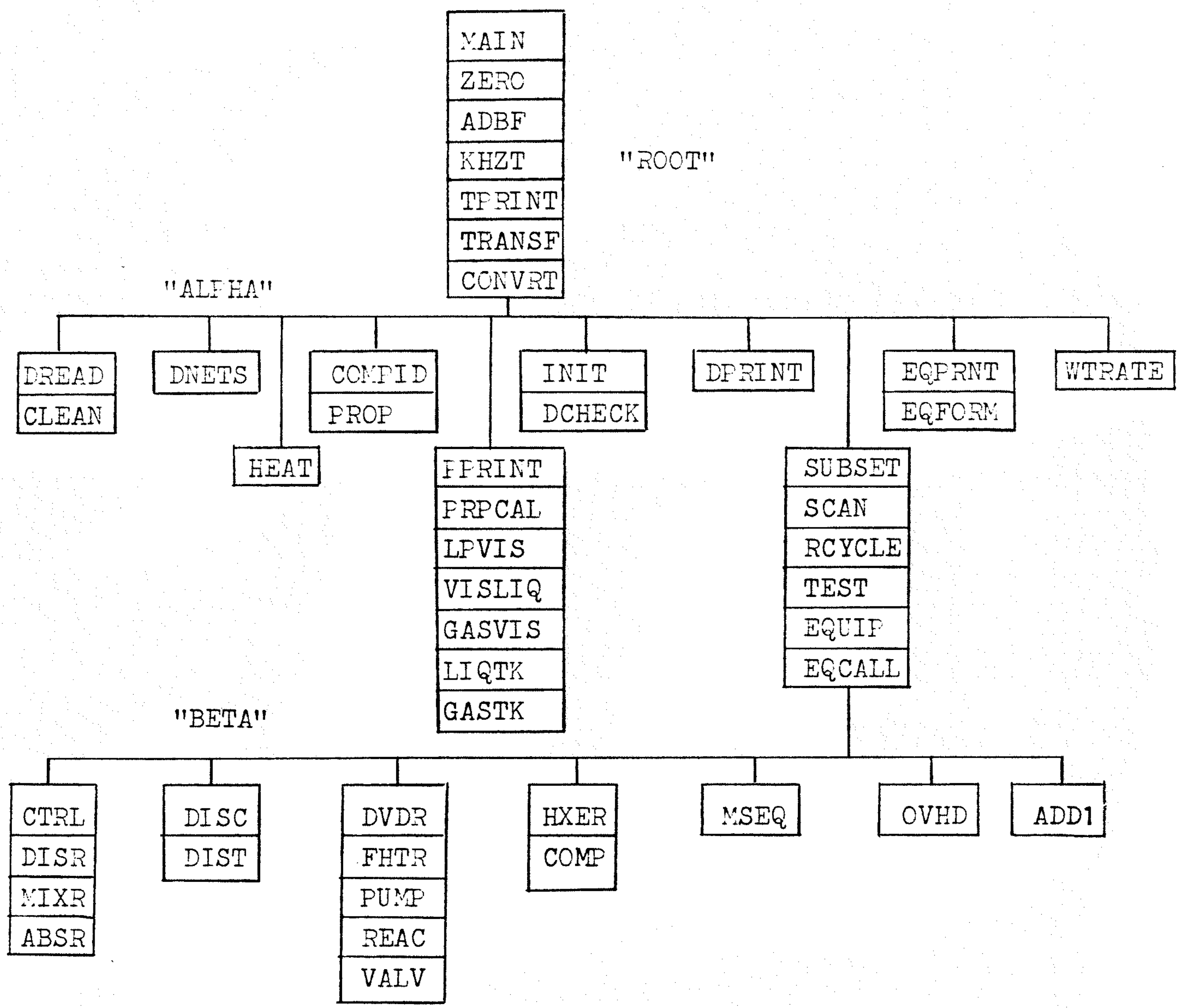


TABLE II

Subroutines Which Have Been Added or Modified in CHESS

| Existing CHESS Subroutines Which Have Been Modified/Revised | New Subroutines Added to CHESS |
|---|---|
| MAIN | COMP |
| CLEAN | CONVRT |
| COMPID | GASVIS |
| DPRINT | GASTK |
| DREAD | HEAT |
| EQCALL | LIQTK |
| EQFORM | PROP |
| EQPRNT | LPVIS |
| KHZT | PRPCAL |
| PUMP | PPRINT |
| RCYCLE | VISLIQ |
| TPRINT | WTRATE |

# CHAPTER IV

## EXAMPLE PROBLEMS

In this Chapter, four example problems are presented to illustrate the improvements made to CHESS. The reader should refer to the CHESS USER'S GUIDE for version 2.1 for explanation of the input data to the program.

## EXAMPLE #1

Two stage Compressor

The process flow diagram for a two stage compressor is given in FIGURE III. The simulation flow diagram is given in FIGURE IV.

The feed to the process is as follows:

| | |
|---|---|
| Temperature, °F | 100 |
| Pressure, psia | 65 |

| Component | lb-mols/hr | Mid TBP, °F | API Gravity | Molecular Weight |
|---|---|---|---|---|
| Nitrogen | 18.00 | | | |
| CO2 | 192.00 | | | |
| Methane | 1455.00 | | | |
| Ethane | 907.00 | | | |
| Propane | 726.00 | | | |
| I-Butane | 77.00 | | | |
| N-Butane | 281.00 | | | |
| I-Pentane | 95.00 | | | |
| N-Pentane | 163.00 | | | |
| N-Hexane | 154.00 | | | |
| BP274 | 1197.00 | 274 | 55.40 | 120.0 |
| BP499 | 907.00 | 499 | 37.80 | 200.0 |
| BP931 | 907.00 | 931 | 17.40 | 500.0 |
| Total | 7079.00 | | | |

Process conditions are:

| | Temperature, °F | Pressure drop < ><br>Pressure, psia |
|---|---|---|
| C-1 Outlet | | 160 |
| E-1 Outlet | 100 | <3> |
| C-2 Outlet | | 377 |
| E-2 Outlet | 100 | <3> |

Exchanger E-1:

Simple temperature controller, determine heat duty

Exchanger E-2:

Simple temperature controller, determine heat duty

COMPRESSOR C-1:

| | | |
|---|---|---|
| Outlet pressure | = | 160 psia |
| adiabatic efficiency | = | 0.78 |
| mechanical efficiency | = | 0.80 |

Compressor C-2:

| | | |
|---|---|---|
| outlet pressure | = | 377 psia |
| adiabatic effeciency | = | 0.75 |
| mechanical efficiency | = | 0.80 |

This example problem utilizes the following new features of CHESS 2.1.

1. New compressor module COMP

2. Petroleum fraction components

3. Stream temperatures and equipment parameters given in °F

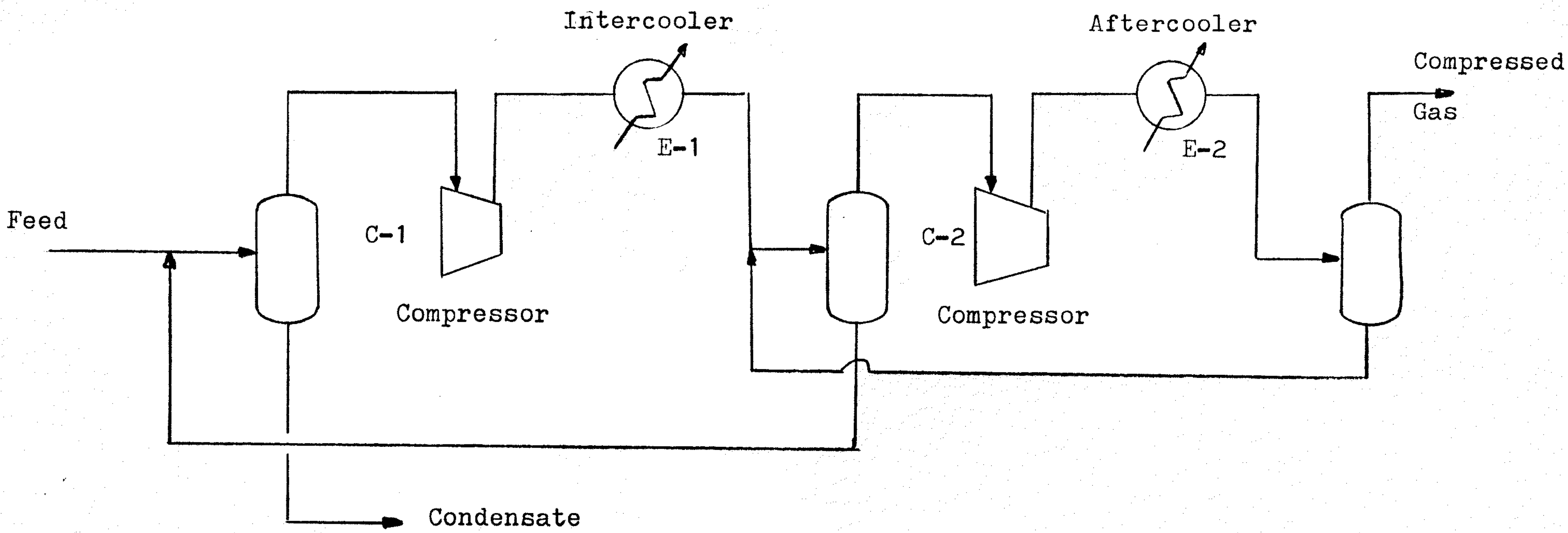
4. Stream properties summary

5. Stream mass summary

6. Heating/cooling curve generation

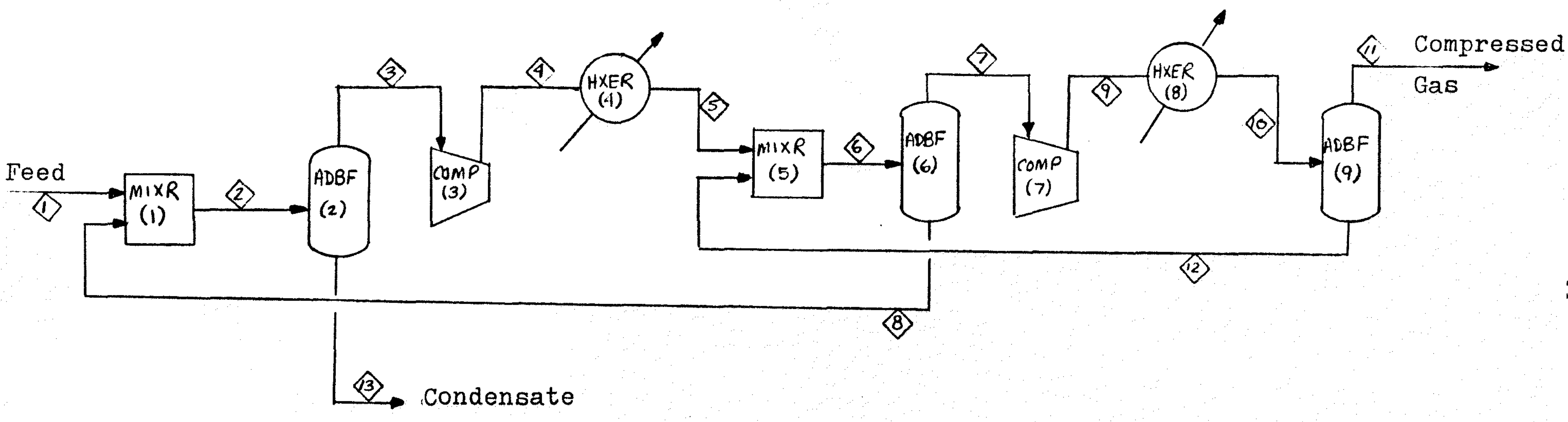
The input data for the simulation is given in TABLE III

The simulation results are given in TABLE IV.




<u>FIGURE III</u>

Process Flow Diagram - Two Stage Compressor




◇ Stream No.

( ) Equipment No.

FIGURE IV

Simulation Flow Diagram - Two Stage Compressor

```
CLEAN,NAMELIST
 CHESS EXAPLE #1 - TWO STAGE COMPRESSOR
 &PMLIST
  KPM1=1,'MIXR','M-1 ',1,8,-2,4*0,
  KPM2=2,'ADBF','F-1 ',2,-3,-13,4*0,
  KPM3=3,'COMP','C-1 ',3,-4,5*0,
  KPM4=4,'HXER','H-1 ',4,-5,5*0,
  KPM5=5,'MIXR','M-2 ',5,12,-6,4*0,
  KPM6=6,'ADBF','F-2 ',6,-7,-8,4*0,
  KPM7=7,'COMP','C-2 '7,-9,5*0,
  KPM8=8,'HXER','H-2 ',9,-10,5*0,
  KPM9=9,'ADBF','F-3 ',10,-11,-12,4*0,
  NOCOMP=13,
  COMPNT=46,49,2,3,4,5,6,7,8,10,200,201,202,7*0,
  KOMNAM(41)=' BP2',KOMNAM(42)='74   ',
  KOMNAM(45)=' BP4',KOMNAM(46)='99   ',
  KOMNAM(49)=' BP9',KOMNAM(50)='31   ',
 &END
 &EQLIST
  EQP1=1.,24*0.,
  EQP2=2.,1.,23*0.,
  EQP3=3.,0.,160.,0.78,0.80,20*0.,
  EQP4=4.,5*0.,5.,100.,3.,16*0.,
  EQP5=5.,24*0.,
  EQP6=6.,1.,23*0.,
  EQP7=7.,0.,377.,0.75,0.80,20*0.,
  EQP8=8.,5*0.,5.,100.,3.,16*0.,
  EQP9=9.,1.,23*0.,
 &END
 &SEXLST
  SEX1=1.,0.,0.,18.,192.,1455.,907.,726.,77.,281.,95.,
       163.,154.,1197.,907.,907.,7*0.,
  SNAME=2,3,4,5,6,7,8,9,11,10,12,13,88*0,
 &END
 &SINLST
  SIN1=1.,1.,0.,100.,65.,5*0.,
  SIN11=11.,2.,8*0.,
  SIN13=13.,2.,8*0.,
  SNAME=2,3,4,5,6,7,8,9,10,12,90*0,
 &END
 &KELIST
  LOOPS=30,
 &END
 &PFCOMP
  BP(11)=274.,API(11)=55.4,ZMW(11)=120.,
  BP(12)=499.,API(12)=37.8,ZMW(12)=200.,
  BP(13)=931.,API(13)=17.4,ZMW(13)=500.,
 &END
 &HCLIST
  CURVES=2.,
  NAME1='INTERCOOLER CONDENSING CURVE',
  HCURV1=4.,0.0,0.0,100.,157.,10.,
  NAME2='AFTERCOOLER CONDENSING CURVE',
  HCURV2=9.,0.0,0.0,100.,374.,10.,
 &END
```

TABLE III

Input Data for CHESS Example #1

TABLE IV

Simulation Results for Example #1

```
CLEAN,NAMELIST
CHESS EXAPLE #1 - TWO STAGE COMPRESSOR
```

```
NOW BEGIN TO READ 'PMLTST'
'PMLTST' READING COMPLETE
```

```
NOW BEGIN TO READ 'EQLTST'
'EQLTST' READING COMPLETE
```

```
NOW BEGIN TO READ 'SEXLST'
'SEXLST' READING COMPLETE
```

```
NOW BEGIN TO READ 'STNLST'
'STNLST' READING COMPLETE
```

```
NOW BEGIN TO READ 'KELTST'
'KELTST' READING COMPLETE
```

```
NOW BEGIN TO READ 'PECOMP'
'PECOMP' READING COMPLETE
```

```
NOW BEGIN TO READ 'HCLTST'
'HCLTST' READING COMPLETE
```

```
CLEAN,NAMELIST
CHESS EXAPLE #1 - TWO STAGE COMPRESSOR
```

---

```
NOW BEGIN TO READ 'PMLTST'
'PMLTST' READING COMPLETE
```

---

```
NOW BEGIN TO READ 'EQLTST'
'EQLTST' READING COMPLETE
```

---

```
NOW BEGIN TO READ 'SEXLST'
'SEXLST' READING COMPLETE
```

---

```
NOW BEGIN TO READ 'STNLST'
'STNLST' READING COMPLETE
```

---

```
NOW BEGIN TO READ 'KELTST'
'KELTST' READING COMPLETE
```

---

```
NOW BEGIN TO READ 'PECOMP'
'PECOMP' READING COMPLETE
```

---

```
NOW BEGIN TO READ 'HCLTST'
'HCLTST' READING COMPLETE
```

** DECOMPOSITION OF NET(S) WILL FOLLOW **

PRECURSOR LIST..

| | | | | | | |
|---|---|---|---|---|---|---|
| 1↑ | 0 | 0 | 0 | 0 | 0 | 0 |
| 2↑ | 1 | 8 | 0 | 0 | 0 | 0 |
| 3↑ | 2 | 0 | 0 | 0 | 0 | 0 |
| 4↑ | 3 | 0 | 0 | 0 | 0 | 0 |
| 5↑ | 4 | 0 | 0 | 0 | 0 | 0 |
| 6↑ | 5 | 12 | 0 | 0 | 0 | 0 |
| 7↑ | 6 | 0 | 0 | 0 | 0 | 0 |
| 8↑ | 6 | 0 | 0 | 0 | 0 | 0 |
| 9↑ | 7 | 0 | 0 | 0 | 0 | 0 |
| 10↑ | 9 | 0 | 0 | 0 | 0 | 0 |
| 11↑ | 10 | 0 | 0 | 0 | 0 | 0 |
| 12↑ | 10 | 0 | 0 | 0 | 0 | 0 |
| 13↑ | 2 | 0 | 0 | 0 | 0 | 0 |

GROUPED CUT-VERTEX PRECURSORS..

6↑ 6

CUT STREAM LIST.. 6

KEP ..

6 7 8 9 1 2 3 4 5

C H E S S

NEW JERSEY INSTITUTE OF TECHNOLOGY

NEWARK COLLEGE OF ENGINEERING

CHEMICAL ENGINEERING SIMULATION SYSTEM

VERSION 2.1 MAY 1985

C H E S S

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

'PROCESS VECTORS'

| ...... EQUIPMENT ...... | | | STREAM NUMBERS | | |
|---|---|---|---|---|---|
| NUMBER | SUBROUTINE | NAME | | | |
| 1 | MIXR | M-1 | 1 | 8 | -2 |
| 2 | ADBF | F-1 | 2 | -3 | -13 |
| 3 | COMP | C-1 | 3 | -4 | 0 |
| 4 | HXER | H-1 | 4 | -5 | 0 |
| 5 | MIXR | M-2 | 5 | 12 | -6 |
| 6 | ADBF | F-2 | 6 | -7 | -8 |
| 7 | COMP | C-2 | 7 | -9 | 0 |
| 8 | HXER | H-2 | 9 | -10 | 0 |
| 9 | ADBF | F-3 | 10 | -11 | -12 |

'STREAM CONNECTIONS'

| STREAM | EQUIPMENT FROM | EQUIPMENT TO |
|---|---|---|
| 1 | 0 | 1 |
| 2 | 1 | 2 |
| 3 | 2 | 3 |
| 4 | 3 | 4 |
| 5 | 4 | 5 |
| 6 | 5 | 6 |
| 7 | 6 | 7 |
| 8 | 6 | 1 |
| 9 | 7 | 8 |
| 10 | 8 | 9 |
| 11 | 9 | 0 |
| 12 | 9 | 5 |
| 13 | 2 | 0 |

'OTHER SYSTEM VARIABLES'

| | |
|---|---|
| NUMBER OF COMPONENTS | 13 |
| COMPONENT NUMBERS USED | 46, 49, 2, 3, 4,<br>5, 6, 7, 8, 10,<br>200,201,202, |
| RECYCLE EQUIPMENT LIST (KE2) | 6, 7, 8, 9, 1,<br>2, 3, 4, 5, |
| TOLERANCE, 'DERROR' | 0.0001 |
| MAX. LOOPS IN RECYCLE CALC. | 30 |

NON-STANDARD & PETROLEUM FRACTION COMPONENTS

| | | |
|---|---|---|
| COMPONENT NO. = 11 | ID NO. = 200 | NAME= BP274 |
| NBP (F) = 274.0 | API GR. = 55.40 | |
| APC = 407.3 | ATC = 1058.3 | AVC = 450.7 |
| AMW = 120.00 | AOMEG = 0.3994 | ADEL = 7.929 |
| AVW = 22.19 | APH = -0.33228E 01 | BET = 0.98539E-01 |
| GAM = -0.21108E-04 | DTA = 0.0 | |
| COMPONENT NO. = 12 | ID NO. = 201 | NAME= BP499 |
| NBP (F) = 499.0 | API GR. = 37.80 | |
| APC = 284.4 | ATC = 1294.8 | AVC = 746.9 |
| AMW = 200.00 | AOMEG = 0.5748 | ADEL = 8.043 |
| AVW = 34.84 | APH = -0.15029E 01 | BET = 0.15405E 00 |
| GAM = -0.35156E-04 | DTA = 0.0 | |
| COMPONENT NO. = 13 | ID NO. = 202 | NAME= BP931 |
| NBP (F) = 931.0 | API GR. = 17.40 | |
| APC = 138.2 | ATC = 1682.1 | AVC = 1723.5 |
| AMW = 500.00 | AOMEG = 0.9933 | ADEL = 7.442 |
| AVW = 79.91 | APH = -0.36816E 01 | BET = 0.38310E 00 |
| GAM = -0.84730E-04 | DTA = 0.0 | |

'INPUT DATA'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.4495 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 100.0000 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 65.0000 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | -13467.1953 | 0.0 | 0.0 | 0.0 |
| | COMPOSITION, MOLES/HOUR | | | |
| NITROGEN | 18.0000 | 0.0 | 0.0 | 0.0 |
| CO2 | 192.0000 | 0.0 | 0.0 | 0.0 |
| METHANE | 1455.0000 | 0.0 | 0.0 | 0.0 |
| ETHANE | 907.0000 | 0.0 | 0.0 | 0.0 |
| PROPANE | 726.0000 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 77.0000 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 281.0000 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 95.0000 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 163.0000 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 154.0000 | 0.0 | 0.0 | 0.0 |
| BP274 | 1197.0000 | 0.0 | 0.0 | 0.0 |
| BP499 | 907.0000 | 0.0 | 0.0 | 0.0 |
| BP931 | 907.0000 | 0.0 | 0.0 | 0.0 |
| TOTAL | 7079.0000 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 6 TO 1 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| | COMPOSITION, MOLES/HOUR | | | |
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.0 | 0.0 | 0.0 |
| BP274 | 0.0 | 0.0 | 0.0 | 0.0 |
| BP499 | 0.0 | 0.0 | 0.0 | 0.0 |
| BP931 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 5 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| | COMPOSITION, MOLES/HOUR | | | |
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.0 | 0.0 | 0.0 |
| BP274 | 0.0 | 0.0 | 0.0 | 0.0 |
| BP499 | 0.0 | 0.0 | 0.0 | 0.0 |
| BP931 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| | | | | |
|---|---|---|---|---|
| STREAM NUMBER | | 13 | | |
| EQUIP. CONXION | FR | 2 TO | 0 | FR |
| VAPOR FRACTION | | 0.0 | | |
| TEMPERATURE, F | | 0.0 | | |
| PRESSURE, PSIA | | 0.0 | | |
| ENTHALPY,K BTU | | 0.0 | | |

| | | |
|---|---|---|
| | | COMPOSITION, MOLES/HOUR |
| NITROGEN | 0.0 | |
| CO2 | 0.0 | |
| METHANE | 0.0 | |
| ETHANE | 0.0 | |
| PROPANE | 0.0 | |
| I-BUTANE | 0.0 | |
| N-BUTANE | 0.0 | |
| I-PENTANE | 0.0 | |
| N-PENTANE | 0.0 | |
| N-HEXANE | 0.0 | |
| BP274 | 0.0 | |
| BP499 | 0.0 | |
| BP931 | 0.0 | |
| TOTAL | 0.0 | |

'INPUT DATA'

CHESS EXAMPLE #1 - TWO STAGE COMPRESSOR

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | M-1 | MIXR |
| 2 | F-1 | ADBF |
| 3 | C-1 | COMP |
| 4 | H-1 | HXER |
| 5 | M-2 | MIXR |
| 6 | F-2 | ADBF |
| 7 | C-2 | COMP |
| 8 | H-2 | HXER |
| 9 | F-3 | ADBF |

# * EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

***MIXERS ***

| | | |
|---|---|---|
| EQUIPMENT NO. | 1 | 5 |
| EXTERNAL NAME | M-1 | M-2 |

.........................................................................

***ADIABATIC FLSH UNITS***

| | | | |
|---|---|---|---|
| EQUIPMENT NO. | 2 | 6 | 9 |
| EXTERNAL NAME | F-1 | F-2 | F-3 |
| MODE<br>0. PHASE DET.<br>1. CONST. T.<br>2. ADIABATIC | 1.0000 | 1.0000 | 1.0000 |

.........................................................................

***EXCHANGER/CONDENSERS***

| | | |
|---|---|---|
| EQUIPMENT NO. | 4 | 8 |
| EXTERNAL NAME | H-1 | H-2 |
| U | 0.0 | 0.0 |
| AREA | 0.0 | 0.0 |
| # SHELLS | 0.0 | 0.0 |
| SHELL PASSES | 0.0 | 0.0 |
| TUBE PASSES | 0.0 | 0.0 |
| MODE | 5.0000 | 5.0000 |
| DT OR T-OUT | 100.0000 | 100.0000 |
| DELTA P-STM 1 | 3.0000 | 3.0000 |
| DELTA P-STM 2 | 0.0 | 0.0 |
| Q-STREAM 1<br>(M BTU/HR) | 0.0 | 0.0 |
| WATER USAGE<br>(GAL/HR) | 0.0 | 0.0 |

.........................................................................

***COMPRESSORS ***

| | | |
|---|---|---|
| EQUIPMENT NO. | 3 | 7 |
| EXTERNAL NAME | C-1 | C-2 |
| WORK CAPACITY | 0.0 | 0.0 |

| | | |
|---|---|---|
| (PSIA) | | |
| ADIABATIC EFF. | 0.7800 | 0.7500 |
| MECH EFF. | 0.8000 | 0.8000 |
| INLET ACFM | 0.0 | 0.0 |
| DRIVER WORK (HORSEPOWER) | 0.0 | 0.0 |

................................................................................

### ***HEAT CURVE GENERATION SUMMARY***

| | CURVE1 | CURVE2 | CURVE3 | CURVE4 | CURVE5 |
|---|---|---|---|---|---|
| PROCESS STREAM | 4.0 | 9.0 | | | |
| INITIAL TEMP. (DEG F) | 0.0 | 0.0 | | | |
| INITIAL PRESS. (PSIA) | 0.0 | 0.0 | | | |
| FINAL TEMP. (DEG F) | 100.0 | 100.0 | | | |
| FINAL PRESS. (PSIA) | 157.0 | 374.0 | | | |
| NUMBER OF POINTS | 10.0 | 10.0 | | | |

NOTE - IF THE INITIAL TEMPERATURE AND PRESSURE HAVE VALUES OF 0.0, THE VALUES IN THE STREAM VECTOR WILL BE USED.

```
*****BEGIN TRIAL AND ERROR RECYCLE CALCULATIONS WITH EQUIPMENT LIST..
      6,  7,  8,  9,  1,  2,  3,  4,  5,

... BEGIN 'LOOP   1' ...

*** INPUT STREAM CANNOT BE COMPRESSED, NE=  7
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =   8

***   DEW POINT TEMP. CANNOT BE DETERMINED, ASSUMED TEMP. WILL BE USED, N

... BEGIN 'LOOP   2' ...

... BEGIN 'LOOP   3' ...

... BEGIN 'LOOP   4' ...

... BEGIN 'LOOP   5' ...

... BEGIN 'LOOP   6' ...

... BEGIN 'LOOP   7' ...

... BEGIN 'LOOP   8' ...

... BEGIN 'LOOP   9' ...

... BEGIN 'LOOP  10' ...

... BEGIN 'LOOP  11' ...

... BEGIN 'LOOP  12' ...

... BEGIN 'LOOP  13' ...

... BEGIN 'LOOP  14' ...

... BEGIN 'LOOP  15' ...

... BEGIN 'LOOP  16' ...

... BEGIN 'LOOP  17' ...

***** END OF RECYCLE CALCULATIONS
```

'FINAL RESULTS'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.4495 | 0.4488 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 100.0000 | 99.8540 | 99.8540 | 204.5686 |
| PRESSURE, PSIA | 65.0000 | 65.0000 | 65.0000 | 160.0000 |
| ENTHALPY,K BTU | -13467.1953 | -13544.8789 | 14128.7500 | 18411.4688 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 18.0000 | 18.0022 | 17.8714 | 17.8714 |
| CO2 | 192.0000 | 192.2448 | 176.8909 | 176.8909 |
| METHANE | 1455.0000 | 1455.6377 | 1416.0972 | 1416.0972 |
| ETHANE | 907.0000 | 908.5664 | 811.2078 | 811.2078 |
| PROPANE | 726.0000 | 729.2087 | 537.8938 | 537.8938 |
| I-BUTANE | 77.0000 | 77.6477 | 38.1238 | 38.1238 |
| N-BUTANE | 281.0000 | 283.7859 | 117.8853 | 117.8853 |
| I-PENTANE | 95.0000 | 96.2972 | 21.5143 | 21.5143 |
| N-PENTANE | 163.0000 | 165.4322 | 30.4710 | 30.4710 |
| N-HEXANE | 154.0000 | 156.7913 | 10.8258 | 10.8258 |
| BP274 | 1197.0000 | 1204.6125 | 8.3165 | 8.3165 |
| BP499 | 907.0000 | 907.0566 | 0.0568 | 0.0568 |
| BP931 | 907.0000 | 907.0000 | 0.0000 | 0.0000 |
| TOTAL | 7079.0000 | 7102.2813 | 3187.1548 | 3187.1548 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 6 TO 1 |
| VAPOR FRACTION | 0.9992 | 0.9929 | 1.0000 | 0.0 |
| TEMPERATURE, F | 100.0000 | 90.2222 | 90.2222 | 90.2222 |
| PRESSURE, PSIA | 157.0000 | 157.0000 | 157.0000 | 157.0000 |
| ENTHALPY,K BTU | 13725.6914 | 13704.1563 | 13781.8711 | -77.7098 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 17.8714 | 17.9005 | 17.8983 | 0.0022 |
| CO2 | 176.8909 | 179.1100 | 178.8652 | 0.2448 |
| METHANE | 1416.0972 | 1422.7971 | 1422.1592 | 0.6378 |
| ETHANE | 811.2078 | 825.1770 | 823.6104 | 1.5664 |
| PROPANE | 537.8938 | 562.6655 | 559.4565 | 3.2088 |
| I-BUTANE | 38.1238 | 41.9288 | 41.2811 | 0.6477 |
| N-BUTANE | 117.8853 | 133.4208 | 130.6346 | 2.7861 |
| I-PENTANE | 21.5143 | 27.0168 | 25.7197 | 1.2972 |
| N-PENTANE | 30.4710 | 40.0896 | 37.6574 | 2.4322 |
| N-HEXANE | 10.8258 | 17.5786 | 14.7873 | 2.7913 |
| BP274 | 8.3165 | 11.9141 | 4.3015 | 7.6126 |
| BP499 | 0.0568 | 0.0572 | 0.0003 | 0.0568 |
| BP931 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| TOTAL | 3187.1548 | 3279.6570 | 3256.3718 | 23.2850 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 5 |
| VAPOR FRACTION | 1.0000 | 0.9716 | 1.0000 | 0.0 |
| TEMPERATURE, F | 196.8486 | 100.0000 | 100.0000 | 100.0000 |
| PRESSURE, PSIA | 377.0000 | 374.0000 | 374.0000 | 374.0000 |
| ENTHALPY,K BTU | 17932.1250 | 12603.9805 | 12625.5156 | -21.5354 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 17.8983 | 17.8983 | 17.8691 | 0.0291 |
| CO2 | 178.8652 | 178.8652 | 176.6461 | 2.2191 |
| METHANE | 1422.1592 | 1422.1592 | 1415.4590 | 6.7000 |
| ETHANE | 823.6104 | 823.6104 | 809.6409 | 13.9693 |
| PROPANE | 559.4565 | 559.4565 | 534.6846 | 24.7719 |
| I-BUTANE | 41.2811 | 41.2811 | 37.4760 | 3.8051 |
| N-BUTANE | 130.6346 | 130.6346 | 115.0992 | 15.5355 |
| I-PENTANE | 25.7197 | 25.7197 | 20.2171 | 5.5025 |
| N-PENTANE | 37.6574 | 37.6574 | 28.0387 | 9.6187 |
| N-HEXANE | 14.7873 | 14.7873 | 8.0344 | 6.7529 |
| BP274 | 4.3015 | 4.3015 | 0.7039 | 3.5976 |
| BP499 | 0.0003 | 0.0003 | 0.0000 | 0.0003 |
| BP931 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| TOTAL | 3256.3718 | 3256.3718 | 3163.8694 | 92.5024 |

STREAM NUMBER 13

| | |
|---|---|
| EQUIP. CONXION | FR 2 TO 0 FR |
| VAPOR FRACTION | 0.0 |
| TEMPERATURE, F | 99.8540 |
| PRESSURE, PSIA | 65.0000 |
| ENTHALPY,K BTU | -27673.6289 |

| | COMPOSITION, MOLES/HOUR |
|---|---|
| NITROGEN | 0.1308 |
| CO2 | 15.3539 |
| METHANE | 39.5403 |
| ETHANE | 97.3585 |
| PROPANE | 191.3149 |
| I-BUTANE | 39.5239 |
| N-BUTANE | 165.9006 |
| I-PENTANE | 74.7828 |
| N-PENTANE | 134.9612 |
| N-HEXANE | 145.9655 |
| BP274 | 1196.2959 |
| BP499 | 906.9998 |
| BP931 | 906.9998 |
| TOTAL | 3915.1262 |

'FINAL RESULTS'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.4495 | 0.4488 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 100.0000 | 99.8540 | 99.8540 | 204.5686 |
| PRESSURE, PSIA | 65.0000 | 65.0000 | 65.0000 | 160.0000 |
| ENTHALPY,K BTU | -13467.1953 | -13544.8789 | 14128.7500 | 18411.4688 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 504.2878 | 504.3501 | 500.6843 | 500.6843 |
| CO2 | 8449.9180 | 8460.6914 | 7784.9648 | 7784.9648 |
| METHANE | 23341.0977 | 23351.3281 | 22717.0195 | 22717.0195 |
| ETHANE | 27271.6680 | 27318.7656 | 24391.3867 | 24391.3867 |
| PROPANE | 32012.2383 | 32153.7227 | 23717.8828 | 23717.8828 |
| I-BUTANE | 4475.2383 | 4512.8828 | 2215.7529 | 2215.7529 |
| N-BUTANE | 16331.7148 | 16493.6328 | 6851.4922 | 6851.4922 |
| I-PENTANE | 6853.8672 | 6947.4531 | 1552.1726 | 1552.1726 |
| N-PENTANE | 11759.7969 | 11935.2695 | 2198.3579 | 2198.3579 |
| N-HEXANE | 13270.4844 | 13511.0156 | 932.8765 | 932.8765 |
| BP274 | 143640.0000 | 144553.5000 | 997.9849 | 997.9849 |
| BP499 | 181400.0000 | 181411.3125 | 11.3629 | 11.3629 |
| BP931 | 453500.0000 | 453500.0000 | 0.0005 | 0.0005 |
| TOTAL | 922810.0625 | 924653.8125 | 93871.6875 | 93871.6875 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 6 TO 1 |
| VAPOR FRACTION | 0.9992 | 0.9929 | 1.0000 | 0.0 |
| TEMPERATURE, F | 100.0000 | 90.2222 | 90.2222 | 90.2222 |
| PRESSURE, PSIA | 157.0000 | 157.0000 | 157.0000 | 157.0000 |
| ENTHALPY,K BTU | 13725.6914 | 13704.1563 | 13781.8711 | -77.7098 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 500.6843 | 501.5010 | 501.4380 | 0.0626 |
| CO2 | 7784.9648 | 7882.6289 | 7871.8516 | 10.7741 |
| METHANE | 22717.0195 | 22824.5000 | 22814.2656 | 10.2318 |
| ETHANE | 24391.3867 | 24811.4141 | 24764.3086 | 47.0998 |
| PROPANE | 23717.8828 | 24810.1680 | 24668.6719 | 141.4910 |
| I-BUTANE | 2215.7529 | 2436.9043 | 2399.2588 | 37.6453 |
| N-BUTANE | 6851.4922 | 7754.4141 | 7592.4805 | 161.9290 |
| I-PENTANE | 1552.1726 | 1949.1572 | 1855.5696 | 93.5874 |
| N-PENTANE | 2198.3579 | 2892.3074 | 2716.8291 | 175.4757 |
| N-HEXANE | 932.8765 | 1514.7866 | 1274.2522 | 240.5291 |
| BP274 | 997.9849 | 1429.6965 | 516.1826 | 913.5156 |
| BP499 | 11.3629 | 11.4307 | 0.0681 | 11.3626 |
| BP931 | 0.0005 | 0.0005 | 0.0000 | 0.0005 |
| TOTAL | 93871.6875 | 98818.6250 | 96975.0000 | 1843.7039 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 5 |
| VAPOR FRACTION | 1.0000 | 0.9716 | 1.0000 | 0.0 |
| TEMPERATURE, F | 196.8486 | 100.0000 | 100.0000 | 100.0000 |
| PRESSURE, PSIA | 377.0000 | 374.0000 | 374.0000 | 374.0000 |
| ENTHALPY,K BTU | 17932.1250 | 12603.9805 | 12625.5156 | -21.5354 |
| | COMPOSITION, LBS/HOUR | | | |
| NITROGEN | 501.4380 | 501.4380 | 500.6211 | 0.8166 |
| CO2 | 7871.8516 | 7871.8516 | 7774.1914 | 97.6622 |
| METHANE | 22814.2656 | 22814.2656 | 22706.7813 | 107.4816 |
| ETHANE | 24764.3086 | 24764.3086 | 24344.2734 | 420.0291 |
| PROPANE | 24668.6719 | 24668.6719 | 23576.3750 | 1092.2930 |
| I-BUTANE | 2399.2588 | 2399.2588 | 2178.1064 | 221.1523 |
| N-BUTANE | 7592.4805 | 7592.4805 | 6689.5586 | 902.9209 |
| I-PENTANE | 1855.5696 | 1855.5696 | 1458.5840 | 396.9854 |
| N-PENTANE | 2716.8291 | 2716.8291 | 2022.8784 | 693.9495 |
| N-HEXANE | 1274.2522 | 1274.2522 | 692.3420 | 581.9102 |
| BP274 | 516.1826 | 516.1826 | 84.4711 | 431.7114 |
| BP499 | 0.0681 | 0.0681 | 0.0003 | 0.0678 |
| BP931 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| TOTAL | 96975.0000 | 96975.0000 | 92027.9375 | 4946.9766 |

STREAM NUMBER 13

| | |
|---|---|
| EQUIP. CONXION | FR 2 TO 0 FR |
| VAPOR FRACTION | 0.0 |
| TEMPERATURE, F | 99.8540 |
| PRESSURE, PSIA | 65.0000 |
| ENTHALPY,K BTU | -27673.6289 |

| | COMPOSITION, LBS/HOUR |
|---|---|
| NITROGEN | 3.6654 |
| CO2 | 675.7244 |
| METHANE | 634.3054 |
| ETHANE | 2927.3733 |
| PROPANE | 8435.8359 |
| I-BUTANE | 2297.1304 |
| N-BUTANE | 9642.1367 |
| I-PENTANE | 5395.2813 |
| N-PENTANE | 9736.9102 |
| N-HEXANE | 12578.1367 |
| BP274 | 143555.5000 |
| BP499 | 181399.9375 |
| BP931 | 453499.8750 |
| TOTAL | 830781.7500 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 100.0000 | 99.8540 | 99.8540 | 204.568 |
| PRESSURE,PSIA | 65.0000 | 65.0000 | 65.0000 | 160.000 |
| MOLES/HR | 7079.0000 | 7102.2773 | 3187.1536 | 3187.153 |
| POUNDS/HR | 922810.0625 | 924653.8125 | 93871.6875 | 93871.687 |
| MOLECULAR WEIGHT | 130.3588 | 130.1912 | 29.4531 | 29.4531 |
| PSEUDO CRITICAL TEMP,DEG F | 414.2563 | 414.1760 | 33.4702 | 33.470 |
| PSEUDO CRITICAL PRES,PSIA | 500.6846 | 500.7078 | 682.9641 | 682.9641 |
| ACENTRIC FACTOR | 0.3271 | 0.3269 | 0.0781 | 0.0781 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.9756 | 0.9648 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.3268 | 0.6853 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 4787.0703 | 2282.9937 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.0 | 0.0 | 0.4376 | 0.4960 |
| VISCOSITY,CENTIPOISE | 0.0 | 0.0 | 0.0114 | 0.0139 |
| THERMAL COND,BTU/HR FT DEG F | 0.0 | 0.0 | 0.0141 | 0.0182 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 100.0000 | 90.2222 | 90.2222 | 90.2222 |
| PRESSURE,PSIA | 157.0000 | 157.0000 | 157.0000 | 157.0000 |
| MOLES/HR | 3187.1536 | 3279.6558 | 3256.3706 | 23.2841 |
| POUNDS/HR | 93871.6875 | 98818.6250 | 96975.0000 | 1843.7039 |
| MOLECULAR WEIGHT | 29.4531 | 30.1308 | 29.7801 | 79.1829 |
| PSEUDO CRITICAL TEMP,DEG F | 33.4702 | 39.3989 | 36.8953 | 389.5781 |
| PSEUDO CRITICAL PRES,PSIA | 682.9641 | 680.3076 | 681.5413 | 507.7344 |
| ACENTRIC FACTOR | 0.0781 | 0.0809 | 0.0796 | 0.2624 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.9351 | 0.0 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.8474 | 0.0 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 1907.3792 | 0.0 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 40.6006 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 80.4450 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 5.6645 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.0 | 0.0 | 0.4514 | 0.4810 |
| VISCOSITY,CENTIPOISE | 0.0 | 0.0 | 0.0120 | 0.2420 |
| THERMAL COND,BTU/HR FT DEG F | 0.0 | 0.0 | 0.0140 | 0.0555 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 196.8486 | 100.0000 | 100.0000 | 100.000 |
| PRESSURE,PSIA | 377.0000 | 374.0000 | 374.0000 | 374.000 |
| MOLES/HR | 3256.3706 | 3256.3706 | 3163.8682 | 92.502 |
| POUNDS/HR | 96975.0000 | 96975.0000 | 92027.9375 | 4946.976 |
| MOLECULAR WEIGHT | 29.7801 | 29.7801 | 29.0872 | 53.479 |
| PSEUDO CRITICAL TEMP,DEG F | 36.8953 | 36.8953 | 30.8494 | 243.678 |
| PSEUDO CRITICAL PRES,PSIA | 681.5413 | 681.5413 | 684.2539 | 588.761 |
| ACENTRIC FACTOR | 0.0796 | 0.0796 | 0.0768 | 0.176 |
| COMPRESSIBILITY FACTOR | 0.9108 | 0.0 | 0.8542 | 0.0 |
| VAPOR DENSITY,LB/CU FT | 1.7498 | 0.0 | 2.1205 | 0.0 |
| VAPOR CU FT/MIN | 923.6670 | 0.0 | 723.3152 | 0.0 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 32.7039 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 124.1542 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 18.8689 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.5197 | 0.0 | 0.5007 | 0.6153 |
| VISCOSITY,CENTIPOISE | 0.0140 | 0.0 | 0.0126 | 0.1265 |
| THERMAL COND,BTU/HR FT DEG F | 0.0185 | 0.0 | 0.0155 | 0.0512 |

| STREAM NUMBER | 13 |
|---|---|
| TEMPERATURE,DEG F | 99.8540 |
| PRESSURE,PSIA | 65.0000 |
| MOLES/HR | 3915.1272 |
| POUNDS/HR | 830781.7500 |
| MOLECULAR WEIGHT | 212.1979 |
| PSEUDO CRITICAL TEMP,DEG F | 724.0930 |
| PSEUDO CRITICAL PRES,PSIA | 352.3403 |
| ACENTRIC FACTOR | 0.5294 |
| COMPRESSIBILITY FACTOR | 0.0 |
| VAPOR DENSITY,LB/CU FT | 0.0 |
| VAPOR CU FT/MIN | 0.0 |
| LIQUID DENSITY,LB/CU FT | 53.6189 |
| LIQUID API @ 60F | 30.0481 |
| LIQUID GAL/MIN | 1932.7461 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.3305 |
| VISCOSITY,CENTIPOISE | 0.6448 |
| THERMAL COND,BTU/HR FT DEG F | 0.0497 |

AFTERCOOLER CONDENSING CURVE

STREAM - 9

| POINT | TEMPERATURE (DEG F) | PRESSURE (PSIA) | MOLE FRACTION VAPORIZED | ENTHALPY K BTU/HR |
|---|---|---|---|---|
| 1 | 196.85 | 377.00 | 1.0000 | 17932.109 |
| 2 | 186.09 | 376.67 | 1.0000 | 17391.566 |
| 3 | 175.33 | 376.33 | 1.0000 | 16854.285 |
| 4 | 164.57 | 376.00 | 1.0000 | 16320.121 |
| 5 | 153.80 | 375.67 | 1.0000 | 15788.754 |
| 6 | 143.04 | 375.33 | 1.0000 | 15259.961 |
| 7 | 132.28 | 375.00 | 1.0000 | 14733.316 |
| 8 | 121.52 | 374.67 | 0.9984 | 14174.164 |
| 9 | 110.76 | 374.33 | 0.9896 | 13470.320 |
| 10 | 100.00 | 374.00 | 0.9716 | 12603.992 |
| DEW POINT | 124.83 | 374.83 | 1.0 | 11284.695 |

'FINAL RESULTS'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | M-1 | MIXR |
| 2 | F-1 | ADBF |
| 3 | C-1 | COMP |
| 4 | H-1 | HXER |
| 5 | M-2 | MIXR |
| 6 | F-2 | ADBF |
| 7 | C-2 | COMP |
| 8 | H-2 | HXER |
| 9 | F-3 | ADBF |

* EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

***MIXERS ***

| EQUIPMENT NO. | 1 | 5 |
|---|---|---|
| EXTERNAL NAME | M-1 | M-2 |

.............................................................................

***ADIABATIC FLSH UNITS***

| EQUIPMENT NO. | 2 | 6 | 9 |
|---|---|---|---|
| EXTERNAL NAME | F-1 | F-2 | F-3 |
| MODE | 1.0000 | 1.0000 | 1.0000 |
| 0. PHASE DET. | | | |
| 1. CONST. T. | | | |
| 2. ADIABATIC | | | |

.............................................................................

***EXCHANGER/CONDENSERS***

| EQUIPMENT NO. | 4 | 8 |
|---|---|---|
| EXTERNAL NAME | H-1 | H-2 |
| U | 0.0 | 0.0 |
| AREA | 0.0 | 0.0 |
| # SHELLS | 0.0 | 0.0 |
| SHELL PASSES | 0.0 | 0.0 |
| TUBE PASSES | 0.0 | 0.0 |
| MODE | 5.0000 | 5.0000 |
| DT OR T-OUT | 100.0000 | 100.0000 |
| DELTA P-STM 1 | 3.0000 | 3.0000 |
| DELTA P-STM 2 | 0.0 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | 4685.7773 | 5328.1445 |
| WATER USAGE (GAL/HR) | 37501.2227 | 42642.2148 |

.............................................................................

***COMPRESSORS ***

| EQUIPMENT NO. | 3 | 7 |
|---|---|---|
| EXTERNAL NAME | C-1 | C-2 |
| WORK CAPACITY | 0.0 | 0.0 |

| | | |
|---|---|---|
| (PSIA) | | |
| ADIABATIC EFF. | 0.7800 | 0.7500 |
| MECH EFF. | 0.8000 | 0.8000 |
| INLET ACFM | 4787.0703 | 1907.3794 |
| DRIVER WORK (HORSEPOWER) | 2101.8494 | 2036.8418 |

••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

** DECOMPOSITION OF NET(S) WILL FOLLOW **

PRECURSOR LIST..

| | | | | | | |
|---|---|---|---|---|---|---|
| 1↑ | 0 | 0 | 0 | 0 | 0 | 0 |
| 2↑ | 1 | 8 | 0 | 0 | 0 | 0 |
| 3↑ | 2 | 0 | 0 | 0 | 0 | 0 |
| 4↑ | 3 | 0 | 0 | 0 | 0 | 0 |
| 5↑ | 4 | 0 | 0 | 0 | 0 | 0 |
| 6↑ | 5 | 12 | 0 | 0 | 0 | 0 |
| 7↑ | 6 | 0 | 0 | 0 | 0 | 0 |
| 8↑ | 6 | 0 | 0 | 0 | 0 | 0 |
| 9↑ | 7 | 0 | 0 | 0 | 0 | 0 |
| 10↑ | 9 | 0 | 0 | 0 | 0 | 0 |
| 11↑ | 10 | 0 | 0 | 0 | 0 | 0 |
| 12↑ | 10 | 0 | 0 | 0 | 0 | 0 |
| 13↑ | 2 | 0 | 0 | 0 | 0 | 0 |

GROUPED CUT-VERTEX PRECURSORS..

6↑ 6

CUT STREAM LIST.. 6

KE2 ..

6 7 8 9 1 2 3 4 5

C H E S S

NEW JERSEY INSTITUTE OF TECHNOLOGY

NEWARK COLLEGE OF ENGINEERING

CHEMICAL ENGINEERING SIMULATION SYSTEM

VERSION 2.1 MAY 1985

C H E S S

CHFSS FXAPLE #1 - TWO STAGF COMPRESSOR

'PROCESS VECTORS'

| ...... EQUIPMENT | ...... | | STREAM NUMBERS | | |
|---|---|---|---|---|---|
| NUMBER | SUBROUTINE | NAME | | | |
| 1 | MIXR | M-1 | 1 | 8 | -2 |
| 2 | ADBF | F-1 | 2 | -3 | -13 |
| 3 | COMP | C-1 | 3 | -4 | 0 |
| 4 | HXER | H-1 | 4 | -5 | 0 |
| 5 | MIXR | M-2 | 5 | 12 | -6 |
| 6 | ADBF | F-2 | 6 | -7 | -8 |
| 7 | COMP | C-2 | 7 | -9 | 0 |
| 8 | HXER | H-2 | 9 | -10 | 0 |
| 9 | ADBF | F-3 | 10 | -11 | -12 |

'STREAM CONNECTIONS'

| STREAM | EQUIPMENT FROM | TO |
|---|---|---|
| 1 | 0 | 1 |
| 2 | 1 | 2 |
| 3 | 2 | 3 |
| 4 | 3 | 4 |
| 5 | 4 | 5 |
| 6 | 5 | 6 |
| 7 | 6 | 7 |
| 8 | 6 | 1 |
| 9 | 7 | 8 |
| 10 | 8 | 9 |
| 11 | 9 | 0 |
| 12 | 9 | 5 |
| 13 | 2 | 0 |

'OTHER SYSTEM VARIABLES'

| | |
|---|---|
| NUMBER OF COMPONENTS | 13 |
| COMPONENT NUMBERS USED | 46, 49, 2, 3, 4,<br>5, 6, 7, 8, 10,<br>200,201,202, |
| RECYCLE EQUIPMENT LIST (KE2) | 6, 7, 8, 9, 1,<br>2, 3, 4, 5, |
| TOLERANCE, 'DERROR' | 0.0001 |
| MAX. LOOPS IN RECYCLE CALC. | 30 |

NON-STANDARD & PETROLEUM FRACTION COMPONENTS

| | | |
|---|---|---|
| COMPONENT NO. = 11 | ID NO. = 200 | NAME= BP274 |
| NBP (F) = 274.0 | API GR. = 55.40 | |
| APC = 407.3 | ATC = 1058.3 | AVC = 450.7 |
| AMW = 120.00 | AOMEG = 0.3994 | ADEL = 7.929 |
| AVW = 22.19 | APH = -0.33228E 01 | BET = 0.98539E-01 |
| GAM = -0.21108E-04 | DTA = 0.0 | |
| COMPONENT NO. = 12 | ID NO. = 201 | NAME= BP499 |
| NBP (F) = 499.0 | API GR. = 37.80 | |
| APC = 284.4 | ATC = 1294.8 | AVC = 746.9 |
| AMW = 200.00 | AOMEG = 0.5748 | ADEL = 8.043 |
| AVW = 34.84 | APH = -0.15029E 01 | BET = 0.15405E 00 |
| GAM = -0.35156E-04 | DTA = 0.0 | |
| COMPONENT NO. = 13 | ID NO. = 202 | NAME= BP931 |
| NBP (F) = 931.0 | API GR. = 17.40 | |
| APC = 138.2 | ATC = 1682.1 | AVC = 1723.5 |
| AMW = 500.00 | AOMEG = 0.9933 | ADEL = 7.442 |
| AVW = 79.91 | APH = -0.36816E 01 | BET = 0.38310E 00 |
| GAM = -0.84730E-04 | DTA = 0.0 | |

'TNPUT DATA'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.4495 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 100.0000 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 65.0000 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | -13467.1953 | 0.0 | 0.0 | 0.0 |
| | COMPOSITION, MOLES/HOUR | | | |
| NITROGEN | 18.0000 | 0.0 | 0.0 | 0.0 |
| CO2 | 192.0000 | 0.0 | 0.0 | 0.0 |
| METHANE | 1455.0000 | 0.0 | 0.0 | 0.0 |
| ETHANE | 907.0000 | 0.0 | 0.0 | 0.0 |
| PROPANE | 726.0000 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 77.0000 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 281.0000 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 95.0000 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 163.0000 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 154.0000 | 0.0 | 0.0 | 0.0 |
| BP274 | 1197.0000 | 0.0 | 0.0 | 0.0 |
| BP499 | 907.0000 | 0.0 | 0.0 | 0.0 |
| BP931 | 907.0000 | 0.0 | 0.0 | 0.0 |
| TOTAL | 7079.0000 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 6 TO 1 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |

COMPOSITION, MOLES/HOUR

| | | | | |
|---|---|---|---|---|
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.0 | 0.0 | 0.0 |
| BP274 | 0.0 | 0.0 | 0.0 | 0.0 |
| BP499 | 0.0 | 0.0 | 0.0 | 0.0 |
| BP931 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 5 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.0 | 0.0 | 0.0 |
| BP274 | 0.0 | 0.0 | 0.0 | 0.0 |
| BP499 | 0.0 | 0.0 | 0.0 | 0.0 |
| BP931 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| | | | |
|---|---|---|---|
| STREAM NUMBER | 13 | | |
| EQUIP. CONXION | FR 2 TO 0 | FR | |
| VAPOR FRACTION | 0.0 | | |
| TEMPERATURE, F | 0.0 | | |
| PRESSURE, PSIA | 0.0 | | |
| ENTHALPY, K BTU | 0.0 | | |
| | | COMPOSITION, MOLES/HOUR | |
| NITROGEN | 0.0 | | |
| CO2 | 0.0 | | |
| METHANE | 0.0 | | |
| ETHANE | 0.0 | | |
| PROPANE | 0.0 | | |
| I-BUTANE | 0.0 | | |
| N-BUTANE | 0.0 | | |
| I-PENTANE | 0.0 | | |
| N-PENTANE | 0.0 | | |
| N-HEXANE | 0.0 | | |
| BP274 | 0.0 | | |
| BP499 | 0.0 | | |
| BP931 | 0.0 | | |
| TOTAL | 0.0 | | |

'INPUT DATA'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | M-1 | MIXR |
| 2 | F-1 | ADBF |
| 3 | C-1 | COMP |
| 4 | H-1 | HXER |
| 5 | M-2 | MIXR |
| 6 | F-2 | ADBF |
| 7 | C-2 | COMP |
| 8 | H-2 | HXER |
| 9 | F-3 | ADBF |

# * EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

***MIXERS ***

| | | |
|---|---|---|
| EQUIPMENT NO. | 1 | 5 |
| EXTERNAL NAME | M-1 | M-2 |

..........................................................................

***ADIABATIC FLSH UNITS***

| | | | |
|---|---|---|---|
| EQUIPMENT NO. | 2 | 6 | 9 |
| EXTERNAL NAME | F-1 | F-2 | F-3 |
| MODE<br>0. PHASE DET.<br>1. CONST. T.<br>2. ADIABATIC | 1.0000 | 1.0000 | 1.0000 |

..........................................................................

***EXCHANGER/CONDENSERS***

| | | |
|---|---|---|
| EQUIPMENT NO. | 4 | 8 |
| EXTERNAL NAME | H-1 | H-2 |
| U | 0.0 | 0.0 |
| AREA | 0.0 | 0.0 |
| # SHELLS | 0.0 | 0.0 |
| SHELL PASSES | 0.0 | 0.0 |
| TUBE PASSES | 0.0 | 0.0 |
| MODE | 5.0000 | 5.0000 |
| DT OR T-OUT | 100.0000 | 100.0000 |
| DELTA P-STM 1 | 3.0000 | 3.0000 |
| DELTA P-STM 2 | 0.0 | 0.0 |
| Q-STREAM 1<br>(M BTU/HR) | 0.0 | 0.0 |
| WATER USAGE<br>(GAL/HR) | 0.0 | 0.0 |

..........................................................................

***COMPRESSORS ***

| | | |
|---|---|---|
| EQUIPMENT NO. | 3 | 7 |
| EXTERNAL NAME | C-1 | C-2 |
| WORK CAPACITY | 0.0 | 0.0 |

| | | |
|---|---|---|
| (PSIA) | | |
| ADIABATIC EFF. | 0.7800 | 0.7500 |
| MECH EFF. | 0.8000 | 0.8000 |
| INLET ACFM | 0.0 | 0.0 |
| DRIVER WORK (HORSEPOWER) | 0.0 | 0.0 |

************************************************************************

***HEAT CURVE GENERATION SUMMARY***

| | CURVE1 | CURVE2 | CURVE3 | CURVE4 | CURVE5 |
|---|---|---|---|---|---|
| PROCESS STREAM | 4.0 | 9.0 | | | |
| INITIAL TEMP. (DEG F) | 0.0 | 0.0 | | | |
| INITIAL PRESS. (PSIA) | 0.0 | 0.0 | | | |
| FINAL TEMP. (DEG F) | 100.0 | 100.0 | | | |
| FINAL PRESS. (PSIA) | 157.0 | 374.0 | | | |
| NUMBER OF POINTS | 10.0 | 10.0 | | | |

NOTE - IF THE INITIAL TEMPERATURE AND PRESSURE HAVE VALUES OF 0.0, THE VALUES IN THE STREAM VECTOR WILL BE USED.

```
*****BEGIN TRIAL AND ERROR RECYCLE CALCULATIONS WITH EQUIPMENT LIST..
      6,  7,  8,  9,  1,  2,  3,  4,  5,

... BEGIN 'LOOP   1' ...

*** INPUT STREAM CANNOT BE COMPRESSED, NE=  7
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =    8

***   DEW POINT TEMP. CANNOT BE DETERMINED, ASSUMED TEMP. WILL BE USED, N

... BEGIN 'LOOP   2' ...

... BEGIN 'LOOP   3' ...

... BEGIN 'LOOP   4' ...

... BEGIN 'LOOP   5' ...

... BEGIN 'LOOP   6' ...

... BEGIN 'LOOP   7' ...

... BEGIN 'LOOP   8' ...

... BEGIN 'LOOP   9' ...

... BEGIN 'LOOP  10' ...

... BEGIN 'LOOP  11' ...

... BEGIN 'LOOP  12' ...

... BEGIN 'LOOP  13' ...

... BEGIN 'LOOP  14' ...

... BEGIN 'LOOP  15' ...

... BEGIN 'LOOP  16' ...

... BEGIN 'LOOP  17' ...

***** END OF RECYCLE CALCULATIONS
```

'FINAL RESULTS'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.4495 | 0.4488 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 100.0000 | 99.8540 | 99.8540 | 204.5686 |
| PRESSURE, PSIA | 65.0000 | 65.0000 | 65.0000 | 160.0000 |
| ENTHALPY,K BTU | -13467.1953 | -13544.8789 | 14128.7500 | 18411.4688 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 18.0000 | 18.0022 | 17.8714 | 17.8714 |
| CO2 | 192.0000 | 192.2448 | 176.8909 | 176.8909 |
| METHANE | 1455.0000 | 1455.6377 | 1416.0972 | 1416.0972 |
| ETHANE | 907.0000 | 908.5664 | 811.2078 | 811.2078 |
| PROPANE | 726.0000 | 729.2087 | 537.8938 | 537.8938 |
| I-BUTANE | 77.0000 | 77.6477 | 38.1238 | 38.1238 |
| N-BUTANE | 281.0000 | 283.7859 | 117.8853 | 117.8853 |
| I-PENTANE | 95.0000 | 96.2972 | 21.5143 | 21.5143 |
| N-PENTANE | 163.0000 | 165.4322 | 30.4710 | 30.4710 |
| N-HEXANE | 154.0000 | 156.7913 | 10.8258 | 10.8258 |
| BP274 | 1197.0000 | 1204.6125 | 8.3165 | 8.3165 |
| BP499 | 907.0000 | 907.0566 | 0.0568 | 0.0568 |
| BP931 | 907.0000 | 907.0000 | 0.0000 | 0.0000 |
| TOTAL | 7079.0000 | 7102.2813 | 3187.1548 | 3187.1548 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 6 TO 1 |
| VAPOR FRACTION | 0.9992 | 0.9929 | 1.0000 | 0.0 |
| TEMPERATURE, F | 100.0000 | 90.2222 | 90.2222 | 90.2222 |
| PRESSURE, PSIA | 157.0000 | 157.0000 | 157.0000 | 157.0000 |
| ENTHALPY,K BTU | 13725.6914 | 13704.1563 | 13781.8711 | -77.7098 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 17.8714 | 17.9005 | 17.8983 | 0.0022 |
| CO2 | 176.8909 | 179.1100 | 178.8652 | 0.2448 |
| METHANE | 1416.0972 | 1422.7971 | 1422.1592 | 0.6378 |
| ETHANE | 811.2078 | 825.1770 | 823.6104 | 1.5664 |
| PROPANE | 537.8938 | 562.6655 | 559.4565 | 3.2088 |
| I-BUTANE | 38.1238 | 41.9288 | 41.2811 | 0.6477 |
| N-BUTANE | 117.8853 | 133.4208 | 130.6346 | 2.7861 |
| I-PENTANE | 21.5143 | 27.0168 | 25.7197 | 1.2972 |
| N-PENTANE | 30.4710 | 40.0896 | 37.6574 | 2.4322 |
| N-HEXANE | 10.8258 | 17.5786 | 14.7873 | 2.7913 |
| BP274 | 8.3165 | 11.9141 | 4.3015 | 7.6126 |
| BP499 | 0.0568 | 0.0572 | 0.0003 | 0.0568 |
| BP931 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| TOTAL | 3187.1548 | 3279.6570 | 3256.3718 | 23.2850 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
| --- | --- | --- | --- | --- |
| EQUIP. CONXION | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 5 |
| VAPOR FRACTION | 1.0000 | 0.9716 | 1.0000 | 0.0 |
| TEMPERATURE, F | 196.8486 | 100.0000 | 100.0000 | 100.0000 |
| PRESSURE, PSIA | 377.0000 | 374.0000 | 374.0000 | 374.0000 |
| ENTHALPY,K BTU | 17932.1250 | 12603.9805 | 12625.5156 | -21.5354 |
| | COMPOSITION, MOLES/HOUR | | | |
| NITROGEN | 17.8983 | 17.8983 | 17.8691 | 0.0291 |
| CO2 | 178.8652 | 178.8652 | 176.6461 | 2.2191 |
| METHANE | 1422.1592 | 1422.1592 | 1415.4590 | 6.7000 |
| ETHANE | 823.6104 | 823.6104 | 809.6409 | 13.9693 |
| PROPANE | 559.4565 | 559.4565 | 534.6846 | 24.7719 |
| I-BUTANE | 41.2811 | 41.2811 | 37.4760 | 3.8051 |
| N-BUTANE | 130.6346 | 130.6346 | 115.0992 | 15.5355 |
| I-PENTANE | 25.7197 | 25.7197 | 20.2171 | 5.5025 |
| N-PENTANE | 37.6574 | 37.6574 | 28.0387 | 9.6187 |
| N-HEXANE | 14.7873 | 14.7873 | 8.0344 | 6.7529 |
| BP274 | 4.3015 | 4.3015 | 0.7039 | 3.5976 |
| BP499 | 0.0003 | 0.0003 | 0.0000 | 0.0003 |
| BP931 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| TOTAL | 3256.3718 | 3256.3718 | 3163.8694 | 92.5024 |

STREAM NUMBER 13

| | |
|---|---|
| EQUIP. CONXION | FR 2 TO 0 FR |
| VAPOR FRACTION | 0.0 |
| TEMPERATURE, F | 99.8540 |
| PRESSURE, PSIA | 65.0000 |
| ENTHALPY,K BTU | -27673.6289 |

| | COMPOSITION, MOLES/HOUR |
|---|---|
| NITROGEN | 0.1308 |
| CO2 | 15.3539 |
| METHANE | 39.5403 |
| ETHANE | 97.3585 |
| PROPANE | 191.3149 |
| I-BUTANE | 39.5239 |
| N-BUTANE | 165.9006 |
| I-PENTANE | 74.7828 |
| N-PENTANE | 134.9612 |
| N-HEXANE | 145.9655 |
| BP274 | 1196.2959 |
| BP499 | 906.9998 |
| BP931 | 906.9998 |
| TOTAL | 3915.1262 |

'FINAL RESULTS'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.4495 | 0.4488 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 100.0000 | 99.8540 | 99.8540 | 204.5686 |
| PRESSURE, PSIA | 65.0000 | 65.0000 | 65.0000 | 160.0000 |
| ENTHALPY,K BTU | -13467.1953 | -13544.8789 | 14128.7500 | 18411.4688 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 504.2878 | 504.3501 | 500.6843 | 500.6843 |
| CO2 | 8449.9180 | 8460.6914 | 7784.9648 | 7784.9648 |
| METHANE | 23341.0977 | 23351.3281 | 22717.0195 | 22717.0195 |
| ETHANE | 27271.6680 | 27318.7656 | 24391.3867 | 24391.3867 |
| PROPANE | 32012.2383 | 32153.7227 | 23717.8828 | 23717.8828 |
| I-BUTANE | 4475.2383 | 4512.8828 | 2215.7529 | 2215.7529 |
| N-BUTANE | 16331.7148 | 16493.6328 | 6851.4922 | 6851.4922 |
| I-PENTANE | 6853.8672 | 6947.4531 | 1552.1726 | 1552.1726 |
| N-PENTANE | 11759.7969 | 11935.2695 | 2198.3579 | 2198.3579 |
| N-HEXANE | 13270.4844 | 13511.0156 | 932.8765 | 932.8765 |
| BP274 | 143640.0000 | 144553.5000 | 997.9849 | 997.9849 |
| BP499 | 181400.0000 | 181411.3125 | 11.3629 | 11.3629 |
| BP931 | 453500.0000 | 453500.0000 | 0.0005 | 0.0005 |
| TOTAL | 922810.0625 | 924653.8125 | 93871.6875 | 93871.6875 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 6 TO 1 |
| VAPOR FRACTION | 0.9992 | 0.9929 | 1.0000 | 0.0 |
| TEMPERATURE, F | 100.0000 | 90.2222 | 90.2222 | 90.2222 |
| PRESSURE, PSIA | 157.0000 | 157.0000 | 157.0000 | 157.0000 |
| ENTHALPY,K BTU | 13725.6914 | 13704.1563 | 13781.8711 | -77.7098 |
| COMPOSITION, LBS/HOUR | | | | |
| NITROGEN | 500.6843 | 501.5010 | 501.4380 | 0.0626 |
| CO2 | 7784.9648 | 7882.6289 | 7871.8516 | 10.7741 |
| METHANE | 22717.0195 | 22824.5000 | 22814.2656 | 10.2318 |
| ETHANE | 24391.3867 | 24811.4141 | 24764.3086 | 47.0998 |
| PROPANE | 23717.8828 | 24810.1680 | 24668.6719 | 141.4910 |
| I-BUTANE | 2215.7529 | 2436.9043 | 2399.2588 | 37.6453 |
| N-BUTANE | 6851.4922 | 7754.4141 | 7592.4805 | 161.9290 |
| I-PENTANE | 1552.1726 | 1949.1572 | 1855.5696 | 93.5874 |
| N-PENTANE | 2198.3579 | 2892.3074 | 2716.8291 | 175.4757 |
| N-HEXANE | 932.8765 | 1514.7866 | 1274.2522 | 240.5291 |
| BP274 | 997.9849 | 1429.6965 | 516.1826 | 913.5156 |
| BP499 | 11.3629 | 11.4307 | 0.0681 | 11.3626 |
| BP931 | 0.0005 | 0.0005 | 0.0000 | 0.0005 |
| TOTAL | 93871.6875 | 98818.6250 | 96975.0000 | 1843.7039 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 5 |
| VAPOR FRACTION | 1.0000 | 0.9716 | 1.0000 | 0.0 |
| TEMPERATURE, F | 196.8486 | 100.0000 | 100.0000 | 100.0000 |
| PRESSURE, PSIA | 377.0000 | 374.0000 | 374.0000 | 374.0000 |
| ENTHALPY,K BTU | 17932.1250 | 12603.9805 | 12625.5156 | -21.5354 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 501.4380 | 501.4380 | 500.6211 | 0.8166 |
| CO2 | 7871.8516 | 7871.8516 | 7774.1914 | 97.6622 |
| METHANE | 22814.2656 | 22814.2656 | 22706.7813 | 107.4816 |
| ETHANE | 24764.3086 | 24764.3086 | 24344.2734 | 420.0291 |
| PROPANE | 24668.6719 | 24668.6719 | 23576.3750 | 1092.2930 |
| I-BUTANE | 2399.2588 | 2399.2588 | 2178.1064 | 221.1523 |
| N-BUTANE | 7592.4805 | 7592.4805 | 6689.5586 | 902.9209 |
| I-PENTANE | 1855.5696 | 1855.5696 | 1458.5840 | 396.9854 |
| N-PENTANE | 2716.8291 | 2716.8291 | 2022.8784 | 693.9495 |
| N-HEXANE | 1274.2522 | 1274.2522 | 692.3420 | 581.9102 |
| BP274 | 516.1826 | 516.1826 | 84.4711 | 431.7114 |
| BP499 | 0.0681 | 0.0681 | 0.0003 | 0.0678 |
| BP931 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| TOTAL | 96975.0000 | 96975.0000 | 92027.9375 | 4946.9766 |

STREAM NUMBER 13

| | |
|---|---|
| EQUIP. CONXION | FR 2 TO 0 FR |
| VAPOR FRACTION | 0.0 |
| TEMPERATURE, F | 99.8540 |
| PRESSURE, PSIA | 65.0000 |
| ENTHALPY,K BTU | -27673.6289 |

| | COMPOSITION, LBS/HOUR |
|---|---|
| NITROGEN | 3.6654 |
| CO2 | 675.7244 |
| METHANE | 634.3054 |
| ETHANE | 2927.3733 |
| PROPANE | 8435.8359 |
| I-BUTANE | 2297.1304 |
| N-BUTANE | 9642.1367 |
| I-PENTANE | 5395.2813 |
| N-PENTANE | 9736.9102 |
| N-HEXANE | 12578.1367 |
| BP274 | 143555.5000 |
| BP499 | 181399.9375 |
| BP931 | 453499.8750 |
| TOTAL | 830781.7500 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 100.0000 | 99.8540 | 99.8540 | 204.568 |
| PRESSURE,PSIA | 65.0000 | 65.0000 | 65.0000 | 160.000 |
| MOLES/HR | 7079.0000 | 7102.2773 | 3187.1536 | 3187.153 |
| POUNDS/HR | 922810.0625 | 924653.8125 | 93871.6875 | 93871.687 |
| MOLECULAR WEIGHT | 130.3588 | 130.1912 | 29.4531 | 29.4531 |
| PSEUDO CRITICAL TEMP,DEG F | 414.2563 | 414.1760 | 33.4702 | 33.4702 |
| PSEUDO CRITICAL PRES,PSIA | 500.6846 | 500.7078 | 682.9641 | 682.9641 |
| ACENTRIC FACTOR | 0.3271 | 0.3269 | 0.0781 | 0.0781 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.9756 | 0.9648 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.3268 | 0.6853 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 4787.0703 | 2282.9937 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.0 | 0.0 | 0.4376 | 0.4960 |
| VISCOSITY,CENTIPOISE | 0.0 | 0.0 | 0.0114 | 0.0139 |
| THERMAL COND,BTU/HR FT DEG F | 0.0 | 0.0 | 0.0141 | 0.0182 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 100.0000 | 90.2222 | 90.2222 | 90.2222 |
| PRESSURE,PSIA | 157.0000 | 157.0000 | 157.0000 | 157.0000 |
| MOLES/HR | 3187.1536 | 3279.6558 | 3256.3706 | 23.2841 |
| POUNDS/HR | 93871.6875 | 98818.6250 | 96975.0000 | 1843.7039 |
| MOLECULAR WEIGHT | 29.4531 | 30.1308 | 29.7801 | 79.1829 |
| PSEUDO CRITICAL TEMP,DEG F | 33.4702 | 39.3989 | 36.8953 | 389.5781 |
| PSEUDO CRITICAL PRES,PSIA | 682.9641 | 680.3076 | 681.5413 | 507.7344 |
| ACENTRIC FACTOR | 0.0781 | 0.0809 | 0.0796 | 0.2624 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.9351 | 0.0 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.8474 | 0.0 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 1907.3792 | 0.0 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 40.6006 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 80.4450 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 5.6645 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.0 | 0.0 | 0.4514 | 0.4810 |
| VISCOSITY,CENTIPOISE | 0.0 | 0.0 | 0.0120 | 0.2420 |
| THERMAL COND,BTU/HR FT DEG F | 0.0 | 0.0 | 0.0140 | 0.0555 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 196.8486 | 100.0000 | 100.0000 | 100.000 |
| PRESSURE,PSIA | 377.0000 | 374.0000 | 374.0000 | 374.000 |
| MOLES/HR | 3256.3706 | 3256.3706 | 3163.8682 | 92.502 |
| POUNDS/HR | 96975.0000 | 96975.0000 | 92027.9375 | 4946.976 |
| MOLECULAR WEIGHT | 29.7801 | 29.7801 | 29.0872 | 53.479 |
| PSEUDO CRITICAL TEMP,DEG F | 36.8953 | 36.8953 | 30.8494 | 243.678 |
| PSEUDO CRITICAL PRES,PSIA | 681.5413 | 681.5413 | 684.2539 | 588.761 |
| ACENTRIC FACTOR | 0.0796 | 0.0796 | 0.0768 | 0.176 |
| COMPRESSIBILITY FACTOR | 0.9108 | 0.0 | 0.8542 | 0.0 |
| VAPOR DENSITY,LB/CU FT | 1.7498 | 0.0 | 2.1205 | 0.0 |
| VAPOR CU FT/MIN | 923.6670 | 0.0 | 723.3152 | 0.0 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 32.703 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 124.154 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 18.868 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.5197 | 0.0 | 0.5007 | 0.615 |
| VISCOSITY,CENTIPOISE | 0.0140 | 0.0 | 0.0126 | 0.126 |
| THERMAL COND,BTU/HR FT DEG F | 0.0185 | 0.0 | 0.0155 | 0.051 |

| STREAM NUMBER | 13 |
|---|---|
| TEMPERATURE,DEG F | 99.8540 |
| PRESSURE,PSIA | 65.0000 |
| MOLES/HR | 3915.1272 |
| POUNDS/HR | 830781.7500 |
| MOLECULAR WEIGHT | 212.1979 |
| PSEUDO CRITICAL TEMP,DEG F | 724.0930 |
| PSEUDO CRITICAL PRES,PSIA | 352.3403 |
| ACENTRIC FACTOR | 0.5294 |
| COMPRESSIBILITY FACTOR | 0.0 |
| VAPOR DENSITY,LB/CU FT | 0.0 |
| VAPOR CU FT/MIN | 0.0 |
| LIQUID DENSITY,LB/CU FT | 53.6189 |
| LIQUID API @ 60F | 30.0481 |
| LIQUID GAL/MIN | 1932.7461 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.3305 |
| VISCOSITY,CENTIPOISE | 0.6448 |
| THERMAL COND,BTU/HR FT DEG F | 0.0497 |

AFTERCOOLER CONDENSING CURVE

STREAM - 9

| POINT | TEMPERATURE (DEG F) | PRESSURE (PSIA) | MOLE FRACTION VAPORIZED | ENTHALPY K BTU/HR |
|---|---|---|---|---|
| 1 | 196.85 | 377.00 | 1.0000 | 17932.109 |
| 2 | 186.09 | 376.67 | 1.0000 | 17391.566 |
| 3 | 175.33 | 376.33 | 1.0000 | 16854.285 |
| 4 | 164.57 | 376.00 | 1.0000 | 16320.121 |
| 5 | 153.80 | 375.67 | 1.0000 | 15788.754 |
| 6 | 143.04 | 375.33 | 1.0000 | 15259.961 |
| 7 | 132.28 | 375.00 | 1.0000 | 14733.316 |
| 8 | 121.52 | 374.67 | 0.9984 | 14174.164 |
| 9 | 110.76 | 374.33 | 0.9896 | 13470.320 |
| 10 | 100.00 | 374.00 | 0.9716 | 12603.992 |
| DEW POINT | 124.83 | 374.83 | 1.0 | 11284.695 |

'FINAL RESULTS'

CHESS EXAPLE #1 - TWO STAGE COMPRESSOR

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | M-1 | MIXR |
| 2 | F-1 | ADBF |
| 3 | C-1 | COMP |
| 4 | H-1 | HXER |
| 5 | M-2 | MIXR |
| 6 | F-2 | ADBF |
| 7 | C-2 | COMP |
| 8 | H-2 | HXER |
| 9 | F-3 | ADBF |

* EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

***MIXERS ***

| | | |
|---|---|---|
| EQUIPMENT NO. | 1 | 5 |
| EXTERNAL NAME | M-1 | M-2 |

.....................................................................

***ADIABATIC FLSH UNITS***

| | | | |
|---|---|---|---|
| EQUIPMENT NO. | 2 | 6 | 9 |
| EXTERNAL NAME | F-1 | F-2 | F-3 |
| MODE | 1.0000 | 1.0000 | 1.0000 |
| 0. PHASE DET. | | | |
| 1. CONST. T. | | | |
| 2. ADIABATIC | | | |

.....................................................................

***EXCHANGER/CONDENSERS***

| | | |
|---|---|---|
| EQUIPMENT NO. | 4 | 8 |
| EXTERNAL NAME | H-1 | H-2 |
| U | 0.0 | 0.0 |
| AREA | 0.0 | 0.0 |
| # SHELLS | 0.0 | 0.0 |
| SHELL PASSES | 0.0 | 0.0 |
| TUBE PASSES | 0.0 | 0.0 |
| MODE | 5.0000 | 5.0000 |
| DT OR T-OUT | 100.0000 | 100.0000 |
| DELTA P-STM 1 | 3.0000 | 3.0000 |
| DELTA P-STM 2 | 0.0 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | 4685.7773 | 5328.1445 |
| WATER USAGE (GAL/HR) | 37501.2227 | 42642.2148 |

.....................................................................

***COMPRESSORS ***

| | | |
|---|---|---|
| EQUIPMENT NO. | 3 | 7 |
| EXTERNAL NAME | C-1 | C-2 |
| WORK CAPACITY | 0.0 | 0.0 |

| | | |
|---|---|---|
| (PSIA) | | |
| ADIABATIC EFF. | 0.7800 | 0.7500 |
| MECH EFF. | 0.8000 | 0.8000 |
| INLET ACFM | 4787.0703 | 1907.3794 |
| DRIVER WORK (HORSEPOWER) | 2101.8494 | 2036.8418 |

••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

## EXAMPLE #2

Simple Ethylene Plant

The process flow diagram for a simple ethylene plant is shown in FIGURE V. The corresponding simulation flow diagram is given in FIGURE VI.

The process consists of two reactors, a compressor and distillation columns for product separation.

The feed to the process is as follows:

| | |
|---|---|
| Temperature, °F | 70 |
| Pressure, psia | 600 |

| Component | lb-mols/HR |
|---|---|
| Ethane | 80 |
| Propane | 120 |
| Total | 200 |

Process Conditions are:

| | Temperature, °F | Pressure drop < ><br>Pressure, psia |
|---|---|---|
| V-1 Outlet | | 90 |
| F-1 Outlet | 160 | <10> |
| C-1 outlet | | 220 |
| H-1 Outlet | 160 | <2> |
| C-2 Outlet | | 602 |
| H-2 Outlet | 150 | <2> |
| F-2 Outlet | 160 | <10> |

Valve V-1:

outlet pressure = 90 psia

Fired Heaters F-1 & F-2:

| | | |
|---|---|---|
| Outlet temperature | = | 160°F |
| rated duty | = | $1.5 \times 10^6$ BTU/hr |
| pressure drop | = | 10 psi |

REACTOR R-1:

$3C_2H_6 + 6C_3H_8 \rightarrow 4H_2 + CH_4 + 5C_2H_4 + 2C_3H_8 + 4C_4H_{10}$

90% conversion of $C_3H_8$

Compressor C-1:

| | | |
|---|---|---|
| outlet pressure | = | 220 psia |
| adiabatic efficiency | = | 0.73 |
| mechanical efficiency | = | 0.85 |

Exchanger H-1:

| | | |
|---|---|---|
| outlet temperature | = | 150°F |
| pressure drop | = | 2 psi |

Compressor C-2:

| | | |
|---|---|---|
| outlet pressure | = | 602 psia |
| adiabatic efficiency | = | 0.73 |
| mechanical efficiency | = | 0.85 |

Distillation Column T-1:

100% of $H_2$ and $CH_4$ overhead

Distillation Column T-2:

99% of $C2H4$ overhead
5% of $C2H6$ overhead

Reactor R-2:

$4\ C_2H6 \longrightarrow 2H2 + 2CH4 + 3C2H6$
80% conversion of C2H6

This example problem utilizes the following new features of CHESS 2.1.

1. New compressor module COMP
2. Stream temperatures and equipment parameters in °F
3. Stream properties summary
4. Stream mass summary

The input data for the problem is given in TABLE V.

The simulation results are also given in TABLE VI.

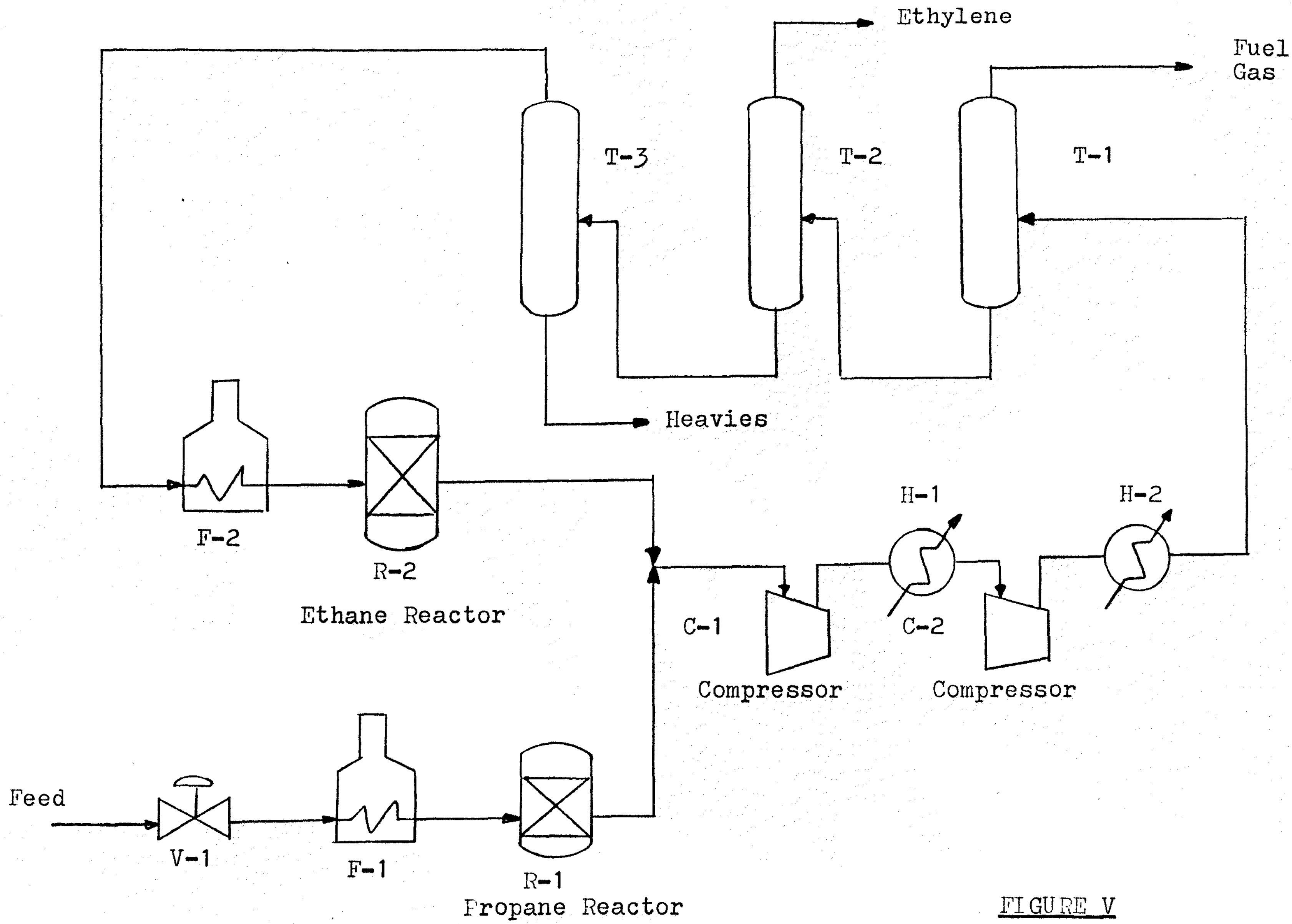



FIGURE V

Process Flow Diagram - Simple Ethylene Plant

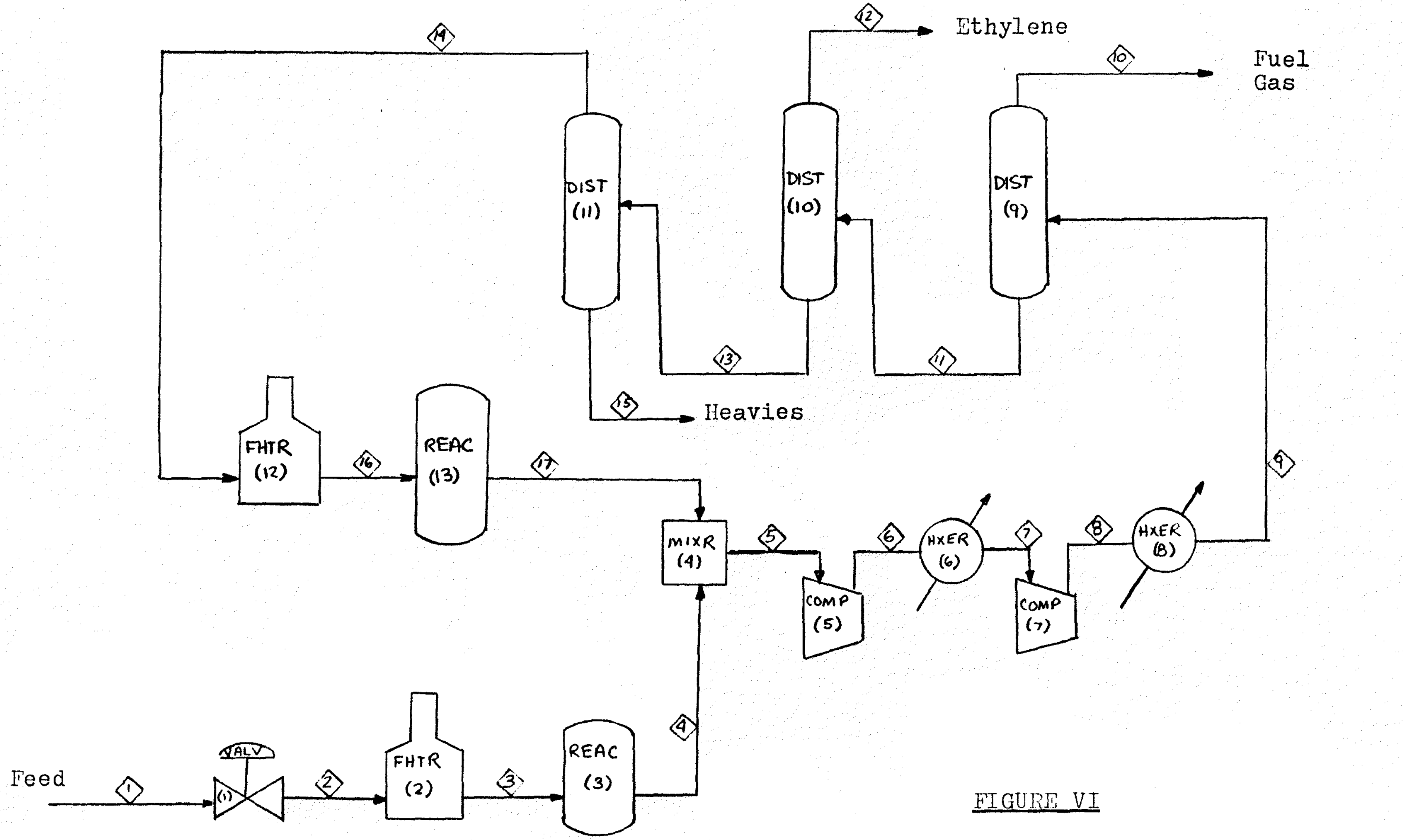



FIGURE VI

Simulation Flow Diagram - Simple Ethylene Plant

◇ Stream No.

( ) Equipment No.

```
CLEAN,NAMELIST
 CHESS EXAPLE #2 - SIMPLE ETHYLENE PLANT
 &PMLIST
  KPM1=1,'VALV','V-1 ',1,-2,5*0,
  KPM2=2,'FHTR','F-1 ',2,-3,5*0,
  KPM3=3,'REAC','R-1 ',3,-4,5*0,
  KPM4=4,'MIXR','M-1 ',4,17,-5,4*0,
  KPM5=5,'COMP','C-1 ',5,-6,5*0,
  KPM6=6,'HXER','H-1 ',6,-7,5*0,
  KPM7=7,'COMP','C-2 ',7,-8,5*0,
  KPM8=8,'HXER','H-2 ',8,-9,5*0,
  KPM9=9,'DIST','T-1 ',9,-10,-11,4*0,
  KPM10=10,'DIST','T-2 ',11,-12,-13,4*0,
  KPM11=11,'DIST','T-3 ',13,-14,-15,4*0,
  KPM12=12,'FHTR','F-2 ',14,-16,5*0,
  KPM13=13,'REAC','R-2 ',16,-17,5*0,
  NOCOMP=7,
  COMPNT=1,2,3,4,22,23,6,13*0,
 &END
 &EQLIST
  EQP1=1.,90.,23*0,
  EQP2=2.,1500.,10.,160.,21*0,
  EQP3=3.,.9,3*4.,-3.,-6.,5.,2.,1.,15*0,
  EQP4=4.,24*0,
  EQP5=5.,0.,220.,0.73,0.85,20*0,
  EQP6=6.,5*0.,5.,150.,2.,16*0,
  EQP7=7.,0.,602.,0.73,0.85,20*0,
  EQP8=8.,5*0.,5.,150.,2.,16*0,
  EQP9=9.,0.0,0.0,2*1.,20*0,
  EQP10=10.,4*0.,0.05,0.0,0.99,17*0,
  EQP11=11.,4*0.,0.99,0.,1.,17*0,
  EQP12=12.,1500.,10.,160.,21*0,
  EQP13=13.,0.8,3.,2.,2.,-4.,0.,3.,17*0,
 &END
 &SEXLST
  SEX1=1.,0.,200.,0.,0.,80.,120.,16*0,
  SNAME=2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,84*0,
 &END
 &SINLST
  SIN1=1.,1.,0.,70.,600.,5*0,
  SIN10=10.,2.,8*0,
  SIN12=12.,2.,8*0,
  SIN15=15.,2.,8*0,
  SNAME=2,3,4,5,6,7,8,9,11,13,14,16,17,87*0,
 &END
 &KELIST
  LOOPS=20,
 &END
 &HCLIST
 &END
```

TABLE V

Input Data for CHESS Example #2

TABLE VI

Simulation Results for Example #2

```
CLEAN,NAMELIST
CHESS EXAPLE #2 - SIMPLE ETHYLENE PLANT


NOW BEGIN TO READ 'PMLIST'
'PMLIST' READING COMPLETE

NOW BEGIN TO READ 'EQLIST'
'EQLIST' READING COMPLETE

NOW BEGIN TO READ 'SEXLST'
'SEXLST' READING COMPLETE

NOW BEGIN TO READ 'SINLST'
'SINLST' READING COMPLETE

NOW BEGIN TO READ 'KELIST'
'KELIST' READING COMPLETE

NOW BEGIN TO READ 'HCLIST'
 'HCLIST' READING COMPLETE
```

** DECOMPOSITION OF NET(S) WILL FOLLOW **

PRECURSOR LIST..

| | | | | | | |
|---|---|---|---|---|---|---|
| 1↑ | 0 | 0 | 0 | 0 | 0 | 0 |
| 2↑ | 1 | 0 | 0 | 0 | 0 | 0 |
| 3↑ | 2 | 0 | 0 | 0 | 0 | 0 |
| 4↑ | 3 | 0 | 0 | 0 | 0 | 0 |
| 5↑ | 4 | 17 | 0 | 0 | 0 | 0 |
| 6↑ | 5 | 0 | 0 | 0 | 0 | 0 |
| 7↑ | 6 | 0 | 0 | 0 | 0 | 0 |
| 8↑ | 7 | 0 | 0 | 0 | 0 | 0 |
| 9↑ | 8 | 0 | 0 | 0 | 0 | 0 |
| 10↑ | 9 | 0 | 0 | 0 | 0 | 0 |
| 11↑ | 9 | 0 | 0 | 0 | 0 | 0 |
| 12↑ | 11 | 0 | 0 | 0 | 0 | 0 |
| 13↑ | 11 | 0 | 0 | 0 | 0 | 0 |
| 14↑ | 13 | 0 | 0 | 0 | 0 | 0 |
| 15↑ | 13 | 0 | 0 | 0 | 0 | 0 |
| 16↑ | 14 | 0 | 0 | 0 | 0 | 0 |
| 17↑ | 16 | 0 | 0 | 0 | 0 | 0 |

GROUPED CUT-VERTEX PRECURSORS..

17↑ 17

CUT STREAM LIST.. 17

KE2 ..

4 5 6 7 8 9 10 11 12 13

C H E S S

NEW JERSEY INSTITUTE OF TECHNOLOGY

NEWARK COLLEGE OF ENGINEERING

CHEMICAL ENGINEERING SIMULATION SYSTEM

VERSION 2.1 MAY 1985

C H E S S

CHESS EXAPLE #2 - SIMPLE ETHYLENE PLANT

'PROCESS VECTORS'

| ...... EQUIPMENT ...... | | | STREAM NUMBERS | | |
|---|---|---|---|---|---|
| NUMBER | SUBROUTINE | NAME | | | |
| 1 | VALV | V-1 | 1 | -2 | 0 |
| 2 | FHTR | F-1 | 2 | -3 | 0 |
| 3 | REAC | R-1 | 3 | -4 | 0 |
| 4 | MIXR | M-1 | 4 | 17 | -5 |
| 5 | COMP | C-1 | 5 | -6 | 0 |
| 6 | HXER | H-1 | 6 | -7 | 0 |
| 7 | COMP | C-2 | 7 | -8 | 0 |
| 8 | HXER | H-2 | 8 | -9 | 0 |
| 9 | DIST | T-1 | 9 | -10 | -11 |
| 10 | DIST | T-2 | 11 | -12 | -13 |
| 11 | DIST | T-3 | 13 | -14 | -15 |
| 12 | FHTR | F-2 | 14 | -16 | 0 |
| 13 | REAC | R-2 | 16 | -17 | 0 |

'STREAM CONNECTIONS'

| STREAM | EQ UIPMENT FROM | TO |
|---|---|---|
| 1 | 0 | 1 |
| 2 | 1 | 2 |
| 3 | 2 | 3 |
| 4 | 3 | 4 |
| 5 | 4 | 5 |
| 6 | 5 | 6 |
| 7 | 6 | 7 |
| 8 | 7 | 8 |
| 9 | 8 | 9 |
| 10 | 9 | 0 |
| 11 | 9 | 10 |
| 12 | 10 | 0 |
| 13 | 10 | 11 |
| 14 | 11 | 12 |
| 15 | 11 | 0 |
| 16 | 12 | 13 |
| 17 | 13 | 4 |

'OTHER SYSTEM VARIABLES'

| | |
|---|---|
| NUMBER OF COMPONENTS | 7 |
| COMPONENT NUMBERS USED | 1, 2, 3, 4, 22, 23, 6, |
| RECYCLE EQUIPMENT LIST (KE2) | 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, |
| TOLERANCE, 'DERROR' | 0.0001 |
| MAX. LOOPS IN RECYCLE CALC. | 20 |

'INPUT DATA'

CHESS EXAPLE #2 - SIMPLE ETHYLENE PLANT

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | V-1 | VALV |
| 2 | F-1 | FHTR |
| 3 | R-1 | REAC |
| 4 | M-1 | MIXR |
| 5 | C-1 | COMP |
| 6 | H-1 | HXER |
| 7 | C-2 | COMP |
| 8 | H-2 | HXER |
| 9 | T-1 | DIST |
| 10 | T-2 | DIST |
| 11 | T-3 | DIST |
| 12 | F-2 | FHTR |

* EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

***FRACTIONATORS ***

| EQUIPMENT NO. | 9 | 10 | 11 |
|---|---|---|---|
| EXTERNAL NAME | T-1 | T-2 | T-3 |
| MODE | 0.0 | 0.0 | 0.0 |
| VAP. FRACT'N | 0.0 | 0.0 | 0.0 |
| OVHD. COMP 1 | 1.0000 | 0.0 | 0.0 |
| OR K-VALUE 2 | 1.0000 | 0.0 | 0.0 |
| 3 | 0.0 | 0.0500 | 0.9900 |
| 4 | 0.0 | 0.0 | 0.0 |
| 5 | 0.0 | 0.9900 | 1.0000 |
| 6 | 0.0 | 0.0 | 0.0 |
| 7 | 0.0 | 0.0 | 0.0 |

..............................................................

***MIXERS ***

| EQUIPMENT NO. | 4 |
|---|---|
| EXTERNAL NAME | M-1 |

..............................................................

***REACTORS ***

| EQUIPMENT NO. | 3 | 13 |
|---|---|---|
| EXTERNAL NAME | R-1 | R-2 |
| KEY COMP CONV | 0.9000 | 0.8000 |
| KEY COMP # | 4.0000 | 3.0000 |
| STOICH. FAC. 1 | 4.0000 | 2.0000 |
| 2 | 4.0000 | 2.0000 |
| 3 | -3.0000 | -4.0000 |
| 4 | -6.0000 | 0.0 |
| 5 | 5.0000 | 3.0000 |
| 6 | 2.0000 | 0.0 |
| 7 | 1.0000 | 0.0 |

..............................................................

***P.C. VALVES ***

EQUIPMENT NO. 1

| | |
|---|---|
| DOWNSTM. P (PSIA) | 90.0000 |

•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

***EXCHANGER/CONDENSERS***

| EQUIPMENT NO. | 6 | 8 |
|---|---|---|
| EXTERNAL NAME | H-1 | H-2 |
| U | 0.0 | 0.0 |
| AREA | 0.0 | 0.0 |
| # SHELLS | 0.0 | 0.0 |
| SHELL PASSES | 0.0 | 0.0 |
| TUBE PASSES | 0.0 | 0.0 |
| MODE | 5.0000 | 5.0000 |
| DT OR T-OUT | 150.0000 | 150.0000 |
| DELTA P-STM 1 | 2.0000 | 2.0000 |
| DELTA P-STM 2 | 0.0 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | 0.0 | 0.0 |
| WATER USAGE (GAL/HR) | 0.0 | 0.0 |

•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

***FIRED HEATERS ***

| EQUIPMENT NO. | 2 | 12 |
|---|---|---|
| EXTERNAL NAME | F-1 | F-2 |
| HEAT DUTY (M BTU/HR) | 1500.0000 | 1500.0000 |
| DELTA PRES. (PSIA) | 10.0000 | 10.0000 |
| TEMP. OUT (DEG F.) | 160.0000 | 160.0000 |
| Q ABSORBED (M BTU/HR) | 0.0 | 0.0 |
| FUEL USAGE (MSCF/HR) | 0.0 | 0.0 |

•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

***COMPRESSORS ***

| EQUIPMENT NO. | 5 | 7 |
|---|---|---|
| EXTERNAL NAME | C-1 | C-2 |
| WORK CAPACITY (HORSEPOWER) | 0.0 | 0.0 |
| OUTLET PRES. (PSIA) | 220.0000 | 602.0000 |
| ADIABATIC EFF. | 0.7300 | 0.7300 |
| MECH EFF. | 0.8500 | 0.8500 |

(HORSEPOWER)

••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

'INPUT DATA'

CHESS EXAPLE #2 - SIMPLE ETHYLENE PLANT

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 70.0000 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 600.0000 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | -206.7526 | 0.0 | 0.0 | 0.0 |
| | | COMPOSITION, MOLES/HOUR | | |
| HYDROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 80.0000 | 0.0 | 0.0 | 0.0 |
| PROPANE | 120.0000 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 200.0000 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 7 TO 8 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| | | COMPOSITION, MOLES/HOUR | | |
| HYDROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 10 | FR 10 TO 0 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| | | COMPOSITION, MOLES/HOUR | | |
| HYDROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 10 TO 11 | FR 11 TO 12 | FR 11 TO 0 | FR 12 TO 13 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| | | COMPOSITION, MOLES/HOUR | | |
| HYDROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 17 |
|---|---|
| EQUIP. CONXION | FR 13 TO 4 FR |
| VAPOR FRACTION | 0.0 |
| TEMPERATURE, F | 0.0 |
| PRESSURE, PSIA | 0.0 |
| ENTHALPY,K BTU | 0.0 |

COMPOSITION, MOLES/HOUR

| | |
|---|---|
| HYDROGEN | 0.0 |
| METHANE | 0.0 |
| ETHANE | 0.0 |
| PROPANE | 0.0 |
| ETHYLENE | 0.0 |
| PROPYLENE | 0.0 |
| N-BUTANE | 0.0 |
| TOTAL | 0.0 |

```
*****BEGIN TRIAL AND ERROR RECYCLE CALCULATIONS WITH EQUIPMENT LIST..
        4,   5,   6,   7,   8,   9,  10,  11,  12,  13,
-----------------------------------------------------------------------
... BEGIN 'LOOP   1' ...
-----------------------------------------------------------------------
... BEGIN 'LOOP   2' ...
-----------------------------------------------------------------------
... BEGIN 'LOOP   3' ...
-----------------------------------------------------------------------
... BEGIN 'LOOP   4' ...
-----------------------------------------------------------------------
***** END OF RECYCLE CALCULATIONS
```

'FINAL RESULTS'

CHESS EXAPLE #2 - SIMPLE ETHYLENE PLANT

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.0 | 0.2968 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 70.0000 | 5.1689 | 160.0000 | 160.0000 |
| PRESSURE, PSIA | 600.0000 | 90.0000 | 80.0000 | 80.0000 |
| ENTHALPY,K BTU | -206.7526 | -206.7526 | 1244.5569 | 1586.0918 |
| | | COMPOSITION, MOLES/HOUR | | |
| HYDROGEN | 0.0 | 0.0 | 0.0 | 80.0000 |
| METHANE | 0.0 | 0.0 | 0.0 | 80.0000 |
| ETHANE | 80.0000 | 80.0000 | 80.0000 | 20.0000 |
| PROPANE | 120.0000 | 120.0000 | 120.0000 | 0.0 |
| ETHYLENE | 0.0 | 0.0 | 0.0 | 100.0000 |
| PROPYLENE | 0.0 | 0.0 | 0.0 | 40.0000 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 20.0000 |
| TOTAL | 200.0000 | 200.0000 | 200.0000 | 340.0000 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 7 TO 8 |
| VAPOR FRACTION | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 158.4470 | 311.9695 | 150.0000 | 305.2446 |
| PRESSURE, PSIA | 80.0000 | 220.0000 | 218.0000 | 602.0000 |
| ENTHALPY,K BTU | 1718.1868 | 2405.7249 | 1648.9258 | 2314.4390 |
| | | COMPOSITION, MOLES/HOUR | | |
| HYDROGEN | 89.4050 | 89.4050 | 89.4050 | 89.4050 |
| METHANE | 89.4050 | 89.4050 | 89.4050 | 89.4050 |
| ETHANE | 20.0000 | 20.0000 | 20.0000 | 20.0000 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 115.2601 | 115.2601 | 115.2601 | 115.2601 |
| PROPYLENE | 40.0000 | 40.0000 | 40.0000 | 40.0000 |
| N-BUTANE | 20.0000 | 20.0000 | 20.0000 | 20.0000 |
| TOTAL | 374.0701 | 374.0701 | 374.0701 | 374.0701 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 10 | FR 10 TO 0 |
| VAPOR FRACTION | 0.8830 | 1.0000 | 0.0 | 1.0000 |
| TEMPERATURE, F | 150.0000 | 150.0000 | 150.0000 | 150.0000 |
| PRESSURE, PSIA | 600.0000 | 600.0000 | 600.0000 | 600.0000 |
| ENTHALPY,K BTU | 993.4250 | 708.8665 | 676.5959 | 382.3508 |
| COMPOSITION, MOLES/HOUR | | | | |
| HYDROGEN | 89.4050 | 89.4050 | 0.0 | 0.0 |
| METHANE | 89.4050 | 89.4050 | 0.0 | 0.0 |
| ETHANE | 20.0000 | 0.0 | 20.0000 | 1.0000 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 115.2601 | 0.0 | 115.2601 | 114.1075 |
| PROPYLENE | 40.0000 | 0.0 | 40.0000 | 0.0 |
| N-BUTANE | 20.0000 | 0.0 | 20.0000 | 0.0 |
| TOTAL | 374.0701 | 178.8100 | 195.2601 | 115.1075 |

| STREAM NUMBER | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 10 TO 11 | FR 11 TO 12 | FR 11 TO 0 | FR 12 TO 13 |
| VAPOR FRACTION | 0.0 | 1.0000 | 0.0 | 1.0000 |
| TEMPERATURE, F | 150.0000 | 150.0000 | 150.0000 | 160.0000 |
| PRESSURE, PSIA | 600.0000 | 600.0000 | 600.0000 | 590.0000 |
| ENTHALPY,K BTU | 63.5110 | 81.3019 | 28.8321 | 85.2297 |
| COMPOSITION, MOLES/HOUR | | | | |
| HYDROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 19.0000 | 18.8100 | 0.1900 | 18.8100 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 1.1526 | 1.1526 | 0.0 | 1.1526 |
| PROPYLENE | 40.0000 | 0.0 | 40.0000 | 0.0 |
| N-BUTANE | 20.0000 | 0.0 | 20.0000 | 0.0 |
| TOTAL | 80.1526 | 19.9626 | 60.1900 | 19.9626 |

| | | |
|---|---|---|
| STREAM NUMBER | 17 | |
| EQUIP. CONXION | FR 13 TO 4 | FR |
| VAPOR FRACTION | 1.0000 | |
| TEMPERATURE, F | 160.0000 | |
| PRESSURE, PSIA | 590.0000 | |
| ENTHALPY,K BTU | 132.0958 | |

| | COMPOSITION, MOLES/HOUR |
|---|---|
| HYDROGEN | 9.4050 |
| METHANE | 9.4050 |
| ETHANE | 0.0 |
| PROPANE | 0.0 |
| ETHYLENE | 15.2601 |
| PROPYLENE | 0.0 |
| N-BUTANE | 0.0 |
| TOTAL | 34.0701 |

'FINAL RESULTS'

CHESS EXAPLE #2 - SIMPLE ETHYLENE PLANT

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.0 | 0.2968 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 70.0000 | 5.1689 | 160.0000 | 160.0000 |
| PRESSURE, PSIA | 600.0000 | 90.0000 | 80.0000 | 80.0000 |
| ENTHALPY,K BTU | -206.7526 | -206.7526 | 1244.5569 | 1586.0918 |
| | | COMPOSITION, LBS/HOUR | | |
| HYDROGEN | 0.0 | 0.0 | 0.0 | 161.2800 |
| METHANE | 0.0 | 0.0 | 0.0 | 1283.3594 |
| ETHANE | 2405.4395 | 2405.4395 | 2405.4395 | 601.3599 |
| PROPANE | 5291.2773 | 5291.2773 | 5291.2773 | 0.0 |
| ETHYLENE | 0.0 | 0.0 | 0.0 | 2805.1985 |
| PROPYLENE | 0.0 | 0.0 | 0.0 | 1683.1194 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 1162.3999 |
| TOTAL | 7696.7148 | 7696.7148 | 7696.7148 | 7696.7109 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 7 | FR 7 TO 8 |
| VAPOR FRACTION | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 158.4470 | 311.9695 | 150.0000 | 305.2446 |
| PRESSURE, PSIA | 80.0000 | 220.0000 | 218.0000 | 602.0000 |
| ENTHALPY,K BTU | 1718.1868 | 2405.7249 | 1648.9258 | 2314.4390 |
| | | COMPOSITION, LBS/HOUR | | |
| HYDROGEN | 180.2404 | 180.2404 | 180.2404 | 180.2404 |
| METHANE | 1434.2341 | 1434.2341 | 1434.2341 | 1434.2341 |
| ETHANE | 601.3599 | 601.3599 | 601.3599 | 601.3599 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 3233.2747 | 3233.2747 | 3233.2747 | 3233.2747 |
| PROPYLENE | 1683.1194 | 1683.1194 | 1683.1194 | 1683.1194 |
| N-BUTANE | 1162.3999 | 1162.3999 | 1162.3999 | 1162.3999 |
| TOTAL | 8294.6211 | 8294.6211 | 8294.6211 | 8294.6211 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 8 TO 9 | FR 9 TO 0 | FR 9 TO 10 | FR 10 TO 0 |
| VAPOR FRACTION | 0.8830 | 1.0000 | 0.0 | 1.0000 |
| TEMPERATURE, F | 150.0000 | 150.0000 | 150.0000 | 150.0000 |
| PRESSURE, PSIA | 600.0000 | 600.0000 | 600.0000 | 600.0000 |
| ENTHALPY,K BTU | 993.4250 | 708.8665 | 676.5959 | 382.3508 |
| | | COMPOSITION, LBS/HOUR | | |
| HYDROGEN | 180.2404 | 180.2404 | 0.0 | 0.0 |
| METHANE | 1434.2341 | 1434.2341 | 0.0 | 0.0 |
| ETHANE | 601.3599 | 0.0 | 601.3599 | 30.0680 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 3233.2747 | 0.0 | 3233.2747 | 3200.9414 |
| PROPYLENE | 1683.1194 | 0.0 | 1683.1194 | 0.0 |
| N-BUTANE | 1162.3999 | 0.0 | 1162.3999 | 0.0 |
| TOTAL | 8294.6211 | 1614.4744 | 6680.1523 | 3231.0093 |

| STREAM NUMBER | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 10 TO 11 | FR 11 TO 12 | FR 11 TO 0 | FR 12 TO 13 |
| VAPOR FRACTION | 0.0 | 1.0000 | 0.0 | 1.0000 |
| TEMPERATURE, F | 150.0000 | 150.0000 | 150.0000 | 160.0000 |
| PRESSURE, PSIA | 600.0000 | 600.0000 | 600.0000 | 590.0000 |
| ENTHALPY,K BTU | 63.5110 | 81.3019 | 28.8321 | 85.2297 |
| | | COMPOSITION, LBS/HOUR | | |
| HYDROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 571.2917 | 565.5789 | 5.7130 | 565.5789 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLENE | 32.3332 | 32.3332 | 0.0 | 32.3332 |
| PROPYLENE | 1683.1194 | 0.0 | 1683.1194 | 0.0 |
| N-BUTANE | 1162.3999 | 0.0 | 1162.3999 | 0.0 |
| TOTAL | 3449.1440 | 597.9119 | 2851.2322 | 597.9119 |

| | | |
|---|---|---|
| STREAM NUMBER | 17 | |
| EQUIP. CONXION | FR 13 TO 4 | FR |
| VAPOR FRACTION | 1.0000 | |
| TEMPERATURE, F | 160.0000 | |
| PRESSURE, PSIA | 590.0000 | |
| ENTHALPY,K BTU | 132.0958 | |
| | | COMPOSITION, LBS/HOUR |
| HYDROGEN | 18.9605 | |
| METHANE | 150.8749 | |
| ETHANE | 0.0 | |
| PROPANE | 0.0 | |
| ETHYLENE | 428.0764 | |
| PROPYLENE | 0.0 | |
| N-BUTANE | 0.0 | |
| TOTAL | 597.9116 | |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 70.0000 | 5.1689 | 160.0000 | 160.0000 |
| PRESSURE,PSIA | 600.0000 | 90.0000 | 80.0000 | 80.0000 |
| MOLES/HR | 200.0000 | 200.0000 | 200.0000 | 340.0000 |
| POUNDS/HR | 7696.7148 | 7696.7148 | 7696.7148 | 7696.7109 |
| MOLECULAR WEIGHT | 38.4836 | 38.4836 | 38.4836 | 22.6374 |
| PSEUDO CRITICAL TEMP,DEG F | 159.7764 | 159.7764 | 159.7764 | -60.3147 |
| PSEUDO CRITICAL PRES,PSIA | 653.7656 | 653.7656 | 653.7656 | 573.4290 |
| ACENTRIC FACTOR | 0.1348 | 0.1348 | 0.1348 | 0.0627 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.9565 | 0.9879 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.4841 | 0.2757 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 265.0090 | 465.2793 |
| LIQUID DENSITY,LB/CU FT | 28.5426 | 0.0 | 0.0 | 0.0 |
| LIQUID API @ 60F | 171.6316 | 0.0 | 0.0 | 0.0 |
| LIQUID GAL/MIN | 33.6370 | 0.0 | 0.0 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.7008 | 0.0 | 0.4677 | 0.5158 |
| VISCOSITY,CENTIPOISE | 0.0849 | 0.0 | 0.0113 | 0.0129 |
| THERMAL COND,BTU/HR FT DEG F | 0.0536 | 0.0 | 0.0131 | 0.0247 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 158.4470 | 311.9695 | 150.0000 | 305.2446 |
| PRESSURE,PSIA | 80.0000 | 220.0000 | 218.0000 | 602.0000 |
| MOLES/HR | 374.0701 | 374.0701 | 374.0701 | 374.0701 |
| POUNDS/HR | 8294.6211 | 8294.6211 | 8294.6211 | 8294.6211 |
| MOLECULAR WEIGHT | 22.1740 | 22.1740 | 22.1740 | 22.1740 |
| PSEUDO CRITICAL TEMP,DEG F | -65.7693 | -65.7693 | -65.7693 | -65.7693 |
| PSEUDO CRITICAL PRES,PSIA | 573.1252 | 573.1252 | 573.1252 | 573.1252 |
| ACENTRIC FACTOR | 0.0609 | 0.0609 | 0.0609 | 0.0609 |
| COMPRESSIBILITY FACTOR | 0.9884 | 0.9865 | 0.9670 | 0.9644 |
| VAPOR DENSITY,LB/CU FT | 0.2706 | 0.5972 | 0.7641 | 1.6864 |
| VAPOR CU FT/MIN | 510.8765 | 231.4698 | 180.9141 | 81.9762 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.5196 | 0.5980 | 0.5293 | 0.6124 |
| VISCOSITY,CENTIPOISE | 0.0129 | 0.0154 | 0.0129 | 0.0156 |
| THERMAL COND,BTU/HR FT DEG F | 0.0250 | 0.0321 | 0.0251 | 0.0328 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 150.0000 | 150.0000 | 150.0000 | 150.0000 |
| PRESSURE,PSIA | 600.0000 | 600.0000 | 600.0000 | 600.0000 |
| MOLES/HR | 374.0701 | 178.8100 | 195.2601 | 115.1075 |
| POUNDS/HR | 8294.6211 | 1614.4744 | 6680.1523 | 3231.0093 |
| MOLECULAR WEIGHT | 22.1740 | 9.0290 | 34.2115 | 28.0695 |
| PSEUDO CRITICAL TEMP,DEG F | -65.7693 | -258.1270 | 110.3833 | 50.1570 |
| PSEUDO CRITICAL PRES,PSIA | 573.1252 | 430.5188 | 703.7175 | 741.8540 |
| ACENTRIC FACTOR | 0.0609 | 0.0 | 0.1166 | 0.0950 |
| COMPRESSIBILITY FACTOR | 0.0 | 1.0044 | 0.0 | 0.8264 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.8245 | 0.0 | 3.1153 |
| VAPOR CU FT/MIN | 0.0 | 32.6361 | 0.0 | 17.2855 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 5.8200 | 0.0 |
| LIQUID API @ 60F | 0.0 | 0.0 | 186.5525 | 0.0 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 143.1753 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.0 | 0.9051 | 1.3040 | 0.5035 |
| VISCOSITY,CENTIPOISE | 0.0 | 0.0132 | 0.0353 | 0.0138 |
| THERMAL COND,BTU/HR FT DEG F | 0.0 | 0.0473 | 0.0176 | 0.0169 |

| STREAM NUMBER | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 150.0000 | 150.0000 | 150.0000 | 160.0000 |
| PRESSURE,PSIA | 600.0000 | 600.0000 | 600.0000 | 590.0000 |
| MOLES/HR | 80.1526 | 19.9626 | 60.1900 | 19.9626 |
| POUNDS/HR | 3449.1440 | 597.9119 | 2851.2322 | 597.9119 |
| MOLECULAR WEIGHT | 43.0322 | 29.9516 | 47.3705 | 29.9516 |
| PSEUDO CRITICAL TEMP,DEG F | 196.8750 | 87.7483 | 233.0684 | 87.7483 |
| PSEUDO CRITICAL PRES,PSIA | 648.9504 | 710.2981 | 628.6038 | 710.2981 |
| ACENTRIC FACTOR | 0.1477 | 0.1057 | 0.1617 | 0.1057 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.7604 | 0.0 | 0.7797 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 3.6125 | 0.0 | 3.4086 |
| VAPOR CU FT/MIN | 0.0 | 2.7585 | 0.0 | 2.9235 |
| LIQUID DENSITY,LB/CU FT | 26.5690 | 0.0 | 29.9395 | 0.0 |
| LIQUID API @ 60F | 140.4868 | 0.0 | 122.7650 | 0.0 |
| LIQUID GAL/MIN | 16.1936 | 0.0 | 11.8794 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.8207 | 0.6011 | 0.6846 | 0.5875 |
| VISCOSITY,CENTIPOISE | 0.0720 | 0.0137 | 0.0904 | 0.0137 |
| THERMAL COND,BTU/HR FT DEG F | 0.0456 | 0.0168 | 0.0504 | 0.0170 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 17 |
|---|---|
| TEMPERATURE,DEG F | 160.0000 |
| PRESSURE,PSIA | 590.0000 |
| MOLES/HR | 34.0701 |
| POUNDS/HR | 597.9116 |
| MOLECULAR WEIGHT | 17.5494 |
| PSEUDO CRITICAL TEMP,DEG F | -120.2024 |
| PSEUDO CRITICAL PRES,PSIA | 570.0984 |
| ACENTRIC FACTOR | 0.0425 |
| COMPRESSIBILITY FACTOR | 0.9571 |
| VAPOR DENSITY,LB/CU FT | 1.6270 |
| VAPOR CU FT/MIN | 6.1250 |
| LIQUID DENSITY,LB/CU FT | 0.0 |
| LIQUID API @ 60F | 0.0 |
| LIQUID GAL/MIN | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.5885 |
| VISCOSITY,CENTIPOISE | 0.0139 |
| THERMAL COND,BTU/HR FT DEG F | 0.0301 |

'FINAL RESULTS'

CHESS EXAPLE #2 - SIMPLE ETHYLENE PLANT

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | V-1 | VALV |
| 2 | F-1 | FHTR |
| 3 | R-1 | REAC |
| 4 | M-1 | MIXR |
| 5 | C-1 | COMP |
| 6 | H-1 | HXER |
| 7 | C-2 | COMP |
| 8 | H-2 | HXER |
| 9 | T-1 | DIST |
| 10 | T-2 | DIST |
| 11 | T-3 | DIST |
| 12 | F-2 | FHTR |
| 13 | R-2 | REAC |

## * EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

### ***FRACTIONATORS ***

| EQUIPMENT NO. | 9 | 10 | 11 |
|---|---|---|---|
| EXTERNAL NAME | T-1 | T-2 | T-3 |
| MODE | 0.0 | 0.0 | 0.0 |
| VAP. FRACT'N | 0.0 | 0.0 | 0.0 |
| OVHD. COMP 1 | 1.0000 | 0.0 | 0.0 |
| OR K-VALUE 2 | 1.0000 | 0.0 | 0.0 |
| 3 | 0.0 | 0.0500 | 0.9900 |
| 4 | 0.0 | 0.0 | 0.0 |
| 5 | 0.0 | 0.9900 | 1.0000 |
| 6 | 0.0 | 0.0 | 0.0 |
| 7 | 0.0 | 0.0 | 0.0 |

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### ***MIXERS ***

| EQUIPMENT NO. | 4 |
|---|---|
| EXTERNAL NAME | M-1 |

•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

### ***REACTORS ***

| EQUIPMENT NO. | 3 | 13 |
|---|---|---|
| EXTERNAL NAME | R-1 | R-2 |
| KEY COMP CONV | 0.9000 | 0.8000 |
| KEY COMP # | 4.0000 | 3.0000 |
| STOICH. FAC. 1 | 4.0000 | 2.0000 |
| 2 | 4.0000 | 2.0000 |
| 3 | -3.0000 | -4.0000 |
| 4 | -6.0000 | 0.0 |
| 5 | 5.0000 | 3.0000 |
| 6 | 2.0000 | 0.0 |
| 7 | 1.0000 | 0.0 |

•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

### ***P.C. VALVES ***

| EQUIPMENT NO. | 1 |
|---|---|

| | |
|---|---|
| DOWNSTM. P (PSIA) | 90.0000 |

••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

***EXCHANGER/CONDENSERS***

| EQUIPMENT NO. | 6 | 8 |
|---|---|---|
| EXTERNAL NAME | H-1 | H-2 |
| U | 0.0 | 0.0 |
| AREA | 0.0 | 0.0 |
| # SHELLS | 0.0 | 0.0 |
| SHELL PASSES | 0.0 | 0.0 |
| TUBE PASSES | 0.0 | 0.0 |
| MODE | 5.0000 | 5.0000 |
| DT OR T-OUT | 150.0000 | 150.0000 |
| DELTA P-STM 1 | 2.0000 | 2.0000 |
| DELTA P-STM 2 | 0.0 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | 756.7988 | 1321.0129 |
| WATER USAGE (GAL/HR) | 6056.8125 | 10572.3320 |

••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

***FIRED HEATERS ***

| EQUIPMENT NO. | 2 | 12 |
|---|---|---|
| EXTERNAL NAME | F-1 | F-2 |
| HEAT DUTY (M BTU/HR) | 1500.0000 | 1500.0000 |
| DELTA PRES. (PSIA) | 10.0000 | 10.0000 |
| TEMP. OUT (DEG F.) | 160.0000 | 160.0000 |
| Q ABSORBED (M BTU/HR) | 1451.3088 | 3.9279 |
| FUEL USAGE (MSCF/HR) | 2.1501 | 0.0058 |

••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

***COMPRESSORS ***

| EQUIPMENT NO. | 5 | 7 |
|---|---|---|
| EXTERNAL NAME | C-1 | C-2 |
| WORK CAPACITY (HORSEPOWER) | 0.0 | 0.0 |
| OUTLET PRES. (PSIA) | 220.0000 | 602.0000 |
| ADIABATIC EFF. | 0.7300 | 0.7300 |
| MECH EFF. | 0.8500 | 0.8500 |
| INLET ACFM | 510.8765 | 180.9141 |

(HORSEPOWER)

••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

# EXAMPLE #3

Separation Plant

The process flow diagram for a separation plant is given in FIGURE VII. The simulation flow diagram is shown in FIGURE VIII.

The process consists of several heat exchangers, compressors and flash drums which separate the C4 and lighter components from the feed.

The feed to the process is as follows:

Temperature, °F 100

Pressure, psia 284.7

| Component | lb-mols/HR |
|---|---|
| Nitrogen | 12.79 |
| CO2 | 112.85 |
| H2S | 9.95 |
| Methane | 117.22 |
| Ethane | 79.58 |
| Propane | 51.95 |
| I-Butane | 10.40 |
| N-Butane | 26.50 |
| I-Pentane | 15.67 |
| N-Pentane | 20.47 |
| N-Hextane | 26.01 |
| N-Heptane | 16.15 |
| N-Octane | 13.02 |
| N-Nonane | 5.84 |
| N-Decane | 7.77 |
| Total | 526.17 |

Process conditions are:

| | Temperature, °F | Pressure drop < ><br>Pressure, psia |
|---|---|---|
| E-1 Outlet | 120 | <2> |
| C-1 Outlet | | 817.7 |
| E-2 Outlet | 100 | <3> |
| E-3 Outlet | 96 | <3> |
| C-2 Outlet | | 135 |
| E-4 Outlet | 96 | <3> |
| C-3 Outlet | | 284.7 |
| V-1 Outlet | | 27.7 |
| E-5 Outlet | 85 | <3> |
| C-4 Outlet | | 67.7 |
| P-1 Outlet | | 65 |

Exchangers E-1, E-2, E-3, E-4, E-6:

Simple temperature controller, determine heat duty

Compressor C-1:

| | | |
|---|---|---|
| driver brake horsepower | = | 750 |
| outlet pressure | = | 817.7 psia |
| adiabatic efficiency | = | 0.70 |
| mechanical efficiency | = | 0.90 |

Compressor C-2:

| | | |
|---|---|---|
| Outlet pressure | = | 135 psia |
| adiabatic efficiency | = | 0.73 |
| mechanical efficiency | = | 0.85 |

Compressor C-3:

| | | |
|---|---|---|
| Outlet pressure | = | 284.7 psia |
| adiabatic efficiency | = | 0.70 |
| mechanical efficiency | = | 0.90 |

Compressor C-4:

| | | |
|---|---|---|
| outlet pressure | = | 67.7 psia |
| adiabatic efficiency | = | 0.70 |
| mechanical efficiency | = | 0.90 |

Valve V-1:

| | | |
|---|---|---|
| Outlet pressure | = | 27.7 psia |

Pump P-1:

| | | |
|---|---|---|
| outlet pressure | = | 65 psia |
| mechanical efficiency | = | 0.87 |

This example problem utilizes the following new features of CHESS 2.1.

1. New compressor module COMP
2. New Pump module PUMP
3. Stream temperatures and equipment parameters given in °F
4. Stream properties summary
5. Stream mass summary
6. Heating/cooling curve generation

The input data for the simulation is given in TABLE VII.

The simulation results are given in TABLE VIII.

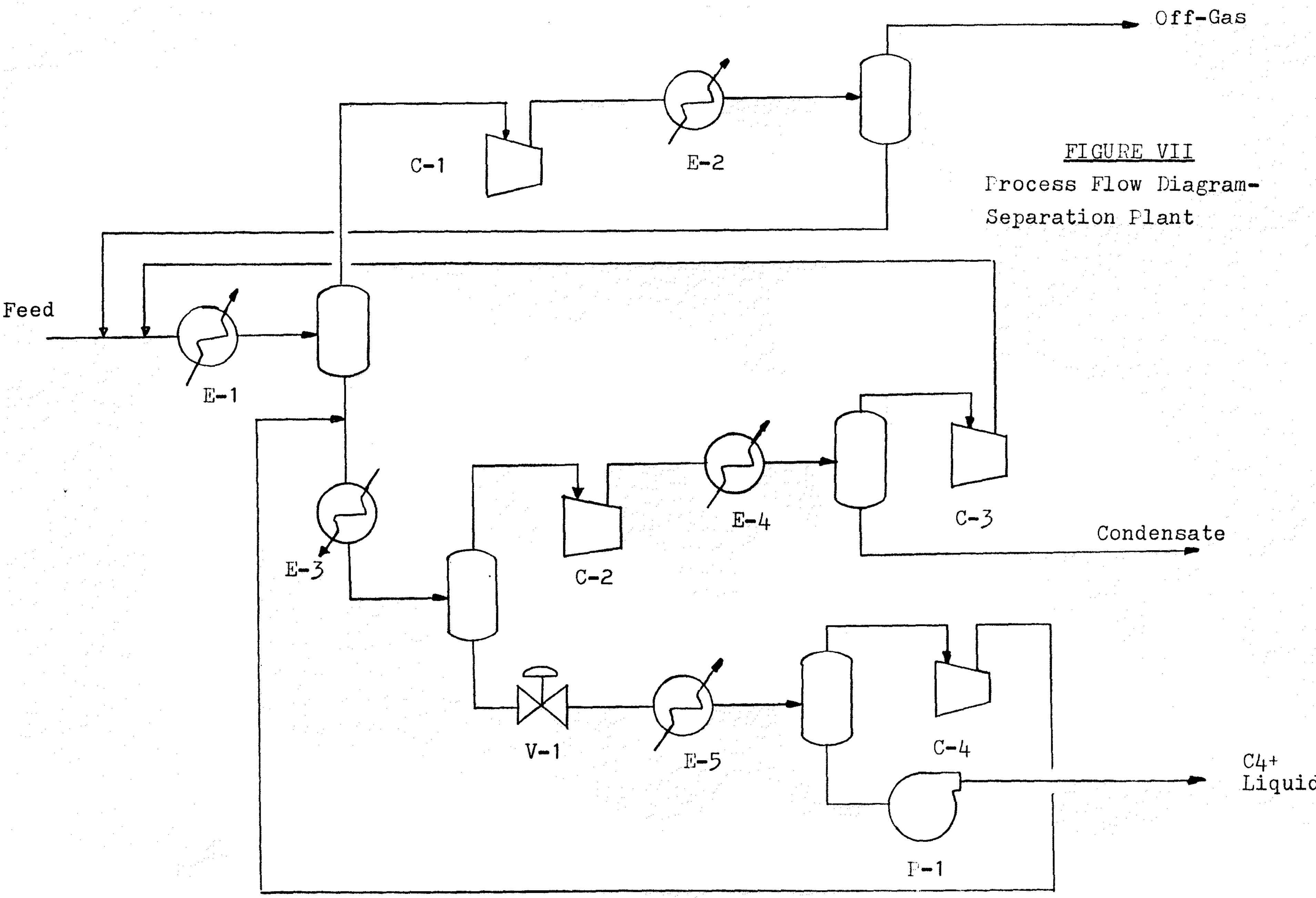
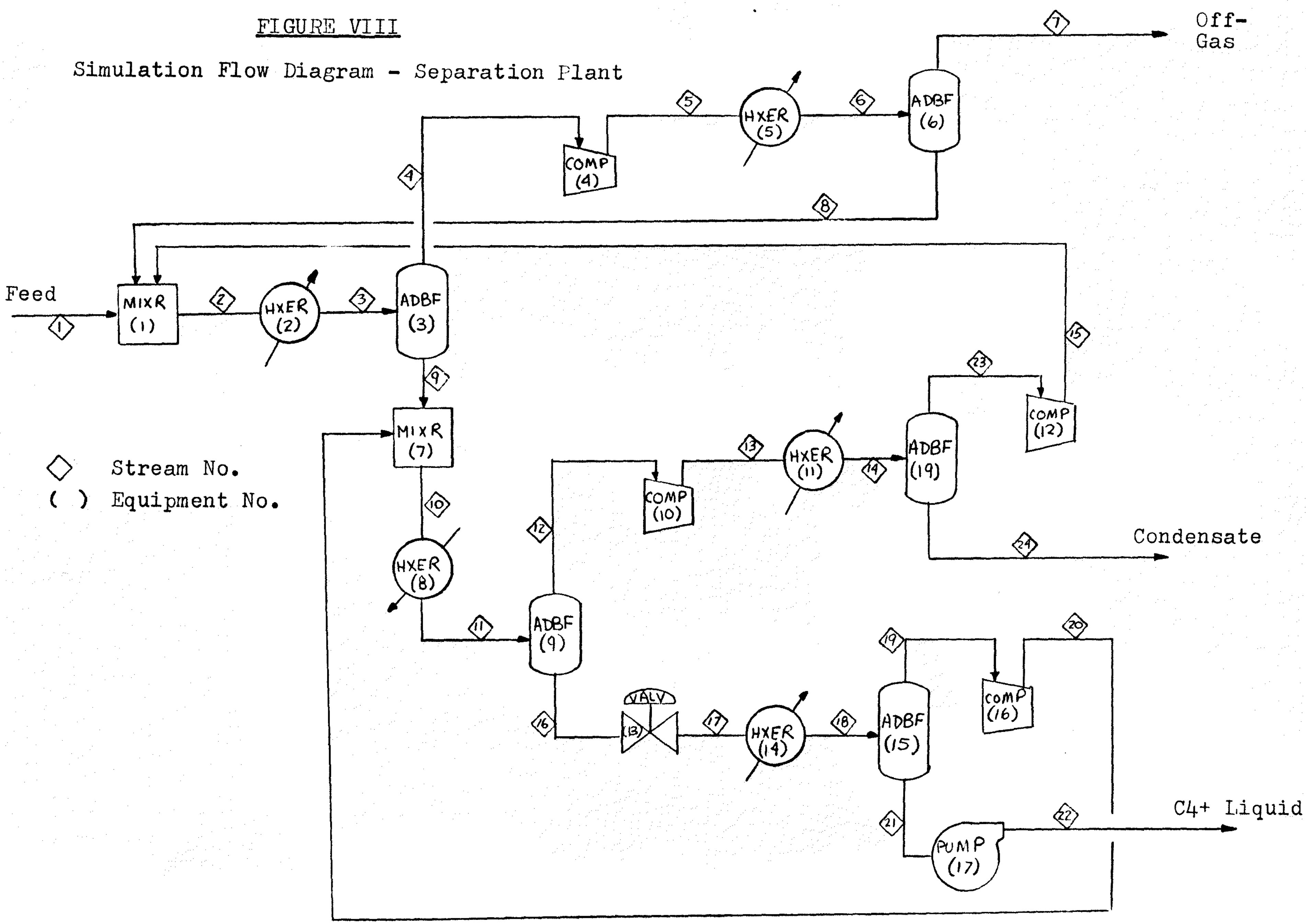



FIGURE VII
Process Flow Diagram-
Separation Plant

FIGURE VIII

Simulation Flow Diagram - Separation Plant



```
CLEAN,NAMELIST
 CHESS EXAMPLE #3 - SEPARATION PLANT
 &PMLIST
  KPM1=1,'MIXR','M-1 ',1,8,15,-2,3*0,
  KPM2=2,'HXER','H-1 ',2,-3,5*0,
  KPM3=3,'ADBF','F-1 ',3,-4,-9,4*0,
  KPM4=4,'COMP','C-1 ',4,-5,5*0,
  KPM5=5,'HXER','H-2 ',5,-6,5*0,
  KPM6=6,'ADBF','F-2 ',6,-7,-8,4*0,
  KPM7=7,'MIXR','M-2 ',9,20,-10,4*0,
  KPM8=8,'HXER','H-3 ',10,-11,5*0,
  KPM9=9,'ADBF','F-3 ',11,-12,-16,4*0,
  KPM10=10,'COMP','C-2 ',12,-13,5*0,
  KPM11=11,'HXER','H-4 ',13,-14,5*0,
  KPM12=12,'COMP','C-3 ',23,-15,5*0,
  KPM13=13,'VALV','V-1 ',16,-17,5*0,
  KPM14=14,'HXER','H-5 ',17,-18,5*0,
  KPM15=15,'ADBF','F-4 ',18,-19,-21,4*0,
  KPM16=16,'COMP','C-4 ',19,-20,5*0,
  KPM17=17,'PUMP','P-1 ',21,-22,5*0,
  KPM19=19,'ADBF','F-5 ',14,-23,-24,4*0,
  NOCOMP=15,
  COMPNT=46,49,50,2,3,4,5,6,7,8,10,11,12,13,14,5*0,
 &END
 &EQLIST
  ENAME=1,7,48*0,
  EQP2=2.,5*0.,5.,120.,3.,16*0,
  EQP3=3.,2.,23*0,
  EQP4=4.,750.,817.7,0.0,0.0,20*0,
  EQP5=5.,5*0.,5.,100.,3.,16*0,
  EQP6=6.,2.,23*0,
  EQP8=8.,5*0.,5.,96.,3.,16*0,
  EQP9=9.,2.,23*0,
  EQP10=10.,0.,135.,0.73,0.85,20*0,
  EQP11=11.,5*0.,5.,96.,3.,16*0,
  EQP12=12.,0.,284.7,0.0,0.0,20*0,
  EQP13=13,27.7,23*0,
  EQP14=14.,5*0.,5.,85.,3.,16*0,
  EQP15=15.,2.,23*0,
  EQP16=16.,0.0,67.7,0.0,0.0,20*0,
  EQP17=17.,0.0,65.,0.87,21*0,
  EQP19=19.,2.,23*0,
 &END
 &SEXLST
  SEX1=1.,0.,0.,12.79,112.85,9.95,117.22,79.58,51.95,10.40,
       26.50,15.67,20.47,26.01,16.15,13.02,5.84,7.77,5*0.,
  SNAME=2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,
       24,77*0,
 &END
 &SINLST
  SIN1=1.,1.,0.,100.,284.7,5*0,
  SIN7=7.,2.,8*0,
  SIN22=22.,2.,8*0,
   SIN24=24.,2.,8*0,
  SNAME=2,3,4,5,6,8,9,10,11,12,13,14,15,16,17,18,19,20,21,23,80*0,
 &END
 &KELIST
  DERROR=0.001,
  LOOPS=30,
 &END
 &HCLIST
  CURVES=2.,
  NAME1='HEAT CURVE FOR H-1',
  HCURV1=2.,0.0,0.0,120.,281.7,10.,
  NAME2='HEAT CURVE FOR H-3',
  HCURV2=10.,0.0,0.0,96.,64.7,5.,
 &END
/*
//
```

TABLE VII

Input Data for CHESS Example #3

TABLE VIII

Simulation Results for Example #3

```
CLEAN,NAMELIST
CHESS EXAMPLE #3 - SEPARATION PLANT

NOW BEGIN TO READ 'PMLIST'
'PMLIST' READING COMPLETE
NOW BEGIN TO READ 'EQLIST'
'EQLIST' READING COMPLETE
NOW BEGIN TO READ 'SEXLST'
'SEXLST' READING COMPLETE
NOW BEGIN TO READ 'SINLST'
'SINLST' READING COMPLETE
NOW BEGIN TO READ 'KELIST'
'KELIST' READING COMPLETE
NOW BEGIN TO READ 'HCLIST'
 'HCLIST' READING COMPLETE
```

```
** DECOMPOSITION OF NET(S) WILL FOLLOW **
PRECURSOR LIST..
      1|    0     0     0     0     0     0
      2|    1     8    15     0     0     0
      3|    2     0     0     0     0     0
      4|    3     0     0     0     0     0
      5|    4     0     0     0     0     0
      6|    5     0     0     0     0     0
      7|    6     0     0     0     0     0
      8|    6     0     0     0     0     0
      9|    3     0     0     0     0     0
     10|    9    20     0     0     0     0
     11|   10     0     0     0     0     0
     12|   11     0     0     0     0     0
     13|   12     0     0     0     0     0
     14|   13     0     0     0     0     0
     15|   23     0     0     0     0     0
     16|   11     0     0     0     0     0
     17|   16     0     0     0     0     0
     18|   17     0     0     0     0     0
     19|   18     0     0     0     0     0
     20|   19     0     0     0     0     0
     21|   18     0     0     0     0     0
     22|   21     0     0     0     0     0
     23|   14     0     0     0     0     0
     24|   14     0     0     0     0     0
GROUPED CUT-VERTEX PRECURSORS..
      2|    2    10
     10|    2    10
CUT STREAM LIST..    2   10
KE2  ..
            2    3    4    5    6    8    9   10   11   13
           14   15   16   19    7   12    1
```

C H E S S

NEW JERSEY INSTITUTE OF TECHNOLOGY

NEWARK COLLEGE OF ENGINEERING

CHEMICAL ENGINEERING SIMULATION SYSTEM

VERSION 2.1 MAY 1985

C H E S S

CHESS EXAMPLE #3 - SEPARATION PLANT

## 'PROCESS VECTORS'

| ...... EQUIPMENT ...... | | | STREAM NUMBERS | | | |
|---|---|---|---|---|---|---|
| NUMBER | SUBROUTINE | NAME | | | | |
| 1 | MIXR | M-1 | 1 | 8 | 15 | -2 |
| 2 | HXER | H-1 | 2 | -3 | 0 | 0 |
| 3 | ADBF | F-1 | 3 | -4 | -9 | 0 |
| 4 | COMP | C-1 | 4 | -5 | 0 | 0 |
| 5 | HXER | H-2 | 5 | -6 | 0 | 0 |
| 6 | ADBF | F-2 | 6 | -7 | -8 | 0 |
| 7 | MIXR | M-2 | 9 | 20 | -10 | 0 |
| 8 | HXER | H-3 | 10 | -11 | 0 | 0 |
| 9 | ADBF | F-3 | 11 | -12 | -16 | 0 |
| 10 | COMP | C-2 | 12 | -13 | 0 | 0 |
| 11 | HXER | H-4 | 13 | -14 | 0 | 0 |
| 12 | COMP | C-3 | 23 | -15 | 0 | 0 |
| 13 | VALV | V-1 | 16 | -17 | 0 | 0 |
| 14 | HXER | H-5 | 17 | -18 | 0 | 0 |
| 15 | ADBF | F-4 | 18 | -19 | -21 | 0 |
| 16 | COMP | C-4 | 19 | -20 | 0 | 0 |
| 17 | PUMP | P-1 | 21 | -22 | 0 | 0 |
| 19 | ADBF | F-5 | 14 | -23 | -24 | 0 |

'STREAM CONNECTIONS'

| STREAM | EQUIPMENT FROM | EQUIPMENT TO |
|---|---|---|
| 1 | 0 | 1 |
| 2 | 1 | 2 |
| 3 | 2 | 3 |
| 4 | 3 | 4 |
| 5 | 4 | 5 |
| 6 | 5 | 6 |
| 7 | 6 | 0 |
| 8 | 6 | 1 |
| 9 | 3 | 7 |
| 10 | 7 | 8 |
| 11 | 8 | 9 |
| 12 | 9 | 10 |
| 13 | 10 | 11 |
| 14 | 11 | 19 |
| 15 | 12 | 1 |
| 16 | 9 | 13 |
| 17 | 13 | 14 |
| 18 | 14 | 15 |
| 19 | 15 | 16 |
| 20 | 16 | 7 |
| 21 | 15 | 17 |
| 22 | 17 | 0 |
| 23 | 19 | 12 |
| 24 | 19 | 0 |

## 'OTHER SYSTEM VARIABLES'

| | |
|---|---|
| NUMBER OF COMPONENTS | 15 |
| COMPONENT NUMBERS USED | 46, 49, 50, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, |
| RECYCLE EQUIPMENT LIST (KE2) | 2, 3, 4, 5, 6, 8, 9, 10, 11, 13, 14, 15, 16, 19, 7, 12, 1, |
| TOLERANCE, 'DERROR' | 0.0010 |
| MAX. LOOPS IN RECYCLE CALC. | 30 |

'INPUT DATA'

CHESS EXAMPLE #3 - SEPARATION PLANT

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.6482 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 100.0000 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 284.7000 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 1502.7688 | 0.0 | 0.0 | 0.0 |
| | COMPOSITION, MOLES/HOUR | | | |
| NITROGEN | 12.7900 | 0.0 | 0.0 | 0.0 |
| CO2 | 112.8500 | 0.0 | 0.0 | 0.0 |
| H2S | 9.9500 | 0.0 | 0.0 | 0.0 |
| METHANE | 117.2200 | 0.0 | 0.0 | 0.0 |
| ETHANE | 79.5800 | 0.0 | 0.0 | 0.0 |
| PROPANE | 51.9500 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 10.4000 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 26.5000 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 15.6700 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 20.4700 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 26.0100 | 0.0 | 0.0 | 0.0 |
| N-HEPTANE | 16.1500 | 0.0 | 0.0 | 0.0 |
| N-OCTANE | 13.0200 | 0.0 | 0.0 | 0.0 |
| N-NONANE | 5.8400 | 0.0 | 0.0 | 0.0 |
| N-DECANE | 7.7700 | 0.0 | 0.0 | 0.0 |
| TOTAL | 526.1687 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 0 | FR 6 TO 1 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| COMPOSITION, MOLES/HOUR | | | | |
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | 0.0 | 0.0 |
| H2S | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEPTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-OCTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-NONANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-DECANE | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 3 TO 7 | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 10 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | C.0 | C.0 |
| PRESSURE, PSIA | C.0 | 0.0 | C.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| | COMPOSITION, MOLES/HOUR | | | |
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | C.0 | 0.0 |
| H2S | C.0 | 0.0 | 0.0 | C.0 |
| METHANE | C.0 | 0.0 | C.0 | 0.0 |
| ETHANE | C.0 | 0.C | C.0 | 0.0 |
| PROPANE | C.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | C.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.C | C.0 | C.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.C | C.0 | 0.0 |
| N-HEPTANE | C.0 | 0.0 | 0.C | C.0 |
| N-OCTANE | C.0 | 0.0 | C.0 | 0.0 |
| N-NONANE | C.0 | 0.0 | 0.0 | C.0 |
| N-DECANE | C.0 | 0.0 | C.0 | 0.0 |
| TOTAL | C.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 10 TO 11 | FR 11 TO 19 | FR 12 TO 1 | FR 9 TO 13 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| COMPOSITION, MOLES/HOUR | | | | |
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | 0.0 | 0.0 |
| H2S | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEPTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-OCTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-NONANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-DECANE | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 17 | 18 | 19 | 20 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 13 TO 14 | FR 14 TO 15 | FR 15 TO 16 | FR 16 TO 7 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| COMPOSITION, MOLES/HOUR | | | | |
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | 0.0 | 0.0 |
| H2S | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEPTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-OCTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-NONANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-DECANE | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 21 | 22 | 23 | 24 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 15 TO 17 | FR 17 TO 0 | FR 19 TO 12 | FR 19 TO 0 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 0.0 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | 0.0 | 0.0 | 0.0 | 0.0 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 0.0 | 0.0 | 0.0 | 0.0 |
| CO2 | 0.0 | 0.0 | 0.0 | 0.0 |
| H2S | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| I-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEXANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-HEPTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-OCTANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-NONANE | 0.0 | 0.0 | 0.0 | 0.0 |
| N-DECANE | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 |

'INPUT DATA'

CHESS EXAMPLE #3 - SEPARATION PLANT

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | M-1 | MIXR |
| 2 | H-1 | HXER |
| 3 | F-1 | ADBF |
| 4 | C-1 | COMP |
| 5 | H-2 | HXER |
| 6 | F-2 | ADBF |
| 7 | M-2 | MIXR |
| 8 | H-3 | HXER |
| 9 | F-3 | ADBF |
| 10 | C-2 | COMP |
| 11 | H-4 | HXER |
| 12 | C-3 | COMP |
| 13 | V-1 | VALV |
| 14 | H-5 | HXER |
| 15 | F-4 | ADBF |
| 16 | C-4 | COMP |
| 17 | P-1 | PUMP |
| 19 | F-5 | ADBF |

## * EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

| ***MIXERS | *** | |
|---|---|---|
| EQUIPMENT NO. | 1 | 7 |
| EXTERNAL NAME | M-1 | M-2 |

.............................................................................

| ***ADIABATIC FLSH UNITS*** | | | | |
|---|---|---|---|---|
| EQUIPMENT NO. | 3 | 6 | 9 | 15 |
| EXTERNAL NAME | F-1 | F-2 | F-3 | F-4 |
| MODE | 2.0000 | 2.0000 | 2.0000 | 2.0000 |
| 0. PHASE DET. | | | | |
| 1. CONST. T. | | | | |
| 2. ADIABATIC | | | | |
| EQUIPMENT NO. | 19 | | | |
| EXTERNAL NAME | F-5 | | | |
| MODE | 2.0000 | | | |
| 0. PHASE DET. | | | | |
| 1. CONST. T. | | | | |
| 2. ADIABATIC | | | | |

.............................................................................

| ***P.C. VALVES | *** |
|---|---|
| EQUIPMENT NO. | 13 |
| EXTERNAL NAME | V-1 |
| DOWNSTM. P (PSIA) | 27.7000 |

.............................................................................

| ***EXCHANGER/CONDENSERS*** | | | | |
|---|---|---|---|---|
| EQUIPMENT NO. | 2 | 5 | 8 | 11 |
| EXTERNAL NAME | H-1 | H-2 | H-3 | H-4 |
| U | 0.0 | 0.0 | 0.0 | 0.0 |
| AREA | 0.0 | 0.0 | 0.0 | 0.0 |
| # SHELLS | 0.0 | 0.0 | 0.0 | 0.0 |
| SHELL PASSES | 0.0 | 0.0 | 0.0 | 0.0 |
| TUBE PASSES | 0.0 | 0.0 | 0.0 | 0.0 |
| MODE | 5.0000 | 5.0000 | 5.0000 | 5.0000 |
| DT OR T-OUT | 120.0000 | 100.0000 | 96.0000 | 96.0000 |
| DELTA P-STM 1 | 3.0000 | 3.0000 | 3.0000 | 3.0000 |
| DELTA P-STM 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | 0.0 | 0.0 | 0.0 | 0.0 |
| WATER USAGE (GAL/HR) | 0.0 | 0.0 | 0.0 | 0.0 |
| EQUIPMENT NO. | 14 | | | |
| EXTERNAL NAME | H-5 | | | |
| U | 0.0 | | | |
| AREA | 0.0 | | | |
| # SHELLS | 0.0 | | | |
| SHELL PASSES | 0.0 | | | |

| | |
|---|---|
| DT OR T-OUT | 85.0000 |
| DELTA P-STM 1 | 3.0000 |
| DELTA P-STM 2 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | 0.0 |
| WATER USAGE (GAL/HR) | 0.0 |

.........................................................................

| ***PUMPS | *** |
|---|---|
| EQUIPMENT NO. | 17 |
| EXTERNAL NAME | P-1 |
| WORK CAPACITY (HORSEPOWER) | 0.0 |
| OUTLET PRES. (PSIA) | 65.0000 |
| MECH EFF. | 0.8700 |
| OPER. GPM | 0.0 |
| DRIVER WORK (HORSEPOWER) | 0.0 |

.........................................................................

| ***COMPRESSORS | *** | | | |
|---|---|---|---|---|
| EQUIPMENT NO. | 4 | 10 | 12 | 16 |
| EXTERNAL NAME | C-1 | C-2 | C-3 | C-4 |
| WORK CAPACITY (HORSEPOWER) | 750.0000 | 0.0 | 0.0 | 0.0 |
| OUTLET PRES. (PSIA) | 817.7000 | 135.0000 | 284.7000 | 67.7000 |
| ADIABATIC EFF. | 0.0 | 0.7300 | 0.0 | 0.0 |
| MECH EFF. | 0.0 | 0.8500 | 0.0 | 0.0 |
| INLET ACFM | 0.0 | 0.0 | 0.0 | 0.0 |
| DRIVER WORK (HORSEPOWER) | 0.0 | 0.0 | 0.0 | 0.0 |

.........................................................................

## ***HEAT CURVE GENERATION SUMMARY***

| | CURVE1 | CURVE2 | CURVE3 | CURVE4 | CURVE5 |
|---|---|---|---|---|---|
| PROCESS STREAM | 2.0 | 10.0 | | | |
| INITIAL TEMP. (DEG F) | 0.0 | 0.0 | | | |
| INITIAL PRESS. (PSIA) | 0.0 | 0.0 | | | |
| FINAL TEMP. (DEG F) | 120.0 | 96.0 | | | |
| FINAL PRESS. (PSIA) | 281.7 | 64.7 | | | |
| NUMBER OF POINTS | 10.0 | 5.0 | | | |

NOTE - IF THE INITIAL TEMPERATURE AND PRESSURE HAVE VALUES OF 0.0, THE VALUES IN THE STREAM VECTOR WILL BE USED.

```
*****BEGIN TRIAL AND ERROR RECYCLE CALCULATIONS WITH EQUIPMENT LIST..
      2,  3,  4,  5,  6,  8,  9, 10, 11, 13, 14, 15, 16, 19,  7, 12,  1,
... BEGIN 'LOOP   1' ...

***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =    2
*** INPUT STREAM CANNOT BE COMPRESSED, NE=  4
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =    5
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =    8
*** INPUT STREAM CANNOT BE COMPRESSED, NE= 10
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =   11
UPSTREAM PRESSURE TOO LOW, EQUIPMENT NO.=  13
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =   14
*** INPUT STREAM CANNOT BE COMPRESSED, NE= 16
*** INPUT STREAM CANNOT BE COMPRESSED, NE= 12
... BEGIN 'LOOP   2' ...

***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =    8
*** INPUT STREAM CANNOT BE COMPRESSED, NE= 10
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =   11
UPSTREAM PRESSURE TOO LOW, EQUIPMENT NO.=  13
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =   14
*** INPUT STREAM CANNOT BE COMPRESSED, NE= 16
*** INPUT STREAM CANNOT BE COMPRESSED, NE= 12
... BEGIN 'LOOP   3' ...

*** DISCHARGE PRESSURE LESS THAN P1, SET P2=P1, NE= 10
***** HXER BY-PASSED, ZERO INPUT(S) EXISTS.
UNIT =   11
*** INPUT STREAM CANNOT BE COMPRESSED, NE= 12
... BEGIN 'LOOP   4' ...

... BEGIN 'LOOP   5' ...

... BEGIN 'LOOP   6' ...

... BEGIN 'LOOP   7' ...

... BEGIN 'LOOP   8' ...

... BEGIN 'LOOP   9' ...

... BEGIN 'LOOP  10' ...

... BEGIN 'LOOP  11' ...

... BEGIN 'LOOP  12' ...

... BEGIN 'LOOP  13' ...

... BEGIN 'LOOP  14' ...

... BEGIN 'LOOP  15' ...
```

```
... BEGIN 'LOOP  17' ...

... BEGIN 'LOOP  18' ...

... BEGIN 'LOOP  19' ...

... BEGIN 'LOOP  20' ...

... BEGIN 'LOOP  21' ...

... BEGIN 'LOOP  22' ...

... BEGIN 'LOOP  23' ...

... BEGIN 'LOOP  24' ...

... BEGIN 'LOOP  25' ...

... BEGIN 'LOOP  26' ...

... BEGIN 'LOOP  27' ...

... BEGIN 'LOOP  28' ...

... BEGIN 'LOOP  29' ...

***** END OF RECYCLE CALCULATIONS



***TEMPERATURE AT INDICATED ENTHALPY CANNOT BE FOUND, ASSUMED TEMPERATURE OF
NE=  17
```

'FINAL RESULTS'

CHESS EXAMPLE #3 - SEPARATION PLANT

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.6482 | 0.6358 | 0.7193 | 1.0000 |
| TEMPERATURE, F | 100.0000 | 94.1570 | 120.0000 | 120.0000 |
| PRESSURE, PSIA | 284.7000 | 284.7000 | 281.7000 | 281.7000 |
| ENTHALPY,K BTU | 1502.7688 | 2050.8708 | 2849.2139 | 2559.7520 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 12.7900 | 13.8049 | 13.8046 | 13.6152 |
| CO2 | 112.8500 | 166.8546 | 166.8360 | 150.1114 |
| H2S | 9.9500 | 19.4563 | 19.4520 | 15.8884 |
| METHANE | 117.2200 | 140.5920 | 140.5842 | 134.8801 |
| ETHANE | 79.5800 | 128.4912 | 128.4737 | 111.3212 |
| PROPANE | 51.9500 | 114.8954 | 114.8602 | 82.1844 |
| I-BUTANE | 10.4000 | 20.7458 | 20.7412 | 10.7988 |
| N-BUTANE | 26.5000 | 48.7805 | 48.7727 | 22.0929 |
| I-PENTANE | 15.6700 | 22.0418 | 22.0405 | 6.2424 |
| N-PENTANE | 20.4700 | 27.2156 | 27.2145 | 6.5661 |
| N-HEXANE | 26.0100 | 29.2795 | 29.2791 | 3.2805 |
| N-HEPTANE | 16.1500 | 17.0064 | 17.0063 | 0.8728 |
| N-OCTANE | 13.0200 | 13.3062 | 13.3062 | 0.2915 |
| N-NONANE | 5.8400 | 5.8990 | 5.8990 | 0.0598 |
| N-DECANE | 7.7700 | 7.8066 | 7.8066 | 0.0370 |
| TOTAL | 526.1687 | 776.1743 | 776.0752 | 558.2424 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 0 | FR 6 TO 1 |
| VAPOR FRACTION | 1.0000 | 0.6949 | 1.0000 | 0.0 |
| TEMPERATURE, F | 267.2493 | 100.0000 | 100.0000 | 100.0000 |
| PRESSURE, PSIA | 817.7000 | 814.7000 | 814.7000 | 814.7000 |
| ENTHALPY,K BTU | 3495.7058 | 1267.3760 | 1224.1118 | 43.2646 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 13.6152 | 13.6152 | 12.7891 | 0.8261 |
| CO2 | 150.1114 | 150.1114 | 112.1597 | 37.9517 |
| H2S | 15.8884 | 15.8884 | 9.5171 | 6.3713 |
| METHANE | 134.8801 | 134.8801 | 117.1540 | 17.7261 |
| ETHANE | 111.3212 | 111.3212 | 78.4397 | 32.8815 |
| PROPANE | 82.1844 | 82.1844 | 42.9971 | 39.1873 |
| I-BUTANE | 10.7988 | 10.7988 | 4.2448 | 6.5541 |
| N-BUTANE | 22.0929 | 22.0929 | 7.3755 | 14.7174 |
| I-PENTANE | 6.2424 | 6.2424 | 1.4778 | 4.7646 |
| N-PENTANE | 6.5661 | 6.5661 | 1.3155 | 5.2505 |
| N-HEXANE | 3.2805 | 3.2805 | 0.3753 | 2.9052 |
| N-HEPTANE | 0.8728 | 0.8728 | 0.0579 | 0.8149 |
| N-OCTANE | 0.2915 | 0.2915 | 0.0104 | 0.2810 |
| N-NONANE | 0.0598 | 0.0598 | 0.0013 | 0.0586 |
| N-DECANE | 0.0370 | 0.0370 | 0.0005 | 0.0365 |
| TOTAL | 558.2424 | 558.2424 | 387.9155 | 170.3269 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 3 TO 7 | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 10 |
| VAPOR FRACTION | 0.0 | 0.3472 | 0.3647 | 1.0000 |
| TEMPERATURE, F | 120.0000 | 94.7993 | 96.0000 | 96.0000 |
| PRESSURE, PSIA | 281.7000 | 67.7000 | 64.7000 | 64.7000 |
| ENTHALPY,K BTU | 289.4619 | 542.1292 | 584.7209 | 512.8281 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 0.1894 | 0.1919 | 0.1919 | 0.1893 |
| CO2 | 16.7247 | 18.7784 | 18.7771 | 16.4288 |
| H2S | 3.5636 | 4.3531 | 4.3521 | 3.2977 |
| METHANE | 5.7041 | 5.9633 | 5.9632 | 5.6923 |
| ETHANE | 17.1524 | 19.9664 | 19.9643 | 16.5700 |
| PROPANE | 32.6758 | 42.4502 | 42.4350 | 26.1318 |
| I-BUTANE | 9.9423 | 12.6661 | 12.6625 | 4.7141 |
| N-BUTANE | 26.6798 | 32.9914 | 32.9844 | 10.0424 |
| I-PENTANE | 15.7982 | 17.7906 | 17.7892 | 2.7715 |
| N-PENTANE | 20.6484 | 22.7533 | 22.7520 | 2.8738 |
| N-HEXANE | 25.9986 | 26.9482 | 26.9477 | 1.2725 |
| N-HEPTANE | 16.1335 | 16.3510 | 16.3509 | 0.2989 |
| N-OCTANE | 13.0147 | 13.0760 | 13.0760 | 0.0878 |
| N-NONANE | 5.8391 | 5.8499 | 5.8499 | 0.0160 |
| N-DECANE | 7.7696 | 7.7753 | 7.7753 | 0.0088 |
| TOTAL | 217.8327 | 247.9036 | 247.8702 | 90.3956 |

| STREAM NUMBER | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 10 TO 11 | FR 11 TO 19 | FR 12 TO 1 | FR 9 TO 13 |
| VAPOR FRACTION | 1.0000 | 0.8814 | 1.0000 | 0.0 |
| TEMPERATURE, F | 165.7068 | 96.0000 | 179.6379 | 96.0000 |
| PRESSURE, PSIA | 135.0000 | 132.0000 | 284.7000 | 64.7000 |
| ENTHALPY,K BTU | 612.4082 | 411.6653 | 504.8379 | 71.8930 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 0.1893 | 0.1893 | 0.1888 | 0.0026 |
| CO2 | 16.4288 | 16.4288 | 16.0529 | 2.3483 |
| H2S | 3.2977 | 3.2977 | 3.1350 | 1.0545 |
| METHANE | 5.6923 | 5.6923 | 5.6459 | 0.2708 |
| ETHANE | 16.5700 | 16.5700 | 16.0297 | 3.3943 |
| PROPANE | 26.1318 | 26.1318 | 23.7580 | 16.3032 |
| I-BUTANE | 4.7141 | 4.7141 | 3.7917 | 7.9484 |
| N-BUTANE | 10.0424 | 10.0424 | 7.5631 | 22.9420 |
| I-PENTANE | 2.7715 | 2.7715 | 1.6072 | 15.0177 |
| N-PENTANE | 2.8738 | 2.8738 | 1.4951 | 19.8782 |
| N-HEXANE | 1.2725 | 1.2725 | 0.3643 | 25.6752 |
| N-HEPTANE | 0.2989 | 0.2989 | 0.0416 | 16.0520 |
| N-OCTANE | 0.0878 | 0.0878 | 0.0052 | 12.9882 |
| N-NONANE | 0.0160 | 0.0160 | 0.0004 | 5.8339 |
| N-DECANE | 0.0088 | 0.0088 | 0.0001 | 7.7665 |
| TOTAL | 90.3956 | 90.3956 | 79.6791 | 157.4746 |

| STREAM NUMBER | 17 | 18 | 19 | 20 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 13 TO 14 | FR 14 TO 15 | FR 15 TO 16 | FR 16 TO 7 |
| VAPOR FRACTION | 0.1263 | 0.1910 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 77.0732 | 85.0000 | 85.0000 | 162.4084 |
| PRESSURE, PSIA | 27.7000 | 24.7000 | 24.7000 | 67.7000 |
| ENTHALPY,K BTU | 71.8930 | 211.5056 | 205.0126 | 252.6674 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 0.0026 | 0.0026 | 0.0025 | 0.0025 |
| CO2 | 2.3483 | 2.3483 | 2.0538 | 2.0538 |
| H2S | 1.0545 | 1.0545 | 0.7895 | 0.7895 |
| METHANE | 0.2708 | 0.2708 | 0.2591 | 0.2591 |
| ETHANE | 3.3943 | 3.3943 | 2.8140 | 2.8140 |
| PROPANE | 16.3032 | 16.3032 | 9.7744 | 9.7744 |
| I-BUTANE | 7.9484 | 7.9484 | 2.7237 | 2.7237 |
| N-BUTANE | 22.9420 | 22.9420 | 6.3117 | 6.3117 |
| I-PENTANE | 15.0177 | 15.0177 | 1.9924 | 1.9924 |
| N-PENTANE | 19.8782 | 19.8782 | 2.1049 | 2.1049 |
| N-HEXANE | 25.6752 | 25.6752 | 0.9496 | 0.9496 |
| N-HEPTANE | 16.0520 | 16.0520 | 0.2174 | 0.2174 |
| N-OCTANE | 12.9882 | 12.9882 | 0.0613 | 0.0613 |
| N-NONANE | 5.8339 | 5.8339 | 0.0107 | 0.0107 |
| N-DECANE | 7.7665 | 7.7665 | 0.0057 | 0.0057 |
| TOTAL | 157.4746 | 157.4746 | 30.0709 | 30.0709 |

| STREAM NUMBER | 21 | 22 | 23 | 24 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 15 TO 17 | FR 17 TO 0 | FR 19 TO 12 | FR 19 TO 0 |
| VAPOR FRACTION | 0.0 | 0.0 | 1.0000 | 0.0 |
| TEMPERATURE, F | 85.0000 | 85.0747 | 96.0000 | 96.0000 |
| PRESSURE, PSIA | 24.7000 | 65.0000 | 132.0000 | 132.0000 |
| ENTHALPY,K BTU | 6.4930 | 8.5282 | 413.4275 | -1.7620 |
| | | COMPOSITION, MOLES/HOUR | | |
| NITROGEN | 0.0000 | 0.0000 | 0.1888 | 0.0005 |
| CO2 | 0.2945 | 0.2945 | 16.0529 | 0.3759 |
| H2S | 0.2650 | 0.2650 | 3.1350 | 0.1626 |
| METHANE | 0.0117 | 0.0117 | 5.6459 | 0.0465 |
| ETHANE | 0.5803 | 0.5803 | 16.0297 | 0.5403 |
| PROPANE | 6.5288 | 6.5288 | 23.7580 | 2.3737 |
| I-BUTANE | 5.2247 | 5.2247 | 3.7917 | 0.9224 |
| N-BUTANE | 16.6304 | 16.6304 | 7.5631 | 2.4792 |
| I-PENTANE | 13.0253 | 13.0253 | 1.6072 | 1.1643 |
| N-PENTANE | 17.7733 | 17.7733 | 1.4951 | 1.3787 |
| N-HEXANE | 24.7256 | 24.7256 | 0.3643 | 0.9083 |
| N-HEPTANE | 15.8345 | 15.8345 | 0.0416 | 0.2573 |
| N-OCTANE | 12.9269 | 12.9269 | 0.0052 | 0.0826 |
| N-NONANE | 5.8231 | 5.8231 | 0.0004 | 0.0156 |
| N-DECANE | 7.7608 | 7.7608 | 0.0001 | 0.0087 |
| TOTAL | 127.4037 | 127.4037 | 79.6791 | 10.7165 |

'FINAL RESULTS'

CHESS EXAMPLE #3 - SEPARATION PLANT

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 4 |
| VAPOR FRACTION | 0.6482 | 0.6358 | 0.7193 | 1.0000 |
| TEMPERATURE, F | 100.0000 | 94.1570 | 120.0000 | 120.0000 |
| PRESSURE, PSIA | 284.7000 | 284.7000 | 281.7000 | 281.7000 |
| ENTHALPY,K BTU | 1502.7688 | 2050.8708 | 2849.2139 | 2559.7520 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 358.3245 | 386.7590 | 386.7488 | 381.4438 |
| CO2 | 4966.5273 | 7343.2656 | 7342.4492 | 6606.3984 |
| H2S | 339.0957 | 663.0708 | 662.9253 | 541.4766 |
| METHANE | 1880.4419 | 2255.3752 | 2255.2512 | 2163.7458 |
| ETHANE | 2392.8103 | 3863.4719 | 3862.9451 | 3347.2053 |
| PROPANE | 2290.6826 | 5066.1914 | 5064.6406 | 3623.8391 |
| I-BUTANE | 604.4478 | 1205.7432 | 1205.4763 | 627.6270 |
| N-BUTANE | 1540.1797 | 2835.1233 | 2834.6675 | 1284.0388 |
| I-PENTANE | 1130.5276 | 1590.2271 | 1590.1367 | 450.3625 |
| N-PENTANE | 1476.8274 | 1963.4980 | 1963.4155 | 473.7161 |
| N-HEXANE | 2241.3330 | 2523.0710 | 2523.0383 | 282.6846 |
| N-HEPTANE | 1618.1970 | 1704.0063 | 1703.9973 | 87.4486 |
| N-OCTANE | 1487.1963 | 1519.8865 | 1519.8828 | 33.2923 |
| N-NONANE | 748.9797 | 756.5474 | 756.5464 | 7.6755 |
| N-DECANE | 1105.4841 | 1110.6948 | 1110.6943 | 5.2612 |
| TOTAL | 24181.0313 | 34786.9102 | 34782.7852 | 19916.1797 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 4 TO 5 | FR 5 TO 6 | FR 6 TO 0 | FR 6 TO 1 |
| VAPOR FRACTION | 1.0000 | 0.6949 | 1.0000 | 0.0 |
| TEMPERATURE, F | 267.2493 | 100.0000 | 100.0000 | 100.0000 |
| PRESSURE, PSIA | 817.7000 | 814.7000 | 814.7000 | 814.7000 |
| ENTHALPY,K BTU | 3495.7058 | 1267.3760 | 1224.1118 | 43.2646 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 381.4438 | 381.4438 | 358.2996 | 23.1441 |
| CO2 | 6606.3984 | 6606.3984 | 4936.1445 | 1670.2537 |
| H2S | 541.4766 | 541.4766 | 324.3430 | 217.1336 |
| METHANE | 2163.7458 | 2163.7458 | 1879.3833 | 284.3621 |
| ETHANE | 3347.2053 | 3347.2053 | 2358.5247 | 988.6802 |
| PROPANE | 3623.8391 | 3623.8391 | 1895.9119 | 1727.9265 |
| I-BUTANE | 627.6270 | 627.6270 | 246.7052 | 380.9219 |
| N-BUTANE | 1284.0388 | 1284.0388 | 428.6633 | 855.3755 |
| I-PENTANE | 450.3625 | 450.3625 | 106.6143 | 343.7483 |
| N-PENTANE | 473.7161 | 473.7161 | 94.9108 | 378.8052 |
| N-HEXANE | 282.6846 | 282.6846 | 32.3362 | 250.3484 |
| N-HEPTANE | 87.4486 | 87.4486 | 5.8010 | 81.6476 |
| N-OCTANE | 33.2923 | 33.2923 | 1.1930 | 32.0993 |
| N-NONANE | 7.6755 | 7.6755 | 0.1621 | 7.5134 |
| N-DECANE | 5.2612 | 5.2612 | 0.0653 | 5.1959 |
| TOTAL | 19916.1797 | 19916.1797 | 12669.0352 | 7247.1445 |

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 3 TO 7 | FR 7 TO 8 | FR 8 TO 9 | FR 9 TO 10 |
| VAPOR FRACTION | 0.0 | 0.3472 | 0.3647 | 1.0000 |
| TEMPERATURE, F | 120.0000 | 94.7993 | 96.0000 | 96.0000 |
| PRESSURE, PSIA | 281.7000 | 67.7000 | 64.7000 | 64.7000 |
| ENTHALPY,K BTU | 289.4619 | 542.1292 | 584.7209 | 512.8281 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 5.3050 | 5.3763 | 5.3763 | 5.3042 |
| CO2 | 736.0518 | 826.4382 | 826.3787 | 723.0293 |
| H2S | 121.4485 | 148.3535 | 148.3211 | 112.3840 |
| METHANE | 91.5053 | 95.6625 | 95.6611 | 91.3166 |
| ETHANE | 515.7393 | 600.3508 | 600.2871 | 498.2263 |
| PROPANE | 1440.8042 | 1871.7979 | 1871.1284 | 1152.2534 |
| I-BUTANE | 577.8491 | 736.1516 | 735.9431 | 273.9814 |
| N-BUTANE | 1550.6277 | 1917.4604 | 1917.0525 | 583.6614 |
| I-PENTANE | 1139.7739 | 1283.5186 | 1283.4194 | 199.9505 |
| N-PENTANE | 1489.6987 | 1641.5613 | 1641.4678 | 207.3337 |
| N-HEXANE | 2240.3535 | 2322.1785 | 2322.1377 | 109.6580 |
| N-HEPTANE | 1616.5474 | 1638.3340 | 1638.3250 | 29.9473 |
| N-OCTANE | 1486.5906 | 1493.5935 | 1493.5901 | 10.0264 |
| N-NONANE | 748.8708 | 750.2456 | 750.2449 | 2.0519 |
| N-DECANE | 1105.4329 | 1106.2402 | 1106.2397 | 1.2553 |
| TOTAL | 14866.5820 | 16437.2383 | 16435.5586 | 4000.3784 |

| STREAM NUMBER | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 10 TO 11 | FR 11 TO 19 | FR 12 TO 1 | FR 9 TO 13 |
| VAPOR FRACTION | 1.0000 | 0.8814 | 1.0000 | 0.0 |
| TEMPERATURE, F | 165.7068 | 96.0000 | 179.6379 | 96.0000 |
| PRESSURE, PSIA | 135.0000 | 132.0000 | 284.7000 | 64.7000 |
| ENTHALPY,K BTU | 612.4082 | 411.6653 | 504.8379 | 71.8930 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 5.3042 | 5.3042 | 5.2904 | 0.0721 |
| CO2 | 723.0293 | 723.0293 | 706.4873 | 103.3487 |
| H2S | 112.3840 | 112.3840 | 106.8419 | 35.9371 |
| METHANE | 91.3166 | 91.3166 | 90.5712 | 4.3445 |
| ETHANE | 498.2263 | 498.2263 | 481.9810 | 102.0607 |
| PROPANE | 1152.2534 | 1152.2534 | 1047.5854 | 718.8740 |
| I-BUTANE | 273.9814 | 273.9814 | 220.3740 | 461.9614 |
| N-BUTANE | 583.6614 | 583.6614 | 439.5691 | 1333.3906 |
| I-PENTANE | 199.9505 | 199.9505 | 115.9523 | 1083.4688 |
| N-PENTANE | 207.3337 | 207.3337 | 107.8658 | 1434.1338 |
| N-HEXANE | 109.6580 | 109.6580 | 31.3909 | 2212.4792 |
| N-HEPTANE | 29.9473 | 29.9473 | 4.1641 | 1608.3767 |
| N-OCTANE | 10.0264 | 10.0264 | 0.5910 | 1483.5637 |
| N-NONANE | 2.0519 | 2.0519 | 0.0542 | 748.1929 |
| N-DECANE | 1.2553 | 1.2553 | 0.0148 | 1104.9844 |
| TOTAL | 4000.3784 | 4000.3784 | 3358.7324 | 12435.1797 |

| STREAM NUMBER | 17 | 18 | 19 | 20 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 13 TO 14 | FR 14 TO 15 | FR 15 TO 16 | FR 16 TO 7 |
| VAPOR FRACTION | 0.1263 | 0.1910 | 1.0000 | 1.0000 |
| TEMPERATURE, F | 77.0732 | 85.0000 | 85.0000 | 162.4084 |
| PRESSURE, PSIA | 27.7000 | 24.7000 | 24.7000 | 67.7000 |
| ENTHALPY,K BTU | 71.8930 | 211.5056 | 205.0126 | 252.6674 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 0.0721 | 0.0721 | 0.0712 | 0.0712 |
| CO2 | 103.3487 | 103.3487 | 90.3870 | 90.3870 |
| H2S | 35.9371 | 35.9371 | 26.9051 | 26.9051 |
| METHANE | 4.3445 | 4.3445 | 4.1572 | 4.1572 |
| ETHANE | 102.0607 | 102.0607 | 84.6121 | 84.6121 |
| PROPANE | 718.8740 | 718.8740 | 430.9941 | 430.9941 |
| I-BUTANE | 461.9614 | 461.9614 | 158.3026 | 158.3026 |
| N-BUTANE | 1333.3906 | 1333.3906 | 366.8333 | 366.8333 |
| I-PENTANE | 1083.4688 | 1083.4688 | 143.7455 | 143.7455 |
| N-PENTANE | 1434.1338 | 1434.1338 | 151.8634 | 151.8634 |
| N-HEXANE | 2212.4792 | 2212.4792 | 81.8263 | 81.8263 |
| N-HEPTANE | 1608.3767 | 1608.3767 | 21.7878 | 21.7878 |
| N-OCTANE | 1483.5637 | 1483.5637 | 7.0031 | 7.0031 |
| N-NONANE | 748.1929 | 748.1929 | 1.3748 | 1.3748 |
| N-DECANE | 1104.9844 | 1104.9844 | 0.8072 | 0.8072 |
| TOTAL | 12435.1797 | 12435.1797 | 1570.6697 | 1570.6697 |

| STREAM NUMBER | 21 | 22 | 23 | 24 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 15 TO 17 | FR 17 TO 0 | FR 19 TO 12 | FR 19 TO 0 |
| VAPOR FRACTION | 0.0 | 0.0 | 1.0000 | 0.0 |
| TEMPERATURE, F | 85.0000 | 85.0747 | 96.0000 | 96.0000 |
| PRESSURE, PSIA | 24.7000 | 65.0000 | 132.0000 | 132.0000 |
| ENTHALPY,K BTU | 6.4930 | 8.5282 | 413.4275 | -1.7620 |
| | | COMPOSITION, LBS/HOUR | | |
| NITROGEN | 0.0009 | 0.0009 | 5.2904 | 0.0138 |
| CO2 | 12.9617 | 12.9617 | 706.4873 | 16.5416 |
| H2S | 9.0320 | 9.0320 | 106.8419 | 5.5421 |
| METHANE | 0.1873 | 0.1873 | 90.5712 | 0.7453 |
| ETHANE | 17.4486 | 17.4486 | 481.9810 | 16.2451 |
| PROPANE | 287.8799 | 287.8799 | 1047.5854 | 104.6675 |
| I-BUTANE | 303.6589 | 303.6589 | 220.3740 | 53.6074 |
| N-BUTANE | 966.5569 | 966.5569 | 439.5691 | 144.0923 |
| I-PENTANE | 939.7231 | 939.7231 | 115.9523 | 83.9981 |
| N-PENTANE | 1282.2700 | 1282.2700 | 107.8658 | 99.4678 |
| N-HEXANE | 2130.6531 | 2130.6531 | 31.3909 | 78.2671 |
| N-HEPTANE | 1586.5889 | 1586.5889 | 4.1641 | 25.7832 |
| N-OCTANE | 1476.5605 | 1476.5605 | 0.5910 | 9.4354 |
| N-NONANE | 746.8179 | 746.8179 | 0.0542 | 1.9977 |
| N-DECANE | 1104.1770 | 1104.1770 | 0.0148 | 1.2405 |
| TOTAL | 10864.5078 | 10864.5078 | 3358.7324 | 641.6440 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 100.0000 | 94.1570 | 120.0000 | 120.0000 |
| PRESSURE,PSIA | 284.7000 | 284.7000 | 281.7000 | 281.7000 |
| MOLES/HR | 526.1687 | 776.1746 | 776.0754 | 558.2405 |
| POUNDS/HR | 24181.0313 | 34786.9102 | 34782.7852 | 19916.1797 |
| MOLECULAR WEIGHT | 45.9568 | 44.8184 | 44.8188 | 35.6767 |
| PSEUDO CRITICAL TEMP,DEG F | 140.7588 | 144.3262 | 144.3250 | 74.1694 |
| PSEUDO CRITICAL PRES,PSIA | 707.1814 | 719.1011 | 719.0989 | 778.6860 |
| ACENTRIC FACTOR | 0.1472 | 0.1460 | 0.1460 | 0.1133 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.0 | 0.8872 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 1.8212 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 0.0 | 182.2587 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.0 | 0.0 | 0.0 | 0.4022 |
| VISCOSITY,CENTIPOISE | 0.0 | 0.0 | 0.0 | 0.0133 |
| THERMAL COND,BTU/HR FT DEG F | 0.0 | 0.0 | 0.0 | 0.0137 |

| STREAM NUMBER | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 267.2493 | 100.0000 | 100.0000 | 100.0000 |
| PRESSURE,PSIA | 817.7000 | 814.7000 | 814.7000 | 814.7000 |
| MOLES/HR | 558.2405 | 558.2405 | 387.9143 | 170.3268 |
| POUNDS/HR | 19916.1797 | 19916.1797 | 12669.0352 | 7247.1445 |
| MOLECULAR WEIGHT | 35.6767 | 35.6767 | 32.6594 | 42.5485 |
| PSEUDO CRITICAL TEMP,DEG F | 74.1694 | 74.1694 | 40.9375 | 149.8518 |
| PSEUDO CRITICAL PRES,PSIA | 778.6860 | 778.6860 | 793.2415 | 745.5334 |
| ACENTRIC FACTOR | 0.1133 | 0.1133 | 0.1002 | 0.1433 |
| COMPRESSIBILITY FACTOR | 0.8473 | 0.0 | 0.6811 | 0.0 |
| VAPOR DENSITY,LB/CU FT | 4.4138 | 0.0 | 6.5052 | 0.0 |
| VAPOR CU FT/MIN | 75.2040 | 0.0 | 32.4586 | 0.0 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 30.4955 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 130.2185 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 29.6440 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.4870 | 0.0 | 0.5731 | 0.7028 |
| VISCOSITY,CENTIPOISE | 0.0177 | 0.0 | 0.0162 | 0.0823 |
| THERMAL COND,BTU/HR FT DEG F | 0.0200 | 0.0 | 0.0170 | 0.0475 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 120.0000 | 94.7993 | 96.0000 | 96.0000 |
| PRESSURE,PSIA | 281.7000 | 67.7000 | 64.7000 | 64.7000 |
| MOLES/HR | 217.8342 | 247.9050 | 247.8714 | 90.3955 |
| POUNDS/HR | 14866.5820 | 16437.2383 | 16435.5586 | 4000.3784 |
| MOLECULAR WEIGHT | 68.2472 | 66.3046 | 66.3068 | 44.2542 |
| PSEUDO CRITICAL TEMP,DEG F | 324.1150 | 314.6599 | 314.6697 | 172.7617 |
| PSEUDO CRITICAL PRES,PSIA | 566.3984 | 573.8396 | 573.8330 | 721.1941 |
| ACENTRIC FACTOR | 0.2298 | 0.2232 | 0.2232 | 0.1503 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.0 | 0.9488 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 0.5061 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 0.0 | 131.7381 |
| LIQUID DENSITY,LB/CU FT | 36.1458 | 0.0 | 0.0 | 0.0 |
| LIQUID API @ 60F | 97.8464 | 0.0 | 0.0 | 0.0 |
| LIQUID GAL/MIN | 51.3050 | 0.0 | 0.0 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.5966 | 0.0 | 0.0 | 0.3900 |
| VISCOSITY,CENTIPOISE | 0.1776 | 0.0 | 0.0 | 0.0119 |
| THERMAL COND,BTU/HR FT DEG F | 0.0522 | 0.0 | 0.0 | 0.0105 |

| STREAM NUMBER | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 165.7068 | 96.0000 | 179.6379 | 96.0000 |
| PRESSURE,PSIA | 135.0000 | 132.0000 | 284.7000 | 64.7000 |
| MOLES/HR | 90.3955 | 90.3955 | 79.6789 | 157.4758 |
| POUNDS/HR | 4000.3784 | 4000.3784 | 3358.7324 | 12435.1797 |
| MOLECULAR WEIGHT | 44.2542 | 44.2542 | 42.1533 | 78.9657 |
| PSEUDO CRITICAL TEMP,DEG F | 172.7617 | 172.7617 | 156.0725 | 396.1301 |
| PSEUDO CRITICAL PRES,PSIA | 721.1941 | 721.1941 | 741.3196 | 489.2441 |
| ACENTRIC FACTOR | 0.1503 | 0.1503 | 0.1438 | 0.2651 |
| COMPRESSIBILITY FACTOR | 0.9226 | 0.0 | 0.8584 | 0.0 |
| VAPOR DENSITY,LB/CU FT | 0.9650 | 0.0 | 2.0380 | 0.0 |
| VAPOR CU FT/MIN | 69.0934 | 0.0 | 27.4673 | 0.0 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 38.5327 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 90.6611 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 40.2558 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.4306 | 0.0 | 0.4526 | 0.5878 |
| VISCOSITY,CENTIPOISE | 0.0131 | 0.0 | 0.0139 | 0.2351 |
| THERMAL COND,BTU/HR FT DEG F | 0.0128 | 0.0 | 0.0140 | 0.0566 |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 17 | 18 | 19 | 20 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 77.0732 | 85.0000 | 85.0000 | 162.4084 |
| PRESSURE,PSIA | 27.7000 | 24.7000 | 24.7000 | 67.7000 |
| MOLES/HR | 157.4758 | 157.4758 | 30.0708 | 30.0708 |
| POUNDS/HR | 12435.1797 | 12435.1797 | 1570.6697 | 1570.6697 |
| MOLECULAR WEIGHT | 78.9657 | 78.9657 | 52.2324 | 52.2324 |
| PSEUDO CRITICAL TEMP,DEG F | 396.1301 | 396.1301 | 246.1697 | 246.1697 |
| PSEUDO CRITICAL PRES,PSIA | 489.2441 | 489.2441 | 627.7466 | 627.7466 |
| ACENTRIC FACTOR | 0.2651 | 0.2651 | 0.1752 | 0.1752 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.9691 | 0.9401 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.2278 | 0.5635 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 114.9223 | 46.4578 |
| LIQUID DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID API @ 60F | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID GAL/MIN | 0.0 | 0.0 | 0.0 | 0.0 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.0 | 0.0 | 0.4047 | 0.4540 |
| VISCOSITY,CENTIPOISE | 0.0 | 0.0 | 0.0105 | 0.0116 |
| THERMAL COND,BTU/HR FT DEG F | 0.0 | 0.0 | 0.0092 | 0.0115 |

| STREAM NUMBER | 21 | 22 | 23 | 24 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 85.0000 | 85.0747 | 96.0000 | 96.0000 |
| PRESSURE,PSIA | 24.7000 | 65.0000 | 132.0000 | 132.0000 |
| MOLES/HR | 127.4049 | 127.4049 | 79.6789 | 10.7165 |
| POUNDS/HR | 10864.5078 | 10864.5078 | 3358.7324 | 641.6440 |
| MOLECULAR WEIGHT | 85.2754 | 85.2754 | 42.1533 | 59.8744 |
| PSEUDO CRITICAL TEMP,DEG F | 431.5247 | 431.5247 | 156.0725 | 296.8494 |
| PSEUDO CRITICAL PRES,PSIA | 456.5549 | 456.5549 | 741.3196 | 571.5569 |
| ACENTRIC FACTOR | 0.2863 | 0.2863 | 0.1438 | 0.1985 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.9036 | 0.0 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 1.0327 | 0.0 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 54.2052 | 0.0 |
| LIQUID DENSITY,LB/CU FT | 39.8538 | 39.8701 | 0.0 | 35.0710 |
| LIQUID API @ 60F | 85.7101 | 85.6203 | 0.0 | 110.2771 |
| LIQUID GAL/MIN | 34.0052 | 33.9914 | 0.0 | 2.2822 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.5900 | 0.5836 | 0.3971 | 0.6049 |
| VISCOSITY,CENTIPOISE | 0.2654 | 0.2654 | 0.0121 | 0.1634 |
| THERMAL COND,BTU/HR FT DEG F | 0.0591 | 0.0591 | 0.0110 | 0.0542 |

HEAT CURVE FOR H-3

STREAM - 10

| POINT | TEMPERATURE (DEG F) | PRESSURE (PSIA) | MOLE FRACTION VAPORIZED | ENTHALPY K BTU/HR |
|---|---|---|---|---|
| 1 | 94.80 | 67.70 | 0.3472 | 542.106 |
| 2 | 95.10 | 66.95 | 0.3515 | 552.629 |
| 3 | 95.40 | 66.20 | 0.3559 | 563.264 |
| 4 | 95.70 | 65.45 | 0.3603 | 573.991 |
| 5 | 96.00 | 64.70 | 0.3647 | 584.831 |

'FINAL RESULTS'

CHESS EXAMPLE #3 - SEPARATION PLANT

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | M-1 | MIXR |
| 2 | H-1 | HXER |
| 3 | F-1 | ADBF |
| 4 | C-1 | COMP |
| 5 | H-2 | HXER |
| 6 | F-2 | ADBF |
| 7 | M-2 | MIXR |
| 8 | H-3 | HXER |
| 9 | F-3 | ADBF |
| 10 | C-2 | COMP |
| 11 | H-4 | HXER |
| 12 | C-3 | COMP |
| 13 | V-1 | VALV |
| 14 | H-5 | HXER |
| 15 | F-4 | ADBF |
| 16 | C-4 | COMP |
| 17 | P-1 | PUMP |
| 19 | F-5 | ADBF |

## * EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

| ***MIXERS | *** | |
|---|---|---|
| EQUIPMENT NO. | 1 | 7 |
| EXTERNAL NAME | M-1 | M-2 |

..............................................................................

***ADIABATIC FLSH UNITS***

| | | | | |
|---|---|---|---|---|
| EQUIPMENT NO. | 3 | 6 | 9 | 15 |
| EXTERNAL NAME | F-1 | F-2 | F-3 | F-4 |
| MODE | 2.0000 | 2.0000 | 2.0000 | 2.0000 |
| 0. PHASE DET. | | | | |
| 1. CONST. T. | | | | |
| 2. ADIABATIC | | | | |
| EQUIPMENT NO. | 19 | | | |
| EXTERNAL NAME | F-5 | | | |
| MODE | 2.0000 | | | |
| 0. PHASE DET. | | | | |
| 1. CONST. T. | | | | |
| 2. ADIABATIC | | | | |

..............................................................................

| ***P.C. VALVES | *** |
|---|---|
| EQUIPMENT NO. | 13 |
| EXTERNAL NAME | V-1 |
| DOWNSTM. P (PSIA) | 27.7000 |

..............................................................................

***EXCHANGER/CONDENSERS***

| | | | | |
|---|---|---|---|---|
| EQUIPMENT NO. | 2 | 5 | 8 | 11 |
| EXTERNAL NAME | H-1 | H-2 | H-3 | H-4 |
| U | 0.0 | 0.0 | 0.0 | 0.0 |
| AREA | 0.0 | 0.0 | 0.0 | 0.0 |
| # SHELLS | 0.0 | 0.0 | 0.0 | 0.0 |
| SHELL PASSES | 0.0 | 0.0 | 0.0 | 0.0 |
| TUBE PASSES | 0.0 | 0.0 | 0.0 | 0.0 |
| MODE | 5.0000 | 5.0000 | 5.0000 | 5.0000 |
| DT OR T-OUT | 120.0000 | 100.0000 | 96.0000 | 96.0000 |
| DELTA P-STM 1 | 3.0000 | 3.0000 | 3.0000 | 3.0000 |
| DELTA P-STM 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | -798.5029 | 2228.3298 | -42.6603 | 200.7429 |
| WATER USAGE (GAL/HR) | -6390.5781 | 17833.7734 | -341.5791 | 1606.5859 |
| EQUIPMENT NO. | 14 | | | |
| EXTERNAL NAME | H-5 | | | |
| U | 0.0 | | | |
| AREA | 0.0 | | | |
| # SHELLS | 0.0 | | | |
| SHELL PASSES | 0.0 | | | |
| TUBE PASSES | 0.0 | | | |

| | |
|---|---|
| CT OR T-OUT | 85.0000 |
| DELTA P-STM 1 | 3.0000 |
| DELTA P-STM 2 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | -139.6125 |
| WATER USAGE (GAL/HR) | -1117.3474 |

•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

| ***PUMPS | *** |
|---|---|
| EQUIPMENT NO. | 17 |
| EXTERNAL NAME | P-1 |
| WORK CAPACITY (HORSEPOWER) | 0.0 |
| OUTLET PRES. (PSIA) | 65.0000 |
| MECH EFF. | 0.8700 |
| OPER. GPM | 34.0054 |
| DRIVER WORK (HORSEPOWER) | 0.9185 |

•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

| ***COMPRESSORS | *** | | | |
|---|---|---|---|---|
| EQUIPMENT NO. | 4 | 10 | 12 | 16 |
| EXTERNAL NAME | C-1 | C-2 | C-3 | C-4 |
| WORK CAPACITY (HORSEPOWER) | 750.0000 | 0.0 | 0.0 | 0.0 |
| OUTLET PRES. (PSIA) | 817.7000 | 135.0000 | 284.7000 | 67.7000 |
| ADIABATIC EFF. | 0.7000 | 0.7300 | 0.7000 | 0.7000 |
| MECH EFF. | 0.9000 | 0.8500 | 0.9000 | 0.9000 |
| INLET ACFM | 182.2593 | 131.7383 | 54.2053 | 114.9226 |
| DRIVER WORK (HORSEPOWER) | 408.3035 | 45.9966 | 39.8772 | 20.7891 |

•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

## EXAMPLE #4

Naphtha Splitter Design

The process flow diagram for a proposed Naphtha splitter column is shown in FIGURE IX. The simulation flow diagram is given in FIGURE X.

The process consists of a pump, feed preheater and column. It is desired to determine the number of theoretical stages, reflux ratio, condenser duty and reboiler duty for a specified separation.

The feed to the column is as follows:

| | |
|---|---|
| Temperature, °F | 72 |
| Pressure, psia | 20 |

| Component | lb-mols/hr | Mid TBP, °F | API Gravity | Molecular Weight |
|---|---|---|---|---|
| Ethane | 17.57 | | | |
| Propane | 29.48 | | | |
| N-Butane | 84.38 | | | |
| C5 | 181.44 | 85 | 92.0 | 72.15 |
| C6 | 205.47 | 145 | 80.0 | 86.17 |
| C7 | 208.09 | 195 | 76.0 | 98.90 |
| C8 | 282.65 | 240 | 67.0 | 114.27 |
| C9 | 255.78 | 285 | 64.0 | 128.25 |
| C10 | 251.39 | 350 | 60.0 | 142.28 |
| C11 | 8.89 | 395 | 58.0 | 156.36 |
| Total | 1535.14 | | | |

Process conditions are:

| | Temperature, °F | Pressure drop < ><br>Pressure, psia |
|---|---|---|
| P-1 outlet | | 45 |
| E-1 outlet | 200 | <10> |
| T-1 operating pressure | | 35 |

Pump P-1:

| | | |
|---|---|---|
| outlet pressure | = | 45 psia |
| inlet pressure | = | 20 psia |
| mechanical efficiency | = | 0.80 |

Exchanger E-1:

simple temperature controller, determine duty

Distillation Column T-1

| | | |
|---|---|---|
| (design option) | | |
| operating pressure | = | 35 psia |
| R/Rmin | = | 1.5 |
| light key | = | C8 |
| Fraction of light key in feed to distillate | = | 0.90 |
| heavy key | = | C9 |
| fraction of heavy key in feed to distillate | = | 0.10 |
| total condenser | | |

The example problem utilizes the following new features of CHESS 2.1.

1. New pump module PUMP
2. Petroleum fraction components
3. Stream temperatures and equipment parameters in °F
4. Stream properties summary
5. Stream mass summary

The input data for the simulation is given in TABLE IX.

The simulation results are given in TABLE X.

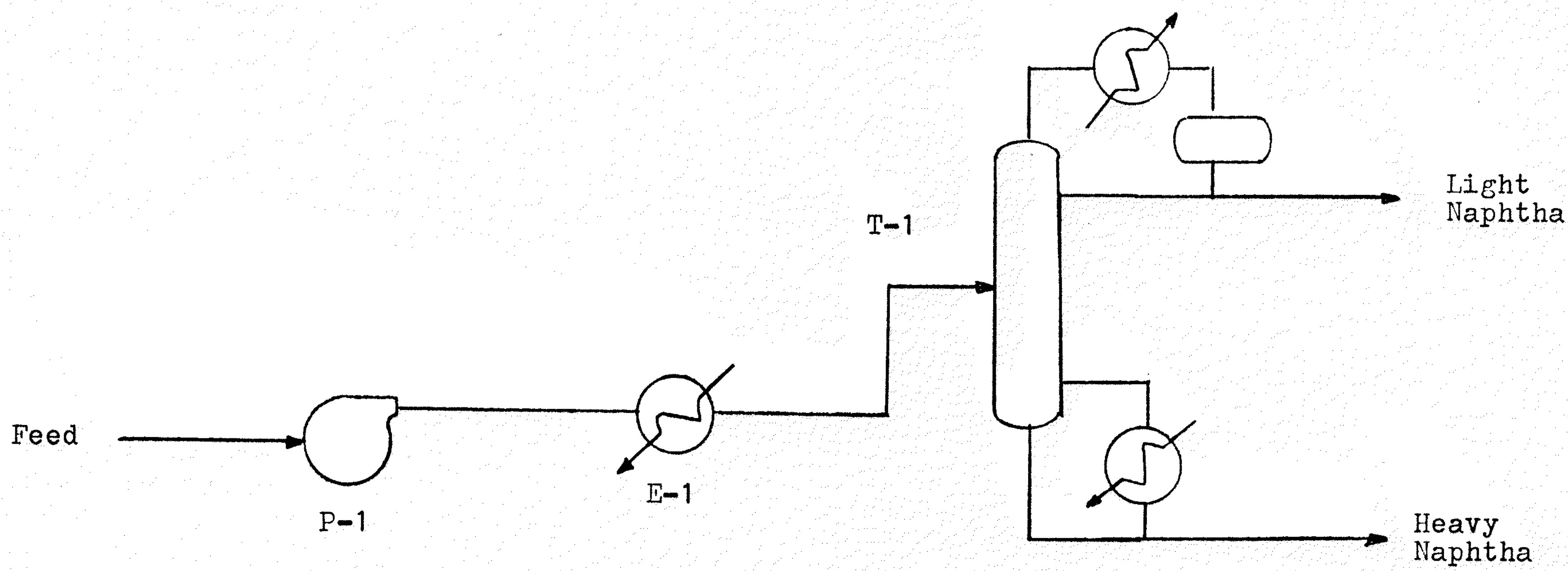



FIGURE IX

Process Flow Diagram - Naphtha Splitter

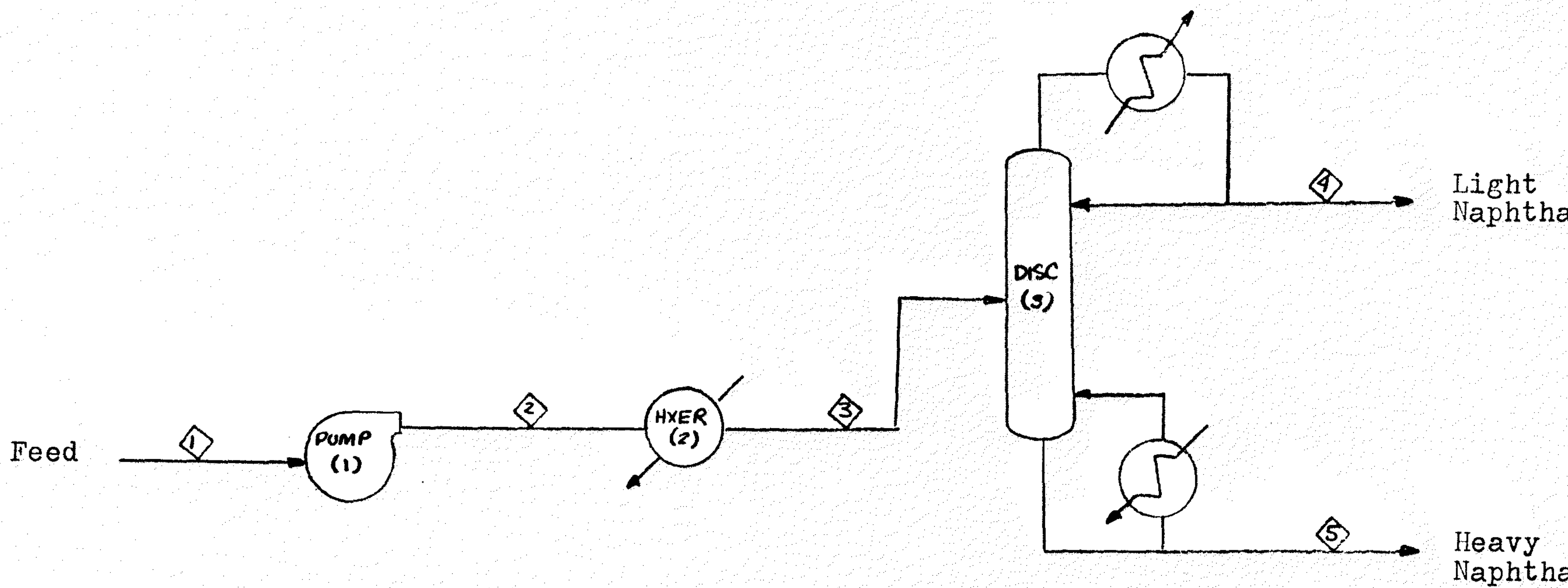



FIGURE X

Simulation Flow Diagram - Naphtha Splitter

◇ Stream No.

( ) Equipment No.

```
CLEAN,NAMELIST
 CHESS EXAMPLE #4 - NAPHTHA SPLITTER
 &PMLIST
 KPM1=1,'PUMP','P-1 ',1,-2,5*0,
 KPM2=2,'HXER','H-1 ',2,-3,5*0,
 KPM3=3,'DISC','COLM',3,-4,-5,4*0,
 NOCOMP=10,
 COMPNT=3,4,6,200,201,202,203,204,205,206,
 KOMNAM(13)= ' C5 ',
 KOMNAM(17)= ' C6 ',
 KOMNAM(21)= ' C7 ',
 KOMNAM(25)= ' C8 ',
 KOMNAM(29)= ' C9 ',
 KOMNAM(33)= ' C10',
 KOMNAM(37)= ' C11',
 &END
 &EQLIST
 EQP1=1.,0.0,45.0,0.80,21*0.,
 EQP2=2.,5*0.,5.0,200.0,10.0,16*0.,
 EQP3=3.,2.,7.,.9,8.,.1,0.,0.,1.5,16*0.,
 &END
 &SEXLST
 SEX1=1.,0.0,1535.14,17.57,29.48,84.38,181.44,215.47,208.09,
      282.65,255.78,251.39,8.89,12*0.0,
 SNAME=2,3,4,5,96*0,
 &END
 &SINLST
 SIN1=1.,1.,0.,72.0,20.,5*0.,
 SIN4=4.,2.,8*0.,
 SIN5=5.,2.,8*0.,
 SNAME=2,3,98*0,
 &END
 &KELIST
 KE2= 1,2,3,97*0,
 &END
 &PFCOMP
 BP(4)  = 85.0, API(4)  = 92.0, ZMW(4)= 72.15,
 BP(5)  =145.0, API(5)  = 80.0, ZMW(5)  = 86.17,
 BP(6)  =195.0, API(6)  = 76.0, ZMW(6)  = 98.90,
 BP(7)  =240.0, API(7)  = 67.0, ZMW(7)  = 114.27,
 BP(8)  =285.0, API(8)  = 64.0, ZMW(8)  = 128.25,
 BP(9)  =350.,  API(9)  = 60.0, ZMW(9)  = 142.28,
 BP(10)=395.,   API(10)= 58.0, ZMW(10)= 156.36,
 &END
 &HCLIST
 &END
/*
```

TABLE IX

Input Data for CHESS Example #4

## TABLE X

Simulation Results for Example #4

```
CLEAN,NAMELIST
CHESS EXAMPLE #4 - NAPHTHA SPLITTER

NOW BEGIN TO READ 'PMLIST'
'PMLIST' READING COMPLETE

NOW BEGIN TO READ 'EQLIST'
'EQLIST' READING COMPLETE

NOW BEGIN TO READ 'SEXLST'
'SEXLST' READING COMPLETE

NOW BEGIN TO READ 'SINLST'
'SINLST' READING COMPLETE

NOW BEGIN TO READ 'KELIST'
'KELIST' READING COMPLETE

NOW BEGIN TO READ 'PFCOMP'
'PFCOMP' READING COMPLETE

NOW BEGIN TO READ 'HCLIST'
 'HCLIST' READING COMPLETE
```

C H E S S

NEW JERSEY INSTITUTE OF TECHNOLOGY

NEWARK COLLEGE OF ENGINEERING

CHEMICAL ENGINEERING SIMULATION SYSTEM

VERSION 2.1 MAY 1985

C H E S S

CHESS EXAMPLE #4 - NAPHTHA SPLITTER

'PROCESS VECTORS'

| ...... EQUIPMENT ...... | | | STREAM NUMBERS | | |
|---|---|---|---|---|---|
| NUMBER | SUBROUTINE | NAME | | | |
| 1 | PUMP | P-1 | 1 | -2 | 0 |
| 2 | HXER | H-1 | 2 | -3 | 0 |
| 3 | DISC | COLM | 3 | -4 | -5 |

'STREAM CONNECTIONS'

| STREAM | EQ UIPMENT FROM | TO |
|---|---|---|
| 1 | 0 | 1 |
| 2 | 1 | 2 |
| 3 | 2 | 3 |
| 4 | 3 | 0 |
| 5 | 3 | 0 |

'OTHER SYSTEM VARIABLES'

| | |
|---|---|
| NUMBER OF COMPONENTS | 10 |
| COMPONENT NUMBERS USED | 3, 4, 6,200,201,<br>202,203,204,205,206, |
| RECYCLE EQUIPMENT LIST (KE2) | 1, 2, 3, |
| TOLERANCE, 'DERROR' | 0.0001 |
| MAX. LOOPS IN RECYCLE CALC. | 0 |

NON-STANDARD & PETROLEUM FRACTION COMPONENTS

```
COMPONENT NO. =  4    ID NO. = 200           NAME=  C5
NBP (F) =  85.0       API GR. =  92.00
APC =  507.9          ATC =  841.8           AVC =  304.3
AMW =  72.15          AOMEG = 0.2106         ADEL =  7.160
AVW =   15.14         APH =  0.19416E 01     BET =  0.56832E-01
GAM = -0.12227E-04    DTA =  0.0

COMPONENT NO. =  5    ID NO. = 201           NAME=  C6
NBP (F) = 145.0       API GR. =  80.00
APC =  453.3          ATC =  904.7           AVC =  358.1
AMW =  86.17          AOMEG = 0.2884         ADEL =  7.437
AVW =   17.41         APH =  0.16535E 01     BET =  0.67570E-01
GAM = -0.14602E-04    DTA =  0.0

COMPONENT NO. =  6    ID NO. = 202           NAME=  C7
NBP (F) = 195.0       API GR. =  76.00
APC =  404.3          ATC =  954.1           AVC =  415.5
AMW =  98.90          AOMEG = 0.3510         ADEL =  7.538
AVW =   19.85         APH =  0.21734E 01     BET =  0.77687E-01
GAM = -0.16760E-04    DTA =  0.0

COMPONENT NO. =  7    ID NO. = 203           NAME=  C8
NBP (F) = 240.0       API GR. =  67.00
APC =  390.2          ATC = 1007.7           AVC =  449.4
AMW = 114.27          AOMEG = 0.3886         ADEL =  7.595
AVW =   22.21         APH =  0.14726E 01     BET =  0.89444E-01
GAM = -0.19378E-04    DTA =  0.0

COMPONENT NO. =  8    ID NO. = 204           NAME=  C9
NBP (F) = 285.0       API GR. =  64.00
APC =  356.1          ATC = 1053.1           AVC =  507.4
AMW = 128.25          AOMEG = 0.4348         ADEL =  7.627
AVW =   24.78         APH =  0.18368E 01     BET =  0.10070E 00
GAM = -0.21765E-04    DTA =  0.0

COMPONENT NO. =  9    ID NO. = 205           NAME=  C10
NBP (F) = 350.0       API GR. =  60.00
APC =  311.7          ATC = 1117.7           AVC =  603.4
AMW = 142.28          AOMEG = 0.4965         ADEL =  7.861
AVW =   27.26         APH =  0.24448E 01     BET =  0.11187E 00
GAM = -0.24147E-04    DTA =  0.0
```

| | | |
|---|---|---|
| COMPONENT NO. = 10 | ID NO. = 206 | NAME= C11 |
| NBP (F) = 395.0 | API GR. = 58.00 | |
| APC = 281.6 | ATC = 1160.5 | AVC = 684.2 |
| AMW = 156.36 | AOMEG = 0.5382 | ADEL = 7.897 |
| AVW = 29.87 | APH = 0.32679E 01 | BET = 0.12289E 00 |
| GAM = -0.26510E-04 | DTA = 0.0 | |

'INPUT DATA'

CHESS EXAMPLE #4 - NAPHTHA SPLITTER

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 0 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0 | 0.0 |
| TEMPERATURE, F | 72.0000 | 0.0 | 0.0 | 0.0 |
| PRESSURE, PSIA | 20.0000 | 0.0 | 0.0 | 0.0 |
| ENTHALPY,K BTU | -10009.9414 | 0.0 | 0.0 | 0.0 |
| | | COMPOSITION, MOLES/HOUR | | |
| ETHANE | 17.5700 | 0.0 | 0.0 | 0.0 |
| PROPANE | 29.4800 | 0.0 | 0.0 | 0.0 |
| N-BUTANE | 84.3800 | 0.0 | 0.0 | 0.0 |
| C5 | 181.4400 | 0.0 | 0.0 | 0.0 |
| C6 | 215.4700 | 0.0 | 0.0 | 0.0 |
| C7 | 208.0900 | 0.0 | 0.0 | 0.0 |
| C8 | 282.6499 | 0.0 | 0.0 | 0.0 |
| C9 | 255.7800 | 0.0 | 0.0 | 0.0 |
| C10 | 251.3900 | 0.0 | 0.0 | 0.0 |
| C11 | 8.8900 | 0.0 | 0.0 | 0.0 |
| TOTAL | 1535.1399 | 0.0 | 0.0 | 0.0 |

| STREAM NUMBER | 5 |
|---|---|
| EQUIP. CONXION | FR 3 TO 0 FR |
| VAPOR FRACTION | 0.0 |
| TEMPERATURE, F | 0.0 |
| PRESSURE, PSIA | 0.0 |
| ENTHALPY,K BTU | 0.0 |
| | COMPOSITION, MOLES/HOUR |
| ETHANE | 0.0 |
| PROPANE | 0.0 |
| N-BUTANE | 0.0 |
| C5 | 0.0 |
| C6 | 0.0 |
| C7 | 0.0 |
| C8 | 0.0 |
| C9 | 0.0 |
| C10 | 0.0 |
| C11 | 0.0 |
| TOTAL | 0.0 |

'INPUT DATA'

CHESS EXAMPLE #4 - NAPHTHA SPLITTER

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | P-1 | PUMP |
| 2 | H-1 | HXER |
| 3 | COLM | DISC |

## * EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

### ***EXCHANGER/CONDENSERS***

| EQUIPMENT NO. | 2 |
|---|---|
| EXTERNAL NAME | H-1 |
| U | 0.0 |
| AREA | 0.0 |
| # SHELLS | 0.0 |
| SHELL PASSES | 0.0 |
| TUBE PASSES | 0.0 |
| MODE | 5.0000 |
| DT OR T-OUT | 200.0000 |
| DELTA P-STM 1 | 10.0000 |
| DELTA P-STM 2 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | 0.0 |
| WATER USAGE (GAL/HR) | 0.0 |

.........................................................................

### ***PUMPS ***

| EQUIPMENT NO. | 1 |
|---|---|
| EXTERNAL NAME | P-1 |
| WORK CAPACITY (HORSEPOWER) | 0.0 |
| OUTLET PRES. (PSIA) | 45.0000 |
| MECH EFF. | 0.8000 |
| OPER. GPM | 0.0 |
| DRIVER WORK (HORSEPOWER) | 0.0 |

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### ***SHORT-CUT DISTILL'NS***

| EQUIPMENT NO. | 3 |
|---|---|
| EXTERNAL NAME | COLM |
| OPTION | 2.0000 |
| LIGHT KEY(LK) | 7.0000 |
| FRACTION LK | 0.9000 |
| HEAVY KEY(HK) | 8.0000 |
| FRACTION HK | 0.1000 |
| CONDENSER | 0.0 |
| REFLUX RATIO(R) | 0.0 |
| R/RM | 1.5000 |
| STAGE NUMBER(S) | 0.0 |
| S-MIN | 0.0 |

| | |
|---|---|
| S-FEED | 0.0 |
| QC (M BTU/HR) | 0.0 |
| QR (M BTU/HR) | 0.0 |

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'FINAL RESULTS'

CHESS EXAMPLE #4 - NAPHTHA SPLITTER

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 0 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0618 | 0.0 |
| TEMPERATURE, F | 72.0000 | 72.0752 | 200.0000 | 126.7146 |
| PRESSURE, PSIA | 20.0000 | 45.0000 | 35.0000 | 35.0000 |
| ENTHALPY,K BTU | -10009.9414 | -9992.8086 | -913.1104 | -3734.5569 |
| | | COMPOSITION, MOLES/HOUR | | |
| ETHANE | 17.5700 | 17.5700 | 17.5700 | 17.5700 |
| PROPANE | 29.4800 | 29.4800 | 29.4800 | 29.4800 |
| N-BUTANE | 84.3800 | 84.3800 | 84.3800 | 84.3800 |
| C5 | 181.4400 | 181.4400 | 181.4400 | 181.4399 |
| C6 | 215.4700 | 215.4700 | 215.4700 | 215.4640 |
| C7 | 208.0900 | 208.0900 | 208.0900 | 207.7160 |
| C8 | 282.6499 | 282.6499 | 282.6499 | 254.3849 |
| C9 | 255.7800 | 255.7800 | 255.7800 | 25.5780 |
| C10 | 251.3900 | 251.3900 | 251.3900 | 0.0352 |
| C11 | 8.8900 | 8.8900 | 8.8900 | 0.0000 |
| TOTAL | 1535.1399 | 1535.1399 | 1535.1399 | 1016.0471 |

| STREAM NUMBER | 5 | |
|---|---|---|
| EQUIP. CONXION | FR 3 TO 0 | FR |
| VAPOR FRACTION | 0.0 | |
| TEMPERATURE, F | 374.8997 | |
| PRESSURE, PSIA | 35.0000 | |
| ENTHALPY,K BTU | 4266.9688 | |
| | | COMPOSITION, MOLES/HOUR |
| ETHANE | 0.0000 | |
| PROPANE | 0.0000 | |
| N-BUTANE | 0.0000 | |
| C5 | 0.0001 | |
| C6 | 0.0060 | |
| C7 | 0.3740 | |
| C8 | 28.2650 | |
| C9 | 230.2020 | |
| C10 | 251.3548 | |
| C11 | 8.8900 | |
| TOTAL | 519.0928 | |

'FINAL RESULTS'

CHESS EXAMPLE #4 - NAPHTHA SPLITTER

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| EQUIP. CONXION | FR 0 TO 1 | FR 1 TO 2 | FR 2 TO 3 | FR 3 TO 0 |
| VAPOR FRACTION | 0.0 | 0.0 | 0.0618 | 0.0 |
| TEMPERATURE, F | 72.0000 | 72.0752 | 200.0000 | 126.7146 |
| PRESSURE, PSIA | 20.0000 | 45.0000 | 35.0000 | 35.0000 |
| ENTHALPY,K BTU | -10009.9414 | -9992.8086 | -913.1104 | -3734.5569 |
| | | COMPOSITION, LBS/HOUR | | |
| ETHANE | 528.2942 | 528.2942 | 528.2942 | 528.2937 |
| PROPANE | 1299.8906 | 1299.8906 | 1299.8906 | 1299.8899 |
| N-BUTANE | 4904.1641 | 4904.1641 | 4904.1641 | 4904.1602 |
| C5 | 13090.8906 | 13090.8906 | 13090.8906 | 13090.8828 |
| C6 | 18567.0469 | 18567.0469 | 18567.0469 | 18566.5273 |
| C7 | 20580.0977 | 20580.0977 | 20580.0977 | 20543.1133 |
| C8 | 32298.3984 | 32298.3984 | 32298.3984 | 29068.5586 |
| C9 | 32803.7813 | 32803.7813 | 32803.7813 | 3280.3767 |
| C10 | 35767.7656 | 35767.7656 | 35767.7656 | 5.0057 |
| C11 | 1390.0400 | 1390.0400 | 1390.0400 | 0.0015 |
| TOTAL | 161230.2500 | 161230.2500 | 161230.2500 | 91286.7500 |

| STREAM NUMBER | 5 | |
|---|---|---|
| EQUIP. CONXION | FR 3 TO 0 | FR |
| VAPOR FRACTION | 0.0 | |
| TEMPERATURE, F | 374.8997 | |
| PRESSURE, PSIA | 35.0000 | |
| ENTHALPY,K BTU | 4266.9688 | |
| | | COMPOSITION, LBS/HOUR |
| ETHANE | 0.0005 | |
| PROPANE | 0.0007 | |
| N-BUTANE | 0.0009 | |
| C5 | 0.0077 | |
| C6 | 0.5181 | |
| C7 | 36.9849 | |
| C8 | 3229.8411 | |
| C9 | 29523.4063 | |
| C10 | 35762.7617 | |
| C11 | 1390.0386 | |
| TOTAL | 69943.5000 | |

'FINAL RESULTS'

STREAM PROPERTIES SUMMARY

| STREAM NUMBER | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| TEMPERATURE,DEG F | 72.0000 | 72.0752 | 200.0000 | 126.7146 |
| PRESSURE,PSIA | 20.0000 | 45.0000 | 35.0000 | 35.0000 |
| MOLES/HR | 1535.1392 | 1535.1392 | 1535.1392 | 1016.0471 |
| POUNDS/HR | 161230.2500 | 161230.2500 | 161230.2500 | 91286.7500 |
| MOLECULAR WEIGHT | 105.0265 | 105.0265 | 105.0265 | 89.8450 |
| PSEUDO CRITICAL TEMP,DEG F | 507.9993 | 507.9993 | 507.9993 | 448.7581 |
| PSEUDO CRITICAL PRES,PSIA | 412.5295 | 412.5295 | 412.5295 | 452.0437 |
| ACENTRIC FACTOR | 0.3563 | 0.3563 | 0.3563 | 0.3013 |
| COMPRESSIBILITY FACTOR | 0.0 | 0.0 | 0.0 | 0.0 |
| VAPOR DENSITY,LB/CU FT | 0.0 | 0.0 | 0.0 | 0.0 |
| VAPOR CU FT/MIN | 0.0 | 0.0 | 0.0 | 0.0 |
| LIQUID DENSITY,LB/CU FT | 43.5836 | 43.5960 | 0.0 | 40.1918 |
| LIQUID API @ 60F | 69.4404 | 69.3654 | 0.0 | 76.9616 |
| LIQUID GAL/MIN | 461.4543 | 461.3232 | 0.0 | 283.3188 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.3973 | 0.3963 | 0.0 | 0.4159 |
| VISCOSITY,CENTIPOISE | 0.3262 | 0.3261 | 0.0 | 0.2503 |
| THERMAL COND,BTU/HR FT DEG F | 0.0567 | 0.0567 | 0.0 | 0.0504 |

| STREAM NUMBER | 5 |
|---|---|
| TEMPERATURE,DEG F | 374.8997 |
| PRESSURE,PSIA | 35.0000 |
| MOLES/HR | 519.0916 |
| POUNDS/HR | 69943.5000 |
| MOLECULAR WEIGHT | 134.7421 |
| PSEUDO CRITICAL TEMP,DEG F | 623.9575 |
| PSEUDO CRITICAL PRES,PSIA | 335.1868 |
| ACENTRIC FACTOR | 0.4639 |
| COMPRESSIBILITY FACTOR | 0.0 |
| VAPOR DENSITY,LB/CU FT | 0.0 |
| VAPOR CU FT/MIN | 0.0 |
| LIQUID DENSITY,LB/CU FT | 37.2216 |
| LIQUID API @ 60F | 58.2536 |
| LIQUID GAL/MIN | 234.4002 |
| SPECIFIC HEAT,BTU/LB DEG F | 0.4415 |
| VISCOSITY,CENTIPOISE | 0.2006 |
| THERMAL COND,BTU/HR FT DEG F | 0.0382 |

'FINAL RESULTS'

CHESS EXAMPLE #4 - NAPHTHA SPLITTER

* EQUIPMENT SUMMARY - EQUIPMENT LIST *

| EQ. # | EXT. NAME | SUB. NAME |
|---|---|---|
| 1 | P-1 | PUMP |
| 2 | H-1 | HXER |
| 3 | COLM | DISC |

## * EQUIPMENT SUMMARY - INDIVIDUAL DETAILS *

### ***EXCHANGER/CONDENSERS***

| | |
|---|---|
| EQUIPMENT NO. | 2 |
| EXTERNAL NAME | H-1 |
| U | 0.0 |
| AREA | 0.0 |
| # SHELLS | 0.0 |
| SHELL PASSES | 0.0 |
| TUBE PASSES | 0.0 |
| MODE | 5.0000 |
| DT OR T-OUT | 200.0000 |
| DELTA P-STM 1 | 10.0000 |
| DELTA P-STM 2 | 0.0 |
| Q-STREAM 1 (M BTU/HR) | -9079.6953 |
| WATER USAGE (GAL/HR) | -72666.6250 |

..........................................................................

### ***PUMPS ***

| | |
|---|---|
| EQUIPMENT NO. | 1 |
| EXTERNAL NAME | P-1 |
| WORK CAPACITY (HORSEPOWER) | 0.0 |
| OUTLET PRES. (PSIA) | 45.0000 |
| MECH EFF. | 0.8000 |
| OPER. GPM | 461.4521 |
| DRIVER WORK (HORSEPOWER) | 8.4084 |

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### ***SHORT-CUT DISTILL'NS***

| | |
|---|---|
| EQUIPMENT NO. | 3 |
| EXTERNAL NAME | COLM |
| OPTION | 2.0000 |
| LIGHT KEY(LK) | 7.0000 |
| FRACTION LK | 0.9000 |
| HEAVY KEY(HK) | 8.0000 |
| FRACTION HK | 0.1000 |
| CONDENSER | 0.0 |
| REFLUX RATIO(R) | 0.7695 |
| R/RM | 1.5000 |
| STAGE NUMBER(S) | 16.5322 |
| S-MIN | 7.4517 |

| | |
|---|---|
| QC (M BTU/HR) | 26308.5898 |
| QR (M BTU/HR) | 27754.0938 |

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# CHAPTER V

## ANALYSIS AND DISCUSSION OF RESULTS

CHESS version 2.1 developed in this work, contains several new capabilities and features which were not available in version 2.0. Multistage compressor trains may now be simulated in a more realistic manner utilizing the new COMP unit module. The adiabatic and mechanical efficiencies are included in the calculation of power requirement for each stage. The actual adiabatic discharge temperature is also determined. The printed results from this module are also more useful to the engineer than version 2.0. The PUMP module has been modified to only simulate liquid pumping. The method of calculation for power requirement has been improved.

The addition of the stream mass summary and stream properties summary to the simulation output provides useful process data to the engineer for equipment design and specification. Properties such as density, viscosity and thermal conductivity are included. Additional hand calculations or referral to graphical data is no longer necessary.

The modifications made to enable temperatures for streams and equipment parameters to be entered in degrees Faherenheit allows the user to work with a more convenient temperature scale. The Rankine scale used in version 2.0, was found to be difficult to use since most people are accustomed to the Faherenheit or Celsius scales.

Petroleum fraction components may now be easily specified in CHESS using only three characteristic parameters in NAMELIST /PFCOMP/. All eleven physical constants required by CHESS are calculated and displayed in the simulation output. In version 2.0, the user would have to perform these calculations by hand, and enter each one in NAMELIST NSCOMP. Time and accuracy are saved with this new feature.

The calculation of heat release curves provides useful vaporization information for two-phase streams undergoing heat exchange. Temperature, pressure, fraction vaporized and enthalpy data are provided in tabular form which may be used in the design of condensers, reboilers, and two-phase exchangers. Whenever a change in phase occurs, the bubble point or dew point is calculated and printed.

# CHAPTER VI

# CONCLUSIONS AND RECOMMENDATIONS

## Conclusions

A new version of the Chemical Engineering Simulation System (CHESS) computer program version 2.1 has been developed. Several new features have been added which provide more power and flexibility than version 2.0. Improvements in the areas of unit operations, petroleum fraction components, physical properties of streams and heating/cooling curves have been made.

## Recommendations

In future work, it is suggested that the following improvements be made to CHESS 2.1.

1. Expand the thermodynamics capability to include several different options for prediction of equilibrium k-values, enthalpy and density.

2. Add a subroutine for rigorous, multicomponent distillation using the Newton-Raphson algorithm.

3. Expand the maximum number of components allowed in a simulation problem to 50.

4. Expand the pure component data base to include chemicals (e.g. alcohols, keytones, esters, etc.)

5. Include an option for the selection of dimensional units (English, Metric, SI).

6. Modify the flash algorithm to handle water as a second liquid phase.

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