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Modeling of a Heat Pump Charged With a Non-Azeotropic Refrigerant Mixture

Piotr Domanski

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NBS technical note

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Piotr Domanski

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ABSTRACT

An analysis of the vapor compression cycle and the main components of an air-to-air heat pump charged with a binary non-azeotropic mixture has been performed for steady-state operation. The general heat pump simulation model HPBI has been formulated which is based on independent, analytical models of system components and the logic linking them together. The logic of the program requires an iterative solution of refrigerant pressure and enthalpy balances, and refrigerant mixture and individual mixture component mass inventories.

The modeling effort emphasis was on the local thermodynamic phenomena which were described by fundamental heat transfer equations and equation of state relationships among material properties. In the compressor model several refrigerant locations were identified and the processes taking place between these locations accounted for all significant heat and pressure losses. Evaporator and condenser models were developed on a tube-by-tube basis where performance of each coil tube is computed separately by considering the cross-flow heat transfer with the external air stream and the appropriate heat and mass transfer relationships. A constant flow area expansion device model was formulated with the aid of Fanno flow theory. Equation of state for mixtures is described and equation constants for a R13B1/R152a mixture are given.

The developed heat pump model was validated by checking computer results against laboratory tests data of one heat pump at two cooling and two heating rating points.

Program HPBI can be used to evaluate potentials of non-azeotropic mixtures working in a split residential heat pump. User's Manual and listing of the program is included in the report.

Key words: air conditioner; capillary tube; coil; compressor; condenser; expansion device; heat pump; modeling; mixture; non-azeotropic refrigerant; vapor modeling cycle

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TABLE OF CONTENTS

	Page
ABSTRACT	iii
ACKNOWLEDGEMENTS	iv
DISCLAIMER	vii
METRIC CONVERSION FACTORS	viii
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xii
1. INTRODUCTION	1
2. GUIDELINES FOR MODEL DEVELOPMENT	7
3. EVALUATION OF THERMODYNAMIC AND TRANSPORT PROPERTIES OF A NON-AZEOTROPIC MIXTURE, R13B1/R152a	9
3.1. Evaluation of Thermodynamic Properties	9
3.2. Evaluation of Transport Properties	19
4. OPERATION OF A HEAT PUMP WITH A CONSTANT FLOW AREA EXPANSION DEVICE	23
5. MODELING OF A HEAT PUMP	29
5.1. Logic of a Model of a Heat Pump Charged with a Non-Azeotropic Mixture Refrigerant	29
5.2. Modeling of a Reciprocating, Hermetic Compressor	33
5.2.1. Compressor Operation	33
5.2.2. Theory and Governing Relations	33
5.3. Modeling of a Constant Flow Area Expansion Device	47
5.3.1. Available Capillary Tube Performance Data	47
5.3.2. Available Short Tube Restrictor Performance Data	50
5.3.3. Critical Flow	50
5.3.4. Model Formulation	53
5.4. Modeling of an Evaporator and a Condenser	56
5.4.1. Modeling Methodology	56
5.4.2. Heat Transfer Rate for a Tube of a Cross-Flow Arrangement	56
5.4.3. Refrigerant and Air Mass Flow Rates Associated with a Tube	61
5.4.4. Overall Heat Transfer Coefficient for a Dry Finned Tube	62
5.4.5. Forced Convection Heat Transfer Inside a Tube	63
5.4.6. Forced Convection Heat Transfer at the Air-Side of a Flat-Finned Tube	66
5.4.7. Overall Heat Transfer Coefficient for a Wet Finned Tube	67
5.4.8. Pressure Drop in a Tube	74
5.5. Modeling of Additional Heat Pump Components	77
5.6. Refrigerant Mass Inventory in a Heat Pump	79
6. MODEL VERIFICATION	85

7. SUMMARY AND CONCLUSIONS	89
8. REFERENCES	91
APPENDIX A. Calculations of Properties of Moist Air	95
APPENDIX B. Calculation of Water and Frost Properties	97
APPENDIX C. Calculation of Critical Pressure for Two-Phase Fanno Flow of a Non-Azeotropic Mixture	99
APPENDIX D. The Logic of the Main Program, BMAIN	103
APPENDIX E. Compressor Simulation Subroutine, COMPRE	107
APPENDIX F. Capillary Tube Simulation Subroutine, CAPIL	109
APPENDIX G. Evaporator and Condenser Subroutines, EVAPHX and CONDHX ..	111
APPENDIX H. User's Manual	113
H1. General Information	113
H2. Input and Output Data Coding	113
H2.1 Refrigerants Constants	113
H2.2 Heat Pump Data	113
H2.3 Run Controlling Data, Indoor and Outdoor Air Conditions, Refrigerant Parameters and Output Data	114
APPENDIX I. Example of Run of the Program, HPBI	131
APPENDIX J. Listing of the Program, HPBI	215

DISCLAIMER

In view of the presently accepted practice of the building industry in the United States and the structure of the computer software used in this project, common U.S. units of measurement have been used in this report. In recognition of the United States as a signatory to the General Conference of Weights and Measures, which gave official status to the SI system of units in 1960, appropriate conversion factors have been provided in the table below. The reader interested in making further use of the coherent system of SI units is referred to: NBS SP330, 1972 Edition, 'The International System of Units,' or E380-72, ASTM Metric Practice Guide (American National Standard 2210.1).

METRIC CONVERSION FACTORS

Length	1 inch (in) = 25.4 millimeters (mm)
	1 foot (ft) = 0.3048 meter (m)
Area	1 ft ² = 0.092903 m ²
Volume	1 ft ³ = 0.028317 m ³
Temperature	F = 9/5 C + 32
Temperature Interval	1°F = 5/9°C or K
Mass	1 pound (lb) = 0.453592 kilogram (kg)
Mass Per Unit Volume	1 lb/ft ³ = 16.0185 kg/m ³
Energy	1 Btu = 1.05506 kilojoules (kJ)
Specific Heat	1 Btu/[(lb)(°F)] = 4.1868 kJ/[(kg)(K)]
Gallon	1 gallon = 0.0037854 m ³

LIST OF TABLES

	Page
1. Equation of State Constants for Refrigerants 13B1 and 152a	11
2. Coefficients to be Used in Equations (17), (18), and (19)	18
3. Coefficients to be Used in Correlations for Fin Efficiency (Equation (89))	70
4. Laboratory Test and Computer Simulation Results in the Cooling Mode	87
5. Laboratory Test and Computer Simulation Results in the Heating Mode	88
B1. Water Property Evaluation Constants which are Used in Equation (B1)	98
H1. Refrigerant Property Single Precision Functions and Subroutines	119
H2. Refrigerant Property Double Precision Functions and Subroutines	121
H3. Functions and Subroutines for Heat Pump Component Simulation, Heat Transfer and Fluid Mechanic Calculations	122
H4. Data File Containing Constants for Evaluation of Thermodynamic Properties of R13B1/R152a Mixture	123
H5. Heat Pump Input Data Code to Program HPBI	124
H6. Example of a Heat Pump Data File	129

LIST OF FIGURES

	Page
1. Oversimplified thermodynamic cycle of a heat pump	2
2. Schematic of a heat pump	3
3. Thermodynamic cycle realized by a heat pump	5
4. Flow chart for calculating the saturation pressure of single component refrigerant	12
5. Flow chart for calculating the bubble point temperature of a non-azeotropic binary mixture.....	15
6. Temperature-composition diagram for a non-azeotropic binary mixture.....	16
7. Simplified thermodynamic cycle realized by a heat pump charged with refrigerant 22 in the cooling mode at different outdoor temperatures	25
8. Schematic of an accumulator	26
9. Overall logic of a program simulating a heat pump employing a constant flow area expansion device and charged with a non-azeotropic binary refrigerant mixture	30
10. Schematic of a hermetic compressor	34
11. Typical speed (RPM) versus load curve for a permanent split-capacitor two pole electric motor [15]	36
12. Simplified indicator diagram for a reciprocating compressor	38
13. Typical efficiency versus load curve for a permanent split-capacitor two pole electric motor [15]	40
14. Pressure and temperature distribution along typical capillary tube [23]	48
15. Mass balance for an element of fluid in one-dimensional steady flow in a constant area duct	51
16. Momentum balance for an element of fluid in one-dimensional flow in a horizontal, constant area duct	51
17. Energy balance for an element of fluid in one-dimensional, adiabatic, steady flow in a horizontal, constant area duct	52
18. Fanno line	52

19. Schematic of a heat pump heat exchanger	57
20. Example of coil circuitry	58
21. Approximation method for treating a rectangular-plate fin of uniform thickness in terms of a flat circular-plate fin of equal area	59
22. Cross section of a flat-finned tube indicating parameters which affect the air-side heat transfer coefficient	68
23. Efficiency for a circular-plate fin of uniform thickness	69
24. Refrigerant phase in heat pump components	80
C1. Logic to evaluate the quality of the Fanno flow of a given pressure for a non-azeotropic mixture	101
D1. Overall logic of program HPBI	105
F1. Logic of a constant flow area expansion device simulation program, CAPIL	110
G1. Flow chart for coil performance simulation programs	112

LIST OF SYMBOLS

A	= flow cross section area
A_f	= fin surface area
A_h	= heat transfer surface area
$A_{n,i}$	= coefficients in equation (89)
$A_{p,i}$	= pipe inside surface area
$A_{p,m}$	= pipe mean surface area
A_o	= pipe total outside surface area
a1,a2,a3	= coefficients in equation (45)
CP	= pressure drop parameter
CQ	= heat transfer parameter
C_c	= correction factor in equation (34)
C_e	= clearance volume, in fraction of compressor stroke volume
C_p	= specific heat at constant pressure
C_v	= specific heat at constant volume
D	= tube inside diameter
D_o	= tube outside diameter
D_f	= fin tip diameter
d1,d2	= dimensions representing arrangement of tubes in a coil, as per figure 21
E	= electrical power input
F1,F2	= dimensionless parameters used in equation (83)
f	= Fanning friction factor
$f_{tp,L}$	= friction factor for the liquid portion of two-phase flow, flowing alone in the tube
G	= $\frac{m}{A}$, mass flux, or Gibbs free energy
G_{max}	= air mass flux between two adjacent fins
H	= liquid refrigerant level in an accumulator
h	= heat transfer coefficient, h_c refers to air-side forced convection heat transfer coefficient for wet air, $h_{c,o}$ refers to air-side

forced convection heat transfer coefficient for dry air, h_i refers to inside tube convection heat transfer coefficient

$h_{D,o}$	= air-side mass transfer coefficient
hp	= horse power
i	= enthalpy
i_{fg}	= latent heat of evaporation or condensation
J	= the mechanical equivalent of heat
K	= flow contraction coefficient
K_f	= $J \cdot i_{fg} \cdot \Delta x/L$, boiling number
k	= thermal conductivity
L	= tube length
Le	= $\frac{h_{c,o}}{h_{D,o} C_p a}$, Lewis number
M	= mass of refrigerant, or molecular weight
m	= mass flow rate
Nu	= $\frac{h \cdot D}{k}$, Nusselt number
n	= polytropic index
P	= pressure
Pr	= $\frac{\mu \cdot C_p}{k}$, Prandtl number
Q	= heat transfer rate
R	= rate of moisture removal per unit area, or universal gas constant
R'	= rate of moisture removal per unit width of a fin
Re	= $\frac{G \cdot D}{\mu}$, Reynolds number
$Re_{tp,L}$	= Reynolds number for the liquid portion of two-phase, flowing alone in the tube
RPM	= compressor number of revolutions per minute
S	= tube perimeter
s	= entropy
T	= temperature

$T_{f,b}$	= fin base temperature
$T_{f,m}$	= mean fin temperature
$T_{r,g}$	= refrigerant saturation temperature
t	= fin thickness
U	= overall heat transfer coefficient
V	= velocity
V_s	= compressor swept volume
V	= volume
v	= specific volume or molar volume
W_c	= mechanical power available for compression process
W_e	= mechanical power input
w_a	= humidity ratio of air, $w_{a,i}$ refers to tube row inlet, $w_{a,e}$ refers to tube row outlet
w_w	= humidity ratio of saturated air at temperature of wetted water film
X_L	= molar composition of liquid phase
X_M	= molar composition of mixture
X_V	= molar composition of vapor phase
X_W	= weight composition of mixture
X_{tt}	$= \left(\frac{1-x}{x}\right)^{0.9} \left(\frac{v_L}{v_V}\right)^{0.5} \left(\frac{\mu_L}{\mu_L}\right)^{0.1}$, Lockhart-Martinelli parameter
x	$= \frac{m_V}{m_V + m_L}$, quality
x_p	= pipe wall thickness
y	= fin height
Z_{tp}	= fraction of the tube in the two-phase region for the tube with liquid and two-phase flow
Z_V	= fraction of the tube in the superheated vapor region for the tube with two-phase and superheated vapor flow
z	= distance between adjacent fins
α	= void fraction

β = exponent in equation (83)
 γ = isentropic index
 σ = liquid layer (frost) thickness or Stefan Baltzman constant
 ϵ = surface emissivity
 η_e = electric motor efficiency
 η_m = mechanical efficiency of compressor
 η_p = polytropic efficiency of compressor
 η_v = volumetric efficiency of compressor
 μ = absolute viscosity
 ρ = density
 τ = skin friction factor
 Φ = correction factor for two-phase pressure drop
 ϕ = fin efficiency

Subscripts:

a = air, a,d refers to dry air
e = exit
f = frost or fin
i = inlet
L = liquid
m = mean value
P = constant pressure process
r = refrigerant
s = constant entropy process
t = total value
V = vapor
v = constant volume process
w = water
1 to 13 = refrigerant key locations in a heat pump, as per figure 4, unless otherwise explained in the text



1. INTRODUCTION

Among equipment providing thermal comfort for indoor spaces, the heat pump has gained in recent years substantial popularity for residential applications. The heat pump is unique since it is the only device, which can provide both heating and cooling. Heat pumps have become very competitive economically and are considered to be a very good investment by homeowners.

A heat pump works on the vapor compression cycle principle. The most important heat pump components are two heat exchangers, a compressor and an expansion device. The heat pump thermodynamic cycle can be explained by analysing the processes that the refrigerant undergoes in these four components. The most convenient diagram for such an explanation and performance analysis is that of a pressure vs. enthalpy coordinate system, as shown in figure 1. The compressor receives low pressure and temperature refrigerant at state 1 and compresses it to a high pressure. This compression process is associated with an increase of refrigerant temperature. At state 2, the high pressure and high temperature vapor enters the condenser. The refrigerant passing through the condenser rejects heat to the high temperature reservoir and changes, usually to a subcooled liquid at state 3. Then, the refrigerant flows through the expansion device undergoing a drop in pressure and temperature. Finally, the low pressure, low temperature, and low quality refrigerant at state 4 enters the evaporator, where it picks up heat from the low temperature reservoir, reaching a superheated (or high quality) vapor state 1 at the evaporator exit. In the explanation above, the low and high temperature reservoirs are the indoor and the outdoor environment, when the heat pump is operating in the cooling mode.

Besides the compressor, two heat exchangers, and the expansion device, there are, for practical reasons, many other components in an actual heat pump system. For modeling consideration, the most important are: tubes connecting basic elements, 4-way valve enabling refrigerant flow reversal in the unit to operate in the heating or cooling mode, and an accumulator (not used in all systems), which acts as a protective device for the compressor by storing excess refrigerant during part load operation and preventing liquid refrigerant from entering the compressor.

There are many concepts and designs of heat pump components, however, certain types are predominant. A reciprocating hermetic compressor is usually used for vapor compression in small systems. Heat exchangers are usually in the form of staggered tubes with closely packed wavy fins (spine-fins or bristle-fins are sometimes used). There are basically two types of expansion devices in application today. Constant flow area restrictors prevail in small capacity units such as household refrigerators, window-type air conditioners, and central residential air conditioners and heat pumps. Larger, more expensive residential units and commercial units are usually equipped with a variable flow area device called a thermostatic expansion valve (TXV).

All the above mentioned components make up an actual vapor compression system. Configuration of such a system and the thermodynamic cycle are illustrated in figure 2 and figure 3, respectively. Refrigerant states in figure 3 correspond to particular locations in the system marked in figure 2, which are:

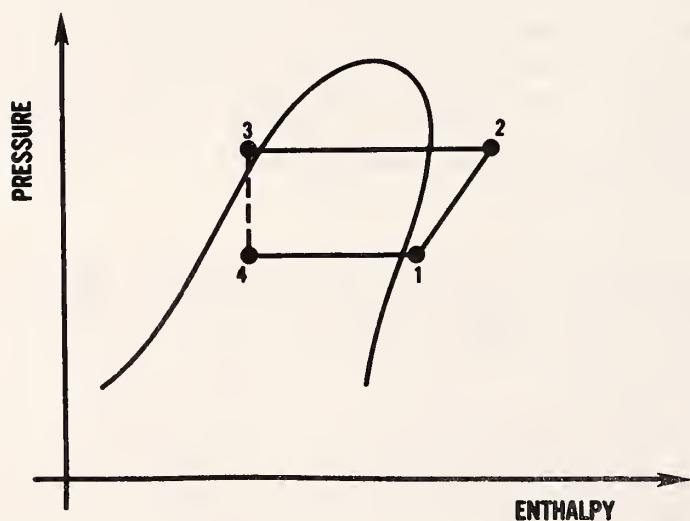
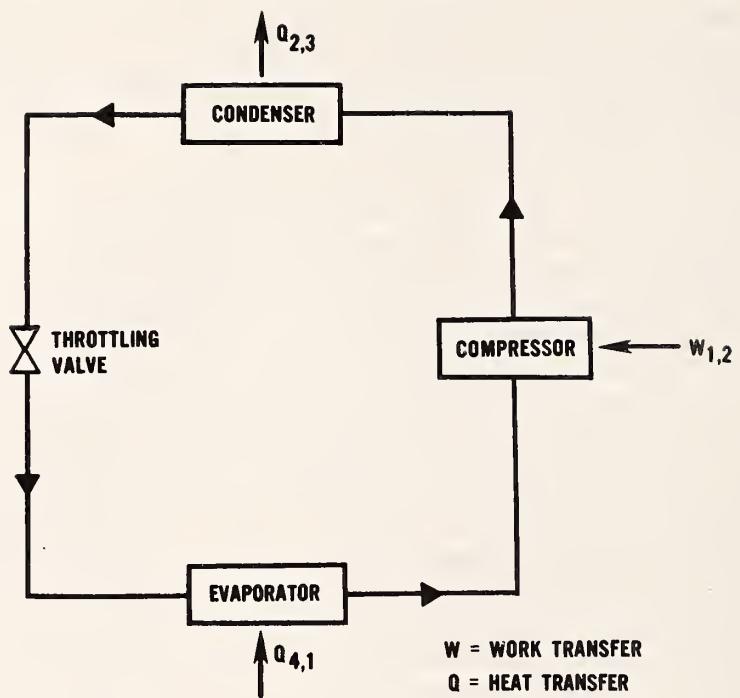
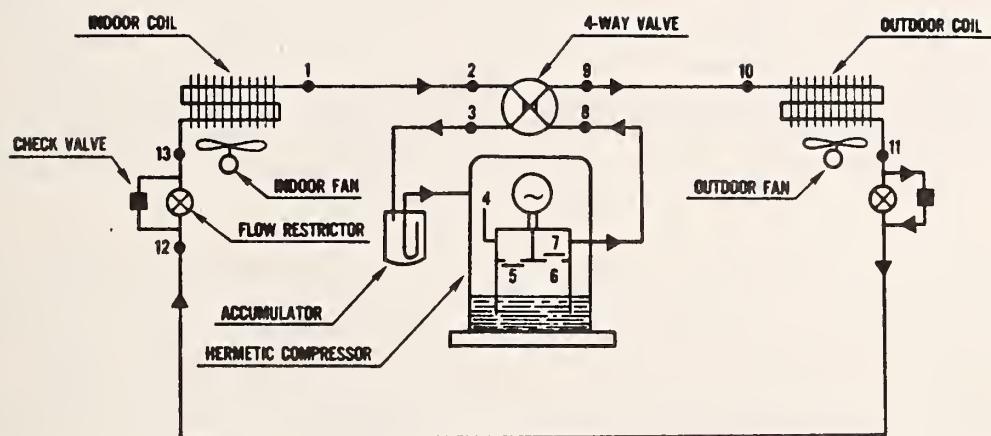


Figure 1. Oversimplified thermodynamic cycle of a heat pump.



- Note:
1. Refrigerant flow direction is marked for cooling operation.
 2. Numbers 5 and 6 situated in the compressor correspond to refrigerant state before and after the compression process.

Figure 2. Schematic of a heat pump.

- 1 - evaporator exit, suction pipe inlet
- 2 - suction pipe outlet, low pressure 4-way valve inlet
- 3 - low pressure 4-way valve exit, compressor enclosure inlet
- 4 - inside compressor enclosure
- 5 - compressor cylinder at suction
- 6 - compressor cylinder at discharge
- 7 - discharge manifold
- 8 - compressor enclosure exit, high pressure 4-way valve inlet
- 9 - high pressure 4-way valve exit, discharge pipe inlet
- 10 - discharge pipe outlet, condenser inlet
- 11 - condenser outlet, liquid line inlet
- 12 - liquid line outlet, expansion device inlet
- 13 - evaporator inlet

In the heat pumping process refrigerant is the carrier of heat from a low temperature reservoir to a high temperature reservoir. There are many kinds of refrigerants of different properties available and they are being used depending on the application. For residential air-to-air heat pumps, refrigerant 22 has been generally accepted as the most advantageous. However, in recent years interest has intensified in non-azeotropic binary mixtures as potential working fluids in heat pumps. Gliding evaporation/condensation temperatures and the possibility of heat pump capacity control via mixture composition shift are often cited as factors giving mixtures a theoretical performance edge over single component refrigerants.

The objective of this study is the development of a mathematical model of an air-to-air heat pump working with a non-azeotropic mixture as the refrigerant in order to be able to investigate performance potentials of mixtures. The type of heat pump considered here is the one most commonly commercially available with a reciprocating hermetic compressor, fin-tube heat exchangers and a constant flow area expansion device. The mixture considered in this study consists of refrigerants 13B1 and 152a.

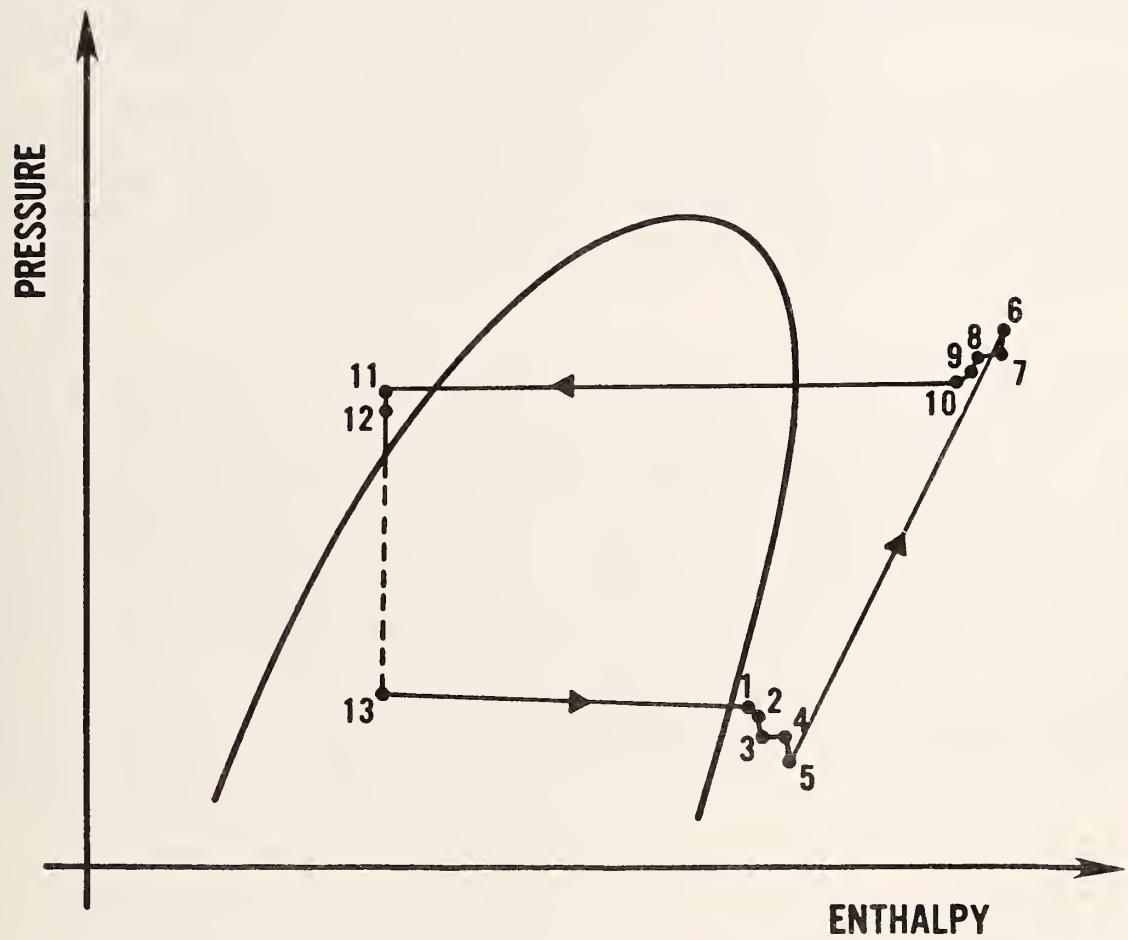


Figure 3. Thermodynamic cycle realized by a heat pump (for number location refer to figure 2).

2. GUIDELINES FOR MODEL DEVELOPMENT

Before beginning the modeling effort, general guidelines for model development have to be established. These guidelines should evolve from future model applications as they are broadly perceived today. It is understood that the model is planned to be used for parametric studies by different users, applied to different hardware and possibly charged with different non-azeotropic refrigerants. The model should help prospective users to evaluate potential benefits of non-azeotropic mixtures, as applied to heat pumps, resulting from changing refrigerant temperature during evaporation/condensation and change of mixture composition which influences heat pump capacity.

It has been stated already that a heat pump equipped with a reciprocating compressor, compact staggered tube and flat fin heat exchangers, and a constant flow area expansion device will be modeled. This choice has been made since, in addition to the fact that components of this design type are most commonly encountered, results of initial research indicated a possibility of inherent to the system capacity modulation in systems employing a capillary tube [1].

The model should be a first principle one. Regression analysis curve fits should be avoided so the program could be applied to simulate systems of different characteristics, size and performance level. Modular structure of the program should allow for later model upgrades on the local basis. Since heat exchangers and changing refrigerant mixture temperatures during change of phase are going to be investigated, a tube-by-tube approach to modeling of an evaporator and condenser was adapted. Finally, an appropriate equation of state is desirable that could be universally used for accurate predictions of thermodynamic properties for a variety of possible non-azeotropic mixtures.

During the past, a heat pump modeling effort has been underway at NBS [2,3]. The latest model [3] fulfills the basic postulates of the guidelines and is adopted here for expansion to the simulation model of a heat pump charged with a non-azeotropic mixture.

3. EVALUATION OF THERMODYNAMIC AND TRANSPORT PROPERTIES OF A NONAZEOTROPIC MIXTURE, R13B1/R152a

The refrigerant mixture, R13B1/R152a, discussed in this chapter showed promising performance in experiments performed by Cooper [1]. The choice of this mixture for development of this heat pump model does not mean this mixture to be optimum and precludes other mixtures to be more suitable for heat pump application.

3.1. Evaluation of Thermodynamic Properties

Evaluation of thermodynamic properties for a non-azeotropic mixture represents an additional complication as compared to single component refrigerants. The employed equation of state has to be able to provide predictions for a broad range of compositions that the circulating mixture may have during heat pump operation. This range of possible compositions is even further expanded by the fact that in the two-phase region, saturated liquid and saturated vapor in equilibrium have different compositions.

Connon and Drew [4] presented application of Redlich-Kwong-Soave (R-K-S) equation to generate R13B1/R152a mixture thermodynamic data. The R-K-S equation successfully generated all vapor thermodynamic information, however, prediction of liquid density of the mixture was based on densities of pure components and application of a mixing rule, since the R-K-S equation did not provide the desired accuracy.

It has been shown by Morrison et al. [5] that it is possible to describe both the liquid and the vapor properties of pure-refrigerants as well as refrigerant mixtures with a single equation of state. They have shown that this approach has a significant advantage over the traditional methods, that of using a vapor equation of state and a library of liquid properties. This advantage is that it will accurately predict property values in the region near or above the critical point of either of the binary components [6]. Because of this advantage, Morrison's equation was adopted in this modeling effort. The basic features of this equation are given below, though for full review, the source report is recommended [5]. The equation of state has the following form:

$$\frac{Pv}{RT} = \frac{1 + y + y^2 - y^3}{(1 - y)^3} - \frac{a}{RT(v + b)} \quad (1)$$

where $y = \frac{b}{4v}$

For single component refrigerants, parameters a and b can be determined by second degree polynomials:

$$a = a_0 + a_1T + a_2T^2 \quad (2)$$

$$b = b_0 + b_1T + b_2T^2 \quad (3)$$

are a_0 , a_1 , a_2 , b_0 , b_1 , and b_2 are constants which are based on empirical data for a given refrigerant. For mixtures, these parameters may be determined by:

$$a = w_I^2 a_I + 2w_I w_{II} a_{I,II} + w_{II}^2 a_{II} \quad (4)$$

$$b = w_I^2 b_I + 2w_I w_{II} b_{I,II} + w_{II}^2 b_{II} \quad (5)$$

Parameters a_I , a_{II} , b_I , and b_{II} are for pure refrigerants and are obtained by equations (2) and (3).

Remaining parameters are:

$$a_{I,II} = (1 - f_{I,II})(a_I a_{II})^{0.5} \quad (6a)$$

$$b_{I,II} = [(b_I^{1/3} + b_{II}^{1/3})/2]^3 \quad (6b)$$

$$f_{I,II} = d - cT \quad (6c)$$

(c and d constants are obtained from mixture measurements to allow for the interactions of the different molecular species.)

w_I, w_{II} = molar composition of the mixture, fraction of I and II components, respectively.

Numerical values of the above explained constants are given in Table 1 for refrigerants R13B1 and R152a.

Having defined the mixture thermodynamic state, by specifying temperature, pressure and mixture composition, in order to evaluate other state thermodynamic properties it is essential to determine if the mixture is liquid, vapor, or two-phase. In the latter case, evaluation of the compositions of liquid and vapor in equilibrium is also required.

The starting point to this calculation procedure is pure component analysis to determine saturation pressure for a given temperature. Since equation (1) also contains molar volume, an iterative process is mandatory for both the liquid and vapor phases. The criteria for verifying that the saturation pressure and molar volume guesses are correct is the equality of the Gibbs free energy and pressure of the two phases. The logic of this procedure is illustrated in the flow diagram in figure 4, and Gibbs free energy is calculated by the equation:

$$G = G^{pg}(p^*, T) + RT \ln \frac{RT}{p^*v} + (pv - RT) - \frac{a}{b} \ln \frac{v+b}{v} + \frac{4RTy}{v-y} + \frac{RTy}{(v-y)^2} \quad (7)$$

where G^{pg} = perfect gas Gibbs free energy
 p^* = equilibrium vapor pressure of the pure liquid at temperature T

Table 1. Equation of State Constants for Refrigerants R13B1 and R152a

	R13B1	R152a
a ₀	25.4145	27.39273
a ₁	-0.063368	-0.059421169
a ₂	4.140051 E-5	3.3176956 E-5
b ₀	0.1353977	0.1239878
b ₁	-1.50409 E-4	-1.445514 E-4
b ₂	-1.354434 E-7	-1.9022381 E-8
c	-2.241 E-4	
d	0.1466	

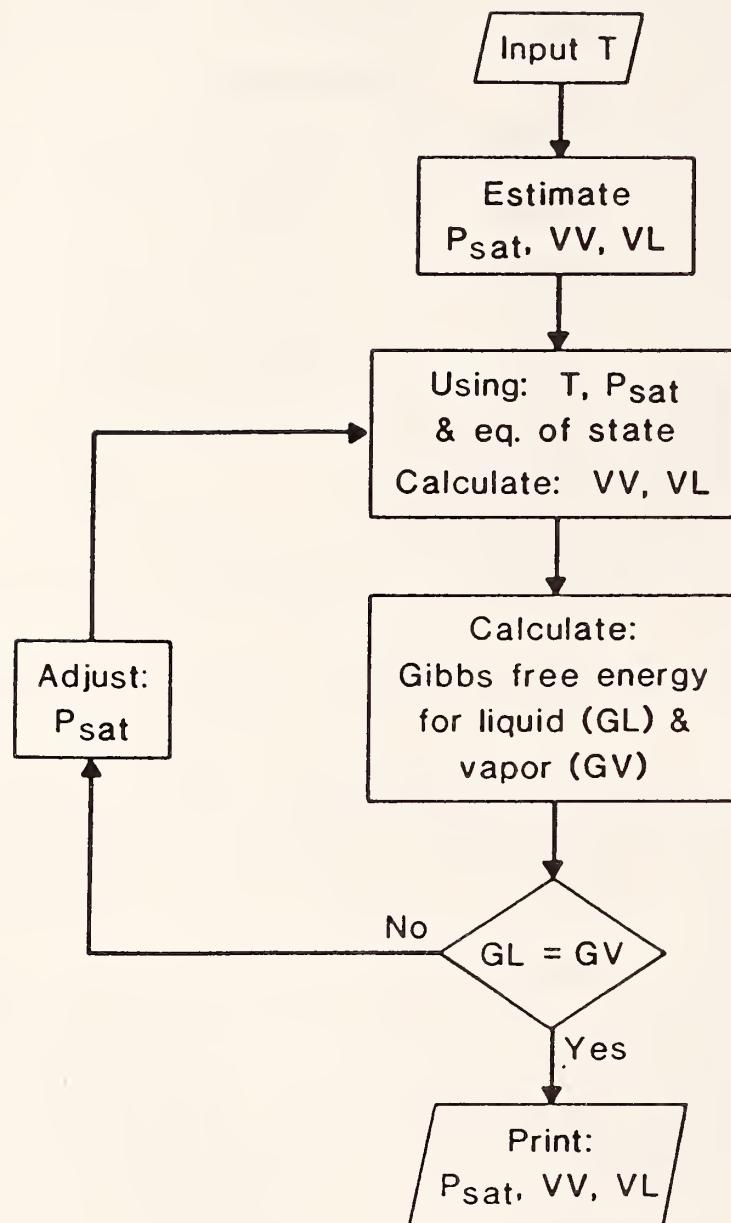


Figure 4. Flow chart for calculating the saturation pressure of single component refrigerant

The evaluation of compositions of the liquid and vapor phases in equilibrium follows the rule that phase equilibrium in mixtures is defined by equality of pressure, temperature and the chemical potential between phases of each of the species in the mixture. Determination of the equilibrium composition is a rather lengthy procedure and it is not practical to use a full algorithm in a large vapor compression cycle simulation program where property values are requested on the order of hundred of thousands of times. For this reason, equation of state was used to generate sufficient data to create a polynomial spline where saturated liquid and saturated vapor compositions are functions of temperature, pressure and saturation pressures of pure components at mixture temperature. Generation of polynomial splines is discussed in [7] and [8]. The following equations were obtained for R13B1/R152a mixture:

$$RP = \frac{P_1 - P}{P_1 - P_2}$$

$$S_1 = 12.58741 - 0.06465226 * TK - 9.56391 * 10^{-5} * TK^2$$

$$S_2 = -48.9799 - 0.289414 * TK - 4.504945 * 10^{-4} * TK^2$$

$$S_3 = 47.7509 - 0.273993 * TK + 4.14487 * 10^{-4} * TK^2$$

$$S = S_1 + S_2 * RP + S_3 * RP^2$$

$$Z_1 = -0.34065414 - 3.337532 * 10^{-3} * TK + 9.66115 * 10^{-6} * TK^2$$

$$Z_2 = -10.3139754 + 0.0653856 * TK - 9.9899162 * 10^{-5} * TK^2$$

$$Z_3 = 10.035917 - 0.05527259 * TK + 7.6821554 * 10^{-5} * TK^2$$

$$Z = 1 + Z_1 * (RP - 1) + Z_2 * (RP^2 - 1) + Z_3 * (RP^3 - 1)$$

$$XL = \frac{(1 + S) * RP}{(1 + S * RP)} \quad (8)$$

$$XV = XL * Z \quad (9)$$

where TK = mixture temperature (K)

 P = mixture pressure (std atm)

 P1 = saturation pressure of pure R13B1 at temperature TK (std atm)

 P2 = saturation pressure of pure R152a at temperature TK (std atm)

 XL = molar composition of liquid phase (fraction of R152a)

 XV = molar composition of vapor phase (fraction R152a)

Knowing saturated liquid and vapor compositions and overall mixture composition, evaluation of mixture quality, XQ, is readily available:

$$XQ = \frac{XL - XM}{XL - XV} \quad (10)$$

where XM = mixture molar composition (fraction of R152a)

Phase equilibrium compositions calculated by the spline agree to the third decimal point with compositions obtained using the equation of state.

Equation of state does not provide us directly with information about the bubble point or dew point. However, the bubble point for a mixture of given composition and pressure can be found by iteration using the criteria that, at bubble point the liquid composition (X_L) is equal to a known mixture composition (X_M). The solution logic is illustrated in the flow diagram of Figure 5, where the parameters are graphed in the phase diagram of Figure 6. Similar logic is used for calculating the dew point temperature; in this case, searching for the unique temperature at which the saturated vapor composition equals to composition of the mixture.

Evaluation of molar enthalpy is straight forward:

$$h = h^{pg} + \frac{a'b'TK - ab'TK - ab}{b^2} \ln \frac{v+b}{v} + \frac{ab'T - ab}{b(v+b)} + \frac{8RTv(8v-b)}{(4v-b)^3} (b - b'T) \quad (11)$$

where prime denotes a temperature derivative.

The molar enthalpy of a perfect gas of a mixture, h^{pg} , is the integral of a linear weighting of the heat capacities of the component perfect gases.

$$h^{pg} = \int_{T_{ref}}^T CpdT = \int_{-40F}^T (w_I C_{pI} + w_{II} C_{pII}) dT \quad (12)$$

where C_{pI} and C_{pII} are perfect gas heat capacities of the respective components, functions of temperature, whose coefficients are determined empirically.

$$C_{pI} = C_I(1) + C_I(2) \cdot T + C_I(3) T^2 \quad (13)$$

$$C_{pII} = C_{II}(1) + C_{II}(2) \cdot T + C_{II}(3) \cdot T^2 \quad (14)$$

Specific entropy can be calculated by the following expression:

$$S_m = w_I \int_{-40}^T \frac{C_{vI}}{T} dT + R \ln \frac{v}{w_I \cdot v_I^*} - \Delta S_I^{pg} (v_I^*, -40^\circ C) + w_{II} \int_{40}^T \frac{C_{vII}}{T} dT + R \ln \frac{v}{w_{II} \cdot v_{II}^*} - \Delta S_{II}^{pg} (v_{II}^*, -40^\circ C) + \Delta S_m^{pg} (v, T) \quad (15)$$

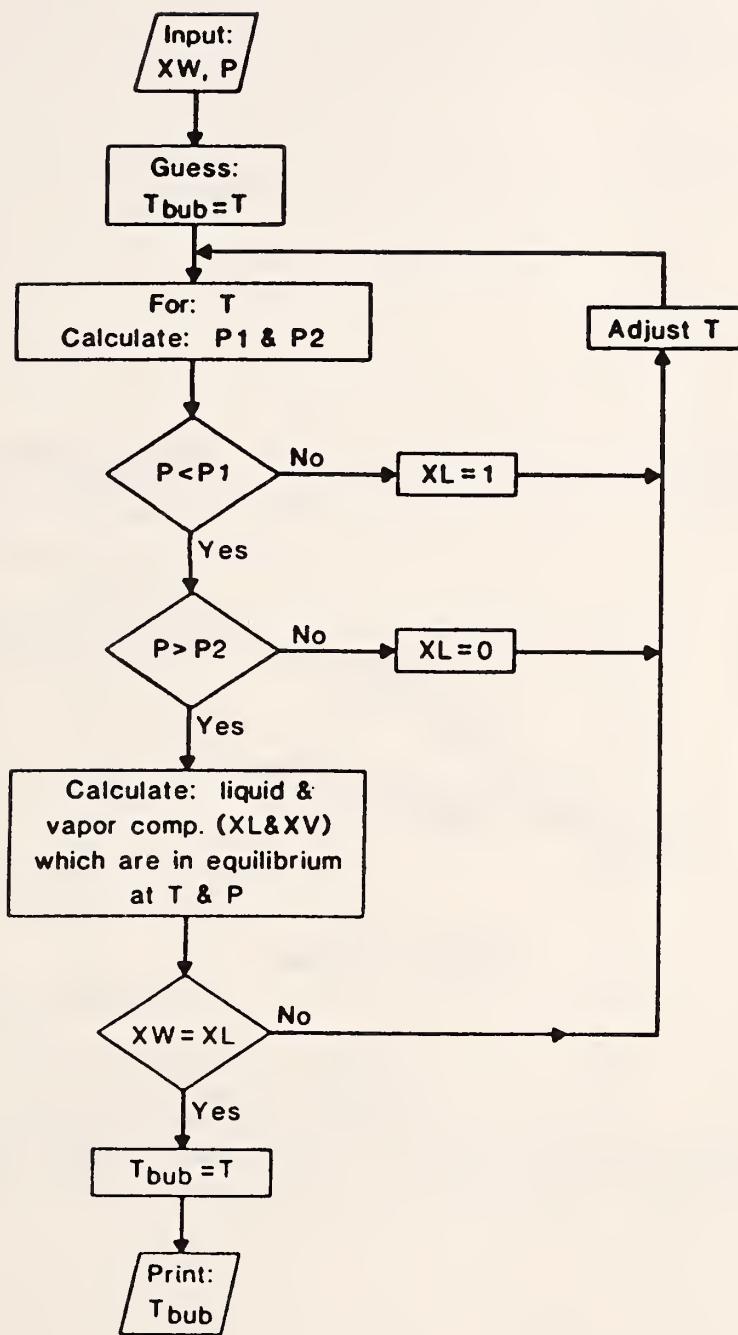


Figure 5. Flow chart for calculating the bubble point temperature of a non-azeotropic binary mixture.

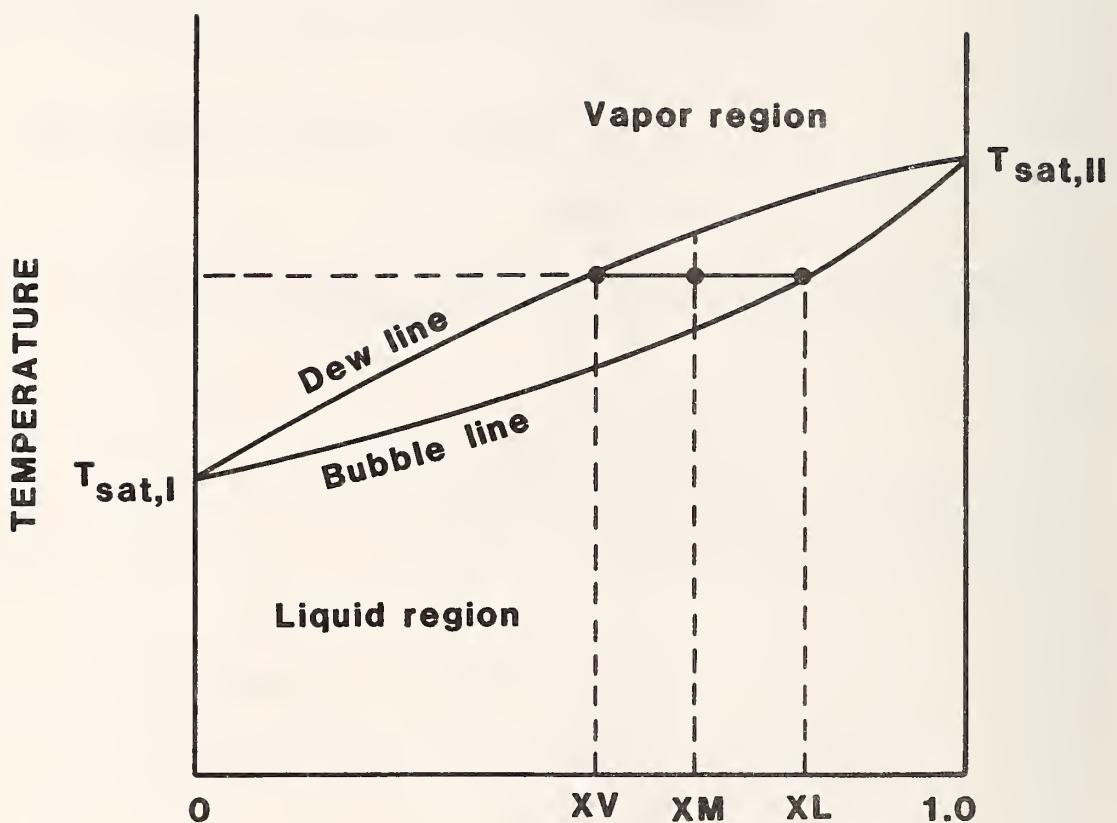


Figure 6. Temperature-composition diagram for a non-azeotropic binary mixture

where:

v_I^* and v_{II}^* are reference state (-40°C) molar volumes of liquid for each of the pure components, ΔS_I^{pg} and $\Delta S_{II}^{\text{pg}}$ are the differences of entropy between the perfect and the real gas having a molar volume of saturated pure component liquid I and II, respectively, at the reference temperature (-40°C), ΔS_m^{pg} is the difference of entropy between perfect and real mixture of the actual molar volume v and at the actual mixture temperature T .

In either case, ΔS^{pg} can be evaluated by the equation (16) with v put to v_I^* or v_{II}^* , if pure components are considered.

$$\Delta S^{\text{pg}} = \frac{a'b - ab'}{b'} \ln \frac{v + b}{v} + \frac{ab'}{b(v + b)} - \frac{Rb(16v - 3b)}{(4v - b)^2} - \frac{8RTbv(8v - b)}{(4v - b)^3} \quad (16)$$

Application of the equation of state requires estimated values of the following pure component properties at saturation as function of temperature; pressure, molar volume of vapor, and molar volume of liquid. Correlations to provide these guesses are given below:

$$P = \exp \sum_{I=1}^3 a(I) \cdot T^{1-I} \quad (17)$$

$$v_V = \sum_{I=1}^3 b(I) \cdot T^I / P \quad (18)$$

$$v_L = \sum_{I=1}^3 c(I) \cdot T^{I-1} \quad (19)$$

where P = saturation pressure
 T = temperature
 v_V = molar volume of saturated vapor
 v_L = molar volume of saturated liquid

The equation coefficients $a(I)$, $b(I)$, $c(I)$ for refrigerants 13B1 and 152a are given in Table 2 along with applicable units of refrigerant state property parameters.

Table 2. Coefficients to be Used in Equations (17), (18) and (19)

Coefficient	R13B1	R152a
a(1)	1.00522804E+1	1.06410518E+1
a(2)	-2.2045632E+3	-2.6428994E+3
a(3)	9.6365313E+3	4.6087585E+2
b(1)	-5.05060051E-2	2.18192958E-2
b(2)	1.11455764E-3	5.416820778E-4
b(3)	-2.56392871E-6	-1.24731336E-6
c(1)	2.749422E-1	1.023688715E-1
c(2)	1.702569E-3	-4.0752759E-4
c(3)	3.71008313E-6	1.0409447E-6

Applicable units of the state parameter in equations (17), (18) and (19) are
 pressure - std. atm
 temperature - °K
 molar volume - L/mol

3.2 Evaluation of Transport Properties

In addition to the thermodynamic state equation, algorithms have to be used to calculate thermal conductivity and absolute viscosity of the liquid and vapor. These algorithms consist of curve-fitted correlations for the prediction of properties of pure components, and of some kind of a mixing rule. Reid, Prausnitz and Sherwood [9] gave a comprehensive review of mixing rules that could be used depending on mixture component characteristics and component property data availability. Following their recommendation, appropriate correlations were selected and are listed below along with the correlations used for evaluation of the transport properties of pure components. Correlations for property calculations are given here as presented in the referenced documents. However, for use in the mixing rule they were converted to common dimensions.

Liquid Thermal Conductivity, k

(The Filippov Equation is used. The error should not exceed 4% [9].)

$$k = k_1 + (k_2 - k_1) * XW * (0.72 * XW + 0.28) \quad (20)$$

where: k_1 , k_2 = thermal conductivity of the pure components of R13B1 and R152a, respectively.

$$k_1 = 0.35 - 1.5 * 10^{-4} \cdot TF \quad (\text{Btu/h ft F}) [8]$$

$$k_2 = 0.11650 - 0.000497 \cdot TC \quad (\text{w/m} \cdot \text{K}) [8]$$

$$TC = \text{temperature} \quad (\text{C})$$

$$TF = \text{temperature} \quad (\text{F})$$

$$XW = \text{weight composition} \quad (\text{fraction of R152a})$$

Vapor Thermal Conductivity, k

(The Wassiljewa Equation is used with the Lindsay and Bromley Modification. The error rarely exceeds 5% [9].)

$$k = \frac{(1 - XM) \cdot k_1}{(1 - XM) \cdot A_{11} + XM \cdot A_{12}} + \frac{XM \cdot k_2}{(1 - XM) \cdot A_{21} + XM \cdot A_{22}} \quad (21)$$

where: k_1 , k_2 = thermal conductivity of the pure components of R13B1 and R152a, respectively.

$$k_1 = 8.2982 * 10^{-3} - 5.1971 * 10^{-5} \cdot TK + 1.8413 * 10^{-7} \cdot TK^2$$

[w/m · K] [8]

$$k_2 = -8.357 * 10^{-3} + 6.32 * 10^{-5} \cdot TK + 4.257 * 10^{-8} * TK^2$$

[w/m · K] [9]

$$A_{ij} = 0.25 \left[1 + \left(\frac{\mu_i}{\mu_j} \left(\frac{M_j}{M_i} \right)^{0.75} \frac{TK + S_i}{TK + S_j} \right)^{0.5} \right]^2 \frac{TK + S_{ij}}{TK + S_i}$$

μ_1, μ_2 = absolute viscosity of the pure components, R13B1 and R152a, respectively.

M_1, M_2 = molecular weight of the pure components, R13B1 and R152a, respectively.

TK = absolute temperature (K)

$$S_i = 1.5 \cdot T_{bi}$$

$$T_{bi} = \text{normal boiling point of 'i' component (K)}$$

$$S_{ij} = 0.73 \cdot (S_i \cdot S_2)^{0.5}$$

$$\bar{x}_M = \text{composition (mole fraction of R152a)}$$

Liquid Absolute Viscosity, μ

(The Lobe correlation is used. The prediction error should be less than 15%, [9].)

$$\mu = \frac{1}{v_m} (\phi_1 \cdot \gamma_1 e^{\phi_2 a_2^*} + \phi_2 \gamma_2 e^{\phi_1 a_1^*}) \quad (22)$$

v_m = mixture specific volume

ϕ_1, ϕ_2 = volume fraction of the pure components, R13B1 and R152a, respectively.

γ_1, γ_2 = kinematic viscosity of the pure components, R13B1 and R152a, respectively. (obtained, as shown below, through evaluation of the absolute viscosities, μ_1 and μ_2)

$$\mu_1 = (e^{-4.22529} + 710.843/TK) * 10^{-3} \quad (N \cdot s/m^2) [10]$$

$$\mu_2 = (e^{-4.28224} + 753.013/TK) * 10^{-3} \quad (N \cdot s/m^2) [10]$$

$$a_1^* = 1.7 \ln \frac{\gamma_2}{\gamma_1}$$

$$a_2^* = 0.27 \ln \frac{\gamma_2}{\gamma_1} + (1.3 * \ln \frac{\gamma_2}{\gamma_1})^{0.5}$$

TK = temperature (K)

Vapor Absolute Viscosity, μ

(The equation derived from the vigorous kinetic theory of Chapman-Ensbog is used. The error seldom exceeds 4% [9].)

$$\mu = \frac{(1 - XM)\mu_1}{(1 - XM) + XM \cdot \phi_{12}} + \frac{XM\mu_2}{XM + (1 - XM)\phi_{21}} \quad (23)$$

where

$$\phi_{12} = \frac{\left[1 + \left(\frac{\mu_1}{\mu_2} \right)^{0.5} \left(\frac{M_2}{M_1} \right)^{0.25} \right]^2}{\left[8 \left[1 + \frac{M_1}{M_2} \right] \right]^{0.5}}$$

$$\phi_{21} = \phi_{12} \cdot \frac{\mu_2}{\mu_1} \frac{M_1}{M_2}$$

χ_M = composition (mole fraction of R152a)
 μ_1, μ_2 = absolute viscosity of the pure components, R13B1 and R152a,
 respectively.

$$\mu_1 = 0.67329 * 10^{-3} + 7.60593 * 10^{-6} * TK - 2.81108 * 10^{-8} TK^2 + \\ 3.47410 * 10^{-11} TK^3 \quad (N \cdot s/m^2) [9]$$

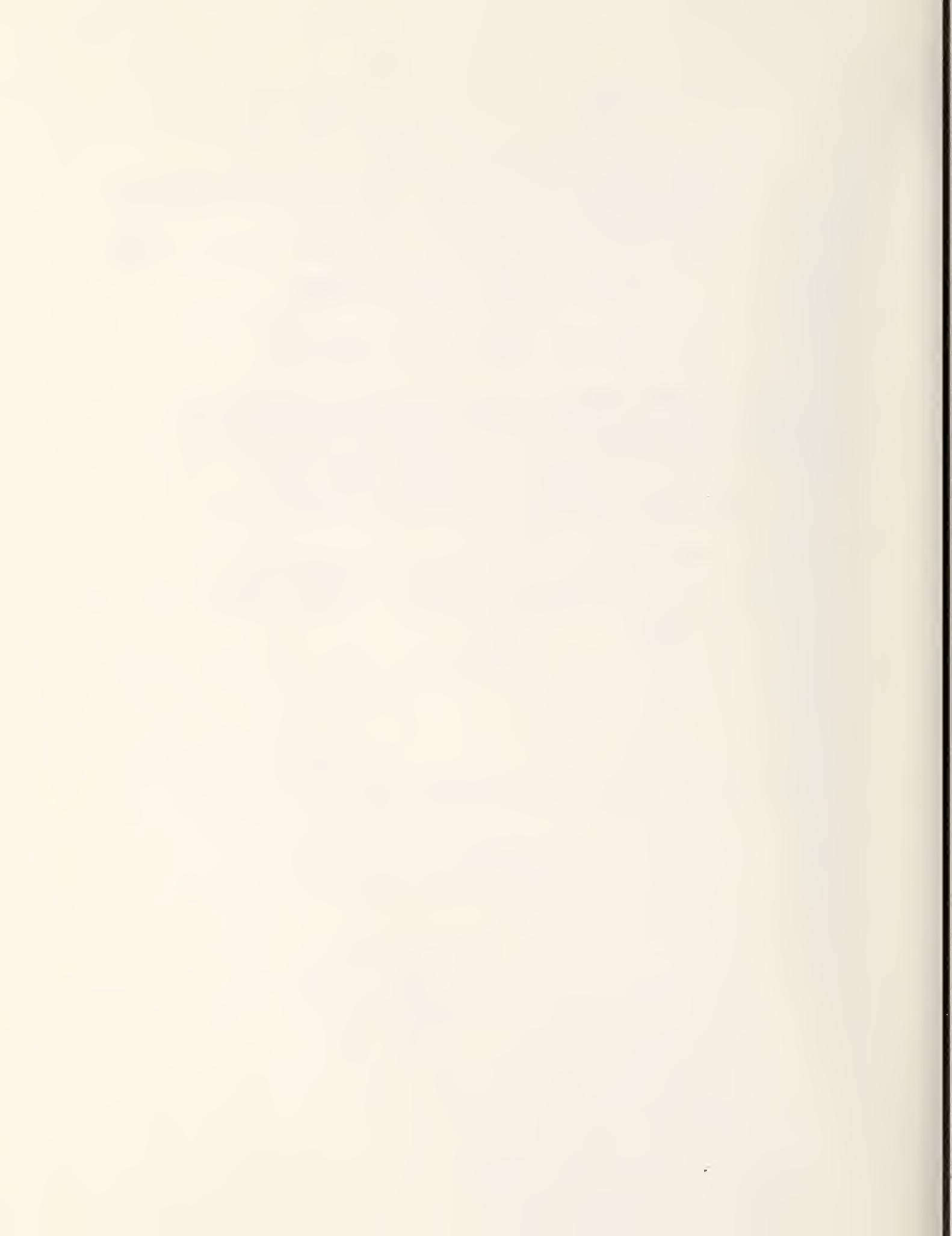
$$\mu_2 = 3.205 * 10^{-5} * \frac{k_2 M_2}{FE} \quad (N \cdot s/m^2) [11]$$

k_2 = thermal conductivity of pure R152a vapor ($W/m \cdot K$)
 M_1, M_2 = molecular weight of the pure components, R13B1 and R152a,
 respectively.

$$FE = 0.115 + 0.354 \frac{Cp_{II}}{R}$$

Cp_{II} = specific heat at constant pressure of R152a vapor.

$$Cp_{II} = -7.33704 + 0.093438 TK - 3.61094 * 10^{-4} TK^2 + 4.80449 * 10^{-7} * TK^3 \\ (\frac{kJ}{kg \cdot K})$$



4. OPERATION OF A HEAT PUMP WITH A CONSTANT FLOW AREA EXPANSION DEVICE

In a heat pump with a capillary tube, vapor superheat at the compressor inlet will vary with changing operating conditions. As a matter of fact, no single refrigerant parameter stays constant when indoor or outdoor air conditions are altered and the system seeks equilibrium under new conditions. To understand the phenomena that cause refrigerant state changes, consider a heat pump working in the cooling mode at constant indoor air conditions subjected to a step increase of the outdoor temperature. For the purpose of the analysis, it is assumed that the overall heat transfer coefficient for both heat exchangers does not vary. It is also assumed, as a first approximation, that the latent heat of evaporation, i_{fg} , is constant under the conditions discussed.

A step increase in the outdoor air temperature first affects the performance of the condenser. Since the condenser environmental temperature increases, the mean temperature difference between the air and the refrigerant decreases. Less heat is rejected by the refrigerant to the air and a smaller enthalpy change is realized in the coil. Consecutively, higher enthalpy, less sub-cooled liquid refrigerant enters the capillary tube. The capillary tube is sensitive to the amount of subcooling and with less subcooling the mass flow rate through the capillary tube decreases. Since the compressor capacity stays unchanged, pressure builds up in the condenser. Thus point 11 on the p - h diagram (figure 3) moves in the direction of higher enthalpy and higher pressure.

The environment of the evaporator was not altered. However, refrigerant parameters in the evaporator change in response to the change of refrigerant state at location 11 as well as to the change in refrigerant mass flow rate. For pressure drop considerations, as a first approximation, the liquid line, the capillary tube, and the evaporator are viewed as one tube, in which a given flow experiences a certain pressure drop. As pressure of the refrigerant at location 11 increases, it pulls up the refrigerant pressure in the evaporator. Conflicting phenomena affect the change of refrigerant enthalpy at point 1. Increased enthalpy at point 11 and reduced refrigerant mass flow rate work against the impact of the smaller temperature difference between the air and the refrigerant causing refrigerant enthalpy to slightly decrease. The significance of the change of the refrigerant state at location 1 is a move towards smaller vapor specific volume. Since the compressor, as a first approximation, is a constant intake volume pump, increase in gas density results in a higher mass flow rate.

The indicated phenomena will balance themselves further until the refrigerant in the key locations of the system acquires the thermodynamic states that satisfy simultaneously the equilibrium of all the heat pump components. Since under steady-state operation, the refrigerant mass flow rate through the compressor and the capillary tube have to match, the pressure in the condenser will rise to an appropriate level. Again, higher pressure in the condenser implies some increase of pressure (and saturation temperature) in the evaporator. The smaller temperature difference between the indoor air and the refrigerant, and higher refrigerant mass flow rate result in a smaller refrigerant enthalpy increase in the evaporator. The refrigerant state at point 1 with respect to point 11 is determined by this enthalpy change and the appropriate pressure drop. Finally, when steady-state conditions are reached the following changes in refrigerant thermodynamic states can be noted:

higher refrigerant pressure in the condenser, higher refrigerant pressure in the evaporator, less superheat at the evaporator exit, and less refrigerant liquid subcooling at the condenser exit. The change of saturation temperature in the condenser corresponds approximately to the change in the outdoor air temperature. The change of pressure in the evaporator is a fraction (approximately 15 percent) of the pressure change in the condenser. Though the refrigerant is circulated in the system at a higher mass flow rate, the capacity of the heat pump is decreased due to the smaller refrigerant enthalpy change in the evaporator. The efficiency also drops since, in addition to a smaller cooling effect, the energy input to the compression process increases due to the higher refrigerant mass flow rate and the higher compression rate. A decrease of the outdoor air temperature would result in the opposite trends.

The change of refrigerant parameters is illustrated in figure 7, where results of three tests of a heat pump charged with refrigerant 22 are plotted on the pressure-enthalpy diagram (the plot is based on measured condenser and evaporator pressures and temperatures only). In these tests, the indoor air conditions were held constant while the outdoor air dry bulb temperature was changed producing modifications of the thermodynamic cycle.

For the heating mode operation, refrigerant flow is reversed by the action of the four-way valve. The flow direction of the refrigerant in the system is the opposite to that in the cooling mode, with the exception of the compressor. The indoor coil becomes the condenser while the outdoor coil serves as the evaporator. It is worthwhile to note the effect this change has on the system. Since pressures in heat pump heat exchangers are functions of environment temperatures, the pressure in the evaporator is now much lower than during cooling operation. Consequently, the density of the refrigerant at the evaporator exit is smaller and less refrigerant is being pumped by the compressor. Also note that an indoor coil is usually much smaller than an outdoor coil. The need for dehumidification is the primary reason. The indoor coil working as a condenser cannot condense and hold as much refrigerant as the outdoor coil during cooling operation. In heat pumps equipped with a capillary tube the excess of liquid refrigerant is stored in an accumulator.

A schematic of an accumulator is given in figure 8. The accumulator is a closed container with two tubes. The longer bent tube has a small diameter hole on the bottom side, and is connected to the compressor. The other connects the tank with the evaporator exit.

If superheated vapor leaves the evaporator, only vapor is contained in the accumulator and no special function is fulfilled by the accumulator. If wet vapor enters the accumulator, liquid droplets accumulate on the bottom of the tank, while saturated vapor enters the tube leading towards the compressor. Some liquid refrigerant enters the vapor stream through the hole in the tube, driven by the static pressure difference in the liquid-vapor stream interface. It should be noted that during steady-state operation with liquid in the accumulator, qualities of the vapor entering and leaving the accumulator must be equal.

In a heat pump charged with a non-azeotropic mixture, incomplete evaporation in the evaporator and collection of liquid refrigerant in the accumulator affect the actual mixture circulating composition. As shown on the temperature-composition diagram (figure 6) the liquid and vapor phases in

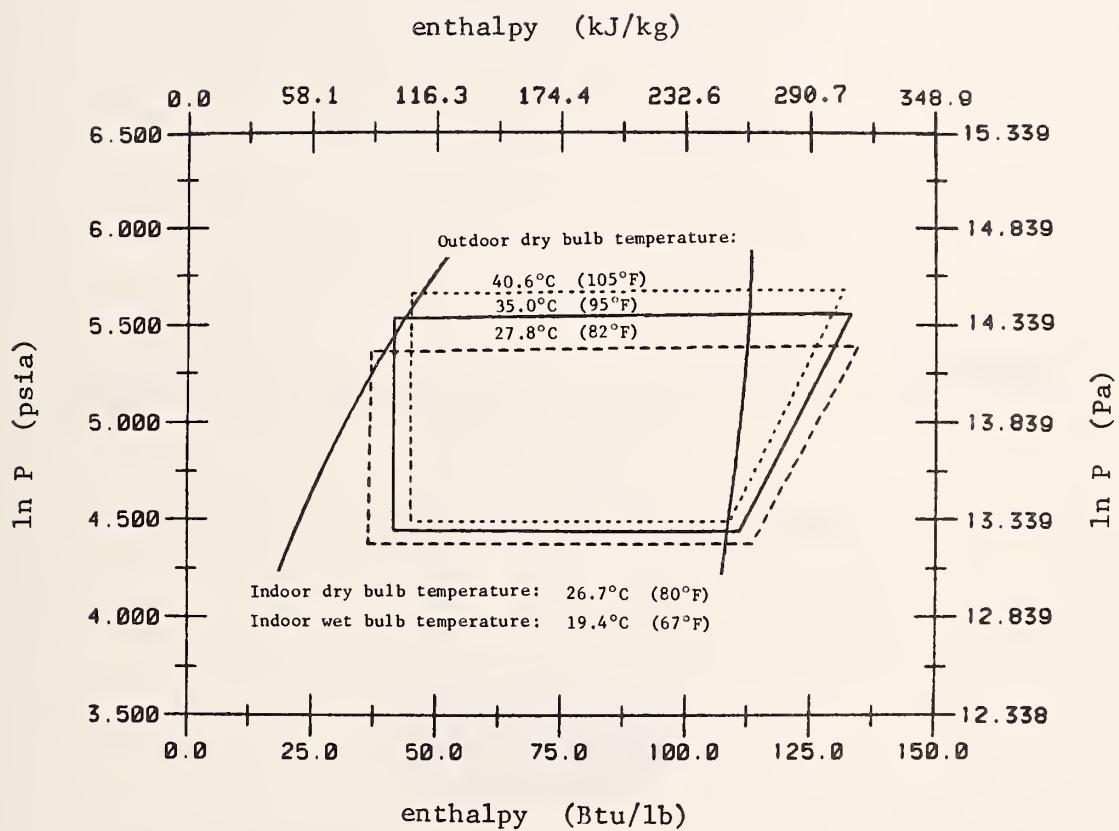


Figure 7. Simplified thermodynamic cycles realized by a heat pump charged with refrigerant 22 in the cooling mode at different outdoor temperatures.

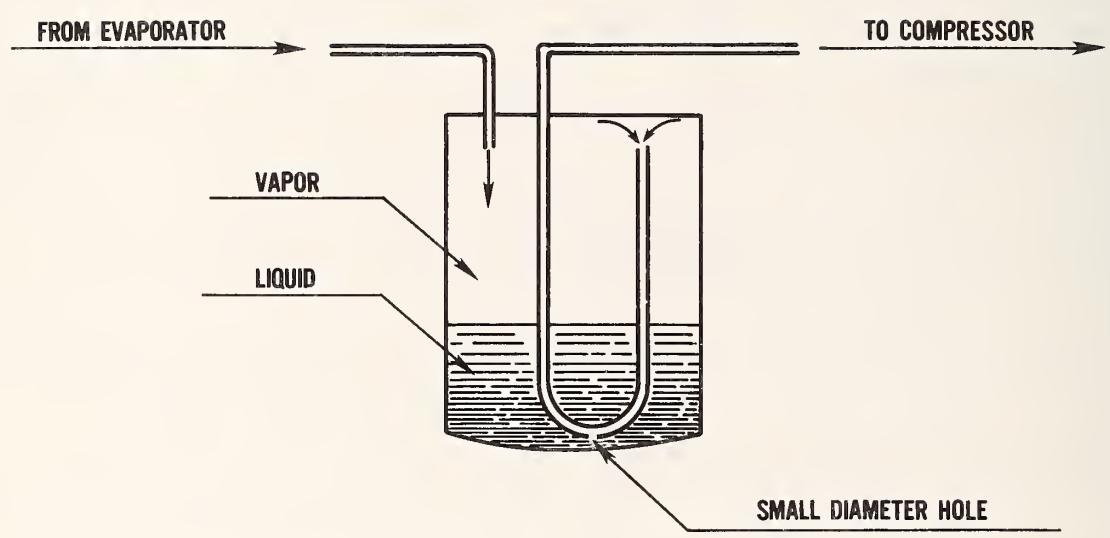


Figure 8. Schematic of an accumulator.

equilibrium at a given temperature and pressure have different compositions, the liquid being richer in less volatile component. Consequently, with the first liquid drop stored in the accumulator, circulating mixture composition becomes richer in the lower boiling point refrigerant. This composition shift increases with the increase of accumulated liquid.



5. MODELING OF A HEAT PUMP

5.1. The Logic of a Model of a Heat Pump Charged with a Non-Azeotropic Refrigerant Mixture

During heat pump operation, refrigerant parameters at any location are established at a level which satisfies the respective components of the system. There is a one-to-one relationship between working medium parameters and the operating conditions, i.e., for given outdoor and indoor air conditions, there is just one set of refrigerant parameters at any location within the system which satisfy steady state operation. This unique set of refrigerant parameters has to be determined by the heat pump simulation program in an iterative process.

In order to set up a heat pump iteration process (Fig. 9), balances taking place during steady state operation have to be recognized. From the fact that a thermodynamic cycle is a closed loop, an analysis of a heat pump cycle on a pressure-enthalpy diagram allows the statement of two balances:

- **Enthalpy Balance**

The net refrigerant enthalpy change in all components of the system has to equal zero.

- **Pressure Balance**

This balance implies that the increase of refrigerant pressure during the compression process has to be equal to the total pressure drop during the other processes forming the cycle. As pressure drop and mass flow rate are strictly related, this balance may be restated that pressure drop through each component has to be such that the mass flow rate in each component is the same.

The enthalpy balance and pressure balance can be supplemented by two additional balances resulting from the law of mass conservation, as expressed by the following equations:

$$\frac{D}{Dt} \int_V \rho_m dV = 0 \quad (24)$$

$$\frac{D}{Dt} \int_V \rho_i dV = 0 \quad (25)$$

where ρ_m = mean density of the mixture
 ρ_i = mean density of 'i' compone
 V = system internal volume

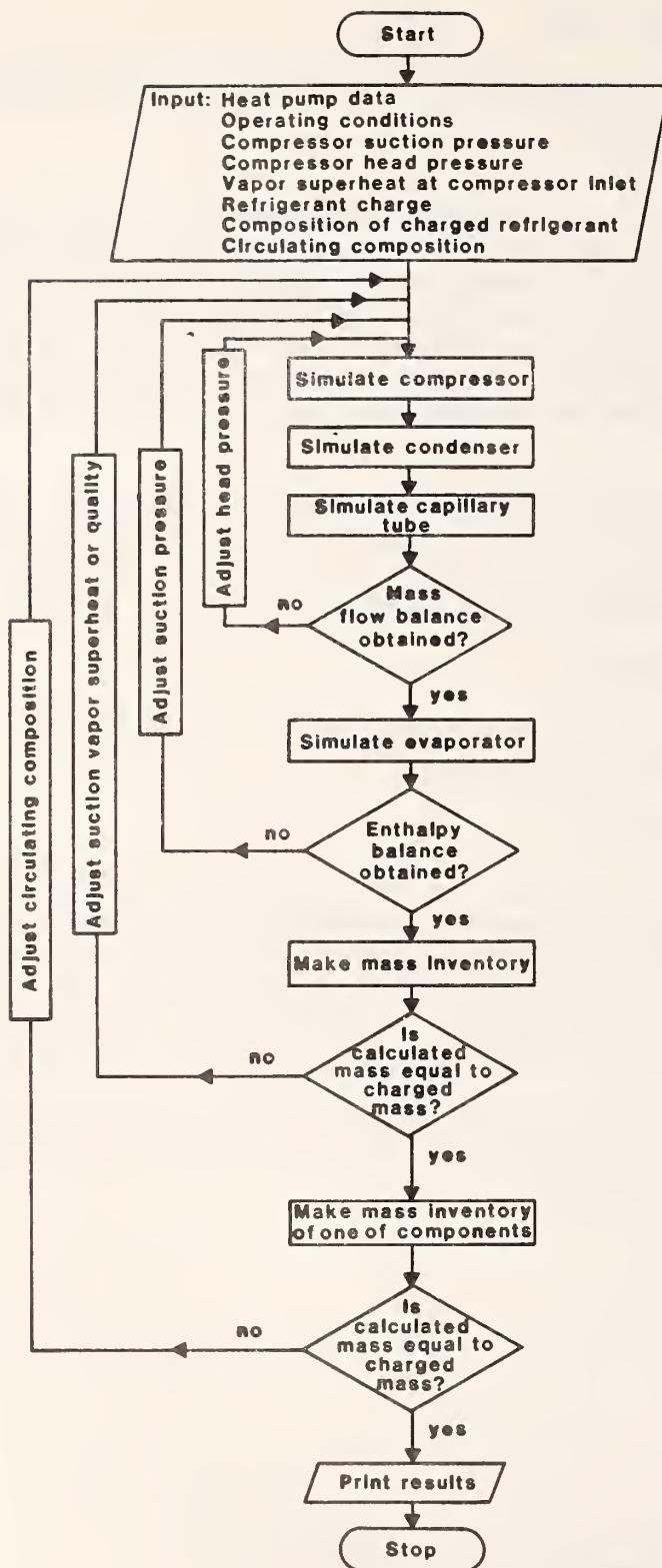


Figure 9. Overall logic of a program simulating performance of a heat pump employing a constant flow area expansion device and charged with a non-azeotropic binary refrigerant mixture.

Equation (24) implies, that the amount of working medium in the system is the same at all times, for any operating conditions. Equation (25) states the same conservation principle for each of the mixture components. Though for a binary mixture the last equation provides us with two balances, we can actually use only one of them with conjunction with equation (24).

It should be noted that the first three balances are sufficient to set up the logic of a simulation program of a heat pump charged with a single component refrigerant. These three balances were utilized in [3] allowing for iteration of the refrigerant thermodynamic states at key system locations without imposed restrictions on the refrigerant state anywhere in the system. In a heat pump charged with a non-azeotropic binary mixture, the circulating composition may change if some liquid refrigerant is collected in the accumulator. The actual composition of the circulating mixture has to be evaluated during simulation. Since this change of composition represents an additional degree of freedom, an additional equation (equation (25)) is used in the solution logic.

The logic of the program is based on these four balances. It provides means for calculation of vapor superheat (quality) at the compressor can inlet and allows for heat pump simulation at the imposed operating conditions. Explanation of the logic, for sake of clarity, is done considering only four main components of a heat pump, i.e., a compressor, a condenser, a capillary tube, and an evaporator.

The required input consists of outdoor and indoor conditions, heat pump data and composition of the charged and circulating mixture. The simulation process begins with estimated refrigerant pressure and vapor superheat at the compressor inlet, and the compressor discharge pressure. Using these data, the compressor performance is simulated yielding the refrigerant mass flow rate. Next, the condenser and the capillary tube are simulated and a mass flow balance is sought by comparing the refrigerant mass flow rates through the compressor and capillary tube. If the compared mass flows are not equal, simulation of the compressor, the condenser, and the capillary tube is redone with an unchanged refrigerant state at the compressor can inlet and a modified estimate of compressor discharge pressure. Increasing this pressure reduces refrigerant mass flow rate through the compressor. Then the condenser works with this smaller mass flow rate and at a higher saturation temperature. Consequently, refrigerant reaching the expansion device inlet is at a higher pressure and has more subcooling. Both factors promote greater mass flow rate through the capillary tube. Thus, increase in the discharge pressure has a clear and opposite impact on mass flow rates through the compressor and through the capillary tube and the appropriate discharge pressure can be found for which mass flow balance exists.

Once mass flow balance is reached, simulation of the evaporator is performed with the known refrigerant state at the evaporator exit and the refrigerant mass flow rate. Since the thermodynamic process in a capillary tube may be viewed as adiabatic, refrigerant enthalpy at the evaporator inlet should be equal to the enthalpy at the condenser outlet. If these enthalpies are not equal (energy balance is not reached), a new calculation starts from the beginning with a modified estimate of the refrigerant pressure at the compressor can inlet. From the condenser operation point of view, a change in compressor suction pressure induces a change in the refrigerant mass flow rate

and a modification of the condenser saturation temperature resulting from the system flow balance search. These two changes have opposite effects on refrigerant enthalpy at the condenser exit, leaving it only slightly altered. On the other hand, the same change of compressor suction pressure has a strong effect on the refrigerant enthalpy at the evaporator inlet due to a change in the evaporator saturation temperature and refrigerant mass flow rate, both working to change the enthalpy in the same direction. Thus an appropriate suction pressure at the compressor inlet can always be found when an energy balance exists.

Once energy and pressure balances are established, two out of four refrigerant parameters estimated at the outset are determined. However, these two parameters, compressor suction and discharge pressures, were obtained for imposed refrigerant superheat (quality) at compressor can inlet and assumed circulating composition which still have to be verified. For refrigerant superheat (quality) verification, the refrigerant mass inventory is made. It is based on refrigerant states in the system which are found to satisfy energy and pressure balances with assumed vapor superheat at the compressor can inlet. The amount of refrigerant obtained from mass inventory calculations is compared to the actual refrigerant mass input (known design parameter). If the amount of refrigerant calculated is smaller than refrigerant input into the heat pump, the superheat (quality) estimate has to be decreased and all calculations have to be repeated from the outset.

Once, in addition to satisfied pressure and energy balances, the refrigerant superheat (quality) at the compressor can inlet is verified by means of mixture mass inventory, the ultimate verification of iterated refrigerant states has to be done by checking if the circulating mixture composition for which all results were obtained is in fact the actual circulation composition. This is done by performing a mass inventory of one of the mixture components. It should be mentioned that a composition shift of circulating mixture can occur only as a result of accumulation somewhere in the system of some of the mixture of composition different from the original, i.e., accumulation of liquid in the accumulator. If such accumulation does not take place (refrigerant entering the compressor is a superheated vapor) the circulation composition equals the original composition of the charged refrigerant. If refrigerant entering the compressor has quality less than 1, the program has to proceed with mass inventory for one mixture component. This mass inventory is based on refrigerant states in the system which are found to satisfy enthalpy and pressure balances, and for which the total mass of refrigerant in the system is conserved. If the amount of calculated mixture component is not equal to the original amount charged into the system, the estimate of composition of the circulating refrigerant has to be adjusted and all calculations have to be repeated from the outset. The solution logic described here is presented graphically in figure 9. The actual implementation of this logic in the main program of the model is presented in Appendix D.

5.2 Modeling of a Reciprocating, Hermetic Compressor

5.2.1 Compressor Operation

The compressor is mechanically the most complex component of a heat pump. A reciprocating, hermetic compressor is most commonly used in heat pump systems. A schematic of this type of compressor is shown in figure 10. The compressor consists of a shell containing an electric motor, a cylinder/piston assembly with valves and manifolds and tubes. The electric motor is coupled to the compressor eccentric. Lubricating oil is collected on the bottom of the can and is in free contact with the refrigerant.

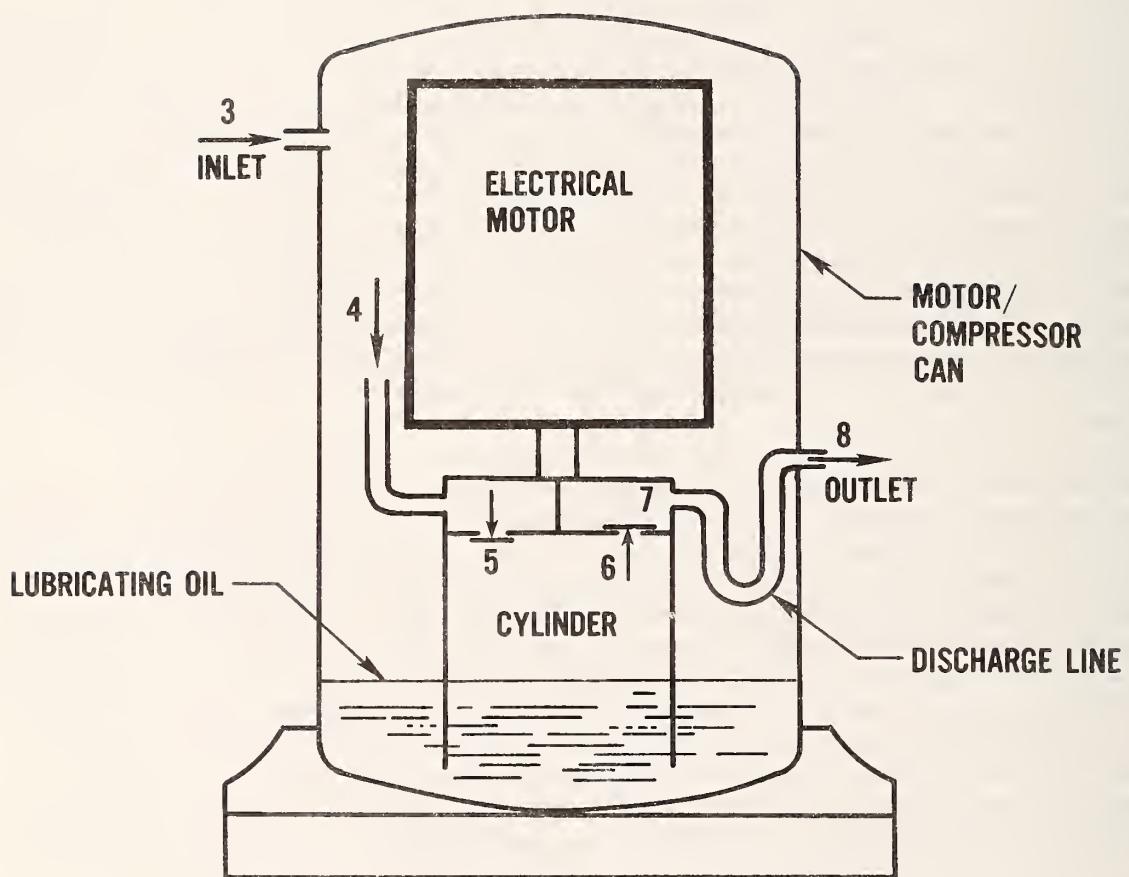
Flow of the refrigerant is from location 3 to location 8, as marked in figure 10. Low pressure refrigerant enters the compressor can and is directed towards the electric motor to cool motor windings. The enthalpy of the refrigerant changes due to this and other heat transfer with other surrounding surfaces, namely, the compressor can, manifolds, the discharge tube and the cylinder body. Then the refrigerant at state 4 undergoes the process in the cylinder, which in case of positive displacement compressors consists of: expansion through the suction valve and mixing the residual gas, compression, expansion through the discharge valve, and re-expansion of residual gas. The compressed, high temperature and high pressure refrigerant vapor leaves the compressor through the discharge manifold and discharge line after giving up some heat to the low pressure refrigerant at state 4.

The numbers marked in figure 10 identify key compressor locations and the corresponding refrigerant states. Even during steady state operation refrigerant parameters in the compressor can are not steady, since pressure changes in a series of rapid pulses. This pulsation is initiated by the periodic compression and suction processes and valve behavior. Because a certain pressure difference is needed for valve opening, the pressure in the cylinder at the end of compression is considerably above the discharge manifold pressure. Similarly, pressure during intake falls below suction manifold pressure. Particularly strong pressure peaks are observed in case of spring equipped valves. These pressure differences vary from compressor to compressor because of valve and manifold design, but also vary for the same compressor with compressor speed, compression pressure ratio, refrigerant, and mass flow rate.

Since processes taking place in a compressor are dynamic in nature, the most correct way of modeling a compressor would require dynamic simulation of valve motion, cylinder-manifold pressure interaction, and cylinder heat transfer. Such models exist and are described in [12], [13], and [14]. However, these models usually require some very detailed experimental data or design information, not necessarily readily available for the prospective user of a heat pump simulation program. That is why a relatively simpler approach to compressor modeling was taken in this study.

5.2.2 Theory and Governing Relations

Several assumptions are made for model formulation. The basic assumption is that the highly dynamic process in the compressor results in steady gas parameters throughout the can. The pressure and temperature in the cylinder and in suction and discharge manifolds are assumed to have constant values.



Note: Numbers 5 and 6 situated in the compressor correspond to the refrigerant state before and after the compression process.

Figure 10. Schematic of a hermetic compressor.

The refrigerant is considered to have uniform thermodynamic properties throughout the space assigned to the particular location. Refrigerant flow through the compressor is assumed to be one-dimensional, so one-dimensional steady flow equations can be used. Though the model does not simulate valve dynamic behavior, it allows for valve representation by a steady difference between manifold and cylinder pressures.

In order to derive equations governing compressor balances, the thermodynamic irreversibilities taking place in the hermetically sealed compressor have to be identified. These losses can be put into four categories:

1. Those associated with incomplete conversion of electric energy into a mechanical energy available for vapor compression.
2. Those associated with the non-isentropic conversion process inside the cylinder.
3. Those due to heat transfer at the different locations.
4. Those due to pressure drop at the different locations.

All of these losses contribute to the overall compressor efficiency and have to be considered in the modeling effort.

Conversion of Electrical to Mechanical Energy

Electric energy is supplied to an electric motor to be converted into mechanical energy. This conversion has losses due to windage, friction, winding resistance, and hysteresis, which are accounted for by a motor efficiency, η_e . By definition

$$\eta_e = \frac{W_e}{E} \quad (26)$$

where E = electric power input
 W_e = mechanical power output

Electric motor efficiency, η_e , depends on load and is customarily given as a function of the fraction of actual mechanical power output to the maximum power output. In heat pumps with power requirements below 5 hp, single phase electric motors are usually used. They are permanent split-capacitor or capacitor-start capacitor-run types. A typical efficiency versus load curve for a permanent split-capacitor 2 pole electric motor is shown in figure 11 [15].

The electric motor is coupled to the compressor eccentric. Moving compressor parts experience friction and a power loss accounted for by the compressor mechanical efficiency, η_m . By definition

$$\eta_m = \frac{W_c}{W_e} \quad (27)$$

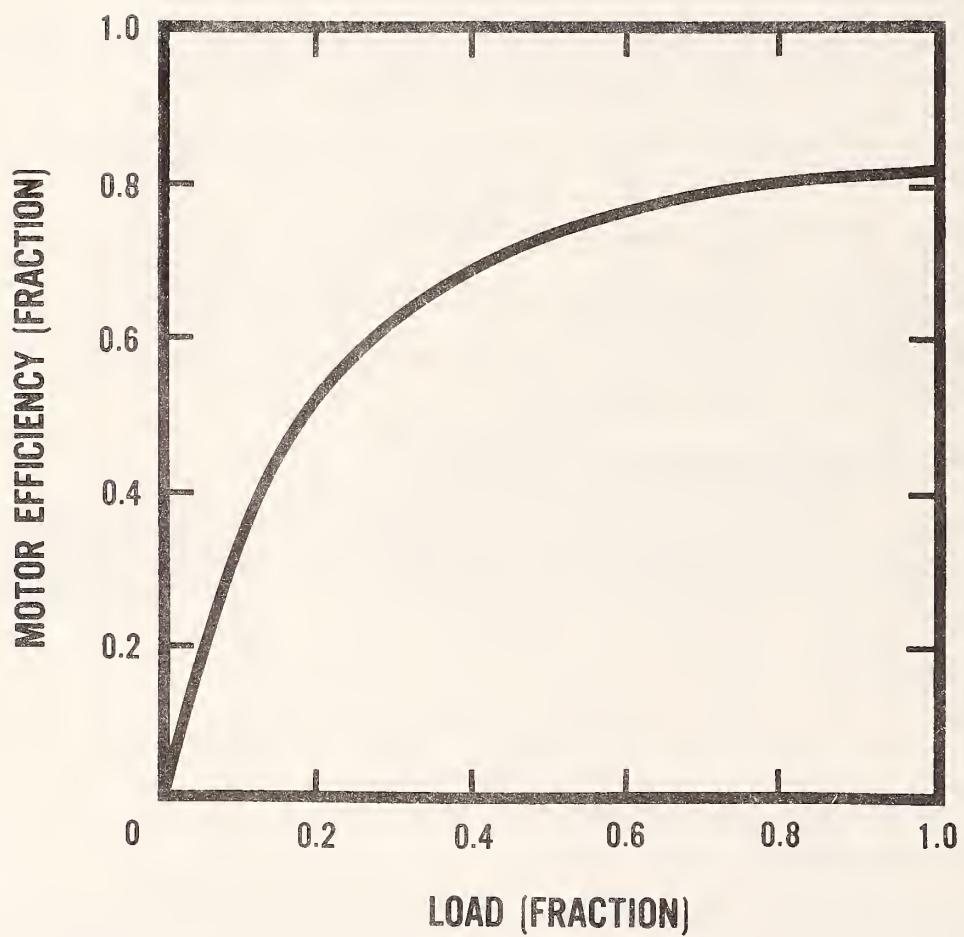


Figure 11. Typical speed (RPM) versus load curve for a permanent split-capacitor 2 pole electrical motor [15].

where W_c = mechanical power available for compression

A common value of compressor mechanical efficiency falls in range of 0.95 to 0.98.

Compression Process

A simplified indicator diagram is shown in figure 12. It shows idealized constant suction and discharge pressures in a cylinder. In modeling the cylinder process, both compression and re-expansion processes are assumed to be polytropic with the same polytropic index, n , following the equation [16]:

$$P \cdot v^n = \text{const} \quad (28)$$

where n = polytropic index

P = pressure

v = refrigerant vapor specific volume

Since constant pressure and temperature are assumed during the discharge process, this implies no change in specific volume between points C and D (figure 12); consequently, the compression and re-expansion polytropic curves will coincide. This further means, that the net work required for compression of the residual gas is zero.

The refrigerant enthalpy increase during polytropic compression, $i_6 - i_5$ (refer to figure 3), can be evaluated by the equation derived from the expressions for isentropic and polytropic work of compression at the same compression ratio. Equating these expressions results in the equation:

$$i_6 - i_5 = (i_{6s} - i_5) \frac{\frac{n}{n-1} \left(\frac{P_6}{P_5} \right)^{\frac{n}{n-1}} - 1}{\frac{\gamma}{\gamma-1} \left(\frac{P_6}{P_5} \right)^{\frac{\gamma}{\gamma-1}} - 1} \quad (29)$$

where i_5 = refrigerant enthalpy before compression

i_6 = refrigerant enthalpy after compression

i_{6s} = refrigerant enthalpy after isentropic compression, defined by pressure P_6 and entropy s_5

n = polytropic index

P_5 = suction pressure

P_6 = discharge pressure

γ = isentropic index

The isentropic index, γ , and the polytropic index, n , are related by the polytropic efficiency of the compressor:

$$\eta_p = \frac{\frac{\gamma-1}{\gamma}}{\frac{n-1}{n}} \quad (30)$$

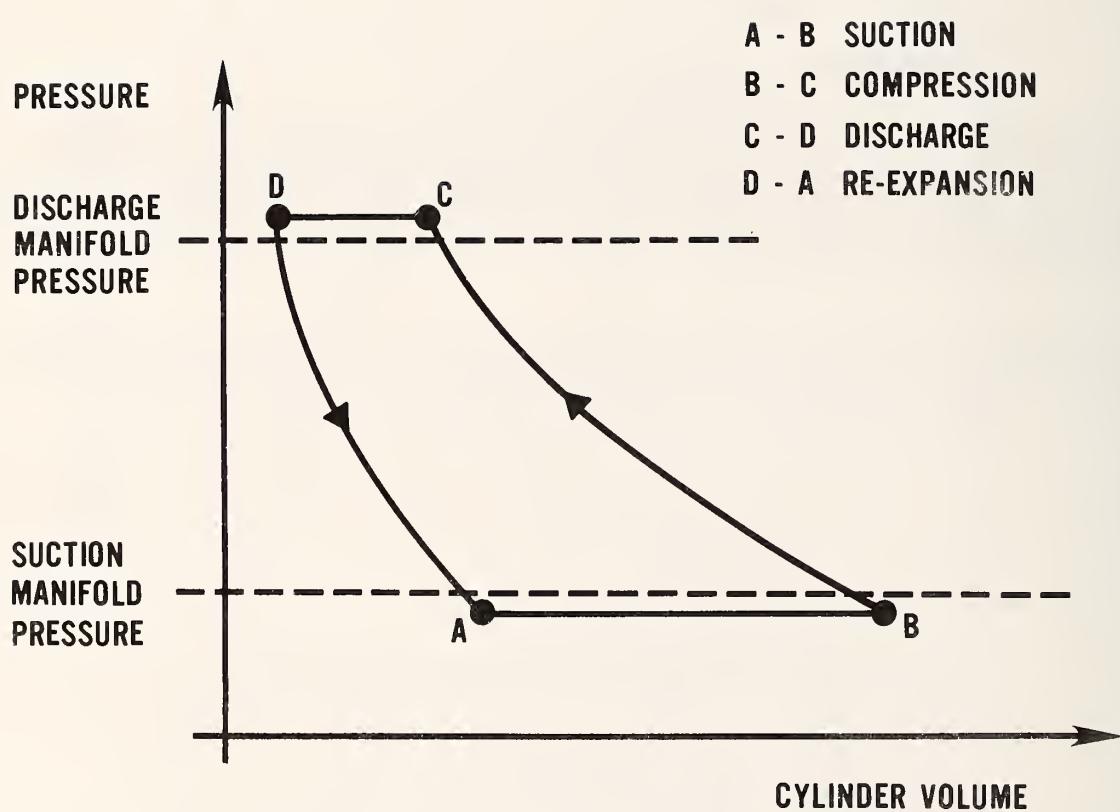


Figure 12. Simplified indicator diagram for a reciprocating compressor.

The isentropic index, γ , equals the ratio of specific heats, as in the following formula:

$$\gamma = \frac{C_p}{C_v} \quad (31)$$

where C_p = specific heat at constant pressure
 C_v = specific heat at constant volume

The specific heats of ideal gases are constant, thus the isentropic index of an ideal gas is also constant. For real gases such as refrigerant vapors, specific heats vary along the compression path. To accommodate this fact, the isentropic index can be evaluated by taking the average of the respective specific heat ratios at points 5 and 6s.

The refrigerant enthalpy increase during polytropic compression could also be calculated using the isentropic efficiency and enthalpy increase during isentropic compression at the same compression ratio. However, isentropic efficiency is sensitive to the compression ratio while polytropic efficiency is more consistent from one application to another and provides a more consistent representation of average compressor performance [17]. The imperfection of using isentropic efficiency may be traced to the general thermodynamic relation:

$$\left(\frac{\partial i}{\partial s}\right)_P = T \quad (32)$$

where i = enthalpy
 P = pressure
 s = entropy
 T = temperature

which requires pressure lines to diverge on a Mollier chart.

The refrigerant mass flow rate pumped by a compressor can be calculated by the following formula:

$$m_r = \frac{60 \cdot RPM \cdot V_s}{V_5} \eta_v \quad (33)$$

where m_r = refrigerant mass flow rate
RPM = compressor speed (revolutions per minute)
 V_s = compressor displacement per revolution
 V_5 = refrigerant specific volume in the cylinder before compression
 η_v = volumetric efficiency

The RPM of a compressor is equal to that of an electric motor and is a function of load on the motor. A typical speed (RPM) versus load curve for a permanent split-capacitor 2-pole electric motor is shown in figure 13.

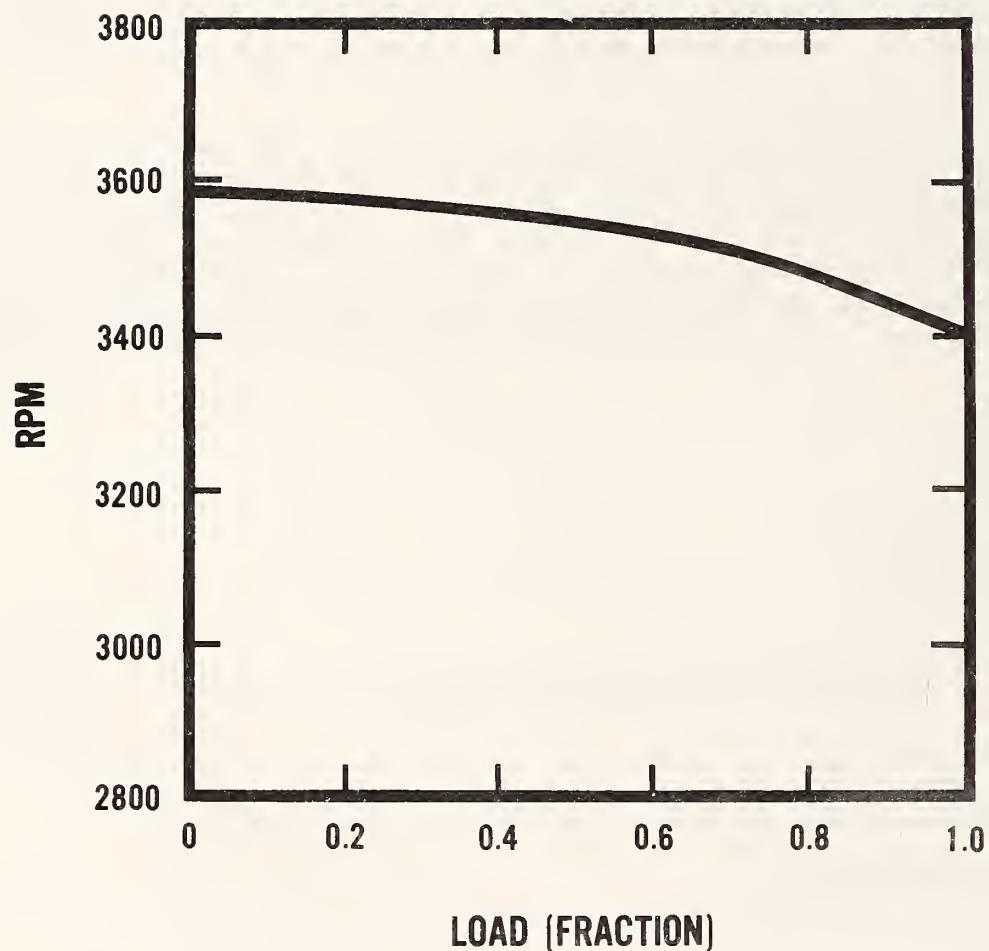


Figure 13. Typical efficiency versus load curve for a permanent split-capacitor 2 pole electric motor [15].

With assumptions stated so far for the compression and re-expansion processes, the following formula for volumetric efficiency of a compressor can be derived [16]:

$$\eta_v = C_c \left[1 - C_e \left[\left(\frac{P_6}{P_5} \right)^{\frac{1}{n}} - 1 \right] \right] \quad (34)$$

where C_c = correction factor for leakage from the piston, valves and for the throttling effect, assumed to be 0.96, [18]
 C_e = clearance volume, fraction of displacement

Heat Transfer Relations

Electrical energy supplied to an electric motor is in part transferred to the refrigerant and in part is dissipated to the compressor environment. This compressor heat balance can be expressed by the following equation:

$$E + m_r (i_3 - i_8) - Q_{C,A} = 0 \quad (35)$$

where E = electric energy input
 i_3, i_8 = refrigerant enthalpy at respective locations (refer to figure 10)
 m_r = refrigerant mass flow rate
 $Q_{C,A}$ = rate of heat rejected to ambient air

Reference is made to figure 10, where key locations of refrigerant in the hermetic compressor are marked. In order to solve the compressor heat balance represented by equation (35), the following heat transfer losses are considered in the compressor model:

1. Heat transfer between the compressor can and ambient air, $Q_{C,A}$
2. Heat transfer between the refrigerant in the compressor can and the compressor can, $Q_{4,C}$
3. Heat transfer between the inlet refrigerant and the suction manifold and valve, $Q_{4,5}$
4. Heat transfer between the discharge refrigerant and the discharge valve and manifold, $Q_{6,7}$
5. Heat transfer between the refrigerant in the compressor can and the refrigerant in the discharge line, $Q_{7,8}$

The heat transfer between the compressor can and ambient air (item 1) is governed by free convection and radiation. Respective heat transfer coefficients, h_c and h_r , are calculated by the following equations [19]:

$$h_c = 0.18(T_c - T_a)^{0.33} \quad (\text{Btu}/(\text{h} \cdot \text{ft}^2 \cdot \text{F})) \quad (36)$$

$$h_r = \sigma \cdot \varepsilon \cdot \frac{(T_c + 459.67)^4 - (T_a + 459.67)^4}{T_c - T_a} \quad (\text{Btu}/(\text{h} \cdot \text{ft}^2 \cdot \text{F})) \quad (37)$$

where T_a = ambient air temperature (F)
 T_c = compressor shell temperature (F)
 $\sigma = 0.1714 \times 10^{-4} \frac{\text{Btu}}{\text{h} \cdot \text{ft} \cdot \text{R}^4}$ = Stefan-Boltzman constant
 ε = surface emissivity ($\varepsilon = 0.9$ is used)

The heat transfer rate between the compressor shell and the ambient air, $Q_{C,A}$ can be calculated by the equation:

$$Q_{C,A} = CQ_{C,A} \cdot (h_c + h_r) \cdot (T_c - T_a) \quad (38)$$

where $CQ_{C,A}$ = heat transfer parameter

The heat transfer inside the compressor shell between the shell and refrigerant vapor (item 2) is governed by forced convection, for which the non-dimensional heat transfer parametric expression in terms of Nusselt, Reynolds, and Prandtl numbers is in the form [20]:

$$Nu \propto Re^{0.8} \cdot Pr^{0.333} \quad (39)$$

where $Nu = \frac{h \cdot L}{k}$ = Nusselt Number

$$Pr = \frac{\mu \cdot Cp}{k} = \text{Prandtl Number}$$

$$Re = \frac{G \cdot L}{\mu} = \text{Reynolds Number}$$

$$G = \frac{m_r}{A} = \text{refrigerant mass flux}$$

L = characteristic length
 k = refrigerant thermal conductivity
 μ = refrigerant dynamic viscosity

Using equation (39) the forced convection heat transfer coefficient, h , can be expressed as:

$$h = C \cdot m_r^{0.8} \cdot k^{0.666} \cdot Cp^{0.333} \cdot \mu^{-0.467} \quad (40)$$

where C = constant of proportionality, a function of wetted surface geometry

Combining equations (36) and (40) yields the following expression for heat transfer rate between the compressor can and refrigerant:

$$Q_{4,C} = C \cdot A_h \cdot m_r^{0.8} \cdot k_4^{0.667} \cdot Cp_4^{0.333} \cdot \mu_4^{-0.467} (T_4 - T_c) \quad (41)$$

or

$$Q_{4,C} = CQ_{4,C} \cdot m_r^{0.8} \cdot k_4^{0.667} \cdot Cp_4^{0.333} \cdot \mu_4^{-0.467} (T_4 - T_c) \quad (42)$$

where $CQ_{4,C}$ = heat transfer parameter

Obviously, heat transfer rates $Q_{C,A}$ and $Q_{4,C}$ are equal. Derivations of equations for the heat transfer rates between the inlet refrigerant and the suction manifold and valve, $Q_{4,5}$, and between the discharge refrigerant manifold valve, $Q_{6,7}$, are similar to the derivation just performed for $Q_{4,C}$, since in these two cases heat transfer is also by forced convection. Resulting expressions for these heat transfer rates are:

$$Q_{4,5} = CQ_{4,5} \cdot m_r^{0.8} \cdot k_{4,5}^{0.666} \cdot Cp_{4,5}^{0.333} \cdot \mu_{4,5}^{-0.467} (T_6 - T_4) \quad (43)$$

$$Q_{6,7} = CQ_{6,7} \cdot m_r^{0.8} \cdot k_{6,7}^{0.667} \cdot Cp_{4,5}^{0.333} \cdot \mu_{6,7}^{-0.467} (T_7 - T_4) \quad (44)$$

The heat transfer between the refrigerant in the compressor can and the refrigerant in the discharge line (item 5) is modeled as forced convection heat transfer between the fluids separated by a barrier non-resistant to heat flow. Assuming that the temperature of refrigerant in the shell does not change (as a result of other heat transfers in the can and mixing) and applying the logarithmic mean temperature difference, the following expression for heat transfer rate $Q_{7,8}$ can be derived [2]:

$$Q_{7,8} = CQ_{7,8} \cdot m_r^{0.8} \frac{a_1}{a_2 + a_3} (T_7 - T_8) / \ln \frac{T_7 - T_4}{T_8 - T_4} \quad (45)$$

where $a_1 = (Cp_4 \cdot Cp_{7,8})^{0.333} (k_4 \cdot k_{7,8})^{0.667}$

$$a_2 = \mu_4^{0.467} \cdot Cp_{7,8}^{0.333} \cdot k_{7,8}^{0.667}$$

$$a_3 = \mu_{7,8}^{0.467} \cdot Cp_4^{0.333} \cdot k_4^{0.667}$$

Subscripts 3 through 8 refer to refrigerant key locations in the compressor in figure 10. If the subscripts are separated by a comma, the average value is implied.

The heat transfer to/from the flowing refrigerant changes the refrigerant enthalpy according to the equation:

$$Q = m_r \cdot \Delta i \quad (46)$$

where Δi = refrigerant enthalpy change

Combining equations (43), (44), (45), and (46) yields the following expressions for the refrigerant enthalpy change during flow between respective locations of the compressor:

$$i_5 - i_4 = CQ_{4,5} \cdot k_{4,5}^{0.667} \cdot Cp_{4,5}^{0.333} (T_6 - T_4) / (m_r^{0.2} \cdot \mu_{4,5}^{0.467}) \quad (47)$$

$$i_6 - i_7 = CQ_{6,7} \cdot k_{6,7}^{0.667} \cdot Cp_{6,7}^{0.333} (T_7 - T_4) / (m_r^{0.2} \cdot \mu_{6,7}^{0.466}) \quad (48)$$

$$i_7 - i_8 = CQ_{6,7} \frac{a_1}{a_2 + a_3} (T_7 - T_8) / (m_r^{0.2} \cdot \ln \frac{T_7 - T_4}{T_8 - T_4}) \quad (49)$$

where a_1, a_2, a_3 are as in equation (45)

The derived heat transfer relations contain heat transfer parameters $CQ_{C,A}$, $CQ_{4,5}$, $CQ_{6,7}$, and $CQ_{7,8}$. These parameters are primarily functions of heat transfer surface geometry and have to be found empirically. If required laboratory test data for a given compressor are not available, typical compressor test data can be used. A large number of experimental compressor measurements have been published. The summary of these data and a list of references can be found in [21].

Pressure Drop Relations

Total pressure drop ΔP_{tot} experienced by a flowing fluid results from pressure drops due to friction, momentum change, and gravity, i.e.,

$$\Delta P_{tot} = \Delta P_{friction} + \Delta P_{accel} + \Delta P_{gravity} \quad (50)$$

Pressure drop due to gravity in the hermetic compressor may be disregarded based on an order of magnitude analysis. On the same grounds, pressure drop of the flowing refrigerant between certain compressor locations may be attributed to either dynamic effect or viscous effect.

Pressure drop due to the dynamic effect, ΔP_{accel} , is proportional to velocity head, i.e.,

$$\Delta P_{accel} \propto \rho \cdot V^2 \quad (51)$$

which can be written, using the continuity equation:

$$\Delta P_{accel} = CP \cdot m_r^2 / \rho \quad (52)$$

where
 CP = pressure drop parameter
 m_r = refrigerant mass flow rate
 V = refrigerant velocity
 ρ = refrigerant density

The relation for the pressure drop due to the viscous effect, P_{friction} , can be derived from the classical Fanning equation for pressure drop in a tube:

$$\Delta P_{\text{friction}} = 2f \cdot \rho \cdot V^2 \cdot L/D \quad (53)$$

where f = friction factor
 D = tube diameter
 L = tube length

The friction factor, f , in the equation above is approximately proportional to the Reynolds number to the -0.2 power for the Reynolds number greater than 2000 [22]. Considering this and applying the equation of continuity, equation (53) becomes:

$$\Delta P_{\text{friction}} = CP \cdot \mu^{0.2} \cdot m_r^{0.8}/\rho \quad (54)$$

The pressure drop of the refrigerant in the compressor can is modeled by evaluating individual pressure drops between refrigerant key locations indicated in figure 10. Based on equations (52) and (54), and attributing pressure drop between particular compressor locations either to the viscous or friction effect, the following pressure drop relations are proposed:

$$P_3 - P_4 = CP_{3,4} \cdot m_r^2/\rho_{3,4} \quad \text{for the compressor can inlet} \quad (55)$$

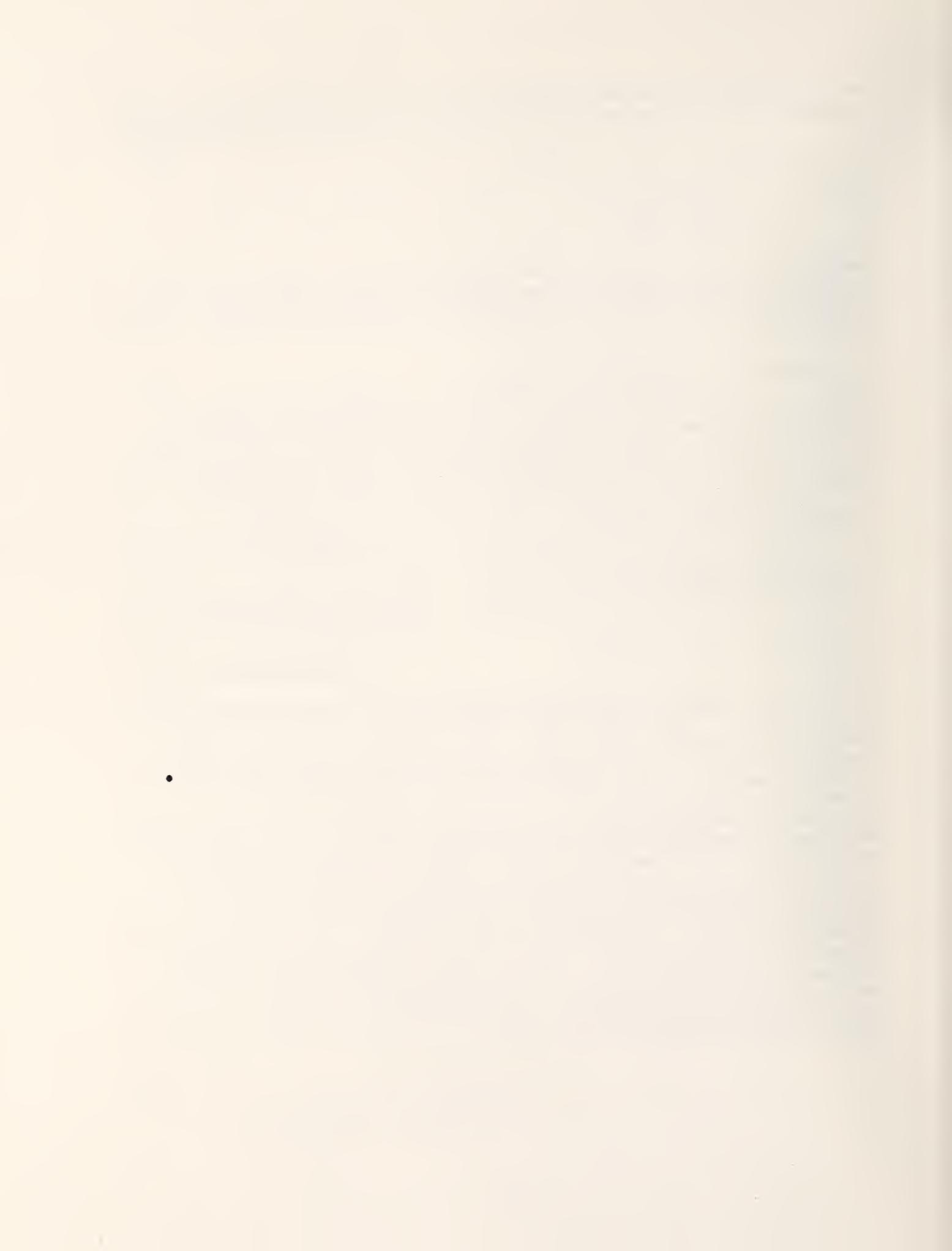
$$P_4 - P_5 = CP_{4,5} \cdot m_r^2/\rho_{4,5} \quad \text{for the suction manifold and valve} \quad (56)$$

$$P_6 - P_7 = CP_{6,7} \cdot m_r^2/\rho_{6,7} \quad \text{for the discharge valve and manifold} \quad (57)$$

$$P_7 - P_8 = CP_{7,8} \cdot m_r^{1.8} \cdot \mu_{7,8}^{0.2}/\rho_{7,8} \quad \text{for the discharge line} \quad (58)$$

Pressure drop parameters $CP_{3,4}$, $CP_{4,5}$, $CP_{6,7}$, and $CP_{7,8}$ have to be found experimentally for a given compressor or can be calculated using test data for a similar compressor. For sources of such data, refer to [21].

Equations derived in this section are used in a compressor subroutine, COMPRE, described in Appendix E. These equations make it possible to carry out an energy balance of a hermetic compressor using an iterative process for electrical energy input, for heat lost to the ambient air, and for refrigerant parameters in compressor key locations. The variety of designs of refrigerant flow passages in the compressor caused the modeling of pressure drop and heat transfer to be done in an approximate manner in this general compressor model. In spite of several assumptions that were made to simplify the modeling process and reduce computing time, the model still retains sufficient details of the underlying physical principles to allow designers to determine which specific changes in the compressor design will lead to increased efficiency of the compressor and the heat pump system.



5.3 Modeling of a Constant Flow Area Expansion Device

A constant flow area expansion device, as used in heating/air conditioning systems, is commonly called a capillary tube or a refrigerant flow restrictor. Usually it is a small bore tube of length as short as one-half inch up to a few feet, connecting the outlet of the condenser (or a liquid line) to the inlet of the evaporator. The main task of the constant flow area expansion device is to maintain the minimum pressure at the condenser at which all the flowing refrigerant can condense. Many researchers have investigated flow of a single component refrigerant through a capillary tube and a bibliography on the subject can be found in [15].

There is no experimental data known to the authors which would refer to the flow of a non-azeotropic mixture through a capillary tube or orifice. Because of lack of data, single component refrigerant flow experience has been extrapolated to the non-azeotropic binary situation and the model developed accordingly.

5.3.1 Available Capillary Tube Performance Data

The capillary tube is a traditionally accepted name for a constant flow area expansion device used in heat pump systems. This name is inadequate and misleading since for tube diameters in the neighborhood of 1/16 of an inch, capillary forces are negligible. The pressure drop consists primarily of:

- the loss due to sudden contraction at the entrance
- the loss due to flow in the tube
- the loss due to sudden enlargement at the exit to the evaporator

The flow of refrigerant through a constant bore tube is more complex than the geometric simplicity of the device would first indicate. The pressure and temperature distribution along a typical capillary tube is shown in figure 14. Bolstad and Jordan's description of the flow is as follows:

At the entrance to the tube, section 0-1, there is a slight pressure drop which was usually unreadable on the gages. From point 1 to point 2 the pressure drop is linear. In the portion of the tube 0-1-2 the refrigerant is entirely in the liquid state and at point 2 the first bubble of vapor forms. From point 2 to the end of the tube the pressure drop is not linear, the pressure drop per unit length increasing as the end of the tube is approached. For this portion of the tube, both the saturated liquid and saturated vapor phases are present, the percent and volume of vapor increasing in the direction of flow . . .

With a saturation temperature scale corresponding to the pressure scale superimposed along the vertical axis, it is possible to plot the observed temperatures in a more meaningful way than if a uniform temperature scale were used. The temperature is constant for the first portion of the tube 0-1-2. At point 2, the pressure has dropped to the saturation pressure corresponding to this temperature. Further pressure drop beyond point 2 is accompanied by a corresponding drop in temperature, the

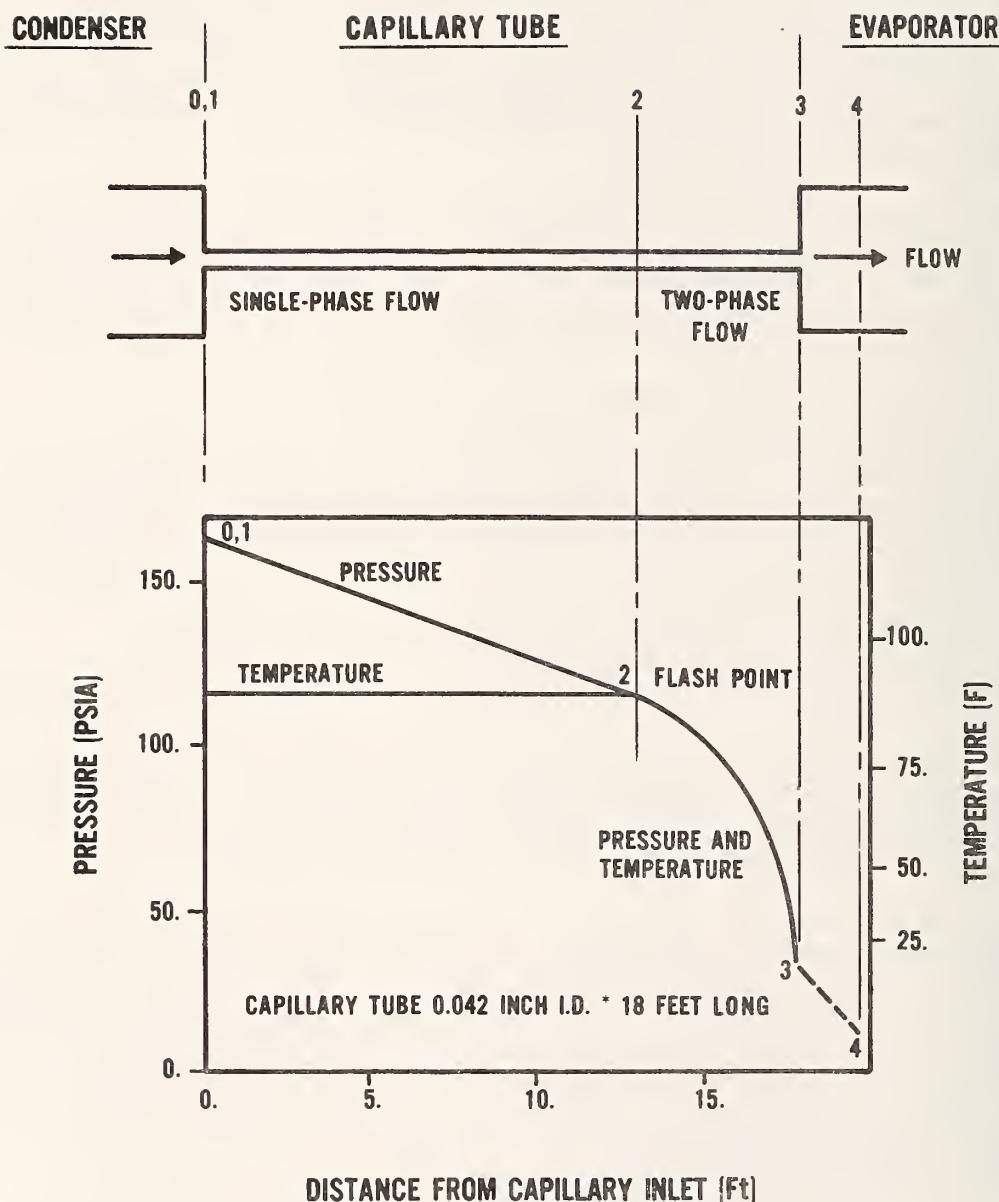


Figure 14. Pressure and temperature distribution along typical capillary tube [23].

temperature being saturation temperature corresponding to the pressure. As a consequence, the pressure and temperature lines coincide from point 2 to the end of the tube [23].

The point of the tube where the first bubble forms is called a bubble point or a flash point. The pressure at the point is called the flash pressure. Bolstad also presented an analytical method of solution for adiabatic flow through the capillary based on the Fanno flow theory.

Mikol [24] performed a capillary tube investigation from which his conclusions can be summarized as follows:

- Fluid flow through small bore tubes conforms to continuous flow as established for large bore tubes and pipes.
- The friction factor correlation of Moody and any others consistent with Moody's correlation [25] is applicable to single-phase flow in small bore tubes.
- The phenomena of metastability, persistence of the liquid state at pressures less than the saturation pressure corresponding to its local temperature, has been found to occur.
- The phenomenon of choked flow in two-phase flow occurs in the same way and for the same reasons as in the case of gaseous flow. Sonic velocity occurs at the tube exit.

One of Mikol's findings, existence of superheated liquid in a small portion of a tube, was not observed by Bolstad and Jordan [23]. However, it was reported by Cooper et al. [26] and Rezk [27]. Investigators have found that delayed evaporation is affected by initial disturbances and flow agitation, but there is not enough data in the current literature to assess all the factors promoting or eliminating this phenomena and making it possible to consider metastability in a capillary tube model at this time.

The pressure and temperature distributions along a capillary tube as shown in figure 14 occur at design operating conditions of a long (a few feet) capillary. Part of the capillary is filled with flowing liquid, while two-phase flow exists in the other part. However, there are also other possible modes of operation, i.e., with only two-phase flow in the capillary (the case of incomplete condensation in the condenser) or with only liquid flow (the case of short restrictor). All these cases are observed in practice and have to be simulated by a general model of the constant flow area expansion device.

Based on the experimental evidence and the theory of large tube fluid mechanics, the following assumptions were used for model formulation:

1. The capillary tube is straight, horizontal, and has a constant inner diameter.
2. Flow in the capillary is one-dimensional and homogeneous.
3. Flow in the capillary is adiabatic.

4. Flow resistance in the capillary tube can be subdivided into
 - a. Resistance due to the entrance effect
 - b. resistance due to flow in a tube which consists, in the general case, of single-phase liquid flow resistance from the entrance to the flash point, and two-phase mixture flow resistance in the rest of the tube. The existence of the delayed evaporation phenomena is neglected. Resistance due to the exit effect is neglected as meaningless for a choked flow and insignificant for a non-choked flow [23].
5. Choked flow phenomenon for two-phase flow of a non-azeotropic mixture is governed by the same laws as for single-phase flow of a single component fluid and can be modeled accordingly.

5.3.2 Available Short Tube Restrictor Performance Data

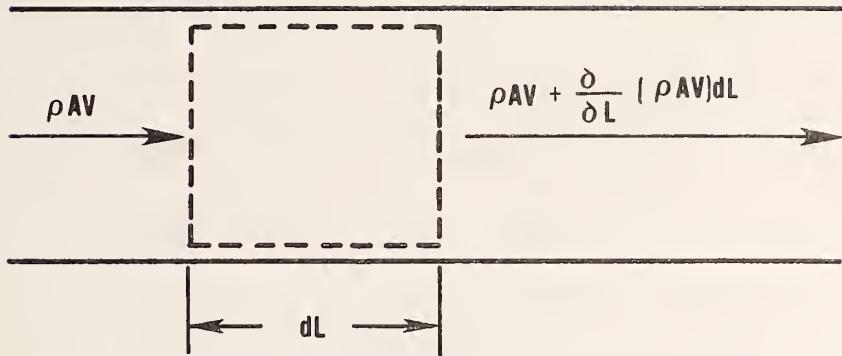
An experimental study on the flow of refrigerant 12 through short tubes was performed by Pasqua [28]. From his visual observations he found that the refrigerant flowed through the restrictor in the form of a metastable liquid core surrounded by a vapor annulus. Based on his experiment, Pasqua also determined flow characteristics of subcooled and saturated liquid through a short tube restrictor. A study of short tube restrictors applied to refrigerant 22 was performed by Mei [29]. He tested five restrictors of a length/diameter ratios from 7.5 to 11.9. He confirmed occurrence of first-stage choking but reported that second-stage choking did not take place at conditions obtainable in his test facility. Mei provided two correlations for evaluation of refrigerant mass flow rate which, however, are limited to the tested refrigerant 22.

As experimentally obtained information available in the literature is not sufficient for a development of a general simulation model of a short restrictor applicable to different refrigerants, such models have to be developed using fundamental equilibrium fluid mechanics. Using this approach, the analysis and basic assumptions made in the previous section regarding a capillary tube would apply to a short tube.

5.3.3 Critical Flow

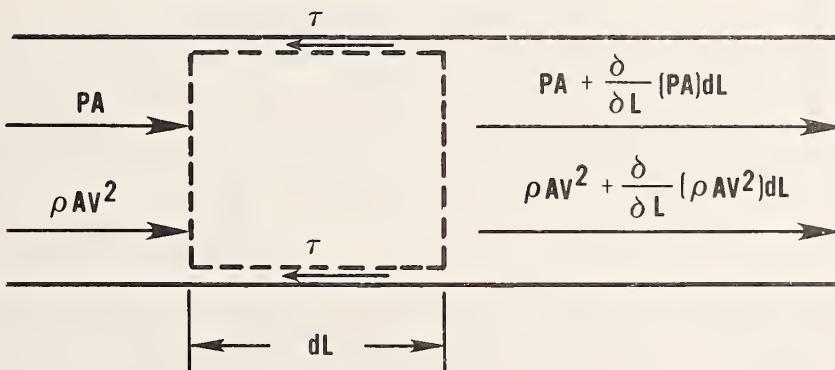
Refrigerant mass flow rate through a given flow restrictor will depend on the inlet refrigerant state and on the pressure that will be established at the tube outlet. This pressure may equal the evaporator pressure or may have a higher value if the flow is choked. Since pressure at the tube exit is one of the parameters affecting the flow, it has to be known for accurate refrigerant mass flow rate prediction.

The assumption that the flow in the flow restrictor is one-dimensional and homogeneous enables the two-phase flow in the tube to be treated as single-phase flow with uniform properties at any cross-section of the flow and allows use of the single-phase, one-dimensional form of the governing equations as presented in figure 15, 16 and 17.



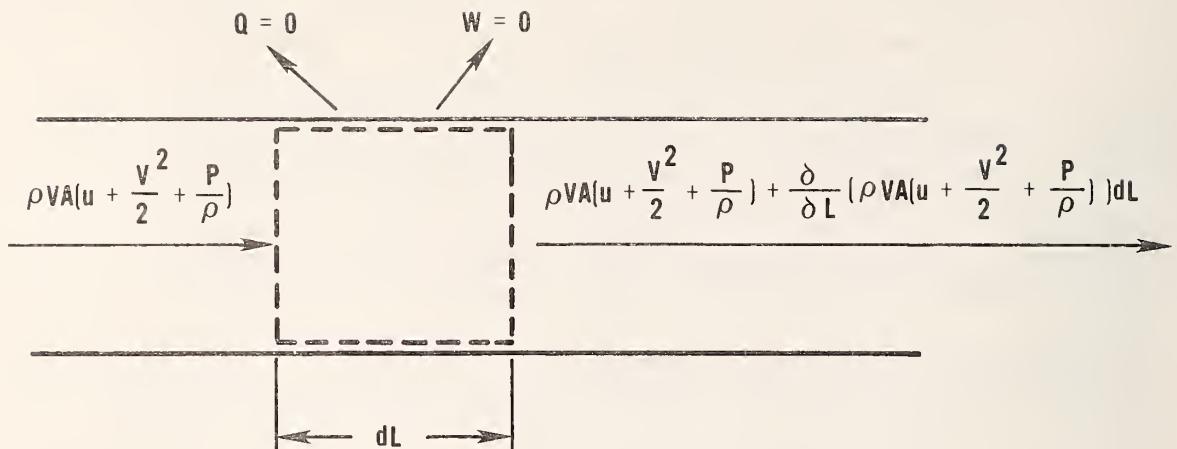
$$\text{CONTINUITY EQUATION: } d(\rho V) = 0$$

Figure 15. Mass balance for an element of fluid in one-dimensional steady flow in a constant area duct.



$$\text{MOMENTUM EQUATION: } AdP + \rho AVdV + \tau SdL = 0$$

Figure 16. Momentum balance for an element of fluid in one-dimensional steady flow in a horizontal, constant area duct.



$$\text{ENERGY EQUATION: } d(u + \frac{V^2}{2} + \frac{P}{\rho}) = d(i + \frac{V^2}{2}) = 0 \quad i + \frac{V^2}{2} = i_0$$

Figure 17. Energy balance for an element of fluid in one-dimensional adiabatic, steady flow in a horizontal, constant area duct.

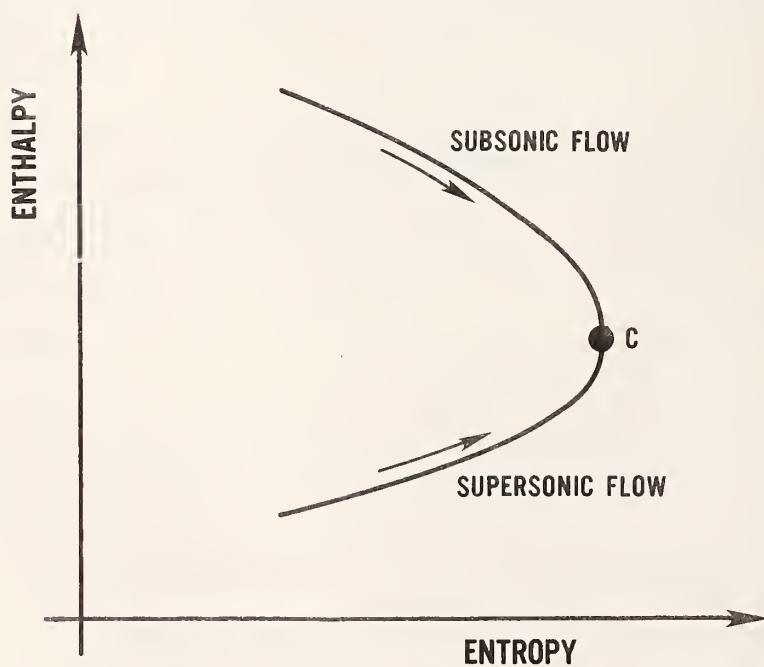


Figure 18. Fanno line.

Adiabatic flow through a capillary tube is a classical example of so called Fanno flow; adiabatic flow with friction in a constant area duct. The energy equation for such flow has the form:

$$di + V \cdot dV = 0 \quad \text{or} \quad i_0 = i + V^2/2 = \text{const} \quad (59)$$

which, when combined with the equation of continuity yields:

$$i_0 = i + \frac{m_r}{A}^2 \cdot v^2/2 = i + G^2 \cdot v^2/2 \quad (60)$$

where A = tube cross-sectional area

$$G = \frac{m_r}{A}, \text{ refrigerant mass flux}$$

$$\begin{aligned} i &= \text{refrigerant enthalpy} \\ i_0 &= \text{refrigerant stagnation enthalpy} \\ m_r &= \text{refrigerant mass flow rate} \\ \dot{V} &= \text{flow velocity} \\ v &= \text{refrigerant specific volume} \end{aligned}$$

Graphical representation of equation (60) on the enthalpy-entropy diagram, as shown in figure 18, is called a Fanno line. Fanno flow, as an irreversible adiabatic process, can sequentially exist only in the direction of increasing entropy. The upper branch of the Fanno line corresponds to subsonic, accelerating flow while the lower branch is the supersonic, decelerating flow. Both flows tend towards point C where the sonic velocity is reached.

The Fanno line implies that fluid cannot reach the velocity of sound inside a constant area duct, because, if this happened, further flow in the duct would have to be associated with a decrease of entropy (figure 18), and that would be in violation of the Second Law of Thermodynamics. Thus, the only location of a tube at which sonic velocity can be reached is the tube exit, and choking will never occur inside the capillary regardless of external outlet pressure.

5.3.4 Model Formulation

Refrigerant flow from the liquid line into the capillary tube experiences a pressure drop due to sudden contraction. This pressure drop consists of an acceleration loss and entrance friction loss and is usually expressed by a decrease in the Bernoulli head and a contraction coefficient referred to the kinetic energy of the flow in the section of smaller flow area:

$$\frac{P_0 - P_1}{\rho_{0,1}} + \frac{V_0^2 - V_1^2}{2} = K \frac{V_1^2}{2} \quad (61)$$

Subscripts in eq. (61) refer to sections shown in figure 14. Combining with the equation of continuity, the above can be rearranged to:

$$P_0 - P_1 = \Delta P = (1 + K) \rho_{0,1} \cdot \frac{V_1^2}{2} \quad (62)$$

The contraction coefficient, K , given in the literature is strictly empirical and is represented as a function of the contraction area ratio. Several sources are in disagreement about its value. The value of $K = 0.15$, used here is from a derivation based on Kays' general formula [30]. It was calculated for a normal range of contraction area ratios for capillary tubes with slightly beveled entrances.

The equation of motion for steady flow in a constant cross-section area pipe has the following form:

$$\rho \cdot A \cdot V \cdot dV + A \cdot dP + \tau \cdot S \cdot dL = 0 \quad (63)$$

The skin friction coefficient, τ , can be expressed in terms of the friction coefficient, f , and the velocity head:

$$\tau = \frac{1}{2} f \cdot \rho \cdot V^2 \quad (64)$$

The flow velocity term, V , can be eliminated by means of the equation of continuity:

$$d(V \cdot \rho) = 0 \quad (65)$$

Substituting and rearranging, the equation of motion assumes the following form:

$$\left(\frac{A}{m_r}\right)^2 \cdot \int_{P_i}^{P_{i+1}} \rho \cdot dP + \frac{2}{D} \int_{L_i}^{L_{i+1}} f \cdot dL + \ln \frac{\rho_i}{\rho_{i+1}} = 0 \quad (66)$$

As discussed before, flow in a capillary tube, in the general case, can be subdivided into two parts separated by a flash point: the liquid flow part and the two-phase mixture part. The same equation will be applicable for both flows though in the case of liquid flow, it can be simplified on grounds of incompressibility. In fact, it reduces to the Fanning pressure drop formula in the following form:

$$\Delta P = \frac{2f \cdot G^2 \cdot L}{\rho D} \quad (67)$$

where the friction factor, f , can be evaluated by the empirical formula:

$$f = 0.046 \cdot Re^{-0.2} \quad (68)$$

for the Reynolds number, Re , greater than 2000 [22].

For the two-phase mixture flow, equation (66) has to be solved in its full form. This was done by Whitesel [31,32] for refrigerants 12 and 22, but with significant oversimplified approximations for the refrigerant properties. In

solving equation (42), difficulty arises with evaluating the first term because it depends directly on the pressure-density relation along the path of flow. However, the relation can be obtained by considering the adiabatic flow case. The specific volume at a given pressure can be expressed in terms of the property values for saturated liquid and vapor and in terms of quality:

$$v = v_L + x(v_V - v_L) \quad (69)$$

where v = specific volume

x = quality

Subscripts L and V are for liquid and vapor, respectively

The quality of the flow in the Fanno path can be found as explained in Appendix C. Thus integration of refrigerant density over a given pressure interval can be done numerically. Still another problem is faced in evaluating the second term of equation (66), which includes a two-phase friction factor as a function of tube length. Erth [33] made an effort to correlate two-phase average friction factor in a capillary tube for refrigerant 12 and refrigerant 22. His regression analysis, based on four sets of data from four different experiments, yielded the following correlation for a two-phase flow mean friction factor, f_m , as a function of the inlet conditions only:

$$f_m = \frac{0.775}{Re^{0.5}} \exp [(1 - x_i^{0.25})/2.4] \quad (70)$$

where x_i = quality of refrigerant entering capillary tube

$$Re = \frac{G \cdot D}{\mu_L + x_i (\mu_V - \mu_L)} \quad (71)$$

Using this mean friction factor, f_m , equation (66) may be written for the two-phase portion of the flow in the following form:

$$m_r = A \left[\frac{\frac{P_2}{P_3} - \int_{P_3}^{P_2} \rho dP}{\frac{2}{D} f_m \cdot (L_3 - L_2) + \ln(\rho_2/\rho_3)} \right]^{0.5} \quad (72)$$

where the numbers used as subscripts denote location consistent with figure 14.

A subroutine, CAPIL, modeling a constant flow area expansion device is based on the equations presented above. These equations have to be solved in a highly iterative process since choking pressure, friction factor, fraction of capillary tube length with liquid and two-phase flow, and the velocity head used to correct enthalpy are functions of refrigerant mass flow rate which has to be determined. Additional information about the subroutine CAPIL is given in Appendix F.

5.4 Modeling of an Evaporator and a Condenser

5.4.1 Modeling Methodology

There are two heat exchangers in a heat pump: an indoor coil and an outdoor coil. Both coils are made in a similar way and both serve as an evaporator or condenser depending on the heat pump operation mode. A schematic of a typical heat pump heat exchanger is shown in figure 19. It consists of a set of finned tubes connected in a specifically designed circuit configuration. The refrigerant flows through the tubing while air flows over the outside of the coil. Various schemes of circuiting the tubes together can be used. An example of the coil circuitry is illustrated in figure 20.

The tube-by-tube modeling technique is applied here to model the coil. This technique depends on imaginary isolation of one tube with appropriate fin surfaces from the coil assembly and calculating the performance independently. The heat transfer to and from a tube is calculated with the aid of the heat exchanger cross-flow theory. Input for calculations consists of finned tube design data, refrigerant and air mass flow rates, and inlet refrigerant and air thermodynamics states. These are uniquely evaluated by the model for each particular tube. Performance calculations are conducted for each tube independently in proper sequence and their summation results in total coil capacity.

In order to perform heat transfer calculations, four surfaces associated with the tubes must be defined. Following Carrier and Anderson [34], it was assumed that the fin area served by each tube is equivalent in performance to a circular-plate fin of equal area. Thus a single tube is considered with a circular fin of diameter, D_t , as shown in figure 21.

5.4.2 Heat Transfer Rate for a Tube in a Cross-Flow Arrangement

Usually a heat pump coil employs some form of cross-flow arrangement. If a separate tube is considered, the problem is one of pure cross flow. Fortunately, this kind of arrangement has received much attention in theoretical investigations. According to the general heat transfer equation:

$$Q = U \cdot A_h \cdot \Delta T \quad (73)$$

where A_h = heat transfer surface area
 U = overall coefficient of heat transfer
 ΔT = temperature difference

In the case of a pure cross-flow arrangement with changing temperatures of both fluids during heat exchange, the following equation for mean temperature difference between fluids applies [16]:

$$\Delta T_m = \frac{\frac{t_2 - t_1}{T_1 - T_2}}{\ln \frac{\frac{t_2 - t_1}{T_1 - T_2} + \frac{1}{\ln \frac{T_2 - t_1}{T_1 - t_1}}}{\frac{T_1 - T_2}{t_2 - t_1} + \frac{1}{\ln \frac{T_2 - t_1}{T_1 - t_1}}}} \quad (74)$$

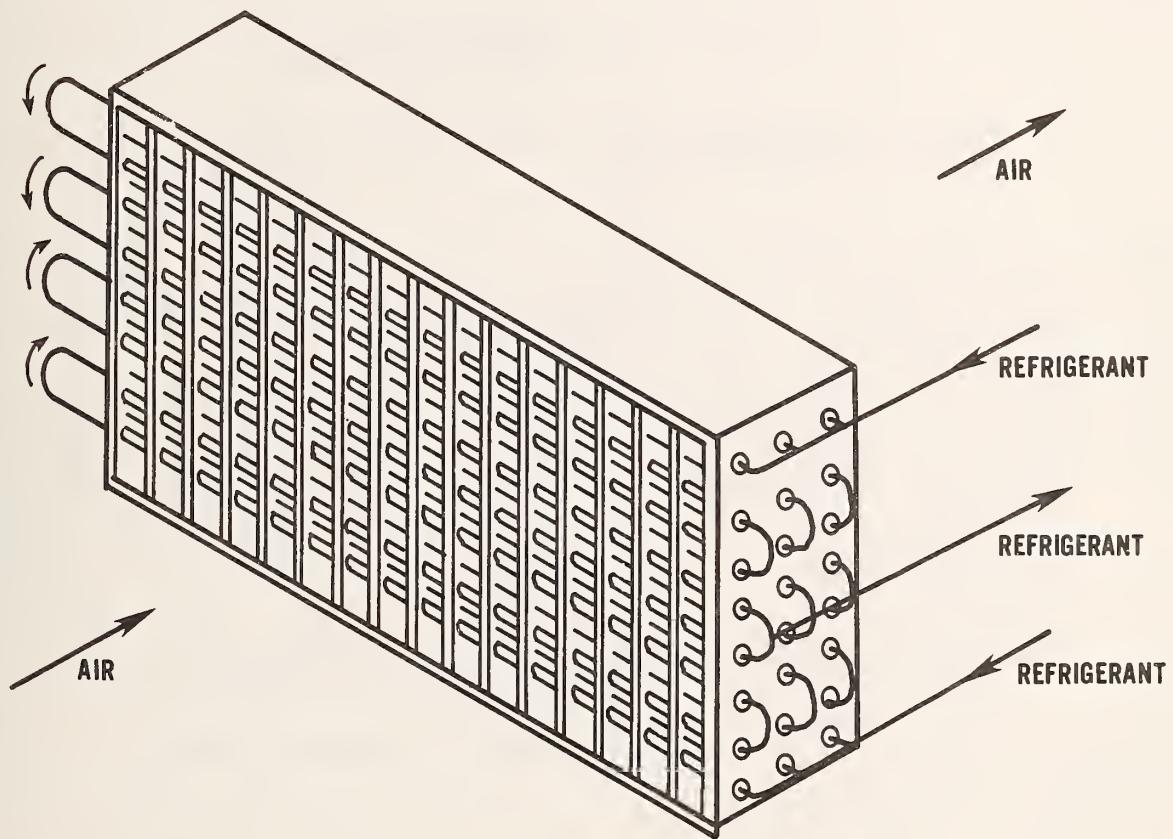
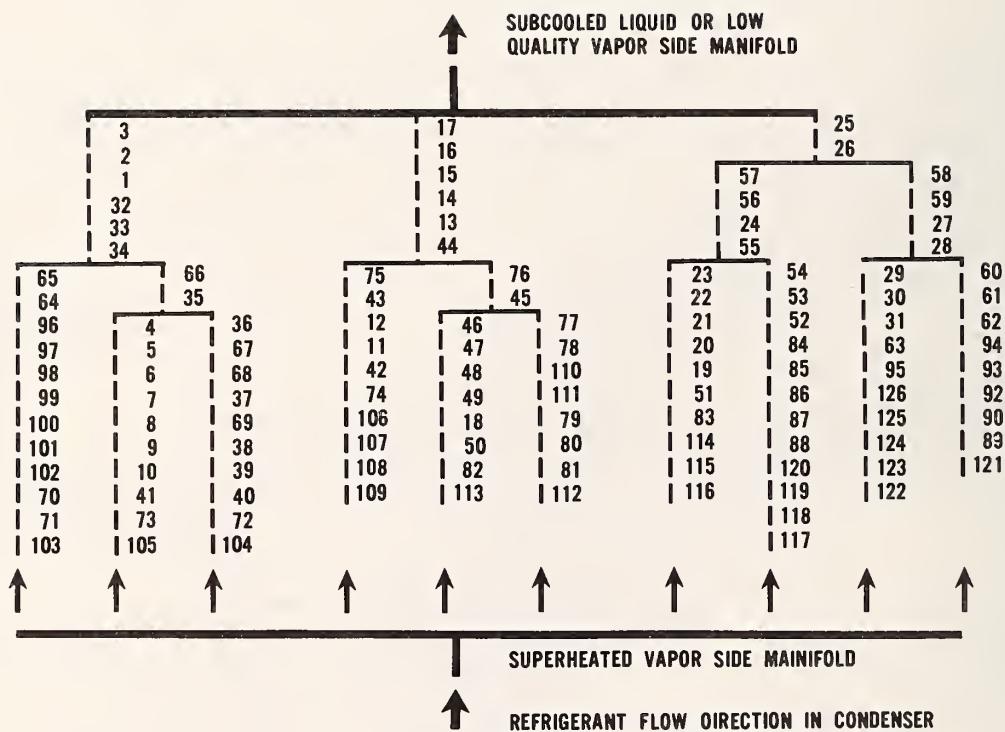


Figure 19. Schematic of a heat pump heat exchanger.



Numbers in the figure represent a location of the particular tube counting them left to right in each depth row starting with the row facing the incoming air.

Figure 20. Example of coil circuitry.

$$D_t = 2 \left(\frac{d_1 \cdot d_2}{\pi} \right)^{0.5}$$

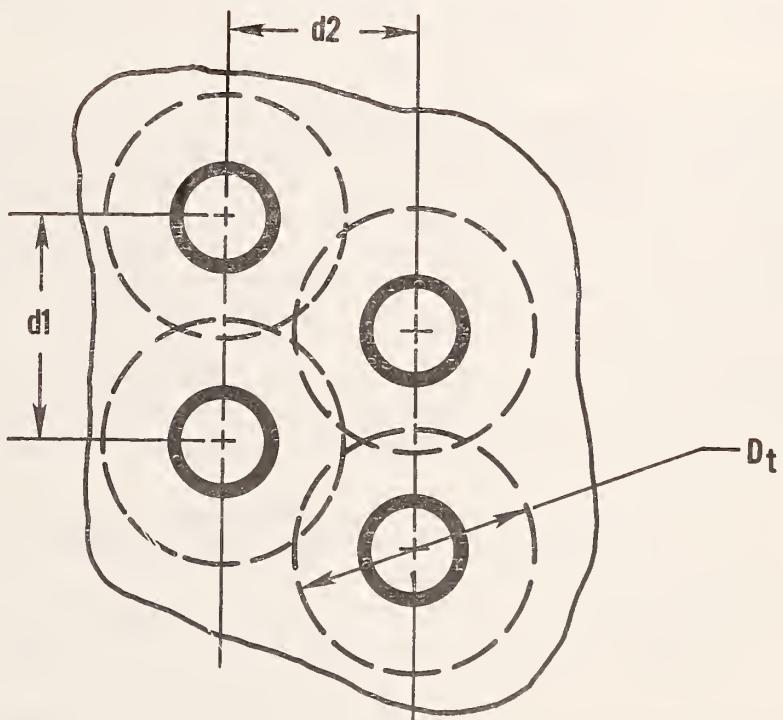


Figure 21. Approximation method for treating a rectangular-plate fin of uniform thickness in terms of a flat circular-plate fin of equal area.

where T = temperature of one fluid
 t = temperature of another fluid
 ΔT_m = mean temperature difference
 subscripts 1 and 2 refer to tube inlet (upstream) and outlet
 (downstream) conditions, respectively.

The heat exchanged with the fluid can be calculated by the equation:

$$Q = m \cdot (i_2 - i_1)$$

or

$$Q = m \cdot C_p \cdot (T_2 - T_1) \quad (75)$$

where C_p = average specific heat of fluid at constant pressure
 i = enthalpy
 m = mass flow rate

Looking at any vapor compression cycle P-h or T-s diagram, it can be realized that both single-phase and two-phase refrigerant flow usually exists in a given heat exchanger. Also, both flow patterns can actually exist in one tube. That means that the rate of change of temperature of refrigerant flowing in the tube will not be uniform over tube length. Not only the mean temperature between fluids is affected by the flow pattern inside the tube but also the refrigerant pressure drop.

Equations presented below, derived from equations (73), (74), and (75), allow for detailed consideration of these problems. The heat transfer rate for each mentioned flow condition can be calculated as follows:

- single-phase or two-phase flow only, refrigerant is superheated, subcooled or in two-phase at both inlet and outlet

$$Q = C_{pr} \cdot m_r (T_{r,i} - T_{a,i}) (1 - \exp(-\frac{C_{pa} \cdot m_a}{C_{pr} \cdot m_r} (1 - \exp(\frac{-U \cdot A_0}{C_{pa} \cdot m_a})))) \quad (76)$$

- superheated vapor at tube inlet, two-phase at the tube outlet

$$Q = m_r (i_{r,i} - i_{r,V}) + C_{pr} \cdot m_r \cdot (T_{r,V} - T_{a,i}) \\ (1 - \exp(\frac{C_{pa} \cdot m_a (1 - Z_V)}{C_{pr} \cdot m_r} (1 - \exp(-\frac{U \cdot A_0}{C_{pa} \cdot m_a})))) \quad (77)$$

where Z_V = fraction of the tube length in the superheated region which can be calculated by the equation:

$$Z_V = \frac{-Cp_r \cdot m_r \cdot \ln(1 - \frac{i_{r,i} - i_{r,V}}{Cp_r(T_{r,i} - T_{a,i})})}{Cp_a \cdot m_a(1 - \exp(-\frac{U \cdot A_o}{Cp_a \cdot m_a}))} \quad (78)$$

- two-phase at tube inlet, subcooled liquid at the tube outlet

$$Q = Cp_r \cdot m_r(T_{r,L} - T_{a,i})(1 - \exp(-\frac{Cp_a \cdot m_a(1 - Z_{tp})}{Cp_r \cdot m_r})) \\ (1 - \exp(-\frac{U \cdot A_o}{Cp_a \cdot m_a}))) + m_r(i_{r,i} - i_{r,L}) \quad (79)$$

where Z_{tp} = fraction of the tube length in the two-phase region which can be calculated by the equation:

$$Z_{tp} = \frac{-Cp_r \cdot m_r \cdot \ln(1 - \frac{i_{r,i} - i_{r,L}}{Cp_r(T_{r,i} - T_{a,i})})}{Cp_a \cdot m_a(1 - \exp(-\frac{U \cdot A_o}{Cp_a \cdot m_a}))}$$

In equations (76) through (79) the following nomenclature was used:

- A_o = total exterior surface area associated with the tube wetted by air
- Cp_a = air specific heat at constant pressure
- Cp_r = refrigerant specific heat at constant pressure (in the two-phase region the specific heat is assumed to be a ratio of enthalpy change to temperature change, i.e., $Cp_r = \Delta i_r / \Delta T_r$)
- $i_{r,i}$ = refrigerant enthalpy at the tube inlet
- $i_{r,L}$ = enthalpy of refrigerant saturated liquid
- $i_{r,V}$ = enthalpy of refrigerant saturated vapor
- m_a = air mass flow rate associated with the tube
- m_r = refrigerant mass flow rate in the tube
- $T_{a,i}$ = air temperature upstream of the tube
- $T_{r,i}$ = refrigerant temperature at tube inlet
- $T_{r,L}$ = refrigerant bubble-point temperature
- U = overall tube heat transfer coefficient

5.4.3 Refrigerant and Air Mass Flow Rates Associated with a Tube

Refrigerant Mass Flow Rate

During flow through a heat pump heat exchanger, the refrigerant undergoes a change of phase in the course of evaporation or condensation. The change of phase is associated with a dramatic change of density which affects the

velocity and pressure drop of the working fluid. In order to prevent a high pressure drop, tubes in some heat pump coils are connected to form branched circuits. An example of such coil circuitry is shown in figure 20.

Refrigerant flow direction marked in figure 20 is for the coil working as a condenser. Superheated vapor enters the vapor side manifold and is distributed into 10 tubes. On its flow path, refrigerant merges several times and finally merges in the liquid manifold to enter the liquid line. For the coil operating as an evaporator, the direction of flow is opposite to that marked in the figure. Low quality refrigerant enters the coil and the flow is subdivided into three circuits. On its way through the coil the refrigerant evaporates and splits several times on its way towards the exit where it is finally collected into one larger diameter vapor line. The mass flow rates through the particular circuits of the coil are self adjusting so the pressure at merging (splitting) tubes is the same.

To perform a simulation of a coil by the tube-by-tube method, refrigerant mass flow rate for each tube has to be known. Since total refrigerant mass flow rate supplied to the coil is known, the problem reduces to the determination of refrigerant distribution. This could be determined by the model itself, however, at expense of going through iterative calculations. Another approach was tried to determine refrigerant flow distribution. Since most of the coil total pressure drop may be expected to result from superheat vapor and two-phase flow, it was assumed that the refrigerant flow is uniformly distributed among tubes connected to the vapor side manifold and that mass flow rates in other tubes may be found by following the refrigerant path with direction of flow as marked in figure 20. The resulting distribution was checked by examining calculated refrigerant (R22) pressures at the ends of circuit branches. These pressures should be equal if the assumed distribution is correct. The maximum pressure discrepancy found was equal to 0.3 psi which represented less than a 0.2°F variation in the saturation temperature of refrigerant 22 between merging tubes. This was considered satisfactory and the method was adopted for determining refrigerant mass flow rate distribution in a coil.

Air Mass Flow Rate

Air mass flow rate was assumed to be distributed uniformly over the whole coil face regardless of the coil and fan respective locations, so each tube in particular depth row was associated with the same air mass flow.

The temperature of the inlet air for a given tube was assumed to be equal to the temperature of air exiting from the upstream tube and not to be affected by mixing with air leaving neighboring tubes.

5.4.4 Overall Heat Transfer Coefficient for a Dry Finned Tube

Dry finned tube analysis is applicable to a condenser and also to an evaporator if no dehumidification takes place. The overall heat transfer coefficient, U , for a dry finned tube can be derived by summing the individual resistances between the refrigerant and the air, [16]:

$$U = \left[\frac{A_o}{A_{p,i} h_i} + \frac{A_o x_p}{A_{p,m} k_p} + \frac{1}{h_{c,o} (1 - \frac{A_f}{A_o} (1 - \phi))} \right]^{-1} \quad (81)$$

where A_f = fin surface area
 A_o = total exterior surface area exposed to air
 $A_{p,i}$ = pipe inside surface area
 $A_{p,m}$ = pipe mean surface area
 $h_{c,o}$ = convection heat transfer coefficient at the exterior surface
 h_i = inside tube convection heat transfer coefficient
 k_p = thermal conductivity of pipe material
 x_p = thickness of pipe wall

$$\phi = \frac{T_{f,m} - T_a}{T_{f,b} - T_a}, \text{ fin efficiency}$$

T_a = air temperature
 $T_{f,b}$ = fin base temperature
 $T_{f,m}$ = mean fin temperature

The second term of equation (81) can be evaluated if the heat exchanger material and geometry are known. Terms 1 and 3, which refer to the inside and outside convection resistance respectively, required considerably more analysis to establish the proper algorithm for determining the heat transfer coefficient.

5.4.5 Forced Convection Heat Transfer Inside a Tube

Analyzing the problem for both an evaporator and a condenser, the following modes of forced convection are encountered:

- single-phase forced convection
- two-phase forced convection with condensation
- two-phase forced convection with evaporation

The physics of these phenomena are very much different and forced convection in each mode have to be considered separately.

Single-Phase Forced Convection

Single-phase forced convection takes place in a condenser, at the entrance section where the superheated vapor is being cooled, and at the exit section where a subcooled liquid is being cooled. It is also applicable in the evaporator, as the superheated vapor passes through the exit tubes. The non-dimensional heat transfer parameter describing this phenomena, Nusselt number, is related to the non-dimensional Reynolds and Prandtl numbers in the following form [19]:

$$Nu = 0.023 \cdot Re^{0.8} \cdot Pr^a \quad (82)$$

where $Nu = \frac{h \cdot D}{k}$ = Nusselt Number

$$Pr = \frac{\mu \cdot Cp}{k} = \text{Prandtl Number}$$

$$Re = \frac{G \cdot D}{\mu} = \text{Reynolds Number}$$

α = 0.3 for cooling; 0.4 for heating

Cp = specific heat at constant pressure

D = inside diameter of a tube

G = refrigerant mass flux

h = convection heat transfer coefficient

k = refrigerant thermal conductivity

μ = refrigerant absolute viscosity

Two-Phase Forced Convection with Condensation

The predominant flow pattern during condensation in a heat pump condenser is annular flow with liquid refrigerant flowing on the pipe wall and vapor refrigerant flowing in the core. To the author's knowledge there are no data or correlations available in the literature on the forced convection condensation heat transfer coefficient of non-azeotropic mixtures flowing inside a tube. The only option left here is to use one of the correlations developed for condensing heat transfer coefficient for single component refrigerant. The correlation proposed by Traviss, Baron and Rohsenow [35] was chosen as the most theoretically derived, thus having most chances to provide reasonable predictions for other than the tested refrigerants 12 and 22. The correlation proposed in [35] and adopted in this modeling effort without modification is expected to overpredict condensing heat transfer coefficient for binary mixtures.

The theoretical background for the Traviss et al. correlation is as follows: the von Karman universal velocity distribution in the condensate film was assumed (like on a flat plate), pressure was calculated using the Lockhart-Martinelli method [22], and the momentum and heat transfer analogy was applied. The proposed correlation has the following form:

$$Nu = \frac{Re_L^{0.9} \cdot Pr_L \cdot F1^\beta}{F2} \quad (83)$$

where $Nu = \frac{h \cdot D}{k_L}$

h = condensation heat transfer coefficient

D = tube inside diameter

k_L = thermal conductivity of liquid refrigerant

$$Re_L = \frac{G(1-x)D}{\mu_L}$$

G = refrigerant mass flux

x = quality

μ_L = liquid refrigerant absolute viscosity

$$Pr_L = \frac{\mu_L \cdot C_{pL}}{k_L}$$

$$\beta = 1 \text{ for } F1 \leq 1, \beta = 1.15 \text{ for } F1 > 1$$

$F1$ and $F2$ in equation (83) are dimensionless parameters expressed as follows:

$$F1 = 0.15 (X_{tt}^{-1} + 2.85 X_{tt}^{0.524})$$

$$F2 = 0.707 \cdot Pr_L \cdot Re_L^{0.5} \quad \text{for } Re_L < 50$$

$$F2 = 5 \cdot Pr_L + 5 \cdot \ln(1 + Pr_L(0.09636 \cdot Re_L^{0.585} - 1)) \quad \text{for } 50 < Re_L < 1125$$

$$F2 = 5 \cdot Pr_L + 5 \cdot \ln(1 + Pr_L) + 2.5 \cdot \ln(0.00313 \cdot Re_L^{0.812})$$

$$\text{for } Re_L < 1125$$

Parameter, X_{tt} , formulated by Lockhart-Martinelli [22] with the assumption of no radial pressure gradient and a smooth pipe, has the following form:

$$X_{tt} = \left(\frac{1-x}{x} \right)^{0.9} \left(\frac{v_L}{v_V} \right)^{0.5} \left(\frac{\mu_L}{\mu_V} \right)^{0.1} \quad (84)$$

Parameter X_{tt} is inversely proportional to flow quality and refers to turbulent vapor and turbulent liquid flow. Physically it is equal to the square root of the ratio of the frictional pressure drop of the liquid phase to the frictional pressure drop of the vapor phase if each of these phases was flowing alone in the tube, i.e.,:

$$X_{tt} = \left[\frac{\left(\frac{dp}{dl} \right)_L}{\left(\frac{dp}{dl} \right)_V} \right]^{0.5} \quad (85)$$

Equation (83) is applicable where conditions for annular condensation in a tube exists. Such conditions may be assumed to exist for flow qualities ranging from 0.1 to 0.9. At qualities larger than 0.9, the whole tube inner surface is not covered by a liquid film and part of the heat transfer is just that of single-phase convection. At qualities less than 0.1, flow was observed to be in the slug regime [35]. It is assumed, that in the quality range 0.0 to 0.1 and 0.9 to 1.0, the heat transfer coefficient changes linearly from a two-phase flow value to a single-phase flow value and is calculated using linear interpolation between values obtained from equations (82) and (83).

Two-Phase Forced Convection with Evaporation

Refrigerant enters an evaporator from an expansion device at a quality of about 20 percent and forms an annular flow instantly. The quality increases with the proceeding flow and the annular flow pattern is maintained until the quality reaches about 0.90, at which point refrigerant vapor has enough kinetic energy to gradually destroy the liquid layer and patches of dry wall appear.

Many experiments were performed and correlations published for calculating the forced convection evaporative heat transfer coefficient for R12 and R22, however, no data are available in the literature on non-azeotropic mixtures. Simultaneous to the development of this model, evaporative heat transfer coefficient measurements were performed at NBS on mixtures of R13B1/R152a at a variety of compositions. The results of preliminary tests with heat balances within 10% were correlated for use in this model in the following form:

$$h_{ev,m} = h * 3.22 X_{tt}^{-0.3} \quad (86)$$

where $h_{ev,m}$ = evaporative heat transfer coefficient of the refrigerant mixture

h = forced convection heat transfer coefficient of the liquid film calculated by equation (82) for liquid flow rate equal to two-phase refrigerant flow rate in the tube.

X_{tt} = Lockhart-Martinelli parameter, equation (84)

It is important to note that all liquid and vapor properties used in X_{tt} parameter have to be evaluated for liquid and vapor phases being in equilibrium based on mixture temperature, pressure and composition of mixture in the tube.

Predictions of the above correlation agree within accuracy of $\pm 10\%$ for 50 percent of experimental data, $\pm 20\%$ for 89% of data, and within $\pm 31\%$ for all data. This correlation is applicable for annual flow at qualities from 10% to 90%.

5.4.6 Forced Convection Heat Transfer at the Air-side of a Flat-Finned Tube

In order to evaluate the forced convection heat transfer outside a flat-finned tube (term 4 of equation (81)), the total exterior surface area, A_o , the fin area, A_f , the air-side heat transfer coefficient, $h_{c,o}$, and fin efficiency, ϵ , have to be known.

From the number of air-side heat transfer correlations available in the literature, the one proposed by Briggs and Young [36] is most applicable here. This correlation was developed after extensive tests on 18 tube banks of different fin geometry. A regression analysis of the test data for the air Reynolds number range from 1000 to 20000 yielded the following equation:

$$Nu = \frac{h_{c,o} \cdot D_o}{K_a} = 0.134 \cdot Re_a^{0.681} \cdot Pr_a^{0.333} \cdot \left(\frac{z}{y}\right)^{0.2} \cdot \left(\frac{z}{t}\right)^{0.1134} \quad (87)$$

where D_o = outside tube diameter

$h_{c,o}$ = air-side mean convective heat transfer coefficient for dry air

k_a = air thermal conductivity

$$Pr_a = \frac{\mu_a \cdot C_p a}{k_a}, \text{ Prandtl number}$$

$$Re_a = \frac{G_{max} \cdot D_o}{\mu_a}, \text{ Reynolds number}$$

G_{max} = air mass flux at minimum cross section

t = fin thickness

y = fin height

z = distance between adjacent fins

The geometric parameters affecting the heat transfer are illustrated in figure 22. The accuracy of equation (87) was further verified by Jones and Russell [37].

The addition of fins to the tubes greatly increases the outer heat transfer area but at the expense of decreasing the mean temperature difference between the surface and the air stream. The parameter, fin efficiency, ϕ , is used to rate the thermal effectiveness of a fin. As mentioned in Section 5.4.1, it is assumed in this study for heat transfer analysis, that each tube is served by a circular-plate fin of equivalent surface area, as in figure 21. Gardner [38] solved the differential equation for describing the temperature distribution in a circular fin and presented fin efficiency curves in terms of two parameters.

$$D_o/D_t \text{ and } y \left[\frac{2 \cdot h_c}{k_f \cdot t} \right]^{0.5} \quad (88)$$

The theoretical results are correlated well by the following equation (see also figure 23) [2]:

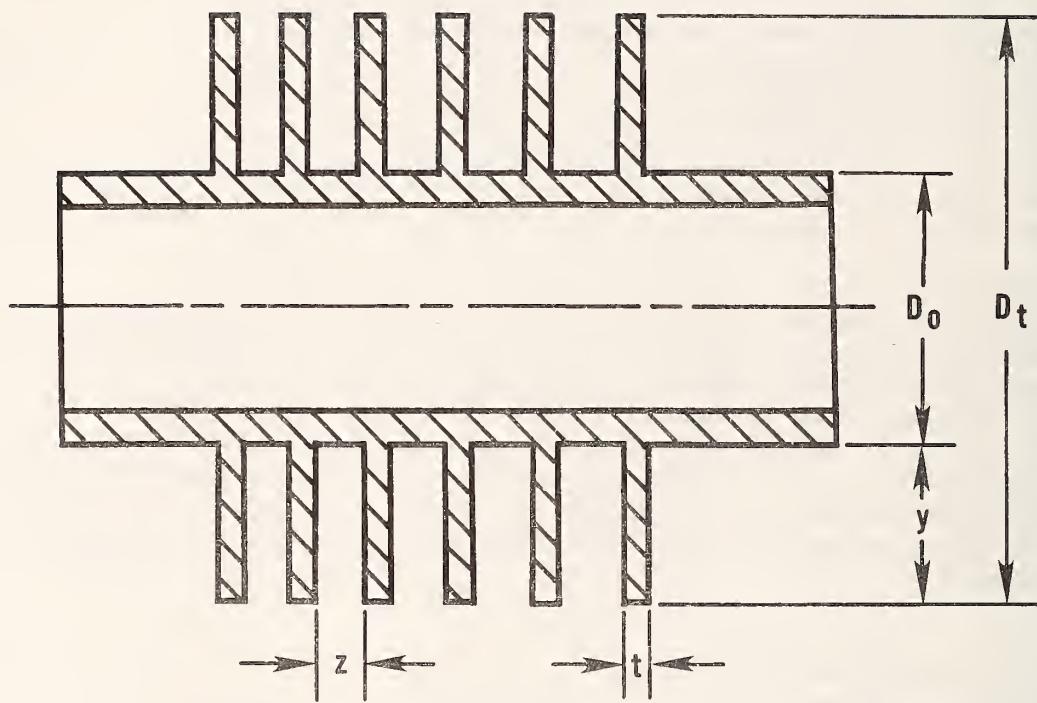
$$\phi = \sum_{i=1}^8 (A_{1,i} + A_{2,i} \frac{D_o}{D_t} + A_{3,i} \frac{D_o}{D_t}^2) \left(y \left(\frac{2 \cdot h_c}{k_f \cdot t} \right)^{0.5} \right)^{i-1} \quad (89)$$

where h_c = air-side convective heat transfer coefficient
 k_f = fin material thermal conductivity

The geometric parameters are indicated in figure 22. The coefficients, $A_{n,i}$, are given in Table 3.

5.4.7 Overall Heat Transfer Coefficient for a Wet Finned Tube

Wet finned tube analysis is applicable to an evaporator when its temperature is below the dew point temperature of ambient air. In such a case, moisture is being removed from an air stream and is transferred to the evaporator external surface. If the evaporator temperature is above 32°F, a water film flows down the fin under force of gravity. If the exterior evaporator temperature is below 32°F, frost is accumulated.



D_o = TUBE OUTSIDE DIAMETER

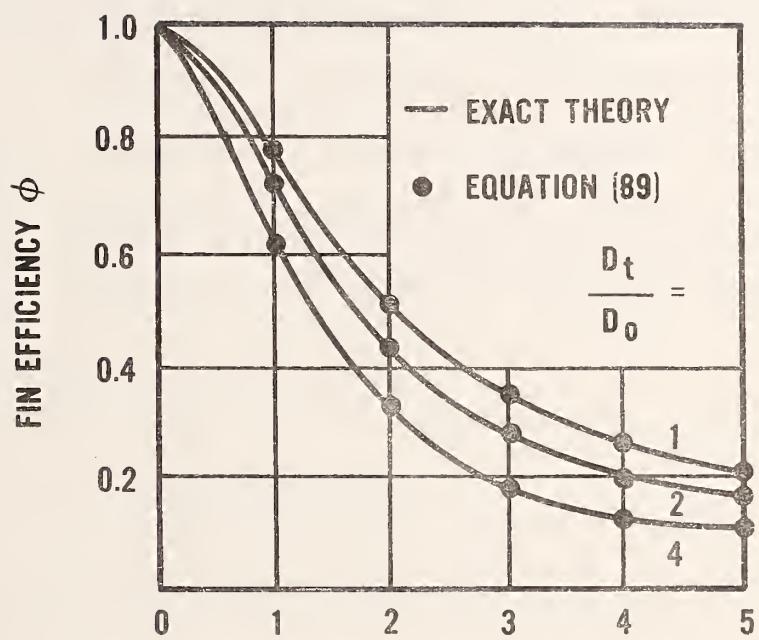
D_t = FIN TIP DIAMETER

y = FIN HEIGHT

t = FIN THICKNESS

z = DISTANCE BETWEEN ADJACENT FINS

Figure 22. Cross section of a flat-finned tube indicating parameters which affect the air-side heat transfer coefficient.



$$y \left(\frac{2h_c}{k_f \cdot t} \right)^{0.5}$$

Figure 23. Efficiency for a circular-plate fin of uniform thickness. Comparison of exact theory results with those obtained by equation (89).

Table 3. Coefficients to be Used in Correlation for Fin Efficiency (Equation (89)).

i	A _{1,i}	A _{2,i}	A _{3,i}
1	1.0	0.0	0.0
2	-0.22920E-01	-0.13755E+00	0.20130E-01
3	0.16106E+00	0.81890E-01	-0.11440E-01
4	-0.64975E+00	-0.55500E-01	-0.28753E-01
5	0.53491E+00	0.18040E-01	0.42477E-01
6	-0.19286E+00	0.36494E-03	-0.20335E-01
7	0.32564E-01	-0.10660E-02	0.40947E-02
8	-0.20972E-02	0.12410E-03	-0.29673E-03

Considering the heat transfer from the refrigerant to the air, one can realize that the dehumidification process will alter the heat transfer situation on the external surface of the finned tube, while other processes in the tube and refrigerant stay unaffected and are governed by relations already proposed in previous sections. Thus only processes connected with dehumidification need to be discussed.

The heat transfer rate between the air stream and the water surface is described by the following equation:

$$dQ = (h_{c,o}(T_a - T_w) + h_{D,o}(w_a - w_w) i_{fg,w}) dA_o \quad (90)$$

The first term accounts for sensible heat transfer and the second term accounts for latent heat transfer. For air at atmospheric pressure the Lewis number,

$$Le = \frac{h_{c,o}}{h_{D,o} C_{p,a}} , \quad (91)$$

is close to 1 [16]. Therefore, equation (90) assumes the following form for a tube with flat fins:

$$dQ = h_c (1 - \frac{A_f}{A_o} (1 - \phi)) (T_a - T_w) dA_o \quad (92)$$

where $h_c = h_{c,o} (1 + \frac{i_{fg,w}(w_a - w_w)}{C_{p,a}(T_a - T_w)})$

Symbols used in equations (90), (91) and (92) denote:

- A_f = fin area
- A_o = total external area
- $C_{p,a}$ = specific heat of air
- h_c = air-side forced convection heat transfer for wet air
- $h_{c,o}$ = air-side forced convection heat transfer coefficient for dry air
- $h_{D,o}$ = air-side mass transfer coefficient
- $i_{fg,w}$ = latent heat of condensation for water (frost sublimation)
- T_a = temperature of liquid water (frost)
- Q = heat transfer rate
- w_a = humidity ratio of air
- w_w = humidity ratio of saturated air at T_w temperature

$$\phi = \frac{T_{w,m} - T_a}{T_{w,b} - T_a}, \text{ fin efficiency}$$

- $T_{w,m}$ = mean temperature of water film (frost)
- $T_{w,b}$ = temperature of water film (frost) at fin base

The one-dimensional heat conduction across the condensate (frost) film can be expressed by the equation:

$$dQ = h_L \cdot \Delta T_L \cdot dA_o \quad (93)$$

where $h_L = \frac{k_w}{\delta}$, heat transfer coefficient for the condensate (frost) film

k_w = thermal conductivity of water (frost)

δ = thickness of condensate (frost) film (for evaluation of water and frost properties see Appendix B)

ΔT_L = temperature difference across the condensate (frost) film

Using equations (92) and (93) and referring to equation (81), the following relation for overall heat transfer coefficient for a wet finned tube can be derived.

$$U = \left[\frac{A_o}{h_i A_{p,i}} + \frac{A_o x_p}{A_{p,m} k_p} + \frac{1}{h_L} + \frac{1}{h_{c,o} (1 + \frac{i_{fg,w} (w_a - w_w)}{C_p a (T_a - T_w)} (1 - \frac{A_f}{A_o} (1 - \phi)))} \right]^{-1} \quad (94)$$

where symbols used are defined as in equations (81) and (92).

In the above formulation of the overall heat transfer coefficient, it is assumed that the temperature difference across the liquid film (frost) is uniform. The calculated value for wet fin efficiency is affected by the change of the air-side heat transfer coefficient caused by the air passage geometry alteration by liquid (frost) accumulation, and by the released latent heat of condensation (sublimation). The effect of water (frost) conductance on fin efficiency is neglected. In summary, the heat transfer phenomena that occurs during dehumidification on the air-side may be itemized as follows:

- (1) the layer of wet (frost) offers additional heat flow resistance
- (2) the air-side heat transfer resistance is decreased due to effect of condensation.
- (3) the air-side heat transfer coefficient, h_c , has an increased value since it is sensitive to external surface geometry and the Reynolds number (see equation (87)).
- (4) fin efficiency decreases as h_c is increased (see figure 23).
- (5) the cross sectional area of the air flow passage between the fins has decreased, decreasing the flow rate.

In order to evaluate water (frost) layer thickness, consider the mass transfer equation:

$$m_{a,d} \cdot dw_a = - h_{D,o} (w_a - w_w) dA_o \quad (95)$$

For the Lewis number equal to 1 equation (95) assumes the following form:

$$m_{a,d} \cdot dw_a = - \frac{h_{c,o}}{Cp_a} (w_a - w_w) \cdot dA_o \quad (96)$$

The change in the air humidity ratio can be calculated by integrating equation (96), which yields:

$$w_{a,e} = w_{a,i} - (w_{a,i} - w_w) \left(1 - \exp \frac{- h_{c,o} \cdot A_o}{Cp_a \cdot m_{a,d}}\right) \quad (97)$$

The rate of moisture removal per unit area, R, can now be calculated:

$$R = m_{a,d} (w_{a,i} - w_{a,e}) / A_o \quad (98)$$

where $m_{a,d}$ = mass flow rate of dry air

$w_{a,e}$ = humidity ratio of air at tube row exit

$w_{a,i}$ = humidity ratio of air at tube row inlet

If the evaporator temperature is below the freezing point, moisture removed from the air stream accumulates on the evaporator external surface in the form of frost. Its thickness, δ_f , can be evaluated by integrating the rate of moisture removal with respect to time, i.e.,:

$$\delta_f = \int_0^t \frac{R}{\rho_f} dt \quad (99)$$

where t = time

R = rate of moisture removal per unit area

δ_f = frost layer thickness

ρ_f = frost density

In case of evaporator temperature above 32°F, condensate flows down on the fin. Assuming no air drag on the liquid layer, its local velocity is expressed by the closed solution of the Navier-Stokes equation for a viscous flow on a vertical wall [39]:

$$V_z = \frac{\rho g \delta^2}{2 \mu} \left[1 - \left(\frac{y}{\delta}\right)^2\right] \quad (100)$$

where V_z = local liquid layer velocity

ρ = liquid density

g = gravitational acceleration

y = distance from the wall

δ = liquid layer thickness

μ = liquid absolute viscosity

Applying to the liquid film the continuity equation:

$$m(z) = \rho \int_0^h V_z dy \quad (101)$$

and assuming uniform condensation rate on the fin (i.e., $m(z) = m * z/h$, where: $m(z) =$ mass flow rate of condensate at elevation z , $m =$ water condensation rate by a fin of height h), the average condensate layer thickness can be obtained by integrating a local layer thickness over the fin height and dividing the obtained expression by the height. The resulting expression is:

$$\delta_f = 1.082 \left[\frac{\mu_w \cdot R'}{g \cdot \rho_w^2} \right]^{1/3} \quad (102)$$

where g = gravitational acceleration
 R' = condensation rate per unit width of a fin
 μ_w = water dynamic viscosity
 ρ_w = water density

5.4.8 Pressure Drop in a Tube

As expressed by equation (50), the total pressure drop experienced by a flowing fluid results from pressure drops due to friction, momentum change, and gravity. In an actual heat pump heat exchanger, pressure drop due to gravity effect is very small and may be neglected. Only pressure drop due to friction and due to momentum change will be considered for the different flow patterns in a tube.

Single-Phase Flow

Frictional pressure drop for a single-phase turbulent flow in a tube can be calculated by the Fanning equation with the Fanning friction factor, equations (67) and (68):

$$\Delta P = \frac{2f \cdot G^2 \cdot L}{D \cdot \rho} \quad (103)$$

$$f = 0.046 Re^{-0.2} \quad (\text{for } Re > 2000, [22]) \quad (104)$$

Pressure drop due to momentum change can be calculated by the following equation:

$$\frac{dP}{dL} = - G^2 \frac{dv}{dL} \quad (105)$$

where G = refrigerant mass flux
 L = tube length
 v = refrigerant specific volume

Two-Phase Flow with Condensation

The frictional pressure drop for two-phase flow with condensation can be calculated by the method proposed by Lockhart and Martinelli [22]. They

performed a semi-empirical study of adiabatic two-phase flow with air and different liquids including benzene, kerosene, water, and various oils in tubes varying in diameter from 0.586 to 1.017 inch. They related the pressure drop of two-phase flow to the pressure drop of the liquid portion of the flow flowing alone in the pipe, by a dimensionless parameter X_{tt} , i.e.:

$$\frac{\Delta P_{tp}}{\Delta P_L} = f(X_{tt}) = \Phi \quad \text{or} \quad \Delta P_{tp} = \Delta P_L \cdot \Phi \quad (106)$$

where ΔP_L = frictional pressure drop of the liquid portion of two-phase flow flowing alone in the tube
 ΔP_{tp} = frictional pressure drop of two-phase flow
 Φ = correction factor for two-phase pressure drop
 X_{tt} = as given by equation (84)

The pressure drop, ΔP_L , is calculated by the single-phase pressure drop relation with the liquid Reynolds number and friction factor calculated as follows:

$$Re_{tp,L} = \frac{(1-x)G \cdot D}{\mu_L} \quad (107)$$

$$f_{tp,L} = 0.046 \cdot Re_{tp,L}^{-0.2} \quad (\text{for } Re_{tp,L} > 2000) \quad (108)$$

where $f_{tp,L}$ = friction factor for the liquid portion of two-phase flow flowing alone in the pipe
 $Re_{tp,L}$ = Reynolds number for the two-phase liquid portion flowing alone in the pipe
 x = quality
 μ_L = liquid dynamic viscosity

A correction factor for two-phase pressure drop, Φ , was correlated by the following equation:

$$\Phi = \exp \left(\sum_{i=1}^5 A_i \cdot X_{tt}^{-0.25 \cdot i} \right)^2 \quad (109)$$

where $A_1 = -0.418956$
 $A_2 = 1.47330$
 $A_3 = 0.668583$
 $A_4 = -0.321168$
 $A_5 = 0.0408167$

Combining equations (106), (107), (108), and (109), the two-phase pressure drop equation assumes the form:

$$\Delta P_{tp} = 2 f_{tp,L} \cdot G^2 (1-x)^2 L \cdot \Phi / (D \cdot \rho_L) \quad (110)$$

The pressure drop due to momentum change for separated two-phase flow can be estimated by the following equation:

$$\frac{dp}{dL} = - G^2 \frac{d}{dL} \left(\frac{v_V + x^2}{a} + \frac{v_L(1-x)^2}{(1-a)} \right) \quad (111)$$

where x = quality

v_L = specific volume of liquid

v_V = specific volume of vapor

a = void fraction

Void fraction, a , percent of tube filled with vapor, was shown by Lockhart and Martinelli to be a function of X_{tt} under any flow conditions for separated flow with both phases turbulent. Wallis [40] correlated their results in the following form:

$$a = (1 + X_{tt}^{0.8})^{-0.378} \quad (112)$$

This expression was found to correlate well with data presented in [22] for values of $X_{tt} \leq 10$. For X_{tt} greater than 10, another curve fitted formula is used:

$$a = 0.823 - 0.157 \cdot \ln X_{tt} \quad (113)$$

Two-Phase Flow With Evaporation

The Lockhart-Martinelli method for pressure drop calculation of two-phase flow is widely used for adiabatic and condensing flows of single component refrigerants. However, it does not yield accurate prediction for evaporative flow. Instead of the Lockhart-Martinelli correlation, Anderson, Rich and Geary [41] recommended a method proposed by Pierre [42]. In order to evaluate the accuracy of this correlation for the R13B1/R152a mixture, pressure drop predictions were compared with laboratory data of evaporator tests performed in NBS environmental chambers. It was found that this correlation underpredicted pressure drop by about 40 percent in a consistent manner. Until pressure drop of non-azeotropic mixtures is fully investigated Pierre's correlation will be used for calculation of pressure drop with a correction factor of 1.4.

The correlation of Pierre based on experiments with refrigerants 12 and 22 has the following form:

$$\Delta P = (f \frac{L}{D} + \frac{\Delta x}{x_m}) G^2 \cdot v_m \quad (114)$$

where D = inner tube diameter

D = tube length

f = friction factor (calculated by equation (115))

x_m = mean quality

Δx = quality change

$v_m = v_L + x_m(v_V - v_L)$, mean specific volume

The friction factor to be used in equation (114) was correlated by Pierre from his experimental data by the following empirical equation valid for $Re/K_f > 1$:

$$f = 0.0185(K_f/Re)^{0.25} \quad (115)$$

where $K_f = \frac{J \cdot ifg \cdot \Delta x}{L}$, boiling number

$$Re = \frac{G \cdot D}{\mu_L}, \text{ Reynolds number}$$

J = mechanical equivalent of heat

The correlation proposed by Pierre is in the conventional format for the single pressure drop formula. The first term of equation (114) is for frictional pressure drop while the second is for pressure drop due to change of momentum. The formula for the friction factor contains the Reynolds number divided by the boiling number, making the friction factor sensitive to vapor generation rate at the vapor-liquid interface.

5.5 Modeling of Additional Heat Pump Components

In the previous sections, modeling of the main heat pump components has been discussed. The analysis included a compressor, a constant flow area expansion device, a condenser, and an evaporator. Additional components that have to be considered for a more accurate heat pump performance prediction by the model are: the vapor suction and discharge lines, the liquid line, and the four-way valve. Their modeling is briefly explained below.

Vapor Lines

A suction line connects the evaporator with the compressor. A compressor and a condenser are connected by a discharge line. Usually, single-phase flow exists in the vapor lines in the form of either saturated or superheated vapor. Heat transfer rates between the refrigerant vapor flowing in the vapor lines and ambient air can be calculated by a general heat transfer equation for a circular duct with insulation [19]. Single-phase forced convection is assumed inside the tube (equation (82)) and free convection is assumed outside the tube. The following equation is used for calculation of the free convection heat transfer coefficient for a horizontal tube [43]:

$$h = 0.27 \left(\frac{\Delta T}{D_o} \right)^{0.25} \quad (116)$$

for Grashof numbers from 10^3 to 10^9 .

where ΔT = temperature difference between tube wall and air
 D_o = tube outside diameter

Pressure drop in vapor lines can be calculated by the single-phase pressure drop equation (67).

Liquid Line

A liquid line connects the evaporator and the condenser. This line is filled with a subcooled liquid or low quality two-phase flow. The pressure drop can be calculated by equations (67) or (108), depending on the flow pattern. Heat loss from the liquid line to the ambient air is neglected.

Four-Way Valve

The main function of a four-way valve is to direct refrigerant flow from the compressor to the indoor or outdoor coil depending on the mode of operation (heating or cooling). The side effects of flow through a four-way valve are changes in the refrigerant thermodynamic state due to the pressure drop and heat exchange. Assuming for simplicity an adiabatic exterior wall, all heat lost by the discharge refrigerant is gained by the suction refrigerant. The heat transfer rate and refrigerant pressure drop in the valve can be evaluated by formulas similar to equations (45) and (55), respectively. Heat transfer and pressure drop parameters in these formulas have to be found using a subroutine VALPAR and a four-way valve (heat pump) one test data as explained in Appendix E.

Accumulator

Simplified schematic of an accumulator is shown in Figure 8. It is assumed that refrigerant experiences no pressure drop while flowing through the accumulator, and the accumulator is adiabatic. With these assumptions the refrigerant state at the accumulator inlet is equal to the state at the outlet during steady-state operation. The main purpose of the simulation of the accumulator is the calculation of mass of refrigerant contained in it. If superheated vapor is entering the accumulator, the accumulator is filled with vapor and calculation is straight forward. If wet vapor is entering the accumulator, refrigerant liquid is collected in it and the liquid level has to be evaluated. The liquid level is found by evaluating the hydrostatic pressure that along with the dynamic pressure exerted at the oil return hole would cause refrigerant liquid to flow through the hole at the rate that would change saturated vapor in the accumulator tube into a wet vapor of the inlet vapor quality.

The basic equations used in the accumulator subroutine, WACCUM, are:

$$m(1 - x) = A \cdot K \cdot 2 \cdot \Delta P \cdot \rho_L \quad (117)$$

$$\Delta P = H \cdot \rho_L \cdot g + 0.5 \left(\frac{x \cdot m}{A} \right)^2 v_V^2 \quad (118)$$

where K = orifice flow coefficient assumed $K = 0.585$ [44])

A = tube cross section area

H = liquid refrigerant level in the accumulator

g = gravitational acceleration

m = refrigerant mass flow rate through the accumulator

Δp = pressure drop through the oil return hole

v_V = specific volume of vapor

x = refrigerant quality

ρ_L = liquid density

Equation (117) is the orifice equation applied to the oil return hole. In equation (118) the first term represents the hydrostatic pressure while the second term expresses the dynamic pressure exerted at the hole (velocity of the liquid is neglected).

Some accumulators have two holes in the accumulator suction line. In addition to the regular oil return hole at the bottom of the suction line, they have another hole located some distance (approximately 1.5 inch) above. The accumulator subroutine is capable of simulating both types of accumulators. In either case the subroutine is solving for the liquid level, H, using equations (117) and (118).

5.6 Refrigerant Mass Inventory in a Heat Pump

The mass, M , of a substance occupying a known volume, V , may be determined by:

$$M = \int_{V} \rho \cdot dV \quad (119)$$

where ρ = local density

In reality, the mass of refrigerant in the system can be found by estimating the masses of the refrigerant in each system component and adding them up. For this purpose, equation (119) can be written in the form:

$$M = \sum M_i \quad (120)$$

$$M_i = V_i \cdot \rho_{m,i}$$

where M_i = mass of refrigerant in particular component i
 V_i = internal volume of component i
 $\rho_{m,i}$ = mean fluid density in component i

In order to make mass inventory of individual mixture components, the following equation can be applied with the known mixture weight composition, x_w , of the considered refrigerant:

$$M_{i,I} = M_i \cdot x_w \quad (121)$$

where $M_{i,I}$ = mass of refrigerant 'I' in heat pump component, 'i'

The heat pump components taken into account in the mass inventory calculations are shown in figure 24. The refrigerant phase in each of the components as indicated in the figure, is based on the following considerations:

Discharge line - receives and is filled with superheated vapor from the compressor.

Condenser - receives superheated vapor from a discharge line. In the course of passage through the condenser tubes, vapor temperature is brought to the dew point temperature. Starting at this point, a thin condensed liquid layer forms on the tube walls. Depending on the mass flux, this liquid film may be swept and entrained within the vapor as a mist forming a dispersed flow. With more condensed vapor,

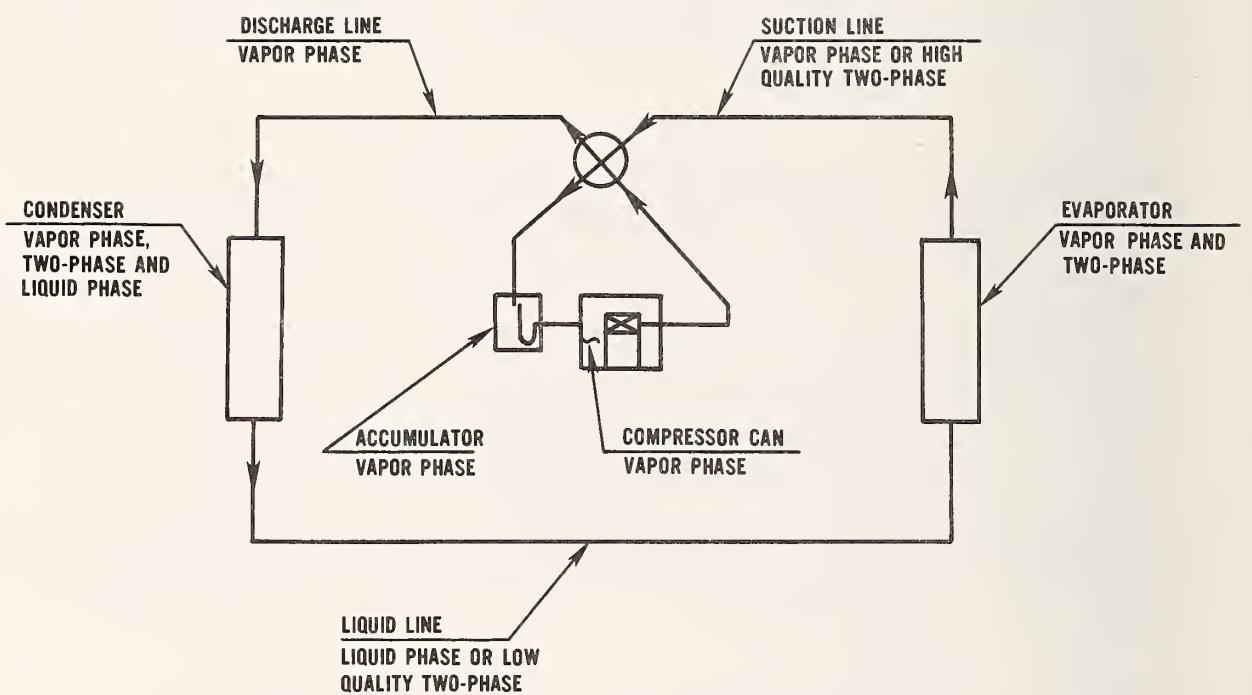


Figure 24. Refrigerant phase in the heat pump components.

the velocity of vapor decreases, a permanent liquid film is formed on the wall, and the flow proceeds further as the annular or semiannular flow. The quality decreases and the flow slows down in the direction of flow. Gravity forces result in a stratifying effect and the liquid flowing in the bottom of the tube periodically wets the upper tube wall (slug flow). If full condensation is reached, there will be subcooled liquid at the condenser exit.

Thus there are four two-phase flow patterns in the condenser, i.e., dispersed flow, annular flow, semi-annular flow, and slug flow as identified by Traviss and Rohsenow [45]. Soliman and Azer [46] identified nine flow regimes, however, five of them may be considered as transition regimes and can be put into the above basic four categories. The effect of return bends connecting condenser tubes was investigated in [47]. It was found that this effect is insignificant and that the annular flow pattern 'recovers' almost immediately in a tube after a return bend.

Liquid line - receives refrigerant from a condenser and delivers it to an expansion device. Entering the expansion device at the end of the liquid line, the flow experiences a sudden contraction. The entrance pressure drop depends upon the mass flow rate and the fluid density. This, along with the capillary tube sensitivity to the amount of subcooling, provides a flow controlling mechanism for the system. It is common practice to design a capillary tube so the refrigerant mass flow rate through it would balance with the mass flow rate through the compressor when a liquid seal exists at the capillary tube entrance. Temporary existence of vapor at the capillary tube would decrease the mass flow rate and build up the pressure. This would provide better conditions for condensation in the condenser and thus cause a return to a subcooled liquid or very low quality two-phase flow in the liquid line.

Expansion device - due to its small internal volume it may be disregarded for mass inventory purposes.

Evaporator - receives refrigerant from a capillary tube in the form of homogeneous flow of about 20 percent quality, at sonic or close to sonic velocity. This flow experiences a sudden deceleration and is assumed to form an annular or semi-annular flow very quickly having a void fraction about 0.8 [48]. The liquid phase flows along the tube in the form of an annulus and the vapor phase flows in the core. This type of flow prevails in most of the evaporator. With increasing quality, the velocity of the vapor increases and becomes eventually high enough to entrain small liquid drops and tear the liquid film apart. This results in a mist flow at qualities close to 1. Finally, the flow may reach the evaporator exit in a superheated vapor state.

Suction line - receives refrigerant from the evaporator as a mist flow or superheated vapor flow and the same flow pattern exists at the exit.

Accumulator - receives the refrigerant from a suction line after some heat is added in the four-way valve. Superheated, saturated or wet vapor may be expected. With wet vapor entering, liquid will be accumulated on the accumulator sump.

Compressor can - receives refrigerant from the accumulator as a saturated or superheated vapor which is further superheated due to heat transfer from an electric motor, discharge line, and compressor cylinder body.

According to the above analysis, refrigerant in the compressor can, suction line, and discharge line is in (or close to) a homogeneous vapor state. In the liquid line, homogeneous liquid flow or two-phase flow exists but in a state so close to saturation that for simplicity of mass inventory no slip is assumed and the flow is considered to be homogeneous. The mass of refrigerant in these components can be then calculated straight forward in a similar manner since refrigerant densities in the components described above will be known as a result of the simulation program iteration process.

In order to calculate the mass of refrigerant in the accumulator, it is necessary to determine the portion of the internal volume filled with liquid. Once this is found, total refrigerant mass in the accumulator can be calculated based on refrigerant state parameters.

In the case of both coils, the refrigerant flow is partly homogeneous, however, in most of the coil some type of annular flow prevails. For a separated flow regime, like an annular flow, density of the flowing fluid is determined from vapor and liquid densities and the fractions of tube volume occupied by the liquid and vapor phase:

$$\rho_m = \frac{\rho_L \cdot V_L + \rho_V \cdot V_V}{V_t} = \rho_L(1 - a) + \rho_V \cdot a \quad (122)$$

where M = mass
 V = occupied volume
 ρ = density
 a = V_V/V_t , void fraction

subscripts refer to:

L = liquid phase
 m = mean value
 t = total value
 V = vapor phase

It should be pointed out that for a two-phase flow of a given quality, mean density depends not only on the thermodynamic parameters affecting densities of the liquid and vapor, but also on the ratio of mean velocities of the vapor and liquid referred to often as the slip ratio. This can easily be noticed by examining the equation for the void fraction, which can be derived, considering mass flow rates of each phase:

$$a = \frac{1}{1 + \frac{1-x}{x} \frac{V_V}{V_L} \frac{\rho_V}{\rho_L}} \quad (123)$$

where V = velocity

Calculation of the void fraction has received much less attention than the calculation of heat transfer or pressure drop, although all three of these quantities are undoubtedly inter-related. The most often referenced method for void fraction calculation is that of Lockhart and Martinelli [22] based on their experimental void fraction data reported along with pressure drop results. They correlated void fraction with the dimensionless parameter, X_{tt} . Their experiment dealt with adiabatic flow, however, in the conclusions of their paper they suggested that their pressure drop correlation could be used for prediction of pressure drop during evaporation and condensation as well. On similar grounds, their void fraction data should be applicable beyond the adiabatic case.

There is another, earlier, method available for void fraction calculation by Martinelli and Nelson [49], derived with the same assumptions for water/steam evaporating flow. The method is similar to the Lockhart-Martinelli method so the Lockhart-Martinelli method was used in this study for calculation of the void fraction in both the evaporator and the condenser coils.

Correlations for void fraction based on [22] have already been given in section 5.4.8 (equations (112) and (113)).

$$a = (1 + X_{tt})^{0.8}^{-0.378} \quad \text{for } X_{tt} \leq 10 \quad (124)$$

$$a = 0.823 - 0.157 \ln X_{tt} \quad X_{tt} > 10 \quad (125)$$

The parameter X_{tt} , as defined by equation (84), is a function of flow quality, specific volume, and the viscosities of the liquid and vapor, and is not sensitive to the mass flux which in turn affects the slip ratio.

Experimental data of Staub and Zuber [48] for evaporating refrigerant 22 indicate that void fraction increases with increased mass flow rate. Comparison of their data with the void fraction predicted by the Martinelli-Nelson method showed a discrepancy which may lead to underestimation of the two-phase flow mean density by as much as 300 percent. (Note that a small difference in void fraction results in a large error in mean density prediction as density of the vapor and liquid are vastly different.) The results of Staub and Zuber also indicate that approximate agreement with the Martinelli-Nelson could be obtained at high mass fluxes, more than five times higher than those observed in usual heat pump evaporators.

In discussing the accuracy of a refrigerant mass prediction method, it should be noted that it also depends upon an accurate measurement of the internal volume of the system. Internal volume can be easily calculated for straight pipes. For valves, bends, etc., it can only be approximated.

Mass inventory of a heat pump system, as explained in Section 5.1, is intended to be used for iteration of refrigerant superheat at the compressor can inlet. The discussions above indicated that mass inventory calculations may have errors from two different sources. These sources are: inaccurate density prediction in the two-phase region, and inaccurate internal volume measurement. However, effect of these inaccuracies can be diminished since the program does not really need prediction of the absolute value of refrigerant mass in the system, but rather requires sensitivity in relative mass predictions in a heat pump with changes of operating conditions. This requirement

should be satisfied by the Lockhart-Martinelli method and very precise knowledge of the internal volume should not be that important. Since the refrigerant vapor superheat at the compressor can inlet is known at the cooling design operating mode at conditions (usually: outdoor temperature 95°F, indoor dry bulb temperature 80°F, and wet bulb 67°F) and does not have to be iterated for solution, refrigerant mass in the system can be calculated at this operating condition. This calculated mass of refrigerant may then be used as input data for refrigerant vapor superheat/quality iteration at other outdoor or indoor air conditions at which heat pump simulation results are required.

6. MODEL VERIFICATION

A verification of the computer model has been done by comparison of computer predictions with performance data obtained from laboratory tests conducted in NBS environmental chambers. In this stage of model development, laboratory data were available on one heat pump tested at two cooling and two heating standard rating operating conditions [50].

The sequence for running laboratory tests was as follows:

1. DoE cooling test A, $T_{out} = 95^{\circ}\text{F}$
indoor conditions: 80°F DB, 67°F WB
refrigerant charge adjusted to obtain 10° superheat at evaporator outlet
2. DoE cooling test B, $T_{out} = 82^{\circ}\text{F}$
indoor conditions: 80°F , 67°F WB
3. DoE high temperature heating test
outdoor conditions: 47°F DB, 43°F WB
indoor temperature: 70°F
4. DoE low temperature heating test
outdoor conditions: 17°F DB, 15°F WB
indoor temperature: 70°F

The laboratory data of DoE cooling Test A were used first to obtain compressor and four-way valve parameters as explained in Appendix E. Then computer model runs were started with simulation of performance at DoE cooling test A conditions with the appropriate imposed superheat at compressor can inlet that resulted in 10°F superheat at evaporator inlet as observed during laboratory test at this operating condition. Along with the performance results, refrigerant charge at the imposed superheat was obtained. This charge was then included in a heat pump data file to be used for iteration of superheat/quality of vapor at compressor can inlet, and composition of the circulating refrigerant at other operating conditions.

The laboratory and simulation results are given in Table 3 for the cooling mode and in Table 4 for heating operation.

During cooling operation no liquid was collected in the accumulator and the composition of the mixture did not change. In the heating mode refrigerant liquid was collected and a shift of composition of the circulating mixture occurred.

For both the cooling and heating modes, agreement between the results is very good, in fact, better than could be expected taking into account the number of simplifications used in the model, even the model is complex. It is not implied that this type of agreement can be obtained for every heat pump. It is believed that the accuracy of prediction stems partially from the effective cancellation of different simulation approximations, and this may not necessarily occur in simulation of every heat pump. However, the model

proved to provide physically consistent predictions including evaluation of refrigerant superheat/quality at the compressor can inlet and the circulating composition. Validation of this model with test data at other heat pumps charged with different mixtures, when available, would further increase confidence in the model.

Since two-phase heat transfer and pressure drop of non-azeotropic mixtures have not been fully presented in the literature and appropriate correlations are not available, the evaporative and condensation heat transfer coefficients and respective pressure drops are calculated in the model by formulas that may provide approximate values of the parameters in question. To evaluate the impact of possible approximate prediction on the final results, a few simulation runs were performed in which the specific parameter calculated within the program was altered by a preset factor. Change of calculated system capacity and COP as compared to performance obtained with unaltered parameter describes sensitivity of the model on this particular parameter.

The following results were obtained. Increase of the evaporative heat transfer coefficient by 50% resulted in 2.5% increase of system capacity and 1.8% of system COP. Decrease of the evaporative heat transfer coefficient by 50% caused reduction in capacity and COP by 6.9% and 5.4%, respectively. Increase in the condensation heat transfer coefficient by 50% increased capacity by 0.6% and COP by 1.1%. The same reduction in the condensation heat transfer coefficient caused reduction of system capacity by 2%, and reduction of COP by 3.1%.

Similar comparison was done for the evaporative and condensation pressure drops. Sensitivity of the final performance predictions was much smaller. In either considered case a change in pressure drop by 50% did not affect system capacity or COP by more than 1%.

Comparison numbers given above were obtained at indoor and outdoor air conditions specified for DoE cooling Test A. These findings should still apply for other operating conditions. Somewhat different results could be obtained simulating different systems.

Table 4. Laboratory Test and Computer Simulation Results in the Cooling Mode

Outdoor Temperature °F	Data Source	Circulating Mixture Composition	Capacity Btu/h	Energy Consumption Rate Watt	EER	Evaporator Outlet Dew Point Temperature °F		Superheat Leaving Evaporator °F	Compressor Discharge Pressure °F		Condenser Outlet Pressure psia	
						Refrigerant Mass Flow Rate lb/h	Btu/(h · Watt)		psia	°F	psia	°F
95°F	Simulation	.65	28050	4359	6.43	562	50.5	9.7	304	212	291	101.6
	Test	.65	27880	4322	6.45	568	51.8	9.7	297	208	292	111.0
82°F	Simulation	.65	30000	4047	7.41	557	48.6	13.2	263	195	249	88.0
	Test	.65	29670	4048	7.33	552	47.8	14.7	252	196	247	97.2

Indoor Air Conditions - 80°DB/67°W

Table 5. Laboratory Test and Computer Simulation Results in the Heating Mode.

Outdoor Temperature	Data Source	Circulating Mixture Composition		Energy Consumption Btu/h	COP	Evaporator Outlet Temperature °F	Compressor Discharge Pressure psia		Condenser Outlet Pressure psia	Temperature °F
		Weight Fraction of R13B1	Btu/h				°F	°F		
47°F DB	Simulation	.667	35180	3673	2.81	37.1	230	159	220	84.9
43°F WB	Test	.667	33800	3776	2.62	40.1	231	176	231	93.3
17°F DB	Simulation	.743	21910	3206	2.00	11.4	211	150	203	80.2
15°F WB	Test	.734	21303	3298	1.89	14.1	209	177	195	82.1

Indoor Air Temperature 70°F

7. SUMMARY AND CONCLUSIONS

This report describes a model of a heat pump equipped with a constant flow area expansion device and operating with a non-azeotropic binary mixture refrigerant.

The model is able to simulate performance of a heat pump at imposed operating conditions without restriction on the refrigerant thermodynamic state at any point of the system. The simulation power includes simulation of the circulating mixture composition shift resulting from incomplete evaporation and accumulation of liquid refrigerant in the accumulator.

The model has a modular structure; it consists of independent models of heat pump components linked together by appropriate logic iterating refrigerant thermodynamic states in thirteen key locations of a heat pump thermodynamic cycle. Heat pump system component models were developed with emphasis on description of processes by fundamental heat transfer and pressure drop equations, and equation of state relationships among material properties. In the compressor model several refrigerant locations were identified and processes taking place between them accounted for all significant heat and pressure losses. Evaporator and condenser models were developed on a tube-by-tube basis where performance of each coil tube is computed separately by considering the cross-flow heat transfer with the external air-stream and the appropriate heat and mass transfer relationship. A constant flow area expansion device model was formulated with the aid of the Fanno flow theory.

The model utilizes an equation of state which is applicable for both liquid and vapor phases. Unlike the usual practice of using separate pressure-saturation temperature and liquid density-saturation temperature correlations with P-V-T relationship, one P-V-T relationship and physical equilibrium criteria are used in this project in establishing saturation state parameters and properties.

Since two-phase heat transfer and pressure drop of non-azeotropic mixtures have not been fully presented in the literature and appropriate correlations for their evaluation are not available, the evaporative and condensation heat transfer coefficients and respective pressure drops are calculated in the model by formulas either derived from a single component flow experiments or at best from limited experiments of one mixture only. There is certainly a need of research in these areas and this model should be updated when our knowledge about these phenomena is advanced.

The model was validated by comparing its performance predictions with laboratory test results of one heat pump charged with R13B1/R152a mixture at two cooling and heating operating conditions. The data presented in this report, established our confidence in the model. The choice of R13B1/R152a for development and verification of this model does not mean recommendation of this mixture as an optimum and precludes other mixtures to be more suitable for heat pump application.

This report is intended for research and development engineers to provide a tool for evaluation of the potential of non-azeotropic binary mixtures in heat

pumps. The User's Manual of the developed program, HPBI, is included in the Appendix Section to enable readers to prepare input data for other heat pumps and to run the program even without detailed knowledge of the main section of this report. An example run and a listing of the program are also included.

HPBI program is applicable to the standard split residential system. It is, however, limited in the form presented here to the R13B1/R152a mixture due to a saturated refrigerant property spline which was incorporated in the program to decrease required computing time. Once a more efficient scheme is developed to use the equation of state directly, the spline will be removed along with present model limitations.

The current version of the model can be used to evaluate performance of a heat pump charged with R13B1/R152a mixture at different operating conditions and different mixture compositions. It is intended to be used, after slight modification, to predict the possible potentials of mixtures working in modified thermodynamic cycles. The computing time required by the program will vary with the size of the heat exchangers and the accuracy of estimated refrigerant parameters given as inputs. On the average, HPBI program run on Sperry 1100/82 computer requires 10 minutes of CPU time to converge with iteration of superheat, and about 40 minutes to converge iterating refrigerant quality at the compressor can inlet and the circulating mixture composition.

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APPENDIX A. CALCULATION OF PROPERTIES OF MOIST AIR

For the selection of moist air property equations, it was assumed that air dry bulb temperature, T, relative humidity, RH, and pressure would be known, and the properties that would be the output were: humidity ratio, specific heat at constant pressure, gas constant, dynamic viscosity, and thermal conductivity. Presented here are the psychometric equations in their fundamental form. They are derived assuming moist air to be a mixture of two independent perfect gases, so that the perfect gas equation of state and Dalton's rule can be applied. The transport properties, dynamic viscosity, and thermal conductivity of air are assumed to be negligibly affected by the moisture content. Correlations for these two properties were based on dry air data.

Relations of this appendix were applied in air properties subroutine AIRPR.

The humidity ratio is determined by [16]:

$$w = 0.622 \text{ PSAT} / (\text{PATM} - \text{RH} \cdot \text{PSAT}) \quad (\text{A1})$$

where PATM = atmospheric pressure
 PSAT = saturation pressure of water vapor at temperature T
 w = humidity ratio (lb water/lb dry air)
 RH = relative humidity (-)

The saturated water vapor pressure, PSAT (psi), is calculated by the polynominal approximation [2]:

$$\text{For } T > 32^{\circ}\text{F} \\ \text{PSAT} = \exp(19.504 - 10.431z - 0.2755z^2 + 0.03940z^3)$$

$$\text{For } 32 \leq T < 180^{\circ}\text{F} \\ \text{PSAT} = \exp(13.4353 - 5.0988z - 1.6896z^2 + 0.17829z^3)$$

$$\text{For } T \geq 180^{\circ}\text{F} \\ \text{PSAT} = \exp(16.8255 - 14.213z + 7.5568z^2 - 4.01506z^3 + 0.17692z^4)$$

$$\text{where } z = \frac{1000}{460 + T} \quad (\text{A2})$$

The specific heat at constant pressure is [16]:

$$C_p = (C_{p,dry} + 0.444) / (1 + w) \quad (\text{A3})$$

where C_p = specific heat at constant pressure of moist air
 (Btu/(1b moist air \cdot F))
 $C_{p,dry}$ = specific heat at constant pressure of dry air (Btu/(1b \cdot F))
 w = humidity ratio (lb water/lb dry air)

The specific heat at constant pressure of dry air is approximated by the following polynominal [2]:

$$C_{p,dry} = 0.2478786 - 0.4204563 \cdot 10^{-4} \cdot TR + 0.567857 \cdot 10^{-7} \cdot TR^2 - 0.14936056 \cdot TR^3 \quad (\text{A4})$$

where $TR = T + 460^{\circ}F$ is the dry bulb air temperature on the Rankine scale

The gas constant is [16]:

$$R = (53.34 + 85.76 \cdot w) / (1 + w) \quad (A5)$$

where $R = \text{moist air gas constant } \frac{1\text{bf} \cdot \text{ft}}{1\text{b}}$

$w = \text{humidity ratio (1b water/1b dry air)}$

The dynamic viscosity and thermal conductivity values are obtained from the respective equations [2]:

$$\begin{aligned} \mu &= 5.5029 \cdot 10^{-3} + 8.7157 \cdot 10^{-5} TR - 2.9464 \cdot 10^{-8} TR^2 \\ &\quad + 6.25 \cdot 10^{-12} TR^3 \end{aligned} \quad (A6)$$

$$\begin{aligned} k &= -2.853 \cdot 10^{-4} + 3.268 \cdot 10^{-5} TR - 8.253 \cdot 10^{-9} TR^2 \\ &\quad + 1.239 \cdot 10^{-12} TR^3 \end{aligned} \quad (A7)$$

where $k = \text{moist air thermal conductivity (Btu/(h \cdot F \cdot ft))}$

$TR = 460 + T = \text{dry bulb air temperature on the Rankine scale (R)}$

APPENDIX B. CALCULATION OF WATER AND FROST PROPERTIES

The equations presented below are for calculation of the properties of water and frost deposited on a heat pump evaporator outer surface. These properties, for specific conditions, are either solely a function of temperature or can be assumed to be constant. The equations below are used in the water and frost properties subroutine, WATPR.

The following fourth degree polynomial expression is used for calculating water density, conductivity, dynamic viscosity and latent heat of condensation [2]:

$$PROP = \sum_{I=1}^5 A(I) \cdot T^I - 1 \quad (B1)$$

where $A(I)$ = five constants per calculated property
 PROP = calculated property
 T = water temperature (F)

Constants $A(I)$ for each property are given in Table B1. The specific heat of water at constant pressure is assumed to be independent of temperature and to have a constant value of $C_p = 1 \frac{\text{Btu}}{\text{lb} \cdot \text{F}}$

The density of frost, as proposed in [51], is calculated by the following equation:

$$\rho_f = \exp(b1 + b2 \cdot (TW - TP)) \quad (B2)$$

where $b1 = 11.9521 + 0.02422 TPR + 35.5498 WA - 9.1742 \cdot 10^{-7} VA + 3.1138 \cdot 10^{-9} VA \cdot TPR - 0.03838$
 $b2 = 13.1606 - 0.02133 TPR - 81.955 WA/32.018 - TP$
 TP = tube temperature (F)
 TPR = TP + 460. tube temperature (R)
 TW = water (frost) temperature (F)
 WA = air humidity ratio
 VA = air velocity (ft/sec)
 ρ_f = density of frost (lb/ft^3)

The frost conductivity, as proposed in [52], is calculated by the equation:

$$k_f = 0.012138 + 3.8909 \cdot 10^{-3} \cdot \rho_f + 5.1409 \cdot 10^{-6} \cdot \rho_f^2 \quad (B3)$$

where k_f = frost conductivity ($\text{Btu}/(\text{h} \cdot \text{F} \cdot \text{ft})$)
 ρ_f = frost density (lb/ft^3)

Frost heat of sublimation, h_{SUBL} , and frost specific heat C_f , are assumed to have the following constant values [52]:

$$h_{\text{SUBL}} = 1219.0 \text{ Btu/lb}$$

$$C_f = 0.46 \text{ Btu}/(\text{lb} \cdot \text{F})$$

Table B1. Water Property Evaluation Constants which are Used in Equation (B1)

Calculated Property A(I)	Density 1b/ft ³	Dynamic viscosity 1b/(h · ft)	Thermal conductivity Btu/(h · F · ft)	Latent heat of condensation Btu/1b
A(1)	0.11647 E+03	0.79422 E+03	-0.27694	0.31514 E+04
A(2)	-0.40054	0.47589 E+01	0.45215 E-03	0.13714 E+02
A(3)	0.10815 E-02	0.10622 E-01	0.49008 E-05	0.35945 E-01
A(4)	0.12387 E-05	0.10416 E-04	0.88613 E-08	0.43525 E-04
A(5)	0.49002 E-09	0.37690 E-08	0.41387 E-11	0.19695 E-07

APPENDIX C. CALCULATION OF CRITICAL PRESSURE FOR TWO-PHASE FANNO FLOW OF A NON-AZEOTROPIC MIXTURE

In this appendix, the procedure is explained for calculation of critical pressure of a flow if mass flow rate and stagnation enthalpy are given. The procedure focuses on the fact that Fanno flow assumes maximum entropy at the flow critical pressure. Hence, the point of maximum entropy on the Fanno line is being sought and once determined, the choking pressure is found.

The entropy of two-phase flow is calculated by the equation:

$$s = s_L + x(s_V - s_L) \quad (C1)$$

where s = entropy

x = quality

subscripts L and V refer to liquid and vapor phase, respectively, being in equilibrium

The quality for Fanno flow can be found using the energy equation:

$$i_0 = i + \frac{G^2}{2} \cdot v^2 \quad (C2)$$

where G = mass flux

i = enthalpy

i_0 = stagnation enthalpy

v = specific volume

Two-phase specific enthalpy and specific volume are:

$$i = i_L + x(i_V - i_L) \quad (C3)$$

$$v = v_L + x(v_V - v_L) \quad (C4)$$

Substituting and rearranging, the following quadratic equation can be obtained [23]:

$$x^2 + x \cdot b + c = 0 \quad (C5)$$

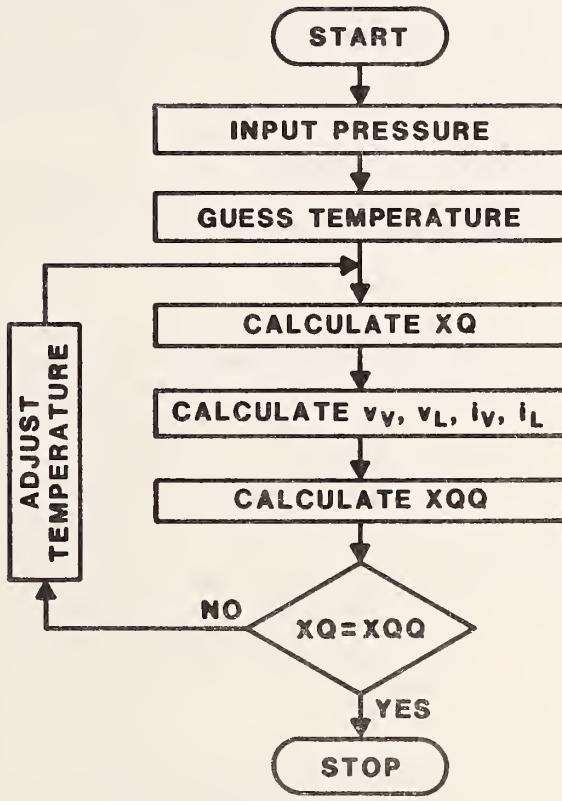
$$\text{where } b = \frac{2(v_V - v_L) \cdot v_L \cdot G^2 + i_V - i_L}{G^2(v_V - v_L)^2}$$

$$c = \frac{2(i_L - i_0)}{G^2} + v_L^2 \cdot \frac{1}{(v_V - v_L)^2}$$

It should be noticed that saturated volumes of liquid and vapor and respective enthalpies are uniquely defined at a given pressure for a single component refrigerant. In such situation, refrigerant quality for a given Fanno flow can be calculated explicitly. When a non-azeotropic mixture is used, saturated liquid and vapor properties needed for evaluation of the quality are function of the quality thus an iterative procedure has to be used as shown

in the figure C1. Once the mixture quality (thus also temperature) at the Fanno flow at a given pressure is known, entropies of the saturated liquid and vapor are readily available and the flow entropy can be evaluated by equation C1.

The above described equations and procedures are applied in a double precision function, DFANNO. The Secant Method is used to provide the solution.



XQ - quality calculated by equation of state

XQQ - quality calculated by equation C5

Figure C1. Logic to evaluate the quality of the Fanno flow at a given pressure for a non-azeotropic mixture.

APPENDIX D. THE LOGIC FOR THE MAIN PROGRAM, BMAIN

The principle of the logic for the heat pump model has been explained in section 5.1. It is based on four balances:

- enthalpy balance
- pressure balance
- mass balance of non-azeotropic mixture
- mass balance of one of the mixture components

The enthalpy balance and pressure (mass flow rate) balance are interdependent and have to be found in a simultaneous iteration process. Their solution provides refrigerant properties in the system which are required for mass inventory calculations. The balances are performed in the manner as shown in figure D1, which presents the logic developed during this study and contained in the main program, BMAIN.

The objective of the logic is to iterate refrigerant states at key locations of a heat pump for given outdoor and indoor conditions. The addresses of the key locations used in the program BMAIN are consistent with those marked in figures 2 and D1:

- 1 - evaporator exit, suction tube inlet
- 2 - suction tube outlet, low pressure four-way valve inlet
- 3 - low pressure four-way valve exit, compressor can inlet
- 4 - inside compressor can
- 5 - compressor cylinder during suction stroke
- 6 - compressor cylinder during discharge
- 7 - discharge manifold
- 8 - compressor can exit, high pressure four-way valve inlet
- 9 - high pressure four-way valve exit, discharge tube inlet
- 10 - discharge tube outlet, condenser inlet
- 11 - condenser outlet, liquid line inlet
- 12 - liquid outlet, expansion device outlet
- 13 - evaporator inlet

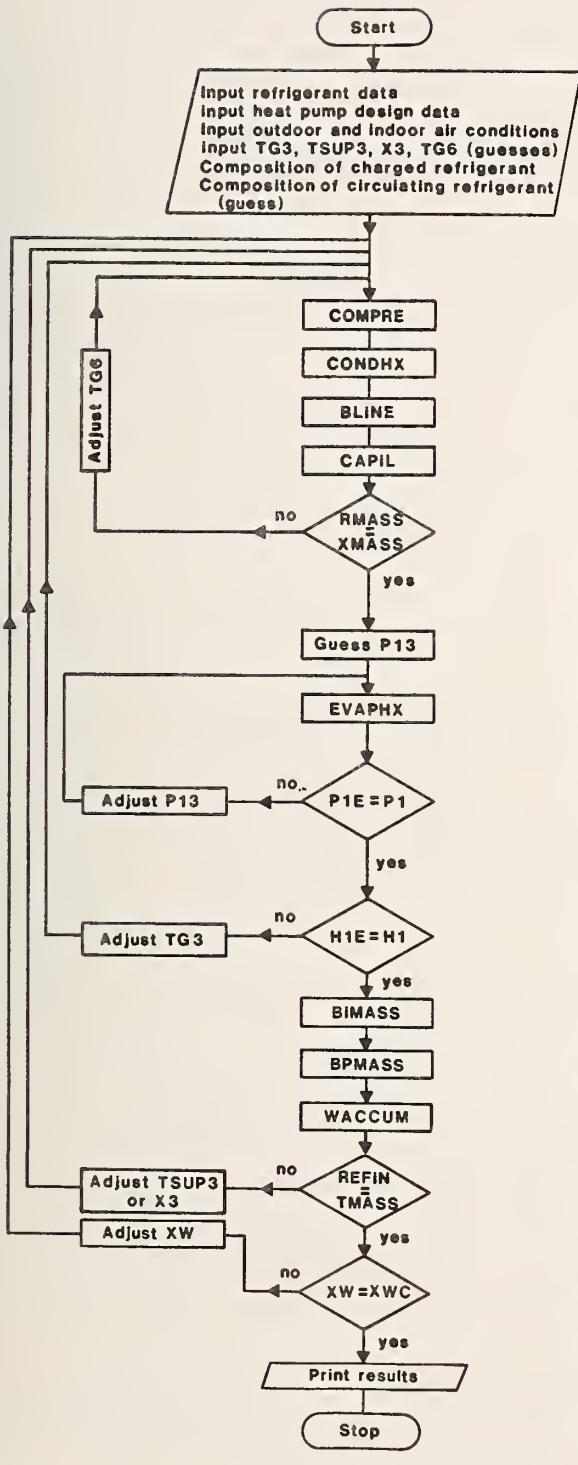
The thermodynamic processes shown in figure D1 are covered by five subroutines: COMPRE, CONDHX, BLINE, CAPIL, and EVAPHX. The iteration process starts with an estimated refrigerant pressure, superheat or quality at the compressor can inlet, and an estimated compressor discharge pressure (points 3 and 6). From these data, the compressor simulation subroutine COMPRE computes the refrigerant mass flow rate through the compressor and refrigerant parameters from point 1 to 10. The condenser and liquid line subroutines CONDHX and BLINE are called next to perform calculations which yield refrigerant states at point 11 and 12. Subsequently, the expansion device simulation program, CAPIL computes refrigerant mass flow rate through the flow restrictor. At this point, the mass flow rate through the compressor, RMASS, and mass flow rate through the expansion device, XMASS, are compared and mass flow balance is sought. This is done by resuming calculations by COMPRE, CONDHX, BLINE, and CAPIL, holding constant refrigerant parameters at the compressor can inlet (point 3) and adjusting refrigerant saturation temperature at discharge (point 6) until an appropriate saturation temperature at point 6 is found at which RMASS and XMASS are equal.

The evaporator performance simulation routine, EVAPHX, was chosen in this logic to be run after the mass flow balance between the compressor and expansion device has been found. (EVAPHX requires the most computing time of all the subroutines.) Evaporator simulation requires input of refrigerant mass flow rate and refrigerant state at the evaporator inlet. The refrigerant enthalpy at the evaporator inlet, H13, is equal to that at point 11, H11, since the thermodynamic processes in the liquid line and flow restrictor are adiabatic. The refrigerant pressure at evaporator inlet, P13, is unknown and has to be guessed based on the known pressure at location 1 and the pressure drop across the evaporator (if known from the previous simulation of the evaporator). The output from EVAPHX is pressure and enthalpy at evaporator outlet, P1E and H1E, respectively. If the pressure P1E is not equal within imposed tolerance to P1, pressure P13 has to be adjusted and evaporator simulation repeated. After the condition of equal P1E and P1 pressures is satisfied, the refrigerant enthalpy at the evaporator outlet obtained from evaporator simulation, H1E, and enthalpy H1 are compared. If these enthalpies are not equal, the refrigerant saturation temperature at the compressor can inlet is adjusted and all calculations repeat.

Once an enthalpy balance and mass flow balance are established, two out of four refrigerant parameters estimated at the outset are temporarily obtained. To verify the third estimated parameter, i.e., the refrigerant vapor superheat at the compressor can inlet, the refrigerant mass inventory in the system is used. Each time the mass inventory is performed, it provides a result based on refrigerant states in the system found after solving enthalpy and pressure balances with the assumed vapor superheat (quality) at points 3 and refrigerant mixture composition. If the amount of refrigerant obtained from the mass inventory calculations is less than the refrigerant in the system, the superheat (quality) estimate has to be decreased and all calculations have to be repeated from the beginning.

After the refrigerant mixture mass inventory agrees with mass of charged refrigerant, the mass inventory of one of the mixture components is made. If, based on this inventory, calculated circulating mixture composition is not equal (within imposed tolerance) to circulating composition estimated for use for simulation calculations, new estimate for the circulating composition is computed and all the calculations have to be repeated from the outset. If the equality between the estimated and calculated compositions is obtained, the iteration process is ended and the results are printed.

In the course of the computing process, the main program gathers information about the heat pump components' performance, updated at each iteration loop, and applies them to anticipate changes of some parameters caused by a change in some state property. This allows for the iteration process to converge faster with each iteration loop. The Secant Method is used in the solution of the two most internal loops and the external loop of the main program. The Binary Search Method was applied to the mixture mass inventory loop due to highly non-linear characteristic of the accumulator.



Symbols:

H_1 - refriger. enthalpy at evaporator outlet calculated by COMPRE
 H_{1E} - refriger. enthalpy at evaporator outlet calculated by EVAPHX
 H_{12} - refriger. enthalpy at point 12
 H_{13} - refriger. enthalpy at point 13
 P_1 - refriger. pressure at evaporator outlet calculated by COMPRE
 P_{1E} - refriger. pressure at evaporator outlet calculated by EVAPHX
 $REFIN$ - mass of refriger. charged into a machine
 $RMASS$ - refriger. mass flow rate through a compressor
 $TG3$ - refriger. dew point temp. at point 3
 $TG6$ - refriger. dew point temp. at point 6
 $TMASS$ - total mass of refriger. calculated by inventory program
 $TSUP3$ - refriger. superheat at point 3
 $XMASS$ - refriger. mass flow rate through an expansion device
 XW - circulating refrigerant mixture composition used for the calculations
 XWC - circulating refrigerant mixture composition resulting from the component refrigerant mass inventory
 $X3$ - refriger. quality at point 3

$BIMASS$ - calculates mass of refrigerant in a coil
 Input: refriger. state at each coil tube end
 Output: mass of refriger. in a coil
 $BLINE$ - calculates pressure drop in a liquid line
 Input: RMASS and refriger. state at point 11
 Output: refriger. state at point 12
 $BPMASS$ - Calculates mass of refriger. in a tube
 Input: refriger. state at tube ends
 Output: mass of refriger. in a tube
 $CAPIL$ - calculates performance of an expansion device
 Input: refriger. state at point 12 and pressure at point 13
 Output: XMASS
 $COMPRESSOR$ - calculates performance of a compressor with a 4-way valve and tubing connecting compressor with both coils
 Input: refriger. state at point 3 and pressure at point 6
 Output: RMASS and refriger. state at points 1 through 10
 $CONDHX$ - calculates performance of a condenser
 Input: RMASS and refriger. state at point 10
 Output: refriger. state at point 11
 $EVAPHX$ - calculates performance of an evaporator
 Input: RMASS and refriger. state at point 13
 Output: refriger. state at point 1
 $WACCUM$ - calculates mass of refrigerant in an accumulator
 Input: refriger. state in an accumulator
 Output: mass of refriger. in an accumulator and mean refriger. composition

Figure D1. Overall logic of the program HPBI.

APPENDIX E. COMPRESSOR SIMULATION SUBROUTINE, COMPRE

Refer to figure 2 where the configuration of the main heat pump components is shown. It was decided to include in one subroutine called COMPRE all refrigerant processes from point 1 to point 10. The refrigerant path covered by this subroutine consists of:

- flow through a suction tube 1-2 and discharge tube 9-10
- flow through a reversing valve on suction side 2-3 and discharge side 8-9
- flow through a compressor 3-8

Input data to COMPRE is detailed in comment statements inserted in the program. Basically they consists of:

- connecting tubing design data
- compressor design and performance parameters
- four-way valve performance parameters
- refrigerant state at the compressor can inlet (point 3)
- refrigerant pressure after compressor (point 6)

The design input data are explained in Table H5. The compressor performance parameters include:

η_e = electric motor efficiency versus load
RPM = electric motor speed (RPM) versus load

η_m = compressor mechanical efficiency

C_e = compressor effective clearance

η_p = compressor polytropic efficiency

CPC34, CPC45, CPC67, CPC78 = pressure drop parameters

CQC4C, CQCCOA, CQC45, CQC67, CQC78 = heat transfer parameters

One of the parameters, the compressor mechanical efficiency, η_m , is assumed here to be constant and equal to 0.96. The rest of the parameters can be calculated by means of subroutine COMPAR using compressor test data. The efficiency, η_e , and RPM as functions of mechanical load are both part of typical electric motor characteristic for its class (see figures 11 and 13). Coefficients describing these curves are required as an input to COMPAR. In the course of calculations, new coefficients are computed which retain the shape of the characteristic curves, although changes in absolute values of efficiency, η_e , and RPM do occur according to test data supplied. The rest of the parameters (compressor effective clearance, compressor polytropic efficiency, five heat transfer parameters, and four pressure drop parameters) are calculated by COMPAR using relations presented in section 5.2.2.

Subroutine COMPAR is incorporated in the general program HPBI and is called by the main program, BMAIN. It is executed by running the HPBI program with appropriate run control data input as explained in Appendix H.

Four-way valve performance parameters are the pressure drop parameter and heat transfer parameter. These parameters are calculated by subroutine VALVPA using four-way valve test data. Similar to the compressor case, VALVPA is a part of the program HPBI and can be accessed by executing it with appropriate run control input data (refer to Appendix H).

Organization of COMPRE may be followed by examining the program listing with inserted comment statements. Based on a known refrigerant state at the can inlet (point 3), refrigerant parameters at the suction valve (point 5) are estimated and since the compression pressure is given, the compression process can be computed. Using the refrigerant mass flow rate from this computation and applying equations given in section 5.2.2, enthalpy and pressure balances are conducted. If balance is not reached, the estimate of the refrigerant state at the suction valve, point 5, is adjusted. Calculations are repeated until balances are satisfied.

Once refrigerant states at compressor stations 3 to 8 and the mass flow rate are known, the properties for other refrigerant paths are computed. Simulation of the four-way valve and tubes are done by routines MVAL4 and PIPE, respectively.

The output from subroutine COMPRE is detailed in the program comment statements and consists of refrigerant thermodynamic properties for points 1 to 10, refrigerant mass flow rate, compressor RPM, energy consumption rate, electric motor efficiency, compression efficiency, and volumetric efficiency.

APPENDIX F. CONSTANT FLOW AREA EXPANSION DEVICE SUBROUTINE, CAPIL

The purpose of the capillary tube simulation subroutine is to calculate the refrigerant mass flow rate when the capillary dimensions, refrigerant inlet state, and pressure in the evaporator are given. Depending on the above input, there are several possible capillary tube operation modes. For example, the refrigerant can be either a single -or a two-phase state prior to the tube entrance. If there is a two-phase mixture at the inlet (a highly undesirable but possible condition under very low load operating conditions), two-phase flow will exist along the whole tube length.

For a subcooled liquid at the inlet, there are three flow alternatives:

- liquid flow only along the whole tube length
- liquid flow in the first portion of the tube and two-phase flow in the latter portion of the tube
- two-phase flow only along the whole tube length

Each of the above flow situations can exist with or without choking condition at the tube exit. The capillary tube simulation routine, CAPIL can distinguish among all of the above operational modes. During the course of the calculations, the refrigerant critical pressure is found by routine CHOKE using a binary search iteration method. Then equations (62), (67), and (72) are used to compute the refrigerant mass flow rate. The density-pressure integral in equation (72) is evaluated by routine SIMP based on Simpson's rule. An iteration solution is required to obtain the final simulation result since choking pressure, friction factor, fractions of tube length with liquid and two-phase flow, and the velocity head used to correct enthalpy are functions of refrigerant mass flow rate which has to be found. The Secant Method is used in the iteration for the final CAPIL solution. The logic of the routine CAPIL is presented in figure F1. The input and output data are listed in comment statements in this routine.

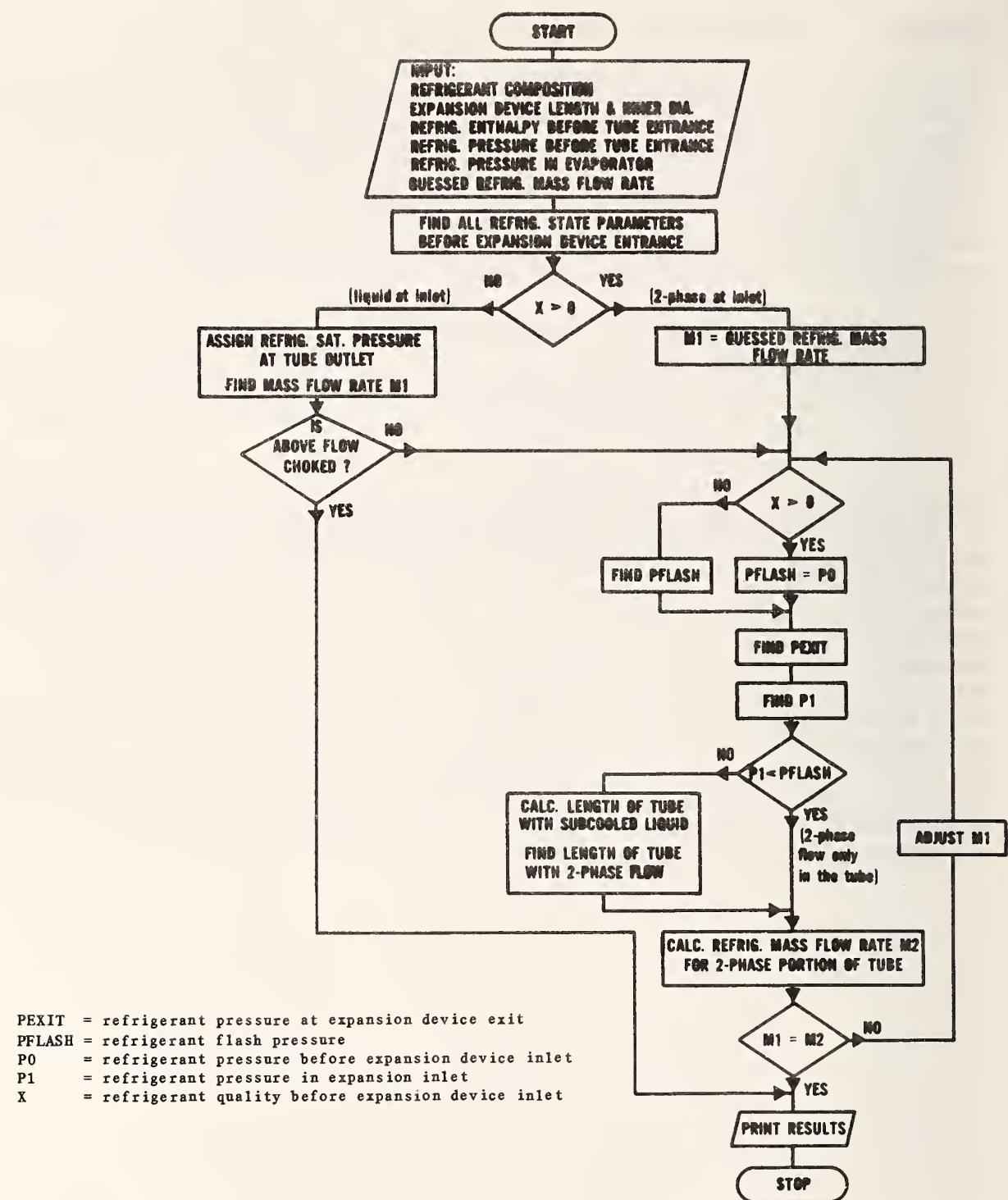


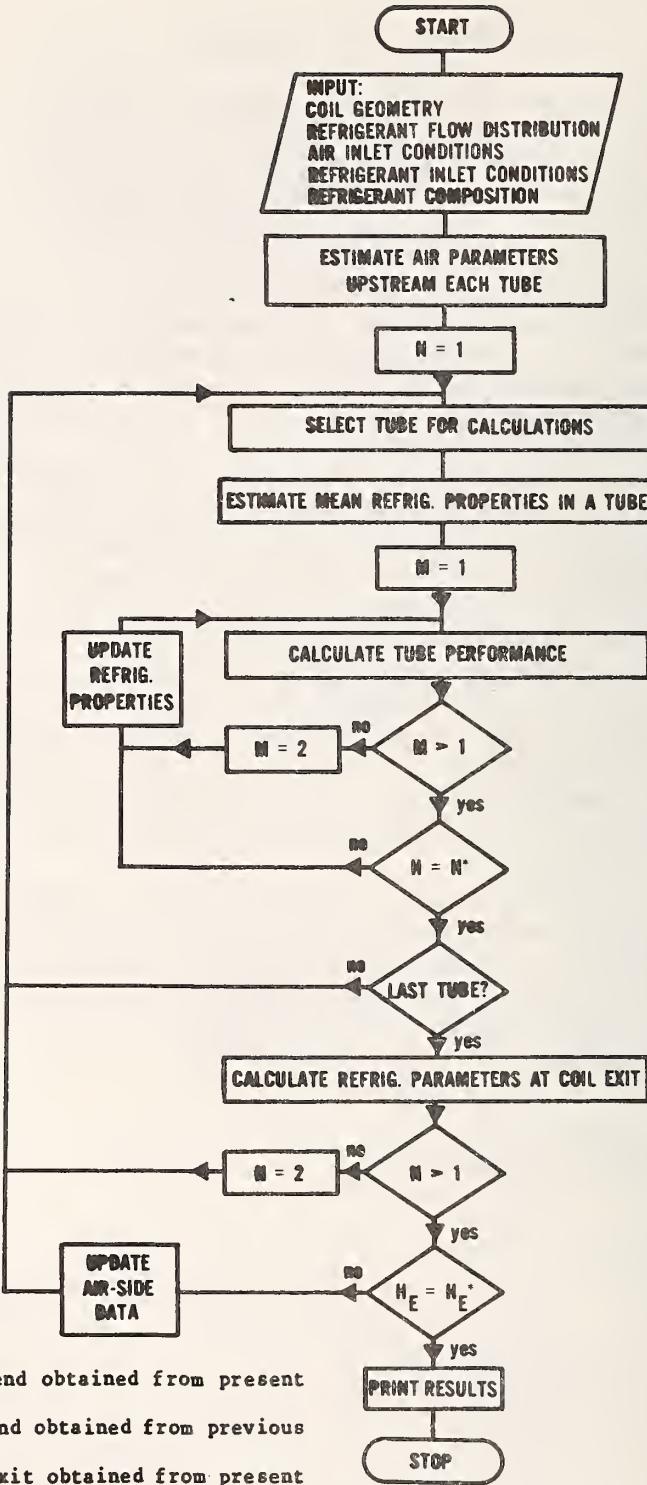
Figure F1. Logic of a constant flow area expansion device simulation program, CAPIL

APPENDIX G. EVAPORATOR AND CONDENSER SIMULATION SUBROUTINES, EVAPHX AND CONDHX

The tube-by-tube approach to coil simulation has been explained in section 5.4 where applicable heat, mass, and momentum transfer equations have also been presented. Though the evaporator and condenser simulation programs require somewhat different heat transfer relations, their logic is the same as shown in figure G1.

The input to coil simulation program are coil design data, refrigerant flow distribution sequence, and air and refrigerant inlet conditions. During the first bank of tubes' performance calculations, the air parameters upstream of each tube row are estimated. The program then computes the heat transer rate and pressure drop tube-by-tube from the inlet to the exit of the coil. Mean refrigerant properties in each tube are used to calculate heat transfer rates and pressure drops applying equations described in section 5.4. An iterative procedure is used for each tube since only refrigerant conditions at tube inlet are known when the calculations begin, and initially the average refrigerant properties in a tube have to be assumed to be those at the inlet conditions. Upstream air temperature and humidity ratio may not be accurately known at the time tube performance is being calculated, so a second iterative loop is used to update air-side data after each loop. It should be realized that, while in the condenser case, update of air-side data means update of air temperature and humidity ratio; for the evaporator it also includes liquid (frost) layer thickness. When refrigerant enthalpy values at the coil exit obtained from two consecutive loops are within the imposed tolerance, the calculations of coil performance are completed and results printed.

Both the evaporator coil simulation model EVAPHX and condenser coil simulation model CONDHX comply with the logic and equations previously described. Input and output data for these programs are detailed in comment statements at the beginning of each subroutine. Other inserted comment statements along with the flow chart (figure G1) facilitate the understanding of both program's organization.



H = refrigerant enthalpy at tube end obtained from present calculation loop
 H^* = refrigerant enthalpy at tube end obtained from previous calculation loop
 H_E = refrigerant enthalpy at coil exit obtained from present calculation loop
 H_E^* = refrigerant enthalpy at coil exit obtained from previous calculation loop

Figure G1. Flow chart for coil performance simulation programs.

APPENDIX H. PROGRAM USER'S GUIDE

H1. General Information

The simulation program of a heat pump charged with a non-azeotropic binary mixture, HPBI, is written in Fortran 77 and makes use of standard Fortran mathematical functions. It is built around the main program, BMAIN, and 65 subprograms for heat pump component simulation, and heat transfer, fluid mechanics, and fluid property calculation. Relations used in the heat pump component simulation subprograms, fluid mechanics, heat transfer and refrigerant property routines are described in the main text of this report. Equations used in moist air, water and frost property routines are described in Appendices A and B.

Tables H1, H2, and H3 list, by categories, all programs used in the heat pump model. Short descriptions of applications are stated in the tables for each program. A listing of all programs is given in Appendix J. A detailed description with specification of input and output parameters is given in the comment statements at the beginning of each program. Comment statements are also located within routines to facilitate understanding of the program organization. Organization of principal program modules is explained in Appendices D, E, F and G.

H2. Input and Output Data Coding

There are five categories of input values for the HPBI runs, namely:

- refrigerant constants
- heat pump data
- run controlling data
- indoor and outdoor air conditions
- refrigerant parameters

H2.1 Refrigerant Constants

Refrigerant constants for evaluation of thermodynamic properties are read into the program by subroutine BCONST from a disc file. File 7 is used in the program for input of these data. Table H4 presents a proper format of refrigerant data file. Comment statements inserted into subroutine BCONST help to identify specific constants.

Refrigerant constants for evaluation of transport properties are contained in function VISCON. Input of these data is not organized through reading of a data file since transport property constants may not have the same format for all mixtures. This may be due to different availability of data as well as different data possibly required by other kinds of mixing rules that could be more applicable for the new mixtures under consideration. Thus, if a new mixture is to be examined, function VISCON has to be redone from the source element.

H2.2 Heat Pump Data

Heat pump data are read into the program by the main program, BMAIN, from a disc file. File 8 is used in the program for input of heat pump data. Coding

of these data is described in Table H5 which includes Fortran symbols with their explanation. An example of a heat pump data file is given in Table H6. Heat pump data include information about each modeled component, i.e., compressor, condenser, expansion device, evaporator, accumulator, four-way valve, vapor line and liquid line. All components with the exception of the compressor and the four-way valve are described by design data only (dimensions, material properties, coil circuitry, etc.). The compressor and the four-way valve simulation also require performance parameters which are derived from test information using subroutines COMPAR and VALVPA, respectively, included in this report (see Appendix E). The subroutines are run by executing the HPBI program and providing appropriate run controlling data, as explained below in this appendix. Heat pump data also include the amount of refrigerant charge. This input is used in simulation runs in which iteration of refrigerant superheat (quality) at the compressor can inlet is required. For determining this input value refer to Chapter 5.6.

H2.3 Run Controlling Data, Indoor and Outdoor Air Conditions, Refrigerant Parameters and Output Data

This category of input data have to be contained in a runstream file or are read from a terminal if simulation run is executed in the interactive mode. They are clearly requested by the program and responses have to be given in a Fortran free format.

The sequence of requests depends on the response to the first request given by the program to determine which one of three possible tasks the user wants the program to perform, i.e.,

1. evaluation of compressor parameters
2. evaluation of four-way valve parameters
3. simulation of heat pump performance

Evaluation of compressor parameters and evaluation of four-way valve parameters has to be done once to generate performance parameters of these components needed as input for simulation of performance of a heat pump system.

Evaluation of Compressor Parameters

The following is the sequence of program requests and explanation of responses for evaluation of compressor parameters:

1. Request: COMPRESSOR PARAMETER (1), FOUR-WAY VALVE PARAMETERS (2)
OR HEAT PUMP PERFORMANCE (3)
Response: 1
2. Request: DETERMINE COMPRESSOR PERFORMANCE PARAMETERS
ENTER: 0 FOR PARTIAL TEST DATA OR 1 FOR FULL TEST DATA =
Response: as explained in the request. Most likely user will not
have detailed compressor test data. Assume then that
response is 0

3. Request: ENTER: ELEFUL, ELEIPT, RPMCP, SWPVOL, RMASS, TOA =
 Response: ELEFUL = compressor motor energy input rate at max. rated load (kW)
 ELEIPT = compressor motor energy input rate at test conditions (kW)
 RPMCP = compressor number of revolution per minute at test (1/min), enter 0 if not measured.
 SWPVOL = total compressor displacement volume per revolution (in³)
 RMASS = refrigerant mass flow rate at test conditions (lb/h)
 TOA = ambient air temperature (F)
4. Request: WEIGHT COMPOSITION OF MIXTURE IN FRACTION OF MORE VOLATILE COMPONENT, XW =
 Response: weight composition (decimal fraction)
5. Request: ENTER: T3, P3 =
 Response: T3 = refrigerant temperature at compressor can inlet (F)
 P3 = refrigerant pressure at compressor can inlet (psia)
6. Request: ENTER: T8, P8 =
 Response: T8 = refrigerant temperature at compressor can inlet (F)
 P8 = refrigerant pressure at compressor can inlet (psia)

At this point, the program will evaluate refrigerant state at key compressor locations and compressor parameters. Output symbols are explained in the comment statements in the beginning of subroutine COMPAR. Note, that evaluation of compressor parameters requires information on standard electric motor characteristic (motor efficiency vs. load and RPM vs. load) that should be contained in the mass storage data file in lines 2, 3, 4, 5 and 6 as explained in Table H5. This file should be assigned to number 8 for program execution.

Evaluation of Four-Way Valve Parameters

The following is the sequence of program requests and explanation of responses for evaluation of four-way valve parameters.

1. Request: COMPRESSOR PARAMETER (1), FOUR-WAY VALVE PARAMTRS (2) OR HEAT PUMP PERFORMANCE (3)
 Response: 2
2. Request: EVALUATION OF FOUR-WAY VALVE PARAMETERS, ENTER: T2, P2,
 T3, P3 =
 Response: T2 = refrigerant temperature at valve low pressure inlet (F)
 P2 = refrigerant pressure at valve low pressure inlet (psia)
 T3 = refrigerant temperature at valve low pressure outlet (F)
 P3 = refrigerant pressure at valve low pressure outlet (psia)

3. Request: ENTER: T8, P8, T9, P9 =
Response: T8 = refrigerant temperature at valve high pressure inlet
(F)
P8 = refrigerant pressure at valve high pressure inlet
(psia)
T9 = refrigerant temperature at valve high pressure
outlet (F)
P9 = refrigerant pressure at valve high pressure outlet
(psia)

4. Request: ENTER: RMASS, XW =
Response: RMASS = refrigerant mass flow rate at test conditions
(lb/h)
XW = refrigerant weight composition (decimal fraction
of the more volatile component)

At this point, the program will evaluate the four-way valve pressure drop parameter, CPD, and heat transfer parameter, CQ. (All output symbols are explained in the comment statements in the beginning of subroutine VALVPA.) Parameters CPD and CQ are to be included in heat pump data file in line 10 as explained in Table H5.

Simulation of Heat Pump Performance

Simulation of heat pump performance is the ultimate purpose of the program HPBI. Once the heat pump data file is completed with the compressor and four-way valve performance parameters, simulation runs of heat pump performance can be conducted for a full range of operating conditions in the heating and cooling mode.

The following is the sequence of program requests and explanation of responses for the heat pump performance simulation run:

1. Request: COMPRESSOR PARAMETERS (1), FOUR-WAY VALVE PARAMETERS (2)
Response: 3
 2. Request: ANSWER 1 FOR YES OR 0 FOR NO
DO YOU WANT ANY INPUT DATA PRINTED? LPF =
Response: 0 for no input data print
or
1 for input data printout (request for specification of
desired data will follow)
 3. Request: OUTDOOR AND INDOOR AIR CONDITIONS, POA, TOA, RHOA, PRA,
TRA, RHRA = ?
Response: POA = outside air pressure (psia)
TOA = outside air temperature (F)
RHOA = outside air relative humidity (decimal fraction)
PRA = indoor air pressure (psia)
TRA = indoor air temperature (F)
RHRA = indoor air relative humidity (decimal fraction)
 4. Request: NSYS = 1 FOR HEATING, NSYS = 2 FOR COOLING, NSYS = ?
Response: as explained in the request

5. Request: IS ITERATION OF SUPERHEAT/QUALITY REQUESTED?
ITER = 0 FOR NO, ITER = 1 FOR YES, ITER = ?
Response: as explained in the request
6. Request: IS ITERATION OF CIRCULATING COMPOSITION REQUESTED?
ITERXW = 0 FOR NO, ITERXW = 1 FOR YES, ITERXW?
Response: as explained in the request
7. Request: COMPOSITION OF CHARGED REFRIGERANT =
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
Response: as explained in the request (decimal fraction)
8. Request: COMPOSITION OF CIRCULATING REFRIGERANT =
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
Response: as explained in the request (decimal fraction)
9. Request: REFRIGERANT STATE ESTIMATES: TG3, X3, TSUP3, TG6
Response: TG3 = dew point temperature of refrigerant at the
compressor can inlet (F)
X3 = refrigerant quality at the compressor can inlet
(decimal fraction)
TSUP3 = refrigerant superheat at the compressor can inlet
(F)
TG6 = dew point temperature of refrigerant vapor in
compressor cylinder after compression
(all above values are estimates, subject to iteration)

At this point, the program starts to iterate the refrigerant thermodynamic states at heat pump key locations following the logic explained in Appendix D. Once a solution is obtained the results are printed in the format shown in a printout of an example run (Appendix I).

The output data consist of refrigerant thermodynamic states at 13 key heat pump locations, identified on figure 4, along with results describing the heat pump performance. Symbols used for output data have the following meaning:

T,P,H,S,X	refrigerant temperature (F), pressure (psia), enthalpy (Btu/lb), entropy, (Btu/(1b ° F)), quality (decimal fraction)
COP	coefficient of performance (-)
ELUSE	total heat pump energy consumption rate (kW)
QLOAD	net capacity of the heat pump (Btu/h)
RMASS	refrigerant mass flow rate (lb/h)
TMASS	refrigerant charge (lb)
TG3	refrigerant dew point temperature at compressor can inlet

TG6 refrigerant dew point temperature at compressor delivery valve (F)

TSUP3 refrigerant superheat at compressor can inlet (F)

The last three output data TG3, TG6, and TSUP3 are final values iterated from TG3, TG6, and TSUP3 supplied as estimated input values.

It should be noted that the program prints the above results every time the enthalpy loop and pressure loop are closed, and proceeds with further calculations until the mass inventories of the mixture and one of mixture components are satisfied. The final results in the printout are the requested heat pump performance data at the imposed operating conditions.

Table H1. Refrigerant Property Single Precision Functions and Subroutines

NAME	PURPOSE
BUBPRE	Calculate bubble point pressure from a given composition and temperature.
BUBTEM	Calculate bubble point temperature from a given composition and pressure.
DEWPRE	Calculate dew point pressure from a given composition and temperature.
DEWTEM	Calculate dew point temperature from a given composition and pressure.
EBUBPR	Estimate bubble point pressure from a given composition and temperature.
EBUBTE	Estimate bubble point temperature from a given composition and pressure.
ENTROP	Calculate specific entropy of refrigerant being in a single phase from given composition, temperature and specific volume.
ENTRO2	Calculate specific entropy from given composition, temperature and pressure.
EQPAR	Calculate parameters for the equation of state.
ESVOL	Estimate specific volume of liquid or vapor from given composition, temperature and pressure
FGIBBS	Calculate Gibbs free energy
HCVCP	Calculate enthalpy, specific heat at constant volume and specific heat at constant pressure from given composition, temperature, and specific volume.
HPAR	Calculate parameters for calculation of specific enthalpy, specific heat at constant volume, specific heat at constant pressure and specific entropy.
HPIN	Calculate temperature from given composition, enthalpy and pressure.
HPPROP	Calculate thermodynamic and transport properties from given composition, pressure and enthalpy.
PXQIN	Calculate temperature of two-phase refrigerant from given composition, pressure and quality.
PXQIN2	Calculate temperature and enthalpy of two-phase refrigerant from given composition, pressure and quality.
QLITY	Calculate quality of R13B1/R152a mixture from given composition, temperature and pressure.
SATCOM	Calculate pressure, specific volume of liquid and specific volume of vapor of mixture pure components at saturation from given temperature.
SPIN	Calculate temperature from given composition, entropy, and pressure.
SATLIB	Estimate saturation pressure, specific volume of liquid and specific volume of vapor at given temperature for pure components.
TPPROP	Calculate specific enthalpy, specific volume and quality from given composition, temperature and pressure.
TXQIN	Calculate pressure of two phase refrigerant from given composition, temperature, and quality.

TXQIN2	Calculate pressure and specific enthalpy of two-phase refrigerant from given composition, temperature and quality.
VISCON	Calculate absolute viscosity and thermal conductivity of liquid or vapor and specific heat of saturated liquid of R13B1/R152a mixture from given composition and temperature.
VOLIT1	Calculate specific volume from given composition, temperature and pressure.

Table H2. Refrigerant Property Double Precision Function and Subroutines

NAME	PURPOSE
DBUBTE	as BUBTEM (Table H1)
DDEWTE	as DEWTEM (Table H1)
DENTRO	as ENTROP (Table H1)
DH	Calculate specific enthalpy from given composition, temperature and specific volume.
DQLITY	as QLITY (Table H1)
DVOL1	as VOLIT1 (Table H1)

Table H3. Functions and Subroutines for Heat Pump Component Simulation, Heat Transfer and Fluid Mechanics Calculations

NAME	PURPOSE
AIRHT	Calculate finned tube air-side heat transfer coefficient.
AIRPR	Calculate air properties.
BCONST	Read refrigerant constants for equation of state.
BIMASS	Calculate mass of refrigerant in a coil.
BLINE	Calculate frictional pressure drop in a liquid line.
BMAIN	Main program, solution logic contained.
BPMASS	Calculate mass of refrigerant in a tube.
BSIMP	Integrate numerically using Simpson's 1/3 Rule.
CAPIL	Simulate performance of a constant flow area expansion device.
CHOKE	Calculate the thermodynamic critical pressure for a non-azeotropic mixture in two-phase Fanno flow.
COMPAR	Evaluate compressor parameters.
COMPRE	Simulate compressor performance.
CONDHX	Simulate condenser performance.
DDENFA	Calculate refrigerant density for two-phase Fanno flow (double precision).
DFANNO	Calculate refrigerant entropy for two-phase Fanno flow (double precision).
DPDYN1	Calculate dynamic pressure drop for a single-phase flow in a tube.
DPDYN2	Calculate dynamic pressure drop for a two-phase flow in a tube.
EVAPHX	Simulate evaporator performance.
EVDP	Calculate frictional evaporation pressure drop.
FINEFF	Calculate fin efficiency.
FEELIQ	Calculate Lockhart-Martinelli correction factor for two-phase pressure drop.
HTCCON	Calculate condensation heat transfer coefficient.
HTCEV	Calculate evaporation heat transfer coefficient.
HXCODE	Determine refrigerant and air flow distribution in a tube.
MVAL4	Simulate four-way valve performance.
OVLHTC	Calculate overall heat transfer coefficient for a dry finned tube.
OVLWET	Calculate overall heat transfer coefficient for a wet finned tube.
PFLASH	Calculate flashing pressure and temperature for a Fanno flow.
PIPE	Simulate flow through a tube.
SPHDP1	Calculate frictional single-phase pressure drop in a tube.
SPHTC	Calculate single-phase heat transfer coefficient in a tube.
VALVPA	Calculate four-way valve parameters.
WACCUM	Calculate mass of refrigerant in accumulator.
WATPR	Calculate water properties.

Table H4. Data File Containing Constants for Evaluation of Thermodynamic Properties of R13B1/R152a Mixture

```
1 25.4145, -0.063368, 4.140051E-05
2 0.1353977, -1.50409E-04, -1.354434E-07
3 27.392729669, -0.0594211671, 3.317695607E-5
4 0.1239878, -1.445514007E-4, -1.90223806E-8
5 0.1466, -2.241E-04
6 148.93, 66.05
7 340.15, 386.65
8 10.0522804, -2204.5632, 9636.5313
9 -0.05060051, 1.1455764E-03, -2.56392871E-06
10 0.2749422, -1.702569E-03, 3.71008313E-06
11 10.6410518, -2642.8994, 460.87585
12 0.0218192958, 5.416820778E-04, -1.24731336E-06
13 0.1023688715, -4.0752759E-04, 1.0409447E-06
```

Table H5. Heat Pump Input Data Code to Program HPBI

All input data are in FORTRAN free field input format with data values on the same line separated by commas.

Line 1: ATITLE
 ATITLE = title, maximum 80 characters

Line 2: EMETA(I), I = 1,5
 EMETA(I) = compressor motor efficiency in fraction at fraction of full load specified by EMOPT(I), I = 1,5 (-)

Line 3: EMETA(I), I = 6,11
 EMETA(I) = compressor motor efficiency in fraction at fraction of full load specified by EMOPT(I), I = 6,11 (-)

Line 4: EMOPT(I), I = 1,5
 EMOPT(I) = compressor motor full load fraction (decimal fraction)

Line 5: EMOPT(I), I = 6,11
 EMOPT(I) = compressor motor full load fraction (decimal fraction)

Line 6: EMRPM(I), I = 1,6
 EMRPM(I) = coefficient for compressor motor RPM calculations (-)

Line 7: ELEFUL, SWPVOL, ETALPY, CLREFF
 ELEFUL = compressor motor energy input rate at max. rated load (kW)
 SWPVOL = compressor displacement volume per revolution (in^3)
 ETALPY = compressor polytropic efficiency (-)
 CLREFF = compressor clearance volume as fraction of displacement volume (-)

Line 8: CPC34, CPC45, CPC67, CPC78
 CPC34 = pressure drop parameter at compressor can inlet
 $((\text{lbf} \cdot \text{h}^2) / (\text{lb} \cdot \text{in}^2 \cdot \text{ft}^3))$
 CPC45 = pressure drop parameter at compressor suction valve
 $((\text{lbf} \cdot \text{h}^2) / (\text{lb} \cdot \text{in}^2 \cdot \text{ft}^3))$
 CPC67 = pressure drop parameter at compressor discharge valve
 $((\text{lbf} \cdot \text{h}^2) / (\text{lb} \cdot \text{in}^2 \cdot \text{ft}^3))$
 CPC78 = pressure drop parameter at compressor can exit
 $((\text{lbf} \cdot \text{h}^{2.2}) / (\text{lb} \cdot \text{in}^2 \cdot \text{ft}^{2.8}))$

Line 9: CQC4C, CQCCOA, CQC45, CQC67, CQC78
 CQC4C = parameter for compressor can wall - refrigerant vapor heat transfer ($\text{ft}^{0.2}$)
 CQCCOA = parameter for compressor can - ambient air heat transfer ($\text{Btu/h} \cdot \text{F}^{1.333}$)
 CQC45 = suction valve heat transfer parameter ($\text{ft}^{0.2}$)
 CQC67 = discharge valve heat transfer parameter ($\text{ft}^{0.2}$)
 CQC78 = heat transfer parameter at can exit ($\text{ft}^{0.2}$)

Line 10: CQ, CPDR, VCAN, REFIN
 CQ = parameter for 4-way valve heat transfer ($\text{ft}^{0.2}$)
 CPDR = pressure drop parameter for a 4-way valve ($\text{lbf} \cdot \text{h}^2 / (\text{lb} \cdot \text{in}^2 \cdot \text{ft}^3)$)
 VCAN = volume of compressor can filled by liquid (ft^3)
 REFIN = refrigerant charge (lb)

Line 11: AHGT, DACC, DHOLE(1), DHOLE(2), DTUBE, HDIS
 AHGT = distance between accumulator top and oil return hole (ft)
 DACC = inner diameter of accumulator (ft)
 DHOLE(1) = diameter of oil return hole (ft)
 DHOLE(2) = diameter of upper hole in accumulator tube (ft)

DTUBE = diameter of accumulator tube (ft)
 HDIS = vertical distance between holes in accumulator tube (ft)
Line 12:
 NDEP(1), NROW(1)
 NDEP(1) = number of indoor coil tube depth rows (-)
 NROW(1) = number of tubes per indoor coil depth row (-)
Line 13:
 DI(1), DO(1), DT(1), RPCH(1), DPCH(1), WIDTH(1)
 DI(1) = inner diameter of indoor coil tubes (in)
 DO(1) = outer diameter of indoor coil tubes (in)
 DT(1) = indoor coil fin tip diameter (in) (refer to figure 21)
 RPCH(1) = pitch between tubes of the same depth row in indoor coil
 (in)
 DPCH(1) = pitch for indoor coil tube depth rows (in)
 WIDTP9H(1) = indoor coil width (equal tube length) (in)
Line 14:
 FPCH(1), FTK(1), FMK(1), TMK(1), AMAS(1)
 FPCH(1) = indoor coil fin pitch (in)
 FTK(1) = indoor coil fin thickness (in)
 FMK(1) = indoor coil fin material thermal conductivity
 (Btu/(ft · h · F))
 TMK(1) = indoor coil tube material thermal conductivity
 (Btu/ft · h · F))
 AMAS(1) = air mass flow rate through indoor coil (lb/h)
Line 15:
 CONST(1), CPOW(1), ANGLE(1)
 CONST(1) = constant for air side heat transfer correlation for
 indoor coil equal to 0.134 (-)
 CPOW(1) = constant for air side heat transfer correlation for
 indoor coil equal to 0.681 (-)
 ANGLE(1) = angle between indoor coil face and air streamlines (rad)
Line 16:
 EIDFAN
 EIDFAN = indoor fan energy input rate (kW)
Line 17:
 NREPTI
 NREPTI = number of repeating sections in indoor coil (-)
Line 18:
 NTUBE(1,I) I = 1,5
 NTUBE(1,1) = number of tubes in first row in each section of indoor
 coil (-)
 NTUBE(1,2) = number of tubes in second row in each section of
 indoor coil (-)
 NTUBE(1,3) = number of tubes in third row in each section of indoor
 coil (-)
 NTUBE(1,4) = number of tubes in fourth row in each section of
 indoor coil (-)
 NTUBE(1,5) = number of tubes in fifth row in each section of
 indoor coil (-)
Line 19:
 IFROM(1,I), I = 1,10
 IFROM(1,1) = number of tube of indoor coil from which tube 1
 receives refrigerant when indoor coil works as
 evaporator (-)
 IFROM(1,2) = number of tube of indoor coil from which tube 2
 receives refrigerant when indoor coil works as
 evaporator (-)
 IFROM(1,3) =
 IFROM(1,9) =
 IFROM(1,10) = number of tube of indoor coil from which tube 10
 receives refrigerant when indoor coil works as
 evaporator (-)

Line 20: IFROM(1,I), I = 11,20
 IFROM(1,I) = number of tube of indoor coil from which tube I receives refrigerant when indoor coil works as evaporator (-)

Line 21: IFROM(1,I), I = 21,30
Line 22: IFROM(1,I), I = 31,40
Line 23: IFROM(1,I), I = 41,50
Line 24: IFROM(1,I), I = 51,60
Line 25: IFROM(1,I), I = 61,70
Line 26: IFROM(1,I), I = 71,80
Line 27: IFROM(1,I), I = 81,90
Line 28: IFROM(1,I), I = 91,100
Line 29: IFROM(1,I), I = 101,110
Line 30: IFROM(1,I), I = 111,120
Line 31: IFROM(1,I), I = 121,130
 IFROM(1,I) = number of tube of indoor coil from which tube I receives refrigerant when indoor coil works as evaporator (-)

Line 32: NDEP(2), NROW(2)
 NDEP(2) = number of outdoor coil tube row depths (-)
 NROW(2) = number of tubes per outdoor coil depth row (-)

Line 33: DI(2), DO(2), DT(2), RPCH(2), DPCH(2), WIDTH(2)
 DI(2) = inner diameter of outdoor coil tubes (in)
 DO(2) = outer diameter of outdoor coil tubes (in)
 DT(2) = outdoor coil fin tip diameter (in) (refer to figure 21)
 RPCH(2) = pitch between tubes of the same depth in outdoor coil (in)
 DPCH(2) = pitch between tube depth rows for outdoor coil (in)
 WIDTH(2) = outdoor coil width (equal tube length) (in)

Line 34: FPCH(2), FTK(2), FMK(2), TMK(2), AMAS(2)
 FPCH(2) = outdoor coil fin pitch (in)
 FTK(2) = outdoor coil fin thickness (in)
 FMK(2) = outdoor coil fin material thermal conductivity (Btu/(ft · h · F))
 TMK(2) = outdoor coil tube material thermal conductivity (Btu/(ft · h · F))
 AMAS(2) = air mass flow rate through outdoor coil (lb/h)

Line 35: CONST(2), CPOW(2), ANGLE(2)
 CONST(2) = constant for air side heat transfer correlation for outdoor coil equal to 0.134 (-)
 CPOW(2) = constant for air side heat transfer correlation for outdoor coil equal to 0.681 (-)
 ANGLE(2) = angle between outdoor coil face and air streamlines (rad)

Line 36: EIDFAN
 EIDFAN = outdoor fan energy input rate (kW)

Line 37: NREPTO
 NREPTO = number of repeating sections in outdoor coil (-)

Line 38: NTUBE(2,I), I = 1,5
 NTUBE(2,1) = number of tubes in first row in each section of outdoor coil (-)
 NTUBE(2,2) = number of tubes in second row in each section of outdoor coil (-)
 NTUBE(2,3) = number of tubes in third row in each section of outdoor coil (-)

NTUBE(2,4) = number of tubes in fourth row in each section of
 outdoor coil (-)
 NTUBE(2,5) = number of tubes in fifth row in each section of
 outdoor coil (-)

Line 39: IFROM(2,I), I = 1,10
 IFROM(2,1) = number of tube of outdoor coil from which tube 1
 receives refrigerant when outdoor coil works as
 evaporator (-)
 IFROM(2,2) = number of tube of outdoor coil from which tube 2
 receives refrigerant when outdoor coil works as
 evaporator (-)
 IFROM(2,3) =
 .
 .
 .
 IFROM(2,9) =
 IFROM(2,10) = number of tube of outdoor coil from which tube 10
 receives refrigerant when outdoor coil works as
 evaporator (-)

Line 40: IFROM(2,I), I = 11,20
 IFROM(2,I) = number of tube of outdoor coil from which tube I
 receives refrigerant when outdoor coil works as
 evaporator (-)

Line 41: IFROM(2,I), I = 21,30
Line 42: IFROM(2,I), I = 31,40
Line 43: IFROM(2,I), I = 41,50
Line 44: IFROM(2,I), I = 51,60
Line 45: IFROM(2,I), I = 61,70
Line 46: IFROM(2,I), I = 71,80
Line 47: IFROM(2,I), I = 81,90
Line 48: IFROM(2,I), I = 91,100
Line 49: IFROM(2,I), I = 101,110
Line 50: IFROM(2,I), I = 111,120
Line 51: IFROM(2,I), I = 121,130
 IFROM(2,I), = number of tube of outdoor coil from which tube I
 receives refrigerant when outdoor coil works as
 evaporator (-)

Line 52: CAPID1, CAPL1, NCPL1, CAPID2, CAPL2, NCPL2
 CAPID1 = inner diameter of cooling operation expansion device (in)
 CAPL1 = length of cooling operation expansion device (in)
 NCPL1 = number of cooling operation expansion devices (-)
 CAPID2 = inner diameter of heating operation expansion device (in)
 CAPL2 = length of heating operation expansion device (in)
 NCPL2 = number of heating operation expansion devices (-)

Line 53: YL, YD, YK1, YD1, YK2, YD2
 YL = length of compressor-outdoor coil tubing (in)
 YD, inner diameter of compressor-outdoor coil tubing (in)
 YK1 = thermal conductivity of compressor-outdoor coil tubing
 material (Btu/(ft · h · F))
 YD1 = outer diameter of compressor-outdoor coil tubing (in)
 YK2 = thermal conductivity of compressor-outdoor coil tubing
 insulation (Btu/(ft · h · F))
 YD2 = outer diameter of compressor-outdoor coil tubing insulation
 (Btu/(ft · h · F))

Line 54: RL, RD, RK1, RD1, RK2, RD2
RL = length of compressor-indoor coil tubing (in)
RD = inner diameter of compressor-indoor coil tubing (in)
RK1 = thermal conductivity of compressor-indoor coil tubing material (Btu/(ft · h · F))
RD1 = outdoor diameter of compressor-indoor coil tubing (in)
RK2 = thermal conductivity of compressor-indoor coil tubing insulation (Btu/(ft · h · F))
RD2 = outer diameter of compressor-outdoor coil tubing insulation (Btu/(ft · h · F))

Line 55: RYL, RYD
RYL = liquid line length (in)
RYD = liquid line diameter (in)

Note on coil input data:

The coil depth is in the direction perpendicular to a coil surface facing the incoming air. Lines 19-31 and 39-51: tubes are numbered consecutively from the first tube in the first row (facing incoming air) to the last tube in the last row. Enter 0 (zero), if considered tube receives refrigerant from coil inlet port; enter 999, if the tube is nonexistent.

Table H6. Example of a Heat Pump Data File

```

1 ***SYST4 WITH ACCUM., 13B1/152A 6-22-84***
2 3.9,3.64,0.706,0.06315
3 0.2076,0.3490,0.5665,0.6803,0.7238
4 0.7523,0.7712,0.7821,0.7900,0.7929,0.7940
5 0.05,0.1,0.2,0.3,0.4
6 0.5,0.6,0.7,0.8,0.9,1.0
7 3578.,-36.01,-39.0558,22.2747,-40.9712,14.7620
8 5.266E-7,1.504E-5,3.603E-4,1.173E-4
9 10.16,5.279,0.2060,0.2027,2.893
10 0.968,4.47E-5,0.104,5.082
11 0.92,0.42,0.0029,0.0033,0.0625,0.27
12 4,36
13 0.311,0.375,1.056,1.,0.875,18.
14 0.068,0.008,118.,223.,5000.
15 0.134,0.681,1.13
16 0.485
17 2
18 18,18,18,18,0
19 2,3,4,5,6,7,69,9,10,11
20 12,13,14,33,0,15,16,17,1,19
21 20,21,22,23,24,8,26,27,28,29
22 30,31,51,35,53,18,38,39,40,41
23 42,61,25,45,46,47,48,49,68,32
24 52,34,71,36,37,55,56,57,58,59
25 43,44,62,63,64,65,66,50,70,52
26 72,54,999,999,999,999,999,999,999,999,999
27 999,999,999,999,999,999,999,999,999,999
28 999,999,999,999,999,999,999,999,999,999
29 999,999,999,999,999,999,999,999,999,999
30 999,999,999,999,999,999,999,999,999,999
31 999,999,999,999,999,999,999,999,999,999
32 3,20
33 0.311,0.375,1.338,1.25,1.125,40.
34 0.075,0.008,118.,223.,10700.
35 0.134,0.681,1.52
36 0.380
37 1
38 20,20,20,0,0
39 21,1,2,3,6,7,8,48,0,9
40 12,10,33,13,14,15,18,19,20,40
41 41,43,44,44,24,46,28,49,50,11
42 11,52,34,55,56,54,36,58,59,60
43 42,22,23,45,27,25,26,47,29,30
44 31,51,32,53,35,57,37,37,38,39
45 999,999,999,999,999,999,999,999,999,999
46 999,999,999,999,999,999,999,999,999,999
47 999,999,999,999,999,999,999,999,999,999
48 999,999,999,999,999,999,999,999,999,999
49 999,999,999,999,999,999,999,999,999,999
50 999,999,999,999,999,999,999,999,999,999
51 999,999,999,999,999,999,999,999,999,999
52 0.08202,0.5,1,0.09,0.5,1
53 192.,0.68,223.,0.75,0.05,1.5
54 36.,0.68,223.,0.75,0.,0.
55 312.,0.249

```


APPENDIX I. EXAMPLE OF RUN OF THE PROGRAM HPBI

The following is a computer printout for a HPBI run in which performance of a heat pump in the heating mode was simulated. Input for this run was as follows:

- refrigerant data - as shown in Table H4
- heat pump data - as shown in Table H6
- run controlling data, operating conditions, estimated refrigerant parameters - as shown on the printout (lines 4-36).

The results of this run are included in Table 5.

The solution was iterated in two loops iterating composition of the circulating refrigerant (lines 39-2592 and 2593-4762). The second loop required eight internal loops in which the total refrigerant mass conservation was sought (TMASS = REFIN). The run required 33 minutes of CPU on a Sperry 1100/82 computer.

WEBER*PRT47(1) 1 @XQT O\$Q\$*Q\$*DOMANSKI.HPBI

```

1 COMPRESSOR PARAMETERS(1), FOUR WAY VALVE PARAMETERS(2)
2 OR HEAT PUMP PERFORMANCE(3), IPTP=
3
4
5 ANSWER 1 FOR YES OR 0 FOR NO
6 DO YOU WANT ANY INPUT DATA PRINTED ? LPR=
7 0
8
9
10
11 OUTDOOR & INDOOR AIR CONDITIONS
12
13 PQA, TOA, RHQA, FRA, TRA, RHRA?
14 14.7,47.,0.73,14.7,70.,0.56
15
16 NSYS=1 FOR HEATING, NSYS=2 FOR COOLING MODE
17
18 IS ITERATION OF SUPERHEAT/QUALITY REQUESTED ?
19 ITER=0 FOR NO, ITER=1 FOR YES, ITER=
20 1
21
22 IS ITERATION OF MIXTURE COMPOSITION REQUESTED ?
23 ITERXW=0 FOR NO, ITERXW=1 FOR YES, ITERXW=
24 1
25
26 COMPOSITION OF CHARGED REFRIGERANT =
27 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
28 .65
29
30 COMPOSITION OF CIRCULATING REFRIGERANT =
31 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
32 .65
33
34 REFRIGERANT STATE GUESSES: TG3,X3,TSUP3,TG6=
35 33.,1.,0.,110.
36
37
38 INPUT DATA TO CONFIR:
39
40 P3
41 6.697+001 T3
42 3.300+001 H3
43
44 COMPRESSOR ITERATION:
45 E1
46 2.663+000 ETAE
47 7.552-001 ETAC
48
49 1 T
50 1 3.828+001 7.458+001 H
51 2 3.765+001 7.372+001 8.773+001 X
52 3 3.300+001 6.697+001 8.929+001
53 4 6.935+001 6.698+001 9.536+001
54 5 7.345+001 6.404+001 9.606+001
55 6 1.808+002 2.343+002 1.097+002
56 7 1.738+002 2.118+002 1.090+002
57 8 1.553+002 2.107+002 1.055+002

```

58 9 1.475+002 2.081+002 1.040+002 1.000+000
 59 10 1.468+002 2.080+002 1.038+002 1.000+000
 60
 61 INPUT DATA TO CONDHN:
 62 T P TAIR RH RMASS:
 63 1.468+002 2.080+002 7.000+001 5.500-00: 4.827+002
 64 H2, H2FH2= 40.91 .01
 65 H2, H2PH2= 41.12 -.21
 66 H2, H2RH2= 41.38 -.26
 67 H2, H2PH2= 41.52 -.13
 68 H2, H2RH2= 41.59 -.07
 69 H2, H2PH2= 41.62 -.03
 70 H2, H2RH2= 41.63 -.01
 71
 72
 73 CONDENSER ITERATION:
 74
 75 T P H X
 76 1.468+002 2.080+002 1.038+002 1.000+000
 77 8.412+001 1.962+002 4.163+001 1.369-001
 78
 79
 80 LIQUID LINE:
 81 INPUT - PIN = 1.962+002 TIN = 8.412+001 XIN = 1.369-001
 82 OUTPUT - POUT = 1.779+002 TOUT = 7.737+001 XOUT = 1.692-001
 83
 84
 85 EXPANSION DEVICE:
 86 INPUT - P12 = 1.779+002 H12 = 4.163+001 P13 = 8.258+001
 87 OUTPUT - POUT = 1.221+002 XMASS = 3.186+002
 88
 89 INPUT DATA TO CONPR:
 90
 91 P3 T3 H3 XQ3 TG6 TRA TGA:
 92 6.697+001 3.300+001 8.929+001 1.000+000 1.125+002 7.300+001 4.700+001
 93
 94 CO:IPRESSOR ITERATION:
 95
 96 EI ETAE ETAC ETAV CPRPN RMASS:
 97 2.719+000 7.576-001 9.483-001 8.580-001 3.549+003 4.796+002
 98
 99 I T P H X
 100 1 3.820+001 7.448+001 8.772+001 9.766-001
 101 2 3.758+001 7.263+001 3.767+001 9.768-001
 102 3 3.300+001 6.657+001 8.923+001 1.000+000
 103 4 7.069+001 6.688+001 9.548+001 1.000+000
 104 5 7.437+001 6.410+001 9.620+001 1.000+000
 105 6 1.849+002 2.426+002 1.103+002 1.000+000
 106 7 1.781+002 2.212+002 1.096+002 1.000+000
 107 8 1.597+002 2.202+002 1.059+002 1.000+000
 108 9 1.511+002 2.177+002 1.043+002 1.000+000
 109 10 1.503+002 2.176+002 1.042+002 1.000+000
 110
 111 INPUT DATA TO CONDHN:
 112
 113 T P TAIR RH RMASS:
 114 1.503+002 2.176+002 7.000+001 5.600-001 4.796+002
 115 H2, H2RH2= 35.34 -.62

116 H₂, H₂P_{H2}= 35.44 -.10
 117 H₂, H₂PH₂= 35.92 -.48
 118 H₂, H₂PH₂= 36.09 -.17
 119 H₂, H₂PH₂= 36.17 -.08
 120 H₂, H₂PH₂= 36.21 -.03
 121 H₂, H₂PH₂= 36.23 -.03
 122 H₂, H₂PH₂= 36.25 -.01
 123
 124 CONDENSER ITERATION:
 125 T P H X
 126 1.503+002 2.176+002 1.042+002 1.000+000
 127 8.739+001 2.089+002 3.525+001 5.999-001
 128
 129
 130 LIQUID LINE:
 131 INPUT - PIN = 2.039+002 TIN = 8.739+001 XIN = 5.989-003 HIN = 3.625+001
 132 OUTPUT - POUT = 2.025+002 TOUT = 8.515+001 XOUT = 1.841-002
 133
 134
 135 EXPANSION DEVICE:
 136 INPUT - P12 = 2.025+002 H12 = 3.625+001 P13 = 8.248+001
 137 OUTPUT - POUT = 1.540+002 XM_{ASS} = 4.513+002
 138
 139
 140 INPUT DATA TO COMPR:
 141 P3 T3 H3 XQ3 TGS TRA TOA
 142 6.697+001 3.300+001 8.929+001 1.000+000 1.130+002 7.000+001 4.700+001
 143
 144
 145 COMPRESSOR ITERATION:
 146 E1 ETAE ETAC ETAV CPRFM RMASS
 147 2.730+000 7.581-001 9.430-001 8.572-001 3.549+003 4.790+002
 148
 149
 150
 151 1 T P H X
 152 2 3.813+001 7.446+001 8.771+001 9.765-001
 153 3 3.757+001 7.362+001 8.766+001 9.767-001
 154 4 3.300+001 6.697+001 8.929+001 1.000+000
 155 5 7.087+001 6.638+001 9.551+001 1.000+000
 156 6 7.453+001 6.411+001 9.624+001 1.000+000
 157 7 1.857+002 2.143+002 1.104+002 1.000+000
 158 8 1.790+002 2.232+002 1.097+002 1.000+000
 159 9 1.605+002 2.222+002 1.060+002 1.000+000
 160 10 1.519+002 2.197+002 1.044+002 1.000+000
 161
 162 INPUT DATA TO CONDHX:
 163 T P TAIR RH
 164 1.511+002 2.196+002 7.000+001 5.600-001 R_H
 165 H₂, H₂PH₂= 31.33 -.01
 166 H₂, H₂PH₂= 34.52 -.19
 167 H₂, H₂PH₂= 35.10 -.58
 168 H₂, H₂PH₂= 35.35 -.25
 169 H₂, H₂PH₂= 35.40 -.05
 170 H₂, H₂PH₂= 35.41 -.01
 171
 172
 173 CONDENSER ITERATION:

174
 175 T 1.511+002 P 2.196+002 H .C42+002 X .000+000
 176 8.528+001 2.116+002 3.541+001 .000
 177
 178
 179
 180 LIQUID LINE:
 181 INPUT - PIN = 2.116+002 TIN = 8.528+001 XIN = .000
 182 OUTPUT - POUT= 2.061+002 TOUT= 8.525+001 XOUT= .000
 183
 184 EXPANSION DEVICE:
 185 INPUT - P12 =2.061+002 H12 =3.541+001 P13 =8.246+001
 186 OUTPUT - POUT =1.593+002 XMASS =4.802+002
 187
 188
 189 INPUT DATA TO EVAPHX:
 190 T P X TAIR RH RMASS
 191 2.834+001 8.246+001 2.548-001 4.700+001 7.300-001 4.790+002
 192 H2= 92.6812
 193 H2= 92.6334
 194 QT,QS= 2.739+004 1.894+004!
 195
 196
 197 EVAPORATOR ITERATION:
 198 T P H X TSUP
 199 2.834+001 8.246+001 3.541+001 2.548-001
 200 4.672+001 4.255+001 9.259+001 1.000+000 3.659+001
 201
 202
 203 INPUT DATA TO EVAPHX:
 204 T P X TAIR RH RMASS
 205 4.742+001 1.144+002 1.799-001 4.700+001 7.300-001 4.790+002
 206 H2= 37.7119
 207 H2= 37.0321
 208 H2= 36.8217
 209 QT,QS= 6.995+002 6.994+002
 210
 211
 212 EVAPORATOR ITERATION:
 213 T P H X TSUP
 214 4.742+001 1.144+002 3.541+001 1.799-001
 215 4.645+001 1.119+002 3.037+001 2.110-001 .000
 216
 217
 218 INPUT DATA TO EVAPHX:
 219 T P X TAIR RH RMASS
 220 3.770+001 9.715+001 2.190-001 4.700+001 7.300-001 4.790+002
 221 H2= 85.2274
 222 H2= 77.3103
 223 H2= 75.9524
 224 QT,QS= 1.942+004 1.851+004
 225
 226
 227 EVAPORATOR ITERATION:
 228 T P H X TSUP
 229 3.770+001 9.715+001 3.541+001 2.190-001 4.700+001 7.300-001 .000
 230 3.915+001 8.021+001 7.596+001
 231

232
 233 INPUT DATA TO EVAPHX:
 234
 235 T P X TAIR RH
 236 3.580+001 9.403+001 2.264-001 4.700+001 7.300-001 RMASS
 237 H2= 91.0432
 238 H2= 89.3155
 239 H2= 87.1500
 240 H2= 87.0712
 241 H2= 86.9629
 242 QT, QS= 2.470+001 2.147+004
 243
 244 EVAPORATOR ITERATION:
 245
 246 T P H X TSUP
 247 3.590+001 9.403+001 3.541+001 2.264-001 TSUP
 248 3.691+001 7.293+001 8.397+001 9.697-001 .000
 249
 250 INPUT DATA TO EVAPHX:
 251
 252 T P X TAIR RH
 253 3.620+001 9.469+001 2.248-001 4.700+001 7.300-001 RMASS
 254 H2= 90.6913
 255 H2= 87.0221
 256 H2= 84.6521
 257 H2= 84.5449
 258 QT, QS= 2.353+004 2.052+004
 259
 260 EVAPORATOR ITERATION:
 261
 262 T P H X TSUP
 263 3.620+001 9.469+001 3.541+001 2.248-001 TSUP
 264 3.752+001 7.459+001 8.454+001 9.412-001 .000
 P1, P1E, P1EP1, DENT2= 74.4634 74.5945 .1311 -3.1760
 265
 266
 267 INPUT DATA TO COMPR:
 268
 269 P3 T3 H3 XQ3 TG6
 270 6.447+001 3.100+001 8.909+001 1.000+000 TRA
 271
 272 COMPRESSOR ITERATION:
 273
 274 EI ETAE ETAC ETAV CPROPN RMASS
 275 2.679+000 7.559-001 9.477-001 6.556-001 3.549+003 4.534+002
 276
 277 I T P H X
 278 1 3.615+001 7.161+001 8.780+001 9.800-001
 279 2 3.554+001 7.080+001 8.774+001 9.799-001
 280 3 3.102+001 6.447+001 8.909+001 1.000+000
 281 4 7.048+001 6.438+001 9.555+001 1.000+000
 282 5 7.433+001 6.174+001 9.629+001 1.000+000
 223 6 1.870+002 2.410+002 1.108+002 1.000+000
 284 7 1.801+002 2.214+002 1.101+002 1.000+000
 285 8 1.615+002 2.204+002 1.053+002 1.000+000
 286 9 1.543+002 2.181+002 1.049+002 1.000+000
 287 10 1.534+002 2.180+002 1.048+002 1.000+000
 288

290
 291 T 1.534+002 P 1.180+002 TAIR 7.000+001 RH 5.600-001 RMASS 4.564+002
 292 H2, H2PH2= 34.10 - .39
 293 H2, H2PH2= 34.16 - .05
 294 H2, H2PH2= 34.61 -.45
 295 H2, H2PH2= 34.76 -.16
 296 H2, H2PH2= 34.82 -.06
 297 H2, H2PH2= 34.82 .00
 298
 299 CONDENSER ITERATION:
 300
 301 T P H X
 302 1.534+002 2.180+002 1.048+002 1.000+000
 303 8.300+001 2.110+002 3.482+001 .000
 304
 305
 306 LIQUID LINE:
 307 INPUT - PIN = 2.110+002 TIN = 8.300+001 XIN = .000
 308 OUTPUT - POUT= 2.059+002 TOUT= 8.298+001 XOUT= .000 HIN = 3.482+001
 309
 310
 311 EXPANSION DEVICE:
 312 INPUT - P12 = 2.059+002 H12 = 3.482+001 P13 = 9.183+001
 313 OUTPUT - POUT = 1.612+002 XMAS = 4.940+002
 314
 315 INPUT DATA TO COMPR:
 316 P3 T3 H3 XQ3
 317 6.447+001 3.100+001 8.909+001 1.000+000 TGA TRA
 318 320
 319
 321 COMPRESSOR ITERATION:
 322 EI ETAE ETAC ETAV CPRPM RMASS
 323 2.665+000 7.553+001 9.481-001 8.547-001 3.550+003 4.592+002
 324
 325
 326
 327 1 T 3.617+001 P H X
 328 2 3.555+001 7.083+001 8.775+001 2.801-001
 329 3 3.100+001 6.447+001 8.906+001 9.800-001
 330 4 7.029+001 6.438+001 9.551+001 1.000+000
 331 5 7.410+001 6.174+001 9.625+001 1.000+000
 332 6 1.853+002 2.388+0C? 1.106+002 1.000+000
 333 7 1.793+002 2.189+002 1.093+002 1.000+000
 334 8 1.605+002 2.110+002 1.062+002 1.000+000
 335 9 1.534+002 2.156+002 1.048+002 1.000+000
 336 10 1.525+002 2.156+002 1.047+002 1.000+000
 337
 338 INPUT DATA TO CRNDHX:
 339
 340 T P TAIR RH RMASS
 341 1.525+002 2.156+002 7.000+001 5.500-001 4.592+002
 342 H2, H2PI2= 34.79 -.51
 343 H2, H2PI2= 35.74 .05
 344 H2, H2PI2= 35.19 -.45
 345 H2, H2PI2= 35.46 -.27
 346 H2, H2PI2= 35.57 -.11
 347 H2, H2PI2= 35.58 -.01

348 H2, H2PH2= 35.58 .00
 349 CONDENSER ITERATION:
 350 T P H X
 351 1.525+002 2.156+002 1.047+002 X
 352 8.591+001 2.077+002 3.558+001 .000
 353
 354
 355
 356
 357 LIQUID LINE:
 358 INPUT - PIN = 2.077+002 XIN = 8.591+001 XIN = .000
 359 OUTPUT - POUT = 2.025+002 XOUT = 8.504+001 XOUT = 4.725-003
 360
 361 EXPANSION DEVICE:
 362 INPUT - P12 = 2.025+002 H12 = 3.552+001 P13 = 9.186+001
 363 OUTPUT - POUT = 1.556+002 XFASS = 4.644+002
 364
 365 INPUT DATA TO COMPRESSOR:
 366 P3 T3 H3 XQ3 TRA TGA
 367 6.447+001 3.100+001 8.909+001 1.000+000 1.113+002 7.000+001 4.700+001
 368
 369
 370
 371 COMPRESSOR ITERATION:
 372 E1 ETAE ETAC ETAV CPRFM RMASS
 373 2.662+000 7.552-001 9.281-001 8.549-001 3.550+003 4.593+002
 374
 375 I T P H X
 376 1 3.617+001 7.164+001 8.782+001 9.801-001
 377 2 3.556+001 7.033+001 8.775+001 9.300-001
 378 3 3.100+001 6.447+001 8.909+001 1.000+000
 379 4 7.025+001 6.4138+001 9.551+001 1.000+000
 380 5 7.405+001 6.173+001 9.624+001 1.000+000
 381 6 1.857+002 2.354+002 1.106+002 1.000+000
 382 7 1.791+002 2.185+002 1.099+002 1.000+000
 383 8 1.603+002 2.175+002 1.052+002 1.000+000
 384 9 1.532+002 2.152+002 1.048+002 1.000+000
 385 10 1.523+002 2.151+002 1.047+002 1.000+000
 386
 387 INPUT DATA TO CONDENSER:
 388 T P TAIR RH RMASS
 389 1.523+002 2.151+002 7.000+001 5.600-001 4.593+002
 390 H2, H2PH2= 35.09 -.44
 391 H2, H2PH2= 35.04 .05
 392 H2, H2PH2= 35.47 -.43
 393 H2, H2PH2= 35.75 .28
 394 H2, H2PH2= 35.83 -.08
 395 H2, H2PH2= 35.84 -.01
 396
 397
 398
 399 CONDENSER ITERATION:
 400 T P H X
 401 1.523+002 2.151+002 1.047+002 1.000+000
 402 8.671+001 2.072+002 3.584+001 9.967-004
 403
 404
 405

LIQUID LINE:
 INPUT - PIN = 2.072+0C2 TIN = 8.671+001 XIN = 9.937-004 HIN = 3.584+001
 OUTPUT - POUT= 2.01E+002 TOUT= 3.477+001 XOUT= 1.179-002

EXPANSION DEVICE:
 INPUT - P12 = 2.016+002 H12 = 3.584+001 P13 = 9.136+001
 OUTPUT - POUT = 1.537+002 XMSS = 1.556+C02

INPUT DATA TO EVAPHX:

	T	P	X	T _{AIR}	RH	RMASS
416	3.454+001	9.186+001	2.372-001	4.700+001	7.300-001	4.592+002
417	H2= 91.4649					
418	H2= 91.2135					
419	H2= 90.9388					
420	H2= 90.8369					
421	QT, QSS= 2.530+004	2.185+0C4				
422						
423						
424						

EVAPORATOR ITERATION:

	T	P	H	X	T _{AIR}	TSUP	RMASS
426	3.454+001	9.185+001	3.574+001	X	2.372-001		
427	H2= 91.4051						
428	4.301+001	6.873+001	9.384+001	1.000+000	8.535+000		
429							
430							

INPUT DATA TO EVAPHX:

	T	P	X	T _{AIR}	RH	RMASS
431	3.532+001	9.311+001	2.342-001	4.700+001	7.300-001	4.592+002
432	H2= 91.2239					
433	H2= 90.4051					
434	H2= 89.6060					
435	H2= 89.0465					
436	H2= 88.9463					
437	QT, QSS= 2.445+004	2.132+004				
438						
439						
440						
441						
442						

EVAPORATOR ITERATION:

	T	P	H	X	T _{AIR}	TSUP	RMASS
443	3.522+001	9.311+001	3.573+001	X	2.342-001		
444	H2= 91.2920						
445	H2= 90.6518						
446	H2= 89.2340						
447	H2= 89.6312						
448	H2= 89.4731						
449	QT, QSS= 2.468+004	2.146+004					
450							
451							
452							
453							
454							
455							
456							
457							
458							
459							
460							

EVAPORATOR ITERATION:

	T	P	H	X	T _{AIR}	TSUP	RMASS
461	3.518+001	9.290+001	2.347-001	4.700+001	7.300-001	.000	
462	H2= 91.1720						
463	3.661+001	7.172+001	8.548+C01	9.980-001	.000		

P1,P1E,P1EP1,DENT2= 71.6394 71.7189 .0795 1.6604

INPUT DATA TO COMPRESSOR:

P3 T3 H3 XQ3 T_{g6} TRA TOA
6.532+001 3.169+001 8.916+001 1.000+000 1.119+002 7.000+001 4.700+001

COMPRESSOR ITERATION:

EI	ETAE	ETAC	ETAV	CPRPM	R ^m SS
2.687+000	7.563-001	9.481-001	8.556-001	3.549+003	1.650+002
1 T P	H	X			
477 1 3.699+001	7.260+001	8.789+001			
478 2 3.623+001	7.178+001	8.783+001			
479 3 3.169+001	6.532+001	8.916+001			
480 4 7.045+001	6.523+001	9.551+001			
481 5 7.423+001	6.254+001	9.624+001			
482 6 1.858+002	2.405+002	1.105+002			
483 7 1.791+002	2.702+002	1.063+002			
484 8 1.604+002	2.192+002	1.061+002			
485 9 1.533+002	2.168+002	1.048+002			
486 10 1.525+002	2.168+002	1.046+002			
487					

INPUT DATA TO CONDENSER:

T	P	TAIR	RH	R ^m SS
490 1.525+002	2.168+002	7.000+001	5.600-001	4.560+002
491 H2, H2PH2=	34.50	.12		
492 H2, H2F, H2=	35.23	.73		
493 H2, H2PH2=	34.95	.28		
494 H2, H2PH2=	35.30	.36		
495 H2, H2PH2=	35.45	.15		
496 H2, H2PH2=	35.53	.07		
497 H2, H2PH2=	35.52	.01		
498 H2, H2PH2=	35.52	.01		
499				

CONDENSER ITERATION:

T	P	H	X
500 1.525+002	2.168+002	1.046+002	1.000+000
501 8.569+001	2.028+002	3.552+001	.000

LIQUID LINE:

INPUT - PIN =	2.088+002	TIN = 8.569+001	XIN = .000
502 8.569+001	2.035+002	TOUT = 6.537+001	XOUT = 1.691-003

EXPANSION DEVICE:

INPUT - P12 =	2.035+002	H12 = 3.552+001	P13 = 9.386+001
503 8.569+001	2.035+002	XFLASS = 4.690+002	

INPUT DATA TO COMPRESSOR:

P3 T3 H3 XQ3 T _{g6} TRA TOA
518 6.532+001 3.169+001 8.916+001 1.000+000 1.118+002 7.000+001 4.700+001

COMPRESSOR ITERATION:

523 EI 2.636+000 EETAET 7.562-001 ETAC 9.481-001 ETAV 8.557-001 CPRPM 3.549+003 RMASS 4.650+002
 524
 525
 526
 527 1 T 3.689+001 P H X
 2 3.620+001 7.260+001 8.789+001 9.801-001
 3 3.169+001 7.178+001 8.783+001 9.801-001
 528 3 3.169+001 6.532+001 8.916+001 1.000+000
 529 4 7.044+001 6.523+001 9.551+001 1.000+000
 530 5 7.422+001 6.754+001 9.624+001 1.000+000
 531 6 1.857+002 2.404+002 1.105+002 1.000+000
 532 7 1.791+002 2.201+002 1.098+002 1.000+000
 533 8 1.604+002 2.191+002 1.061+002 1.000+000
 534 9 1.532+002 2.167+002 1.018+002 1.000+000
 535 10 1.524+002 2.166+002 1.016+002 1.000+000
 536
 537
 538 INPUT DATA TO CONDHX:
 539
 540 T P TAIR RH RMASS
 541 1.524+002 2.166+002 7.200+001 5.690-001 4.360+002
 542 H2, H2PH2= 34.60 .12
 543 H2, H2PH2= 34.57 -.06
 544 H2, H2PH2= 35.18 -.52
 545 H2, H2PH2= 35.50 -.32
 546 H2, H2PH2= 35.61 -.11
 547 H2, H2PH2= 35.61 .00
 548 H2, H2PH2= 35.61 .00
 549
 550 CONDENSER ITERATION:
 551
 552 T P H X
 553 1.524+002 2.166+002 1.046+002 1.000+000
 554 8.601+001 2.073+002 3.561+001 .000
 555
 556 LIQUID LINE:
 557 INPUT - PIN = 2.085+002 TIN = 8.604+001 XIN = .000
 558 OUTPUT - POUT = 2.033+002 TOUT = 8.531+001 XOUT = 3.950-003 HIN = 3.561+001
 559
 560
 561 EXPANSION DEVICE:
 562 INPUT - P12 = 2.033+002 H12 = 3.561+001 P13 = 9.386+001
 563 OUTPUT - POUT = 1.560+002 XMSS = 4.666+002
 564
 565
 566 INPUT DATA TO EVV,PHX:
 567 T P X TAIR RH RMASS
 568 3.575+001 9.386+001 2.303-001 4.700+001 7.300-001 4.660+002
 569 H2= 91.0376
 570 H2= 89.3069
 571 H2= 87.2812
 572 H2= 86.8036
 573 QT, QS= 2.369+004 2.114+004
 574
 575
 576 EVAPORATOR ITERATION:
 577
 578 T P H X TSUP
 579 3 575+001 9.366+001 3.561+001 2.303-001

3.735+001 7.356+001 8.689+001 9.682-001 .000
 580
 581
 582 INPUT DATA TO EVAPHX:
 583
 584 T P X TAIR RH
 585 3.554+001 9.352+001 2.311-001 4.700+00 7.300-001
 586 H2= 91.1463
 587 H2= 89.8963
 588 H2= 88.5308
 589 H2= 88.0712
 590 QT, QS= 2.445+004 2.152+004
 591
 592 EVAPORATOR ITERATION:
 593
 594 T P H X TSUP
 595 3.554+001 9.352.001 3.561+001 2.311-001
 596 3.701+001 7.270+001 8.808+001 9.821-001 .000
 597 P1, P1E, P1EP1, DENT2= 72.5026 72.690 .0965 .1938
 598 INTERF, INTERE, POUT, P13= 0 0 156.00 93.52
 599 COMPOSITION OF REFRIG. IN ACCUMULATOR = .650
 600 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 601
 602 REFRIG. IN ACCUMULATOR = .181 LB
 603
 604 REFRIG. IN INDOOR COIL = 2.311 LB
 605
 606 REFRIG. IN OUTDOOR COIL= .848 LB
 607
 608 TMASS = 4.434+000 REFIN = 4.968+000
 609
 610 ****SYST4 WITH ACCUM. , 13B1/152A 6-22-64***
 611
 612 TOA RHOA TRA RHRA
 613 4.700+001 7.300-001 7.000+001 5.600-001
 614
 615
 616 CFMIND CFMDUT
 617 1.113+003 2.264+003
 618
 619
 620 RESULTS:
 621 I T P H S
 622 1 3.689+001 7.260+001 8.789+001 1.921-001 9.801-001
 623 2 3.623+001 7.178+001 8.782+001 1.921-001 9.801-001
 624 3 3.169+001 6.532+001 8.916+001 1.965-001 1.000+000
 625 4 7.044+001 6.523+001 9.551+001 2.039-001 1.000+000
 626 5 7.422+001 6.254+001 9.624+001 2.110-001 1.000+000
 627 6 1.857+002 2.404+002 1.105+002 2.122-001 1.000+000
 628 7 1.781+002 2.201+002 1.098+002 2.126-001 1.000+000
 629 8 1.604+002 2.191+002 1.061+002 2.068-001 1.000+000
 630 9 1.533+002 2.167+002 1.048+002 2.043-001 1.000+000
 631 10 1.524+002 2.166+002 1.046+002 2.045-001 1.000+000
 632 11 8.601+001 2.036+002 3.561+001 8.132-002 .000
 633 12 8.531+001 2.033+002 3.561+001 8.135-002 3.958-003
 634 13 3.554+001 9.352+001 3.561+001 8.335-002 2.311-001
 635
 636
 637 TSUP3 T6S TMASS

638 3. 169+001 .000 , 1. 118+002 4. 650+002 4. 434+000
 639 QLGAD ELUSE COP
 640 3. 381+004 3. 551+000 2. 790+000
 641 G42
 642 REFRIG. COMPOSITION = 650
 643 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 644
 645
 646
 647
 648 INPUT DATA TO CONFR:
 649
 650
 651 P3 T3 H3 XQ3 TG6 TRA TOA
 652 6. 657+001 3. 226+001 8. 740+001 9. 800-001 1. 138+002 7. 000+001 4. 700+001
 653
 654 COMPRESSOR ITERATION:
 655
 656 EI ETAE ETAC ETAV CPRPM RMASS
 657 2. 749+000 7. 589+001 9. 461-001 8. 563+001 3. 543+003 4. 823+002
 658
 659 I T P H X
 660 1 3. 756+001 7. 407+001 6. 622+001 9. 204+001
 661 2 3. 692+001 7. 320+001 6. 617+001 9. 306+001
 662 3 3. 226+001 6. 657+001 8. 740+001 9. 300+001
 663 4 6. 457+001 6. 648+001 9. 428+001 1. 000+000
 664 5 6. 829+001 6. 769+001 9. 521+001 1. 000+000
 665 6 1. 812+002 2. 471+002 1. 094+002 1. 000+000
 666 7 1. 744+002 2. 263+002 1. 087+002 1. 000+000
 667 8 1. 550+002 2. 253+002 1. 050+002 1. 000+000
 668 9 1. 492+002 2. 229+002 1. 037+002 1. 000+000
 669 10 1. 485+002 2. 228+002 1. 036+002 1. 000+000
 670
 671 INPUT DATA TO CONDENSER:
 672
 673 T P TAIR RH RMASS
 674 1. 485+002 2. 228+002 7. 000+001 5. 600+001 4. 323+002
 675 H2, H2PH2= 33. 96 -. 42
 676 H2, H2PH2= 33. 90 .06
 677 H2, H2PH2= 34. 44 -. 54
 678 H2, H2PH2= 34. 20 .24
 679 H2, H2PH2= 34. 47 -. 27
 680 H2, H2PH2= 34. 53 -. 06
 681 H2, H2PH2= 34. 58 -. 05
 682 H2, H2PH2= 34. 56 .01
 683
 684 CONDENSER ITERATION:
 685
 686
 687 T P H X
 688 1. 485+002 2. 228+002 1. 036+002 1. 000+000
 689 8. 205+001 2. 152+002 3. 456+001 .000
 690
 691 LIQUID LINE:
 692 INPUT - PIN = 2. 152+002 TIN = 8. 205+001 XIN = .000
 693 OUTPUT - POUT = 2. 095+002 TOUT = 8. 231+001 XOUT = .000
 694
 695

EXPANSION DEVICE:
 INPUT - $P_{12} = 2.096 \times 10^2$ $H_{12} = 3.453 \times 10^1$ $P_{13} = 9.499 \times 10^1$
 OUTPUT - $P_{OUT} = 1.658 \times 10^2$ $XMASS = 3.173 \times 10^2$

INPUT DATA TO COMPRESSOR ITERATION:

701	P3	T3	H3	XQ3	TG6	TRA
702	6.657+001	3.226+001	8.740+001	9.800+001	1.134+002	7.000+001
703						
704						
705						
706	EI	ETAE	ETAC	ETAV	CPRPM	RMASS
707	2.738+000	7.534+001	9.463+001	8.711+001	3.543+003	4.828+002
708						
709						

INPUT DATA TO CONDENSER ITERATION:

710	T	P	H	X	RH	RMASS
711	1	3.757+001	7.409+001	8.623+001	9.605.001	
712	2	3.693+001	7.321+001	8.618+001	9.607+001	
713	3	3.226+001	6.557+001	8.740+001	9.500+001	
714	4	6.443+001	6.642+001	9.446+001	1.000+000	
715	5	6.812+001	6.162+001	9.518+001	1.000+000	
716	6	1.804+002	2.456+002	1.093+002	1.000+000	
717	7	1.736+002	2.244+002	1.086+002	1.000+000	
718	8	1.551+002	2.236+002	1.049+002	1.000+000	
719	9	1.482+002	2.211+002	1.037+002	1.000+000	
720	10	1.478+002	2.210+002	1.035+002	1.000+000	
721						

INPUT DATA TO CONDENSER:

722	T	P	TAIR	RH	RMASS
723					
724					
725					
726					
727					
728					
729					
730					
731					
732					
733					
734					
735					
736					
737					
738					
739					
740					
741					
742					
743					
744					
745					
746					
747					
748					
749					
750					
751					
752					
753	T	P	X	TAIR	RH

3.636+001 9.501+001 2.220-001 4.700+001 7.300-001 4.830+002
 H2= 90.4425
 H2= 85.3278
 H2= 83.4042
 H2= 03.3173
 QT, QS= 2.321+004 2.072+004
 754
 755
 756
 757
 758
 759
 760
 761
 762
 763
 764
 765
 766
 767
 768
 769
 770
 771
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 780
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 811

EVAPORATOR ITERATION:

T	P	H	X	TSUP
3.636+001	9.501+001	3.528+001	2.220-001	1.830+002
3.762+001	7.516+001	8.334+001	9.272-001	.000

INPUT DATA TO EVAPHX:

T	P	H	X	TAIR	RH	RMASS
3.613+001	9.463+001	2.229-001	4.700+001	7.300-001	1.830+002	
H2= 90.7213	H2= 87.2462	H2= 84.9296	QT, QS= 2.397+004	2.152+004		

EVAPORATOR ITERATION:

T	P	H	X	TSUP	
3.613+001	9.463+001	3.528+001	2.229-001	1.830+002	
3.732+001	7.419+001	8.491+001	9.457-001	.000	
P1, P1E, P1EP1, DENT2=	74.093	74.1922	.1030	-1.3240	

INPUT DATA TO COMPR:

P3	T3	H3	XQ3	TG6	TRA	TOA
6.588+001	3.172+001	8.734+001	9.800-001	1.128+002	7.000+001	4.700+001

COMPRESSOR ITERATION:

EI	ETAE	ETAC	ETAV	CPRPM	RMASS
2.717+000	7.575-001	9.465-001	8.563-001	3.549+003	1.775+002
I	T	P	H	X	
1	3.700+001	7.331+001	8.617+001	9.606-001	
2	3.636+001	7.244+001	8.611+001	9.607-001	
3	3.172+001	6.734+001	8.734+001	9.800+001	
4	6.422+001	6.579+001	9.415+001	1.000+000	
5	6.794+001	6.103+001	9.518+001	1.000+000	
6	1.802+002	2.435+002	1.093+002	1.000+000	
7	1.734+002	2.228+002	1.066+002	1.000+000	
8	1.518+002	2.217+002	1.049+002	1.000+000	
9	1.483+002	2.193+002	1.037+002	1.000+000	
10	1.475+002	2.192+002	1.035+002	1.000+000	

INPUT DATA TO COMPDHX:

T	P	TAIR	RH	RMASS
1.475+002	2.192+002	7.000+001	5.600-001	4.775+002
H2, H2PH2=	34.21	.03		
H2, H2PH2=	34.42	-.21		
H2, H2PH2=	35.16	-.74		

812 H₂, H₂PH2= 35.42 -.27
 813 H₂, H₂RH2= 34.83 .59
 814 H₂, H₂PH2= 35.01 -.18
 815 H₂, H₂RH2= 35.14 -.12
 816 H₂, H₂PH2= 35.21 -.07
 817 H₂, H₂FH2= 35.20 .01
 818
 819 CONDENSER ITERATION:
 820 T P H X
 821 1.475+002 2.192+002 1.035+002 1.000+000
 822 8.445+001 2.108+002 3.520+001 .000
 823
 824
 825 LIQUID LINE:
 826 INPUT - PIN = 2.108+002 TIN = 8.445+001 XIN = .000
 827 OUTPUT - POUT = 2.053+002 TOUT = 8.444+001 XOUT = .000
 828
 829
 830 EXPANSION DEVICE:
 831 INPUT - P12 = 2.053+002 H12 = 3.520+001 P13 = 9.385+001
 832 OUTPUT - POUT = 1.594+002 XMASS = 4.326+002
 833
 834 INPUT DATA TO COMPR:
 835
 836 P3 T3 H3 XQ3 TG6 TRA TGA
 837 6.583+001 3.172+001 8.734+001 9.800+001 1.127+002 7.000+001 4.700+001
 838
 839
 840 COMPRESSOR ITERATION:
 841 EI ETAE ETAC ETAV CPRPM RMASS
 842 2 714+000 7.574+001 9.465+001 8.568+001 3.549+003 4.776+002
 843
 844
 845 I T P H X
 846 1 3.700+001 7.332+001 8.617+001 9.606+001
 847 2 3.635+001 7.245+001 8.611+001 9.607+001
 848 3 3.172+001 6.598+001 8.731+001 9.000+001
 849 4 6.420+001 6.573+001 9.445+001 1.000+000
 850 5 6.791+001 6.303+001 9.517+001 1.000+000
 851 6 1.801+002 2.432+002 1.093+002 1.000+000
 852 7 1.732+002 2.224+002 1.086+002 1.000+000
 853 8 1.547+002 2.214+002 1.049+002 1.000+000
 854 9 1.481+002 2.199+002 1.037+002 1.000+000
 855 10 1.474+002 2.189+002 1.035+002 1.000+000
 856
 857 INPUT DATA TO CONDHX:
 858
 859 T P TAIR RH RMASS
 860 1.474+002 2.189+002 7.000+001 5.600-001 4.776+002
 861 H₂, H₂PH2= 34.40 -.02
 862 H₂, H₂FH2= 34.61 -.21
 863 H₂, H₂PH2= 35.33 -.71
 864 H₂, H₂FH2= 34.98 .35
 865 H₂, H₂PH2= 35.22 -.24
 866 H₂, H₂FH2= 35.35 -.13
 867 H₂, H₂PH2= 35.42 -.08
 868 H₂, H₂FH2= 35.42 .01
 869

CONDENSER ITERATION:

870
 871 T P H X
 872 1.474+002 2.189+002 1.035+002 1.000+000
 873 8.529+001 2.124+002 3.542+001 .000
 874
 875
 876 LIQUID LINE:
 877 INPUT - PIN = 2.104+002 TIN = 8.529+001 XIN = .000
 878 OUTPUT - POUT= 2.049+002 TOUT= 8.518+001 XOUT= .000 HIN = 3.542+001
 879
 880
 881 EXPANSION DEVICE:
 882 INPUT - P12 = 2.049+002 H12 = 3.542+001 P13 = 9.385+001
 883 OUTPUT - POUT = 1.576+002 XMAGS = 4.751+002
 884
 885 INPUT DATA TO EVAPHX:
 886 T P X TAIR RH RMASS
 887 3.567+001 9.385+001 2.258-001 4.700+001 7.300-001 1.776+002
 888 H2= 91.0917
 889 H2= 89.5983
 890 H2= 67.5974
 891 H2= 87.4747
 892 H2= 87.3638
 893 QT ,QS= 2.484+004 2.154+004
 894
 895
 896 E:97 EVAPORATOR ITERATION:
 897
 898 T P H X TSUP
 899 3.567+001 9.385+001 3.535+001 2.758-001
 900 3.683+001 7.269+001 8.737+001 8.742-001 .000
 901
 902
 903 INPUT DATA TO EVAPHX:
 904 T P X TAIR RH RMASS
 905 3.581+001 9.403+001 2.252-001 4.700+001 7.300-001 4.776+002
 906 H2= 90.9892
 907 H2= 89.0026
 908 H2= 86.7588
 909 H2= 86.6626
 910 H2= 86.5777
 911 QT ,QS= 2.447+004 2.135+004
 912
 913
 914 E:97 EVAPORATOR ITERATION:
 915 T P H X TSUP
 916 3.581+001 9.408+001 3.534+001 2.252-001
 917 3.706+001 7.326+001 8.659+001 9.652-001 .000
 918 P1,PIE,P1EP1,DENT2= 73.3157 73.2571 -.0586 .4132
 919 INTERM,INTERE,POUT,P13= 1 0 157.55 94.03
 920
 921 INPUT DATA TO COMPR:
 922 P3 T3 H3 X03 T66 TRA TGA
 923 6.588+001 3.172+001 8.734+001 9.800-001 1.127+002 7.000+001 4.700+001
 924
 925
 926
 927 COMPRESSOR ITERATION:

928
 929 EI ETAE ETAC ETAV CP/CPM RMASS
 930 2.715+000 7.575-001 5.465-001 6.367-001 3.549+003 4.776+002
 931
 932 1 T P H X
 933 1 3.700+001 7.331+001 8.617+001 9.606+001
 934 2 3.636+001 7.245+001 8.611+001 9.607+001
 935 3 3.172+001 5.588+001 8.734+001 9.800+001
 936 4 6.420+001 6.579+001 9.445+001 1.000+000
 937 5 6.791+001 6.303+001 9.518+001 1.000+000
 938 6 1.301+002 2.433+002 1.093+002 1.000+000
 939 7 1.733+002 2.225+002 1.086+002 1.000+000
 940 8 1.547+C02 2.215+002 1.040+002 1.000+000
 941 9 1.482+002 2.191+002 1.037+002 1.000+000
 942 10 1.474+C02 2.190+002 1.035+002 1.000+000
 943
 944 INPUT DATA TO CONDHX:
 945
 946 T P TAIR RH RMASS
 947 1.474+002 2.190+002 7.000+001 5.600-001 4.776+002
 948 H₂, H2PH2= 34.33 .04
 949 H₂, H2PH2= 24.55 -.22
 950 H₂, H2PH2= 35.27 -.72
 951 H₂, H2PH2= 34.91 .36
 952 H₂, H2PH2= 35.15 -.23
 953 H₂, H2PH2= 35.27 -.13
 954 H₂, H2PH2= 35.35 -.08
 955 H₂, H2PH2= 35.34 .01
 956
 957 CONDENSER ITERATION:
 958 T P H X
 959 1.474+002 2.190+002 1.035+002 1.000+000
 960 8.502+001 2.105+002 3.534+001 .000
 961
 962
 963
 964
 965 LIQUID LINE:
 966 INPUT - PIN = 2.125+002 TIN = 8.502+001 XIN = .000
 967 OUTPUT - POUT = 2.050 002 TOUT = 8.500 001 XOUT = .000
 968
 969 EXPANSION DEVICE:
 970 INPUT - P12 = 2.050+002 H12 = 3.534+001 P13 = 9.400+001
 971 DDENFA DOES NOT CONVERGE, DIFXQ2= -8.01178-006
 972 OUTPUT - POUT = 1.534+002 XMASS = 4.730+002
 973
 974 INPUT DATA TO EVAPHX:
 975 T P X TAIR RH RMASS
 976 3.581+001 9.408+001 2.252-001 4.700+001 7.300-001 4.776+002
 977 H2= 90.0594
 978 H2= 89.0039
 979 H2= 86.7603
 980 H2= 86.6543
 981 H2= 86.5732
 982 QT,QS= 2.447+004 2.135+004
 983
 984
 985 EVAPORATOR ITERATION:

986
 987 T P H X TSUP
 988 3.581+001 9.408+001 3.534+001 2.252-001
 989 3.706+001 7.326+001 8.659+001 9.152-001 .000
 P1, P1E, P1EP1, DFNT2= 73.3118 73.2557 -.0591 .4153
 990 INTERM, INTERE, POUT, P13= 0 0 158.40 94.08
 991 WACUM DOES NOT CONVERGE, MAX. ERROR = 2.902-002 (LB)
 992 COMPOSITION OF REFRIG. IN ACCUMULATOR = .333
 993 WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 994
 995 REFRIG. IN ACCUMULATOR = 2.740 LB
 996 REFRIG. IN INDOOR COIL = 2.361 LB
 997
 998 REFRIG. IN OUTDOOR COIL= .885 L3
 999
 1000 TMASS = 7.110+000 REFIN = 4.968+000
 1001
 1002
 1003 **** SYSTEM WITH ACCUM., 13B1/152A 6-22-84****
 1004 ****
 1005 ****
 1006
 1007 TGA RHQA TRA RHRA
 1008 4.700+001 7.300-001 7.300+001 5.600-001
 1009
 1010 CFMIND CFMCUT
 1011 1.118+003 2.284+003
 1012
 1013
 1014
 1015 RESULTS:
 1016 I T P H S X
 1017 1 3.700+001 7.231+001 8.617+001 1.884-001 9.606-001
 1018 2 3.636+001 7.245+001 8.611+001 1.885-001 9.607-001
 1019 3 3.172+001 6.588+001 8.734+001 1.926-001 9.800-001
 1020 4 6.420+001 6.575+001 9.445+001 2.063-001 1.000+000
 1021 5 6.791+001 6.303+001 9.518+001 2.089-001 1.000+000
 1022 6 1.301+002 1.433+002 1.093+002 2.101-001 1.000+000
 1023 7 1.733+002 2.225+002 1.046+002 2.104-001 1.000+000
 1024 8 1.547+002 2.215+002 1.049+002 2.046-001 1.000+000
 1025 9 1.482+002 2.191+002 1.037+002 2.023-001 1.000+000
 1026 10 1.474+002 2.190+002 1.035+002 2.025-001 1.000+000
 1027 11 8.502+001 2.105+002 3.534+001 3.082-002 .000
 1028 12 8.500+001 2.050+002 3.531+001 8.035-002 .000
 1029 13 3.581+001 9.103+001 3.534+001 8.278-002 2.252-001
 1030
 1031 T63 TSUP3 T66 RMASS TMASS
 1032 3.214+001 .000 1.127+002 4.776+002 7.110+000
 1033
 1034 QLOAD EIUSE COP
 1035 3.422+004 3.560+000 2.801+000
 1036
 1037 REFRIG. COMPOSITION = .650
 1038 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 1039
 1040 1C11
 1042
 1043 INPUT DATA TO CONFIR:

1044
 1045 P3 6.543+001 T3 3.157+001 H3 8.823+001 XQ3 9.900-001 TG6 1.120+002 TRA 7.000+001 TGA 4.700+001
 1046
 1047
 1048
 1049 COMPRESSOR ITERATION:
 1050 EI 2.694+000 ETAE 7.566-001 ETAC 9.474-001 ETAV 8.562-001 CPRPM 3.549+003 RMASS 4.705+002
 1051
 1052
 1053 I T P H X
 1054 1 3.631+001 7.277+001 8.702+001 9.704-001
 1055 2 3.618+001 7.193+001 8.696+001 9.704-001
 1056 3 3.157+001 6.543+001 8.823+001 9.900-001
 1057 4 6.723+001 6.534+001 9.493+001 1.000-000
 1058 5 7.102+001 6.262+001 9.571+001 1.000+000
 1059 6 1.828+002 2.210+002 1.099+002 1.000-000
 1060 7 1.760+002 2.205+002 1.092+002 1.000+000
 1061 8 1.574+002 2.197+002 1.055+002 1.000+000
 1062 9 1.506+002 2.170+002 1.042+002 1.000+000
 1063 10 1.482+002 2.179+002 1.041+002 1.000+000
 1064
 1065 INPUT DATA TO CONDHX:
 1066
 1067 T P TAIR RH RMASS
 1068 1.493+002 2.170+002 7.000+001 5.600-001 4.705+002
 1069 H2, H2PH2= 34.65 .08
 1070 H2, H2FH2= 34.75 -.10
 1071 H2, H2PH2= 35.33 -.58
 1072 H2, H2FH2= 35.65 -.32
 1073 H2, H2PH2= 35.76 -.11
 1074 H2, H2PH2= 35.76 .00
 1075 H2, H2FH2= 35.76 .00
 1076
 1077 CONDENSER ITERATION:
 1078 T P H X
 1079 1.498+002 2.170+002 1.041+002 1.000+000
 1080 8.660+001 2.080+002 3.576+001 .000
 1081
 1082
 1083
 1084 LIQUID LINE:
 1085 INPUT - PIN = 2.088+002 TIN = 8.660+001 XIN = .000
 1086 OUTPUT - POUT = 2.033+002 TOUT = 8.533+001 XOUT = 6.555-003 HIN = 3.576+001
 1087
 1088 EXPANSION DEVICE:
 1089 INPUT - P12 = 2.033+002 H12 = 3.576+001 P13 = 9.353+001
 1090 OUTPUT - POUT = 1.560+002 XMASS = 4.632+002
 1091
 1092 INPUT DATA TO CONFR:
 1093
 1094 P3 6.543+001 T3 3.157+001 H3 8.823+001 XQ3 9.900-001 TG6 1.121+002 TRA 7.000+001 TGA 4.700+001
 1095
 1096
 1097
 1098 COMPRESSOR ITERATION:
 1099 EI 2.695+000 7.567-001 ETAE 9.474-001 ETAV 8.561-001 CPRPM 3.543+003 RMASS 4.701+002
 1100
 1101

```

1102
1103   I   T      P      H      X
1104   1   3.681+001  7.277+001  8.702+001  X
1105   2   3.618+001  7.192+001  8.696+001  9.703-001
1106   3   3.157+001  6.543+001  8.823+001  9.704-001
1107   4   6.731+001  6.534+001  9.498+001  9.900-001
1108   5   7.105+001  6.263+001  9.571+001  1.000+000
1109   6   1.821+002  2.413+002  1.999+002  1.000+000
1110   7   1.752+002  2.208+002  1.092+002  1.000+000
1111   8   1.575+002  2.198+002  1.055+002  1.000+000
1112   9   1.507+002  2.174+002  1.043+002  1.000+000
1113  10   1.439+002  2.173+002  1.041+002  1.000+000
1114

1115 INPUT DATA TO CONDHX:
1116
1117   T      P      TAIR     RH      RMASS
1118   1.499+002  2.173+002  7.C20+001  5.600-001  4.704+002
1119   H2, H2RH2= 34.43    .07
1120   H2, H2PH2= 35.21    .78
1121   H2, H2PI2= 35.21    .01
1122   H2, H2PH2= 35.29    .07
1123   H2, H2PH2= 35.46    .17
1124   H2, H2RH2= 35.55    .09
1125   H2, H2PH2= 35.56    .01
1126

1127 CONDENSER ITERATION:
1128
1129   T      P      H      X
1130   1.499+002  2.173+002  1.041+002  1.000+000
1131   8.584+001  2.092+002  3.556+001  .000
1132

1133
1134 LIQUID LINE:
1135   INPUT - PIN = 2.092+002  TIN = 8.584+001  XIN = 1.000
1136   OUTPUT - POUT = 2.038+002  TOUT = 8.519+001  XOUT = 1.359-003
1137

1138 EXPANSION DEVICE:
1139   INPUT - P12 = 2.038+002  H12 = 3.556+001  P13 = 9.353+001
1140   OUTPUT - POUT = 1.571+002  XMASS = 4.701+002
1141
1142

1143 INPUT DATA TO EVAPHX:
1144
1145   T      P      X      TAIR     RH      RMASS
1146   3.553+001  9.353+001  2.302-001  4.700+001  7.300-001  1.704+002
1147   H2= 91.1647
1148   H2= 89.3796
1149   H2= 88.6931
1150   H2= 88.3154
1151   Q1, CS= 2.480+004  2.173+004
1152
1153 EVAPORATOR ITERATION:
1154
1155   T      P      H      X      TSUP
1156   3.553+001  9.353+001  3.555+001  2.302-001
1157   3.679+001  7.234+001  8.828+001  9.846-001  .000
1158
1159 INPUT DATA TO EVAPHX:

```

1160
 1161 T 5.62+001 9.368-001 X TAIR 4.700+001 RH 7.300-001 RMASS
 1162 H2= 91.1256 1.791+002
 1163 H2= 89.7738 .780+001
 1164 H2= 88.1679 9.790-001 .000
 1165 H2= 87.0335 P1, P1E, P1EP1, DENT2= 72.7675 - .0447 .7846
 1166 QT, QS= 2.457+004 2.157+004
 1167
 1168
 1169 EVAPORATOR ITERATION:
 1170 T P H X TSUP
 1171 3.562+001 9.368-001 3.556+001 2.298-001 TSUP
 1172 3.562+001 9.368-001 3.556+001 2.298-001
 1173 3.696+001 7.272+001 6.780+001 9.790-001 .000
 1174 P1, P1E, P1EP1, DENT2= 72.7228 - .0447 .7846
 1175
 1176 INPUT DATA TO CONPR:
 1177 P3 T3 H3 XQ3 T66 CPROPM RMASS
 1178 6.584+001 3.189-001 8.927+001 9.900-001 1.124+002 7.000+001 4.730+001
 1179
 1180
 1181 COMPRESSOR ITERATION:
 1182 E1 ETAE ETAC ETAV CPROPM RMASS
 1183 2.707+000 7.571-001 9.474-001 8.565-001 3.549+003 1.736+002
 1184
 1185
 1186
 1187 1 T 3.715+001 7.323+001 H 3.705+001 X 9.703-001
 1188 2 3.652+001 7.238+001 8.692+001 9.704-001
 1189 3 3.189+001 6.584+001 6.827+001 9.900-001
 1190 4 6.740+001 6.575+001 9.498+001 1.000+000
 1191 5 7.114+001 6.301+001 9.571+001 1.000+000
 1192 6 1.829+002 2.422+002 1.039+002 1.000+000
 1193 7 1.761+002 2.215+002 1.092+002 1.000+000
 1194 8 1.576+002 2.205+002 1.055+002 1.000+000
 1195 9 1.506+002 2.161+002 1.042+002 1.000+000
 1196 10 1.500+002 2.160+002 1.041+002 1.000+000
 1197
 1198 INPUT DATA TO CONDHX:
 1199
 1200 T P TAIR RH RMASS
 1201 1.500+002 2.180-002 7.000+001 5.600-001 4.736+002
 1202 H2, H2PH2= 34.29 .04
 1203 H2, H2PH2= 35.11 -.82
 1204 H2, H2PH2= 35.12 -.01
 1205 H2, H2PH2= 35.18 -.06
 1206 H2, H2PH2= 35.35 -.17
 1207 H2, H2PH2= 35.44 -.09
 1208 H2, H2PH2= 35.46 -.02
 1209
 1210 CONDENSER ITERATION:
 1211 T P H X
 1212 1.500+002 2.180+002 1.041+002 1.000+000
 1213 0.545+001 2.099+002 3.546+001 .000
 1214
 1215
 1216 LIQUID LINE:
 1217

1218 INPUT = PIN = 2.098+002 TIN = 8.545+001 XIN = .000
 1219 OUTPUT = POUT= 2.044+002 TOUT= 8.513+001 XOUT= .000 HIN = 3.546+001
 1220
 1221 EXPANSION DEVICE:
 1222 INPUT = P12 = 2.044+002 H12 = 3.546+001 P13 = 9.414+001
 1223 OUTPUT = POUT = 1.572+002 X_{MASS} = 4.727+002
 1224
 1225
 1226 INPUT DATA TO EVAPHX:
 1227 T P X TAIR RH RMASS
 1228 3.588+001 9.4*4+001 2.270-001 4.700+001 7.300-001 4.736+002
 1229 H2= 90.9402
 1230 H2= 88.7216
 1231 H2= 86.4685
 1232 H2= 86.2656
 1233 QT,QS= 2.405+004 2.122+004
 1234
 1235
 1236 EVAPORATOR ITERATION:
 1237 T P H X TSUP
 1238 3.588+001 9.4*4+001 3.546+001 2.270-001
 1239 3.726+001 7.368+001 8.623+C01 9.609-001 .000
 1240
 1241
 1242 INPUT DATA TO EVAPHX:
 1243 T P X TAIR RH RMASS
 1244 3.578+001 9.398+001 2.274-001 4.700+001 7.300-001 4.736+002
 1245 H2= 91.0247
 1246 H2= 39.2156
 1247 H2= 87.0729
 1248 H2= 86.6743
 1249 H2= 86.6123
 1250 QT,QS= 2.433+004 2.127+004
 1251
 1252
 1253 EVAPORATOR ITERATION:
 1254 T P H X TSUP
 1255 3.578+001 9.390+001 3.546+001 2.274-001
 1256 3.712+001 7.327+001 8.682+001 9.678-001 .000
 1257 P1,P1E,P1EP1,DENT2= 73.2274 73.2701 .0427 -.2317
 1258 INTERM,INTERE,PCUT,P13= 0 0 157.22 93.98
 1259 COMPOSITION OF REFRIG. IN ACCUMULATOR = .365
 1260 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 1261
 1262 REFRIG. IN ACCUMULATOR = 1.083 LB
 1263
 1264 REFRIG. IN INDOOR COIL = 2.340 LB
 1265 REFRIG. IN OUTDOOR COIL = .878 LB
 1266
 1267 TMAGS = 5.419+000 REFIN = 4.968+000
 1268
 1269 ****SYST4 WITH ACCUM., 13F1/152A 6-22-84***
 1270 ****
 1271 ****
 1272 ****
 1273 ****
 1274 TOA RHOA TRA RHRA
 4.700+001 7.300-001 7.000+001 5.600-001
 1275

1276
 1277 CFMINND
 1278 1.118+003 CFMOUT
 1279 2.234+003
 1280
 1281 RESULTS:
 1282
 1283 1 T P H S X 9.703-001
 1284 1 3.715+001 7.323+001 8.705+001 1.902-001
 1285 2 3.652+001 7.238+001 8.699+001 1.903 001 9.704-001
 1286 3 3.180+001 6.564+001 8.827+001 1.915+001 9.900-001
 1287 4 6.740+001 6.575+001 9.498+001 2.078-001 1.000+000
 1288 5 7.114+001 6.301+001 9.571+001 2.099-001 1.000+000
 1289 6 1.829+002 2.422+002 1.099+002 2.111-001 1.000+000
 1290 7 1.761+002 2.215+002 1.092+002 2.115-001 1.000+000
 1291 8 1.576+002 2.205+002 1.055+002 2.057-001 1.000+000
 1292 9 1.508+002 2.181+002 1.042+002 2.038-001 1.000+000
 1293 10 1.500+002 2.180+002 1.041+002 2.035-001 1.000+000
 1294 11 8.545+001 2.099+002 3.516+001 8.104-002 .000
 1295 12 8.543+001 2.041+002 3.546+001 8.106-002 .000
 1296 13 3.578+001 9.398+001 3.546+001 8.302-002 2.274-001
 1297
 1298 TG3 TSUP3 TG6 RMASS TMASS
 1299 3.210+001 .000 1.124+002 4.736+002 5.412+000
 1300
 1301 QLOAD ELUSE COP
 1302 3.415+004 3.572+000 2.802+000
 1303
 1304 REFRIG. COMPOSITION = .650
 1305 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 1306
 1307
 1308
 1309 INPUT DATA TO COMPRESSOR:
 1310
 1311 P3 T3 H3 XG3 TG6 TRA TOA
 1312 6.582+001 3.199+001 8.873+001 9.950-001 1.123+002 7.000+001 4.700+001
 1313
 1314 COMPRESSOR ITERATION:
 1315
 1316 EI ETAE ETAC ETAV C2RPM RMASS
 1317 2.702+000 7.569-001 9.477-001 8.563-001 3.549+003 4.717+002
 1318
 1319
 1320 1 T P H X 9.752-001
 1321 1 3.723+001 7.319+001 8.749+001 1.000+000
 1322 2 3.661+001 7.236+001 8.743+001 9.753-001
 1323 3 3.129+001 6.582+001 8.873+001 9.950-001
 1324 4 6.899+001 6.573+001 9.524+001 1.000+000
 1325 5 7.273+001 6.301+001 9.507+001 1.000+000
 1326 6 1.843+002 2.419+002 1.102+002 1.000+000
 1327 7 1.775+002 2.213+002 1.095+002 1.000+000
 1328 8 1.590+002 2.203+002 1.055+002 1.000+000
 1329 9 1.520+002 2.179+002 1.045+002 1.000+000
 1330 10 1.512+002 2.178+002 1.043+002 1.000+000
 1331
 1332 INPUT DATA TO CONDENSER:
 1333
 1334

1334 T P TAIR RH RMASS
 1 512+002 2.178+002 7.000+001 5.600-001 4.717+002
 1335 H2, H2PH2= 34.33 .06
 1336 H2, H2PH12= 35.12 -.80
 1337 H2, H2PH12= 24.88 .25
 1338 H2, H2PH2= 35.21 -.34
 1339 H2, H2RH2= 35.36 -.15
 1340 H2, H2PH2= 35.44 -.08
 1341 H2, H2PH2= 35.44 .00
 1342 H2, H2PH2= 35.44 .00
 1343
CONDENSER ITERATION:
 1344
 1345 T P H X
 1346 1.512+002 2.173+002 1.043+002 X
 1347 8.538+001 2.097+002 3.514+001 1.000+000
 1348 .000 .000
 1349
 1350
LIQUID LINE:
 1351 INPUT - PIN = 2.097+002 TIN = 8.538+001 XIN = .000
 1352 OUTPUT - POUT= 2.043+002 TOUT= 8.536+001 XOUT= .000
 1353
 1354
 1355
EXPANSION DEVICE:
 1356 INPUT - P12 = 2.043+002 H12 = 3.544+001 P13 = 9.391+001
 1357 OUTPUT - POUT = 1.573+002 XMSS = 4.729+002
 1358
 1359
INPUT DATA TO EVAFHX:
 1360
 1361 T P X
 1362 3.575+001 9.394+001 2.271-001 TAIR RH RMASS
 1363 H2= 91.0172 H2= 69.1768
 1364 H2= 87.0406 H2= 86.8044
 1365 QT, QS= 2.421+004 2.132+004
 1366
 1367
 1368
 1369
EVAPORATOR ITERATION:
 1370
 1371 T P H TSUP
 1372 3.575+001 9.394+001 3.544+001 2.271-001
 1373 3.720+001 7.339+001 8.276+001 9.669-001 .000
 1374 P1, P1E, P1EP1, DENT2= 73.1945 73.3925 .1981 -.7351
 1375
 1376
INPUT DATA TO COMPR:
 1377
 1378 P3 T3 H3 T66 TRA
 1379 6.545+001 3.168+001 8.879+001 9.950-001 1.120+002 7.000+001
 1380
 1381
COMPRESSOR ITERATION:
 1382 E1 ETAE ETAV CPRPM
 1383 2.692+000 7.365-001 9.477-001 8.539-001 3.548+003
 1384
 1385
 1386
 1387 I T P H X
 1388 1 3.691+001 7.276+001 8.746+001 9.752-001
 2 3.629+001 7.193+001 8.740+001 9.753-001
 1389 3 3.163+001 6.545+001 8.870+001 9.950-001
 1390 4 6.890+001 6.536+001 9.524+001 1.000+000
 1391

1392 5 7.266+001 6.265+001 9.593+001 1.000+000
 1393 6 1.813+002 2.110+002 1.102+002 1.000+000
 1394 7 1.776+002 2.206+002 1.095+002 1.000+000
 1395 8 1.581+002 2.126+002 1.058+002 1.000+000
 1396 9 1.520+002 2.172+002 1.045+002 1.000+000
 1397 10 1.512+002 2.171+002 1.044+002 1.000+000
 1398

1399 INPUT DATA TO CONDHX:

1400 T P TAIR RH RMASS

1401 1.512+002 2.171+002 7.000+001 5.600+001 4.687+002

1402 H2, H2PH2= 34.46 .09

1403 H2, H2PH2= 35.21 -.75

1404 H2, H2PH2= 34.96 .25

1405 H2, H2PH2= 35.32 -.35

1406 H2, H2PH2= 35.47 -.15

1407 H2, H2PH2= 35.54 -.08

1408 H2, H2PH2= 35.54 .01

1409 H2, H2PH2= 35.54 .01

1410 CONDENSER ITERATION:

1411

1412 T P H X

1413 1.512+002 2.171+002 1.044+002 1.000+000

1414 8.575+001 2.091+002 3.554+001 .000

1415

1416

1417

1418 LIQUID LINE:

1419 INPUT - P1N = 2.091+002 T1N = 8.575+001 X1N = .000 H1N = 3.554+001

1420 OUTPUT - POUT = 2.037+002 TOUT = 8.516+001 XOUT = 1.535+003

1421

1422 EXPANSION DEVICE:

1423 INPUT - P12 = 2.037+002 H12 = 3.554+001 P13 = 9.351+001

1424 OUTPUT - POUT = 1.566+002 XMMASS = 4.695+002

1425

1426 INPUT DATA TO EVAPHX:

1427

1428 T P X TAIR RH RMASS

1429 3.551+001 9.351+001 2.298+001 4.700+001 7.300+001 4.337+002

1430 H2= 91.1552

1431 H2= 89.9336

1432 H2= 88.6044

1433 H2= 88.2019

1434 QT, QS= 2.458+004 2.165+004

1435

1436 EVAPORATOR ITERATION:

1437

1438 T P H TSUP

1439 3.551+001 9.351+001 3.554+001 2.298+001

1440 3.688+001 7.249+001 8.818+001 9.834+001 .000

1441

1442

1443 INPUT DATA TO EVAPHX:

1444

1445 T P X TAIR RH RMASS

1446 3.557+001 9.361+001 2.296+001 4.700+001 7.300+001 4.337+002

1447 H2= 91.1332

1448 H2= 89.8058

1449 H2= 88.2652

H2 = 87.8343
QT, CS= 2.453+004 2.156+004

EVAPORATOR ITERATION:

1453
1454 T P H X TSUP
1455 3.557+001 9.361+001 3.554+001 2.296-001
1456 3.698+001 7.273+001 8.788+001 9.798-001 .000
1457 P1, P1E, P1EP1, DENT2= 72.7637 72.7340 -.0297 .4190
1458 INTETM, INTERE, POUT, P13= 0 0 156.59 93.61
1459 COMPOSITION OF REFRIG. IN ACCUMULATOR = .625
1460 WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
1461
1462 REFRIG. IN ACCUMULATOR = .196 LB
1463 REFRIG. IN INDOOR COIL = 2.324 LB
1464 REFRIG. IN OUTDOOR COIL= .854 LB
1465
1466
1467
1468 TMASS = 4.482+000 REFIN = 4.968+000
1469
1470 ****SYST4 WITH ACCUM., 13B1/152A 6-22-84**
1471
1472
1473 TOA RHOA TRA RHRA
1474 4.700+001 7.300-001 7.000+001 5.600-001
1475
1476 CFMIND
1477 CFMOUT
1478 1.118+003 2.284+003
1479
1480
1481 RESULTS:
1482
1483 I T P H X
1484 1 3.691+001 7.276+001 8.746+001 1.912-001 9.752-001
1485 2 3.629+001 7.193+001 8.740+001 1.912-001 9.753-001
1486 3 3.163+001 6.515+001 8.870+C01 1.955-001 9.950-001
1487 4 6.890+001 6.536+001 9.524+001 2.084-001 1.000+000
1488 5 7.266+001 6.265+201 9.598+001 2.105-001 1.000+000
1489 6 1.843+002 2.410+002 1.102+002 2.117-001 1.000+000
1490 7 1.776+002 2.206+002 1.095+002 2.120-001 1.000+000
1491 8 1.589+002 2.196+002 1.053+012 2.062-001 1.000+000
1492 9 1.520+002 2.172+002 1.045+002 2.043-001 1.000+000
1493 10 1.512+002 2.171+002 1.044+002 2.040-001 1.000+000
1494 11 8.575+001 2.091+002 3.554+001 8.118-002 .000
1495 12 8.546+001 2.037+002 3.554+001 8.121-002 1.539-003
1496 13 3.557+001 9.361+001 3.554+001 8.319-002 2.206-001
1497
1498 TG3 TSUP3 T66 RMASS TMASS
1499 3.179+001 .000 1.120+002 4.687+002 4.482+000
1500
1501 QLLOAD ELUSE COP
1502 3.391+004 3.557+000 2.794+000
1503
1504 COMPOSITION = .650
1505 WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
1506
1507

1508
 1509 INPUT DATA TO COMPR:
 1510
 1511 P3 T3 H3 X03 TRA TGA
 1512 6.565+001 3.179+001 8.848+001 9.925+001 1.122+002 7.000+001 4.700+001
 1513
 1514
 1515 COMPRESSOR ITERATION:
 1516 EI ETAE ETAC ETAV CPRPM RMASS
 1517 2.699+000 7.568-001 9.475-001 8.562-001 3.549+003 4.712+002
 1518
 1519
 1520 I T P H X
 1521 1 3.703+001 7.300+001 8.726+001 9.728-001
 1522 2 3.641+001 7.216+001 8.720+001 9.729-001
 1523 3 3.179+001 6.565+001 8.848+001 9.925+001
 1524 4 6.814+001 6.556+001 9.511+001 1.000+000
 1525 5 7.189+001 6.284+001 9.584+001 1.000+000
 1526 6 1.835+002 2.416+002 1.100+002 1.000+000
 1527 7 1.768+002 2.211+002 1.093+002 1.000+000
 1528 8 1.592+002 2.201+002 1.057+002 1.000+000
 1529 9 1.513+002 2.177+002 1.044+002 1.000+000
 1530 10 1.505+002 2.176+002 1.042+002 1.000+000
 1531
 1532 INPUT DATA TO CONDHN:
 1533
 1534 T P TAIR RH RMASS
 1535 1.505+002 2.176+002 7.000+001 5.600-001 4.712+002
 1536 H2, H2PH2= 34.37 .06
 1537 H2, H2FH2= 35.16 -.79
 1538 H2, H2FH2= 34.92 .23
 1539 H2, H2PH2= 35.26 -.34
 1540 H2, H2FH2= 35.41 -.15
 1541 H2, H2PH2= 35.49 -.08
 1542 H2, H2PH2= 35.49 .00
 1543
 1544 CONDENSER ITERATION:
 1545 T P X
 1546 1.505+002 2.176+002 1.042+002 X .000+000
 1547 8.557+001 2.095+002 2.549+001 .000
 1548
 1549
 1550
 1551 LIQUID LINE:
 1552 INPUT - PIN = 2.095+002 TIN = 8.557+001 XIN = .000
 1553 OUTPUT - POUT = 2.041+002 TOUT = 8.555+001 XOUT = .000 HIN = 3.549+001
 1554
 1555 EXPANSION DEVICE:
 1556 INPUT - P12 = 2.041+002 H12 = 3.549+001 P13 = 9.385+001
 1557 OUTPUT - POUT = 1.571+002 XMSS = 4.712+002
 1558
 1559
 1560 INPUT DATA TO EVAPHX:
 1561 T P TAIR RH RMASS
 1562 3.571+001 9.385+001 2.282-001 1.700+001 4.712+002
 1563 H2= 91.0517
 1564 H2= 89.4687
 1565

H2= 87.4577
H2= 87.1759
QT, QS= 2.433+004 2.139+004

EVAPORATOR ITERATION:

1571 T P H X TSUP
1572 3.571+001 9.385+001 3.549+001 2.282-001
1573 3.711+001 7.315+001 8.713+001 9.712-001 .000
1574 P1,P1E,PIEP1,DENT2= 73.0043 73.1545 .1503 -.1317
1575 INTERM,INTERE,POUT,P13= 0 0 157.13 93.85
1576 COMPOSITION OF REFRIG. IN ACCUMULATOR = .615
1577 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
1578
1579 REFRIG. IN ACCUMULATOR = .204 LB
1580
1581 REFRIG. IN INDOR COIL = 2.333 LB
1582
1583 REFRIG. IN OUTDOOR COIL= .872 LB
1584
1585 TMASS = 4.525+000 REFIN = 4.968+000
1586
1587 ****SYST4 WITH ACCUM., 13r1/152A 6-22-34****
1588 ****SYST4 WITH ACCUM., 13r1/152A 6-22-34****
1589
1590 TOA RHOA TRA RHRA
1591 4.700+001 7.300-001 7.200+001 5.600-001
1592
1593
1594 CFMIND CFMOUT
1595 1.118+003 2.234+003
1596
1597

RESULTS:

1598
1599
1600 I T P H X S
1601 1 3.703+001 7.300+001 8.726+001 1.907-001 9.728-001
1602 2 3.641+001 7.216+001 8.720+001 1.808-001 9.729-001
1603 3 3.179+001 6.565+001 8.848+001 1.950-001 9.925-001
1604 4 6.814+001 6.556+001 9.511+001 2.081-001 1.000+000
1605 5 7.189+001 6.284+001 9.584+001 2.102-001 1.000+000
1606 6 1.836+002 2.415+002 1.100+002 2.114-001 1.000+000
1607 7 1.768+002 2.211+002 1.093+002 2.117-001 1.000+000
1608 8 1.582+002 2.201+002 1.057+002 2.059-001 1.000+000
1609 9 1.513+002 2.177+002 1.044+002 2.040-001 1.000+000
1610 10 1.505+002 2.176+002 1.042+002 2.038-001 1.000+000
1611 11 8.557+001 2.095+002 2.549+001 8.109-002 .000
1612 12 8.555+001 2.041+002 3.549+001 8.112-002 .000
1613 13 3.571+001 9.385+001 3.549+001 8.308-001 2.282-001
1614
1615 TG3 TSUP3 TG6 RMASS TMASS
1616 3.195+001 .000 1.122+002 4.712+002 4.525+000
1617 QLND ELUSE COP
1618 3.404+004 3.564+0000 2.799+000
1619
1620
1621 REFRIG. COMPOSITION = .650
1622 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
1623

1624
 1625
 1626
 1627 INPUT DATA TO COMPR:
 1628 P3 T3 H3 XQ3 TG6 TRA TOA
 1629 6.777+001 3.344+001 8.854+001 9.912-001 1.141+002 7.000+001 4.700+001
 1630
 1631
 1632 COMPRESSOR ITERATION:
 1633 EI ETAE ETAC ETAV CPRPM RMASS
 1634 2.765+000 7.596-001 9.471-001 8.577-001 3.518+003 4.881+002
 1635
 1636
 1637 I T P H X
 1638 1 3.876+001 7.540+001 8.732+001 9.714-001
 1639 2 3.813+001 7.451+001 8.727+001 9.717-001
 1640 3 3.844+001 6.777+001 8.854+001 9.912-001
 1641 4 6.837+001 6.767+001 9.506+001 1.000+000
 1642 5 7.205+001 6.485+001 9.579+001 1.000+000
 1643 6 1.838+002 2.479+002 1.099+002 1.000+000
 1644 7 1.769+002 2.265+002 1.092+002 1.000+000
 1645 8 1.585+002 2.254+002 1.055+002 1.000+000
 1646 9 1.518+002 2.229+002 1.043+002 1.000+000
 1647 10 1.510+002 2.228+002 1.041+002 1.000+000
 1648
 1649 INPUT DATA TO COND/HX:
 1650
 1651 T P TAIR RH RMASS
 1652 1.510+002 2.228+002 7.000+001 5.600-001 4.881+002
 1653 H2, H2PH2= 33.92 -.26
 1654 H2, H2FH2= 34.60 -.68
 1655 H2, H2PK2= 34.59 .01
 1656 H2, H2PH2= 34.78 -.20
 1657 H2, H2PH2= 34.88 -.10
 1658 H2, H2PH2= 34.95 -.06
 1659 H2, H2PH2= 34.95 .00
 1660 CONDENSER ITERATION:
 1661
 1662 T P H X
 1663 1.510+002 2.228+002 1.041+002 1.000+000
 1664 8.350+001 2.151+002 3.495+001 .000
 1665
 1666
 1667
 1668 LIQUID LINE:
 1669 INPUT - PIN = 2.151+002 TIN = 8.350+001 XIN = .000
 1670 OUTPUT - POUT = 2.093+002 TOUT = 8.348+001 XOUT = .000 HIN = 3.495+001
 1671
 1672 EXPANSION DEVICE:
 1673 INPUT - P12 = 2.093+002 H12 = 3.495+001 P13 = 9.625+001
 1674 OUTPUT - POUT = 1.643+002 XMAS = 5.049+002
 1675
 1676
 1677 INPUT DATA TO COMPR:
 1678 P3 T3 H3 XQ3 TG6 TRA TOA
 1679 6.777+001 3.344+001 8.854+001 9.912-001 1.139+002 7.000+001 4.700+001
 1680

COMPRESSOR ITERATION:

1682
 1683 EI
 1684 2.760+000 ETAE 7.594-001 ETAC 9.472-001 ETAV 8.580-001 CPM 3. 543+003 RMASS 4.062+002
 1685
 1686
 1687 1 T P H X
 1688 1 3.876+001 7.541+001 8.732+001 9.715-001
 1689 2 3.813+001 7.454+001 8.723+001 9.717-001
 1690 3 3.344+001 6.777+001 8.854+001 9.912-001
 1691 4 6.830+001 6.767+001 9.505+001 1.000+000
 1692 5 7.197+001 6.834+001 9.577+001 1.000+000
 1693 6 1.834+002 2.472+002 1.092+002 1.000+000
 1694 7 1.765+002 2.257+002 1.091+002 1.000+000
 1695 8 1.582+002 2.247+002 1.055+002 1.000+000
 1696 9 1.515+002 2.221+002 1.042+002 1.000+000
 1697 10 1.507+002 2.221+002 1.041+002 1.000+000

1698 INPUT DATA TO CONDHX:

1700
 1701 T P TAIR RH RMASS
 1702 1.507+002 2.221+002 7.000+001 5.600-001 4.883+002
 H2, H2PH2= 34.20 -.11
 1703 H2, H2PH2= 34.44 -.25
 1704 H2, H2PH2= 34.58 -.14
 1705 H2, H2PH2= 34.82 -.23
 1706 H2, H2PH2= 34.98 -.17
 1707 H2, H2PH2= 35.02 -.04
 1708 H2, H2PH2= 35.03 -.01
 1709
 1710

CONDENSER ITERATION:

1711
 1712 T P H X
 1713 1.507+002 2.221+002 1.041+002 1.000+000
 1714 8.383+001 2.140+002 3.503+001 .000
 1715
 1716

LIQUID LINE:

1717
 1718 LIQUID LINE:
 1719 INPUT - PIN = 2. 140+002 TIN = 8.383+001 XIN = .000
 1720 OUTPUT - POUT= 2.083+002 TEUT= 8.380+001 XOUT= .000
 1721

EXPANSION DEVICE:

1722
 1723 INPUT - P12 = 2.083+002 H12 = 3.503+001 P13 = 9.626+001
 1724 OUTPUT - POUT = 1.631+002 XMASS = 4.383+002
 1725
 1726

INPUT DATA TO EVAPHX:

1727
 1728 T P TAIR RH RMASS
 1729 3.709+001 9.626+001 2.167-001 4.700+001 7.300-001 4.887+002
 H2= 83.2819
 1730 H2= 80.3385
 1731 H2= 78.9247
 1732
 1733
 1734 QT, QS= 2.140+004 1.974+004
 1735
 1736
 1737
 1738 T P H X TSUP
 1739 3.709+001 9.626+001 3.515+001 2.167-001

EVAPORATOR ITERATION:

3.831+001 7.777+001 7.834+001 8.742-001 .000
 1740
 1741
 1742 INPUT DATA TO EVAPHX:
 1743
 1744 T P X TAIR RH RMASS
 1745 3.658+001 9.542+001 2.137-001 4.700+001 7.300-001 4.887+002
 H2= 89.9611
 1746 H2= 84.2842
 1747 H2= 81.9561
 1748 H2= 81.9561
 1749 H2= 81.9561
 1750 QT,QS= 2.286+004 2.053+004
 1751
 1752 EVAPORATOR ITERATION:
 1753
 1754 T P H X TSUP
 1755 3.658+001 9.542+001 3.515+001 2.187-001
 1756 3.773+001 7.581+001 8.193+001 9.107-001 .000
 1757
 1758 INPUT DATA TO EVAPHX:
 1759
 1760 T P H X TAIR RH RMASS
 1761 3.647+001 9.525+001 2.191-001 4.700+001 7.300-001 4.837+002
 H2= 90.1903
 1762 H2= 85.0249
 1763 H2= 82.5664
 1764 QT,QS= 2.319+004 2.091+004
 1765
 1766
 1767 EVAPORATOR ITERATION:
 1768
 1769 T P H X TSUP
 1770 3.647+001 9.525+001 3.515+001 2.191-001
 1771 3.760+001 7.539+001 8.250+001 9.187-001 .000
 P1,P1E,P1EP1,DENT2= 75.4106 75.3918 -.0188 -4.7252
 1772
 1773
 1774 INPUT DATA TO COMPRESSOR:
 1775 P3 T3 H3 X33 TG5 TRA TGA
 1776 6.531+001 3.149+001 8.834+001 9.912-001 1.119+002 7.000+001 4.700+001
 1777
 1778
 1779 COMPRESSOR ITERATION:
 1780 E1 ETAE ETAC ETAV CPRPN RMASS
 1781 2.690+000 7.564+001 9.473+001 8.561+001 3.540+003 4.650+002
 1782
 1783
 1784 I T P H X
 1785 1 3.672+001 7.262+001 8.712+001 9.716-001
 1786 2 3.610+001 7.178+001 8.706+001 9.716-001
 1787 3 3.143+001 6.531+001 8.824+001 9.912-001
 1788 4 6.765+001 6.521+001 9.504+001 1.000+000
 1789 5 7.140+001 6.251+001 9.577+001 1.000+000
 1790 6 1.831+002 2.406+002 1.100+002 1.000+000
 1791 7 1.764+002 2.202+002 1.093+002 1.000+000
 1792 8 1.578+002 2.192+002 1.056+002 1.000+000
 1793 9 1.500+002 2.168+002 1.043+002 1.000+000
 1794 10 1.501+002 2.167+002 1.042+002 1.000+000
 1795
 1796
 1797 INPUT DATA TO CONDHX:

1798 T P TAIR RH RMASS
 1.501+002 2.167+002 7.000+001 5.600-001 4.690+002
 1799 H2, H2PH2= 34.36 -.61
 1800 H2, H2PH2= 34.89 -.02
 1801 H2, H2PH2= 34.39 -.51
 1802 H2, H2PH2= 35.39 -.27
 1803 H2, H2PH2= 35.66 -.11
 1804 H2, H2PH2= 35.78 -.01
 1805 H2, H2PH2= 35.79 .00
 1806 H2, H2PH2= 35.79 .00
 1807
CONDENSER ITERATION:
 1808 T P H X
 1809 1.501+002 2.167+002 1.042+002 1.000+000
 1810 8.671+001 2.036+002 3.579+001 .000
 1811
 1812
 1813
 1814
 1815
LIQUID LINE:
 1816 INPUT - PIN = 2.086+002 TIN = 8.671+001 XIN = .000
 1817 OUTPUT - POUT = 2.030+002 TCUT= 8.525+001 XOUT= 8.115-003 HIN = 3.579+001
 1818
 1819
EXPANSION DEVICE:
 1820 INPUT - P12 = 2.030+002 H12 = 3.579+001 P13 = 9.246+001
 1821 OUTPUT - POUT = 1.553+002 XMASS = 4.615+002
 1822
 1823
INPUT DATA TO COMPRESSOR:
 1824
 1825 P3 T3 H3 X03
 1826 6.531+001 3.149+001 6.834+001 9.912-001 TG6
 1827
 1828
COMPRESSOR ITERATION:
 1829
 1830 EI ETAE ETAC ETAV CPRPM RMASS
 1831 2.695+000 7.566-001 9.474-001 8.557-001 3.519+003 4.688+002
 1832
 1833
 1834 I T P H X
 1835 1 3.672+001 7.261+001 8.711+001 9.715-001
 1836 2 3.609+001 7.177+001 8.705+001 9.716-001
 1837 3 3.149+001 6.531+001 8.824+001 9.912-001
 1838 4 6.771+001 6.521+001 9.505+001 1.000+000
 1839 5 7.147+001 6.251+001 9.579+001 1.000+000
 1840 6 1.835+002 2.413+002 1.100+002 1.000+000
 1841 7 1.768+002 2.210+002 1.093+002 1.000+000
 1842 8 1.581+002 2.200+002 1.056+002 1.000+000
 1843 9 1.512+002 2.176+002 1.043+002 1.000+000
 1844 10 1.504+002 2.175+002 1.042+002 1.000+000
 1845
INPUT DATA TO CONDUX:
 1846
 1847 T P TAIR RH RMASS
 1848 1.504+002 2.175+002 7.000+001 5.600-001 4.603+002
 1849 H2, H2PH2= 34.72 -.48
 1850 H2, H2PH2= 34.80 -.08
 1851 H2, H2PH2= 34.85 -.05
 1852 H2, H2PH2= 34.96 -.12
 1853 H2, H2PH2= 35.18 -.22
 1854 H2, H2PH2= 35.27 -.09
 1855

1856 H₂,H₂PH₂= 35.28 - .01
 1857
 1858 CONDENSER ITERATION:
 1859 T P H X
 1860 1.504+002 2.175+002 1.042+002 1.000+000
 1861 8.477+001 2.096+002 3.528+001 .000
 1862 1.363
 1863
 1864
 1865 LIQUID LINE:
 1866 INPUT - PIN = 2.036+002 TIN = 8.477+001 XIN = .000
 1867 OUTPUT - POUT= 2.042+002 TOUT= 8.475+001 XCOUT= .000 HIN = 3.528+001
 1868
 1869 EXPANSION DEVICE:
 1870 INPUT - P12 = 2.042+002 H12 = 3.528+001 P13 = 9.245+001
 1871 DDFNFA DOES NOT CONVERGE, DIFXN2= -5.66260-006
 1872 OUTPUT - POUT = 1.580+002 XFLASS = 4.766+002
 1873
 1874
 1875 INPUT DATA TO COMPRESSOR ITERATION:
 1876
 1877 P3 T3 H3 XG3 TG6 TRA
 1878 6.531+001 3.143+001 8.834+001 9.912-001 1.120+002 7.000+001 4.700+001
 1879
 1880
 1881 E1 EТАE EТАC EТАV CPRPM RMASS
 1882 2.692+000 7.565+001 9.475-001 8.559-001 3.549+003 4.690+002
 1883
 1884
 1885 1 T P H X
 1886 1 3.672+001 7.262+001 8.712+001 9.716-001
 1887 2 3.610+001 7.178+001 8.705+001 9.716-001
 1888 3 3.149+001 6.531+001 8.834+001 9.912-001
 1889 4 6.763+001 6.521+001 9.505+001 1.000+000
 1890 5 7.144+001 6.251+001 9.578+001 1.000+000
 1891 6 1.833+002 2.410+002 1.100+002 1.000+000
 1892 7 1.766+002 2.203+002 1.093+002 1.000+000
 1893 8 1.579+002 2.195+002 1.056+002 1.000+000
 1894 9 1.511+002 2.172+002 1.043+002 1.000+000
 1895 10 1.502+002 2.171+002 1.042+002 1.000+000
 1896
 1897 INPUT DATA TO CONDHX:
 1898
 1899 T P TAIR RH RMASS
 1900 1.503+002 2.171+002 7.300+001 5.600+001 4.683+002
 1901 H₂,H₂PH₂= 34.44 .08
 1902 H₂,H₂PH₂= 35.20 -.76
 1903 H₂,H₂PH₂= 34.97 .23
 1904 H₂,H₂PH₂= 35.32 -.35
 1905 H₂,H₂PH₂= 35.47 -.15
 1906 H₂,H₂PH₂= 35.55 -.08
 1907 H₂,H₂PH₂= 35.54 .01
 1908 CONDENSER ITERATION:
 1909
 1910 T P H X
 1911 1.503+002 2.171+002 1.042+002 1.000+000
 1912 6.577+001 2.091+002 3.554+001 .000
 1913

1914

LIQUID LINE:

1915 INPUT - PIN = 2.091+002 TIN = 8.577+001 XIN = .000 HIN = 3.554+001
 1917 OUTPUT - POUT = 2.037+002 TOUT = 6.544+001 XOUT = 1.716-003

1918

1919

1920

EXPANSION DEVICE:

1921 INPUT - P12 = 2.037+002 H12 = 3.554+001 P13 = 3.245+001
 1922 OUTPUT - POUT = 1.562+002 XMASS = 4.692+002

1923

1924

INPUT DATA TO EVAPHX:

1925 T 3.486+001 P 9.245+001 X 2.325-001 TAIR 4.700+001 RH 7.300-001 RMASS 4.685+002
 H2= 91.4095
 H2= 91.0235

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EVAPORATOR ITERATION:

T 3.486+001 P 9.245+001 H 3.554+001 X 2.325-001 TAIR 4.700+001 RH 7.300-001 RMASS 4.685+002
 H2= 90.6844
 H2= 90.4082
 H2= 90.3057

QT,QS= 2.567+004 2.190+004

INPUT DATA TO EVAPHX:

T 3.561+001 P 9.367+001 X 2.295-001 TAIR 4.700+001 RH 7.300-001 RMASS 4.692+002
 H2= 91.1227
 H2= 89.7332

H2= 88.0675
 H2= 87.7171

QT,QS= 2.441+004 2.148+004

EVAPORATOR ITERATION:

T 3.561+001 P 9.367+001 H 3.554+001 X 2.295-001 TAIR 4.700+001 RH 7.300-001 RMASS 4.692+002
 H2= 89.8541
 H2= 88.4274

H2= 88.0450
 QT,QS= 2.461+004 2.161+004

EVAPORATOR ITERATION:

T 3.555+001 P 9.357+001 H 3.554+001 X 2.298-001 TSUP .000

T 3.555+001 P 9.357+001 H 3.554+001 X 2.298-001 TSUP .000

3.693+001 7.261+001 8.803+001 9.815+001 .000
 P1,P1E,P1ER1,RENT2= 72.6171 72.6117 -.0054 .9032

INPUT DATA TO COMPRESSOR:

1972	P3	T3	H3	XQ3	T66	TRA
1973	6.570+001	3.181+001	8.837+001	9.912+001	1.123+002	7.100+001
1974						
1975						
1976						
1977						
1978						
1979						

COMPRESSOR ITERATION:

1980	EI	ETAE	ETAC	ETAV	CPRPM	RMASS
1981	2.702+000	7.569+001	9.474+001	8.563+001	3.549+003	4.720+002
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						

INPUT DATA TO CONDENSER:

1999	T	P	TAIR	RH	RMASS	
2000	1.503+002	2.177+002	7.000+001	5.600-001	4.720+002	
2001	H2,H2PH2=	34.34	.06			
2002	H2,H2PH2=	35.14	.80			
2003	H2,H2PH2=	34.92	.23			
2004	H2,H2PH2=	35.25	.34			
2005	H2,H2PH2=	35.41	.15			
2006	H2,H2PH2=	35.49	.08			
2007	H2,H2PH2=	35.48	.01			
2008						
2009						
2010						
2011						
2012	1.503+002	2.177+002	1.041+002	1.000+000		
2013	8.554+001	2.096+002	3.548+001	.000	HIN = 3.548+001	
2014						
2015						
2016						
2017	INPUT - PIN = 2.096+002		TIN = 8.554+001	XIN = .000		
2018	OUTPUT - POUT = 2.042+002		TOUT = 8.552+001	XOUT = .000		
2019						
2020						
2021						
2022	INPUT - P12 = 2.042+002		H12 = 3.548+001	P13 = 9.402+001		
2023	OUTPUT - POUT = 1.560+002		XMASS = 4.714+002			
2024						
2025						
2026						
2027	T 3.581+001	P 9.402+001	X 2.277+001	TAIR 4.700+001	RH 7.300+001	RMASS 4.720+002
2028	H2= 90.9949					
2029						

LIQUID LINE:

2011	T	P	H	X
2012	1.503+002	2.177+002	1.041+002	1.000+000
2013	8.554+001	2.096+002	3.548+001	.000
2014				
2015				
2016				
2017				
2018				
2019				
2020				
2021				
2022				
2023				
2024				
2025				
2026				
2027				
2028				
2029				

EXPANSION DEVICE:

2021	INPUT - P12 = 2.042+002		
2022	OUTPUT - POUT = 1.560+002		
2023			
2024			
2025			
2026			
2027			
2028			
2029			

INPUT DATA TO EVAPHX:

2021	T	P	X	TAIR	RH	RMASS
2022						
2023						
2024						
2025						
2026						
2027						
2028						
2029						

H2= 89.0392
 H2= 86.8653
 H2= 36.6291
 QT,QS= 2.413+004 2.127+004
 2030
 2031
 2032
 2033
 2034
 2035
EVAPORATOR ITERATION:
 2036
 2037
 2038
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 2040
 2041
INPUT DATA TO EVAPHX:
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EVAPORATOR ITERATION:
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RESULTS:
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	T	P	H	X	TSUP
2037	3.581+001	9.402+001	3.543+001	2.277-001	TSIP
2038	3.723+001	7.350+001	8.659+C01	9.650-001	.000
2039					
2040					
2041					
2042					
2043					
2044	3.570+001	9.385+001	2.281-001	4.700+001	RMASS
2045	H2= 91.0722				
2046	H2= 89.5154				
2047	H2= 87.5181				
2048	H2= 87.2596				
2049	H2= 87.1924				
2050	QT,QS= 2.441+004	2.131+004			
2051					
2052					
2053					
2054					
2055	3.570+001	9.385+001	3.548+001	2.281-001	
2056	3.706+001	7.326+001	8.720+001	9.721-001	
2057	P1,P1E,P1EP1,DENT2=	73.0641	73.0637	.000	
2058	INTERP,INTERE,FOUT,F13=	0 0	156.78	.0004	.0495
2059	COMPOSITION OF REFRIG. IN ACCUMULATOR =				
2060	(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)				
2061	REFRIG. IN ACCUMULATOR =				
2062	REFRIG. IN OUTDOOR COIL =				
2063	REFRIG. IN INDOOR COIL =				
2064	REFRIG. IN OUTDOOR COIL =				
2065					
2066					
2067					
2068	TMASS = 4.553+000	REFIN = 4.963+000			
2069					
2070					
2071	**SYSTEM WITH ACCUM., 1351/152A €-22-34***				
2072					
2073	TDA	RHOA	TRA	RHRA	
2074	4.700+001	7.220-001	7.000+001	5.600-001	
2075					
2076	CFMIND	CFMOUT			
2077	1.118+003	2.294+002			
2078					
2079					
2080					
2081	I	T	P		
2082	1	3.705+001	7.306+001	8.715+001	\$ 1.905-001
2083	2	3.643+001	7.222+001	8.709+001	X 9.716-001
2084	3	3.181+001	6.570+001	8.337+C01	9.716-001
2085	4	6.776+001	6.561+001	9.505+001	9.912-001
2086	5	7.150+001	6.288+001	9.578+001	1.000+000
2087					1.000+000

2088 6 1.832+002 2.418+002 1.100+002 2.113-001 1.000+000
 2069 7 1.735+002 2.212+002 1.093+002 2.116-001 1.000+000
 2060 8 1.579+002 2.202+002 1.056+002 2.058-001 1.000+000
 2091 9 1.511+002 2.178+002 1.C43+002 2.039-001 1.000+000
 2092 10 1.503+002 2.177+002 1.041+002 2.03,-001 1.000+000
 2093 11 8.5,-1+001 2.096+002 3.548+001 8.106+002 .000
 2094 12 8.552+001 2.042+002 3.548+001 8.111+002 .000
 2095 13 3.570+001 9.385+001 3.543+001 8.307+002 2.281-001
 2096 TG3 TSUP3 TG6 RMASS TMSS
 2098 3.199+001 .000 1.123+002 4.720+002 4.563+000
 2099 QLGAD ELU3E COP
 2100 3.407+004 3.567+000 2.799+000
 2101 2102
 2103 REFRIG. COMPOSITION = .650
 2104 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 2105
 2106
 2107
 2108 INPUT DATA TO CONPR:
 2110 P3 T3 H3 XQ3 TRA
 2111 6.622+001 3.221+001 8.836+001 9.906-001 7.000+001 TOA
 2112 2113
 2114 COMPRESSOR ITERATION:
 2115 EI ETAE ETAC ETAV CPRPM
 2116 2.721+000 7.577-001 9.472-001 8.565-001 3.549+003 RMAS
 2117 2118
 2119 1 T P H X
 2120 1 3.747+001 7.366+001 8.714+001 9.709-001
 2121 2 3.685+001 7.280+001 8.708+001 9.710-001
 2122 3 3.221+001 6.622+001 8.835+001 9.906-001
 2123 4 6.776+001 6.613+001 9.502+001 1.000+000
 2124 5 7.148+001 6.338+001 9.575+001 1.000+000
 2125 6 1.824+002 2.437+002 1.099+002 1.000+000
 2126 7 1.766+002 2.230+002 1.092+002 1.000+000
 2127 8 1.530+002 2.219+002 1.056+002 1.000+000
 2128 9 1.512+002 2.195+002 1.043+002 1.000+000
 2129 10 1.504+002 2.194+002 1.041+002 1.000+000
 2130 2131 INPUT DATA TO CONDHX:
 2132 T P TAIR RH RMASS
 2133 1.504+002 2.194+002 7.000+001 5.600-001 4.762+002
 2134 H2, H2PH2= 34.17 .00
 2135 H2, H2RH2= 34.90 -.72
 2136 H2, H2PH2= 34.95 -.05
 2137 H2, H2PH2= 35.07 -.12
 2138 H2, H2PH2= 35.20 -.12
 2139 H2, H2FH2= 35.26 -.07
 2140 H2, H2PH2= 35.27 -.01
 2141 2142
 2143 CONDENSER ITERATION:
 2144 T P H
 2145 X

1.504+002 2.194+002 1.041+002 1.000+000
 8.475+001 2.116+002 3.527+001 .000

LIQUID LINE:
 INPUT - PIN = 2.116+002 TIN = 8.475+001 XIN = .000
 OUTPUT - POUT= 2.061+002 TOUT= 8.472+001 XOUT= .000 HIN = 3.527+001

EXPANSION DEVICE:
 INPUT - P12 = 2.061+002 H12 = 3.527+001 P13 = 9.441+001
 OUTPUT - POUT = 1.597+002 XMSS = 4.835+002

INPUT DATA TO CONFR:

P3	T3	H3	XQ3	TG6	TRA
6.622+001	3.221+001	8.835+001	8.906-001	1.127+002	7.000+001

 4.700+001

COMPRESSOR ITERATION:

EI	ETAE	ETAC	ETAV	CPRFM	R ^{MASS}
2.719+000	7.576-001	9.473-001	8.567-001	3.549+003	4.763+002

CONDENSER ITERATION:

T	P	H	X
1	3.748+001	7.366+001	8.714+001
2	3.685+001	7.281+001	9.708+001
3	3.221+001	6.622+001	8.836+001
4	6.773+001	6.610+001	9.502+001
5	7.115+001	6.338+001	9.575+001
6	1.832+002	2.434+002	1.099+002
7	1.764+002	2.226+002	1.092+002
8	1.579+002	2.215+002	1.055+002
9	1.511+002	2.191+002	1.043+002
10	1.503+002	2.190+002	1.C41+002

 .000+000

INPUT DATA TO CONDUX:

T	P	TAIR	RH	R ^{MASS}
2.183	1.503+002	2.190+002	7.000+001	5.600-001
2.184	H2,H2PH2=	34.38	.01	4.763+002
2.185	H2,H2PH2=	34.38	.01	
2.186	H2,H2PH2=	34.56	.18	
2.187	H2,H2PH2=	35.32	.76	
2.188	H2,H2PH2=	35.35	.03	
2.189	H2,H2PH2=	35.42	.08	
2.190	H2,H2PH2=	35.45	.02	
2.191	H2,H2PH2=	24.62	.63	
2.192	H2,H2PH2=	34.98	.16	
2.193	H2,H2PH2=	35.08	.11	
2.194	CONDUX DOES NOT CONVERGE, MAX. ERROR= -1.059-001 (BTU/LR)			
2.195	CONDENSER ITERATION:			
2.197	T	P	H	X
2.198	1.503+002	2.190+002	1.041+002	1.000+000
2.199	8.401+001	2.110+002	3.500+001	.000
2.200				
2.201				
2.202	LIQUID LINE:			
2.203				

INPUT - PIN = 2.110+002 TIN = 8.4C1+001 XIN = .000 HIN = 3.508+001
 OUTPUT - POUT= 2.055+002 TOUT= 8.399+001 XOUT= .000

EXPANSION DEVICE:
 INPUT - P12 = 2.055+002 H12 = 3.508+001 P13 = 9.441+001
 OUTPUT - POUT = 1.600+002 XMASS = 4.861..002

INPUT DATA TO EVMPHX:

2213	T	P	X	TAIR	RH	RMASS
2214	3.615+001	9.444+001	2.322-001	4.700+001	7.300-001	4.752+002
2215	H2= 90.8930					
2216	H2= 88.4190					
2217	H2= 86.1198					
2218	H2= 85.9054					
2219	QT,QS= 2.393+004	2.110+004				
2220						

EVAPORATOR ITERATION:

2223	T	P	H	X	TSUP	
2224	3.615+001	9.444+001	3.581+001	2.322-001		
2225	3.733+001	7.386+001	8.589+001	9.569-001	.000	
2226						

INPUT DATA TO EVMPHX:

2227	T	P	X	TAIR	RH	RMASS
2228	3.610+001	9.436+001	2.324-001	4.700+001	7.300-001	4.753+002
2229	H2= 90.9397					
2230	H2= 88.6861					
2231	H2= 86.4198					
2232	H2= 86.2107					
2233	QT,QS= 2.397+004	2.118+004				
2234						
2235						
2236						

EVAPORATOR ITERATION:

2237	T	P	H	X	TSUP	
2238	3.610+001	9.436+001	3.581+001	2.324-001		
2239	3.725+001	7.366+001	8.68+001	9.603-001	.000	
2240	P1,P1E,F1EP1,DENT2=	73.6589	73.6608	.0019	-.9602	

INPUT DATA TO COMPRESSOR:

2241	P3	T3	H3	XQ3	TG6	TGA
2242	6.581+001	3.158+001	8.832+001	9.906-001	1.129+002	7.000+001
2243						
2244						

COMPRESSOR ITERATION:

2245	E1	ETAE	ETAC	ETAV	CPRPM	RMASS
2246	2.717+000	7.575-001	9.471-001	6.556-001	3.540+003	4.725+CO2
2247						
2248						
2249						

2262 1 1.772+002 2.234+002 1.093+002 1.000+000
 2263 8 1.585+002 2.224+002 1.056+002 1.000+000
 2264 9 1.517+002 2.200+002 1.043+002 1.000+000
 2265 10 1.503+002 2.199+002 1.042+002 1.000+000

INPUT DATA TO CONDHX:

2268	T	P	TAIR		RMASS
2269	1.508+002	2.199+002	7.000+001	5.600-001	4.725+002
2270	H2,I'2FH2=	34.04	.00		
2271	H2,H2PH2=	34.22	.18		
2272	H2,H2PH2=	34.86	.64		
2273	H2,H2PH2=	34.93	.08		
2274	H2,H2RH2=	34.45	.48		
2275	H2,H2RH2=	34.63	.18		
2276	H2,H2PH2=	34.74	.11		
2277	H2,H2PH2=	34.78	.04		
2278	H2,H2PH2=	34.77	.01		
2279					

CONDENSER ITERATION:

2281	T	P	H	X	
2282	1.508+002	2.199+002	1.012+002	1.000+000	
2283	8.280+001	2.123+002	3.477+001	.000	
2284					
2285					
2286					

INPUT DATA TO CONDHX:

2287	Liquid Line:				
2288	INPUT - PIN = 2.123+002		TIN = 8.280+001	XIN = .000	
2289	OUTPUT - POUT = 2.039+002		TOUT = 8.273+001	XOUT = .000	
2290					
2291					

EXPANSION DEVICE:

2292	INPUT - P12 = 2.069+002		H12 = 3.477+001	P13 = 9.387+001	
2293	OUTPUT - POUT = 1.626+002		XMAS = 4.399+002		
2294					
2295					
2296					

INPUT DATA TO COMP:

2297	P3	T3	H3	X03	TG6	TRA	TOA
2298	6.581+001	3.100+001	8.832+001	9.306-001	1.140+002	7.000-001	4.700+001
2299							
2300							
2301							

COMPRESSOR ITERATION:

2302	EI	ETAE	ETAC	ETAV	CPRFM	RMASS	
2303	2.742+000	7.536-001	9.464-001	8.539-001	3.548+003	4.711+002	
2304							
2305							
2306							
2307	I	T	P	H	X		
2308	1	3.708+001	7.313+001	8.708+001	9.707-001		
2309	2	3.645+001	7.229+001	8.702+001	9.708-001		
2310	3	3.188+001	6.561+001	8.832+001	9.905-001		
2311	4	6.868+001	6.571+001	9.502+001	1.000+000		
2312	5	7.191+001	6.300+001	9.581+001	1.000+000		
2313	6	1.857+002	2.175+002	1.103+002	1.000+000		
2314	7	1.791+002	2.275+002	1.036+002	1.000+000		
2315	8	1.602+002	2.265+002	1.058+002	1.000+000		
2316	9	1.533+002	2.242+002	1.045+002	1.000+000		
2317	10	1.524+002	2.241+002	1.043+002	1.000+000		
2318							
2319							

INPUT DATA TO CONDHX:

2320
 2321 T P TAIR RH RMASS
 2322 1.524+002 2.241+002 7.000+001 5.600-001 4.711+002
 H2, H2PH2= 33.51 -.28
 2323 H2, H2PH2= 33.62 -.08
 2324 H2, H2PH2= 33.87 -.26
 2325 H2, H2PH2= 33.73 .14
 2326 H2, H2PH2= 33.89 .15
 2327 H2, H2PH2= 33.95 -.06
 2328 H2, H2PH2= 33.94 .01
 2329 H2, H2PH2= 33.94 .01
 2330
CONDENSER ITERATION:
 2331 T P TAIR RH RMASS
 2332 2333 1.524+002 2.241+002 H X
 2334 7.862+001 2.176+002 1.043+002 1.000+000 1.000+000
 2335 2336
 2337
LIQUID LINE:
 INPUT - PIN = 2.176+002 TIN = 7.962+001 XIN = .000
 OUTPUT - POUT = 2.122+002 TOUT = 7.959+001 XOUT = .000
 2338
EXPANSION DEVICE:
 INPUT - P'2 = 2.122+002 H12 = 3.394+001 P13 = 9.382+001
 OUTPUT - P'1 = 1.820+002 XMSS = 5.922+002
 2339
 2340
 2341
 2342
 2343
 2344
 2345
 2346
 2347
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 2349
 2350
 2351
 2352
 2353
 2354
 2355
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 2359
 2360
 2361
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 2363
 2364
 2365
 2366
 2367
 2368
 2369
 2370
 2371
 2372
 2373
 2374
 2375
 2376
 2377

2378 H₂,H₂PH2= 35.35 -.02
 H₂,H₂PH2= 35.37 -.02
 2379
 2380
 2381 CONDENSER ITERATION:
 2382
 2383 T P H X
 2384 1.504+002 2.187+002 1.041+002 1.200+000
 8.513+001 2.108+002 3.537+001 .000
 2385
 2386
 2387 LIQUID LINE:
 2388 INPUT - PIN = 2.108+002 TIN = 3.513+001 P13 = 3.537+001
 2389 OUTPUT - POUT= 2.054+002 TOUT= 3.510+001 XIN = .000
 2390 XOUT= .000
 2391
 2392 EXPANSION DEVICE:
 2393 INPUT - P12 = 2.054+002 H12 = 3.537+001 P13 = 3.537+001
 2394 DDENFA DOES NOT CONVERGE, DIFXG2= -9.61527-006
 2395 OUTPUT - POUT = 1.538+002 XMES = -4.789+002
 2396
 2397 INPUT DATA TO EVA.PHX:
 2398 T P X TAIR RH RMASS
 2399 3.572+001 9.388+001 2.274-001 4.700+001 7.200-001 4.730+002
 2400 H2= 91.0375
 2401 H2= 89.4202
 2402 H2= 87.3639
 2403 H2= 87.1429
 2404 H2= 87.0711
 2405 QT,QS= 2.142+004 2.132+004
 2406
 2407
 2408
 2409 EVAPORATOR ITERATION:
 2410
 2411 T P H X TSUP
 2412 3.572+001 9.388+C01 3.544+001 2.274-001
 2413 3.707+001 7.311+001 3.708+001 9.707-001 .000
 P1,P1E,P1EP1,DENT2= 73.1819 73.1082 -.0737 -.0226
 2414 INTERM,INTERE,POUT,P13= 1 0 158.83 93.88
 2415
 2416 INPUT DATA TO COMPR:
 2417
 2418 P3 T3 H3 T96 TRA RMASS
 2419 6.581+001 3.188+C01 8 832+001 9.905-00; 1.125+002 7.000+001 4.700+001
 2420
 2421
 2422 COMPRESSOR ITERATION:
 2423
 2424 EI ETAE ETAC ETAV CPRPM RMASS
 2425 2.708+000 7.572-001 9.473-0C1 8.563-001 3.549+003 4.730+002
 2426
 2427 I T P H X
 2428 1 3.713+001 7.318+001 8.710+001 9.709-001
 2 3.650+001 7.232+001 8.704+001 9.710-001
 2429 3 3.183+001 6.581+001 8.822+001 9.906-001
 2430 4 6.763+001 6.571+001 9.502+001 1.000+000
 2431 5 7.137+001 6.293+C01 9.575+001 1.000+000
 2432 6 1.833+002 2.425+002 1.100+002 1.000+000
 2433 7 1.765+002 2.219+002 1.093+002 1.000+000
 2434 8 1.579+002 2.209+002 1.056+002 1.000+000

2436 9 1.511+002 2.184+002 1.043+002 1.000+000
2437 10 1.503+002 2.184+002 1.041+002 1.000+000

INPUT DATA TO CONDHX:

2440 T P TAIR RH RMASS
2441 1.503+002 2.184+002 7.000+001 5.600-001 4.730+002
H2, H2PH2= 34.60 -.54
2442 H2, H2PH2= 34.71 -.10
2443 H2, H2PH2= 34.71 -.04
2444 H2, H2PH2= 34.75 -.11
2445 H2, H2PH2= 34.86 -.21
2446 H2, H2PH2= 35.08 -.09
2447 H2, H2PH2= 35.17 -.01
2448 H2, H2PH2= 35.18 -.01
2449 H2, H2PH2= 35.18 -.01

CONDENSER ITERATION:

2450 T P H X
2451 1.503+002 2.184+002 1.041+002 X
2452 INPUT - PIN = 2.104+002 1.000+000
2453 OUTPUT - POUT = 2.104+002 1.000+000
2454 8.439+001 3.518+001 .000
2455 8.439+001 3.518+001 .000
2456

LIQUID LINE:

2457 INPUT - PIN = 2.104+002 TIN = 8.439+001 XIN = .000
2458 OUTPUT - POUT = 2.049+002 TOUT = 8.437+001 XOUT = .000
2459

EXPANSION DEVICE:

2460 INPUT - P12 = 2.049+002 H12 = 3.518+001 P13 = 9.389+001
2461 OUTPUT - POUT = 1.503+002 XMMASS = 4.814+002

INPUT DATA TO COMPR:

2462 P3 T3 H3 X03 TOA
2463 6.581+001 3.188+001 8.332+001 9.906-001 1.124+002 7.000+001
2464

COMPRESSOR ITERATION:

2465 E1 ETAE ETAC ETAV TG6 CPRPM RMASS
2466 2.706+000 7.571-001 9.474-001 8.564-001 3.549+C03 4.731+002
2467 T P H X
2468 1 3.713+001 7.319+001 8.710+001 9.709-001
2469 2 3.650+001 7.234+001 8.705+001 9.710-001
2470 3 3.188+001 6.531+001 8.632+001 9.706-001
2471 4 6.759+001 6.571+001 9.501+001 1.000-000
2472

2473 T P H X
2474 5 7.133+001 6.293+001 9.574+001 1.000-000
2475 6 1.831+002 2.421+002 1.099+002 1.000+000
2476 7 1.763+002 2.215+002 1.092+002 1.000+000
2477 8 1.577+002 2.205+002 1.055+002 1.000+000
2478 9 1.502+002 2.187+002 1.043+002 1.000+000
2479 10 1.501+002 2.180+002 1.041+002 1.000+000
2480

2481 INPUT DATA TO CONDHX:
2482 T P TAIR RH RMASS
2483 1.501+002 2.180+002 7.000+001 5.600-001 4.731+002
2484 H2, H2PH2= 34.82 -.50

2494 H2, H2PH2= 34.92 -.10
 2495 H2, H2PH2= 34.77 .16
 2495 H2, H2PH2= 35.16 -.39
 2496 H2, H2PH2= 35.36 -.21
 2497 H2, H2PH2= 35.44 -.07
 2498 H2, H2PH2= 35.43 .01
 2500
 2501 CONDENSER ITERATION:
 2502 T P H X
 2503 1.501+002 2.180+002 1.341+002 1.000+000 HIN = 3.543+001
 2504 8.534+001 2.099+002 3.543+001 .000 XOUT= .000
 2505 2506
 2507 LIQUID LINE:
 2508 INPUT - PIN = 2.099+002 TIN = 8.534+001 XIN = .000
 2509 OUTPUT - POUT= 2.044+002 TOUT= 8.532+001 XOUT= .000
 2510
 2511 EXPANSION DEVICE:
 2512 INPUT - P12 = 2.044+002 H12 = 3.543+001 P13 = 9.389+001
 2513 OUTPUT - POUT = 1.576+002 XIMASS = 4.737+002
 2514
 2515
 2516 INPUT DATA TO EVAPHX:
 2517
 2518 T P H X
 2519 3.572+001 9.389+001 2.271-001 TAIR FMASS
 2520 H2= 91.0529 7.300-001 4.731+002
 2521 P2= 89.3513
 2522 H2= 87.3205
 2523 H2= 87.1003
 2524 H2= 87.0362
 2525 QT, QS= 2.442+304 2.132+004
 2526
 2527 EVAPORATOR ITERATION:
 2528
 2529 T P H X TSUP
 2530 3.572+001 9.389+001 3.543+001 2.271-001
 2531 3.707+001 7.313+001 8.704+001 9.773-001 .000
 2532 P1, P1E, P1EP1, DENT2= 73.1284 73.1278 -.0620
 2533 INTERN, INTERE, POUT, P13= 0 0 157.59 93.09
 2534 COMPOSITION OF REFRIG. IN ACCUMULATOR = .404
 2535 WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 2536
 2537 REFRIG. IN ACCUMULATOR = .649 LB
 2538
 2539 REFRIG. IN INDOOR COIL = 2.344 LB
 2540 REFRIG. IN OUTDOOR COIL = .875 LB
 2541
 2542
 2543
 2544 TMASS = 4.924+000 REFIN = 4.968+000
 2545
 2546 ***SYSTEM WITH ACCUMUL., 1361/152A 6-22-84***
 2547
 2548 TOA RHOA TRA RHRA
 2549 4.700+001 7.300-001 7.300+001 5.600-001
 2550
 2551

CFMIND 1.118+003 CFMOUT 2.284+003

RESULTS:

	T	P	H	S	X
2556					
2557	1	3.713+001	8.312+001	8.710+001	1.903+001
2558	2	3.650+001	7.234+001	8.705+001	1.904+001
2559	3	3.188+001	6.581+001	8.032+001	1.916+001
2560	4	6.759+001	6.571+001	9.501+001	2.073+001
2561	5	7.133+001	6.298+001	9.574+001	2.100+001
2562	6	1.831+002	2.421+002	1.099+002	2.112+001
2563	7	1.763+002	2.215+002	1.092+002	2.115+001
2564	8	1.577+002	2.205+002	1.055+002	2.057+001
2565	9	1.509+002	2.180+002	1.043+002	2.033+001
2566	10	1.501+002	2.180+002	1.041+002	2.036+001
2567	11	8.534+001	2.099+002	3.543+001	8.093+002
2568	12	8.532+001	2.044+002	3.543+001	8.101+002
2569	13	3.572+001	9.339+001	3.543+001	8.295+002
2570					2.271+001
2571					
2572					
2573	TG3	TSUP3	TG6	RMASS	
2574	3.208+001	.000	1.124+002	4.731+002	4.934+000
2575					
2576	QLOAD	ELUSE	COP		
2577	3.415+004	3.571+000	2.802+000		
2578					
2579	REFRIG. COMPOSITION = .650				
2580	(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)				
2581					
2582					
2583					
2584					
2585					
2586	FOR THE AMOUNT OF REFRIGERANT STORED IN THE ACCUMULATOR				
2587	CIRCULATING COMPOSITION SHOULD BE .687				
2588					
2589	NEW CALCULATED COMPOSITION FOR THE NEXT LOOP IS .668				
2590	(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)				
2591					
2592	*****				
2593	INPUT DATA TO COMPRESSOR:				
2594					
2595	P3	T3	H3	X03	TGA
2596	6.773+001	3.187+001	8.642+001	9.506-001	1.124+002
2597					7.000+001
2598					4.700+001
2599	COMPRESSOR ITERATION:				
2600					
2601	EI	ETAE	ETAC	ETAV	CPRPM
2602	2.763+000	7.595-001	9.470-001	8.577-001	3.548+003
2603					4.065+002
2604	I	P	H		X
2605	1	3.722+001	7.547+001	8.524+001	9.708+001
2606	2	3.658+001	7.459+001	8.518+001	9.709+001
2607	3	3.187+001	6.773+001	8.642+001	9.806+001
2608	4	6.722+001	6.764+001	9.295+001	1.000+000
2609	5	7.087+001	6.477+001	9.366+001	1.000+000

6 1.825+002 2.478+002 1.075+002 1.000+000
 2610 7 1.757+002 2.250+002 1.068+002 1.000+000
 2611 8 1.573+002 2.249+002 1.033+002 1.000+C0C
 2612 9 1.506+002 2.223+002 1.020+002 1.000+000
 2613 10 1.428+002 2.222+002 1.019+002 1.000+000
 2614
 2615
INPUT DATA TO CONDHX:
 2617 T P TAIR RH RMASS
 2618 1.498+002 2.222+002 7.000+001 5.600-001 4.965+C02
 2619 H2, H2PH2= 34.64 -.09
 2620 H2, H2PH2= 35.39 -.75
 2621 H2, H2PH2= 35.80 -.41
 2622 H2, H2PH2= 35.95 -.15
 2623 H2, H2PH2= 36.02 -.07
 2624 H2, H2PH2= 36.07 -.05
 2625 H2, H2PH2= 36.10 -.03
 2626 H2, H2PH2= 36.11 -.01
 2627
 2628 CONDENSER ITERATION:
 2629
 2630 T P H X
 2631 1.498+002 2.222+002 1.019+002 1.000+000
 2632 8.773+001 2.130+002 3.611+001 1.170-002
 2633 2634
 2535
Liquid Line:
 INPUT - PIN = 2.130+002 TIN = 8.773+001 XIN = 1.170-002 HIN = 3.611+001
 OUTPUT - POUT = 2.C58+002 TOUT = 8.524+001 XOUT = 2.552-C02
 2639
 2640 EXPANSION DEVICE:
 INPUT - P12 = 2.058+002 H12 = 3.611+001 P13 = 9.617+001
 OUTPUT - PCUT = 1.549+002 XMSS = 4.529+002
 2641
 2642 INPUT DATA TO COMPR:
 2643 P3 T3 H3 XQ3
 6.773+001 3.187+001 8.642+001 9.905-001 T66 TRA TOA
 2644 2645
 2646
 2647
 2648
 2649
 2650 COMPRESSOR ITERATION:
 2651 EI ETAE ETAC X
 2652 2.775+000 7.600-001 9.467-001 8.568-001 CFPMPM RMASS
 2653 2654
 2655 1 T P H X
 2656 1 3.720+001 7.545+001 8.523+001 9.707-001
 2657 2 3.657+001 7.457+001 8.518+001 9.709-001
 2658 3 3.187+001 6.773+001 8.642+001 9.906-001
 2659 4 6.733+001 6.764+001 9.298+001 1.000+000
 2660 5 7.107+001 6.477+001 9.370+001 1.000+000
 2661 6 1.831+002 2.496+002 1.076+002 1.000+000
 2662 7 1.766+002 2.280+002 1.070+002 1.000+000
 2663 8 1.582+002 2.269+002 1.033+002 1.000+000
 2664 9 1.514+002 2.244+002 1.021+002 1.000+000
 2665 10 1.506+002 2.243+002 1.019+002 1.000+000
 2666
 2667
INPUT DATA TO CONDHX:

2668 T P TAIR RH RMASS
 2669 1.50G+002 2.243+C02 7.000+001 5.600-001 4.953+002
 2670 H2, H2PH2= 34.14 -.10
 2671 H2, H2PH2= 34.41 -.27
 2672 H2, H2PH2= 31.94 -.53
 2673 H2, H2PH2= 34.59 .35
 2674 H2, H2PH2= 31.81 -.22
 2675 H2, H2PH2= 34.92 -.11
 2676 H2, H2PH2= 34.99 -.07
 2677 H2, H2PH2= 34.93 .01
 2678 H2, H2PH2= 34.93 .01
 2679 CONDENSER ITERATION:
 2680 T P H X
 2681 1.506+002 2.243+002 1.019+002 1.000+000
 2682 8.545+001 2.153+002 3.498+001 .300
 2683
 2684
 2685
 2686 LIQUID LINE:
 2687 INPUT - PIN = 2.158+002 TIN = 8.545+001 XIN = .000
 2688 OUTPUT - POUT = 2.099+002 TOUT = 8.543+001 XOUT = .000
 2689
 2690 EXPANSION DEVICE:
 2691 INPUT - P12 = 2.099+002 H112 = 3.498+001 P13 = 9.615+001
 2692 OUTPUT - POUT = 1.627+002 XMMASS = 4.909+002
 2693
 2694
 2695 INPUT DATA TO COMPRESSOR:
 2696
 2697 P3 T3 H3 XQ3 TG6 TRA TGA
 2698 6.773+001 3.187+001 8.642+001 9.906-001 1.130+002 7.000+001 4.700+001
 2699
 2700
 2701 COMPRESSOR ITERATION:
 2702 EI ETAE ETAC ETAV CPROFM RMASS
 2703 2.777+000 7.601-001 9.466-001 8.567-001 3.543+003 4.957+002
 2704
 2705
 2706
 2707
 2708
 2709
 2710
 2711
 2712
 2713
 2714
 2715
 2716
 2717
 2718
 2719
 2720
 2721
 2722
 2723
 2724
 2725
 INPUT DATA TO CONDHX:
 T P TAIR RH RMASS
 1.507+002 2.246+002 7.000+001 5.600-001 4.957+002
 H2, H2PH2= 34.01 -.11
 H2, H2PH2= 34.27 -.26
 H2, H2PH2= 34.82 -.55
 H2, H2PH2= 35.06 -.24

2726 H₂, H₂PH2= 35.11 - .05
 2727 H₂, H₂PH2= 35.12 -.01
 2728
 2729 CONDENSER ITERATION:
 2730 T P H X
 2731 1.507+002 2.246+002 1.020+002 1.000+000
 2732 8.602+001 2.162+002 3.512+001 .000
 2733
 2734
 2735 LIQUID LINE:
 2737 INPUT - PIN = 2.162+002 TIN = 8.602+001 XIN = .000 HIN = 3.512+001
 2738 OUTPUT - POUT = 2.104+002 TOUT = 8.592+001 XOUT = .000
 2739
 2740 EXPANSION DEVICE:
 2741 INPUT - P12 = 2.104+002 H12 = 3.512+001 P13 = 9.615+001
 2742 OUTPUT - POUT = 1.624+002 XMASS = 4.885+002
 2743
 2744 INPUT DATA TO EVAPHX:
 2745 T P X TAIR RH RMASS
 2746 3.576+001 9.615+001 2.212-001 4.700+001 7.300-001 4.360+002
 2747 H2= 89.0996
 2748 H2= 87.5652
 2749 H2= 85.5736
 2750 Q_T, Q_S= 2.522+004 2.238+004
 2751
 2752
 2753
 2754 EVAPORATOR ITERATION:
 2755 T P H X TSUP RMASS
 2756 3.576+001 9.615+001 3.467+001 2.212-001 4.700+001 7.300-001 4.360+002
 2757 3.685+001 7.485+001 8.552+001 9.745-001 .000
 2758
 2759
 2760 INPUT DATA TO EVAPHX:
 2761 T P X TAIR RH RMASS
 2762 3.591+001 9.639+001 2.206-001 4.700+001 7.300-001 4.360+002
 2763 H2= 88.9841
 2764 H2= 86.9319
 2765 H2= 84.7277
 2766 Q_T, Q_S= 2.482+004 2.210+004
 2767
 2768
 2769
 2770
 2771 T P H X TSUP
 2772 3.591+001 9.639+001 3.467+001 2.206-001
 2773 3.707+001 7.546+001 6.471+001 9.648-001 .000
 2774 P1, P1E, P1EP1, DENT2= 75.4489 75.4758 .0068 - .5204
 2775 INTERM, INTERE, FOUT, F13= 1 0 162.35 96.39
 2776
 2777 INPUT DATA TO COMPR:
 2778
 2779 P3 T3 H3 XG3 TGA
 2780 6.773+001 3.167+001 8.642+001 9.906-001 1.128+002 7.000+001 4.700+001
 2781
 2782 COMPRESSOR ITERATION:
 2783

2781
 2785 EI ETAE ETAC ETAV CPRPM RMASS
 2.772+000 7.599-001 9.458-001 8.571-001 3.548+003 4.360+002
 2786
 2787 I T P H X
 2788 1 3.721+001 7.546+001 8.523+001 9.708-001
 2789 2 3.657+001 7.457+001 8.513+001 9.709-001
 2790 3 3.187+001 6.773+001 8.542+001 9.906-001
 2791 4 6.731+001 6.764+001 9.297+001 1.000+000
 2792 5 7.101+001 6.477+001 9.369+001 1.000+000
 2793 6 1.832+002 2.491+002 1.076+002 1.000+000
 2794 7 1.763+002 2.274+002 1.069+002 1.000+000
 2795 8 1.579+002 2.263+002 1.033+012 1.000+000
 2796 9 1.512+002 2.238+002 1.021+002 1.000+000
 2797 10 1.504+002 2.237+002 1.019+002 1.000+000
 2798
 2800 INPUT DATA TO CONDHX:
 2801 T P TAIR RH RMASS
 2802 1.504+002 2.237+002 7.000+001 5.000-001 4.960+002
 2803 H2, H2PH2= 34.09 -.10 .10 4.960+002
 2804 H2, H2PH2= 34.97 -.88 .88
 2805 H2, H2PH2= 34.77 .20 .20
 2806 H2, H2PH2= 35.10 -.33 .33
 2807 H2, H2PH2= 35.25 -.15 .15
 2808 H2, H2PH2= 35.33 -.08 .08
 2809 H2, H2FH2= 35.32 .00 .00
 2810
 2811 CONDENSER ITERATION:
 2812
 2813 T P H X
 2814 1.504+002 2.237+002 1.019+002 1.000+000
 2815 8.677+001 2.150+002 3.532+001 .000
 2816
 2817 LIQUID LINE:
 2818 INPUT - PIN = 2.150+002 TIN = 8.677+001 XIN = .000
 2819 OUTPUT - POUT = 2.091+002 TOUT = 8.626+001 XOUT = 2.741-003
 2820
 2821
 2822 EXPANSION DEVICE:
 2823 INPUT - P12 = 2.C91+002 H12 = 3.532+001 P13 = 9.640+001
 2824 OUTPUT - POUT = 1.503+002 XMASS = 4.795-002
 2825
 2826 INPUT DATA TO COMPRESSOR:
 2827
 2828
 2829 P3 T3 H3 XQ3 TG6 TRA TGA
 2630 6.773+001 3.187+001 8.642+001 9.906-001 1.123+002 7.000+001 4.700+001
 2831
 2832 COMPRESSOR ITERATION:
 2533
 2833 EI ETAE ETAC ETAV CPRPM RMASS
 2E35 2.760+000 7.594-001 9.471-001 6.578-001 3.548+003 4.360+002
 2836
 2837 I T P H X
 2838 1 3.722+001 7.548+001 6.524+001 9.708-001
 2839 2 3.659+001 7.459+001 6.519+001 9.710-001
 2840 3 3.187+001 6.773+001 6.642+001 9.906-001
 2841 4 6.720+001 6.764+001 6.295+001 1.000+000

5 7.084+001 6.476+001 9.366+001 1.000+000
 6 1.823+002 2.474+002 1.075+002 1.000+000
 7 1.755+002 2.255+002 1.068+002 1.000+000
 8 1.572+002 2.244+002 1.032+002 1.000+000
 9 1.524+002 2.218+002 1.020+002 1.000+000
 10 1.497+002 2.218+002 1.019+002 1.000+000

2849 INPUT DATA TO CONDHX:

2850	T	P	TAIR	RH	RMASS
2851	1.497+002	2.218+002	7.000+001	5.600-001	4.266+002
2852	H2, H2PH2=	34.99	.08		
2853	H2, H2RH2=	35.62	.63		
2854	H2, H2RH2=	35.95	.33		
2855	H2, H2RH2=	36.13	.13		
2856	H2, H2RH2=	36.23	.09		
2857	H2, H2RH2=	36.29	.06		
2858	H2, H2RH2=	36.32	.03		
2859	H2, H2RH2=	36.33	.02		
2860	H2, H2RH2=	36.33	.02		

2861 CONDENSER ITERATION:

2862	T	P	H	X	
2863	1.497+002	2.218+002	1.019+002	1.000+000	
2864	8.756+001	2.124+002	3.633+001	1.752-002	
2865					
2866					
2867					

2868 LIQUID LINE:

2869	INPUT -	PIN = 2.124+002	TIN = 8.756+001	XIN = 1.752-002	
2870	OUTPUT -	POUT = 2.017+002	TOUT = 8.491+001	XOUT = 3.220-002	
2871					
2872					

2873 EXPANSION DEVICE:

2874	INPUT -	P12 = 2.047+002	H12 = 3.633+001	P13 = 9.511+001	
2875	OUTPUT -	POUT = 1.536+002	XMASS = 4.455+002		
2876					

2877 INPUT DATA TO COMPR:

2878	P3	T3	H3	XQ3	TG6	TOA
2879	6.773+001	3.187+001	8.642+001	9.506-001	1.130+002	7.000+001
2880						
2881						
2882						

2883 COMPRESSOR ITERATION:

2884	EI	ETAE	ETAC	ETAV	CPRFM	RMASS
2885	2.777+000	7.601-001	9.466-001	8.567-001	3.548+003	4.9057+002
2886						
2887						

2888 I T P H X

2889	1	3.720+001	7.545+001	8.523+001	9.707-001	
2890	2	3.656+001	7.457+001	8.517+001	9.703-001	
2891	3	3.187+001	6.773+001	8.642+001	9.906-001	
2892	4	6.741+001	6.764+001	9.299+001	1.000+000	
2893	5	7.109+001	6.177+001	9.370+001	1.000+000	
2894	6	1.835+002	2.499+002	1.077+002	1.000+000	
2895	7	1.767+002	2.283+002	1.070+002	1.000+000	
2896	8	1.583+002	2.273+002	1.031+002	1.000+000	
2897	9	1.515+002	2.247+002	1.021+002	1.000+000	
2898	10	1.507+002	2.247+002	1.020+002	1.000+000	

INPUT DATA TO CONDHX:

2900
 2901 T P TAIR RH RMASS
 2902 1.507+002 2.247+002 7.000+001 5.600-001 4.257+002
 2903 H2, H2PH2= 33.97 -.11
 2904 H2, H2PH2= 34.23 -.26
 2905 H2, H2PH2= 34.79 -.55
 2906 H2, H2PH2= 35.03 -.24
 2907 H2, H2PH2= 35.08 -.05
 2908 H2, H2PH2= 35.09 -.01
 2909
 2910
 2911 CONDENSER ITERATION:
 2912 T P H X
 2913 1.507+002 2.247+002 1.020+002 1.000+000
 2914 8.583+001 2.163+002 3.500+001 .000
 2915
 2916
 2917 LIQUID LINE:
 2918 INPUT - PIN = 2.163+002 TIN = 8.508+001 YIN = .000
 2919 OUTPUT - POUT = 2.105+002 TOUT = 8.534+001 XOUT = .000
 2920
 2921
 2922 EXPANSION DEVICE:
 2923 INPUT - P12 = 2.105+002 H12 = 3.509+001 P13 = 9.639+001
 2924 DENSEA DOES NOT CONVERGE, DIFXQ2= -8.006+8-006
 2925 OUTPUT - POUT = 1.626+002 XMASS = 4.304+002
 2926
 2927
 2928 INPUT DATA TO COMP:

P3	T3	H3	X03	TG5	TOA
6.773+001	3.187+001	8.642+001	9.906-001	1.131+002	7.000+001

2929
 2930
 2931
 2932
 2933 COMPRESSOR ITERATION:
 2934
 2935 EI ETAE ETAC ETAV CPRPM RMASS
 2936 2.779+000 7.602-001 9.466-001 8.566-001 3.543+003 4.256+002
 2937
 2938 I T P H X
 2939 1 3.720+001 7.544+001 8.523+001 9.707-001
 2940 2 3.656+001 7.456+001 8.517+001 9.708-001
 2941 3 3.187+001 6.773+001 8.642+001 9.306-001
 2942 4 6.744+001 6.764+001 9.299+001 1.000+000
 2943 5 7.113+001 6.478+001 9.371+001 1.000+000
 2944 6 1.837+002 2.502+002 1.077+002 1.000+000
 2945 7 1.769+002 2.286+002 1.070+002 1.000+000
 2946 8 1.584+002 2.276+002 1.034+002 1.000+000
 2947 9 1.516+002 2.251+002 1.021+002 1.000+000
 2948 10 1.509+002 2.250+002 1.020+002 1.000+000
 2949
 2950
 2951
 2952 T P TAIR RH RMASS
 2953 1.509+002 2.250+002 7.000+001 5.600-001 4.956+002
 2954 H2, H2PH2= 33.80 -.12
 2955 H2, H2PH2= 34.57 -.77
 2956 H2, H2PH2= 34.47 .10
 2957 H2, H2PH2= 34.78 -.31

INPUT DATA TO CONDCHX:
 2951
 2952
 2953
 2954
 2955
 2956
 2957

2958 H₂,H₂PH₂= 34.88 - .10
 2959 H₂,H₂PH₂= 34.94 - .06
 2960 H₂,H₂PH₂= 34.94 .00
 2961
CONDENSER ITERATION:
 2962
 2963 T P H X
 2964 1.509+002 2.250+002 1.020+002 X
 2965 8.530+001 2.167+002 3.494+001 1.000+000
 2966 .000 .000 .000 .000
 2967
Liquid Line:
 2968 INPUT - PIN = 2.167+002 TIN = 8.530+001 XIN = .000
 2969 OUTPUT - POUT = 2.109+002 TOUT = 8.527+001 XOUT = .000
 2970 HIN = 3.494+001
 2971
EXPANSION DEVICE:
 2972 INPUT - P12 = 2.109+002 H12 = 3.494+001 P13 = 9.639+001
 2973 OUTPUT - POUT = 1.638+002 XMASS = 4.954+002
INPUT DATA TO EVAPHX:
 2974 T P X
 2975 3.597+001 9.638+001 2.253-001 TAIR
 2976 H2= 89.0563 4.700+001 RH
 2977 H2= 87.3074 7.300-001 RMASS
 2978
INPUT DATA TO EVAPHX:
 2979 T P X
 2980 3.597+001 9.638+001 2.253-001 TAIR
 2981 H2= 89.0563 4.700+001 RH
 2982 H2= 87.3074 7.300-001 RMASS
 2983 H2= 85.2126
 2984 H2= 85.1421
 2985 H2= 85.0411
 2986 QT,QS= 2.483+004 2.153+004
 2987
EVAPORATOR ITERATION:
 2988
 2989 T P H X
 2990 3.597+001 9.638+001 3.194+001 X
 2991 H2= 89.0079 2.253-001 TSUP
 2992 3.603+001 7.544+001 6.505+001 2.253-001
 2993 3.628+001 7.520+001 6.505+001 9.689-001 .000
 2994
INPUT DATA TO EVAPHX:
 2995 T P X
 2996 3.603+001 9.618+001 2.251-001 TAIR
 2997 H2= 89.0079 4.700+001 RH
 2998 H2= 87.0411 7.300-001 RMASS
 2999 H2= 87.0411 4.954+002
 3000 H2= 84.8757
 3001 H2= 84.6077
 3002 H2= 84.7199
 3003 QT,QS= 2.468+004 2.145+004
 3004
EVAPORATOR ITERATION:
 3005
 3006 T P H X
 3007 3.603+001 9.646+001 3.494+001 2.251-001 TSUP
 3008 3.707+001 7.544+001 8.473+001 9.651-001 .000
 3009 P1,PIE,P1EP1,DENT= 75.4447 75.4447 -.0024 -.4981
 3010 INTERM,INFERE,FOUT,P13= 0 0 163.83 26.48
 3011 CCOMPOSITION OF REFRIG. IN ACCUMULATOR = .414
 3012 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 3013
 3014
 3015

3016 REFRIG. IN ACCUMULATOR = .796 LB
 3017 REFRIG. IN INDOOR COIL = 2.492 LB
 3018 REFRIG. IN OUTDOOR COIL = .915 LB
 3019
 3C20
 3021 TMASS = 5.359+000 REFIN = 4.963+000
 3022
 3023 **** SYSTEM WITH ACCUM. , 13E1 / 152A 6-22-81***
 3024 *** SYSTEM WITH ACCUM. , 13E1 / 152A 6-22-81***
 3025
 3026 TOA 4.700+001 RHQA TRA RHRA
 3027 7.300+001 7.000+001 5.600+001
 3028
 3029
 3030 CFMIND CFMOUT
 3031 1.118+003 2.284+003
 3032
 3033
 3034 RESULTS:
 3035 I T P H S X
 3036 1 3.720+001 7.514+001 8.323+001 1.862+001 9.707+001
 3037 2 3.656+001 7.456+001 8.517+001 1.863+001 9.703+001
 3038 3 3.187+001 6.773+001 8.642+001 1.905+001 9.906+001
 3039 4 6.744+001 6.764+001 9.259+001 2.035+001 1.000+000
 3040 5 7.113+001 6.478+001 9.371+001 2.056+001 1.000+000
 3041 6 1.837+002 2.502+002 1.077+002 2.067+001 1.000+000
 3042 7 1.765+002 2.786+002 1.070+002 2.071+001 1.000+000
 3043 8 1.584+002 2.276+002 1.037+002 2.014+001 1.000+000
 3044 9 1.516+002 2.251+002 1.021+002 1.996+001 1.000+000
 3045 10 1.509+002 2.250+002 1.020+002 1.993+001 1.000+000
 3046
 3047 11 8.530+001 2.167+002 3.494+001 7.987+002 .000
 3048 12 8.527+001 2.109+002 3.494+001 7.989+002 .000
 3049 13 3.603+001 9.648+001 3.494+001 8.179+002 2.251+001
 3050
 3051 TG3 TSUP3 TG6 RMASS TMASS
 3052 3.208+001 .000 1.131+002 4.953+002 5.350+000
 3053
 3054 QLOAD ELUSE COP
 3.487+004 3.644+000 2.804+000
 3055
 3056
 3057 REFRIG. COMPOSITION = .668
 3058 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 3059
 3060
 3061
 3062
 3063 INPUT DATA TO COMPRESSOR:
 3064 P3 T3 H3 XQ3 TG6
 6.713+001 3.151+001 8.723+001 1.000+000 1.121+002 TRA
 3065
 3066
 3067 COMPRESSOR ITERATION:
 3068
 3069 EI ETAE ETAC CPROFM RMASS
 3070 2.750+000 7.539-001 9.475-001 8.562-001 3.518+003 4.877+002
 3071
 3072
 3073 I T P H X

1 3.689+001 7.474+001 8.599+001 9.799-001
 2 3.627+001 7.383+001 8.593+001 9.799-001
 3 3.161+001 6.713+001 8.723+001 1.000+000
 4 7.018+001 6.704+001 9.346+001 1.000+000
 5 7.389+001 6.422+001 9.418+001 1.000+000
 6 1.858+002 2.470+002 1.052+002 1.000+000
 7 1.791+002 2.257+002 1.075+002 1.000+000
 8 1.606+002 2.246+002 1.039+002 1.000+000
 9 1.535+002 2.221+002 1.026+002 1.000+000
 10 1.527+002 2.221+002 1.024+002 1.000+000

3084 INPUT DATA TO CONDHX:

3085

T	P	T _{AIR}	RH	F _{MASS}
3087	1.527+002	2.221+002	7.000+001	5.600-001 4.877+002
3088	H2, H2PH2=	34.66	.68	
2089	H2, H2PH2=	34.60	.06	
3090	H2, H2PH2=	35.22	.62	
3091	H2, H2PH2=	35.47	.25	
3092	H2, H2PH2=	35.57	.10	
3093	H2, H2PH2=	35.57	.00	
3094	H2, H2PH2=	35.57	.00	
3095	H2, H2PH2=	35.57	.00	

3096 CONDENSER ITERATION:

3097

T	P	H	X
3098	1.527+002	2.221+002	1.024+002 1.000+000
3100	8.772+001	2.135+002	3.557+001 .000
3101			
3102			

3103 LIQUID LINE:

INPUT	PIN =	2.135+002	TIN =	8.772+001	XIN =	.000
OUTPUT	POUT =	2.074+002	TOUT =	8.571+001	XOUT =	1.127-002

3104

3105 EXPANSION DEVICE:

INPUT	P12 =	2.074+002	H12 =	3.557+001	P13 =	9.577+001
OUTPUT	POUT =	1.582+002	XMASS =	4.691+002		

3106

3107

3108

3109 INPUT DATA TO COMP:

P3	T3	H3	XQ3	TG6	TRA	TOA
3110 6.713+001	3.161+001	8.723+001	1.000+001	1.124+002	7.000+001	4.700+001
3111						
3112						
3113						
3114						
3115						
3116						
3117						
3118						
3119						
3120	E1	ETAE	ETAC	ETAV	CP7FM	RM7SS
3121	2.756+000	7.592-001	5.473-001	8.553-001	3.518+003	4.873+002
3122						
3123						
3124	1 T	P	H	X		
3125	1 3.688+001	7.473+001	8.599+001	9.798-001		
3126	2 3.626+001	7.387+001	8.593+001	9.799-001		
3127	3 3.161+001	6.713+001	8.723+001	1.000+000		
3128	4 7.026+001	6.724+001	9.348+001	1.000+000		
3129	5 7.399+001	6.423+001	9.420+001	1.000+000		
3130	6 1.863+002	2.480+002	1.083+002	1.000+000		
3131	7 1.796+002	2.268+002	1.076+002	1.000+000		
3132	8 1.610+002	2.258+002	1.039+002	1.000+000		

3132 9 1.540+002 2.233+002 1.026+002 1.000+000
 3133 10 1.531+002 2.232+002 1.025+002 1.000+000
 3134
 3135 INPUT DATA TO CONDHX:
 3136 T P TAIR RH RMASS
 3137 1.531+002 2.232+002 7.000+001 5.600-001 4.873+002
 3138 H2, H2PH2= 3.1.30 -.58
 3139 H2, H2PH2= 34.33 -.03
 3140 H2, H2PH2= 34.32 -.59
 3141 H2, H2PH2= 34.49 .43
 3142 H2, H2PH2= 34.71 -.22
 3143 H2, H2PH2= 34.82 -.11
 3144 H2, H2PH2= 34.89 -.07
 3145 H2, H2PH2= 34.88 .01
 3146 H2, H2PH2= 34.88 .01
 3147
 3148 CONDENSER ITERATION:
 3149 T P H X
 3150 1.531+002 2.232+002 1.025+002 1.000+000
 3151 8.504+001 2.149-.002 3.438+001 .000
 3152 3153
 3154 LIQUID LINE:
 3155 INPUT - PIN = 2.149+002 TIN = 8.504+001 XIN = .000
 3156 OUTPUT - POUT= 2.093+002 TOUT= 8.502+001 XOUT= .000 HIN = 3.488+001
 3157
 3158
 3159 EXPANSION DEVICE:
 3160 INPUT - P12 = 2.093+002 H12 = 3.483+001 P13 = 9.576+001
 3161 OUTPUT - POUT = 1.620+002 XMMASS = 4.908+002
 3162
 3163
 3164 INPUT DATA TO CONFIR:
 3165 P3 T3 H3
 3166 6.713+001 3.161+001 8.723+001 XQ3
 3167 1.000+000 1.124+002 TRA
 3168
 3169 COMPRESSOR ITERATION:
 3170 EI EETA EТАC ETAV TG6 TOA
 3171 2.755+000 7.592-001 9.474-001 3.553-001 7.000+001 4.700+001
 3172
 3173
 3174 I T P H X
 3175 1 3.688+001 7.473+001 3.599+001 9.798-001
 3176 2 3.625+001 7.383+001 8.503+001 9.709-001
 3177 3 3.151+001 6.713+001 8.723+001 1.000+000
 3178 4 7.025+001 6.704+001 9.347+C11 1.000+000
 3179 5 7.393+001 6.423+001 9.419+021 1.000+000
 3180 6 1.862+002 2.478+002 1.083+002 1.000+000
 3181 7 1.795+002 2.267+002 1.076+C02 1.000+000
 3182 8 1.609+002 2.256+002 1.039+002 1.000+000
 3183 9 1.539+002 2.231+002 1.026+002 1.000+000
 3184 10 1.531+002 2.230+002 1.025+002 1.000+000
 3185
 3186 INPUT DATA TO CONDHX:
 3187 T P TAIR RH RMASS
 3188 1.531+002 2.230+002 7.000+001 5.600-001 4.874+002
 3189

3190 H₂, H₂PH2= 34.40 -.56
 3191 H₂, H₂PH2= 34.42 -.63
 3192 H₂, H₂PH2= 35.00 -.58
 3193 H₂, H₂RH2= 34.60 .41
 3194 H₂, H₂RH2= 34.83 -.23
 3195 H₂, H₂PH2= 34.93 -.11
 3196 H₂, H₂RH2= 34.99 -.06
 3197 H₂, H₂PH2= 34.98 .01
 3198 CONDENSER ITERATION:
 3200 T P H X
 3201 1.531+002 2.230+002 1.025+002 1.000+000 HIN = 3.498+001
 3202 8.546+001 2.147+002 3.490+001 .000
 3203
 3204
 3205 LIQUID LINE:
 3206 INPUT - PIN = 2.147+002 TIN = 8.546+001 XIN = .000
 3207 OUTPUT - POUT= 2.091+002 TOUT= 8.544+001 XOUT= .000
 3208
 3209
 3210 EXPANSION DEVICE:
 3211 INPUT - P12 = 2.091+002 H12 = 3.198+001 P13 = 9.576+001
 3212 DDENFA DOES NOT CONVERGE, DIFXQ2= -3.42636-006 RMASS = 4.067+002
 3213 OUTPUT - POUT = 1.612+002 XMASS = 4.067+002
 3214
 3215 INPUT DATA TO EVAPHX:
 3216
 3217
 3218 T P H X TAIR RH RMASS
 3219 3.560+001 9.576+001 2.276-001 4.700+001 7.300-001 4.874+002
 3220 H2= 89.2099
 3221 H2= 88.1069
 3222 H2= 86.9356
 3223 H2= 85.5808
 3224 QT, QS= 2.513+004 2.190+004
 3225 EVAPORATOR ITERATION:
 3226
 3227
 3228 T P H X TSUP
 3229 3.560+001 9.576+001 3.493+001 2.276-001
 3230 3.676+001 7.436+001 8.655+001 9.864-001 .000
 3231
 3232 INPUT DATA TO EVAPHX:
 3233 T P H X TAIR RH RMASS
 3234 3.569+001 9.591+001 2.273-001 4.700+001 7.300-001 4.874+002
 3235 H2= 89.1770
 3236 H2= 87.9079
 3237 H2= 86.4816
 3238 H2= 86.1747
 3239 QT, QS= 2.493+004 2.177+004
 3240
 3241 EVAPORATOR ITERATION:
 3242
 3243
 3244 T P H X TSUP
 3245 3.569+C01 9.591+001 3.499+001 2.273-001
 3246 3.691+001 7.472+001 8.614+001 9.815-001 .000
 3247 P1, P1E, P1EP1, DENIT2= 74.7282 74.7190 -.0091 .1507

3248 INTERE, INTEFE, POUT, F13= 0 0 161.18 95.91
 3249 COMPOSITION OF REFRIG. IN ACCUMULATOR = .668
 3250 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 3251
 3252 REFRIG. IN ACCUMULATOR = .190 LB
 3253
 3254 REFRIG. IN INDOOR COIL = 2.392 LB
 3255 REFRIG. IN OUTDOOR COIL= .882 LB
 3256
 3257 TMASS = 4.602+000 REFIN = 4.968+000
 3258
 3259
 3260 ****SYST4 WITH ACCUM. , 13B1/152A 6-22-81****
 3261
 3262
 3263 TOA RHQA TRA RHRA
 3264 4.700+001 7.300+001 7.000+001 5.600-001
 3265
 3266 CFMIND CFMOUT
 3267 1.118+003 2.284+003
 3268
 3269
 3270 RESULTS:
 3271 I T P H S X
 3272 1 3.668+001 7.473+001 8.599+001 1.879-001 X
 3273 2 3.626+001 7.388+001 8.573+001 1.800-001 9.799-001
 3274 3 3.161+001 6.713+001 8.723+001 1.923-001 1.000+000
 3275 4 7.025+001 6.704+001 9.347+001 2.045-001 1.000+000
 3276 5 7.398+001 6.423+001 9.419+001 2.066-001 1.000+000
 3277 6 1.062+002 2.473+002 1.083+002 2.078-001 1.000+000
 3278 7 1.795+002 2.267+002 1.076+002 2.082-001 1.000+000
 3279 8 1.609+002 2.256+002 1.039+002 2.025-001 1.000+000
 3280 9 1.539+002 2.231+002 1.026+002 2.005-001 1.000+000
 3281 10 1.531+002 2.230+002 1.025+002 2.003-001 1.000+000
 3282 11 3.546+001 2.147+002 3.498+001 7.996-0C2 .000
 3283 12 8.514+001 2.091+002 3.498+001 7.988-002 .000
 3284 13 3.569+001 3.591+001 3.493+001 8.191-002 2.273-001
 3285
 3286
 3287 TG3 TSUP3 TG6 RMASS TMASS
 3.161+001 .000 1.124+002 4.871+002 4.602+000
 3288
 3289
 3290 QLOAD FLUSE COP
 3.455+004 3.620+000 2.795+000
 3291
 3292
 3293 REFRIG. COMPOSITION = .668
 3294 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 3295
 3296
 3297
 3298
 3299 INPUT DATA TO COMPRESSOR:
 3300
 3301 P3 T3 H3 XH3
 6.743+001 3.173+001 8.683+001 9.953-001
 3302 TMASS TRA T66
 7.000+001 7.127+002 1.127+002
 3303
 3304 COMPRESSOR ITERATION:
 3305

3306
 3307 EI 7.67+000 ETAE 7.597-001 ETAC 9.470-001 ETAV 8.562-001 CPRPM 3.548+003 RMASS 4.914+002
 3308
 3309
 3310 1 T 3.703+001 P 7.508+001 H 8.561+001 X 9.753-001
 3310 2 3.641+001 7.421+001 8.555+001 9.754-001
 3311 3 3.173+001 6.743+001 8.603+001 9.953-001
 3312 4 6.034+001 6.733+001 9.323+001 1.000+000
 3313 5 7.235+001 6.449+001 9.395+001 1.000+000
 3314 6 1.850+002 2.490+002 1.080+002 1.000+000
 3315 7 1.762+002 2.273+002 1.073+002 1.000+000
 3316 8 1.597+002 2.266+002 1.037+002 1.000+000
 3317 9 1.528+002 2.241+002 1.024+002 1.000+000
 3318 10 1.520+002 2.240+002 1.022+002 1.000+000
 3319
 3320
 3321 INPUT DATA TO CONDHX:
 3322
 3323 T P TAIR RH RMASS
 3324 1.520+002 2.240+002 7.000+001 5.690-001 4.914+002
 3325 H2, H2PH2= 34.03 -07
 3326 H2, H2FH2= 34.28 -.25
 3327 H2, H2PH2= 34.78 -.51
 3328 H2, H2PH2= 35.03 -.25
 3329 H2, H2PH2= 35.06 -.05
 3330 H2, H2PH2= 35.09 -.01
 3331 CONDENSER ITERATION:
 3332 T P H X
 3333 1.520+002 2.240+002 1.022+002 X 1.000+000
 3334 8.589+001 2.153+002 3.509+001 .000
 3335
 3336
 3337
 3338
 3339 LIQUID LINE:
 3340 INPUT - PIN = 2.158+002 TIN = 8.589+001 XIN = .000
 3341 OUTPUT - POUT = 2.100+002 TOUT = 8.506+001 XOUT = .000
 3342
 3343 EXPANSION DEVICE:
 3344 INPUT - P12 = 2.100+002 H12 = 3.509+001 P13 = 9.620+001
 3345 3346 OUTPUT - POUT = 1.618+002 XMASS = 4.878+002
 3347
 3348 INPUT DATA TO COMPRI:
 3349 P3
 3350 6.743+001 T3 H3 XQ3
 3351 3.173+001 6.603+001 9.353-001 T66
 3352
 3353 COMPRESSOR ITERATION:
 3354 EI ETAE ETAC ETAV XQ3 CPRPM RMASS
 3355 2.769+000 7.537-001 9.469-001 6.561-001 3.543+003 4.914+002
 3356
 3357 1 T P H X
 3358 1 3.703+001 7.508+001 8.561+001 9.753-001
 3359 2 3.641+001 7.421+001 8.555+001 9.754-001
 3360 3 3.173+001 6.743+001 8.603+001 9.953-001
 3361 4 6.033+001 6.733+001 9.323+001 1.000+000
 3362 5 7.254+001 6.450+001 9.395+001 1.000+000

3364 6 1.850+002 2.491+002 1.087+002 1.000+000
 3365 7 1.783+002 2.278+002 1.073+002 1.000+000
 3366 8 1.567+002 2.268+002 1.037+002 1.000+000
 3367 9 1.529+002 2.242+002 1.024+002 1.000+000
 3368 10 1.520+002 2.242+002 1.022+002 1.000+000
 3369
 3370 INPUT DATA TO CONDIX:
 3371 T P TAIR RH RMASS
 3372 1.520+002 2.242+002 7.000+001 5.300-001 4.914+002
 3373 H2, H2PH2= 33.94 -.07
 3374 H2, H2PH12= 34.18 -.24
 3375 H2, H2PH12= 34.70 -.52
 3376 H2, H2PH12= 34.94 -.24
 3377 H2, H2PH12= 34.99 -.05
 3378 H2, H2PH12= 35.01 -.01
 3379
 3380 CONDENSER ITERATION:
 3381
 3382 T P H X
 3383 1.520+002 2.242+002 1.022+002 X
 3384 8.556+001 2.160+002 3.501+001 1.000+000
 3385 .000
 3386
 3387 LIQUID LINE:
 3388 INPUT - PIN = 2.160+002 TIN = 8.556+001 XIN = .000
 3389 OUTPUT - POUT = 2.102+002 TOUT = 8.352+001 XOUT = .000
 3390
 3391 EXPANSION DEVICE:
 3392 INPUT - P12 = 2.102+002 H12 = 3.501+001 P13 = 9.626+001
 3393 OUTPUT - POUT = 1.628+002 XMASS = 4.915+002
 3394
 3395 INPUT DATA TO EVAPHX:
 3396
 3397 T P X TAIR RH RMASS
 3398 3.591+001 9.626+001 2.268-001 4.700+001 7.300-001 4.914+002
 3399 H2= 89.0907
 3400 H2= 87.5102
 3401 H2= 85.5453
 3402 H2= 85.3566
 3403 H2= 85.2817
 3404 QT, QS= 2.471+004 2.146+004
 3405
 3406
 3407
 3408 EVAPORATOR ITERATION:
 3409
 3410 T P H X TSUP
 3411 3.591+001 9.626+001 3.501+001 2.268-001
 3412 3.704+001 7.520+001 6.529+001 3.716-001 .000
 3413 P1, P1E, P1EP1, DENT2= 75.0783 75.2007 1.225 -.3170
 3414 INTERM, INTEFE, POUT, P13= 0 0 162.77 96.26
 3415 COMPOSITION OF REFRIG. IN ACCUMULATOR = .645
 3416 WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 3417
 3418 REFRIG. IN ACCUMULATOR = .205 LB
 3419
 3420 REFRIG. IN INDOOR COIL = 2.475 LB
 3421

REFRIG. IN OUTDOOR COIL = .903 LB

3422

TMASS = 4.726+000 REFIN = 4.968+000

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** SYSTEM WITH ACUM. , 13D; /152A 6-22-81***

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RESULTS:

	I	T	P	H	S	X	TMASS
3438	1	3.703+001	7.503+001	8.561+001	1.871+001	9.753+001	
3439	2	3.641+001	7.421+001	8.555+001	1.872+001	9.754+001	
3440	3	3.173+001	6.743+001	8.633+001	1.914+001	9.753+001	
3441	4	6.883+001	6.733+001	9.323+001	2.040+001	1.003+000	
3442	5	7.254+001	6.450+001	9.395+001	2.061+001	1.000+000	
3443	6	1.850+002	2.491+002	1.080+002	2.073+001	1.000+000	
3444	7	1.783+002	2.278+002	1.073+002	2.076+001	1.000+000	
3445	8	1.597+002	2.265+002	1.037+002	2.019+001	1.000+000	
3446	9	1.528+002	2.242+002	1.024+002	2.001+001	1.000+000	
3447	10	1.520+002	2.242+002	1.022+002	1.998+001	1.000+000	
3448	11	8.556+001	2.160+002	3.501+001	0.000+000	0.000+000	
3449	12	8.532+001	2.102+002	3.501+001	0.002+002	0.000+000	
3450	13	3.591+001	9.626+001	3.501+001	0.002+002	0.000+000	
3451					2.194+002	2.263+001	
3452							
3453		TG3	TSUP3	TG6	RMASS	TMASS	
3454		3.181+001	.000	1.123+002	4.914+002	4.725+000	
3455							
3456		QLOAD	ELUSE	COP			
3457		3.469+004	3.634+000	2.797+000			
3458							
3459							
3460							
3461							
3462							
3463							
3464							
3465							
3466							
3467		P3	T3	H3	XG3		
3468		6.800+001	3.213+001	8.665+001	9.930+001	1.135+002	
3469							
3470							
3471							
3472		E1	ETAE	ETAC	ETAV	CPRPM	RMASS
3473		2.792+000	7.607+001	9.465+001	8.563+001	3.548+003	4.965+002
3474							
3475	I	T	P	H	X		
3476	1	3.745+001	7.573+001	8.545+001	9.729+001		
3477	2	3.682+001	7.485+001	8.539+001	9.731+001		
3478	3	3.212+001	6.800+001	8.666+001	9.930+001		
3479	4	6.834+001	6.791+001	9.313+001	1.000+000		

REFRIG. COMPOSITION = .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

INPUT DATA TO CONPR:

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5 7.204+001 6.504+001 9.365+001 1.000+000
 6 1.849+002 2.517+002 1.079+002 1.000+000
 7 1.781+002 2.302+002 1.072+002 1.000+000
 8 1.506+002 2.292+002 1.035+002 1.000+000
 9 1.527+002 2.266+002 1.023+002 1.000+000
 10 1.519+002 2.268+002 1.021+002 1.000+000
 3486
 3487 INPUT DATA TO CONDHX:
 3488
 3489 T P TAIR RH RMASS
 3490 1.519+002 2.256+002 7.000+001 5.600-001 4.965+002
 3491 H2, H2FH2= 33.58 -.25
 3492 H2, H2PH2= 33.83 -.25
 3493 H2, H2RH2= 34.28 -.45
 3494 H2, H2FH2= 34.53 -.25
 3495 H2, H2RH2= 34.57 -.04
 3496 H2, H2FH2= 34.57 .00
 3497
 3498 CONDENSER ITERATION:
 3499
 3500 T P H X
 3501 1.519+002 2.256+002 1.021+002 1.000+000
 3502 8.305+001 2.167+002 3.457+001 .000
 3503
 3504
 3505 LIQUID LINE:
 3506 INPUT - PIN = 2.187+002 TIN = 8.395+001 XIN = .000
 3507 OUTPUT - POUT = 2.129+002 TOUT = 8.393+001 XDUT = .000
 3508
 3509 EXPANSION DEVICE:
 3510 INPUT - P12 = 2.129+002 H12 = 3.457+001 P13 = 9.691+001
 3511 OUTPUT - POUT = 1.675+002 XMASS = 5.131+002
 3512
 3513
 3514 INPUT DATA TO COMPRESSOR:
 3515 P3 T3 H3 XQ3 T96 TRA TOA
 3516 6.800+001 3.213+001 8.663+001 9.930-001 1.133+002 7.050+001 4.700+001
 3517
 3518
 3519 COMPRESSOR ITERATION:
 3520 E1 ETAE ETAC ETAV CPROPM RMASS
 3521 2.787+000 7.605-001 9.467-001 8.566-001 3.543+003 4.133+002
 3522
 3523
 3524 I T P H X
 3525 1 3.746+001 7.574+001 8.545+001 9.730-001
 2 3.633+001 7.486+001 8.540+001 9.731-001
 3 3.213+001 6.800+001 8.666+001 9.930-001
 3526 3527 4 6.828+001 6.791+001 9.312+001 1.000+000
 3528 5 7.196+001 6.504+001 9.313+001 1.000+000
 3529 6 1.845+002 2.500+002 1.079+002 1.000+000
 3530 7 1.777+002 2.294+002 1.071+002 1.000+000
 3531 3 1.592+002 2.283+002 1.035+002 1.000+000
 3532 9 1.524+002 2.257+002 1.022+002 1.000+000
 3533 10 1.516+002 2.257+002 1.021+002 1.000+000
 3534
 3535
 3536 INPUT DATA TO CONDHX:
 3537

3538 T P TAIR RH RMASS
 3539 1.516+002 2.257+002 7.000+001 5.600-001 4.938+002
 H2, H2PH2= 34.03 -.58
 3540 H2, H2PH2= 34.25 -.22
 3541 H2, H2PH2= 34.19 .06
 3542 H2, H2PH2= 34.54 -.35
 3543 H2, H2PH2= 34.70 -.16
 3544 H2, H2PH2= 34.74 -.04
 3545 H2, H2PH2= 34.74 .00
 3546 H2, H2PH2= .00
 3547
 CONDENSER ITERATION:
 3548 T P H X
 3549 1.516+002 2.257+002 1.021+002 1.000+000
 3550 8.452+001 2.175+002 3.474+001 .000
 3551
 3552
 3553
 3554 LIQUID LINE:
 3555 INPUT = PIN = 2.175+002 TIN = 8.452+001 XIN = .000
 3556 OUTPUT = POUT = 2.117+002 TEUT = 8.418+001 XCUT = .000
 3557
 3558
 3559 EXPANSION DEVICE:
 3560 INPUT = P12 = 2.117+002 H12 = 3.474+001 P13 = 3.692+001
 3561 OUTPUT = POUT = 1.656+002 XMASS = 5.038+002
 3562
 3563
 3564 INPUT DATA TO EVAPHX:
 3565 T P X TAIR RH RMASS
 3566 3.627+001 9.692+001 2.227-001 4.700+001 7.300-001 4.970+002
 3567 H2= 83.7629
 3568 H2= 85.5637
 3569 H2= 83.2565
 3570 QT, QS= 2.403+004 2.155+004
 3571
 3572
 3573
 3574
 3575
 3576
 3577
 3578
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 3595
 CONDENSER ITERATION:
 INPUT DATA TO EVAPHX:
 EVAPORATOR ITERATION:
 INPUT DATA TO EVAPHX:
 EVAPORATOR ITERATION:
 INPUT DATA TO COMPR:

P3 T3 H3 XQ3 TG6 TRA TOA
 6.743+001 3.173+001 8.662+001 9.930-001 1.128+002 7.00C+001 4.700+001
 COMPRESSOR ITERATION:
 3F01 E1 ETAE ETAC ETAV CPRFM RMASS
 3602 2.770+000 7.598-201 9.463-001 8.563-001 3.543+003 4.928+002
 3603
 3604
 3605 1 T P H X
 3606 1 3.704+001 7.516+001 8.541+001 9.730+001
 3607 2 3.641+001 7.428+001 8.535+001 9.731+001
 3608 3 3.173+001 6.749+001 8.562+001 9.330+001
 3609 4 6.810+001 6.739+001 9.311+001 1.000+000
 3610 5 7.180+001 6.454+001 9.383+001 1.000+000
 3611 6 1.843+002 2.493+002 1.078+002 1.000+000
 3612 7 1.775+002 2.279+002 1.071+002 1.000+000
 3613 8 1.590+002 2.268+002 1.035+002 1.000+000
 3614 9 1.522+002 2.243+002 1.023+002 1.000+000
 3615 10 1.514+002 2.242+002 1.021+002 1.000+000
 3616
 3617 INPUT DATA TO CONDHX:
 3618 T P TAIR RH RMASS
 3619 1.514+002 2.242+002 7.000+001 5.600-001 4.928+002
 3620 H2, H2PH2= 33.99 - .08
 3621 H2, H2PH2= 33.99 - .08
 3622 H2, H2PH2= 34.24 -.25
 3623 H2, H2PH2= 34.77 -.53
 3624 H2, H2PH2= 35.01 -.24
 3625 H2, H2PH2= 35.07 -.05
 3626 H2, H2FH2= 35.36 -.01
 3627 CONDENSER ITERATION:
 3628 T P H X
 3629 1.514+002 2.242+002 1.021+002 1.000+000
 3630 8.583+001 2.150+002 3.508+001 .000
 3631
 3632
 3633
 3634
 3635
 3636 INPUT - PIN = 2.160+002 TIN = 9.533+001 XIN = .000
 3637 OUTPUT - POUT = 2.102+002 TOUT = 8.510+001 XCUT = .000
 3638
 3639 EXPANSION DEVICE:
 3640 INPUT - P12 = 2.102+002 H12 = 3.508+001 P13 = 9.604+001
 3641 DDENFA DOES NOT CONVERGE, DIFXQ2= -5 18214-006
 3642 OUTPUT - POUT = 1.628+002 XMASS = 4.397+002
 3643
 3644
 3645 INPUT DATA TO COMPR:
 3646 P3 T3 H3 XQ3 TG6 TRA TOA
 3647 6.749+001 3.173+001 8.662+001 9.930-001 1.129+002 7.000+001 4.700+001
 3648
 3649 COMPRESSOR ITERATION:
 3650 E1 ETAE ETAC ETAV CPRFM RMASS
 3651 2.772+000 7.595-001 9.467-001 8.562-001 3.543+003 4.927+002

3654
 3655 1 T P H X
 1 3.704+001 7.515+001 8.541+001 9.730+001
 2 3.641+001 7.426+001 8.525+001 9.731+001
 3558 3 3.173+001 6.745+C01 8.662+001 9.930+001
 3659 4 6.813+001 6.739+001 9.311+001 1.000+000
 3660 5 7.183+001 6.455+C01 9.383+001 1.000+000
 3561 6 1.844+002 2.495+002 1.078+002 1.000+000
 3662 7 1.776+002 2.281+002 1.072+002 1.000+000
 3653 8 1.591+002 2.271+002 1.035+002 1.000+000
 3654 9 1.523+002 2.246+002 1.023+002 1.000+000
 3665 10 1.515+002 2.245+002 1.021+002 1.000+000
 3666
 3667 INPUT DATA TO CONDHX:
 3668
 3669 T P TAIR RH RMASS
 3670 1.515+002 2.243+002 7.000+001 5.600-001 4.927+002
 3671 H2, H2PH2= 33.35 -.09
 3672 H2, H2PH2= 34.09 -.25
 3673 H2, H2PH2= 34.65 -.55
 3674 H2, H2PH2= 34.88 -.24
 3675 H2, H2PH2= 34.93 -.05
 3676 H2, H2PH2= 34.94 -.01
 3677
 3678 CONDENSER ITERATION:
 3679 T P H X
 3680 1.515+002 2.245+002 1.021+002 X
 3681 8.530+001 2.163+002 3.494+001 1.000+000
 3682 .000
 3683
 3684
 3685 LIQUID LINE:
 3686 INPUT - PIN = 2.163+002 TIN = 8.530+001 XIN = .000
 3687 OUTPUT - POUT = 2.105+002 TOUT = 8.527+001 XOUT = .000
 3688
 3689
 3690 EXPANSION DEVICE:
 3691 INPUT - P12 = 2.105+002 H12 = 3.491+0C1 P13 = 9.60A+0C1
 3692 OUTPUT - POUT = 1.635+002 XMASS = 1.942+002
 3693
 3694 INPUT DATA TO EVA.PHX:
 3695 T P X TAIR RH RMASS
 3696 3.576+001 9.604+001 2.262-001 4.700+001 7.300-001 4.927+002
 3697 H2= 89.1718
 3698 H2= 87.8456
 3699 H2= 86.2828
 3700 H2= 86.0935
 3701 H2= 86.0377
 3702 QT, QS= 2.516+004 2.170+004
 3703
 3704
 3705 EVAFOR,TOR ITERATION:
 3706 T P H X TSUP
 3707 3.576+001 9.604+001 3.434+001 2.262-001
 3708 3.679+001 7.459+001 8.601+001 9.802-001
 3709 .000
 3710
 3711 INPUT DATA TO EVA.PHX:

3712
 3713 T 3.589+001 P 9.626+001 X 2.257-001 TAIP 4.700+001 RH 7.300-001 RMASS
 3714 H2= .89.0366
 3715 H2= 87.4873
 3716 H2= 85.5003
 3717 H2= 85.3471
 3718 H2= 85.2596
 3719 QT, QS = 2.479+004 2.150+004
 3720
 3721
 3722 EVAPORATOR ITERATION:
 3723
 3724 T P H X TSUP
 3725 3.529+001 9.526+001 3.491+001 2.257-001
 3726 3.700+001 7.515+001 8.527+001 3.714-001 .000
 3727 P1,PIE,P1EP1,DENT2= 75.1531 75.1549 .0019 -.1412
 3728 INTERM,INTERE,FOUT,P13= 0 0 163.49 96.26
 3729 COMPOSITION OF REFRIG. IN ACCUMULATOR = .637
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 3730
 3731 REFRIG. IN ACCUMULATOR = .212 LB
 3732 REFRIG. IN INDOOR COIL = 2.487 LB
 3733 REFRIG. IN OUTDOOR COIL= .905 LB
 3734
 3735
 3736
 3737
 3738 TMASS = 4.749+000 REFIN = 4.958+000
 3739 **** SYSTEM WITH ACCUM1, 13B1/152A G-22-34****
 3740 ***SYST4 WITH ACCUM1, 13B1/152A G-22-34***
 3741
 3742
 3743
 3744
 3745
 3746
 3747
 3748
 3749
 3750 RESULTS:
 3751
 3752 1 T P H S
 3753 1 3.704+001 7.515+001 8.541+001 8.867-001 X
 3754 2 3.641+001 7.426+001 8.525+001 8.868-001 S
 3755 3 3.173+001 6.749+001 8.662+001 8.902-001 .731-001
 3756 4 6.813+001 6.739+001 9.311+001 2.038-001 9.930-001
 3757 5 7.183+001 6.455+001 9.383+001 2.059-001 1.000+000
 3758 6 1.844+002 2.465+002 1.078+002 2.070-001 1.000+000
 3759 7 1.776+002 2.281+002 1.072+002 2.074-001 1.000+000
 3760 8 1.591+002 2.271+002 1.035+002 2.017-001 1.000+000
 3761 9 1.523+002 2.246+002 1.023+002 1.998-001 1.000+000
 3762 10 1.513+002 2.245+002 1.021+002 1.926-001 1.000+000
 3763 11 8.530+001 2.163+002 3.494+001 7.987-002 .000
 3764 12 8.527+001 2.165+002 3.481+001 7.309-002 .000
 3765 13 3.589+001 9.626+001 3.421+001 8.130-002 2.257-001
 3766
 3767 TG3 TSUP3 TG6 RMASS
 3768 3.188+001 .000 1.129+002 4.927+002 4.749+000
 3769

3770 QLOAD 1E1USE COP
 3771 3.475+004 3.637+000 2.800+000
 3772
 3773 REFRIG. COMPOSITION = .668
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 3774
 3775
 3776
 3777
 3778 INPUT DATA TO COMPRESSOR:
 3779
 3780 P3 T3 H3 X03 TG6 TRA TOA
 3781 6.805+001 3.214+001 8.655+001 9.913-001 1.139-002 7.000+001 4.700+001
 3782
 3783
 3784 COMPRESSOR ITERATION:
 3785 E1 ETAE ETAC ETAV CFPFM RMASS
 3786 2.801+000 7.611-001 9.462-001 8.558-001 3.547+003 4.969+002
 3787
 3788
 3789
 3790 1 T P H X
 3791 1 3 745+001 7.577+001 8.534+001 9.717+001
 3792 2 3.682+001 7.489+001 8.529+001 9.719+001
 3793 3 3.214+001 5.805+001 8.655+001 9.918+001
 3794 4 6.807+001 6.795+001 9.308+001 1.000+000
 3795 5 7.178+001 6.508+001 9.380+001 1.000+000
 3796 6 1.851+002 2.530+002 1.079+002 1.000+000
 3797 7 1.783+002 2.316+002 1.072+002 1.000+000
 3798 8 1.597+002 2.306+002 1.023+002 1.000+000
 3799 9 1.529+002 2.280+002 1.023+002 1.000+000
 3800 10 1.521+002 2.230+002 1.021+002 1.000+000
 3801 INPUT DATA TO CONDENSER:
 3802 T P TAIR RH RMASS
 3803 1.521+002 2.280+002 7.000+001 5.600-001 4.969+002
 3804 H2, H2PH2= 33.61 -.28
 3805 H2, H2PH2= 33.54 .07
 3806 H2, H2PH2= 33.99 -.45
 3807 H2, H2PH2= 34.20 -.20
 3808 H2, H2PH2= 33.85 .34
 3809 H2, H2PH2= 33.98 -.13
 3810 H2, H2PH2= 34.06 -.08
 3811 H2, H2PH2= 34.11 -.05
 3812 H2, H2PH2= 34.09 .02
 3813
 3814 CONDENSER ITERATION:
 3815
 3816
 3817 T P H X
 3818 1.521+002 2.230+002 1.021+002 1.000+000
 3819 8.202+001 2.204+002 3.409+001 .000
 3820
 3821
 3822 LIQUID LINE:
 3823 INPUT - PIN = 2.204+002 TIN = 8.202+001 XIN = .000
 3824 OUTPUT - POUT = 2.146+002 TOUT = 8.198+001 XOUT = .000 HIN = 3.409+001
 3825
 3826
 3827 EXPANSION DEVICE:

3828 INPUT = P12 = 2.146+002 H12 = 3.409+001 P13 = 9.682+001
 3829 OUTPUT = POUT = 1.712+002 XMASS = 5.341+002
 3830
 3831 INPUT DATA TO COMPRESSOR:
 3832 P3 T3 H3 XQ3 TGA
 3833 6.805+001 3.214+001 8.655+001 9.913-00 1.130+002 7.005+001 4.700+001
 3834
 3835 COMPRESSOR ITERATION:
 3836 EI ETAE ETAC ETAV CPRFL; RMASS
 3837 2.781+000 7.603-001 9.468-001 8.572-001 3.54R+003 4.98C+002
 3838 3839
 3840
 3841 1 T P H X
 3842 1 3.748+001 7.581+001 8.536+001 9.719-001
 3843 2 3.685+001 7.452+001 8.530+001 9.720-001
 3844 3 3.214+001 6.805+001 8.655+001 9.912-001
 3845 4 6.782+001 6.792+001 9.304+001 1.000+000
 3846 5 7.148+001 6.507+001 9.375+001 1.000+000
 3847 6 1.836+002 2.500+002 1.977+002 1.000+000
 3848 7 1.768+002 2.282+002 1.070+002 1.000+000
 3849 8 1.584+002 2.271+002 1.034+002 1.000+000
 3850 9 1.516+002 2.246+002 1.021+002 1.000+000
 3851 10 1.506+002 2.245+002 1.020+002 1.000+000
 3852
 3853 INPUT DATA TO CONDENSER:
 3854
 3855 T P TAIR RH RMASS
 3856 1.508+002 2.245+002 7.000+001 5.600-001 4.980+002
 3857 H2,H2PH2= 34.37 -.67
 3858 H2,H2PH2= 34.59 -.23
 3859 H2,H2PH2= 35.06 -.47
 3860 H2,H2PH2= 34.67 .39
 3861 H2,H2PH2= 34.91 -.24
 3862 H2,H2PH2= 35.03 -.12
 3863 H2,H2PH2= 35.09 -.07
 3864 H2,H2PH2= 35.08 .01
 3665
 3856 CONDENSER ITERATION:
 3867
 3868 T P H X
 3869 1.508+002 2.245+002 1.020+002 1.000+000
 3870 8.564+001 2.159+002 3.508+001 .000
 3871
 3872
 3873 LIQUID LINE:
 3874 INPUT = PIN = 2.159+002 TIN = 8.584+001 XIN = .000
 3875 OUTPUT = POUT = 2.100+002 TOUT = 8.582+001 XOUT = .000
 3876
 3877 EXPANSION DEVICE:
 3878 INPUT = P12 = 2.100+002 H12 = 3.503+001 P13 = 9.691+001
 3879 OUTPUT = POUT = 1.619+002 XMASS = 4.880+002
 3880
 3881 INPUT DATA TO EVAPORATOR:
 3882
 3883
 3884
 3885 T P X TAIR RH RMASS
 3.627+001 9.691+001 2.230+001 4.700+001 7.300-001 4.977+002

3886 H2= 88.7753
 3887 H2= 85.6529
 3888 H2= 83.3127
 3889 QT, QS= 2.412+004 2.161+004
 3890
 3891 EVAPORATOR ITERATION:

	T	P	H	X	T _{AIR}	RH	RMASS
3892	3.627+001	9.691+001	3.487+001	2.230-001	7.300-001	4.977+002	
3893	3.737+001	7.639+001	8.333+001	9.483-001	.000		
3894							
3895							
3896							
3897							
3898							
3899							
3900							
3901							
3902							
3903							
3904							
3905							
3906							
3907							
3908							
3909							
3910							
3911							
3912							
3913							
3914							
3915	P3	T3	H3	XQ3	TG6	TRA	
3916	6.751+001	3.172+001	8.651+001	9.918-001	1.129+002	7.000+001	4.700+001
3917							
3918							
3919							
3920	EI	ETAE	ETAC	ETAV	CPRPM	RMASS	
3921	2.772+000	7.599-001	9.4167-001	8.564-001	3.548+003	4.931+002	
3922							
3923	I	T	P	H	X		
3924	1	3.704+001	7.519+001	8.531+001	9.719-001		
3925	2	3.640+001	7.431+001	8.525+001	9.720-001		
3926	3	3.172+001	6.751+001	8.651+001	9.918-001		
3927	4	6.774+001	6.741+001	9.305+001	1.300+000		
3928	5	7.144+001	6.156+001	9.377+001	1.000+000		
3929	6	1.840+002	2.495+002	1.078+002	1.000+000		
3930	7	1.772+002	2.281+002	1.071+002	1.000+000		
3931	8	1.587+002	2.270+002	1.034+002	1.000+000		
3932	9	1.519+002	2.245+002	1.022+002	1.000+000		
3933	10	1.511+002	2.244+002	1.020+002	1.000+000		
3934							
3935							
3936							
3937	T	P	TAIR	RH	RMASS		
3938	1.511+002	2.244+002	7.000+001	5.600-001	4.934+002		
3939	H2, H2PH2=	33.93	-0.09				
3940	H2, H2RH2=	31.18	-25				
3941	H2, H2RH2=	34.73	-55				
3942	H2, H2PH2=	34.97	-24				
3943	H2, H2PH2=	35.02	-05				

3944 H₂, H₂PH₂= 35.03 - .01
 3945 CONDENSER ITERATION:
 3946
 3947 T P H X
 3948 1.511+002 2.244+002 1.020+002 1.000+000
 3949 8.565+001 2.162+002 3.503+001 .000
 3950
 3951
 3952 LIQUID LINE:
 3953 INPUT - P_{IN}= 2.162+002 T_{IN}= 8.565+001 X_{IN}= .000
 3954 OUTPUT - P_{OUT}= 2.104+002 T_{OUT}= 8.561+001 X_{OUT}= .000 HIN = 3.503+001
 3955
 3956
 3957 EXPANSION DEVICE:
 3958 INPUT - P₁₂= 2.104+002 H₁₂= 3.503+001 P₁₃= 9.605+001
 3959 OUTPUT - P_{OUT}= 1.630+002 X_{M13}= 4.915+002
 3960
 3961 INPUT DATA TO EVAPHX:
 3962
 3963 T P X TAIR RH RMASS
 3964 3.530+001 9.606+001 2.277+001 4.700+001 7.300+001 4.734+002
 3965 H₂= 89.1784
 3966 H₂= 87.8765
 3967 H₂= 86.3823
 3968 H₂= 86.1836
 3969 H₂= 86.0991
 3970 QT, QS= 2.520+004 2.172+004
 3971
 3972
 3973 EVAPORATOR ITERATION:
 3974
 3975 T P H X TSUP
 3976 3.580+001 9.606+001 3.503+001 2.277+001
 3977 3.674+001 7.449+001 8.610+001 9.813+001 .000
 3978
 3979 INPUT DATA TO EVAPHX:
 3980 T P X TAIR RH RMASS
 3981 3.596+001 9.634+001 2.270+001 4.700+001 7.300+001 4.734+002
 3982 H₂= 89.0790
 3983 H₂= 87.4263
 3984 H₂= 85.4180
 3985 H₂= 85.2754
 3986 H₂= 85.1920
 3987 QT, QS= 2.475+004 2.148+004
 3988
 3989
 3990
 3991
 3992 T P H X TSUP
 3993 3.596+001 9.634+001 3.503+001 2.270+001
 3994 3.701+001 7.519+001 8.520+001 9.706+001 .000
 3995 P₁, P_{1E}, P_{1EP1}, DFNT2= 75.1867 75.1382 .0014 -.1117
 3996 INTERM, INTRC, POUT, P₁₃= 0 0 163.04 96.34
 3997 COMPOSITION OF REFRIG. IN ACCUMULATOR = .631
 3998 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 3999
 4000
 4001

.216 LR

4002 REFRIG. IN INDOOR COIL = 2.475 LB
 4003 REFRIG. IN OUTDOOR COIL = .905 LB
 4004 TMASS = 4.740+000 REFIN = 4.963+000
 4005 ****SYST4 WITH ACCUM., 13P1/152A 6-22-8.4***
 4006 ****
 4007 ****
 4008 ****
 4009 ****
 4010 TOA 4.700+001 RHOA 7.500+001 TRA 7.000+001 RHRA 5.600+001
 4011 4012 4013 4014 4015 4016 4017
 4018 CFMIND CFMOUT
 1.118+003 2.284+003
 4019 RESULTS:
 4020 1 T 3.704+001 P 7.519+001 H 8.531+001 S X
 4021 1 3.610+001 7.431+001 8.525+001 1.865+001 9.719+001
 4022 2 3.172+001 6.751+001 8.651+001 1.865+001 9.720+001
 4023 3 3.174+001 6.741+001 9.305+001 1.907+001 9.313+001
 4024 4 6.774+001 6.456+001 2.377+001 2.036+001 1.003+000
 4025 5 7.144+001 1.840+002 2.495+002 2.057+001 1.000+000
 4026 6 1.840+002 2.291+002 1.071+002 2.057+001 1.000+000
 4027 7 1.772+002 2.270+002 1.034+002 2.073+001 1.000+000
 4028 8 1.587+002 2.245+002 1.022+002 2.016+001 1.000+000
 4029 9 1.519+002 2.244+002 1.020+002 1.937+001 1.000+000
 4030 10 1.511+002 2.244+002 1.020+002 1.995+001 1.000+000
 4031 11 8.555+001 2.162+002 3.503+001 8.004+002 .000
 4032 12 8.561+001 2.104+002 3.503+001 8.006+002 .000
 4033 13 3.596+001 9.634+001 3.503+001 8.198+002 2.273+001
 4034 TG3 TSUP3 TG6 RMASS TMASS
 4035 3.190+001 .000 1.129+002 4.931+002 4.749+000
 4036
 4037
 4038 QLOAD ELUSE CQP
 3.472+004 3.637+000 2.797+000
 4039
 4040
 4041 REFRIG. COMPOSITION = .668
 4042 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 4043
 4044
 4045
 4046 INPUT DATA TO COMP1:
 4047
 4048 P3 T3 H3 XG3 TG6 TRA TMASS
 6.686+001 3.120+001 6.641+001 3.912+001 1.132+002 7.000+001 4.700+001
 4049
 4050
 4051
 4052 COMPRESSOR ITERATION:
 4053 EI ETAE ETAC ETAV CPRPM RMASS
 4054 2.774+000 7.592+001 9.462+001 8.545+001 3.543+003 4.871+002
 4C55
 4056
 4057 1 T 3.617+001 7.442+001 8.519+001 X 9.712+001
 4058 2 3.584+001 7.356+001 8.513+001 9.712+001

4060 3 3.120+001 6.6r6+001 8.641+001 9.912-001
 4061 4 6.761+001 6.677+001 9.306+001 1.000+000
 4062 5 7.141+001 6.396+001 9.373+001 1.000+000
 4063 6 1.852+002 2.506+002 1.000+002 1.000+000
 4064 7 1.734+002 2.299+002 1.073+002 1.000+000
 4065 8 1.597+002 2.788+002 1.036+002 1.000+000
 4066 9 1.524+002 2.254+002 1.003+002 1.000+000
 4067 10 1.520+002 2.263+002 1.023+002 1.000+000
 4068 10 1.520+002 2.263+002 1.022+002 1.000+000

4069 INPUT DATA TO CONDHX:

4070	T	P	TAIR	RH	RMASS	
4071	1.520+002	2.263+002	7.000+001	5.600-001	4.874+002	
4072	H2, H2PH2=	33.58	.34			
4073	H2, H2PH2=	33.57	.01			
4074	H2, H2PH2=	33.99	.42			
4075	H2, H2PH2=	34.18	.19			
4076	H2, H2PH2=	33.83	.35			
4077	H2, H2PH2=	33.97	.13			
4078	H2, H2PH2=	34.05	.08			
4079	H2, H2PH2=	34.09	.04			
4080	H2, H2PH2=	34.08	.02			
4081	H2, H2PH2=					
4082	CONDENSER ITERATION:					
4083	T	P	H	X		
4084	1.520+002	2.263+002	1.022+002	1.000+000		
4085	8.194+001	2.190+002	3.408+001	.000		
4086						
4087						
4088						
4089	LIQUID LINE:					
4090	INPUT -	PIN =	2.190+002	TIN =	8.194+001	XIN = .000
4091	OUTPUT -	POUT =	2.134+002	TOUT =	8.191+001	XOUT = .000
4092						
4093						
4094	EXPANSION DEVICE:					
4095	INPUT -	P12 =	2.134+002	H12 =	3.408+001	P13 = 9.557+001
4096	OUTPUT -	PAUT =	1.699+002	XMAS5 =	5.295+002	
4097						
4098						
4099	INPUT DATA TO COMP:					
4100	P3	T3	H3	XQ3	TG6	TOA
4101	6.686+001	3.120+001	8.641+001	9.912-001	1.124+002	7.000+001
4102						4.700+001
4103						
4104	COMPRESSOR ITERATION:					
4105	E1	ETAE	ETAC	ETAV	CPRFM	FMASS
4106	2.754+000	7.591-001	9.467-001	8.358-001	3.548+003	4.321+002
4107						
4108						
4109	I	T	P	H	X	
4110	1	3.610+001	7.445+001	3.521+001	9.713-001	
4111	2	3.586+001	7.358+001	8.515+001	9.714-001	
4112	3	3.120+001	6.686+001	8.541+001	9.912-001	
4113	4	6.740+001	6.677+001	9.302+001	1.000+000	
4114	5	7.113+001	6.395+001	9.374+001	1.000+000	
4115	6	1.838+002	2.480+002	1.078+002	1.000+000	
4116	7	1.770+002	2.269+002	1.071+002	1.000+000	
4117	8	1.585+002	2.258+002	1.035+002	1.000+000	

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4118   9  1.517+002  2.233+0C2  1.0222+002  1.000+000
4119  10  1.509+002  2.233+002  1.020+002  1.000+000
4120
4121      INPUT DATA TO CONDHN:
4122      T          P          TAIR          RH          RMASS
4123      1.509+002  2.233+002  7.000+001  5.600-001  4.804+002
4124      H2,H2PH2=  34.24     -.62
4125      H2,H2PH2=  34.41     -.18
4126      H2,H2PH2=  34.89     -.47
4127      H2,H2PH2=  34.47     .42
4128      H2,H2PH2=  34.70     -.23
4129      H2,H2PH2=  34.82     -.12
4130      H2,H2PH2=  34.88     -.07
4131      H2,H2PH2=  34.87     .01
4132
4133      CONDENSER ITERATION:
4134
4135      T          P          H          X          XIN=    .000
4136      1.509+002  2.233+002  1.020+002  1.000+000
4137      8.503+001  2.150+002  3.437+001  .000
4138
4139
4140
4141      LIQUID LINE:
4142      INPUT = PIN = 2.150+002  TIN = 8.503+001  XIN =    .000
4143      OUTPUT = POUT = 2.093+002  TOUT = 8.501+001  XOUT =    .000
4144
4145
4146      EXPANSION DEVICE:
4147      INPUT = P12 = 2.093+002  H12 = 3.487+001  P13 = 9.560+001
4148      OUTPUT = POUT = 1.624+002  XMMASS = 4.910+002
4149
4150      INPUT DATA TO EVAPHX:
4151      T          P          X          TAIR          RH          RMASS
4152      3.549+001  9.560+001  2.270-001  4.700+001  7.300-001  4.884+002
4153      H2= 89.2513
4154      H2= 88.3391
4155      H2= 87.3552
4156      H2= 86.9869
4157
4158      QT,QS= 2.542+004  2.207+004
4159
4160      EVAPORATOR ITERATION:
4161
4162      T          P          H          X          TSUP
4163      3.549+001  9.560+001  3.493+001  2.270-001
4164      3.655+001  7.393+001  8.696+001
4165
4166      INPUT DATA TO EVAPHX:
4167
4168      T          P          X          TAIR          RH          RMASS
4169      3.562+001  9.581+001  2.265-001  4.700+001  7.300-001  4.884+002
4170      H2= 89.1969
4171      H2= 88.0232
4172      H2= 86.7563
4173      H2= 86.4446
4174      QT,QS= 2.514+004  2.190+004
4175

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4176 EVAPORATOR ITERATION:
 4177 T P H X TSUP
 4178 3.562+001 9.581+001 3.493+001 2.265-001
 4179 3.678+001 7.445+001 8.640+001 9.846-001
 4180 P1, P1E, P1EP1, DENT2= 74.4542 74.4459 .000
 4181 .000
 4182 1.1886
 4183 INPUT DATA TO COMPR:
 4184 P3 T3 H3 XQ3 TGA
 4185 6.739+001 3.161+001 8.645+001 9.912-001 1.127+002 7.000+001
 4186 4.700+001
 4187
 4188 COMPRESSOR ITERATION:
 4189 EI ETAE ETAC ETAV CPRPM RMASS
 4190 2.766+000 7.596-001 9.467-001 8.564-001 3.548+003 4.927+002
 4191
 4192
 4193 T P H X
 4194 1 3.693+001 7.505+001 8.525+001 9.713-001
 4195 2 3.630+001 7.418+001 8.519+001 9.714-001
 4196 3 3.161+001 6.739+001 8.645+001 9.912-001
 4197 4 6.751+001 6.729+001 9.302+001 1.000+000
 4198 5 7.121+001 6.445+001 9.373+001 1.000+000
 4199 6 1.837+002 2.489+002 1.077+002 1.000+000
 4200 7 1.769+002 2.275+002 1.070+002 1.000+000
 4201 8 1.584+002 2.265+002 1.034+002 1.000+000
 4202 9 1.516+002 2.240+002 1.022+002 1.000+000
 4203 10 1.508+002 2.239+002 1.020+002 1.000+000
 4204
 4205 INPUT DATA TO CONDHX:
 4206 T P TAIR RH RMASS
 4207 1.508+002 2.239+002 7.000+001 5.600-001 4.927+002
 4208 H2, H2PH2= 34.12 -.08
 4209 H2, H2PH2= 34.38 -.25
 4210 H2, H2PH2= 34.90 -.52
 4211 H2, H2PH2= 34.55 .35
 4212 H2, H2PH2= 34.76 -.21
 4213 H2, H2PH2= 34.87 -.11
 4214 H2, H2PH2= 34.94 -.07
 4215 H2, H2PH2= 34.93 .01
 4216 H2, H2PH2= 34.93 .01
 4217
 4218 CONDENSER ITERATION:
 4219
 4220 T P H X XIN = .000
 4221 1.508+002 2.239+002 1.020+002 1.000+000
 4222 8.525+001 2.155+002 3.493+001 .000
 4223
 4224 LIQUID LINE:
 4225 INPUT - PIN = 2.155+002 TIN = 8.525+001 XIN = .000
 4226 OUTPUT - POUT = 2.097+002 TOUT = 8.523+001 XOUT = .000
 4227
 4228
 4229
 4230 EXPANSION DEVICE:
 4231 INPUT - P12 = 2.097+002 H12 = 3.493+001 P13 = 9.641+001
 4232 OUTPUT - POUT = 1.626+002 XMASS = 4.911+002
 4233

INPUT DATA TO EVAPHX:

4234
 4235 T P X TAIR RH RMASS
 4236 3.598+001 9.641+001 2.252-001 4.700+001 7.300-001 4.927+002
 4237 H2= 89.0122
 4238 H2= 87.0705
 4239 H2= 84.9381
 4240 H2= 84.8139
 4241 H2= 84.7435
 4242 QT,QS= 2.455+004 2.138+004
 4243
 4244
 4245 EVAPORATOR ITERATION:
 4246 T P H TAIR RH RMASS
 4247 3.598+001 9.641+001 3.493+001 2.252-001
 4248 3.715+001 7.554+001 8.475+001 9.653-001 .000
 4249
 4250
 4251 INPUT DATA TO EVAPHX:
 4252 T P X TAIR RH RMASS
 4253 3.587+001 9.622+001 2.256-001 4.700+001 7.300-001 4.927+002
 4254 H2= 89.0816
 4255 H2= 87.5769
 4256 H2= 85.6249
 4257 H2= 85.4721
 4258 H2= 85.3758
 4259 QT,QS= 2.486+004 2.154+004
 4260
 4261
 4262 EVAPORATOR ITERATION:
 4263 T P H TAIR RH RMASS
 4264 3.587+001 9.622+001 3.493+001 2.256-001
 4265 3.697+001 7.506+001 8.536+001 9.728-001 .000
 4266 P1,P1E,P1EP1,DENT2=
 4267 INTERM,INTERE,POUT,P13= 75.0545 75.0516 .0071 .1320
 4268 COMPOSITION OF REFRIG. IN ACCUMULATOR = .508
 4269 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 4270
 4271 REFRIG. IN ACCUMULATOR = .368 LB
 4272
 4273 REFRIG. IN INDOOR COIL = 2.407 LB
 4274
 4275 REFRIG. IN OUTDOOR COIL= .903 LB
 4276
 4277
 4278 TMASS = 4.822+000 REFIN = 4.968+000
 4279
 4280 ****SYST4 WITH ACCUM , 13B1/152A 6-22-84****
 4281
 4282
 4283 TOA RHQA TRA RHRA
 4284 4.700+001 7.300-001 7.000+001 5.600-001
 4285
 4286 CFMIND CFMDUT
 4287 1.118+003 2.284+003
 4288
 4289
 4290
 4291 RESULTS:

4292
 4293 1 T 3.693+001 7.505+001 H 8.525+001 1.864-001 X
 4294 2 3.630+001 7.410+001 8.519+001 1.865-001 9.714-001
 4295 3 3.161+001 6.739+001 8.645+001 1.906-001 9.912-001
 4296 4 6.751+001 6.729+001 9.302+001 2.036-001 1.000+000
 4297 5 7.121+001 6.445+001 9.373+001 2.057-001 1.000+000
 4298 6 1.837+002 2.489+002 2.077+002 2.069-001 1.000+000
 4299 7 1.769+002 2.275+002 1.070+002 2.072-001 1.000+000
 4300 8 1.584+002 2.265+002 1.034+002 2.016-001 1.000+000
 4301 9 1.516+002 2.240+002 1.022+002 1.997-001 1.000+000
 4302 10 1.508+002 2.239+002 1.020+002 1.994-001 1.000+000
 4303 11 8.525+001 2.155+002 3.493+001 7.985-002 .000
 4304 12 8.523+001 2.097+002 3.493+001 7.988-002 .000
 4305 13 3.587+001 9.622+001 3.493+001 8.179-002 2.256-002 ●
 4306 TG3 TSUP3 TG6 RMASS TMASS
 4307 3.181+001 .000 1.127+002 4.927+002 4.822+000
 4308 3.470+004 3.631+000 2.800+000
 4309 QLOAD ELUSE CDP
 4310 4311 3.470+004 3.144+001 H3 XQ3 TG6 TRA TGA
 4312 REFrig. COMPOSITION = 668
 4313 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 4314
 4315
 4316
 4317
 4318 INPUT DATA TO COMPRESSOR:
 4319
 4320 P3 T3 H3 XQ3 TG6 TRA TGA
 4321 6.717+001 3.144+001 8.641+001 9.109-00: 1.124+002 7.000+001 4.700+001
 4322
 4323
 4324
 4325
 4326 EI ETAE ETAC ETAV CPRPM RMASS
 4327 2.758+000 7.593-001 9.468-001 8.564-001 3.548+003 4.912+002
 4328
 4329 T P H X
 4330 1 3.675+001 7.481+001 8.521+001 9.710-001
 4331 2 3.612+001 7.394+001 8.515+001 9.711-001
 4332 3 3.144+001 6.717+001 8.641+001 9.909-001
 4333 4 6.732+001 6.708+001 9.293+001 1.000+000
 4334 5 7.102+001 6.424+001 9.371+001 1.000+000
 4335 6 1.834+002 2.480+002 1.077+002 1.000+000
 4336 7 1.765+002 2.266+002 1.070+002 1.000+000
 4337 8 1.581+002 2.256+002 1.034+002 1.000+000
 4338 9 1.513+002 2.230+002 1.021+002 1.000+000
 4339 10 1.505+002 2.230+002 1.020+002 1.000+000
 4340
 4341 INPUT DATA TO CONDHN:
 4342 T P TAIR RH RMASS
 4343 1.505+002 2.230+002 7.000+001 5.600-001 4.912+002
 4344 H2, H2PH2= 34.11 -.06
 4345 H2, H2PH2= 34.96 -.85
 4346 H2, H2PH2= 34.75 .21
 4347 H2, H2PH2= 35.08 -.34
 4348 H2, H2PH2= 35.24 -.15

4350 H₂, H₂PH2= 35.31 -.08
 4351 H₂, H₂PH2= 35.31 .00
 4352 CONDENSER ITERATION:
 4353 T P H X
 4354 INPUT - PIN = 2.230+002 1.020+002 1.000+000
 4355 1.505+002 2.144+002 3.531+001 .000
 4356 8.670+001 2.144+002 3.531+001 .000
 4357
 4358
 4359 LIQUID LINE:
 4360 INPUT - PIN = 2.144+002 TIN = 8.670+001 XIN = .000
 4361 OUTPUT - POUT = 2.086+002 TOUT = 8.607+001 XOUT = 3.445-003 HIN = 3.531+001
 4362
 4363
 4364 EXPANSION DEVICE:
 4365 INPUT - P12 = 2.086+002 H12 = 3.531+001 P13 = 9.598+001
 4366 OUTPUT - POUT = 1.600+002 XM_{ASS} = 4.785+002
 4367
 4368 INPUT DATA TO COMPRESSOR:
 4369 P3 T3 H3 XQ3 TRA
 4370 6.717+001 3.144+001 8.641+001 9.909-001 1.127+002 7.000+001 4.700+001 TGA
 4371
 4372
 4373
 4374 COMPRESSOR ITERATION:
 4375 E! ETAE ETAC ETAV CFPRM RMASS
 4376 2.763+000 7.595-001 9.466-001 8.560-001 3.548+003 4.909+002
 4377
 4378
 4379 T P H X
 4380 1 3.674+001 7.481+001 8.521+001 9.710-001
 4381 2 3.611+001 7.393+001 8.515+001 9.711-001
 4382 3 3.144+001 6.717+001 8.641+001 9.909-001
 4383 4 6.740+001 6.708+001 9.301+001 1.000+000
 4384 5 7.111+001 6.424+001 9.372+001 1.000+000
 4385 6 1.838+002 2.488+002 1.077+002 1.000+000
 4386 7 1.770+002 2.276+002 1.070+002 1.000+000
 4387 8 1.585+002 2.265+002 1.034+002 1.000+000
 4388 9 1.517+002 2.240+002 1.022+002 1.000+000
 4389 10 1.509+002 2.240+002 1.020+002 1.000+000
 4390 INPUT DATA TO CONDHX:
 4391 T P TAIR RH RMASS
 4392
 4393 T P TAIR RH RMASS
 4394 1.509+002 2.240+002 7.000+001 5.600-001 4.909+002
 4395 H₂, H₂PH2= 33.95 -.08
 4396 H₂, H₂PH2= 34.19 -.24
 4397 H₂, H₂PH2= 34.74 -.55
 4398 H₂, H₂PH2= 34.98 -.24
 4399 H₂, H₂PH2= 35.03 -.05
 4400 H₂, H₂PH2= 35.04 -.01
 4401 CONDENSER ITERATION:
 4402
 4403 T P H X
 4404 1.509+002 2.240+002 1.020+002 1.000+000
 4405 8.569+001 2.158+002 3.504+001 .000

4408
 4409 LIQUID LINE:
 INPUT - PIN = 2.158+002 TIN = 8.563+001 XIN = .000 HIN = 3.504+001
 OUTPUT - POUT= 2.100+002 TOUT= 8.565+001 XOUT= .000
 4410
 4411
 4412
 4413
 4414 EXPANSION DEVICE:
 INPUT - P12 =2.100+002 H12 =3.504+001 P13 =9.597+001
 DDENFA DOES NOT CONVERGE, DIFXQ2= -9.38367-006
 OUTPUT - POUT =1.626+002 XMASS =4.900+002
 4415
 4416
 4417
 4418
 4419 INPUT DATA TO EVAPHX:
 4420
 4421 T P X TAIR RH RMASS
 4422 3.574+001 9.597+001 2.281-001 4.700+001 7.300-001 4.909+002
 4423 H2= 89.1871
 4424 H2= 87.9454
 4425 H2= 86.5718
 4426 H2= 86.3075
 4427 H2= 86.2429
 4428 QT,QS= 2.513+004 2.169+004
 4429
 4430 EVAPORATOR ITERATION:
 4431 T P H TSUP
 4432 3.574+001 9.597+001 3.504+001 2.281-001
 4433 3.677+001 7.448+001 8.624+001 9.828-001 .000
 4434
 4435
 4436 INPUT DATA TO EVAPHX:
 4437
 4438 T P X TAIR RH RMASS
 4439 3.582+001 9.610+001 2.278-001 4.700+001 7.300-001 4.909+002
 4440 H2= 89.1628
 4441 H2= 87.7873
 4442 H2= 86.1445
 4443 H2= 85.9260
 4444 H2= 85.8617
 4445 QT,QS= 2.494+004 2.158+004
 4446
 4447 EVAPORATOR ITERATION:
 4448 T P H TSUP
 4449 3.582+001 9.610+001 3.504+001 2.278-001
 4450 3.690+001 7.480+001 8.584+001 9.781-001 .000
 4451 P1,P1EP1,DENT2= 74.8051 74.8045 -.0006 .6326
 4452
 4453
 4454 INPUT DATA TO COMPRESSOR ITERATION:
 4455 P3 T3 H3 XQ3 TG6 TRA TGA
 4456 6.745+001 3.166+001 8.643+001 9.909-001 1.129+002 7.000+001 4.700+001
 4457
 4458
 4459
 4460
 4461
 4462
 4463
 4464
 4465

4466 2 3.634+001 7.425+001 8.517+001 9.711-001
 4467 3 3.166+001 6.745+001 8.643+001 9.909-001
 4468 4 6.746+001 6.736+001 9.300+001 1.000+000
 4469 5 7.116+001 6.451+001 9.372+001 1.000+000
 4470 6 1.837+002 2.494+002 1.077+002 1.000+000
 4471 7 1.769+002 2.280+002 1.070+002 1.000+000
 4472 8 1.584+002 2.270+002 1.034+002 1.000+000
 4473 9 1.517+002 2.245+002 1.021+002 1.000+000
 4474 10 1.509+002 2.244+002 1.020+002 1.000+000
 4475
4476 INPUT DATA TO CONDHX:
 4477 T P TAIR RH RMASS
 4478 1.509+002 2.244+002 7.000+001 5.600-001 4.932+002
 4479 H2, H2PH2= 33.91 -.09
 4480 H2, H2PH2= 34.16 -.25
 4481 H2, H2PH2= 34.71 -.56
 4482 H2, H2PH2= 34.95 -.24
 4483 H2, H2PH2= 35.00 -.05
 4484 H2, H2PH2= 35.01 -.01
 4485 H2, H2PH2= .01
 4486
4487 CONDENSER ITERATION:
 4488 T P H X
 4489 1.509+002 2.244+002 1.020+002 1.000+000
 4490 8.559+001 2.162+002 3.501+001 .000
 4491
 4492
 4493
4494 LIQUID LINE:
 4495 INPUT - PIN = 2.162+002 TIN = 8.559+001 XIN = .000
 4496 OUTPUT - POUT = 2.104+002 TOUT = 8.555+001 XOUT = .000
 4497
 4498
4499 EXPANSION DEVICE:
 4500 INPUT - P12 = 2.104+002 H12 = 3.501+001 P13 = 9.642+001
 4501 OUTPUT - POUT = 1.632+002 XMMASS = 4.919+002
 4502
4503 INPUT DATA TO EVAPHX:
 4504 T P X TAIR RH RMASS
 4505 3.601+001 9.642+001 2.266-001 4.700+001 7.300-001 4.932+002
 4506 H2= 89.0363
 4507 H2= 87.1973
 4508 H2= 85.0951
 4509 H2= 84.9684
 4510 H2= 84.8924
 4511 QT, QS= 2.461+004 2.141+004
 4512
 4513
4514 EVAPORATOR ITERATION:
 4515 T P H X TSUP
 4516 3.601+001 9.642+001 3.501+001 2.266-001 9.670-001 .000
 4517 3.710+001 7.542+001 8.490+001
 4518
4519 INPUT DATA TO EVAPHX:
 4520 T P X TAIR RH RMASS
 4521 3.594+001 9.630+001 2.268-001 4.700+001 7.300-001 4.932+002
 4522
 4523

H2= 89.0900
 H2= 87.5004
 H2= 85.5169
 H2= 85.3627
 H2= 85.2751
 GT, QS= 2.479+004 2.150+004
 4530
 4531 EVAPORATOR ITERATION:
 4532
 4533 T P H X TSUP
 4534 3.594+001 9.630+001 3.501+001 2.268-001
 4535 3.699+001 7.513+001 8.528+001 9.716-001 .000
 P1, P1E, P1EP1, DENT2= 75.1244 75.1281 .0037 .0523
 4536 INTER, POUT, P13= 0 0 163.24 96.30
 4537 COMPOSITION OF REFRIG. IN ACCUMULATOR = .445
 4538 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 4539
 4540 REFRIG. IN ACCUMULATOR = .571 LB
 4541 REFRIG. IN INDOOR COIL = 2.477 LB
 4542 REFRIG. IN OUTDOOR COIL= .904 LB
 4543
 4544
 4545
 4546
 4547 TMASS = 5.097+000 REFIN = 4.968+000
 4548
 4549 *****
 4550 **SYST4 WITH ACCUM., 13B1/15B2A 6-22-81***
 4551
 4552 TOA RHOA TRA RHRA
 4553 4.700+001 7.300-001 7.000+001 5.600-001
 4554
 4555 CFMIND CFMOUT
 4556 1.118+003 2.284+003
 4557
 4558
 4559 RESULTS:
 4560 I T P H X TSUP
 4561 1 3.697+001 7.512+001 8.523+001 1.863-001 9.710-001
 4562 2 3.634+001 7.425+001 8.517+001 1.864-001 9.711-001
 4563 3 3.166+001 6.745+001 8.643+001 1.906-001 9.909-001
 1564 4 6.746+001 6.735+001 9.300+001 2.036-001 1.000+000
 4565 5 7.116+001 6.451+001 9.372+001 2.057-001 1.000+000
 4566 6 1.837+002 2.494+002 1.077+002 2.068-001 1.000+000
 4567 7 1.769+002 2.280+002 1.079+002 2.072-001 1.000+000
 4568 8 1.584+002 2.270+002 1.034+002 2.015-001 1.000+000
 4569 9 1.517+002 2.245+002 1.021+002 1.996-001 1.000+000
 4570 10 1.509+002 2.244+002 1.020+002 1.994-001 1.000+000
 4571 11 8.559+001 2.162+002 3.501+001 8.001-002 .000
 4572 12 8.555+001 2.104+002 3.501+001 8.003-002 .000
 4573 13 3.594+001 9.630+001 3.501+001 8.195-002 2.268-001
 4574
 4575
 4576 TG3 TSUP3 T86 RMASS TMASS
 4577 3.186+001 .000 1.129+002 4.932+002 5.097+000
 4578
 4579 QLGAD ELUSE CGP
 4580 3.469+004 3.635+000 2.796+000
 4581

REFRIG. COMPOSITION = .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

	P3	T3	H3	XQ3	TG6	TRA	TOA
4582	6.742+001	3.164+001	8.644+001	3.911-001	1.128+002	7.000+001	4.700+001
4583							
4584							
4585							
4586							
4587							
4588							
4589							
4590							
4591							
4592							
4593							
4594							
4595							
4596							
4597							
4598							
4599	1	T	P	H	X		
	1	3.695+001	7.509+001	8.524+001	9.711-001		
	2	3.632+001	7.421+001	8.518+001	9.712-001		
	3	3.164+001	6.742+001	8.644+001	9.911-001		
	4	6.749+001	6.733+001	9.301+001	1.000-000		
	5	7.119+001	6.448+001	9.373+001	1.000-000		
	6	1.837+002	2.492+002	1.077+002	1.200+000		
	7	1.769+002	2.278+002	1.070+002	1.000+000		
	8	1.584+002	2.267+002	1.034+002	1.000+000		
	9	1.516+002	2.242+002	1.022+002	1.000+000		
	10	1.508+002	2.242+002	1.020+002	1.000+000		
4609							
4610							
4611							
4612		T	P	TAIR	RH	RMASS	
4613		1.508+002	2.242+002	7.000+001	5.600-00*	4.930+002	
4614		H2, H2PH2=	34.01	.09			
4615		H2, H2PH2=	34.26	.25			
4616		H2, H2FH2=	34.80	.54			
4617		H2, H2PH2=	35.04	.24			
4618		H2, H2PH2=	35.10	.05			
4619		H2, H2PH2=	35.11	.01			
4620							
4621							
4622							
4623		T	P	H	X		
4624		1.508+002	2.242+002	1.020+002	1.000+000		
4625		8.593+001	2.159+002	3.511+001	.000		
4626							
4627							
4628							
4629							
4630							
4631							
4632							
4633							
4634		PIN = 2.159+002		TIN = 8.593+001	XIN = .000		
4635		INPUT - P12 = 2.101+002		TOUT= 8.591+001	XOUT= .000		
4636		OUTPUT - POUT = 1.618+002					
4637							
4638							
4639							

4640 6.742+001 3.164+001 6.644+001 9.911-001 1.129+002 7.000+001 4.700+001
 4641 COMPRESSOR ITERATION:
 4642
 4643 E1 ETAE ETAC ETAV CPRPM RMASS
 4644 2.771+000 7.598-001 9.466-001 8.562-001 3.548+003 4.928+002
 4645
 4646
 4647 I T P H X
 4648 1 3.695+001 7.509+001 8.524+001 9.711-001
 4649 2 3.632+001 7.421+001 8.518+001 9.712-001
 4650 3 3.164+001 6.742+001 8.644+001 9.911-001
 4651 4 6.752+001 6.733+001 9.302+001 1.000+000
 4652 5 7.122+001 6.148+001 9.373+001 1.000+000
 4653 6 1.839+002 2.495+002 1.077+002 1.000+000
 4654 7 1.771+002 2.282+002 1.070+002 1.000+000
 4655 8 1.586+002 2.271+002 1.034+002 1.000+000
 4656 9 1.518+002 2.246+002 1.022+002 1.000+000
 4657 10 1.510+002 2.246+002 1.020+002 1.000+000
 4658
 4659 INPUT DATA TO CONDHX:
 4660 T P TAIR RH RMASS
 4661 1.510+002 2.246+002 7.000+001 5.600-001 4.928+002
 4662 H2, H2PH2= 33.81 - .10
 4663 H2, H2PH2= 34.57 -.76
 4664 H2, H2PH2= 34.46 .11
 4665 H2, H2PH2= 34.77 -.32
 4666 H2, H2PH2= 34.87 -.10
 4667 H2, H2PH2= 34.93 -.06
 4668 H2, H2PH2= 34.93 .00
 4669 H2, H2PH2= 34.93 .00
 4670 CONDENSER ITERATION:
 4671
 4672 T P H X
 4673 1.510+002 2.246+002 1.020+002 1.000+000
 4674 8.525+001 2.164+002 3.493+001 .000
 4675
 4676
 4677 LIQUID LINE:
 4678 INPUT - PIN = 2.164+002 TIN = 8.5225+001 XIN = .000
 4679 OUTPUT - POUT = 2.106+002 TOUT = 8.5222+001 XOUT = .000
 4680
 4681 EXPANSION DEVICE:
 4682 INPUT - P12 = 2.106+002 H12 = 3.493+001 P13 = 9.626+001
 4683 OUTPUT - POUT = 1.637+002 XMASS = 4.946+002 HIN = 3.493+001
 4684
 4685 INPUT DATA TO EVAPHX:
 4686 T P TAIR RH RMASS
 4687 3.589+001 9.626+001 2.254-001 4.700+001 4.928+002
 4688
 4689 3.589+001 9.626+001 2.254-001 4.700+001 4.928+002
 4690 H2= 89.0827
 4691 H2= 87.4651
 4692 H2= 85.4580
 4693 H2= 85.3255
 4694 H2= 85.2310
 4695 QT, QS= 2.480+004 2.151+004
 4696

EVAPORATOR ITERATION:

4698
 4699
 4700 T P H TSUP
 4701 3.589+001 9.626+001 3.493+001 2.254-001
 4702 3.700+001 7.517+001 8.524+001 9.711-001 .000
 4703 P1,PIE,P1EP1,DENT2= 75.0876 75.1672 .0795 .0004
 4704 INTERM,INTERE,POUT,P13= 0 0 163.71 96.26
 4705 COMPOSITION OF REFRIG. IN ACCUMULATOR = .470
 4706 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 4707 REFRIG. IN ACCUMULATOR = .469 LB
 4709 REFRIG. IN INDOOR COIL = 2.490 LB
 4710 REFRIG. IN OUTDOOR COIL= .905 LB
 4711 TMASS = 5.009+000 REFIN = 4.968+000
 4712 ****SYST4 WITH ACCUM., 13B1/152A 6-22-84****
 4713
 4714
 4715
 4716
 4717
 4718
 4719 TCA RHQA TRA RHR4
 4720 4.700+001 7.300-001 7.000+001 5.600-001
 4721 CFMIND CFMOUT
 4722 1.118+003 2.284+003
 4723
 4724
 4725
 4726 RESULTS:
 4727 I T P H S X
 4728 1 3.695+001 7.509+001 6.524+001 1.663-001 9.711-001
 4729 2 3.632+001 7.421+001 8.518+001 1.864-001 9.712-001
 4730 3 3.164+001 6.742+001 8.644+001 1.906-001 9.911-001
 4731 4 6.752+001 6.733+001 9.302+001 2.036-001 1.000+000
 4732 5 7.122+001 6.448+001 9.373+001 2.057-001 1.000+000
 4733 6 1.839+002 2.495+002 1.077+002 2.069-001 1.000+000
 4734 7 1.771+002 2.282+002 1.070+002 2.072-001 1.000+000
 4735 8 1.586+002 2.271+002 1.034+002 2.015-001 1.000+000
 4736 9 1.518+002 2.246+002 1.022+002 1.997-001 1.000+000
 4737 10 1.510+002 2.246+002 1.020+002 1.994-001 1.000+000
 4738 11 8.525+001 2.164+002 3.493+001 7.985-002 .000
 4739 12 8.522+001 2.106+002 3.493+001 7.987-002 .000
 4740 13 3.589+001 9.626+001 3.493+001 8.178-002 2.254-001
 4741
 4742
 4743 TG3 TSUP3 TG6 RMASS TMASS
 4744 3.183+001 .000 1.129+002 4.928+002 5.009+000
 4745
 4746 GLOAD ELUSE COP
 4747 3.472+004 3.636+000 2.798+000
 4748 REFRIG. COMPOSITION = .668
 4749 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
 4750
 4751
 4752
 4753
 4754
 4755

4756 FOR THE AMOUNT OF REFRIGERANT STORED IN THE ACCUMULATOR
4757 CIRCULATING COMPOSITION SHOULD BE .669
4758
4759
4760
4761 1=999 FOR DISCONTINUATION
4762 999

END PRT

OFF

APPENDIX J. LISTING OF THE PROGRAM, HPBI

The following is a complete listing of the program HPBI. All source elements of the program are listed in alphabetical order. For fast reference, the reader can review Tables H1, H2 and H3, which contain name lists of all functions and subroutines with a short statement of their purpose.

***** AIRHT *****

DATE 072184

@ELT,L DD.AIRHT
ELT 0R1 S7401C 07/21/84 15:54:51 (0)
10. 00 FUNCTION AIRHT(AMASS,ACP,AMU,AK,DO,DT,NROW,WIDTH,
20. 00 & RPCH,FPCH,CONST,CF01,ANGLE)
30. 00
40. 00

C**** PURPOSE:

C TO CALCULATE AIR-SIDE FINNED-TUBE
HEAT TRANSFER COEFFICIENT

C**** INPUT DATA:

C ACP - AIR SPEC. HEAT AT CONSTANT PRESSURE (BTU/LBM*F)
C AK - AIR THERMAL CONDUCTIVITY (BTU/H*FT*F)
C AMASS - AIR MASS FLOW RATE (LBM/H)
C AMU - AIR DYNAMIC VISCOSITY (LBM/FT*H)
C ANGLE - ANGLE BETWEEN COIL FACE & AIR STREAM LINES (RAD)
C CONST - COEFFICIENT FOR NUSSELT NUMBER (-)
C CP0W - POWER FOR REYNOLDS NUMBER (-)
C D0 - TUBE OUTSIDE DIAMETER (FT)
C DT - FIN TIP DIAMETER (FT)
C FPCH - FIN PITCH (FT)
C FTK - FIN THICKNESS (FT)
C NROW - NUMBER OF TUBES PER ROW (-)
C RPCH - TUBE ROW PITCH (FT)
C WIDTH - HEAT EXCHANGER WIDTH (FT)

C**** OUTPUT DATA:

C AIRHT - AIR-SIDE HEAT TRANSFER COEFFICIENT (BTU/H*F*FT**2)
C
C APR=AMU*ACP/AK
C FS=FPCH-FTK
C FL=0.5*(DT-D0)
C HGT=NROW*RPCH
C TA=D0*WIDTH*NROW
C FN=WIDTH/FPCH
C FA=(RPCH-D0)*FTK*FN
C EA=(WIDTH*HGT-TA-FA)*SIN(ANGLE)
C G=AMASS/EA
C RE=G*DO/AMU
C ANU=CONST*RE**CP0W*4*PIR**0.333*(FS/FL)**0.2*(FS/FT)**0.1134
C AIRHT=ANU*AK/D0
C RETURN
C END

END ELT. ERR0FS: NONE. TIME: 0.098 SEC. IMAGE COUNT: 41
@HDG,P ***** AIRPR ***** .L,O

©ELT,L DD.AIRPR
 ELT 8R1 S7401C 07/21/84 15:54:51 (0)
 10. 00 SUBROUTINE AIRPR(I,T,PATM,RH,W,CP,R,AM,AK)
 20. 00
 30. 00
 40. 00
 50. 00

```

C**** PURPOSE:  

C      TO CALCULATE AIR PROPERTIES  

C**** INPUT DATA:  

C      I   = 1    IF RELATIVE HUMIDITY IS GIVEN (-)  

C      C   = 2    IF HUMIDITY RATIO IS GIVEN (-)  

C      T   - AIR TEMPERATURE (-)  

C      PATH - AIR PRESSURE (PSIA)  

C      RH  - RELATIVE HUMIDITY IN FRACTION (IF I=1) (-)  

C      W   - HUMIDITY RATIO (IF I=2) (LEM I;25/LBN DRY AIR)  

C**** OUTPUT DATA:  

C      AK  - AIR THERMAL CONDUCTIVITY (BTU/H*F*FT)  

C      AM  - AIR DYNAMIC VISCOSITY (LBM/FT*H)  

C      CP  - AIR SPEC. HEAT AT CONSTANT PRESSURE (BTU/LBM*F)  

C      R   - GAS CONSTANT OF AIR (LBF*FT/LB*degR)  

C      RH  - RELATIVE HUMIDITY IN FRACTION (FOR I=2) (-)  

C      W   - HUMIDITY RATIO (FOR I=1) (LBM H2O/LBM DRY AIR)  

C  

C      IF(I.EQ.1)GOTO100  

C      P=W*PATM/(C.622+W)  

C100  CONTINUE  

C      TR=T+460.  

C      Z=1000./TR  

C      IF(TR.GE.492.)GOTO10  

C      PSAT=EXP(0.03940*Z**3-0.2755*Z**2-10.431*Z+19.509)  

C      GOTO30  

C10  IF(TR.GE.672.)GOTO20  

C      PSAT=EXP(0.17829*Z**2-1.6895*Z**2-5.0988*Z+13.4353)  

C      GOTO30  

C20  PSAT=EXP(0.711692*Z**4-4.0150G*Z**3+7.8566*Z**2-14.2131*Z+16.8255)  

C30  IF(I.EQ.1)GOTO110  

C      RH=P/TSAT  

C110 CONTINUE  

C      IF(RH.GE.0.00001)GOTO40  

C      W=0.  

C      GOTO50  

C40  PW=RH*PSAT  

C      W=0.622*PW/(PATM-PW)  

C50  CONTINUE  

C      CP=0.2478786-0.4204563E-04*TR+0.5767657F-07*TR**2  

C      & -0.1493056E-10*TR**3  

C      CP=(CP+0.444*W)/(1.+W)  

C      R=(53.34+85.76*W)/(1.+W)  

C      AM=5.5022E-03+B.7157E-05*TR-2.9464E-08*TR**2  

C      & +6.250E-12*TR**3  

C      AK=-2.853E-04+3.268E-05*TR-8.253E-09*TR*TR  

C      & +1.239E-12*TR**3  

C      RETURN  

CEND
```

END ELT. ERRORS: NONE. TIME: 0.093 SEC. IMAGE COUNT: 53

***** BCONST *****

DATE 072184

```
@ELT,L DD,BCONST
ELT 8R1 S74Q1C 07/21/84 15:54:52 (0)
      00      SUBROUTINE BCONST
      20.
      30.      00      C
      40.      00      C
      50.      00      C
      60.      00      C
      70.      00      C
      80.      00      C
      90.      00      C
     100.      00      C
     110.      00      C
     120.      00      C
     130.      00      C
     140.      00      C
     150.      00      C
     160.      00      C
     170.      00      C
     180.      00      C
     190.      00      C
     200.      00      C
     210.      00      C
     220.      00      C
     230.      00      C
     240.      00      C
     250.      00      C
     260.      00      C
     270.      00      C
     280.      00      C
     290.      00      C
     300.      00      C
     310.      00      C
     320.      00      C
     330.      00      C
     340.      00      C
     350.      00      C
     360.      00      C
     370.      00      C
     380.      00      C
     390.      00      C
     400.      00      C
     410.      00      C
     420.      00      C
     430.      00      C
     440.      00      C
     450.      00      C
     460.      00      C
     470.      00      C
     480.      00      C
     490.      00      C
     500.      00      C
     510.      00      C
     520.      00      C
     530.      00      C

      C*** PURPOSE:
      C   TO READ CONSTANTS FOR FURF COMPONENTS OF MIXTURE.
      C
      COMMON/RDATA1/A3,A4,A5,A6,A7,A8,B3,B4,B5,
      & B6,B7,B8,F0,F1
      COMMON/RDATA2/WMOL1,WMOL2,TC1,TC2
      COMMON/ESDATA/AA(2,3),BB(2,3),CC(2,3)

      C
      C*** READ EQ. OF STATE CONSTANTS
      C
      C   MORE VOLATILE COMPONENT
      A0,A1,A2,B0,B1,B2
      READ(7,777)A3,A4,A5
      READ(7,777)B3,B4,B5

      C
      C   LESS VOLATILE COMPONENT
      A0,A1,A2,B0,B1,B2
      READ(7,777)A6,A7,A8
      READ(7,777)B6,B7,B8

      C
      C   INTERACTION COEFFICIENTS; C,D
      READ(7,777)F1,F0

      C
      C********
      C
      C   READ MOLECULAR WEIGHTS
      C
      C   MORE & LESS VOLATILE COMPONENT
      READ(7,777)WMOL1,WMOL2

      C
      C   READ CRITICAL TEMPERATURES
      C
      C   MORE & LESS VOLATILE COMPONENT
      READ(7,777)TC1,TC2

      C
      C*** READ CONSTANTS FOR ESTIMATING EQUATIONS
      C
      PSAT=EXP((AA1+AA2/T+,AA3/T**2))
      C
      VVAPOR=T*(B31+3B2*T+D53*T**2)/P
      C
      VLIQUID=CC1+CC2*T+CC3*T**2

      C*** MORE VOLATILE COMPONENT
      READ(7,777)AA(1,1),AA(1,2),AA(1,3)
      READ(7,777)BB(1,1),BB(1,2),BB(1,3)
      READ(7,777)CC(1,1),CC(1,2),CC(1,3)

      C
      C*** LESS VOLATILE COMPONENT
      READ(7,777)AA(2,1),AA(2,2),AA(2,3)
      READ(7,777)BB(2,1),BB(2,2),BB(2,3)
      READ(7,777)CC(2,1),CC(2,2),CC(2,3)
      777 FORMAT()
      RETURN
      END
```

END ELT. ERRORS: NONE. TIME: 0.101 SEC. IMAGE COUNT: 53

***** BIIMASS *****

DATE 072184

@ELT,L DD.BIIMASS
ELT 8R1 S7401C 07/21/84 15:54:52 (0) FUNCTION BIIMASS(N)

```

10.      00
20.      00
30.      00
40.      00
50.      00
60.      00
70.      00
80.      00
90.      00
100.     00
110.     00
120.     00
130.     00
140.     00
150.     00
160.     00
170.     00
180.     00
190.     00
200.     00
210.     00
220.     00
230.     00
240.     00
250.     00
260.     00
270.     00
280.     00
290.     00
300.     00
310.     00
320.     00
330.     00
340.     00
350.     00
360.     00
370.     00
380.     00
390.     00
400.     00
410.     00
420.     00
430.     00
440.     00
450.     00
460.     00
470.     00
480.     00
490.     00
500.     00
510.     00
520.     00
530.     00
540.     00
550.     00
560.     00
570.     00
580.     00

```

C*** PURPOSE:
C TO COMPUTE MASS OF A NON-AZOTROPIC REFRIGERANT
C IN A COIL

C*** INPUT DATA:

DI(N)	- INNER DIAMETER OF COIL TUBES (FT)
N	= 1 FOR AN INDOOR COIL (-)
	= 2 FOR AN OUTDOOR COIL (-)
NSECT(N)	- NUMBER OF REPEATING SECTIONS IN COIL (-)
NTFS(N)	- NUMBER OF TUBES PER COIL SECTION (-)
TRM(N,1,1)	- REFRIG. TEMP. AT TUBE 1 END OF HIGHER REFRIG. ENTHALPY (F)
TRM(N,2,1)	- REFRIG. TEMP. AT TUBE 1 END OF LOWER REFRIG. ENTHALPY (F)
VGM(N,1,1)	- SPEC. VOL. OF REFRIG. VAOR IN TUBE 1 END OF HIGHER REFRIG. ENTHALPY (FT**3/LB)
VGM(N,2,1)	- SPEC. VOL. OF REFRIG. VAOR IN TUBE 1 END OF LOWER REFRIG. ENTHALPY (FT**3/LB)
VLH(N,1,K)	- SPEC. VOL. OF REFRIG. LIQUID IN TUBE 1 END OF HIGHER REFRIG. ENTHALPY (FT**3/LB)
VLH(N,2,K)	- SPEC. VOL. OF REFRIG. LIQUID IN TUBE 1 END OF LOWER REFRIG. ENTHALPY (FT**3/LB)
XRM(N,1,K)	- REFRIG. QUALITY AT TUBE K END OF HIGHER REFRIG. ENTHALPY (-)
XRM(N,2,K)	- REFRIG. QUALITY AT TUBE K END OF LOWER REFRIG. ENTHALPY (-)
XTUBE(N,K)	- FRACTION OF TUBE K WITH SUBCOOLED VAPOR (WHEN 2-PHASE FLOW IS IN REST OF TUBE) (-)
	OR
	- FRACTION OF TUBE K WITH 2-PHASE FLOW (WHEN SUPERCOOLED LIQUID IS IN REST OF TUBE) (-)
XTT(N,K)	- LOCKHART-MARTINELLI PARAMETER FOR REFRIG. IN TUBE K (-)
XW	- WEIGHT COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
WIDTH(N)	- LENGTH OF COIL TUBES (FT)

C*** OUTPUT DATA:

EIMASS	- MASS OF REFRIGERANT IN COIL (LB)
--------	------------------------------------

C*** SURROGATE CALLED BY BIIMASS:

BUBTEM, NEWTEM, VISCON	
------------------------	--

COTTON/RDATA3/XW,XM,WM
COTTON/HPIX/NCEP(2),NROW(2),DI(2),DO(2),DT(2),R2CH(2),DPCH(2),
EWIDTH(2),F1CH(2),F1K(2),TMK(2),TMK(2),ANAL(2),ANGLE(2),
ECONST(2),CPW(2),NTUB(2,5),IFROM(2,130),NSEC(2),NPS(2),
COTTON/MASS/TRH(2,2,130),PR1(2,2,130),XRM(2,2,130),
8. VLM(2,2,130),VSM(2,2,130),XTUBE(2,2,130),XTT(2,130)

AREA=3.14159*DI(N)*DI(N)/4.
VTUBE=AFFA*WIDTH(N)
VREND=AREA*20.0*DI(N)
BIIMASS=0.

DO 100 I=1,NPS(N)
IF (XRH(N,2,1).GT..9999) THEN @SUPERHEATED VAPOR ONLY
CM=VTUBE/(5*(VGM(N,1,1)+VGM(N,2,1)))
CM=CM+VBEND/VEM(N,2,1)
GOTO 210

***** BIMASS *****

DATE 07/184

```

590.      00      C
600.      00      C
610.      00      C
620.      00      C
630.      00      C
640.      00      C
650.      00      C
660.      00      C
670.      00      C
680.      00      C
690.      00      C
700.      00      C
710.      00      C
720.      00      C
730.      00      C
740.      00      C
750.      00      C
760.      00      C
770.      00      C
780.      00      C
790.      00      C
800.      00      C
810.      00      C
820.      00      C
830.      00      C
840.      00      C
850.      00      C
860.      00      C
870.      00      C
880.      00      C
890.      00      C
900.      00      C
910.      00      C
920.      00      C
930.      00      C
940.      00      C
950.      00      C
960.      00      C
970.      00      C
980.      00      C
990.      00      C
1000.     00      C
1010.     00      C
1020.     00      C
1030.     00      C
1040.     00      C
1050.     00      C
1060.     00      C
1070.     00      C
1080.     00      C
1090.     00      C
1100.     00      C
1110.     00      C
1120.     00      C
1130.     00      C
1140.     00      C
1150.     00      C
1160.     00      C

      IF (XRM(N, 1).GT. .999) THEN
        VSAT=VGM(N, 1, 1)+XTUBE(N, 1)*(VGM(N, 2, 1)-VCM(N, 1, 1))
        TM1=VTUBE*(XTUBE(N, 1)/(.5)*(VSAT-VGM(N, 1, 1)))
        PDEW=PRM(N, 1, 1)+XTUBE(N, 1)*(PRM(N, 2, 1)-PRM(N, 1, 1))
        PA=PDEW/14.6959
        TKDEW=(TIN(N, 2, 1)+460.)/1.8
        CALL DEWTEM(1, PA, XM, TKDEW, XL)
        TKDEW=TKDEW*.1.8-.459.67
        XRAV=0.5*(1.+XRM(N, 2, 1))
        TRAV=.5*(TDEW+TRM(N, 2, 1))
        VISL=VISCON(1, TRAV, XM)
        VISV=VISCON(3, TRAV, XM)
        XTTT=(1.-XRAV)/XRAV)**.9*(VISL/VISV)**.1
        XTTT=XTTT*(VLM(N, 2, 1)/VCM(N, 2, 1))**.5
        IF (XTTT.LT.10.) VOID=(1.+XTTT**.8)*(-.378)
        IF (XTTT.GE.10.) VOID=.823-.157*ALOG(XTTT)
        TM2=VTUBE*(1.-XTUBE(N, 1))*VOID/(0.5*(VSAT+VCM(N, 2, 1)))
        TM3=VTUBE*(1.-XTUBE(N, 1))*((1.-VOID)/VLM(N, 2, 1))
        TM4=VBEND*((1.-VOID)/VLM(N, 2, 1)+VOID/VCM(N, 2, 1))
        CM=TM1+TM2+TM3+TM4
        GOTO 210
      END IF

      IF (XRM(N, 2, 1).GT. 0. 9) THEN
        XRAV=.5*(XRM(N, 1, 1)+XRM(N, 2, 1))
        TRAV=.5*(TRM(N, 1, 1)+TRM(N, 2, 1))
        VISL=VISCON(1, TRAV, XM)
        VISV=VISCON(3, TRAV, XM)
        XTTT=((1.-XRAV)/XRAV)**.9*(VISL/VISV)**.1
        XTTT=XTTT*(VLM(N, 2, 1)/VCM(N, 2, 1))**.5
        IF (XTTT.LT.10.) VOID=(1.+XTTT**.8)*(-.378)
        IF (XTTT.GE.10.) VOID=.823-.157*ALOG(XTTT)
        TM1=VTUBE*VOID/(0.5*(VGM(N, 1, 1)+VGM(N, 2, 1)))
        TM2=VTUBE*((1.-VOID)/(.5*(VLM(N, 2, 1)+VLM(N, 1, 1)))
        TM3=VBEND*(VOID/VGM(N, 2, 1)+(1.-VOID)/VLM(N, 2, 1))
        CM=TM1+TM2+TM3
        GOTO 210
      END IF

      IF (XRM(N, 2, 1).LT. 1.) THEN
        IF (XTT(N, 1).GE. 10.) VOID=(1.+XTT(N, 1)*. 8)**(-.378)
        IF (XTT(N, 1).GE. 10.) VOID=.823-.157*ALOG(XTT(N, 1))
        TM1=VTUBE*VOID/(0.5*(VGM(N, 1, 1)+VGM(N, 2, 1)))
        TM2=VTUBE*((1.-VOID)/(.5*(VLM(N, 2, 1)+VLM(N, 1, 1)))
        TM3=VBEND*(VOID/VGM(N, 2, 1)+(1.-VOID)/VLM(N, 2, 1))
        CM=TM1+TM2+TM3
        GOTO 210
      END IF

      IF (XRM(N, 2, 1).GT. 0. 0001) THEN
        XRAV=.5*(XRM(N, 1, 1)+XRM(N, 2, 1))
        TRAV=.5*(TRM(N, 1, 1)+TRM(N, 2, 1))
        VISL=VISCON(1, TRAV, XM)
        VISV=VISCON(3, TRAV, XM)
        XTTT=XTTT*(VLM(N, 2, 1)/XRAV)**.9*(VISL/VISV)**.5
        XTTT=XTTT*(VLM(N, 2, 1)/VGM(N, 2, 1))**.5

```

***** BIMASS *****

```

1170.      00      IF(XTTT.LT.10.)VOID=(1.+XTTT**.8)**(-.378)
1180.      00      IF(XTTT.GE.10.)VOID=.823-.157*ALOG(XTTT)
1190.      00      TM1=VTUBE*VOID/(0.5*(VGM(N,1,1)+VGH(N,2,1)))
1200.      00      TM2=VTUBE*(1.-VOLID)/(.5*(VLM(N,2,1)+V_M(N,1,1)))
1210.      00      TM3=VBEND*(VOLID/VGM(N,2,1):(1.-VOLID)/VLM(N,2,1))
1220.      00      CM=TM1+TM2+TM3
1230.      00      GOTO 210
1240.      00
1250.      00
1260.      00      IF(XRM(N,1,1).GT.0.0001)THEN    @2-PHASE AND SUBCOOLED LIQUID
1270.      00      XRAY=0.5*XRM(N,1,1)
1280.      00      PA=PRM(N,1,1)+XTURE(N,1)*(PRM(N,2,1)-PRM(N,1,1))
1290.      00      PA=PA/14.6259
1300.      00      CALL_BUBBLE(0,PA,XH,TK,XV)
1310.      00      TRAV=.5*(TK*.1.8-459.67+TRM(N,1,1))
1320.      00      VISL=VISCON(1,TRAV,XW)
1330.      00      VISV=VISCON(3,TRAV,XW)
1340.      00      XTTT=((1.-XRAY)/XRAV)**.9*(VISL/VISV)**.1
1350.      00      XTTT=XTTT*(VLM(N,1,1)/VGH(N,1,1))**.5
1360.      00      IF(XTTT.LT.10.)VOID=(1.+XTTT**.8)**(-.378)
1370.      00      IF(XTTT.GE.10.)VOID=.823-.157*ALOG(XTTT)
1380.      00      TM1=XTUBE(N,1)*VOID*VTUBE/VGHN(1,1)
1390.      00      TM2=XTUBE(N,1)*(1.-VOID)*VTUBE/VLM(N,1,1)
1400.      00      TM3=((1.-XTURE(N,1))*VTUBE*VEND)/VLM(N,2,1)
1410.      00      CH=TM1+TM2+TM3
1420.      00      GOTO 210
1430.      00
1440.      00
1450.      00      CM=VTUBE/(.5*(VLM(N,1,1)+VLM(N,2,1)))
1460.      00      CM=CM+VEND/VLM(N,2,1)
210  CONTINUE
BIMASS=BIMASS+CM
100  CONTINUE
BIMASS=BIMASS*NSECT(N)
IF(N.EQ.1)THEN
WRITE(6,220)BIMASS
220  FORMAT(1/2X,'REFRIG. IN INDOOR COIL = ',F8.3,' LB')
ELSE
WRITE(6,222)BIMASS
222  FORMAT(1/2X,'REFRIG. IN OUTDOOR COIL = ',F8.3,' LB')
END IF
RETURN
END
```

END ELT. ERRORS: NONE. TIME: 0.237 SEC. IMAGE COUNT: 157

@HDG,P **** BISYS1 ***** .L,O

***** BLINE *****

```
EELT,L DD,BLINE
ELT 8R1 S74Q1C 07/21/84 15:54:53 (0)
      00          SUBROUTINE BLINE(D,TL,RMASS)
      10.
      20.
      30.          C
      40.          C *** PURPOSE:
      50.          C   TO CALCULATE FRICTIONAL PRESSURE DROP
      60.          C   OF A NON-AZEOTROPIC MIXTURE IN A LIQUID LINE
      70.          C
      80.          C *** INPUT DATA:
      90.          C   D - INNER LIQUID LINE DIAMETER (FT)
     100.         C   H11 - REFRIG. ENTHALPY AT INLET (BTU/LBM)
     110.         C   P11 - REFRIG. PRESSURE AT INLET (PSIA)
     120.         C   RMASS - REFRIG. MASS FLOW RATE (LBM/H)
     130.         C   TL - LIQUID LINE LENGTH (FT)
     140.         C   T11 - REFRIG. TEMPERATURE AT INLET (F)
     150.         C   XM - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
     160.         C   XW - WEIGHT COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
     170.         C   X11 - REFRIG. QUALITY AT INLET (-)
     180.         C   YM - MIXTURE MOLECULAR WEIGHT (G/MOL)
     190.         C
     200.         C *** OUTPUT DATA:
     210.         C   H12 - REFRIG. ENTHALPY AT OUTLET (BTU/LBM)
     220.         C   P12 - REFRIG. PRESSURE AT OUTLET (PSIA)
     230.         C   T12 - REFRIG. TEMPERATURE AT OUTLET (F)
     240.         C   X12 - REFRIG. QUALITY AT OUTLET (-)
     250.         C
     260.         C *** SUBPROGRAMS CALLED BY BLINE:
     270.         C   COMMON/RDATA2/W1,W2,TC1,TC2
     280.         C   COMMON/RDATA3/X2,XM,W1
     290.         C   COMMON/COND1/F11,T11,H11,X11
     300.         C   COMMON/COND12/P12,T12,H12,X12
     310.         C   DATA NO,N1/0,1/
     320.         C
     330.         C   WRITE(6,100)P11,T11,X11,H11
     340.         C   H12=H11
     350.         C   IF(X11.GT.999)THEN
     360.         C   X12=X11
     370.         C   P12=P11
     380.         C   T12=T11
     390.         C   WRITE(6,99)
     400.         C   FORMAT(1X,'FORMAT: ERROR IN CALLING BLINE, X11=0. ')
     410.         C   GOTO 50
     420.         C
     430.         C   END IF
     440.         C   TLL=TL
     450.         C   TK11=(T11+459.67)/1.8
     460.         C   PA11=P11/14.6959
     470.         C   ACUP=0.003
     480.         C   IF(X11.GT.0.)GOTO 10
     490.         C
     500.         C *** SUBCOOLED LIQUID AT ENTRANCE
     510.         C   CALL VOLIT1(0,TK11,PA11,X11,VL_)
     520.         C   VL=VL*16.01845/W1
     530.         C   VISL=VISCON(1,T11,XW)
     540.         C   PD1=SIRHDF1(RMASS,TL,D,VL,VISL)
     550.         C   P12=P11-PD1
     560.         C   PA12=P12/14.6959
     570.         C   TK12=TK11
```

```

570.      00      CALL H:PIN(N1,H12,PA12,XM,ACCUR,TK12,X12,XL,XV,VL,VV)
580.      00      T12=TK12*1.8-459.67
590.      00      IF(X12.LT.0.0001) GOTO 50
600.      C       PRESSURE DROPS BELOW SAT. PRESSURE
610.      C       CALL BUPPRE(NO,TK11,XM,PRI,XVIN)
620.      00      XLIN=XM
630.      00      CALL VOLIT1(NO,TK11,PARI,XLIN,VLIN)
640.      00      CALL VOLIT1(N1,TK11,PARI,XVIN,VVIN)
650.      00      TRI=T11
660.      00      PRI=P/R1*14.6959
670.      00      XRI=0.
680.      00      TLL=TLL*(PRI-P12)/PD1
690.      00      GOTO 20
700.      C       C**** 2-PHASE AT INLET
710.      00      CALL QLITY(TK11,PA11,XM,XQ11,XVIN,XLIN)
720.      00      CALL VOLIT1(NO,TK11,PA11,XLIN,VLIN)
730.      00      CALL VOLIT1(N1,TK11,PA11,XVIN,VVIN)
740.      00      XRI=X11
750.      00      TRI=T11
760.      00      PRI=P11
770.      00      X12=XRI+0.02
780.      00      PRE=PRI
790.      00      T12=TRI
800.      00      TK12=(T12+459.67)/1.8
810.      00      XLE=XLIN
820.      00      YVE=XVIN
830.      00      VLE=VLIN
840.      00      VVE=VVIN
850.      00      DC 40 I=1,15
860.      00      XRAV=0.5*(XRI+X12)
870.      00      TRAV=0.5*(TRI+T12)
880.      00      VL=0.5*(VLIN+VLE)
890.      00      VV=0.5*(VVIN+VVE)
900.      00      XL=0.5*(XLIN+XLE)
910.      00      XV=0.5*(XVIN+XVE)
920.      00      W1L=-W1*(1.-XL)+Y2*XLE
930.      00      VLW=Y1L*16.04816/WML
940.      00      XLV=XL/(W1/W2*(1.-XL)+XL)
950.      00      WMV=W1*(1.-XV)+W2*XV
960.      00      VVJ=VV*16.04816/WMV
970.      00      VMIX=VLW*(1.-XRAV)+VVJ*XRAV
980.      00      VISL=VISCON(1,TRAV,XLN)
990.      00      PD1=SFHDPP1(RMASS,TLL,D,VNIX,VISL)
1000.     00      P12=PRI-PD1
1010.     00      IF(P12.LE.0.) THEN
1020.     00      WRITE(6,98)
1030.     00      END IF
1040.     00      98 FORMAT(' CALC. OUTLET. PRESSURE BELOW ZERO, LIQ. LINE BY PASSWD')
1050.     00      X12=X11
1060.     00      T12=T11
1070.     00      P12=P11
1080.     00      GOTO 50
1090.     00      C
1100.     00      PA12=P12/14.6959
1110.     00      CALL H:PIN(N1,H12,PA12,XM,ACCUR,TK12,X12,XLE,XV,E,VLE,VVE)
1120.     00      T12=TK12*1.8-459.67
1130.     00
1140.     00

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***** BLINE *****

```
1150.      00      DELP=FRE-P12
1160.      00      IF(ABS(DELP).LT.0.001)GOTO 50
1170.      00      PRE=P12
1180.      00
1190.      00      40 CONTINUE
1200.      00      WRITE(5,105)DELP
1210.      00      50 WRITE(6,110)T12,T12,X12
1220.      00      100 FORMI(//, LIQUID LINE: ', '
1230.      00      @     INPUT - PIN = ', 1PE10.3,3X,'TIN = ', 1FE10.3,3X,
1240.      00      @     XIN = ', 1PE10.3,3X,'HIN = ', 1PE10.3)
1250.      00      105 FORMAT(' BLINE DOES NOT CONVERGE', DELP= ', 1PE14.5')
1260.      00      110 FORMAT(' OUTPUT - POUT= ', 1PE10.3,3X,'TCUT= ', 1PE10.3,3X,
1270.      00      @     'XOUT= ', 1PE10.3)
1280.      00      RETURN
END
```

END ELT. ERRORS: NONE. TIME: 0.195 SEC. IMAGE COUNT: 128

@HDG,P ***** BMAIN ***** .L,O

DATE 072184

PAGE

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ELT OR1 S74Q1C 07/21/84 15:54:54 (0)

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10.    00      C
20.    00      C**** THIS IS THE MAIN PROGRAM OF ** HPBI ***
30.    00      C PROGRAM FOR SIMULATION OF VAPOR COMPRESSION CYCLE
40.    00      C WITH CONSTANT FLOW AREA EXPANSION DEVICE,
50.    00      C WORKING WITH NON-AZOTROPHIC, BINARY REFRIGERANT.
60.    00      C
70.    00      C**** THIS PROGRAM HAS BEEN DEVELOPED AT NATIONAL BUREAU OF STANDARDS,
80.    00      C WASHINGTON, D.C.
90.    00      C UNDER THE CONTRACT FROM ELECTRIC POWER RESEARCH INSTITUTE,
100.   00      C PALO ALTO, CA.
110.   00      C
120.   00      C
130.   00      C
140.   00      C**** THIS PROGRAM PROVIDES LOGIC AND ITERATION PROCEDURES
150.   00      C FOR EVALUATION OF PERFORMANCE OF VAPOR COMPRESSION CYCLE
160.   00      C WITH CONSTANT FLOW AREA EXPANSION DEVICE
170.   00      C
180.   00      C**** THIS PROGRAM PROVIDES ALSO LOGIC FOR EVALUATION
190.   00      C OF PERFORMANCE PARAMETERS OF RECIPROCATING, HERMETIC COMPRESSOR.
200.   00      C
210.   00      C**** INPUT DATA:
220.   00      C [1] REFRIGERANT CONSTANTS - CONTAINED IN PROGRAM BCONST
230.   00      C [2] HEAT PUMP DATA - READ FROM FILE 8
240.   00      C REFER TO ****
250.   00      C [3] RUN CONTROLLING DATA - READ FROM A TERMINAL
260.   00      C [4] INDOOR/OUTDOOR AIR CONDITIONS DATA - READ FROM A TERMINAL
270.   00      C [5] REFRIGERANT PARAMETERS (GUESS) - READ FROM A TERMINAL
280.   00      C
290.   00      C [2], [3], [4] & [5] ARE EXPLAINED IN ALPHABETIC ORDER BELOW
300.   00      C AHGT - DISTANCE BETWEEN ACCUMULATOR TOP AND OIL RETURN HOLE (FT)
310.   00      C AMAS(110) - AIR MASS FLOW RATE THROUGH COIL (LB/M/H)
320.   00      C ANGLE(110) - ANGLE BETWEEN COIL FACE & AIR STREAMLINES (RAD)
330.   00      C CAPL1 - LENGTH OF COOLING OPERATION EXPANSION DEVICE (IN)
340.   00      C CAPL2 - LENGTH OF HEATING OPERATION EXPANSION DEVICE (IN)
350.   00      C CAPI1 - INNER DIA. OF COOLING OPERATION EXPANSION DEVICE (IN)
360.   00      C CAF1D2 - INNER DIA. OF HEATING OPERATION EXPANSION DEVICE (IN)
370.   00      C CONST(110) - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION (-)
380.   00      C CPW(110) - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION (-)
390.   00      C CLRUFF - COMPRESSOR CLEARANCE VOLUME AS FRACTION OF STROKE VOLUME (-)
400.   00      C CPC34 - PRESSURE DROP PARAMETER AT COMPRESSOR CAN INLET
410.   00      C (LBF*H**2/15)*1N**2*(FT**3)
420.   00      C CPC45 - PRESSURE DROP METER AT COMPRESSOR SUCTION VALVE
430.   00      C (LBF*H**2/LB**1N**2*FT**3)
440.   00      C CPC67 - PRESSURE DROP PARAMETER AT COMPRESSOR DISCHARGE VALVE
450.   00      C (LBF*H**2/LB**1N**2*FT**3)
460.   00      C CPC78 - PRESSURE DROP PARAMETER AT COMPRESSOR CAN EXIT
470.   00      C (LBF*H**2/LB**1N**2*FT**3)
480.   00      C CPDR - PRESSURE DROP PARAMETER FOR 4-WAY VALVE
490.   00      C (LBF*H**2/LB**1N**2*FT**3)
500.   00      C CQ - PARAMETER FOR 4-WAY VALVE HEAT TRANSFER (FT**2)
510.   00      C COCCOA - PARAMETER FOR COMPRESSOR CAN WALL-AIRHEAT TRANSFER (BTU/H*F**1.3333
520.   00      C CQCAC - PARAMETER FOR COMPRESSOR CAN WALL-REFRIG. VOLATILE HEAT TRANSFER (FT**2)
530.   00      C CQC45 - SUCTION VALVE HEAT TRANSFER PARAMETER (FT**2)
540.   00      C CQC67 - DISCHARGE VALVE HEAT TRANSFER PARAMETER (FT**2)
550.   00      C CQC78 - CAN EXIT HEAT TRANSFER PARAMETER (FT**2)
560.   00      C DACC - ACCUMULATOR INNER DIAMETER (FT)

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***** BM_{MAIN} *****

DATE 072184

570.	00	DHOLE(1)	- DIA. OF A HOLE IN ACCUMULATOR TUBE (FT)
580.	00	C	I=1 - OIL RETURN HOLE
590.	00	C	I=2 - UPPER HOLE
600.	00	C	- INNER DIAMETER OF COIL TUBES (IN)
610.	00	C	- OUTER DIAMETER OF COIL TUBES (IN)
620.	00	C	- DEPTH PITCH FOR COIL TUBES (IN)
630.	00	C	- FIN TIP DIAMETER (IN)
640.	00	C	- INNER DIA. OF ACCUMULATOR TUBE (FT)
650.	00	C	- INDOOR FAN ENERGY INPUT RATE (KW)
660.	00	C	- COMPRESSOR MOTOR ENERGY INPUT RATE AT FULL LOAD (KW)
670.	00	C	- COMPRESSOR MOTOR EFFICIENCY IN FRACTION AT FRACTION OF FULL LOAD SPECIFIED BY EMORT(K) (-)
680.	00	C	- COMPRESSOR MOTOR FULL LOAD FRACTION (-)
690.	00	C	- COEFFICIENT FOR COMPRESSOR MOTOR RPM CALCULATION (-)
700.	00	C	- OUTDOOR FAN ENERGY INPUT RATE (KW)
710.	00	C	- COMPRESSOR POLYTROPIC EFFICIENCY (-)
720.	00	C	- FIN MATERIAL THERMAL CONDUCTIVITY (BTU/FT*HF)
730.	00	C	- FIN THICKNESS (IN)
740.	00	C	- VERTICAL DISTANCE BETWEEN HOLES IN AN ACCUMULATOR (FT)
750.	00	C	- NUMBER OF TUBE FROM WHICH TUBE M RECEIVES REFRIG. WHEN COIL WORKS AS EVAPORATOR (-)
760.	00	C	= 1 FOR INDOOR COIL (-)
770.	00	C	= 2 FOR OUTDOOR COIL (-)
780.	00	C	- EVALUATION OF COMPRESSION CYCLE PERFORMANCE (-)
790.	00	C	= 1 FOR EVALUATION OF COMPRESSOR CYCLE PERFORMANCE (-)
800.	00	C	= 2 FOR EVALUATION OF EXPANSION CYCLE PERFORMANCE (-)
810.	00	C	- 1 FOR ENTALPY & REF. FLUID BALANCE (-)
820.	00	C	= 1 FOR ABOVE + REFRIG. CHARGE BALANCE (-)
830.	00	C	= 2 FOR NO INPUT DATA PRINTOUT (-)
840.	00	C	- FOR INPUT DATA PRINTOUT REQUEST (-)
850.	00	C	- NUMBER OF COPLING OPERATION EXPANSION DEVICES (-)
860.	00	C	- NUMBER OF HEATING OPERATION EXPANSION DEVICES (-)
870.	00	C	- NUMBER OF COIL TUBE ROW DEPTHS (-)
880.	00	C	- NUMBER OF REPEATING SECTION IN INDOOR COIL (-)
890.	00	C	- NUMBER OF REPEATING SECTION IN OUTDOOR COIL (-)
900.	00	C	- NUMBER OF TUBES PER ROW (-)
910.	00	C	- NUMBER OF TUBES IN ROW 1 FOR EACH SECTION OF COIL (-)
920.	00	C	- 1 FOR HEATING OPERATION (-)
930.	00	C	= 2 FOR COOLING OPERATION (-)
940.	00	C	- OUTDOOR AIR REL. HUMIDITY (PSIA)
950.	00	C	- INDOOR AIR PRESSURE (PSIA)
960.	00	C	- REFRIGERANT CHARGE (REQUIRED FOR ITER=1 ONLY) (LBIN)
970.	00	C	- INNER DIAMETER COMPRESSOR-INDOOR COIL TUBING (IN)
980.	00	C	- OUTER DIAMETER COMPRESSOR-INDOOR COIL TUBING (IN)
990.	00	C	- OUTER DIAMETER COMPRESSOR-INDOOR COIL TUBING (IN)
1000.	00	C	- INSULATION (BTU/FT*HF)
1010.	00	C	- LENGTH OF COMPRESSOR-INDOOR COIL TUBING (IN)
1020.	00	C	- PITCH BETWEEN TUBES OF THE SAME DEPTH (IN)
1030.	00	C	- LIQUID LINE DIAMETER (IN)
1040.	00	C	- LIQUID LINE LENGTH (IN)
1050.	00	C	- THERMAL CONDUCTIVITY OF COMPRESSOR-INDOOR COIL TUBING
1060.	00	C	- MATERIAL (BTU/FT*HF)
1070.	00	C	- THERMAL CONDUCTIVITY OF COMPRESSOR-INDOOR COIL TUBING
1080.	00	C	- INSULATION (BTU/FT*HF)
1090.	00	C	- LENGTH OF COMPRESSOR-INDOOR COIL TUBING (IN)
1100.	00	C	- PITCH BETWEEN TUBES OF THE SAME DEPTH (IN)
1110.	00	C	- LIQUID LINE DIAMETER (IN)
1120.	00	C	- COMPRESSOR SWEEP VOLUME PER REVOLUTION (IN*HF)
1130.	00	C	- TUBE MATERIAL THERMAL CONDUCTIVITY (BTU/FT*HF)
1140.	00	C	- TMK (110)

DATE 07/21/84

1150. 00 C - REFRIG. SAT. TEMP. AT COMPRESSOR CAN INLET (F) (GUESS)
 1160. 00 C - REFRIG. SAT TEMP. AT COMPRESSOR DISCHARGE VALVE (F) (GUESS)
 1170. 00 C - OUTDOOR AIR TEMPERATURE (F)
 1180. 00 C - INDOOR AIR TEMPERATURE (F)
 1190. 00 C - REFRIG. SUPERHEAT AT COMPRESSOR CAN FILLED BY REFRIG. (F) (GUESS)
 1200. 00 C - VOLUME OF COMPRESSOR CAN (IN³)
 1210. 00 C - COIL WIDTH (IN)
 1220. 00 C - REFRIG. QUALITY AT COMPRESSOR CAN INLET (-)
 1230. 00 C - IN'NER DIAMETER COMPRESSOR-OUTDOOR COIL TUBING (IN)
 1240. 00 C - OUTER DIAMETER OF COMPRESSOR-OUTDOOR COIL TUBING (IN)
 1250. 00 C - OUTER DIAMETER OF COMPRESSOR-OUTDOOR COIL TUBING INSULATION (IN)
 1260. 00 C - THERMAL CONDUCTIVITY OF COMPRESSOR-OUTDOOR COIL TUBING
 1270. 00 C - MATERIAL (BTU/FT²H^{0.5}F)
 1280. 00 C - THERMAL CONDUCTIVITY OF COMPRESSOR-OUTDOOR COIL TUBING
 1290. 00 C - INSULATION (BTU/F^{1.5}H^{0.5}F)
 1300. 00 C - LENGTH OF COMPRESSOR-OUTDOOR COIL TUBING (IN)
 1310. 00 C *** OUTPUT DATA:
 1320. 00 C CFMIND
 1330. 00 C CFMOUT
 1340. 00 C COP
 1350. 00 C ELLUSE
 1360. 00 C RMASS
 1370. 00 C TG3
 1380. 00 C TG6
 1390. 00 C TMASS
 1400. 00 C TSUF3
 1410. 00 C QLOAD
 1420. 00 C REFRIG. PARAMETERS H,P,S,T,X FOR SYSTEM LOCATIONS FROM 1 TO 13
 WHERE:
 1430. 00 C
 1440. 00 C
 1450. 00 C
 1460. 00 C
 1470. 00 C
 1480. 00 C
 1490. 00 C
 1500. 00 C
 1510. 00 C
 1520. 00 C
 1530. 00 C
 1540. 00 C
 1550. 00 C
 1560. 00 C
 1570. 00 C
 1580. 00 C
 1590. 00 C
 1600. 00 C
 1610. 00 C
 1620. 00 C
 1630. 00 C
 1640. 00 C
 1650. 00 C
 1660. 00 C
 1670. 00 C
 1680. 00 C
 1690. 00 C
 1700. 00 C
 1710. 00 C
 1720. 00 C
 C*** SUBPROGRAMS CALLED BY THIS MAIN PROGRAM:
 AIRPR, BIMASS, RLINF, BPHASS, CAPIL, COMPAR, COMD�X, DEWPRE,
 ENTRO2, EVAPFH, HCVP, PXQIN2, VALVPA, VOL1+1, VACUM
 COTTON/RDATA1/A3,A4,A5,A6,A7,A8,A3,B4,B5,B6,B7,B8,F0,F1
 COTTON/RDATA2/W1,W2,TC1,TC2
 COTTON/RDATA3/X3,X4,X5,X6

***** BMAIN *****

DATE 07/18/4

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1730.      00      COMMON/PARAM/A,B,C1,C2,D1,D2
1740.      00      COMMON/STORE1/A1,A2,B1,B2,SI,G31
1750.      00      COMMON/ESDATA/AA(2,3),BB(2,3),CC(2,3)
1760.      00      COMMON/ACCURA/1ACC,1TP
1770.      00      @ P7, T7, H7, X7
1780.      00      COMMON/COND1/P1,T1,H1,X1
1790.      00      COMMON/COND2/F2,T2,H2,X2
1800.      00      COMMON/COND3/P3,T3,H3,X3
1810.      00      COMMON/COND17/P4,T4,H4,X4,F5,T5,H5,X5,S5,P5,T6,H6,X6,
1820.      00      COMMON/COND18/P5,T5,H5,X5,S5,P5,T6,H6,X6,
1830.      00      COMMON/COND9/79,T9,H9,X9
1840.      00      COMMON/COND10/P10,T10,H10,X10
1850.      00      COMMON/COND11/P11,T11,H11,X11
1860.      00      COMMON/COND12/P12,T12,H12,X12
1870.      00      COMMON/COND13/P13,T13,H'2,X13
1880.      00      COMMON/CORP/CFC34,CFCAC,CFCVA,CFC45,
1890.      00      & EMETA(111),EMOPT(111),EMREM(G),ELFULI,,SURVOL,
1900.      00      & ETAPL,CLREFF,CPC67,COC67,CPC78,COC78
1910.      00      COMMON/WAY4/CG,CPDR
1920.      00      COMMON/HPHX/NDEP(2),NROW(2),DO(2),DT(2),RPCH(2),DPCH(2),
1930.      00      & WIDTH(2),FPCH(2),FTK(2),FMK(2),TRK(2),AMAS(2),ANGLE(2),
1940.      00      & CONST(2),CPOM(2),NTUB(2,5),FROM(2,130),NTECT(2),NTPS(2)
1950.      00      COMMON/CFIN/CHX(2,8)
1960.      00      COMMON/MERG/MERGE(2,20,2),IMER(2),ISTART(2,20),IST(2),
1970.      00      & IDEPTH(2,130),FLCW(2,130),JFRM(2,130),KTFID(2,130,3),
1980.      00      & KSTART(2,20),YST(2)
1990.      00      COMMON/MA35/TRM(2,2,130),PRM(2,2,130),XRM(2,2,130),
2000.      00      & VRM(2,2,130),VGM(2,2,30),XTUBE(2,130),XTT(2,130),
2010.      00      COMMON/RLINE/RL,RD,RK1,RD1,RK2,RD2
2020.      00      COMMON/YLINE/YL,YD,YK1,YD1,YK2,YD2
2030.      00      COMMON/ACCDIM/AHGT,DACC,DIQUE(2),DTUBE,HOIS
2040.      00      DIMENSION ATITLE(20),CEFI(8,3)
2050.      00      DATA X6,X7,X8,X9,X10/5*1./
2060.      00      DATA CEFF(1,1),CEFF(1,2),CEFF(1,3)/1.,0.,0./
2070.      00      *CEFF(2,1),CEFF(2,2),CEFF(2,3)/-.02382,-.13755,.20130E-01/
2080.      00      *CEFF(3,1),CEFF(3,2),CEFF(3,3)/.16106,.8189E-01,-.1144E-01/
2090.      00      *CEFF(4,1),CEFF(4,2),CEFF(4,3)/-.64775,-.5558E-01,-.28753E-01/
2100.      00      *CEFF(5,1),CEFF(5,2),CEFF(5,3)/.53491,.1804E-01,.42477E-01/
2110.      00      *CEFF(6,1),CEFF(6,2),CEFF(6,3)/-.19286,.36494E-03,-.20335E-01/
2120.      00      *CEFF(7,1),CEFF(7,2),CEFF(7,3)/.021534,-.1958E-02,.40947E-02/
2130.      00      *CEFF(8,1),CEFF(8,2),CEFF(8,3)/-.0020972,.1241E-03,-.29673E-03/
2140.      00      DATA NO,N1/0,1/
2150.      00      C***** INPUT REFRIGERANT DATA
2160.      00      C*** CALL ECONST
2170.      00      C*** INPUT COMPRESSOR DATA
2180.      00      C*** READ(8,894) IPTP
2190.      00      IF(IPTP.EQ.2)GOTO 240
2200.      00      C*** INPUT HEAT PUMP DATA
2210.      00      INPUT MOTOR/COMPRESSOR DATA
2220.      00      READ(5,777) IPIPTP
2230.      00      IF(IPIPTP.EQ.2)GOTO 240
2240.      00      C*** READ(8,777)(EMETA(1),I=1,5)
2250.      00      READ(8,777)(EMETA(1),I=6,11)
2260.      00      READ(8,777)(EMOPT(1),I=1,5)
2270.      00      READ(8,777)(EMETA(1),I=12,17)
2280.      00      READ(8,777)(EMOPT(1),I=1,5)
2290.      00      READ(8,777)(EMOPT(1),I=1,5)
2300.      00      READ(8,777)(EMOPT(1),I=1,5)

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***** BMMAIN *****

DATE 072184

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2310.      00      READ(8,777)(ENGRPT(1), I=6, 11)
2320.      00      READ(8,777)(ENIRPM(1), I=1, 6)
2330.      00      IF(IPTP.EQ.1) GOTO 301
2340.      00      READ(8,777)FILEFUL,SAPVOL,ETAPLY,CLEEFF
2350.      00      READ(8,777)CPC737,CPC45,CPC7,CPC78
2360.      00      READ(8,777)CQC4C,CQC45,CQC57,CQC78
2370.      00      READ(8,777)CO,CFTR,VCAN,JEFIN
2380.      00      READ(8,777)AUGT,DACC,DHOLE(2),DTURE,HDIS
2390.      00      C***** INPUT INDOOR COIL DATA
2400.      00      READ(8,777)INDOOR COIL DATA
2410.      00      READ(8,777)DI(1),DO(1),DT(1),RPCH(1),DPCH(1),WIDTH(1)
2420.      00      READ(8,777)FPCH(1),FTK(1),FMK(1),TMK(1),AM,S(1)
2430.      00      READ(8,777)CONST(1),CPOW(1),ANGLE(1)
2440.      00      READ(8,777)EIDEAN
2450.      00      READ(8,777)NSECT(1)
2460.      00      READ(8,777)(INTUR(1), I=1, 5)
2470.      00      DO 12 I=1,13
2480.      00      N=10*I
2490.      00      M=N-9
2500.      00      12 READ(8,777)(IFROM(1,J),J=M,N)
2510.      00      C***** INPUT OUTDOOR COIL DATA
2520.      00      READ(8,777)NDEP(2),NROW(2)
2530.      00      READ(8,777)DI(2),DO(2),DT(2),RFCH(2),DPCH(2),WIDTH(2)
2540.      00      READ(8,777)FPCH(2),FTK(2),TMK(2),TM(2),AM,S(2)
2550.      00      READ(8,777)CONST(2),CPOW(2),ANGLE(2)
2560.      00      READ(8,777)EODFAN
2570.      00      READ(8,777)NSECT(2)
2580.      00      READ(8,777)(INTUB(2,I), I=1, 5)
2590.      00      DO13I=1,13
2600.      00      N=10*I
2610.      00      M=N-9
2620.      00      13 READ(8,777)(IFROM(2,J),J=M,N)
2630.      00      C***** INPUT EXHAUSION DEVICE D/T/A
2640.      00      READ(8,777)CAPID1,ICPL1,CAPID2,ICPL2,ICPL2
2650.      00      C***** INPUT CONNECTING TUBING DATA
2660.      00      READ(8,777)YL,YD,YK1,YD1,YK2,YD2
2670.      00      READ(8,777)RL,RD,RK1,RD1,RK2,RD2
2680.      00      READ(8,777)RYL,RYD
2690.      00      C***** EVALUATION OF PERFORMANCE.
2710.      00      C***** OF VAPOR COMPRESSION CYCLE
2720.      00      C***** WRITE INPUT DATA
2730.      00      LPR1=1
2740.      00      LPR2=1
2750.      00      LPR3=1
2760.      00      WRITE(6,851)
2770.      00      READ(5,777)LPR
2780.      00      IF(LPR.EQ.0)GOTO 32
2790.      00      WRITE(6,852)
2800.      00      READ(5,777)LPR
2810.      00      WRITE(6,853)
2820.      00      READ(5,777)LPR2
2830.      00      WRITE(6,854)
2840.      00      READ(5,777)LPR3
2850.      00      WRITE(6,855)
2860.      00      READ(5,777)LPR4
2870.      00
2880.      00
2890.      00

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00 IF(LPR1.EQ.0)GOTO 22
00 WRITE(6,505)
00 WRITE(6,856)ELEFUL,SHFWJL.,ETAPLY,CLEEFF
00 WRITE(6,592)
00 WRITE(6,556)(EMETA(I),I=1,5)
00 WRITE(6,856)(EMETA(I),I=6,11)
00 WRITE(6,921)
00 WRITE(6,356)(EMOPT(I),I=1,5)
00 WRITE(6,356)(EMOPT(I),I=6,11)
00 WRITE(6,900)
00 WRITE(6,356)(EMSPM(I),I=1,6)
00 WRITE(6,906)
00 WRITE(5,856)CPC34,CPC45,CPCG7,CPC79
00 WRITE(6,907)
00 WRITE(6,856)CCAC,CACCA,AC45,CAC67,CAC78
00 WRITE(6,951)
00 WRITE(6,856)CO,CPDP,VCAN,RETIN
00 WRITE(6,952)
00 WRITE(6,856)AHCT,DACC,DHOLE(1),DPIPE(2),DTURE,HDIS
22 CONTINUE
00 IF(LPR2.EQ.0)GOTO 28
00 WRITE(6,911)
00 WRITE(6,912)NDEF(1),NROW(1)
00 WRITE(6,913)
00 WRITE(6,856)DI(1),DO(1),DT(1),RPCH(1),FPCH(1),WIDTH(1)
00 WRITE(6,914)
00 WRITE(6,856,FPCH(1),FTK(1),FMK(1),TMK(1),AMAS(1)
00 WRITE(6,918)
00 WRITE(6,856)CONST(1),CPDV(1),ANGLE(1)
00 WRITE(6,935)EIDFAN
00 WRITE(6,915)NSECT(1)
00 WRITE(6,916)(NTUB(1,I),I=1,5)
DO 24 I=1,13
N=10*I
M=N-9
24 WRITE(6,917)(IFROM(1,J),J=M,N)
00 WRITE(6,919)
00 WRITE(6,920)NDEF(2),NROW(2)
00 WRITE(6,921)
00 WRITE(6,856)DI(2),DO(2),DT(2),RPCH(2),DPCH(2),WIDTH(2)
00 WRITE(6,922)
00 WRITE(6,856,FPCH(2),FTK(2),FMK(2),TMK(2),AMAS(2)
00 WRITE(6,923)
00 WRITE(6,856)CONST(2),CPDV(2),ANGLE(2)
00 WRITE(6,936)EIDFAN
00 WRITE(6,915)NSECT(2)
00 WRITE(6,924)(NTUB(2,I),I=1,5)
DO 26 I=1,13
N=10*I
M=N-9
26 WRITE(6,917)(IFROM(2,J),J=M,N)
28 CONT'NUE
00 IF(LPR3.EQ.0)GOTO 30
00 WRITE(6,946)CAF1D1,CAPL1,NCPL1,CAPL2,NCPL2
30 CONT'NUE
00 IF(LPR4.EQ.0)GOTO 32
00 WRITE(6,903)
00 WRITE(6,929)

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BMAIN *****

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3480.    00      WRITE(6,856)RL,RD,FK1,RD1,RK2,RD2
3490.    00      WRITE(6,909)
3500.    00      WRITE(6,910)
3510.    00      WRITE(6,356)YL,YD,YK1,YD1,YK2,YD2
3520.    00      WRITE(6,948)
3530.    00      WRITE(6,949)
3540.    00      WRITE(6,852)RYL,RYD
3550.    00      32 CONTINUE
3560.    00      C***** PREPARE DATA FOR CALCULATIONS
3570.    00      C***** INDOOR & OUTDOOR COIL
3580.    00      DO 34 I=1,2
3590.    00      D1(I)=D1(I)/12.
3600.    00      DQ(I)=DQ(I)/12.
3610.    00      DT(I)=DT(I)/12.
3620.    00      RPCH(I)=RPCH(I)/12.
3630.    00      DPCH(I)=DPCH(I)/12.
3640.    00      WIDTH(I)=WIDTH(I)/12.
3650.    00      FPCH(I)=FPCH(I)/12.
3660.    00      FTK(I)=FTK(I)/12.
3670.    00      CALL HXCODE(1)
3680.    00      CALL HXCODE(2)
3690.    00      DO 40 I=1,2
3700.    00      CRR=DT(I)/DQ(I)
3710.    00      DO 40 J=1,8
3720.    00      CHX(I,J)=0.
3730.    00      DO 40 K=1,3
3740.    00      L=K-1
3750.    00      DO 40 CHX(I,J)=CHX(I,J)+CFFF(J,K)*CRF**I
3760.    00      C***** EXPANSION DEVICE
3770.    00      CAPID1=CAPID1/12.
3780.    00      CAPL1=CAPL1/12.
3790.    00      CAPID2=CAPID2/12.
3800.    00      CAPL2=CAPL2/12.
3810.    00      C***** CONNECTING TUBING
3820.    00      RL=RL/12.
3830.    00      RD=RD/12.
3840.    00      RD1=RD1/12.
3850.    00      RD2=RD2/12.
3860.    00      YL=YL/12.
3870.    00      YD=YD/12.
3880.    00      YD1=YD1/12.
3890.    00      YD2=YD2/12.
3900.    00      RYL=RYL/12.
3910.    00      RYD=RYD/12.
3920.    00      C***** WRITE(6,926)
3930.    00      50 WRITE(6,926)
3940.    00      READ(5,777)POA,TCA,RHOA,FRA,TRA,RHRA
3950.    00      WRITE(6,949)
3960.    00      READ(5,777)NSYS
3970.    00      IF(NSYS.EQ.1)THEN
3980.    00      CAPID=CAPID2
3990.    00      CAPL=CAPL2
4000.    00      NCPL=NCPL2
4010.    00      PAIRC=FRA
4020.    00      TAIRC=TRA
4030.    00      RHC=RHRA
4040.    00
4050.    00

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4060.          00 PAIRE=POA
4070.          00 TAIRE=TOA
4080.          00 RHE=RHOA
4090.          00
4100.          00 CAPID=CAPID1
4110.          00 CAPL=CAPL1
4120.          00 NCPL=NCPL1
4130.          00 PAIRE=TRA
4140.          00 TAIRE=TRA
4150.          00 RHE=RHA
4160.          00 PAIRC=POA
4170.          00 TAIRC=TOA
4180.          00 RHIC=RHOA
4190.          00
4200.          00 END IF
4210.          00 WRITE(6, 941)
4220.          00 READ(5, 777)ITER
4230.          00 WRITE(6, 954)
4240.          00 READ(5, 777)ITERXW
4250.          00 IF (ITER.EQ.0)ITERXW=0
4260.          00 WRITE(6, 927)
4270.          00 READ(5, 777)XWORG
4280.          00 WRITE(6, 928)
4290.          00 READ(5, 777)XWW
4300.          00 WRITE(6, 908)
4310.          00 READ(5, 777)TG3,X3,TSUR3,TG5
4320.          00 XW=1.-XWW
4330.          00 CALL AIRPR(1,TRA,PRA,RHRA,W,CT,R,AM,AT)
4340.          00 V=R*(459.67+TRA)/144./PRA
4350.          00 CF11=ANAS(1)*V/60.
4360.          00 CALL AIRPR(1,TOA,POA,RHOA,W,CT,R,AM,AT)
4370.          00 V=R*(459.67+TOA)/144./POA
4380.          00 CF12=ANAS(2)*V/60.
4390.          00 IACC=0
4400.          00 RTGG=0.
4410.          00 PDR113=8.
4420.          00 FILTER=0.
4430.          00 SPAD=0.
4440.          00
4450.          00 ***** MAIN ITERATION PROCESS *****
4460.          00
4470.          00
4480.          00
4490.          00
4500.          00
4510.          00
4520.          00
4530.          00
4540.          00
4550.          00
4560.          00
4570.          00
4580.          00
4590.          00
4600.          00
4610.          00
4620.          00
4630.          00
***** START MIXTURE COMPOSITION LOOP
D7 250 NXW=1,4
X3MIN=0.8
X3MAX=1.
XM=XW/(W2/W1*(1.-XW)+XW)
WN=W1*(1.-XW)+W2*XW
C
C*** START REFRIGERANT MASS CONSERVATION LOOP
DO 200 NMASS=1,12
C
C*** START ENTHALPY LOOP
DO 130 1TH=1,8
TKG3=(TG3+459.67)/1.8
CALL DFNPRE(NO,TKG3,XM,PA3,XL)
P3=PA3*1.6959
1F(X3,LT,1.)THEN
CALL PXQIN2(XM,PA3,Y3,TG3,XL,XV,VL,VN,13)
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***** BMAIN *****

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4640.      00      T3=TK3*1.8-459.67
4650.      00
4660.      00      ELSE
4670.      00      T3=TG3+TSUP3
4680.      00      TK3=(T3+459.67)/1.8
4690.      00      CALL VNL_I11(N1,TK3,PA3,XM,V)
4700.      00      CALL HCVCP(N1,TK3,V,X11,H3,CV,CP)
4710.      00      END IF
4720.      00
4730.      00      C***** START REFRIGERANT FLOW RATE LOOP
4740.      00      INTERM=1
4750.      00      INTERE=1
4760.      00      DO 120 ICLAR=1,3
4770.      00      DO 112 ITM=1,8
4780.      00      IF(INTERM.FQ.O)GOTO 114
4790.      00      CALL CONDIX(NSYS,TG6,TRA,TOA,EI,PMASS)
4800.      00      C
4810.      00      C
4820.      00      X12A=X12
4830.      00      CALL BLINE(RYD,RYL,RMASS)
4840.      00      C
4850.      00      P13=P1*PDR113
4860.      00      POUT=P13
4870.      00      XMASS=RMASS
4880.      00      CALL CAPIL(XW,XMASS,P12,H12,FOUT,CAP1D,NCPL)
4890.      00      C
4900.      00      DRMS2=RMASS-XMASS
4910.      00      INTERM=0
4920.      00      IF(ABS(DRMS2/RMASS).LT.0.005)GOTO 114
4930.      00      INTERM=1
4940.      00      C
4950.      00      IF(ITM.FQ.1)THEN
4960.      00      TG6X=TG6
4970.      00      IF(FILTER.NE.0.)THEN
4980.      00      TG6CH=-FILTER*DRMS2
4990.      00      IF(ABS(TG6CH).GT.8.)TG6CH=SIGN(E,TG6CH)
5000.      00      ELSE
5010.      00      TG6CH=SIGN(2.5,DRMS2)
5020.      00      END IF
5030.      00      TG6=TG6X+TG6CH
5040.      00      GOTO 108
5050.      00      END IF
5060.      00      C
5070.      00      FILTER=(TG6X-TG6)/(DRMS21-DR1S2)
5080.      00      DDR=DRMS2/(DR1S21-DRM52)
5090.      00      IF((X12*X12A).EQ.0.OR.(X12*X12A).NE.0.)THEN
5100.      00      IF(ABS(DRMS2/RMASS).GT..05)GOTO 105
5110.      00      TG6=TG6-DDR*(TG6X-TG6)
5120.      00      RMASS=RMASS-DRR*(RMASS1-RMASS)
5130.      00      H12=H12-DRR*(H121-H12)
5140.      00      IF(ICLAR.NE.1)GOTO 112
5150.      00      GOTO 114
5160.      00      END IF
5170.      00      C
5180.      00      105 TG6Y=TG6
5190.      00      TG6CH=-DDR*(TG6X-TG6)
5200.      00      IF(ABS(TG6CH).GT.8.)TG6CH=SIGN(B.,TG6CH)
5210.      00

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***** BM MAIN *****

DATE 072184

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5220.      00   TGEY=TG6Y
5230.      00   RMASS1=RMASS
5240.      00   H12=H12
5250.      00   DRMS2=DRMS2
5260.      00   CONTINUE. WRITE(6,113)DRMS2,TGCH
5270.      00   FORMAT(//, ' 1M LOOP DID NOT CONVERGE, DRMS2= ', F6.2, ' TGCH= ', F6.2)
5280.      00   CONTINUE
5290.      00   H13=H12
5300.      00   TK13=(T1+459.67)/1.8
5310.      00
5320.      00   C**** ITERATE. EVAPORATOR TO CLOSE FNTIALPY LCOP
5330.      00   DO 116 1TE=1 6
5340.      00   PA13=P13/14.6959
5350.      00   CALL HPIN(N1,H13,PA13,XM,0.003,TK13,X13,XL,XV,VL,VV)
5360.      00   T13=TK13*1.8-459.67
5370.      00   NSY=2/NSYS
5380.      00   CALL EVAPHX(NSY,RMASS,T13,P13,TAIRE,RAE,X13,TIE,P1E,H1E,X1E)
5390.      00   P1EP1=P1E-P1
5400.      00   INTERE=0
5410.      00   IF(ABS(P1EP1).LT.0.2)GOTO 118
5420.      00   INTERE=1
5430.      00   TV=P13
5440.      00   IF(1TE.EQ.1)TIEN
5450.      00   P13=P13-P1EP1
5460.      00   IF(SPAD.NE.0.)P13=TV-P1EP1*SPAD
5470.      00   ELSE
5480.      00   SPAD=(P13-PI3F)/(P1EP1-P1EP1F)
5490.      00   PI3=PI3-P1EP1*SPAD
5500.      00   H1EE=H1E-P1EP1*(H1E-H1F)/(P1EP1-P1EP1F)
5510.      00   END IF
5520.      00   P13F=TV
5530.      00   P1EP1F=P1EP1
5540.      00   H1F=H1E
5550.      00   H1F=H1E
5560.      00   CONTINUE
5570.      00   WRITE(6,117)
5580.      00   FORIAT(//, ' 1TE LOOP FAILED TO CONVERGE= ')
5590.      00   INTERE=1
5600.      00   H1E=H1EE
5610.      00
5620.      00   C 118 PDR13=P13-P1
5630.      00   DENT2=H1E-H1
5640.      00   PRINT 640,P1,P1E,P1EP1,DFNT2
5650.      00   IF(ABS(DENT2).GT.0.60010 123
5660.      00   PRINT 3020,INTERM,INTERE,POUT,P13
5670.      00   3020 FORMAT(' 1TERM,1TERE,POUT,P13= ',214,2F8.2)
5680.      00   IF(INTERM.NE.0)GOTO 120
5690.      00   IF((POUT-P13).LT.-0.5)GOTO 120
5700.      00   GOTO 140
5710.      00   CONTINUE
5720.      00   WRITE(6,642)
5730.      00   642 FORMAT(' 1M LOOP 120 DID NOT CONVERGE, RUN TERMINATED')
5740.      00   C**** ITERATE INPUT DATA FOR NEXT LOOP (1TH)
5750.      00   COTD 999
5760.      00
5770.      00
5780.      00
5790.      00

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***** DENT1=DENT2
      00
      00 TG3A=TG3
      00 TG6A=TG6
      00 IF (RTG6.NE.0.) THEN
      00   TG3=TC3-DENT2*RTG3
      00   TG6=TG6-DENT2*RTG6
      00 ELSE
      00   TCH=SIGN(2.,DENT2)
      00   TG3=TG3+TCH
      00   TG6=RTG6+TCH/2.
      00 END IF
      00
      00 RTE3=(TG3A-TG3)/(DENT1-DENT2)
      00 RTG6=(TG6A-TG6)/(DENT1-DENT2)
      00 IF (ABS(DENT1).LT.ABS(DENT2))GOTO 124
      00 DENT1=DENT2
      00 TG3A=TG3
      00 TG6A=TG6
      00 TG3=TG3A-DENT1*RTG3
      00 TG6=RTG6-DENT1*RTG6
      00 END IF
      00
      00 130 CONTINUE
      00 WRITE(6,133)DENT2
      00 133 FORMAT(//,1TH LGOP DID NOT CONVERGE, DENT2=',F8.3)
      00
      00 C***** END OF ENTHALPY AND FLOW RATE LOOP
      00 C**** DO REFRIGERANT MASS INVENTORY
      00 PMASS1=BPMASS(RD,RL,P1,T1,P2,T2)
      00 PMASS2=DPMASS(YD,YL,P9,T9,P10,T100)
      00 CALL WACCUM(T3,P3,PMASS,PMASS3,XWA)
      00 PM/CS4=BPMASS(1.128,VCAN,P4,T4,P4,T4)
      00 PMASS5=BPMASS(RYD,RYL,P11,T11,P12,T12)
      00 PMASS=PMASS1+PMASS2+PMASS3+PMASS4+PMASS5
      00 TMASS=PMASS+BIAMSS(1+DIIMAS(2))
      00 PRINT RESULTS: MASS INVENTORY, REF. STATES, PERFORMANCE
      00 WRITE(6,862)TMASS,REFIN
      00 CALL ENTRO2(XW,T1,P1,S1,XQ)
      00 CALL ENTRO2(XW,T2,P2,S2,XQ)
      00 CALL ENTRO2(XW,T3,P3,S3,XQ)
      00 CALL ENTRO2(XW,T4,P4,S4,XQ)
      00 CALL ENTRO2(XW,T5,P5,S5,XQ)
      00 CALL ENTRO2(XW,T6,P6,S6,XQ)
      00 CALL ENTRO2(XW,T7,P7,S7,XQ)
      00 CALL ENTRO2(XW,T8,P8,S8,XQ)
      00 CALL ENTRO2(XW,T9,F9,S9,XQ)
      00 CALL ENTRO2(XW,T10,P10,S10,XQ)
      00 CALL ENTRO2(XW,T11,P11,S11,XQ)
      00 CALL ENTRO2(XW,T12,P12,S12,XQ)
      00 CALL ENTRO2(XW,T13,P13,S13,XQ)
      00 WRITE(6,864)
      00 WRITE(6,800)ATITLE
      00 WRITE(6,924)TOA,RHOA,TRA,RHRA
      00 WRITE(6,947)CFM1,CFM2
      00 WRITE(6,931)
      00 INN=1
      00 WRITE(6,933)INN,T1,P1,H1,S1,X1
      00 INN=2
      00

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6380.      00      WRITE(6,933)INN,T2,P2,H2,S2,X2
6390.      00      INN=3
6400.      00      WRITE(6,933)INN,T3,P3,H3,S3,X3
6410.      00      INN=4
6420.      00      WRITE(6,933)INN,T4,P4,H4,S4,X4
6430.      00      INN=5
6440.      00      WRITE(6,933)INN,T5,P5,H5,S5,X5
6450.      00      INN=6
6460.      00      WRITE(6,933)INN,T6,P6,H6,S6,X6
6470.      00      INN=7
6480.      00      WRITE(6,933)INN,T7,P7,H7,S7,X7
6490.      00      INN=8
6500.      00      WRITE(6,933)INN,T8,P8,H8,S8,X8
6510.      00      INN=9
6520.      00      WRITE(6,933)INN,T9,P9,H9,S9,X9
6530.      00      INN=10
6540.      00      WRITE(6,933)INN,T10,P10,H10,S10,X10
6550.      00      INN=11
6560.      00      WRITE(6,933)INN,T11,P11,H11,S11,X11
6570.      00      INN=12
6580.      00      WRITE(6,933)INN,T12,P12,H12,S12,X12
6590.      00      INN=13
6600.      00      WRITE(6,933)INN,T13,P13,H13,S13,X13
6610.      00      QLOAD=RMASS*(H10-H11)+3412.66*EIDFAN
6620.      00      IF(NYSYS.EQ.2)QLOAD=RMASS*(H1-H13)-3412.66*EIDFAN
6630.      00      ELUSE=E1+EIDFAN+EIDFUSE
6640.      00      CC=QLOAD/(3412.66*EIDFUSE)
6650.      00      WRITE(6,942)TG3,TSUP3,TGG,RMASS,TMASS
6660.      00      WRITE(6,943)QLOAD,ELUSE,CCP
6670.      00      WRITE(6,945)XWW
6680.      00      IF(IITER.EQ.0)GOTO 260
C      C*** CHECK ON REFLIG. CHARGE REQUESTED
C      DMASS=TMASS-REFIN
C*** BALANCE NOT OBTAINED
C*** ITERATE INPUT DATA FOR THE NEXT LOOP (NMASS)
C*** IF(ABS(DMASS/REFIN).LT.0.015)GOTO 202
158      IF(NMASS.NE.1)GOTO 164
DMASS1=DMASS
TSUP31=1SUP3
X31=X3
TG31=TG3
TGG1=TGG
DMM1=DMASS1
DMM1N=DMASS1
CC+++
X3MAX=X3
X3MIN=X3
TG3MAX=TG3
TG3MIN=TG3
TG6MIN=TG6
TG6MAX=TG6
DMM1V=X=DMASS1
DMM1N=DMASS1
IF(DMASS.GT.0.)GOTO 160
IF(TSUP3.GT.0.)THEN
TSUP3=TSUP3-4.
TSUP3=ANAX1(0.,TSUP3)
TG3=TG31+(TSUP31-TSUP3)/4.

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6960. 00 TG6=TG31+(TSUP31-TSUP3)/2.
6970. 00 ELSE
6980. 00 X3=X31-0.02
6990. 00 TG3=TG31+1.
7000. 00 TG6=TG31+2.
7010. 00 X3MAX=X31
7020. 00 DM1MAX=DMASS1
7030. 00 TG3MAX=TG31
7040. 00 TG6MAX=TG61
7050. 00 END IF
7060. 00 GOTO 195
7070. 00 160 !F(X3,LT.1.)THEN @MOVE TOWARDS HIGHER TSUP3 OF X3
7080. 00 X3MIN=X31
7090. 00 DM1H=DMASS1
7100. 00 TG3MIN=TG31
7110. 00 TG6MIN=1G61
7120. 00 X3=X31+0.02
7130. 00 X3=ANIN(1.,X3)
7140. 00 TG3=TG31-(X3-X31)/0.02
7150. 00 TG6=TG61-(X3-X31)/0.01
7160. 00 ELSE
7170. 00 IF(NXM,NE.1)THEN
7180. 00 WRITE(6,956)
7190. 00 GOTO 202
7200. 00 END IF
7210. 00 TSUP3=TSUP31+4.
7220. 00 TG3=TG31-1.
7230. 00 TG6=TG61-2.
7240. 00 END IF
7250. 00 GOTO 196
7260. 00 C*****INTERPOLATION ****
7270. 00 164 DMASS2=DMASS
7280. 00 TSUP32=TSUP3
7290. 00 X32=X3
7300. 00 TG32=TG3
7310. 00 TG62=TG6
7320. 00 FACT=DMASS2/(DMASS1-DMASS2)
7330. 00 C
7340. 00 IF(DMASS.GT.0.)GOTO 166
7350. 00 IF(TSUP3.GT.0.)THEN @MOVE TOWARDS SMALLER TSUP3 OR X3
7360. 00 TSUPCH=(TSUP31-TSUP32)*FACT
7370. 00 IF(TSUPCH.LT.-10.)THEN
7380. 00 TSUPCH=-10.
7390. 00 FACT=-10./(TSUP31-TSUP32)
7400. 00 END IF
7410. 00 TSUP3=TSUP3+TSUPCH
7420. 00 IF((TSUP3,L.T.0.)THEN
7430. 00 TSUP3=0.
7440. 00 X3=1.
7450. 00 FACT=-TSUP32/(TSUP31-TSUP32)
7460. 00 END IF
7470. 00 ELSE
7480. 00 X3MAX=X3
7490. 00 TG3MAX=TG3
7500. 00 TGCMAX=TG6
7510. 00 DM1MAX=DMASS
7520. 00 IF(X3MIN,LT,X3MAX)THEN
7530. 00 X3=0.5*(X3MIN+X3MAX)

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***** BMMAIN *****
      7540.    00   TG3=0.5*(TG3MIN+TG3MAX)
      7550.    00   TG6=0.5*(TG6MIN+TG6MAX)
      7560.    00   ELSE X3=X3MAX-0.015
      7570.    00   END IF
      7580.    00   1F((ABSDMASS1-DM(SS2)/REFIN).LT.0.005)THEN
      7590.    00   C+ XCH=-0.01
      7600.    00   C+ 1F(X3MIN.EQ..8)GOTO 165
      7610.    00   C+ X3=X3MIN+0.00199
      7620.    00   C+ X31=X3MIN
      7630.    00   C+ TG31=TG3MIN
      7640.    00   C+ TG61=TG6MIN
      7650.    00   C+ DMASS1=DMIN
      7660.    00   C+ TG3=TG3MIN
      7670.    00   C+ TG6=TG6MIN
      7680.    00   C+ GOTO 198
      7690.    00   C+ END IF
      7700.    00   C+ XCH=(X31-X32)*FACT
      7710.    00   C+ 1F(XCH.LT.-0.06)THEN
      7720.    00   C+ XCH=-0.06
      7730.    00   C+ FACT=-0.06/(X31-X32)
      7740.    00   C+ END IF
      7750.    00   C+ X3=X32*XCH
      7760.    00   C+ 1F(X3.LT.X3MIN)THEN
      7770.    00   C+ FACT=-D(MASS2/(DM1IN-D(MASS2))
      7780.    00   C+ X3=X32+(X3MIN-X32)*FACT
      7790.    00   C+ END IF
      7800.    00   C+ END IF
      7810.    00   C+ GOTO 170
      7820.    00   C+ 165  END IF
      7830.    00   C+ 166  IF(X3.LT.1.)THEN
      7840.    00   C+ X3MIN=X3
      7850.    00   C+ TG6MIN=TG6
      7860.    00   C+ TG3MIN=TG3
      7870.    00   C+ DMIN=D(MASS
      7880.    00   C+ 1F(X3MAX.GT.X3MIN)THEN
      7890.    00   C+ X3=0.5*(X3MIN+X3MAX)
      7900.    00   C+ TG3=0.5*(TG3MIN+TG3MAX)
      7910.    00   C+ TG6=0.5*(TG6MIN+TG6MAX)
      7920.    00   C+ ELSE X3=X3MIN+0.015
      7930.    00   C+ END IF
      7940.    00   C+ X3=X32+(X31-X32)*FACT
      7950.    00   C+ 1F(X3.GT.1.)THEN
      7960.    00   C+ X3=1.0001
      7970.    00   C+ FACT=(1.-X32)/(X31-X32)
      7980.    00   C+ END IF
      7990.    00   C+ 1F(X3.GT.X3MAX)THEN
      8000.    00   C+ FACT=-D(MASS2/(DMMAX-D(MASS2))
      8010.    00   C+ X3=X32+(X3MAX-X32)*FACT
      8020.    00   C+ END IF
      8030.    00   C+ ELSE
      8040.    00   C+ IF(NXW.NE.1)THEN
      8050.    00   C+ WRITE(6,956)
      8060.    00   C+ GOTO 202
      8070.    00   C+ END IF
      8080.    00   C+ 1F(TSUP31.EQ.0..AND.TSUP32.EQ.0.)GOTO 158
      8090.    00   C+
      8100.    00   C+
      8110.    00   C+

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***** BMAIN *****
      8120.    00      TSUPCH=(TSUP31-TSUP32)*FACT
      8130.    00      IF(TSUPCH.GT.10.)THEN
      8140.    00      TSUPCH=10.
      8150.    00      FACT=10./ (TSUP31-TSUP32)
      8160.    00      END IF
      8170.    00      TSUP3=TSUP3+TSUFCH
      8180.    00      END IF
      8190.    00      TG3=TG32+(TG31-TG32)*FACT
      8200.    00      TG6= TG62+(TG61-TG62)*FACT
      8210.    00      DMASS1=DMASS2
      8220.    00      TSUP31=TSUP32
      8230.    00      TG31=TG32
      8240.    00      TG61=TG62
      8250.    00      TG6 IF(X3.LT.0.,80.0R.TSUP3 GT.55.,)THEN
      8260.    00      WRITE(6,941)
      8270.    00      X31=X32
      8280.    00      GOTO 202
      8290.    00      198 END IF
      8300.    00      C+ 198 IF((X3MAX-X3MIN).LT..002)THEN
      8310.    00      C+      WRITE(6,950)X3MAX,X3MIN
      8320.    00      C+      GOTO 202
      8330.    00      C+      END IF
      8340.    00      200 CONTINUE
      8350.    00      WRITE(6,201)DMASS
      8360.    00      201 FORMAT(//, DMASS LOOP DID NOT CONVERGE, DMASS= ', F9.3)
      8370.    00      C*** END OF REFRIGERANT MASS CONSERVATION LOOP
      8380.    00      C
      8390.    00      C***** C***** C***** C***** C***** C***** C*****
      8400.    00      202 IF(ITERN.EQ.0)GOTO 250
      8410.    00      XWCIR=(TMASS*(1.-XWORG)-TMASS3*X'A)/(TMASS-TMASS3)
      8420.    00      XWCIRW=1.-XWCIR
      8430.    00      PRINT 957,XWCIRW
      8440.    00      XWDIF=XW-XWCIR
      8450.    00      IF(ABS(XWDIF).LT.0.01)GOTO 250
      8460.    00      IF(NXW.EQ.1)THEN
      8470.    00      XW1=XW
      8480.    00      XW=XW-.5*(XW-XWCIR)
      8490.    00      XWDIF1=XWDIF
      8500.    00      ELSE
      8510.    00      FUCH=(XW-XW1)/(XWDIF-YWDIF)
      8520.    00      XWO=XW-XWDIF*FUCH
      8530.    00      XW1=XW
      8540.    00      XW=XW/O
      8550.    00      XW=MIN1(XW,.95)
      8560.    00      XW=MAX1(XW,.05)
      8570.    00      IF(XW.EQ.XW1)GOTO 260
      8580.    00      XWDIF1=XWDIF
      8590.    00      END IF
      8600.    00      XWW=.1.-XW
      8610.    00      PRIUT 958,XWW
      8620.    00      250 CONTINUE
      8630.    00      C*** END OF MIXTURE COMPOSITION LOOP
      8640.    00      C
      8650.    00      WRITE(6,955)
      8660.    00      260 CONTINUE
      8670.    00      C*** END OF EVALUATION OF PERFORMANCE
      8680.    00      C*** OF VAPOR COMPRESSION CYCLE
      8690.    00      WRITE(6,953)

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8700. 00 READ(5,777)I
8710. 00 IF(I.NE.999)GOTO 50
8720. 00 GOTO 999
8730. 00
8740. 00
8750. 00 C***** EVALUATION OF PARAMETERS
8760. 00 C***** OF VAPCR COMPRESSOR
8770. 00
8780. 00 CW WRITE(6,899)
8790. 00 CW WRITE(6,856)(EMETA(1),I=1,5)
8800. 00 CW WRITE(6,856)(EMETA(1),I=6,11)
8810. 00 CW WRITE(6,901)
8820. 00 CW WRITE(6,856)(EMOPT(1),I=1,5)
8830. 00 CW WRITE(6,856)(EMOPT(1),I=6,11)
8840. 00 CW WRITE(6,900)
8850. 00 CW WRITE(6,856)(ENRPM(1),I=1,6)
8860. 00
8870. 00 CALL COMPAR
8880. 00 GOTO 999
8890. 00
8900. 00 C***** EVALUATION OF FOUR-VALVE PARTIETERS
8910. 00
8920. 00
8930. 00
8940. 00 C 340 CALL VALVPA
8950. 00
8960. 00
8970. 00
8980. 00 851 FORMAT(/2X,'ANSWER 1 FOR YES OR 0 FOR NO',)
8990. 00 * /2X,'DO YOU WANT ANY INPUT DATA PRINTED ? LPR=')
9000. 00
9010. 00
9020. 00
9030. 00
9040. 00
9050. 00
9060. 00
9070. 00
9080. 00
9090. 00
9100. 00
9110. 00
9120. 00
9130. 00
9140. 00
9150. 00
9160. 00
9170. 00
9180. 00
9190. 00
9200. 00
9210. 00
9220. 00
9230. 00
9240. 00
9250. 00
9260. 00
9270. 00
C 777 FORMAT( )
800 FORMAT(20A4)
851 FORMAT(/2X,'T1,TG3,RMASS,P13=',4(1PE11.3))
852 FORMAT(/2X,'MOTOR/COMPRESSOR DATA ??')
853 FORMAT(/2X,'INDOOR COIL DATA',
&/2X,'OUTDOOR COIL DATA ??')
854 FORMAT(/2X,'EXTRUDE DEVICE DATA ??')
855 FORMAT(/2X,'CONNECTING TUBING DATA ??')
856 FORMAT(6(1PE11.3))
858 FORMAT(' RMASS=',1PE11.3)
860 FORMAT(/2X,'T1,TG3,RMASS,P13=',4(1PE11.3))
862 FORMAT(/2X,'TMATS = ',1PE11.3,5X,'REFIN = ',1PE11.3)
864 FORMAT(/'*****',1=393 FOR DISCONTINUATION')
893 FORMAT(/2X,'REFRIGERANT STATE GUESSES: Tc3,X1,TSUR3,Tg6= ')
894 FORMAT(/2X,'COMPRESSOR PARAMETERS(1), FCUR WAY VALVE PARAMETERS',
1'(2)', //', OR HEAT PUMP PERFORMANCE(3), IPTR= ')
899 FORMAT(/2X,'EMETA(1) : ')
900 FORMAT(/2X,'ENRPM(6) : ')
901 FORMAT(/2X,'EMCPT(1) : ')
903 FORMAT(/2X,'TURING CONNECTING COMPRESSOR @ IND. COIL')
905 FORMAT(/2X,'MOTOR/COMPRESSOR DATA',//,
&2X,'ELEFUL',5X,'FTAPLY',5X,'CLREFF')
906 FORMAT(/2X,'CPC34',6X,'CPC45',6X,'CPC67',6X,'CPC78')
907 FORMAT(/2X,'OCAC',6X,'OCGGA',6X,'OCG45',6X,'OCG57',6X,'OCG78')
908 FORMAT(/2X,'REFRIGERANT STATE GUESSES: Tc3,X1,TSUR3,Tg6= ')
909 FORMAT(/2X,'TUBING CONNECTING COMPRESSOR @ OUT. COIL')
910 FORMAT(/2X,'YL',7X,'YD',6X,'YK1',6X,
&'YD1',6X,'YK2',6X,'YD2')
911 FORMAT(/2X,'INDOOR COIL DATA : ')
912 FORMAT(/2X,'NDEP(1)',4X,'NROW(1)',14,111)
913 FORMAT(/2X,'D(1)',6X,'D(1)',6X,'DT(1)',6X,'RPCH(1)',4X,
&'DPCH(1)',4X,'WIDTH(1)')

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9280.          914 FORMAT(//2X, 'FPCH(1)', '4X, 'FTK(1)', '5X, 'FMK(1)', '5X,
00           & 'TMK(1)', '5X, 'AM3(1)'), )
00           915 FORMAT(//2X, 'NO. OF REPEATING SECTIONS: ', I3)
00           916 FORMAT(//2X, 'NTUB(1) : /515//2X, 'IFPCM(1) : ')
00           917 FORMAT(1015)
00           918 FORMAT(/2X, 'CONST(1)', '3X, 'CPWV(1)', '4X, 'ANGLE(1)', )
00           919 FORMAT(//2X, 'OUTDOOR COIL DATA: ')
00           920 FORMAT(//2X, 'NDEF(2)', '4X, 'NROW(2)', '14, 111)
00           921 FORMAT(/2X, 'DI(2)', '6X, 'DO(2)', '6X, 'DT(2)', 'GX, 'RPCH(2)', '4X,
00           & 'DPCH(2)', '4X, 'WIDTH(2)', )
00           922 FORMAT(//2X, 'FPCH(2)', '4X, 'FTK(2)', '5X, 'FMK(2)', '5X,
00           & 'TMK(2)', '5X, 'AMAS(2)', )
00           923 FORMAT(/2X, 'CONST(2)', '3X, 'CPWV(2)', '4X, 'ANGLE(2)', )
00           924 FORMAT(//2X, 'NTUB(2) : /515//2X, 'IFROM(2) : ')
00           926 FORMAT(/2X, 'OUTDOOR & INDOOR AIR CONDITIONS',
00           & 'POA, TRA, RHOA, PRA, TRA, RHRA=? //')
00           927 FORMAT(//2X, 'COMPOSITION OF CHARGED REFRIGERANT =',
00           1 /2X, '(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)', )
00           928 FORMAT(/2X, 'COMPOSITION OF CIRCULATING REFRIGERANT =',
00           1 /2X, '(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)', )
00           929 FORMAT(//2X, 'RL', '7X, 'RD', '6X, 'RK1', '6X,
00           & 'RD1', '6X, 'RK2', '6X, 'RD2', )
00           931 FORMAT(//2X, 'RESULTS: //2X, 'I', '2X, 'T', '10X, 'P', '10X, 'H', '10X,
00           & 'S', '10X, 'X')
00           933 FORMAT(13.5(1PE11.3))
00           934 FORMAT(//2X, 'TOA', '8X, 'RHOA', '7X, 'TRA', '8X, 'RHRA' /4(1PE11.3))
00           935 FORMAT(//2X, 'INDOOR FAN KW= ', '1PE11.3)
00           936 FORMAT(/2X, 'OUTDOOR FAN KW= ', '1PE11.3)
00           940 FORMAT(/2X, 'NSYS=1 FOR HEATING, NSYS=2 FOR COOLING MODE',
00           & '4X, 'NSYS=?')
00           941 FORMAT(//2X, 'IS ITERATION OF SUPERHEAT/QUALITY REQUESTED ? ', '/',
00           & '2X, 'ITER=0 FOR NO, 'ITER=1 FOR YES, 'ITER=?')
00           942 FORMAT(/2X, 'TG3', '8X, 'TSU', '3', '6X, 'TGE', '8X, 'RMASS', 'GX, 'TMASS', /
00           & '5(1PE11.3))
00           943 FORMAT(//2X, 'CLOAD', '6X, 'ELUSE', '6X, 'CCP', '3(1PE11.3))
00           944 FORMAT(//2X, 'QUALITY OR SUPERHEAT LIMIT EXCEEDED')
00           945 FORMAT(/1X, 'REFRIG. COMPOSITION = ', 'F7.3, /'
00           & ' (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)', '///')
00           946 FORMAT(//2X, 'EXP. DEVICE: ', '8X, 'ID', '5X, 'TEMPITI
00           & ' AT INDOOR COIL', 'F10.4, F8.2, 16, /
00           @ ' AT OUTDOOR COIL', 'F9.4, F8.2, 16)
00           947 FORMAT(/2X, 'CFMIND', '5X, 'CFMCUT', '2', '1PE11.3))
00           948 FORMAT(//2X, 'LIQUID LINE')
00           949 FORMAT(/2X, 'RYL', '8X, 'RYD')
00           950 FORMAT(' QUALITY X3 IS WITHIN THE RANGE ', 'F6.3, ' - , 'F5.3)
00           951 FORMAT(//2X, 'CG', '11X, 'CPDR', '7X, 'VCAN', '7X, 'REFIN')
00           952 FORMAT(/2X, 'AIGT', '7X, 'DACC', '7X, 'DHOLE(1)', 'GX, 'DHOLE(2)', ,
00           & '3X, 'DTUBE', '6X, 'HDIS')
00           954 FORMAT(/2X, 'S ITERATION OF MIXTURE COMPOSITION REQUESTED ? ', '/',
00           & '2X, 'ITERN=0 FOR NO, 'ITERN=1 FOR YES,
00           955 FORMAT(/2X, 'CONVERGENCE NOT OBTAINED IN CIRCUITATION LOOP')
00           956 FORMAT(/2X, 'GUESSIN COMPOSITION TO RICH IN MORE VOLATILE',
00           & 'COMPONENT')
00           957 FORMAT(//. FOR THE AMOUNT OF REFRIGERANT STORED IN THE ACCUMULA
00           & 'TOR', 'CIRCUITATING COMPOSITION SHOULD BE ', 'F7.3)
00           958 FORMAT(//
00           & ' NEW CALCULATED COMPOSITION FOR THE NEXT LOOP IS ', 'F7.3, /
00           & ' (WEIGHT FRACTION OF MORE VOLATILE COMPONENT) //,
```

DATE 072184

***** BMAIN *****
9860. 00 & * * * * *
9870. 00 999 STOP
9880. 00 END

END ELT. ERRORS: NONE. TIME: 1.146 SEC. IMAGE COUNT: 987
©HDG,P ***** BPMASS ***** .L,O

***** * BPMASS *****

DATE 072184

```
©ELT,L DD.BPMASS
ELT 8R1 S74Q1C 07/21/84 15:54:55 (0)
10.    00      FUNCTION BPMASS(DI,DL,P1,T1,P2,T2)
20.    00
30.    00      C*** * PURPOSE
40.    00      C*** * TO COMPUTE MASS OF A NON-ADIABATIC REFRIGERANT
50.    00      C*** * IN A TUBE
60.    00      C*** * (HYPOTHETICAL FLOW ASSUMED)
70.    00
80.    00      C*** * INPUT DATA:
90.    00      C   DI   - INLET DIAMETER OF TUBE      (FT)
100.   00      C   DL   - LENGTH OF TUBE      (FT)
110.   00      C   P1   - REFRIG. INLET PRESSURE      (PSIA)
120.   00      C   P2   - REFRIG. OUTLET PRESSURE      (PSIA)
130.   00      C   T1   - REFRIG. INLET TEMPERATURE      (F)
140.   00      C   T2   - REFRIG. OUTLET TEMPERATURE      (F)
150.   00      C   XW   - WEIGHT COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
160.   00
170.   00      C*** * OUTPUT DATA:
180.   00      C   BPMASS - REFRIG. MASS IN TUBE      (LB)
190.   00
200.   00      C*** * SUBPROGRAMS CALLED BY BPMASS:
210.   00      C   TPPROP
220.   00
230.   00      C   COMMON/RDATA3/XW,XM,WM
240.   00
250.   00      C   AREA=3.14159*DI*DI/4.
260.   00      C   VTUBE=AREA*DL
270.   00      CALL TPPROP(T1,P1,XW,XQ,H,V1)
280.   00      CALL TPPRCP(T2,F2,XW,XQ,H,V2)
290.   00      BPMASS=2.*VTUBE/(V1+V2)
300.   00      RETURN
310.   00
END ELT.  ERRORS: NONE. TIME: 0.075 SEC. IMAGE COUNT: 31
©HDG,P ***** BSIMP ***** .L,0
```

***** BSIMP *****

DATE 072184

```
@ELT,L DD.BSIMP
ELT 8R1 S74QIC 07/21/84 15:54:55 (0)
      FUNCTION BSIMP(FX,A1,A2,F,MAXIT,H1,GN,XM),
10.    00      C-
20.    00      C-      NUMERICAL INTEGRATION USING SIMSON-S 1/3 RULE
30.    00      C-
40.    00      C-      INITIALIZATIONS
50.    00      C      REAL*8 FX
60.    00      C
70.    00      C
80.    00      C      S1=0.
90.    00      C      PR=0.
100.   00      C      X=A2
110.   00      C      H=A1-A2
120.   00      C      LOOP TO COUNT THE MAXIMUM NUMBER OF ITERATIONS
130.   00      C      DO J=0,MAXIT
140.   00      C
150.   00      C      M=2
160.   00      C      LOOP TO COUNT THE NUMBER OF FUNCTION EVALUATIONS
170.   00      C      DO I=1,M
180.   00      C      SUM THE FUNCTION EVALUATIONS
190.   00      C      S=S+FX(XM,X,H1,GN)
200.   00      C      INCREMENT X
210.   00      C      1 X=X+H
220.   00      C      OBTAIN NEW VALUE OF INTEGRATION
230.   00      C      BSIMP=(2.*S+S1)*H/3.
240.   00      C      IF(J-1) 2,4,3
250.   00      C      FIRST LOOP. SET M TO 1 AND DIVIDE THE FUNCTION EVALUATIONS
260.   00      C      BY 2
270.   00      C      M=1
280.   00      C      2 S1=-S/2.
290.   00      C      GO TO 5
300.   00      C      CHECK ERROR CONTROL
310.   00      C      3 PR:=PR-BSIMP
320.   00      C      PR=PR/BSIMP
330.   00      C      EVALUATION WITHIN ERROR LIMITS. FINISH
340.   00      C      IF(ABS(PR).LT.E) GO TO 7
350.   00      C      SECOND ITERATION. HALVE H AND DOUBLE M
360.   00      C      4 H=H*.5
370.   00      C      M=2*M
380.   00      C      OBTAIN NEW LOWER FOR FUNCTION EVALUATIONS
390.   00      C      5 X=A2+.5*X
400.   00      C      PREVIOUS VALUE OF INTEGRATION
410.   00      C      PR=B3E IM;
420.   00      C      6 S1=S1+S
430.   00      C      7 RETURN
440.   00      C
END ELT.  ERRORS: NONE.  TIME: 0.096 SEC.  IMAGE COUNT: 44
@HDG,F ***** BUPRE ***** .L,0
```

***** BUBPRE *****

DATE 072184

@ELT,L DD.BUBPRE
ELT 8R1 S74Q1C 07/21/84 15:54:56 (0)
SUBROUTINE BUBPRE(IG,T,X,P,XV)

```

20..    00      C
30..    00      C*** PURPOSE:
40..    00      C   TO CALC. BUBBLE POINT PRESSURE OF BINARY MIXTURE
50..    00      C   FROM GIVEN TEMPERATURE AND COMPOSITION
60..    00      C
70..    00      C*** INPUT:
80..    00      C   IG = 0, IF GUESS OF PRESSURE IS NOT GIVEN
90..    00      C   = 1, IF GUESS OF PRESSURE IS GIVEN
100..   00      C   T - TEMPERATURE (K)
110..   00      C   P - GUESS OF PRESSURE, OPTIONAL (STD ATM)
120..   00      C   X - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
130..   00      C
140..   00      C*** OUTPUT:
150..   00      C   P - BINARY MIXTURE PRESSURE AT BUBBLE POINT (STD ATM)
160..   00      C   XV - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
170..   00      C   IN SAT. VAPOR IN EQUILIBRIUM WITH LIQUID (-)
180..   00      C
190..   00      C*** SUBPROGRAMS CALLED BY BUBPRE:
200..   00      C   EBUBFR, QLITY
210..   00      C
220..   00      C   DATA SLOPE/0., TLAST/0./
230..   00      C
240..   00      C   IF(ABS(T-TLAST).GT.1.E-3)GOTO 10
250..   00      C   IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
260..   00      C   P=PLAST
270..   00      C   XV=XLAST
280..   00      C   RETURN
290..   00      C
300..   00      C   10 IF(IG.NE.1)P=EBUBPR(T,X)
310..   00      C   DO 50 I=1,20
320..   00      C   CALL QLITY(T,P,X,XQ,XV,XL)
330..   00      C   P2=P
340..   00      C   XDIF2=X-XL
350..   00      C   IF(ABS(XDIF2).LT.0.00001)GOTO 100
360..   00      C   IF(I.NE.1)GOTO 20
370..   00      C   15 P1=P2
380..   00      C   XDIF1=XDIF2
390..   00      C   IF(SLOPE.NE.0.)THEN
400..   00      C   DP=XDIF2*SLOPE
410..   00      C   IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)
420..   00      C   P=P2-DP
430..   00      C   GOTO 50
440..   00      C
450..   00      C   END IF
460..   00      C   P=P2+0.5
470..   00      C   IF(XDIF2.GT.0.)P=P2-0.5
480..   00      C   GOTO 50
490..   00      C
500..   00      C   20 IF(XDIF1.EQ.XDIF2)GOTO 15
510..   00      C   SLOPE=(P2-P1)/(XDIF2-XDIF1)
520..   00      C   IF(ABS(XDIF1).LT.ARS(XDIF2))GOTO 30
530..   00      C   P1=P2
540..   00      C   XDIF1=XDIF2
550..   00      C   DP=XDIF1*SLOPE
560..   00      C   IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)

```

***** BUBPRE *****
570. 00 P=P1-DP
580. 00 50 CONTINUE
590. 00 WRITE(6,600)XDIF2
600. 00 600 FORMAT(' ERROR GOO IN BUPRE, XDIF2=' ,1FE12.4)
610. 00 100 TLAST=T
620. 00 XLAST=X
630. 00 PLAST=P
640. 00 XVLAST=XV
650. 00 RETURN
660. 00 END

END ELT. ERRORS: NONE. TIME: 0.128 SEC. IMAGE COUNT: 66

@HDG,P ***** BUBTEM ***** .L,0

***** BUBTEM *****

DATE 072184

```

@ELT_L DD,BUBTEM
ELT 8R1 S74Q1C 07/21/84 15:54:56 (O)
10.    00      SUBROUTINE BUBTEM(IG,P,X,T,XV)
20.    00      C
30.    00      C
40.    00      C*** PURPOSE:
50.    00      C   TO CALC. BUBBLE POINT TEMPERATURE OF BINARY MIXTURE
60.    00      C   FROM GIVEN PRESSURE AND COMPOSITION
70.    00      C
80.    00      C*** INPUT:
90.    00      C   IG = 0, IF GUESS OF TEMPERATURE IS NOT GIVEN
100.   00      C   = 1, - IF GUESS OF TEMPERATURE IS GIVEN
110.   00      C   P - PRESSURE (STD ATM)
120.   00      C   T - GUESS OF TEMPERATURE, OPTIONAL (K)
130.   00      C   X - MOLEAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)

140.   00      C*** OUTPUT:
150.   00      C   T - BINARY MIXTURE TEMPERATURE AT BUBBLE POINT (K)
160.   00      C   XV - MOLEAR CONCENTRATION OF LESS VOLATILE COMPONENT
170.   00      C   IN SAT. VAPOR IN EQUILIBRIUM WITH LIQUID (-)

180.   00      C*** SUBPROGRAMS CALLED BY BUBTEM:
190.   00      C   EBUBTE, QLIITY
200.   00      C
210.   00      C
220.   00      C   DATA SLOPE/O./,PLAST/O./
230.   00      C
240.   00      C   IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
250.   00      C   IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
260.   00      C   T=LAST
270.   00      C   XV=XVLAST
280.   00      C   RETURN
290.   00      C
300.   00      C   10  T1=N=T
310.   00      C   IF(IG.NE.1)T=EBUBTE(P,X)
320.   00      C   DO 50 I=1,20
330.   00      C   CALL QLIITY(T,P,X,XQ,XV,XL)
340.   00      C   T2=T
350.   00      C   XDIF2=X-XL
360.   00      C   IF(I.NE.1)GOTO 20
370.   00      C   T1=T2
380.   00      C   XDIF1=XDIF2
390.   00      C   IF(SLOPE.NE.0.)THEN
400.   00      C   DT=XDIF2*SLOPE
410.   00      C   IF(AJS(DT).GT.10.)DT=SIGN(10.,DT)
420.   00      C   T=T2-DT
430.   00      C   GOTO 50
440.   00      C   END IF
450.   00      C   T=T2+5.
460.   00      C   IF(XDIF2.GT.0.)T=T2-5.
470.   00      C   GOTO 50
480.   00      C
490.   00      C   20  IF(XDIF1.EQ.XDIF2)GOTO 15
500.   00      C   SLOPE=(T2-T1)/(XDIF2-XDIF1)
510.   00      C   IF(ABS(XDIF1).LT.ABS(XDIF2))GOTO 30
520.   00      C   T1=T2
530.   00      C   XDIF1=XDIF2
540.   00      C   DT=XDIF1*SLOPE
550.   00      C   IF(ABS(DT).LT.0.003)GOTO 100

```

```
***** BUBTEM *****  
560.      00      IF (ABS(DT) .GT. 10.) DT=SIGN(10.,DT)  
570.      00      T=T1-DT  
580.      00      CONTINUE  
590.      00      WRITE(6,600)IG,P,X,TIN,XDIF2,DT  
600.      00      600  FORMAT(' ERROR 600 IN BUBTEM, IG,P,X,TIN,XDIF2,DT=',I2,5F10.6)  
610.      00      100  PLAST=P  
620.      00      XLAST=X  
630.      00      TLAST=T  
640.      00      XVLAST=XV  
650.      00      RETURN  
660.      00      END  
  
END ELT.  ERRORS: NONE. TIME: 0.138 SEC. IMAGE COUNT: 67  
@Hdg, P ***** CAPIL ***** .L,O
```

@ELT,L DD.CAPIL
ELT 8R1 S74Q1C 07/21/84 15:54:56 (O)
10. 00 C
20. 00 C
30. 00 C
40. CO C
50. CO C
60. 00 C
70. 00 C
80. 00 C
90. 00 C
100. 00 C
110. 00 C
120. 00 C
130. 00 C
140. 00 C
150. 00 C
160. 00 C
170. 00 C
180. 00 C
181. 00 C
190. 00 C
200. 00 C
210. 00 C
220. 00 C
230. 00 C
240. 00 C
250. 00 C
260. 00 C
270. 00 C
280. 00 C
290. 00 C
300. 00 C
310. 00 C
320. 00 C
330. 00 C
340. 00 C
350. 00 C
360. 00 C
370. 00 C
380. 00 C
390. 00 C
400. 00 C
410. 00 C
420. 00 C
430. 00 C
440. 00 C
450. 00 C
460. 00 C
470. 00 C
480. 00 C
490. 00 C
500. 00 C
510. 00 C
520. 00 C
530. 00 C
540. 00 C
550. 00 C

C**** PURPOSE:
C TO COMPUTE MASS FLOW RATE OF NON-AZEOTROPIC MIXTURE
C THROUGH EXPANSION DEVICE OF CONSTANT FLOW AREA
C
C**** INPUT DATA:
C D - EXPANSION DEVICE DIAMETER (FT)
C NC - NUMBER OF EXPANSION DEVICES (-)
C H1 - REFRIG. ENTHALPY BEFORE EXP. DEVICE (BTU/LBM)
C P1 - REFRIG. PRESSURE BEFORE EXP. DEVICE (PSIA)
C P2 - EVAPORATOR INLET PRESSURE (PSIA)
C TL - EXPANSION DEVICE LENGTH (FT)
C XMASS - MASS FLOW RATE THROUGH NC EXP. DEVICES (GUESS) (LB/HR)
C XW - COMPOSITION (WEIGHT FRACTION OF LESS VOLATILE COMPONENT)
C
C**** OUTPUT DATA:
C P2 - REFRIG. PRESSURE AT OUTLET OF EXP. DEVICE (PSIA)
C XMASS - MASS FLOW RATE THROUGH NC EXP. DEVICES (LB/HR)
C
C**** SUBPROGRAMS CALLED BY CAPIL:
C BSIMP, CIRCLE, DDE1FA, DFANNO, HPROP, PFLASH, VISON
C COMMON/RDATA2/W1,W2,TC1,TC2
C EXTERNAL DDENFA
C REAL*3 DFANNO,S1,S2,DDENFA
C
C NO=0
C PRINT 44, P1,H1,P2
C IF(P1.LE.P2)GOTO 5n
C **** PRELIMINARY CALCULATIONS
C PA1=P1/14.6959
C XM=XW/(W2/W1*(1.-XW)+XW)
C AREA=3.141593*D*D/4.
C G=XMASS/AREA/3600./FLCAT(NC)
C IF(G.LT.200.)G=200.
C IF((TL.LT.0.2.AND.G.LT.1000.)G=1000.
C GMIN=0.
C GMAY=5.E4
C **** FIND REFRIG. COND. BEFORE EXPANSION DEVICE
C ACC=0.0005
C CALL HPROP(NO,H1,P1,XM,ACC,TK1,XIN,XML,XMV,VLM,VVN,
C @ VM,V,CP,CV,AM,AK)
C TIN=TK1*1.8-459.67
C IF(XIN.GT.0.)THEN
C VL=V
C FVL=TL
C PFLA=P1
C TFLA=TIN
C GOTO 20
C
C END IF
C E=G
C DO 4 LIQ=1,15
C EE=E*E
C EN=EE/(64.4*778.104)

***** CAPII *****

DATE 07/21/84

```

560.      00      CALL FFLASH(XM,H1,EN,TIN,TFLA,PFLA,VL)
570.      00      POUT=AMAX1(PFLA,P2)
580.      00      ZF=VISCON(1,TIN,XM)
590.      00      RF=3500.*E*D/ZF
600.      00      FF=16./RE
610.      00      IF (RE.GT.2000.)FF=0.046/RE*.#0.2
620.      00      PDL=EE*FF*TL; VL*2./((32.2*144.*D)
630.      00      PDE=1.15*EE*VL/(64.4*144.)
640.      00      P1A:=PDU+PDL+PDE
650.      00      P1P1A=P1-P1A
660.      00      IF (ARS(P1P1A).LT.0.02)GOTO 6
670.      00      IF (LIQ.EQ.1)GOTO 2
680.      00      EY=E-P1P1A*(EB-E)/(P1P1B P1P1A)
690.      00      EB:=E
700.      00      E=EY
710.      00      GOTO 3
720.      00      EB=E
730.      00      E=.8*E
740.      00      IF (P1P1A.GT.0.)E=1.5*E
750.      00      P1P1B=P1P1A
760.      00      CONTINUE
770.      00      PRINT 5
780.      00      FFORMAT('CAP:L*ERROR 5')
790.      00      C
800.      00      6 CONTINUE
810.      00      G2=E
820.      00      IF (PCUT.EQ.R2)GOTO 1000
830.      00      S1=DFANNO(XM,PFLA,H1,EN)
840.      00      S2=DFANID(XM,PFLA=0.1,H1,EN)
850.      00      IF (S2.LT.S1)GOTO 1000
860.      00      GMIN=G2
870.      00      G=1.05*GMIN
880.      00      IF ((P1-POUT).LT.1.)G=20.*G
890.      00      START THE LOOP
900.      00      DO 40 IA=1,25
910.      00      DO 30 II=1,10
920.      00      GG=G*G
930.      00      GN=GG/(64.4*778.101)
940.      00      C**** FIND FLASHING PRESSURE
950.      00      IF (XIN.EQ.0.)CALL PFLASH(XM,H1,GN,TIN,TFLA,PFLA,VL)
960.      00      C**** FIND PRESSURE AT EXIT
970.      00      POUT=CHKE(XM,PFLA,P2,II1,GN)
980.      00      IF (PCUT.EQ.PFLA)GOTO 32
990.      00      C**** FIND PRESSURE IN ENTRANCE
1000.     00      PINN=PIN
1010.     00      DO 35 IEN=1,5
1020.     00      PIN=P1-1.15*CG*VL/(64.4*144.)
1030.     00      IF (PIN.GE.PFLA)GOTO 22
1040.     00      IF (PIN.LT.POUT)GOTO 32
1050.     00      YL=1./DDENFA(XM,PIN,II1,GN)
1060.     00      IF (ABS(PIN-PINN).LT.0.01)GOTO 21
1070.     00      PINN=PIN
1080.     00      35 CONTINUE
1090.     00      21 P2PH=PIN
1100.     00      FVL=TL
1110.     00      GOTO 23
1120.     00      C**** CALC. LENGTH OF SUBCOOLED LIQUID
1130.     00      P2PH=PFLA

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```

1140.      00      ZF=VISCON(1,TFLA,XW)
1150.      00      RE=2600.*G*D/ZF
1160.      00      FF=16./RE
1170.      00      IF (RE.GT.2000.) FF=0.046*PE**0.2
1180.      00      FL=(32.2*141.)*(FIN-PFLA)*D/(2.*FF*GC*VL)
1190.      00      FVL=TL-FL
1200.      00      IF (FVL.LT.2.) THEN
1210.      00      G2=G
1220.      00      IF ((FVL/TL.).LT.-0.01) GOTO 41
1230.      00      GOTO 1000
1240.      00      END IF
1250.      00      CALC. 2-PHASE FRICTION FACTOR
1260.      00      ZF=VISCON(1,TFLA,XW)
1270.      00      ZG=VISCGN(3,TFLA,XW)
1280.      00      ZU=ZG*XIN*.7F*(1.-XIN)
1290.      00      RE=3600.*G*D/ZU
1300.      00      FF=0.775/SQRT(RE)*EXP((-1.-XIN**.25)/2.4)
1310.      00      EVALUATE DENSITY-PRESSURE INTEGRAL
1320.      00      Y=PSIMP(DDENFA,F2PH,POUT,0.002,10,H1,GN,XM)
1330.      00      CALCULATE MASS FLOW RATE
1340.      00      RO1=1./VL
1350.      00      RO2=DDENFA(XM,POUT,H1,GN)
1360.      00      G2=SQRT(4636.8*Y/(2.*FF*FVL/2+ALOG((RO1/RO2))))
1370.      00      GD=G-G2
1380.      00      IF (ABS(GD/G).LT..005) THEN
1390.      00      G2=0.5*(G+G2)
1400.      00      GOTO 1000
1410.      00      END IF
1420.      00      IF (1.1.EQ.1.) GOTO 24
1430.      00      IF (ABS(GD1-GD).LT..001.AND.(3-GHIN).LT.0.01) THEN
1440.      00      G2=G
1450.      00      GOTO 1000
1460.      00      END IF
1470.      00      G3=G-GD*(G1-G)/(Gn1-GD)
1480.      00      GOTO 25
1490.      00      G3=0.1*G+0.9*G2
1500.      00      G1=G
1510.      00      GD1=GD
1520.      00      IF (G3.LT.GMIN) G3=C-(G-GMIN)*(GMIN-G3)/(G-G3)
1530.      00      IF (G3.GT.GMAX) G3=G+(GMAX-G)*(G3-GMAX)/(G3-G)
1540.      00      G=G3
1550.      00      CONTINUE
1551.      00      G2=G
1560.      00      PRINT 31,G,GD
1570.      00      31 FORMAT(' CAPII DOES NOT CONVERGE , RG, GD= ',F10.4)
1580.      00      GOTO 1000
1590.      00      CMAX=G
1600.      00      G=0.5*(GMIN+GMAX)
1610.      00      CONTINUE
1620.      00      PRINT 42, GD
1630.      00      42 FORMAT(' CAPII DID NOT CONVERGE, GD = ',F10.4)
1640.      00      XMASS=3600.*G2*AREAN*FLOAT(NC)
1641.      00      P2=POUT
1650.      00      44 FORMAT('// EXPANSION DEVICE: /'
@.      INPUT - P12 = ',1PE9.3,3X,'H12 = ',1PE9.3,3X,'P13 = ',1PE9.3)
1660.      00      PRINT 46, POUT,XMASS
1670.      00      46 FORMAT(' OUTPUT - POUT = ',1PE9.3,3X,'XMASS = ',1PE9.3)
1680.      00      RETURN
1690.      00

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DATE 072184

```
***** CAPIL *****  
1700.      00      50 XMASS=0.  
1710.      00      PRINT 52,P1,P2  
1720.      00      52 FORMAT('/* ***ERROR IN CALLING CAPIL, P1 LF,P2***',//  
1730.      00      &4X,'P1=' ,1PE11.3,' P2=' ,1PE11.3,' XMASS=0.0')  
1740.      00      RETURN  
1750.      00      END  
  
END ELT.  ERRORS: NONE. TIME: 0.236 SEC. IMAGE COUNT: 178  
@Hdg,P ***** CHOKE ***** .L,0
```

***** CHOKE *****

DATE 072184

```

@ELT,L DD,CHOKE
ELT 8R1 S74Q1C 07/21/84 15:54:57 (0)
      00      FUNCTION CHOKE(XW,PF,PEVAP,H0,GG)
      00
      00      C*** PURPOSE:
      00      C   TO CALCULATE THE THERMODYNAMIC CRITICAL PRESSURE
      00      OF NON-AZEOTROPIC BINARY MIXTURE IN TWO-PHASE FANNO FLOW
      00
      00      C*** NOTE: EVAPORATOR PRESSURE IS RETURNED AS CHOKE PRESSURE
      00      IF CHOKE PRESSURE IS SMALLER THAN PRESSURE
      00      IN THE EVAPORATOR
      00
      00      C*** INPUT DATA:
      00      G6 = G*G/(64.4*778.104) (BTU*LBM/FT**3)
      00      WIENE G - REFRIG. MASS FLUX (LBIN/(SEC*FT**2))
      00      H0 - TOTAL ENTHALPY (BTU/LBM)
      00      PEVAP - EVAPORATOR PRESSURE (PSIA)
      00      PF - FLASH PRESSURE (PSIA)
      00      XW - COMPOSITION (WEIGHT FRACTION OF LESS VOLATILE COMPONENT)
      00
      00      C*** OUTPUT DATA:
      00      CHOKE - CRITICAL PRESSURE (PSIA)
      00
      00      C*** SUBPROGRAMS CALLED BY CHOKE:
      00      DFANND
      00
      00      COMMON/RDATA2/W1,W2,TC1,TC2
      00      DIMENSION P(3),S(3),DS(3),LN(2),LP(2)
      00
      00      C
      00      IF(PF.GT.PEVAP)GOTO 10
      00      PRINT 666,PF,PEVAP
      00      666 FORMAT(' ERROR IN CALLING CHOKE, PF, PEVAP=' ,2(1PE15.5))
      00      CHOKE=PEVAP
      00      RETURN
      00
      00      C 10 XM=XW/(W2/W1*(1.-XW)+XW)
      00
      00      C*** CHECK, IF CHOKE PRESSURE IS BELOW PEVAP
      00      P(1)=PEVAP
      00      S(1)=DFANND(XM,P(1),H0,GG)
      00      SS=DFANNR(XM,P(1)-.1,H0,GG)
      00      DS(1)=S(1)-SS
      00      IF(DS(1).LT.0.)GOTO 1000
      00
      00      C*** SELECT PRESSURE STEP
      00      1D0=8
      00      OPEND=PF-PEVAP
      00      DP=40.
      00      D0 12 I=1,6
      00      DP=0.5*DP
      00      1DC=1D0-1
      00      IF(DP>ND.GT.DP)GOTO 14
      00
      00      12 CONTINUE
      00      1A CONTINUE
      00
      00      C*** SEARCH FOR SONIC AND SUBSONIC POINT
      00      DO 20 I=1,20
      00
      00      620.

```

***** CHOKE *****

DATE 07/21/64

```
630.      00
640.      00
650.      00
660.      00
670.      00
700.      00
710.      00
720.      00
730.      00
740.      00
750.      00
760.      00
770.      00
780.      00
810.      00
820.      00
830.      00
840.      00
850.      00
860.      00
870.      00
880.      00
890.      00
900.      00
930.      00
940.      00
950.      00
960.      00
970.      00
980.      00
990.      00
1000.     00
1010.     00
1020.     00
1030.     00
1040.     00
1050.     00
1060.     00
1070.     00
1080.     00
1090.     00
1100.     00
1110.     00
1120.     00
1130.     00
1140.     00
1150.     00
1160.     00
1170.     00
1180.     00
1190.     00
1200.     00
1210.     00
1220.     00
1230.     00
1240.     00
1250.     00
1260.     00

P(2)=P(1)+20.
IF(P(2).GT.PF) THEN
  P(1)=P+
  S(1)=DFANNO(XM,P(1),HO,GG)
  DS(1)=S(1)-DFANNO(XM,P(1),HO,GG)
  IF(DS(1).GT.0.)GOTO 1000
  P(2)=P(1)-DP
  S(2)=DFANNO(XM,P(2),HO,GG)
  DS(2)=S(2)-DFANNO(XM,P(2),HO,GG)
  GOTO 30
END IF
S(2)=DFANNO(XM,P(2),HO,GG)
SS=DFANNO(XM,P(2),HO,GG)
DS(2)=S(2)-SS
IF(DS(2).LT.0.)GOTO 30
P(1)=P(2)
S(1)=S(2)
DS(1)=DS(2)
CONTINUE
C      30 CONTINUE
DC 5C 1D=1,1D0
P(3)=.5*(P(1)+P(2))
S(3)=DFANNO(XM,P(3),HO,GG)
SS=DFANNO(XM,P(3)-0,1,HO,GG)
DS(3)=S(3)-SS
IF(DS(3).EQ.0.)GOTO 1010
C*** FIND TWO OF THE SAME SLOPE, SELECT ONE WITH BIGGER S
NDS=0
NNDSDS=0
DO 35 I=1,3
IF(DS(I).GT.0.)GOTO 32
NDS=NDS+1
LN(NDS)=I
GOTO 35
32 NNDSDS=NNDSDS+1
LP(NNDSDS)=I
CONTINUE
C*** ASSIGN VALUE OF SING_E DS POINT FOR FUTURE USE
IF(NNDSDS.EQ.1)GOTO 40
ITO=LN(1)
IT1=LP(1)
IT2=LP(2)
GOTO 45
40 ITO=LP(1)
IT1=LN(1)
IT2=LN(2)
PS=P(IT0)
SS=S(IT0)
DSS=DS(IT0)
C*** PICK UP THE POINT WITH BIGGER ENTRPY
IBIG=IT2
IF(S(IT1).GT.S(IT2))IBIG=IT1
C*** ASSIGN VALUES TO PRINTS 1 AND 2
P(1)=P(IBIG)
S(1)=S(IBIG)
DS(1)=DS(IBIG)
P(2)=PS
00
```

***** CHOKE *****

```

1270.    00      S(2)=SS
1280.    00      DS(2)=DSS
1290.    00      50 CONTINUE
1300.    00
C       DO 60 N=1,2
1310.    00      IL=1
1320.    00      IF(S(2).LT.S(1))IL=2
1330.    00      IF(S(3).LT.S(IL))IL=3
1340.    00      DO 55 I=1,2
1350.    00      IF(I.NE.IL)GOTO 55
1360.    00      P(I)=P(3)
1370.    00      S(I)=S(IL)
1380.    00
55  CONTINUE
1390.    00      P(3)=0.5*(P(1)+F(2))
1400.    00      S(3)=DFANN(XM,P(3),HO,GG)
1410.    00
60  CONTINUE
1440.    00
1450.    00      IL=1
1460.    00      IF(S(2).GT.S(1))IL=2
1470.    00      IF(S(3).GT.S(IL))IL=3
1480.    00      CHOKE=P(IL)
1490.    00      RETURN
1500.    00
C       1000 CHOKE=P(1)
1510.    00      RETURN
1520.    00
C       1010 CHOKE=P(3)-.05
1530.    00      RETURN
1540.    00
1550.    00      END
1560.    00
END ELT.  ERRORS: NONE. TIME: 0.182 SEC. IMAGE COUNT: 142
©HDG,P  ***** COMPAR ***** .L,0

```

***** COMPAR *****

©ELT.L DD. COMPAR
ELT 8R1 S74QIC 07/21/64 15:54:57 (0)

DATE 072184

00 C**** PURPOSE: TO DETERMINE PERFORMANCE PARAMETERS OF A HERMETIC COMPRESSOR
00 C WORKING WITH A NON-ADIABATIC MIXTURE FROM TEST UNDER
00 C ONE OPERATING CONDITION

00 C**** INPUT DATA:
00 C * STANDARD ELECTRIC MOTOR CHARACTERISTICS:
00 C * EMETAK - COMPRESSOR MOTOR EFFICIENCY IN FRACTION AT FRACTION
00 C OF FULL LOAD SPECIFIED BY E1OPT(K) (-)
00 C EMOPT(K) - COMPRESSOR MOTOR FULL LOAD FRACTION (-)
00 C EMRFM(L) - COEFFICIENT FOR COMPRESSOR MOTOR RPM CALCULATION (-)
00 C * COMPRESSOR DESIGN DATA:
00 C * ELEFLU - COMPRESSOR MOTOR ENERGY INPUT RATE AT FULL LOAD (KW)
00 C SWPVOL - TOTAL COMPRESSOR SWEEP VOLUME PER REVOLUTION (IN**3)
00 C * TEST DATA AVAILABILITY:
00 C ILONG = 0 FOR SHORT TEST DATA AVAILABLE
00 C = 1 FOR LONG TEST DATA AVAILABLE
00 C * SHORT TEST DATA INPUT (ILONG=0):
00 C ELEIPT - COMPRESSOR MOTOR ENERGY INPUT RATE AT TEST CONDITION (KW)
00 C P3,T3 - REFRIG. PRESSURE & TEMPERATURE AT COMPRESSOR CAN INLET (PSIA), (F)
00 C P8,T8 - REFRIG. PRESSURE & TEMPERATURE AT COMPRESSOR CAN OUTLET (PSIA), (F)
00 C RMASS - REFRIG. MASS FLOW RATE AT TEST (LBH/H)
00 C RPMCP - COMPRESSOR NUMBER OF REVOLUTIONS PER MINUTE AT TEST (1/MIN)
00 C IF NOT MEASURED RPMCP=0.
00 C TOA - AMBIENT AIR TEMPERATURE (F)
00 C XW - WEIGHT COMPOSITION (FRACTION OF LEAST VOLATILE COMPONENT)
00 C * LONG TEST DATA INPUT (ILONG=1):
00 C AS FOR ILONG=0 PLUS
00 C P3,T3 - PRESSURE & TEMPERATURE INSIDE COMPRESSOR CAN (PSIA), (F)
00 C P4,T4 - PRESSURE & TEMPERATURE IN CYLINDER AT SUCTION (PSIA), (F)
00 C P5,T5 - PRESSURE & TEMPERATURE IN CYLINDER AT DISCHARGE (PSIA), (F)
00 C P6,T6 - PRESSURE & TEMPERATURE AT DISCHARGE MANIFOLD (PSIA), (F)
00 C TCAN - COMPRESSOR CAN TEMPERATURE (F)
00 C**** OUTPUT DATA:
00 C CLRFFF - CLEARANCE VOLUME, IN FRACTION OF STROKE VOLUME (-)
00 C CPC34 - PRESSURE DROP PARAMETER AT COMPRESSOR CAN INLET
00 C (LBFT**2/LFM**1IN**2*FT**3)
00 C CPC45 - PRESSURE DROP PARAMETER AT COMPRESSOR SUCTION VALVE
00 C (LBFT**2/LFM**1IN**2*FT**3)
00 C CPC67 - PRESSURE DROP PARAMETER AT CO. COMPRESSOR DELIVERY VALVE
00 C (LBFT**2/LFM**1IN**2*FT**3)
00 C CPC78 - PRESSURE DROP PARAMETER AT COMPRESSOR CAN EXIT
00 C (LBFT**2/LDM**1IN**2*FT**3)
00 C CCCOA - PARAMETER FOR CAN WALL-AMBIENT AIR HEAT TRANSFER (FT**.2)
00 C COCAC - PARAMETER FOR CAN WALL-REFRIG. VAPOR HEAT TRANSFER (FT**.2)
00 C CCA45 - SUCTION VALVE HEAT TRANSFER PARAMETER (FT**.2)
00 C CCG67 - DELIVERY VALVE HEAT TRANSFER PARAMETER (FT**.2)
00 C CGC78 - CAN EXIT HEAT TRANSFER PARAMETER (FT**.2)
00 C EFTYM - COMPRESSOR MOTOR EFFICIENCY AT TEST (-)
00 C EFTYV - COMPRESSOR VOLUMETRIC EFFICIENCY AT TEST (-)
00 C EMETAK - COMPRESSOR MOTOR EFFICIENCY IN FRACTION AT FRACTION
00 C OF FULL LOAD SPECIFIED BY E1OPT(K) (-)
00 C EMRPM(L) - COEFFICIENT FOR COMPRESSOR MOTOR RPM CALCULATION (-)

```

      570.      C      ETAPFLY - COMPRESSOR POLYTROPIC EFFICIENCY (-)
      580.      C      GAMMA - REFRIG. AVE. SPECIFIC HEAT RATIO AT COMPRESSION (-)
      590.      C      RPM - COMPRESSOR MOTOR RPM (1/MIN)
      600.      C      V5 - REFRIG. SPECIFIC VOLUME AT SUCTION (FT**3/LBM)
      610.      C      WM - REFRIG. MOLECULAR WEIGHT (G/MOL)
      620.      C      X11 - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)

      630.      C      C***** SUBPROGRAMS CALLED BY COMPAR:
      640.      C      DEWTEM, ENTROP, HCVCP, HPIN, SPIN, VISCON, VOLITI
      650.      C
      660.      C
      670.      C***** NOTE: NUMBERS AT DIFFERENT SYMBOLS INDICATING LOCATION USED IN THIS SUBROUTINE
      680.      C***** CORRESPOND TO NUMBERS GREATER BY 1 USED IN MAIN PROGRAM & PROGRAM DOCUMENTATION
      690.      C
      700.      C      COMMON/RDATA2/W1,W2,TC1,TC2
      710.      C      COMMON/RDATA3/XV,XM,VM
      720.      C      COMMON/COND3/P2,T2,H2,XQ2
      730.      C      COMMON/COND47/P3,T3,H3,XQ3,P1,T4,H4,XQ4,S4,P5,T5,H5,XQ5,
      740.      C      @ P6,T6,H6,XQ6
      750.      C      COMMON/COND8/P7,T7,H7,XQ7
      760.      C      COMMON/COND9/P8,T8,H8,XQ8
      770.      C      COMMON/CCMP/CPC23,CQC3C,CQC3A,CPC3A,
      780.      C      & EMETA(11),EMOPT(11),EMPI(6),ELETPU,SWPVOL,
      790.      C      & ETAPLY,CLREFF,CPC56,CQC56,CPC67,CQC67
      800.      C      DATA N0,N1,N3,N5/0,1,3,5/
      810.      C
      820.      C
      830.      C      5 CONTINUE
      840.      C      WRITE(6,290)
      850.      C      READ(5,777)XW
      860.      C      XM=1.-XW
      870.      C      XM=XW/(W2/W1*(1.-XW)+XW)
      880.      C      WM=W1*(1.-XM)+W2*XM
      890.      C      WRITE(6,300)
      900.      C      READ(5,295)ILONG
      910.      C      IF(ILONG.EQ.1)GOTO 20
      920.      C      INPUT SHORT FORM COMPRESSOR DATA
      930.      C      WRITE(6,301)
      940.      C      READ(5,777)ELEFUL,ELEIPT,RPMCP,SWPVOL,RMASS,TOA
      950.      C
      960.      C      EBTUI=3414.*ELEIPT
      970.      C      EBTUF=3414.*ELEFUL
      980.      C      WRITE(6,302)
      990.      C      READ(5,777)T2,P2
      1000.     C      WRITE(6,303)
      1000.     C      READ(5,777)T7,P7
      1010.     C
      1020.     C      TK2=(T2+459.67)/1.8          @POINT 2
      1030.     C      PA2=P2/14.6959
      1040.     C      CALL VOLIT1(N1,TK2,PA2,XM,VM2)
      1050.     C      CALL HCVCP(N1,TK2,V12,XM,I12,CP2,CV2)
      1050.     C
      1070.     C      TK7=(T7+459.67)/1.8          @POINT 7
      1070.     C      PA7=P7/14.6959
      1080.     C      CALL VOLIT1(N1,TK7,PA7,XM,VM7)
      1090.     C      CALL HCVCP(N3,TK7,V117,XM,H7,CP7,CV7)
      1100.     C      V7=VM7*16.01346/VM
      1110.     C      QCAN=ETATUI-RMASS*(H7-H2)
      1120.     C      T6=T7+20.
      1130.     C      P6=P7+1.
      1140.     C      TK6=(T6+459.67)/1.8          @POINT 6

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***** COMPAR *****

DATE 07/18/84

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1150.    00      PA5=P6/14 6.959
1160.    00      CALL VOLIT1(N1, TK6, FA5, XM1, VM5)
1170.    00      CALL HCVCP(N3, TK6, VM6, XM1 H6, CV6, CP6)
1180.    00      VG=VM6*16.01816/M
1190.    00      P5=PG+20.
1200.    00      H5=H6+0.2*(H6-H7)      ER01NT 5
1210.    00      TK5=TK6
1220.    00      PA5=P5/14.6959
1230.    00      ACC=0.001
1240.    00      CAL_ HPIN(N1, H5, PA5, XM, ACC, TK5, XM5, XL, XV, VI_, VM5)
1250.    00      T5=TK5*1.8-459.67
1260.    00      S5=ENTROP(TK5, VM5, XM)
1270.    00      CALL HCVCP(N5, TK5, VM5, XM, DUM. CV5, CP5)
1280.    00      GA5=CF5/CV5
1290.    00      GN5=(GA5-1.)/GA5      EPOINTNS 3, 4 & 5
1300.    00      P3=P2-0.1
1310.    00      P4=P3-3.
1320.    00      PA4=P4/14.6959
1330.    00      CALL DEWTEM1(N0, FA4, XM TKD1, XL)
1340.    00      CALL VOLIT1(N1, TKD1, FA4, XM, VD4)
1350.    00      SD4:=ENTROP(TKD4, VD4, XM)
1360.    00      S4=S5+0.1
1370.    00      DS4=0.1
1380.    00      P5P4=P5/P4
1390.    00      P4P5=P4/P5
1400.    00      INT=5
1410.    00      JNT=1
1420.    00      EMFFRN=ELEIPT/ELEFUL
1430.    00      DO 16 I=1, INT
1440.    00      DO 12 J=1, JNT
1450.    00      S4=S4-DS4
1460.    00      IF (S4.GT. SD4) GOTO 10
1470.    00      INT=INT+1
1480.    00      JNT=2*JNT-1
1490.    00      S4=S4+DS4
1500.    00      DS4=0.5*DS4
1510.    00      GOTO 16
1520.    00      CONTINUE
1530.    00      TK4=TK5*P4P5**GG5
1540.    00      IF (TK4.LT. TKD4; TK4=TKD4+0.01
1550.    00      ACC=0.00001
1560.    00      CALL SF1(N1, S4, FA4, XM, ACC, TK4, VM4)
1570.    00      CALL HCVCP(N3, TK4, VM4, XM, FA4, CV4, CP4)
1580.    00      GA1=CGA-1.)/CGA
1590.    00      GN=CG '0.76
1600.    00      ACC=0.001
1610.    00      CALL SF1(N1, S4, PA5, XM, ACC, TK5S, VM5S)
1620.    00      CALL HCVCP(N3, TK5S, VM5S, XM, HE5S, CV5S, CP5S)
1630.    00      GA5S=CG5S/CV5S
1640.    00      GG=0.5*(GA1+GA5S)
1650.    00      CGA=(CGA-1.)/CGA
1660.    00      GN=CG '0.76
1670.    00      CETA=(P5F 1**GG-1.)/(0.76*(P5P4**GN-1.))
1680.    00      H35=1.4+(1.155-H4)/CETA
1690.    00      IF (H455.LE.H5) GOTO 14
1700.    00      CONTINUE
1710.    00      IF (L.EQ.5) GOTO 16
1720.    00      S4=S4+DS4

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***** COMPAR *****

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1730.      00      16 DS4=0. 1*DS4
1740.      00      CONTINUE
1750.      00      CBTUI = RMASS*(I:5-H4)
1760.      00      H3=H2+(H6-H7)*(EBTUI-CBTUI-QCAH)/RMASS
1770.      00      TK3=TK4
1780.      00      PA3=PA3/14. 6959
1790.      00      ACC=0.001
1800.      00      CALL I:PIN(M1,H3,FA3,XM,ACC,TK3,XQ,XL,XV,VL,VM3)
1810.      00      V3=VM3*16.01846/WM
1820.      00      T3=TK3*1.8-459.67
1830.      00      CALL HCVCVP(N5,TK3,V13,XM,DUM,CV3,CP3)
1840.      00      TCAN=(TOA+2.*T3)/3.
1850.      00      T4=TK4*1.8-459.67
1860.      00      GOTO 22
1870.      00      C**** ENTER LONG FORM COMPRESSOR DATA
1880.      00      20 WRITE(6,304)
1890.      00      READ(5,777)ELEFUL,ELEIPT,RMCP,SWPVAL,RMASS,TCAN,TOA
1900.      00      I=2
1910.      00      20 WRITE(6,305)
1920.      00      WRITE(6,306)I
1930.      00      READ(5,777)T2,P2
1940.      00      I=I+1
1950.      00      WRITE(6,306)I
1960.      00      READ(5,777)T3,P3
1970.      00      I=I+1
1980.      00      WRITE(6,306)I
1990.      00      READ(5,777)T4,P4
2000.      00      I=I+1
2010.      00      WRITE(6,306)I
2020.      00      READ(5,777)T5,P5
2030.      00      I=I+1
2040.      00      WRITE(6,306)I
2050.      00      READ(5,777)T6,P6
2060.      00      I=I+1
2070.      00      WRITE(6,306)I
2080.      00      READ(5,777)T7,P7
2090.      00      C**** CALCULATE REFRIGERANT STATE
2100.      00      TK2=(T2+459.67)/1.8
2110.      00      TK3=(T3+459.67)/1.8
2120.      00      TK4=(T4+459.67)/1.8
2130.      00      TK5=(T5+459.67)/1.8
2140.      00      TK6=(T6+459.67)/1.8
2150.      00      TK7=(T7+459.67)/1.8
2160.      00      PA2=P2/14.6959
2170.      00      PA3=PA3/14.6959
2180.      00      PA4=PA4/14.6959
2190.      00      PA5=PA5/14.6959
2200.      00      PA6=PA6/14.6959
2210.      00      PA7=P7/14.6959
2220.      00      CALL VOLIT1(N1,TK2,PA2,XM,VM2)
2230.      00      CALL VOLIT1(N1,TK3,PA3,XM,VM3)
2240.      00      CALL VOLIT1(N1,TK4,PA4,XM,VM4)
2250.      00      CALL VOLIT1(N1,TK5,PA5,XM,VM5)
2260.      00      CALL VOLIT1(N1,TK6,PA6,XM,VM6)
2270.      00      CALL VOLIT1(N1,TK7,PA7,XM,VM7)
2280.      00      CALL HCVCVP(N3,TK2,VM2,XM,H2,CV2,CP2)
2290.      00      CALL HCVCVP(N3,TK3,V13,XM,H3,CV3,CP3)
2300.      00

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***** COMPAR *****

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2310.      00      CALL  HCVCPL(N3,TK4,V14,XM,H4,CV4,CP4)
2320.      00      CALL  HCVCPL(N3,TK5,V15,XM,H5,CV5,CP5)
2330.      00      CALL  HCVCPL(N3,TK6,V16,XM,H6,CV6,CP6)
2340.      00      CALL  HCVCPL(N3,TK7,V17,XM,H7,CV7,CP7)
2350.      00      S4=ENTROP(TK4,V14,XM)
2360.      00      S5=ENTROP(TK5,V15,XM)
C***** CALCULATE COMPRESSOR PERFORMANCE PARAMETERS
2380.      00      S2=ENTROP(TK2,V12,XM)
2390.      00      S3=ENTROP(TK3,V13,XM)
2400.      00      S4=ENTROP(TK6,V16,XM)
2410.      00      S7=ENTROP(TK7,V17,X1)
2420.      00      S1'PV=SMPVCL/1728.
2430.      00      GA4=CP4/CV4
2440.      00      GA5=CP5/CV5
2450.      00      GA=0.5*(GA1+GA5)
2460.      00      DUM=(GA-1)/GA
2470.      00      TK5S=TK4*P5P4**DUM
2480.      00      S5S=S4
2490.      00      ACC=0.00001
2500.      00      CALL SPIN(N1,S5S,PAS,XM,ACC,TK5S,VM5S)
2510.      00      T5S=TK5*1.8-459.67
2520.      00      CALL HCVCPL(N3,TK5S,VM5S,X1,H55,CV55,CP55)
2530.      00      GA5S=CP5S/CV5S
2540.      00      AM2=VISCON(3,T2,XW)          @VISCOSEITY
2550.      00      AM3=VISCON(3,T3,XW)
2560.      00      AM4=VISCON(3,T4,XW)
2570.      00      AM5=VISCON(3,T5,XW)
2580.      00      AM6=VISCON(3,T6,XW)
2590.      00      AM7=VISCON(3,T7,XW)          @CONDUCTIVITY
2600.      00      AK2=VISCON(4,T2,XW)
2610.      00      AK3=VISCON(4,T3,XW)
2620.      00      AK4=VISCON(4,T4,XW)
2630.      00      AK5=VISCON(4,T5,XW)
2640.      00      AK6=VISCON(4,T6,XW)
2650.      00      AK7=VISCON(4,T7,XW)
2660.      00      WRITE(6,310)
2670.      00      WRITE(6,297)T2,P2,H2,S2
2680.      00      WRITE(6,297)T3,P3,H3,S3
2690.      00      WRITE(6,297)T4,P4,H4,S4
2700.      00      WRITE(6,297)T5,P5,H5,S5
2710.      00      WRITE(6,297)T5S,P5,H5S,S5S
2720.      00      WRITE(6,297)T6,P6,H6,S6
2730.      00      WRITE(6,297)T7,P7,H7,S7
EMFRN=ELEIPT/ELEIPT
2740.      00      EBTUI=3414.*ELEIPT
2750.      00      EBTUF=3414.*ELEIPT
C***** DETERMINE CAN HEAT LOSS COEFFICIENTS C0C3C AND C0CC0A
2770.      00      QCAN=EBTUI-RMASS*(H7-H2)
2780.      00      C0C3A=QCAN/(TCAN-TOA)*1.333
2790.      00      C0C3C=QCAN*AM3**0.467/(RMASS*0.6*CP3**0.323*H3*0.667*
8 *(T3-TCAN))
2800.      00      V3=VM3*16.01816/WM
2820.      00      CPC23=1./(V3*RMASS**2)
2830.      00      CPC25=(P2-P3)*CPC23
C***** DETERMINE SUCION VOLUME HEAT TRANSFER COEFFICIENT
2840.      00      QSUCV=RMASC*(H4-H3)
2860.      00      T34=0.5*(T3+TA)
2870.      00      AM34=0.5*(AM3+AM4)
2880.      00

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***** COMPAR *****

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2890.      00 CP34=0.5*(CP3+CP4)
2900.      00 AK34=0.5*(AK3+AK4)
2910.      00 CQC34=A1/34**0.467/(RMASS**0.8*CP34**0.333
2920.      00 & *AK34**0.667*(T5-T3))
2930.      00 CQC34=QSUCL*CQC34
2940.      00 V4=VM4*.6.01846/WM
2950.      00 CPC34=1./(V4*RMASS**2)
2960.      00 CPC34=(P3-P4)*CPC34
2970.      00 C***** DETERMINE COMPRESSION AND MOTOR COEFFICIENTS
2980.      00 RPMEM=0.
2990.      00 ETAEM=0.
3000.      00 EMFFF=RMASS*(H5-H4)/(0.96*FBTUF)
3010.      00 DO 23 I=1,6
3020.      00 J=1-1
3030.      00 AA=EMFFF**J
3040.      00 RPMEM=RPMEM+AA*EMRPM(1)
3050.      00 23 CONTINUE
3060.      00 J=12
3070.      00 DO 25 I=1,11
3080.      00 J=J-1
3090.      00 IF (EMFFF.LE.EMOPT(J)) GOTO 24
3100.      00 ETAEM=EMETA(J)+(EMETA(J+1)-EMETA(J))*(EMFFF-EMOPT(J))
3110.      00 & /EMOPT(J+1)-EMOPT(J)
3120.      00 GOTO 28
3130.      00 24 IF (I.NE.11) GOTO 25
3140.      00 ETAEM=EMFFF*EMETA(J)/EMOPT(J)
3150.      00 25 CONTINUE
3160.      00 28 CONTINUE
3170.      00 RPMRT=1.
3180.      00 IF (RPMCP.GE.100.) RPMRT=RPMCP/RPMEM
3190.      00 CPOPT=RMASS*(H5-H4)
3200.      00 CP1PT=CPOPT/0.96
3210.      00 ETART=CP1PT
3220.      00 ETART=ETART/(ETAEM*FBTUI)
3230.      00 DO 30 I=1,11
3240.      00 IF (I.GT.6) GOTO 30
3250.      00 CMRPM(1)=RPMRT*EMRPM(1)
3260.      00 EMETA(1)=ETART*EMETA(1)
3270.      00 CETA=(H5S-H4)/(H5-H4)
3280.      00 ETAFLY=1.1
3290.      00 DE=0.1
3300.      00 P5P4=P5/P4
3310.      00 GGA=0.5*(GA4+GA5$)
3320.      00 GG=(GGA-1.)/GGA
3330.      00 P5P4=P5P4*GG
3340.      00 DO 36 I=1,3
3350.      00 DO 32 J=1,11
3360.      00 POLY=1./ETAPLY
3370.      00 CC=(P5P4-1.)/(ETAPLY*(P5P4**POLY-1.))
3380.      00 32 ETAPLY=ETAPLY-DE
3390.      00 34 IF (CC.LE.CETA) GOTO 38
3410.      00 ETAPLY=FTAPLY+DE
3420.      00 DE=0.1*DE
3430.      00 36 CONTINUE
3440.      00 38 CONTINUE
3450.      00 CRPM=0.
3460.      00 DO 40 I=1,6

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***** COMPAR *****

DATE 072184

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3470.    00
3480.    00
3490.    00
3500.    00
3510.    00
3520.    00
3530.    00
3540.    00
3550.    00
3560.    00
3570.    00
3580.    00
3590.    00
3600.    00
3610.    00
3620.    00
3630.    00
3640.    00
3650.    00
3660.    00
3670.    00
3680.    00
3690.    00
3700.    00
3710.    00
3720.    00
3730.    00
3740.    00
3750.    00
3760.    00
3770.    00
3780.    00
3790.    00
3800.    00
3810.    00
3820.    00
3830.    00
3840.    00
3850.    00
3860.    00
3870.    00
3880.    00
3890.    00
3900.    00
3910.    00
3920.    00
3930.    00
3940.    00
3950.    00
3960.    00
3970.    00
3980.    00
3990.    00
4000.    00
4010.    00
4020.    00
4030.    00
4040.    00

      J=I-1
      AA=EM1FF**J
      40  CRFM=CRPM+AA*EMRFM(1)
      TVOL=60.*CRM*SMFV
      AVOL=RMASS*VA
      VET=AVOL/TVOL
      AN=ETAPLY*CGA
      AN=AN/(1.+AN-GGA)
      ANR=1./AN

      CLREFF=1.-1.0417*VETA
      CLREFF=CLREFF/((P5/P4)**ANR-1.)
      WRITE(6,323)
      WRITE(6,297)(EMETA(I),I=1,5)
      WRITE(6,297)(EMETA(I),I=6,11)
      WRITE(6,324)
      WRITE(6,297)(EMRFM(I),I=1,6)
      WRITE(6,325)
      WRITE(6,297)ELEFUL,SWPVOL,ETAPLY,CLREFF
      WRITE(6,307)
      WRITE(6,297)CRFM,ETACM,VETA,VA,GCA,SMFV
      DETERMINE DISCHARGE VA,VIF HEAT TRANSFER & PRESSURE COEFFICIENT
      QDISV=RMASS*(H5-H6)
      IF(QDISV.LE.0.0)QDISV=0.
      T56=0.5*(T5+T6)
      AM56=0.5*(AM5+AM6)
      AK56=0.5*(AK5+AK6)
      CP56=0.5*(CP5+CP6)
      CNC56=AM56**0.467/(RMASS**0.8*CP56**0.333*AK56**0.667*
      E.(T5-T4))
      CAC56=CAC56*QDISV
      V6=VM6*16.01846/WM
      CFC56=1./(V6*RMASS**2)
      CPC56=CPC56*(F5-F6)
      DETERMINE DISCHARGE LINE HEAT TRANSFER COEFFICIENT
      AM67=0.5*(AM6+AM7)
      AK67=0.5*(AK6+AK7)
      CP67=0.5*(CP6+CP7)
      DD1=AM67**0.467*CP3**0.233*AK2**0.667
      DD2=1.5*AN13**0.167*CP67**0.353*AK67**0.667
      QDISC=RMASS*(H6-H7)
      IF(QDISC.LE.0.01)GOTO 42
      ALONG=(T7-T6)/ALONG((T7-T3)/(T6-T3))
      CAC67=QDISC*(DD1+DD2)/(ALONG*(T7-T3))
      CAC67=CAC67/((CP3*CP67)**0.333*(AK3**0.8)
      GOTO 44
      42  CAC67=0.
      V7=VM7*16.01846/WM
      44  CPC67=1./(0.5*(V6,V7)*RMASS**1.0*AM(G7**0.2)
      CPC67=CPC67*(P6-P7)
      WRITE(6,327)
      WRITE(6,297)CFC23,CPC34,CFC53,CPC57
      WRITE(6,326)
      WRITE(6,297)CAC34,CACCOA,CAC31,CAC56,CAC67
      WRITE(6,320)
      READ(5,777)ICON
      IF(ICON.NE.999)GOTO 5
      C 290 FORMAT(/' WEIGHT COMPOSITION OF MIXTURE IN FRACTION '
```

***** COMPAR *****

```

4050.    00      @ / * OF MORE VOLATILE COMPONENT, XW= ' '
4060.    00      295 FORMAT(110)
4070.    00      297 FORMAT(6(1PE11.3))
4080.    00      298 FORMAT(4(1PE11.3),2X,'ISENTROPIC 6')
4090.    00      300 FORMAT(//2X,'DETERMINING CTRNSOR PERFORMANCE PARAMETERS'//
4100.    00      & 2X,'ENTER: ILONG EQUAL TO OR 1 FOR SHORT OR LONG TEST DATA=')
4110.    00      301 FORMAT(/2X,'ENTER:ELEFLU, ELEIPT, RVMCP, SURVOL, RMASS, TOA= ')
4120.    00      302 FORMAT(/2X,'ENTER:T3, P3=?')
4130.    00      303 FORMAT(/2X,'ENTER:T8,P3=?')
4140.    00      304 FORMAT(/2X,'ENTER:ELEFLU, ELEIPT, RPMCP, SWFVOL, RMASS, TOA: '
4150.    00      & /)
4160.    00      305 FORMAT(/2X,'ENTER T AND P AT DIFFERENT STATIONS: ')
4170.    00      306 FORMAT(2X,'STATION' 12 ':')
4180.    00      307 FORMAT(/2X,'R11' ,8X,'EFFYM' ,6X,'EFFYV' ,6X,'V5' ,
4190.    00      & 9X,'GAMMA' ,6X,'SWPV' )
4200.    00      310 FORMAT(/2X,'T' ,10X,'P' ,10X,'H' ,10X,'S' )
4210.    00      323 FORMAT(/2X,'EMRTA(11):')
4220.    00      324 FORMAT(/2X,'EMRPM(6):')
4230.    00      325 FORMAT(/2X,'ELEFLU' ,5X,'SMPVOL' ,5X,'ETAPFLY' ,5X,'CLREFF' )
4240.    00      327 FORMAT(/2X,'CPC34' ,6X,'CPC45' ,6X,'CPC67' ,5X,'CPC78')
4250.    00      326 FORMAT(/2X,'CCAC4C' ,6X,'CCAC5' ,5X,'CCAC67' ,6X,'CCAC78')
4260.    00      330 FORMAT(/' PUT ICON=999 TO STOP, ICON=?')
4270.    00      777 FORMAT(  )
4280.    00      RETURN
4290.    00      END

END ELT.  ERRORS: NONE.  TIME: 0.518 SEC. IMAGE COUNT: 429
@HDG, P ***** COMPRE ***** .L,0

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***** COMPRE *****

DATE 072184

©ELT,L DD.COMPRE
ELT 8R1 S74Q1C 07/21/84 15:54:58 (0)
10. 00 SUBROUTINE COMPRESSOR(NSYS,TCS,TRA,TA,EI,RISSA)

```

C
C
C*** SIMULATION OF A HERMETIC COMPRESSOR
C WORKING WITH A NON-IDEOTROPIC MIXTURE
C
C*** CALCULATIONS PERFORMED BY THIS PROGRAM INCLUDE SIMULATION
C OF HERMETIC COMPRESSOR, FLOW THROUGH 4-WAY VALVE AND TUBING
C CONNECTING COMPRESSOR WITH BOTH HEAT EXCHANGERS.
C
C*** INPUT DATA:
C     CLREFF   - CLEARENCE OF VOLUME AS FRACTION OF STROKE VOLUME      (-)
C     CPC23    - PRESSURE DROP PARAMETER AT COMPRESSOR CAN INLET
C                 (LBF*H**2/LB11IN**2*FT**2 .8)
C     CPC34    - PRESSURE DROP PARAMETER AT COMPRESSOR SUCTION VALVE
C                 (LBF*H**2/LB11IN**2*FT**3)
C     CPC56    - PRESSURE DROP PARAMETER AT COMPRESSOR DELIVERY VALVE
C                 (LBF*H**2/LFM*IN**2*FT**3)
C     CPC67    - PRESSURE DROP PARAMETER AT COMPRESSOR CAN EXIT
C                 (LBF*H**2/LN1*IN**2*FT**3)          (BTU/H*F**1.333)
C
C     CCCOCA   - PARAMETER FOR CAN WALL-AMBIENT AIR HEAT TRANSFER
C     CC23C    - PARAMETER FOR REFRIG. VAPOR-CAN WALL HEAT TRANSFER      (FT**.2)
C     CQC34    - SUCTION VALVE HEAT TRANSFER PARAMETER (FT**.2)
C     CQC56    - DELIVERY VALVE HEAT TRANSFER PARAMETER (FT**.2)
C     CQC67    - CAN EXIT HEAT TRANSFER PARAMETER (FT**.2)
C
C     ELEFTUL  - COMPRESSOR MOTOR ENERGY INPUT RATE AT FULL LOAD (KW)
C     EMETAK   - COMPRESSOR MOTOR EFFICIENCY IN FRACTION AT FRACTION
C                 OF FULL LOAD SPECIFIED BY EP(PT(K))      (-)
C     EMOPT(L) - COMPRESSOR MOTOR FULL LOAD FRACTION      (-)
C     EMRPM(M) - COEFFICIENT FOR COMPRESSOR MOTOR RPM CALCULATION (-)
C     ETAPPLY  - COMPRESSOR POLYTROPIC EFFICIENCY      (-)
C
C     H2        - REFRIG. ENTHALPY AT COMPRESSOR CAN INLET (BTU/LBM)
C     NSYS     = 1 FOR HEATING OPERATION (-)
C             = 2 FOR COOLING OPERATION (-)
C
C     P2        - REFRIG. PRESSURE AT COMPRESSOR CAN INLET (PSIA)
C     RD        - INNER DIAMETER COMPRESSOR-INDOOR COIL TUBING (FT)
C     RD1      - OUTER DIAMETER COMPRESSOR-INDOOR COIL TUBING (FT)
C     RD2      - OUTER DIAMETER OF COMPRESSOR-INDOOR COIL TUBING
C                 INSULATION (FT)
C
C     RK1      - THERMAL CONDUCTIVITY OF COMPRESSOR-INDOOR COIL TUBING
C                 MATERIAL (BTU/FT**H)
C     RK2      - THERMAL CONDUCTIVITY OF COMPRESSOR-INDOOR COIL TUBING
C                 INSULATION (BTU/FT**H)
C
C     RL        - LENGTH OF COMPRESSOR-INDOOR COIL TUBING (FT)
C     SWPVOL  - COMPRESSOR SWEEP VOLUME PER REVOLUTION (IN**3)
C     TA        - OUTDOOR AIR TEMPERATURE (F)
C
C     TG5      - REFrig. SAT. TEMP. AT COMPRESSOR DELIVERY VALVE (F)
C     TRA      - INDOOR AIR TEMPERATURE (F)
C
C     YD       - INNER DIAMETER COMPRESSOR-OUTDOOR COIL TUBING (FT)
C     YD1      - OUTER DIAMETER COMPRESSOR-OUTDOOR COIL TUBING (FT)
C     YD2      - OUTER DIAMETER OF COMPRESSOR-OUTDOOR COIL TUBING
C
C     YK1      - THERMAL CONDUCTIVITY OF COMPRESSOR-OUTDOOR COIL TUBING
C                 MATERIAL (BTU/FT**H)
C     YK2      - THERMAL CONDUCTIVITY OF COMPRESSOR-OUTDOOR COIL TUBING
C                 INSULATION (BTU/FT**H)

```

570. 00 C **** COMPRE *****

580. 00 C **** YL - LENGTH OF COMPRESSOR-OUTDOOR COIL TUBING (FT)

590. 00 C **** OUTPUT DATA:

600. 00 C CPM - COMPRESSOR MOTOR RHM (1./MIN) (KW)

610. 00 C EI - COMPRESSOR ENERGY CONSUMPTION RATE (KW)

620. 00 C ETAC - COMPRESSION EFFICIENCY (-)

630. 00 C ETAE - ELECTRIC MOTOR EFFICIENCY (-)

640. 00 C ETAV - VOLUMETRIC EFFICIENCY (-)

650. 00 C RMASS - REFRIG. MASS FLOW RATE (LBM/H)

660. 00 C REFREG. THERMODYNAMIC STATE AT KEY LOCATIONS:

670. 00 C H0, P0, T0, XQ0 - AT LOW PRESSURE VAPOR LINE INLET

680. 00 C H1, F1, T1, XQ1 - AT LOW PRESSURE A-WAY VALVE INLET

690. 00 C H2, P2, T2, XQ2 - AT LOW PRESSURE A-WAY VALVE OUTLET

700. 00 C H3, P3, T3, XQ3 - AT SUCTION VALVE

710. 00 C H4, P4, T4, XQ4, S4 - AT PISTON BEFORE COMPRESSION

720. 00 C H5, P5, T5, XQ5 - AT PISTON AFTER COMPRESSION

730. 00 C H6, P6, T6, XQ6 - PAST DELIVERY VALVE

740. 00 C H7, P7, T7, XQ7 - AT COMPRESSOR CAN EXIT

750. 00 C H8, P8, T8, XQ8 - AT HIGH PRESSURE A-WAY VALVE INLET

760. 00 C H9, P9, T9, XQ9 - HIGH PRESSURE VAFOF LINE OUTLET

770. 00 C WHERE NUMBERS IN ABOVE SYMBOLS STAY FOR LOCATION AND LETTERS DENOTE:

780. 00 C H - REFRIG. ENTHALPY (BTU/I LB)

790. 00 C P - REFRIG. PRESSURE (PSIA)

800. 00 C S - REFRIG. ENTROPY (PTU/I LB1* F)

810. 00 C XQ - REFRIG. QUALITY (-)

820. 00 C **** SUBROUTINE'S CALLED BY COMPRE:

830. 00 C DEUPRE, ENTROP, HCVCVP, HPIN, HPPROP, MWALA, PIPE, SPIN, VISCON

840. 00 C

850. 00 C **** NOTE: NUMBERS AT DIFFERENT SYMBOLS INDICATING LOCATION

860. 00 C USED IN THIS SUBROUTINE CORRESPOND TO NUMBERS GREATER BY 1

870. 00 C USED IN THE MAIN PROGRAM MAIN AND PROGRAM DOCUMENTATION

880. 00 C

890. 00 C

900. 00 C

910. 00 C

920. 00 C

930. 00 C COMMON/COND10/F9, T9, H9, XQ9

940. 00 C COMMON/COND1/PO, T0, H0, XQ0

950. 00 C COMMON/COND2/P1, T1, H1, XQ1

960. 00 C COMMON/COND2/F2, T2, H2, XQ2

970. 00 C COMMON/CCND47/P3, T3, H3, XQ3, P4, T4, H4, XQ4, S4, P5, T5, H5, XQ5,

980. 00 C & PG, T6, H6, XQ6

990. 00 C COMMON/COND8/P7, T7, H7, XQ7

1000. 00 C COMMON/COND9/P8, T8, H8, XQ8

1010. 00 C COMMON/CCMP/CPC23, CACCM, CPC24, EMETA(11), EMOPT(11),

1020. 00 C & EMOPM(6), ELEFUL, SWPFL, ETAPIY, CLREFF, CPC55, CPC67, CQC67

1030. 00 C COMMON/RLINE/RL, RD, RK1, RD1, RK2, RD2

1040. 00 C COMMON/YLINE/YL, YD, YK1, YD1, YK2, YD2

1050. 00 C DATA NO, N1, N2, N4, N5/0, 1, 3, 4, 5,/

1060. 00 C DATA XQ5, XQ6, XQ7, XQ8/4*1./

1070. 00 C

1080. 00 C PA2=F2/14.6959

1090. 00 C ACC=0.0005

1100. 00 C CALL HPRROP(NO, H2, PA2, XM, ACC, TK2, XQ2, XM2, X1V2, VML2, VMV2,

1110. 00 C @ VM2, V2, CP2, CV2, AM2, AK2)

1120. 00 C T2=TK2*1.8~459.67

1130. 00 C WRITE(6,200)P2, T2, H2, XQ2, TG5, TRA, TA

1140. 00 C **** PRELIMINARY CALCULATIONS

1150. 00 C

***** COMPRE *****

DATE 07/21/84

```

BTUFQ=3413.*ELE7UL
SWPV=SWPyCIL/1728.
P4=R2-2.
H4=H2+9.
TK4=TK2
TGK5=(TG5+459.67)/1.8
CAL.DENPRE(M0,TGK5,XM1,PA5,XL)
P5=PA5*14.6959
SLOPE=0.

C***** ITERATE THREE-DYNAMIC STATE OF REFRIGERANT
C***** WITHIN COMPRESSOR CAN
C***** START ENTHALPY LOOP
DO 50 MH=1,15
ROB=0.

C**** START PRESSURE LOOP
DO 50 MP=1,10
PA4=PA4/14.6959

CC
ACC=0.0005
CALL HPPROP(N1,H4,PA4,XM,ACC,TK1,XG1,XML4,VML4,VML4,
@ VM4,VA,CP4,CV4,AM4,AK4)
T4=TK4*1.8-459.67
GA4=CP4/CV4
IF(XQ4.LT.1.) THEN
S4=(1.-XQ4)*ENTROP(TK4,VML4,XML4)
S4=S4+XG4*ENTROP(TK4,VML4,XML4)
ELSE
S4=ENTROP(TK4,VM4,XM)
END IF
C**** CALCULATE POINT 5
F5=P5/P4
T5S=(T4+460)*P5P4**0.15-460.
ACC=0.00002
CALL SPIN(N1,S4,PA5,XM,ACC,TK5S,VMS)
CALL HCVRP(N3,TK5S,VM5S,XI1,H5S,CV5S,CP5S)
GA5S=CP5S/CV5S
GA45=5*(GA4+GA5S)
GA45=(GA45-1.)/GA45
fNA45=-(GA45-1.)/ETAPLY
AN=(1.+ETAPLY*GA45-GA45)/(ETAPLY*GA45)
ETAV=0.95*(1.-CLREF)*(P5P4*AN-1.)
ETAC=(P5P4*GA45-1.)/(P5P4*AN45-1.)
ETAC=ETAC/ETAPLY
UCPIPT=(H5S-14)/ETAC
H5=H4+UCPIPT
T5=T4+2.*UCPIPT/(CP4+CP5S)
TK5=(T5+459.67)/1.8
ACC=0.0005
CALL HPPROP(N1,H5,PA5,XM,ACC,TK5,XG5,XML,VML,VML,VML,
@ VM5,CP5,CV5,AM5,AK5)
T5=TK5*1.8-459.67
C**** CALCULATE REFRIGERANT MASS FLOW RATE
FCPT=-0.0098
DOPT=0.10
DO 16 IC=1,4
DO 16

```

***** COMPRE *****

```

1760.      00      DO 12 JC=1,11
1770.      00      FOPT=FOPT+DOPT
1780.      00      CI RRM=0.
1790.      00      DO 10 KC=1,6
1800.      00      LC=KC-1
1810.      00      AA=FORT*xLC
1820.      00      10 CPRM=CPRM+AA*EMRIM(KC)
1830.      00      RMASS=CO.*CPRM*ETAV*SPPV/V4
1840.      00      WE=DTUFO*FOPT
1850.      00      WC=0.96*xVE
1860.      00      RMACF=WC/UCP1PT
1870.      00      IF(RM.CP.GE.RMASS)GOTO 14
1880.      00      12 CONTINUE
1890.      00      14 IF(IC EQ 4)GOTO 16
1900.      00      FOPT=FOPT-DOPT
1910.      00      DCPT=0.1*DOPT
1920.      00      16 CONTINUE
1930.      00      RMASS2=RMASS*RMASS
1940.      00      RMASS3=RMASS*x0.8
1950.      00      JJ=12
1960.      00      DO 20 II=1,11
1970.      00      JJ=JJ-1
1980.      00      IF(FORT.LE.ENOPT(JJ))GOTO 18
1990.      00      ETAE=EMETA(JJ)+(EMETA(JJ+1)-EMFTA(JJ))*2
2000.      00      (FOPT-EMOPT(JJ))/(EMOPT(JJ+1)-EMCPT(JJ))
2010.      00      GOTO 22
2020.      00      18 IF(II.NE.11)GOTO 20
2030.      00      ETAE=FOPT*EMETA(JJ)/EMOPT(JJ)
2040.      00      20 CONTINUE
2050.      00      EI=WC/(0.96*ETAE)
2060.      00      IF((IP.GT.1.OR.MH.GT.1))GOTO 24
2070.      00      C*** C\LCULATE POINTS 3,6,7
2080.      00      T3=T4
2090.      00      P3=P4
2100.      00      V3=V4
2110.      00      VM3=VMA
2120.      00      AM3=AM2
2130.      00      AK3=AK2
2140.      00      CP3=CP2
2150.      00      T6=T5
2160.      00      P6=P5
2170.      00      V6=V5
2180.      00      VM6=VM5
2190.      00      AM6=AM5
2200.      00      AK6=AK5
2210.      00      CP6=CP5
2220.      00      T7=T5
2230.      00      P7=P5
2240.      00      V7=V5
2250.      00      VM7=VM5
2260.      00      AM7=AM5
2270.      00      AK7=AK5
2280.      00      CF7=CP5
2290.      00      24 CONTINUE
2300.      00      DO 40 K=1,12
2310.      00      IF(CK.EQ.1)GOTO 26
2320.      00      AM3=VISCON(N4,T3,XW)
2330.      00      AK3=VISCON(N4,T3,XW)

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***** COMPARE *****

DATE 072184

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2340.      00      C      TK3=(T3+459.67)/1.8
2350.      00      C      CALL HCVCP(H5,TK3,VM3,XM,DM,CV3,CP3)
2360.      00      C      AM6=V1SCON(N3,T6,XW)          @POINT 6
2370.      00      C      AK6=V1SCON(N4,T6,XW)
2380.      00      C      TK6=(T6+159.67)/1.8
2390.      00      C      CALL HCVCP(N5,TK6,VM6,XM,DM,CV6,CP6)
2400.      00      C
2410.      00      C      AM7=V1SCON(N3,T7,XW)          @POINT 7
2420.      00      C      AK7=V1SCON(N4,T7,XW)
2430.      00      C
2440.      00      C      TK7=(T7+459.67)/1.8
2450.      00      C      CALL HCVCP(N5,TK7,VM7,XM,DM,CV7,CP7)
2460.      00      C      CP2=1.5*(CP3+CF4)
2470.      00      C      CP56=0.5*(CP5+CP6)
2480.      00      C      CP67=0.5*(CP6+CP7)
2490.      00      C      AM34=C.5*(AMC+AM4)
2500.      00      C      AM56=0.5*(AM5+AM6)
2510.      00      C      AM67=0.5*(AM6+AM7)
2520.      00      C      AK34=0.5*(AK3'AK4)
2530.      00      C      AK56=0.5*(AK5+AK6)
2540.      00      C      AK67=0.5*(AK6'AK7)
2550.      00      C      V67=0.5*(V6+V7)
2560.      00      C      QM3=E1-NC
2570.      00      C      Q34=CQC34*RMASS*CP34**0.333*AK34**0.667
2580.      00      C      & *(T5-T3)/(AM34*0.467)
2590.      00      C      Q56=CQC56*RMAS56*CP56**0.333*AK56**0.667
2600.      00      C      & *(T6-T4)/(AM56*0.447)
2610.      00      C      Q67=RMASS8*(CP3*CP37)**0.333*(AK3*AK67)**0.667
2620.      00      C      Q67=Q67/(CP3**0.333*AK3**0.667*AM157**0.467+
2630.      00      C      & 1.5*CP67**0.333*AK67**0.667*AM3**0.467)
2640.      00      C      Q67=CQC67*Q67
2650.      00      C      IF(ABS(T6-T7).GT.0.01)GOTO 28
2660.      00      C      T673=0.5*(T6+T7)-T3
2670.      00      C      GOTO 30
2680.      00      C      28 T673=(T6-T7)/ALOG((T6-T3)/(T7-T3))
2690.      00      C      30 Q67=Q67*T673
2700.      00      C      AAX=CQC3C*RMASS8*CP3**0.333*AK3**0.667/AM3**0.467
2710.      00      C      BHX=CQC3COA
2720.      00      C      TC=(4.*T3+TA)/5.
2730.      00      C      SA=1.
2740.      00      C      DO 32 LTR=1,20
2750.      00      C      IF(T3.LT.TC)SA=-1.
2760.      00      C      QG=SAA*AAX*(T3-TC)-BBY*ABS(TC-TA)**1.333
2770.      00      C      DQDT=3AA*(-AAX-1.333*DBX*ABS(TC-TA)**0.333)
2780.      00      C      TCC=TC-QG/DQDT
2790.      00      C      IF(ABS(TCC-TC).LT.0.001)GOTO 34
2800.      00      C      TC=TCC
2810.      00      C      32 CONTINUE
2820.      00      C      34 TC=TCC
2830.      00      C      CCA=anax*(T3-TC)
2840.      00      C      H3=H4-Q34/RMASS
2850.      00      C      H6=H5-Q56/RMASS
2860.      00      C      H7=H5-Q67/RMASS
2870.      00      C      H2A=H7-(E1-Q3A)/RMASS
2880.      00      C      P3=P4+CPC34*V4*RMASS2
2890.      00      C      P2A=P3+CFC23*V3*RMASS2
2900.      00      C      P6=P5-CPC56*V6*RMASS2
2910.      00      C      P7=P6-CPC67*V67*AM67**0.2*RMASS*RMASS8

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LUFRE *****

2920.    00
2930.    00
2940.    00
2950.    00
2960.    00
2970.    00
2980.    00
2990.    00
3000.    00
3010.    00
3040.    00
3050.    00
3060.    00
3070.    00
3080.    00
3090.    00
3100.    00
3110.    00
3120.    00
3130.    00
3140.    00
3150.    00
3160.    00
3190.    00
3200.    00
3210.    00
3220.    00
3221.    00
3222.    00
3230.    00
3240.    00
3250.    00
3260.    00
3270.    00
3280.    00
3290.    00
3300.    00
3310.    00
3320.    00
3330.    00
3340.    00
3350.    00
3360.    00
3370.    00
3380.    00
3390.    00
3400.    00
3420.    00
3430.    00
3440.    00
3450.    00
3460.    00
3470.    00
3480.    00
3490.    00
3500.    00
3510.    00

      CC          ACC=0.001
                  TK3=(T3+459.67)/1.8
                  PA3=F3/14.659
                  CALL HPIN(N1,H3,PA3,XM,AR:C,TK3,XQ3,XL,XV,VL,VM3)
                  T3=TK3*1.8-459.67
                  V3=VM3*16.01846/WM
                  PA6=PA6/4.659
                  TK6=(T6+459.67)/1.8
                  CALL HPIN(N1,H6,PA6,XM,ACC,TK6,XQ,XL,XV,VL,VM6)
                  T6=TK6*1.8-459.67

      C          VG=VM6*16.01845/WM
                  PA7=P7/14.6959
                  TK7=(T7+459.67)/1.8
                  CALL HPIN(N1,H7,PA7,XM,ACC,TK7,XQ,XL,XV,VL,VN7)
                  T7=TK7*1.8-459.67
                  V7=VN7*16.01346/WM
                  IF (K.EQ.1) GOTO 36
                  IF (ADS(H2B-H2A).LT.ACC) AND (ADS(H7B-H7).LT.ACC) GOTO 42
                  H2B=H2A
                  H7B=H7
                  36 CONTINUE
                  WRITE(6,202) H2A, H2B
                  202 FORMAT(' LOOP 4 DID NOT CONVERGE, H2A, H2B= ', 2F8.3)
                  42 CONTINUE
                  H2A=(H2A+H2B)/2.
                  H7=(H7+H7B)/2.
                  P2A=P2+CP2C3*V3*EMASS2
                  ROA=P2-P2A
                  SAA=0.002
                  IF (ABS(H2-H2A).LT.5.) SAA=0.001
                  IF (ABS(ROA).LT.SAA) GOTO 52
                  IF (ADS(ROB).GT.0) GOTO 44
                  IF (SLOPE.NE.0) GOTO 45
                  PAB=P4
                  P4=P4+ROA
                  ROB=ROA
                  GOTO 50
                  44 SLOPE=(P4B-P4)/(ROB-ROA)
                  IF (ABS(ROB).LT.ABS(ROA)) GOTO 46
                  PAB=PI
                  P4=P4-ROB*SLOPE
                  46 CONTINUE
                  50 ROB=ROA
                  45 PAB=PI
                  46 P4=P4-ROB*SLOPE
                  50 CONTINUE
                  44 END OF PRESSURE ! QOP
                  WRITE(6,204)
                  C*****END OF PRESSURE ! QOP
                  C*****52 CONTINUE
                  FMA=H2-H2A
                  IF (ABS(RMA).LT.0.005) GOTO 62
                  IF (MH.GT.1) GOTO 54
                  PAY=P4
                  P4=P4+0.1

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3520.    00 H4B=H4
        00 H4=H4+2.
3530.    00 IF (RHA.LT.0.0) H4=H4-4.
        00 IF (RHA.LT.0.0) P4=P4-0.2
        00 RHB=RHA
      GOTO 60
3540.    00
3550.    00
3560.    00
3570.    00
3580.    00 SLOPH=(H4B-H4)/(RHB-RHA)
        00 SLOP=(P4Y-P4)/(RHB-RHA)
        00 IF (ABS(RHB).LT.AES(RHA)) GOTO 56
        00 RHB=RHA
        00 H4B=H4
3620.    00 P4Y=P4
        00 H4=H4B-RHB*SLOPH
        00 P4=P4Y-RHB*SLOPP
      60 CONTINUE
3670.    00 WRITE(6,206)RHA
        00 C**** END OF ENTHALPY LOOP
3680.    00
3690.    00 C**** END OF ITERATION PROCESS
3700.    00 C**** END OF COMPRESSOR CAN
3710.    00 C**** REFRIG. STATE INSIDE COMPRESSOR CAN
3720.    00 C**** AND REFRIGERANT MASS FLOW RATE ARE KNOWN
3730.    00 C**** CALC. REFRIG. STATE AT 4-WAY VALVE AND CONNECTING TUBING
3740.    00
3750.    00 62 CALL. MVAL(XW,RMASS,V2,AM2,AK2,CP2,V7,AM7,AK7,CP7,
        00 & V1,AM1,AK1,CP1,V6,AM8,AK8,CP8)
        00 IF (NSYS.EQ.2) GOTO 64
3760.    00 CALL PIPE(NO,XW,TRA,RMASS,T8,P3,V8,H8,AM8,AK8,CP8,
        00 & T9,F9,H9,XQ9,RL,RD,RK1,RD1,RK2,RD2,0.,0.)
        00 CALL PIPE(N1,XW,TA,RMASS,T1,P1,V1,H1,AM1,AK1,CP1,
        00 E,TO,PO,HO,XQ0,YL,YD,YK1,YD1,YK2,YD2,0.,0.)
      GOTO 66
3770.    00
3780.    00 64 CALL PIPE(N1,XW,TRA,RMASS,T1,P1,V1,H1,AM1,AK1,CP1,
        00 & TO,PO,HO,XQ0,RL,RD,RK1,RD1,RK2,RD2,0.,0.)
        00 CALL PIPE(NO,XW,TA,RMASS,T3,P3,V3,H3,AM3,AK3,CP3,
        00 & T9,P9,H9,XQ9,YL,YD,YK1,YD1,YK2,YD2,0.,0.)
      66 E1:E1/3412.7
3820.    00
3830.    00 C**** PRINT RESULTS
3840.    00
3850.    00
3860.    00
3870.    00
3920.    00
3942.    00
3950.    00
3960.    00
3970.    00
3980.    00
3990.    00
4010.    00
4020.    00
4030.    00
4040.    00
4050.    00
4060.    00
4070.    00
4080.    00
4090.    00
4100.    00
4110.    00
4120.    00
4130.    00
4140.    00
        00 WRITE(6,207)
        00 WRITE(6,208)E1,ETAE,ETAC,ETAV,CPRPM,RMASS
        00 WRITE(6,210)
        I=1
        00 WRITE(6,212)I,TO,PO,HO,XQ0
        I=I+1
        00 WRITE(6,212)I,T1,P1,H1,XQ1
        I=I+1
        00 WRITE(6,212)I,T2,P2,H2,XQ2
        I=I+1
        00 WRITE(6,212)I,T3,P3,H3,XQ3
        I=I+1
        00 WRITE(6,212)I,T4,P4,H4,XQ4
        I=I+1
        00 WRITE(6,212)I,T5,P5,H5,XQ5
        I=I+1
        00 WRITE(6,212)I,T6,P6,H6,XQ6
        I=I+1
        00 WRITE(6,212)I,T7,P7,H7,XQ7
        I=I+1

```

```

***** COMPRE *****

4150.      00      WRITE(6,212)I,T8,P8,H8,XG9
4160.      00      I=1+
4170.      00      WRITE(6,212)I,T9,P9,H3,XG9
4180.      00
C       200 FFORMAT(/2X,'INPUT DATA TO COMPRESSOR: //2X,'P2','9X,'T3','9X,'H3',
        2,'9X,'XQ3','8X,'TGE','8X,'TRA','9X,'TDA','7(1PE11.3))
4200.      00
        204 FORMAT(/2X,'COMPRESSOR ERROR PRESSURE LOOP: ')
        205 FORMAT(' COMPRESSOR DOES NOT CONVERGE, RHA='1PE16.6)
        206 FORMAT(/2X,'COMPRESSOR ITERATION: ')
        207 FORMAT(/2X,'E1','9X,'ETAE','7X,'FTAV','7X,
        & 'CFRPM','6X,'RMASS','6(1PE11.3)
        210 FORMAT(/2X,'I','2X,'T','10X,'H','10X,'X')
        212 FORMAT(13,4(1PE11.2))
        RETURN
        00
END
00

```

END ELT. ERRORS: NONE. TIME: 0.506 SEC. IMAGE COUNT: 419

@HDG,P *** CONDHX ***** .L,0**

***** CONDHX *****

DATE 072184

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●ELT,L DD.CONDHX
ELT 8R1 S74Q1C 07/21/84 15:54:59 (O)
10.          00          SUBROUTINE CONDIX(110,FMASS,T1,P1,ATIN,APIN,ARHIN,
20.          00
30.          00          T2,P2,112,X2)
40.          00          6
50.          00          C
60.          00          C*** SIMULATION OF A CONDENSER WORKING WITH A NON-AZEOTROPIC MIXTURE
70.          00          AS REFRIGERANT
80.          00          C
90.          00          C*** THIS PROGRAM COMPUTES IN TUBE-BY-TUBE SCHEME
100.         00          C*** PERFORMANCE OF CROSS-FLOW AIR COOLED CONDENSER
110.         00          C*** WITH UP TO 130 PLATE FINNED TUBES
120.         00          C*** PLACED IN UP TO 5 DEPTH ROWS.
130.         00          C
140.         00          C*** INPUT DATA:
150.         00          C      AMAS(110)           - AIR MASS FLOW RATE THROUGH COIL (LBM/H)
160.         00          C      ANGLE(110)          - ANGLE BETWEEN COIL FACE & AIR STREAMLINES (RAD)
170.         00          C      APIN                - AIR INLET PRESSURE (PSIA)
180.         00          C      ARHIN               - AIR INLET RELATIVE HUMIDITY (-)
190.         00          C      ATIN                - AIR INLET TEMPERATURE (F)
200.         00          C      CONST(110)          - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION (-)
210.         00          C      CPOW(110)          - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION (-)
220.         00          C      DI(110)             - INNER DIAMETER OF TUBES (FT)
230.         00          C      DO(110)             - OUTER DIAMETER OF TUBES (FT)
240.         00          C      DPCH(110)          - TUBE DEPTH PITCH (FT)
250.         00          C      DT(110)             - FIN TIP DIAMETER (FT)
260.         00          C      FLOW(110,M)        - FRACTION OF COIL TOTAL REFRIG. MASS FLOW PASSING
270.         00          C      THROUGTH TUBE M (-)
280.         00          C      FMK(110)            - FIN MATERIAL THERMAL CONDUCTIVITY (BTU/FT*H°F)
290.         00          C      FPCH(110)           - FIN PITCH (FT)
300.         00          C      FTK(110)            - FIN THICKNESS (FT)
310.         00          C      IDEPTH(110,M)       - DEPTH ROW OF A TUBE M (-)
320.         00          C      IFROM(110,M)        - NUMBER OF TUBE FROM WHICH TUBE M RECEIVES REFRIG.
330.         00          C      IST(110)             - WHEN COIL WORKS AS EVAPORATOR (-)
340.         00          C      110                 = 1 FOR INDOR COIL (-)
350.         00          C      110                 = 2 FOR OUTDOOR COIL (-)
360.         00          C      IMERC(110)          - NUMBER OF MERGING TUBES (-)
370.         00          C      IST(110)             - NUMBER OF TUBES REFRIG. FLOWS INTO COIL
380.         00          C      ISTART(110,L)        - WORKING AS CONDENSER, FOUND AS L SUCH TUBE (-)
390.         00          C      MERGE(110,K,1)       - NUMBER OF TUBE FOUND AS K MERGING TUBE (-)
400.         00          C      MERGE(110,K,2)       - NUMBER OF TUBES MERGING INTO TUBE K (-)
410.         00          C      NDEP(110)            - NUMBER OF TUBE ROW DEPTHS (-)
420.         00          C      NRUN(110)            - NUMBER OF TUBES PER ROW (-)
430.         00          C      NSECT(110)           - NUMBER OF REPEATING SECTIONS OF COIL (-)
440.         00          C      NTPS(1)              - NUMBER OF TUBES PER SECTION (-)
450.         00          C      NTUB(110,1)          - NUMBER OF TUBES IN ROW 1 OF EACH SECTION (-)
460.         00          C      P1                  - REFRIGERANT PRESSURE AT CONDENSER INLET (PSIA)
470.         00          C      RMASS               - TOTAL REFRIG. MASS FLOW RATE THROUGH COIL (LBM/H)
480.         00          C      RPCH(110)            - PITCH BETWEEN TUBES OF THE SAME DEPTH (FT)
490.         00          C      TMK(110)             - TUBE MATERIAL THERMAL CONDUCTIVITY (BTU/FT*H°F)
500.         00          C      T1                  - REFRIGERANT TEMPERATURE AT CONDENSER INLET (F)
510.         00          C      WIDTH(110)           - COIL WIDTH (FT)
520.         00          C
530.         00          C
540.         00          C
550.         00          C
560.         00          C

```

(FRACTION OF LESS VOLATILE COMPONENT)

570. 00 C WM - MIXTURE MOLECULAR WEIGHT (G/MOL)
 580. 00 C W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT (G/MOL)
 590. 00 C W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT (G/MOL)

C**** OUTPUT DATA:

600. 00 C H2 - REFRIGERANT ENTHALPY AT CONDENSER OUTLET (BTU/LBM)
 610. 00 C PRM(110,1,1) - REFRIG. PRESSURE AT 1 TUBE INLET (PSIA)
 620. 00 C PRN(110,2,1) - REFRIG. PRESSURE AT 1 TUBE OUTLET (PSIA)
 630. 00 C P2 - REFRIGERANT PRESSURE AT CONDENSER OUTLET (PSIA)
 640. 00 C TRM(110,1,1) - REFRIG. TEMP. AT 1 TUBE INLET (F)
 650. 00 C TRM(110,2,1) - REFRIG. TEMP. AT 1 TUBE OUTLET (F)
 660. 00 C T2 - REFRIGERANT TEMPERATURE AT CONDENSER OUTLET (F)
 670. 00 C XRM(110,1,1) - REFRIG. QUALITY AT 1 TUBE INLET (-)
 680. 00 C XRM(110,2,1) - REFRIG. QUALITY AT 1 TUBE OUTLET (-)
 690. 00 C XTUBE(110,J) - FRACTION OF TUBE J WITH SUPERIATED VAPOR
 700. 00 C OR (WHEN 2-PHASE FLOW IS IN REST OF TUBE) (-)
 710. 00 C
 720. 00 C
 730. 00 C
 740. 00 C
 750. 00 C
 760. 00 C
 770. 00 C
 780. 00 C
 790. 00 C
 800. 00 C
 810. 00 C
 820. 00 C
 830. 00 C
 840. 00 C
 850. 00 C
 860. 00 C
 870. 00 C
 880. 00 C
 890. 00 C
 900. 00 C
 910. 00 C
 920. 00 C
 930. 00 C
 940. 00 C
 950. 00 C
 960. 00 C
 970. 00 C
 980. 00 C
 990. 00 C
 1000. 00 C
 1010. 00 C
 1020. 00 C
 1030. 00 C
 1040. 00 C
 1050. 00 C
 1060. 00 C
 1070. 00 C
 1080. 00 C
 1090. 00 C
 1100. 00 C
 1110. 00 C
 1120. 00 C
 1130. 00 C
 1140. 00 C

C**** OUTPUT DATA:
 H2 - REFRIGERANT ENTHALPY AT CONDENSER OUTLET (BTU/LBM)
 PRM(110,1,1) - REFRIG. PRESSURE AT 1 TUBE INLET (PSIA)
 PRN(110,2,1) - REFRIG. PRESSURE AT 1 TUBE OUTLET (PSIA)
 P2 - REFRIGERANT PRESSURE AT CONDENSER OUTLET (PSIA)
 TRM(110,1,1) - REFRIG. TEMP. AT 1 TUBE INLET (F)
 TRM(110,2,1) - REFRIG. TEMP. AT 1 TUBE OUTLET (F)
 T2 - REFRIGERANT TEMPERATURE AT CONDENSER OUTLET (F)
 XRM(110,1,1) - REFRIG. QUALITY AT 1 TUBE INLET (-)
 XRM(110,2,1) - REFRIG. QUALITY AT 1 TUBE OUTLET (-)
 XTUBE(110,J) - FRACTION OF TUBE J WITH SUPERIATED VAPOR
 OR (WHEN 2-PHASE FLOW IS IN REST OF TUBE) (-)
 XTT(110,K) - FRACTION OF TUBE J WITH 2-PHASE FLOW
 (WHEN SUPCOOLED LIQUID IS IN REST OF TUBE) (-)
 - LOCKHART-MARTINELLI PARAMETER FOR REFRIG.
 IN TUBE K (-)
 X2 - REFRIGERANT QUALITY AT CONDENSER OUTLET (-)
 VGM(110,1,1) - SPEC. VOLUME OF SATURATED REFRIG. VAPOR AT
 SAT. TEMP. OF 1 TUBE INLET (FT**3/LBM)
 VGM(110,2,1) - SPEC. VOLUME OF SATURATED REFRIG. VAPOR AT
 SAT. TEMP. OF 1 TUBE OUTLET (FT**3/LBM)
 VLM(110,1,1) - REFRIG. SPEC. VOLUME AT 1 TUBE INLET (FT**3/LBM)
 VLM(110,2,1) - REFRIG. SPEC. VOLUME AT 1 TUBE OUTLET (FT**3/LBM)

C**** SUBPROGRAMS CALLED BY CONDX:
 AIRHT, AIRPR, BURTEM, DENT1, DYNDP1, DFDDYNP, ESBUBT, ESVOL, FEELIQ,
 FINEFF, HCVCVP, HF1N, HTCCCN, SPHTC, VISC0M, VOLIT1

COMMON/RDATA3/W1, W2, TC1, TC2
 COMMON/RPHIX/NDEP(2), NROW(2), DI(2), DO(2), DT(2), RPCH(2), DPCH(2),
 &WIDTH(2), FPCH(2), FTK(2), FMK(2), TMK(2), AMAS(2), ANGLE(2),
 &CONST(2), CPOW(2), NTUB(2,5), IFRONT(2,130), NSECT(2), NTPS(2)
 COMMON/MERG/MERGE(2,20,2), IMER(2), ISTART(2,20), IST(2),
 &DEPTH(2,130), FLOW(2,130), JFROM(2,130), KFREE(2,130,3),
 &KSTART(2,20), KST(2)
 COMMON/MASS/TRM(2,2,130), PRM(2,2,130), XPM(2,2,130),
 & VLM(2,2,130), VGM(2,2,130), XTUBE(2,130), XTT(2,130)
 DIMENSION TAIR(2,6), AIRN(5), IIR(2,120), INC(20), IEND(10), MY(130),
 @ DTR(130), DPR(130), DIR(130), DXR(130), GPRS(130), HCO(5), FFE(5)
 DIMENSION XLS(2,130), XVS(2,130), VLS(2,130), VVS(2,130)
 DIMENSION TAIR(2,130), AMSI(5), CPAS(5)
 DATA NO, N1, N3, N4, N5/0, 1, 3, 4, 5/
 C WRITE(6,500)T1, P1, ATIN, ARHN, RHSS
 C**** DATA PREPARATION
 NNDCP=NDEP(110)
 DD i = DI(110)
 DDO=DO(110)
 DDT=DT(110)
 RRPCH=RPCH(110)

***** CONDHX *****

DATE 072184

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00 DDPCH=DPCH(110)
00 WWIDTH=WIDTH(110)
00 FPCH=FPCH(110)
00 FFTK=FTK(110)
00 FFMK=FMK(110)
00 TTMK=TMK(110)
00 AAMAS=AMAS(110)
00 ANGLF=ANGLE(110)
00 CCONST=CONST(110)
00 CCPW=CFCW(110)
00 API=3.1415927*DDI*WWIDTH
00 APD=3.1415927*DDO*WIDTH
00 APR=0.5*(API+APC)
00 APO=APD*(FFPCH-FFTAK)/FFPCH
00 AF=1.570795*(DDT+DDO)*(DDT-DDO)
00 AF=AF*WWIDTH/FFPCH
00 AO=APD+AF
00 HD=5000.
HP=2.*TTMK/(DDO-DDI)
00 C***** FIND INLET STATE FROM PRESSURE AND TEMPERATURE
00 PA1=P1/14.6959
00 TK1=(T1+459.67)/1.8
00 CALL VOLIT1(N1,TK1,PA1,XM,VM1)
00 V1=16.01846*VM1/WM1
00 CALL HCVCP(N1,TK1,VM1,XM,H1,CV,CP)
00 X1=1.
00 C***** ESTIMATE CHANGE OF AIR TEMPERATURE
00 PA2=PA1
00 TK2=EBUBTE(PA2,XM)
00 VM2=ESVOL(NO,TK2,PA2,XM)
00 CALL HCVCP(N1,TK2,VM2,XM,H2,CV,CP)
00 CALL AIRFR(1,ATIN,APIN,ARIN,PAIR,RAIR,
&AMAIR,AKAIR)
00 TAIR(1,1)=ATIN
00 DTAIR=RMASS*(H1-H2)/(CPAIR*AMAS*NNDEP)
00 DC101=1,NNDEP
J=1+1
00 10 TAIR(1,J)=TAIR(1,1)+DTAIR
00 DO 11 I=1,NTPS(110)
11 ICT=IDEPHT(110,1)
TAIR(1,1)=ATIN+(ICT-1.)*DTAIR
11 TAIR(2,1)=TAIR(1,1)+DTAIR
00 C***** EVALUATE 'TWO-PHASE SPEC. HEAT'
00 CALL DEWTEM(No,PA1,XM,TKD,XL)
00 CALL VOLIT1(N1,TKD,PA1,XM,VM)
00 CALL HCVCP(N1,TKD,VM,XM,HGV,CV,CP)
00 CPR=(HGV-H2)/(1.8*(TKD-TK2))
00 DQ 12 I=1,NTPS(110)
00 VLM(110,2,1)=0.0
00 VGM(110,2,1)=0.0
00 DPR(1)=0.
00 DTR(1)=0.
00 DHR(1)=0.
00 DXR(1)=0.
00 CPRS(1)=CPR
12 HY(1)=0
00 NIST=IST(110)
00

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CONDHX *****

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1730.      00      DO 13 IA=1,NIMER
           00      J=MERGE(110,1,1)
1740.      00      13 MY(J)=1
           00      ACC=0.005
1750.      00      C***** START MAIN LOOP
           00      C***** MAIN LOOP
1760.      00      DO 100 IAIR=1,10
           00      PRINT 805,IAIR
1770.      00      CXZ     FORMAT(' IAIR=',14)
           00      CAA     IF((IAIR.EQ.1)PRINT 803,TAIR(1,1),TAIR(1,2),TAIR(1,3))
           00      803     FORMAT(' TAIR 1,2,3,4= ',4F10.3)
1780.      00      DO 14 IA=1,NNDEP
           00      NT=INSECT(110)*NTUB(110,1)
           00      AMS=AMAS/NT
1790.      00      TAAV=0.5*(TAIR(1,1)+TAIR(1,1+1))
           00      CALL AIRPR(2,TAAV,APIN,RIN,RAIP,CFA,RA,AMA,AKA)
1800.      00      NNRDW=NTUB(110,1)
1810.      00      HCO(1)=AIRHT(AMAS,CPA,AMA,AKA,DIO,DDT,NNRDW,WIDTH,
           00      &RRPCH,FFPK,FFTK,CCONST,CPQH,ANGLE)
1820.      00      FFE(E(I)=FINEFF(110,DDT,RIC,FFTK,FFRk,HCO(1))
           00      /MS(I)=AMS
           00      CPAS(I)=CPA
1830.      00      14 AIRN(I)=0.
           00      DO 16 IA=1,NIMER
           00      I=MERGE(110,IA,1)
           00      HR(1,1)=0.
           00      PRM(110,1,1)=0.
           00      IMC(IA)=MERGE(110,IA,2)
1840.      00      16 CONTINUE
           00      IEN=0
1850.      00      C***** FIND TUBE REFRIG. FLOWS INTO CONDENSER
           00      DO 86 NUMB=1,NIST
           00      I=ISTART(110,NUMB)
           00      TRM(110,1,1)=T1
           00      PRM(110,1,1)=P1
           00      HR(1,1)=H1
           00      XRM(110,1,1)=1.
           00      VGM(110,1,1)=V1
           00      TRI=T1
           00      PRI=P1
           00      HRI=H1
           00      XRI=1.
           00      GOTO 34
1860.      00      C***** FIND NEXT TUBE
           00      18 CONTINUE
           00      I=IFROM(110,JJ)
           00      IF(I.EQ.0)GOTO 85
           00      IF(MY(1).EQ.1)GOTO 22
           00      TRI=TRM(110,2,JJ)
           00      PRI=PRM(110,2,JJ)
           00      HRI=HR(2,JJ)
           00      XRI=XRM(110,2,JJ)
           00      VLM(110,1,1)=VLM(110,2,JJ)
           00      VGM(110,1,1)=VGM(110,2,JJ)
           00      XLS(1,1)=XLS(2,JJ)
           00      XVS(1,1)=XVS(2,JJ)
           00      VLS(1,1)=VLS(2,JJ)
1870.      00      2250.
           00      2260.
           00      2270.
           00      2280.
           00      2290.
           00      2300.

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2310.      00      VVS(1,1)=VVS(2, JJ)
2320.      00      GOTO 32
2330.      00      C***** REFrig. MERGES IN TUBE 1. FIND INLET STATE
2340.      00      HR(1,1)=HR(1,1)+HR(2, JJ)*FLOU(110, JJ)
2350.      00      PRM(110, 1, 1)=PRM(110, 1, 1)+PRM(110, 2, JJ)*FLDH(110, JJ)
2360.      00      DO 23   IP=1, NIMER
2370.      00      23 IF(MERGE(110, IP, 1).EQ.1) GOTO 24
2380.      00      24 IMC(IP)=MC(IP)-1
2390.      00      IF(IMC(IP).NE.0)GOTO 86
2400.      00      HR(1,1)=HR(1,1)/FLDH(110, 1)
2410.      00      PRM(110, 1, 1)=PRM(110, 1, 1)/FLOU(110, 1)
2420.      00      HRI=HR(1, 1)
2430.      00      PRI=PRMC(110, 1, 1)
2440.      00      PARI=PRI/14.6959
2450.      00      CALL APIINC1, HRI, PARI, XM, ACC, TKRI, XRI, XL, XV, VL, VV
2460.      00      TRI=TKRI*1.8-459.67
2470.      00      IF(XRI.EQ.0.0) THEN
2480.      00      VLM(110, 1, 1)=16.01846*VL/WM
2490.      00      ELSE
2500.      00      IF(XRI.LT.1.) THEN
2510.      00      WMV=W1*(1.-VV)+W2*XV
2520.      00      VGM(110, 1, 1)=16.01346*VV/WMV
2530.      00      WML=W1*(1.-XL)+W2*XL
2540.      00      VLM(110, 1, 1)=16.01346*VL/WML
2550.      00      XL3(1, 1)=XL
2560.      00      XVS(1, 1)=XV
2570.      00      VLS(1, 1)=VL
2580.      00      VVS(1, 1)=VV
2590.      00      ELSE
2600.      00      VGM(110, 1, 1)=16.01346*VV/WM
2610.      00      END IF
2620.      00      END IF
2630.      00      32 CONTINUE
2640.      00      TRM(110, 1, 1)=TRI
2650.      00      PRM(110, 1, 1)=PRI
2660.      00      HR(1, 1)=HRI
2670.      00      XRM(110, 1, 1)=XRI
2680.      00      C***** TUBE 1 SELECTION FOR CALCULATION DONE
2690.      00      C***** COMPUTE HEAT TRANSFER & REFRIG. PRESSURE DROP FOR TUBE 1
2700.      00      C***** FIND REFRIG. STATE AT OUTLET
2710.      00      34 CONTINUE
2720.      00      TKRI=(TRI+459.67)/1.8
2730.      00      RMS=RMASS*FLOU(110, 1)
2740.      00      TRE=TRI-DTR(1)
2750.      00      PRE=PRI-DPR(1)
2760.      00      HRE=HRI-DHR(1)
2770.      00      XRE=XRI-DXR(1)
2780.      00      PRAV=0.5*(PRI+PRE)
2790.      00      PARAV=PRAV/14.6959
2800.      00      ICT=IDEPTH(110, 1)
2810.      00      AMS=AMSI(1, ICT)
2820.      00      CPA=CPAS(1, ICT)
2830.      00      TAI=TAIRI(1, 1)
2840.      00      IF((TAI-.1).GE.TRI)TAI=TRI-.1
2850.      00      PRINT 805, 1, ICT, XRI, PRI, TRI, HRI, TAI
2860.      00      805 FORMAT('1, ICT, XRI, PRI, TRI, HRI, TAI=' , 214, F6.2, 5F6.1)
2870.      00      IF(XRI.EQ.1.)GOTO 42
2880.      00

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2890. 00      C      CASE 1
2900. 00      C***** SUBCOOLED LIQUID AT TUBE 1 INLET
2920. 00      DO 36 IS=1,5
2930. 00      TRAV=0.5*(TRI+TRE)
2940. 00      AKR=VISCON(1,TRAV,XW)
2950. 00      CALL VOLIT1(N0,TKRAV,PARAV,XM,VL)
2960. 00      CALL HCVCP(N5,TKRAV,VL,XI,H,CV,CPR)
2970. 00      HI=SFRHTC(CPR,AMR,AKR,RMS,DDI)
2980. 00      UAO=OVLHTC(AO,API,AMR,APC,AF,HI,HD,HP,HCO(1CT),FFEE(1CT))
2990. 00      QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
3000. 00      Q1=1.-EXP(-QQ/(CFR*RMS))
3010. 00      Q1=CFR*RMS*(TRI-TAI)*Q1
3020. 00      HRE=HRI-Q1/RMS
3030. 00      TRE=TRI+(HRE-HRI)/CPR
3040. 00      IF (TRE.GT.TAI) GOTO 38
3050. 00      36 CONTINUE
3060. 00      38 XRE=0.
3070. 00      AL1=WIDTH*20.*DDI
3080. 00      VL=VL*16.01845/WM
3090. 00      PRE=FRI-SPIDP1(RMS,AL1,DII,VL,AMR)
3100. 00      TAE=TAI+Q1/(CPA*AMS)
3110. 00      GOTO 78
3120. 00
3130. 00
3140. 00
3150. 00
3160. 00      C***** CASE 2 & 3
3170. 00      C***** SUPERHEATED VAPOR AT TUBE 1 INLET
3180. 00      42 CONTINUE
3190. 00      DO 46 ISUP=1,6
3200. 00      CXZ      PRINT 807,FARAV,TKRAV'
3210. 00      807  FORMAT('FARAV,TKRAV=','?F8.2')
3220. 00      TRAV=0.5*(TRI+TRE)
3230. 00      TKRAV=(TRAV+459.67)/1.8
3240. 00      CALL VOLIT1(N1,TKRAV,PARAV,XM,VV)
3250. 00      CALL HCVCP(N5,TKRAV,VV,YM,H,CV,CPR)
3260. 00      AMR=VISCON(N3,TRAV,XW)
3270. 00      AKR=VISCON(N4,TRAV,XW)
3280. 00      HI=SFRHTC(CPR,AMR,AKR,RMS,DDI)
3290. 00      UAO=OVLHTC(AO,API,AMR,APC,AF,HI,HD,HP,HCC(1CT),FFEE(1CT))
3300. 00      QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
3310. 00      Q1=1.-EXP(-QQ/(CFR*RMS))
3320. 00      Q1=CFR*RMS*(TRI-TAI)*Q1
3330. 00      HRE=HRI-Q1/RMS
3340. 00      TRE=TRI-(HRI-HRE)/CPR
3350. 00      IF (ISUP.EQ.1) GOTO 44
3360. 00      HDIF=HRE1-HRE
3370. 00      IF (ABS(HDIF).LT.0.01) GOTO 48
3380. 00      44 HRE1=HRE
3390. 00      46 CONTINUE
3400. 00      WRITE(6,650) 1,HDIF
3410. 00      650 FORMAT('CASE 2 TUBE DOES NOT CONVERGE, I : HDIF = ',14,1PE14.4)
3420. 00
3430. 00      CXZ      PRINT 808,HRE
3440. 00      808 FORMAT('HRE = ',F8.2)
3450. 00      CALL DEWTEM1(N0,PARAV,XM,TKD,XLD)
3460. 00      CALL VOLIT1(N1,TKD,PARAV,XM,VVD)

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CONDHX *****

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3470.      00      CALL HCVCP(N1,TKD,VVD,XM,HGV,CV,CP)
3480.      00      CVX      PRINT 809,HGV
3490.      00      809  FORIAT( ' HGV= ',F6.2)
3500.      00      IF(HRE.GE.HGV) THEN
3510.      00      XRE=1.
3520.      00      Q2=0.
3530.      00      XSUP=1.
3540.      00      VW=VVD*16.01846/VW
3550.      00      GOTO 52
3560.      00      END IF
3570.      00      C***** CASE 3
3580.      00      C***** 2-PHASE FLOW AT OUTLET OF A TUBE WITH SUPERHEATED VAPOR AT INLET
3590.      00      C***** COMPUTE HEAT TRANSFERED BY PART OF A TUBE WITH SUPERHEATED VAPOR
3600.      00      TKRAV=0.5*(TKR+TKD)
3610.      00      TRAV=TKRAV*1.8-459.67
3620.      00      TD=TKD*1.8-459.67
3630.      00      VMAV=0.5*(VVD+VCM*118,1,1)*WM/16.01846)
3640.      00      VW=VMAV*16.0816/WM
3650.      00      CALL HCVCP(115,TKRAV,VMAV,XM,H,CV,CPR)
3660.      00      AMR=VISCON(3,TRAV,XW)
3670.      00      AKR=VISCON(4,TRAV,XW)
3680.      00      HI=SPHTC(CPR,AMR,AKR,RMS,DDI)
3690.      00      UAO=OVLHTC(AO,API,APM,APL,AF,HI,HD,HP,HCO(1CT),FFEE(1CT))
3700.      00      Q1=RMS*(HRI-HGV)
3710.      00      QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
3720.      00      XSUP=-CPR*RMS*ALOG(1.-Q1/(RMS*CPR*(TRI-TAI)))/QQ
3730.      00      PRINT 811,XSUP
3740.      00      IF(XSUP.GT.1.)THEN
3750.      00      PRINT( ' XSUP= ',F6.2)
3760.      00      HRE=HGV
3770.      00      XRE=1.
3780.      00      Q2=0.
3790.      00      XSUP=1.
3800.      00      GOTO 52
3810.      00      END IF
3820.      00      C***** HEAT TRANSFERED BY PART OF A TUBE WITH 2-PHASE
3830.      00      TKRE=(TRE+459.67)/1.8
3840.      00      DO 50 IQ=1,6
3850.      00      CPR=CPRS(I)
3860.      00      IF(TRE.GT.TD)TRE=TD-2.
3870.      00      TRAV=0.5*(TD+TRE)
3880.      00      HI=HTCCON(TRAV,PRAV,RMS,DDI)
3890.      00      UAO=OVLHTC(AO,API,APM,APL,AF,HI,HD,HP,HCO(1CT),FFEE(1CT))
3900.      00      QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
3910.      00      PRINT 813,CPR
3920.      00      FORMT( ' CPR= ',1PE15.6)
3930.      00      Q2=(1.-XSUP)*CPR*RMS*(TD-TAI)*(1.-EXP(-QQ/(CFR*RMS)))
3940.      00      HRE=HGV-Q2/RMS
3950.      00      CALL HPIN(N1,HRE,PARAV,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
3960.      00      TRE=TKRE*1.8-459.67
3970.      00      PRINT 812,HGV,HRE,TD,TRE,XRE
3980.      00      812  FORMAT( ' HGV,HRE,TD,TRE,XRE= ',1F12.6,F6.2)
3990.      00      IF(TRE.EQ.TD)THEN
4000.      00      IF((IQ.GT.1)GO10 52
4010.      00      CPRS(I)=2.*CPR
4020.      00      GOTC 49
4030.      00      END IF

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***** CONDHN *****

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4050.      00      CPRS(1)=(HGV-HRE)/(TD-TRE)
4060.      00      IF(IQ.EQ.1)GOTO 49
4070.      00      HDIF=HRE-HRE1
4080.      00      IF(ABS(HDIF).LT.0.01)GOTO 52
4090.      00      49 HRE1=HRE
4100.      00      50 CONTINUE
4110.      00      WRITE(6,650)I,HDIF
4120.      00      650 FORMAT(' CASE 3 TUBE DOES NOT CONVERGE, I, HRE, IF= ',I4,1FE14.4)
4130.      00      Q=Q1+Q2
4140.      00      XRAV=0.5*(1.+XRE)
4150.      00      TAE=TAI+Q/(CPA*AMIS)
4160.      00      810 FORMAT(' XSUP= ',F8.2)
4170.      00      CVXCDE PRINT 810,XSUP
C
C**** CALCULATE FRICTIONAL PRESSURE DROP IN A TUBE
4180.      00      C**** IF(XPAV.GT.-.99)THEN   @SUPERHEATED VAPOR IN A TUBE ONLY
4200.      00      AL1=WLIDTH+20.*DDI
4210.      00      DP1=SPHDP1(RMS,AL1,DD1,VW,AMR)
4220.      00      DP2=0.
4230.      00      ELSE          @SUPERHEATED VAPOR & 2-PHASE IN A TUBE
4240.      00      AL1=XSUP*WLIDTH
4250.      00      DP1=SPHDP1(RMS,AL1,DD1,VW,AMR)
4260.      00      XL=0.5*(XL0+XL)
4270.      00      XLW=XL/(W1/W2*(1.-XL)+XL)
4280.      00      WML=W1*(1.-XL)+W2*XL
4290.      00      TKRAV=(TRAV+159.67)/1.8
4300.      00      CVV PRINT 814,TKRAV,PRAV
4310.      00      814 FORMAT(' TKRAV,PRAV= ',2F10.3)
4320.      00      CALL VOLUTI(NO,TKRAV,PRAV,XL,VL)
4330.      00      VLW=VL*16.01846/WML
4340.      00      AMR=VISCON(N1,TRAV,XLW)
4350.      00      CVV PRINT 819,AMR
4360.      00      819 FORMAT(' AMR= ',1PE15.5)
4370.      00      AL2=(1.-XSUP)*WLIDTH+20.*DDI
4380.      00      RMSX=(1.-XRAV)*RMS
4390.      00      DP2=SPHDF1(RNSX,AL2,DD1,VLW,AMR)
4400.      00      XV=0.5*(XM+XV)
4410.      00      VW=0.5*(VV0+VV)
4420.      00      CVV PRINT 818,XPAV,TRAV,XL,XV,VV
4430.      00      818 FORMAT(' XRAV,TRAV,XL,XV,VV= ',F4.2,F5.2,2F10.4)
4440.      00      FEE2=FEE1*(XRAV,TRAV,XL,XV,VV,XTT(IID,1))
4450.      00      DP2=DP2*FEE2
4460.      00      END IF
4470.      00      CVV PRINT 815,DP1,DP2
4480.      00      815 FORMAT(' DP1,DP2= ',2F10.3)
4490.      00      PRE=PRI-DP1-DP2
4500.      00      GOTO 78
C
C**** CASE 4 & 5
C**** 2-PHASE FLOW AT TUBE 1 INLET
4510.      00      56 IXRE=0
4520.      00      X2FH=1.
4530.      00      TKRE=(TRE+459.57)/1.8
4540.      00      DC 63 1TP1=1,6
4550.      00      CPR=CPNS(1)
4550.      00      TRAV=0.5*(TR1+TRE)
4550.      00      XRAV=0.5*(XR1+XRE)
4550.      00      HI =HTCCDN(TRAV,PRAV,RMS,NDI)
4570.
4580.
4590.
4600.
4610.
4620.

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***** CONDHX *****

4630.    00 UAO=CVLHTC(AO,API,APM,APU,AF,HI,HD,HP,HCO(1CT),FFEE(1CT))
        00 QQ=CPA*AMS*(1.-EXP(-A5*(AO/(CPA*AMS)))
        00 Q1=CPR*RMS*(TRI-TAI)*(1.-EXP(-QQ/(CPR*RMS)))
        00 HRE=HRI-Q1/RMS
        00      IF (1.EQ.72) PRINT 821,IRE
        00 CCC 821 FORMAT('IRE= ',F9.3)
        00 CALL H2IN(N1,HRE,PARAV,XH,ACC,TKRE,XRE,XL,XV,VL,VW)
        00 TRE=TKRE*1.8-450.67
        00 IF (XRE.EQ.0.) THEN
        00      IF (XRE.EQ.1.) GOTO 65
        00      TKB=TKR1
        00      CALL RUBITEM(N1,PARAV,XM,TKB,XVB)
        00      CALL VOLIT1(N0,TKB,FA1AV,XM,VLB)
        00      CALL HCVCPI(N1,TKB,VLB,XM,HGL,CV,CP)
        00      CALL VOLIT1(N1,TKB,PARAV,XVB,VVB)
        00      TB=TKB*1.8-459.67
        00      TRE=TB
        00      CPRS(1)=(HRI-HGL)/(TRI-TB)
        00      XRE=1
        00      GOTO 62
        00 END IF
        00 IXRE=0
        00 IF (TRI.EQ.TRE) THEN
        00      IF (ITPH.GT.1) GOTO 68
        00      CPRS(1)=2.*CPR
        00      GOTO 62
        00 END IF
        00 CPRS(1)=(HRI-HRE)/(TRI-TRE)
        00 IF (ITPH.EQ.1) GOTO 62
        00 HDIF=HRE1-HRE
        00 Q2=0.
        00 IF (ABS(HDIF).LT.0.01) GOTO 68
        00 HRE1=HRE
        00 62 CONTINUE
        00 WRITE(6,670)1,HDIF
        00 IF (CASE 4 TIME DOES NOT CONVERGE, 1,HDIF=1,14,1PE14.4)
        00 GOTO 68
        00 65 CONTINUE
        00 C
        00 C***** CASE 5
        00 C***** SURCOOLED LIQUID AT OUTLET OF TUBE WITH 2-PHASE FLOW AT INLET
        00 C***** COMPUTE HEAT TRANSFERRED BY 2-PHASE PART OF A TUBE
        00 Q1=RMS*(HRI-HGL)
        00 X2PH=-CPR*RMS*ALOG(1.-Q1/(RMS*CPR*(TRI-TAI)))/QQ
        00 IF (X2PH.GE.1.) THEN
        00      HRE=HGL
        00      Q2=0.
        00      X2FH=1.
        00      GOTO 68
        00 END IF
        00 C***** COMPUTE HFAT TRANSFERRED BY A SINGLE-PHASE PART OF A TUBE
        00 DO 67 ITPL=1,6
        00      IF (IRE.GT.TB) TRE=TB-1.
        00      TRAV=0.5*(TRE+TB)
        00      TKRAV=(TRAV+459.67)/1.8
        00      CALL VOLIT1(N0,TKRAV,PARAV,XM,VL)
        00      CALL HCVCPI(N0,TKRAV,PARAV,XM,H,CV,CR)
        00      AMR=VISCON(1,TRAV,XW)
        00

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***** CONDHX *****

DATE 072184

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00 AKR=VISCON(2, TRAV, XW)
00 HI=SPHTC(CPA, AMR, AKR, RMS, DDI)
00 UAC=CYLHTC(AQ, API, APM, API, AF, HI, ID, HP, HC0(1CT), FFFF(1CT))
00 QQ=CPA*AM2*(1.-EXP(-AQ*UAC/(CPA*AM2)))
00 Q2=CPA*RMS*(TD-TAI)*(1.-EXP(-QD/(CPA*RMS)))*(1.-X2FH)
00 HRE=HGL-Q2/RMS
00 IF (ITPH.EQ.1)GOTO 66
00 HDIF=HGL-HRE
00 IF (ABS(HDIF).LT.0.01)GOTO 68
00 HRE1=HRE
00 66 CONTINUE
00 67 CONTINUE
00 68 CONTINUE
00 CCC IF((1.EQ.72)PRINT 320,HRE
00 CCC 820 FORMAT(, HRE=' , F8.2)
00 00 Q=Q1+Q2
00 TAE=TA1+Q/(CPA*AM2)
00 TAIR=(2,1)=TAE
00 COMPUTE FRICTIONAL PRESSURE DROP
00 XTUNE((110,1)=X2FH
00 IF (X2PH.LT.1.) THEN
00 XML=0.5*(XL_S(1,1)+XM)
00 XMY=0.5*(XVS(1,1)+XYB)
00 XWL=YML/(W1/W2*(1.-XML)+XML)
00 TRT=0.5*(TR1+TB)
00 AMR=VISCON(1,TRT,XWL)
00 VLW=0.5*(VLM(111C,1,1)-VLB*16.01846/VM)
00 AL1=VW1DTH*X2PH
00 RMSX=(1.-XRAV)*RMS
00 DP1=SFRDP1(RMSX,AL1,DDI,VLW,AMR)
00 WML=W1*(1.-XML)+W2*XML
00 VML=0.5*(VLB+VLS(1,1))
00 VMV=0.5*(VVS(1,1)+VVB)
00 FEE2=FFEL1Q(XRAV,TRT,XWL,XMV,VML,VMV,XTT(110,1))
00 DP1=DPI*FEE2
00 AL2=(1.-X2FH)*WM1DTH+20.*DDI
00 VLW=VL*16.01846/VM
00 DP2=SFRDP1(RMS,AL2,DDI,VLW,AMR)
00 ELSE @2-PHASE FLOW IN TUBE ONLY
00 WML=Y1*(1.-XL)+W2*XL
00 VLW=0.5*(VLM(111C,1,1)+16.01846*VL/WM)
00 XL=0.5*(X1_S(1,1)+XL)
00 XWL=XL/(W1/W2*(1.-XL)+XL)
00 AMR=VISCON(1,TRAV,XWL);
00 AL1=WM1DTH+20.*DDI
00 RMSX=(1.-XRAV)*RMS
00 DP1=SFRDP1(RMSX,AL1,DDI,VLW,AMR)
00 VL=0.5*(VL+VLS(1,1))
00 VM=0.5*(VW+VVS(1,1))
00 FEE2=FFEL1Q(XRAV,TRAV,XL,XV,VL,VV,XTT(110,1))
00 DP1=DPI*FEE2
00 DP2=0.
00 END IF
00 PRE=PRI-DFP1-DP2
00 73 CONTINUE
00 CC * FOLLOWING STATEMENTS FOR CALC. OF DYNAMIC PRESSURE DROP ARE
00 CC SKIPPED. THEY PROVIDE LITTLE CORRECTION FOR PRESSURE DROP
00 AT EXPENSE OF A LOT OF COMPUTING.
00 CC IF (XRI.LT.1. AND. XPE.GT.0.1) THEN
00

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***** CONDHX *****
      5790.    00   CC   DIX=DYNNDP2(PRI,TRI,PRE,TRE,RMS,DD1)
      5800.    00   CC   ELSE
      5810.    00   CC   DIX=DYNNDP1(PRI,IRI,PRE,HRE,RMS,DD1)
      5820.    00   CC   END IF
      5830.    00   CC   PRE=PRE-DIX
      5840.    00   C    C**** ENTHALPY & PRESSURE AT TUBE 1 OUTLET ARE KNOWN
      5850.    00   C    C**** FIND TEMP, QUALITY & SPEC. VOLUME
      5860.    00   C    TKRE=(TRE+450.67)/1.8
      5870.    00   C    PARE=FRE/14.6959
      5880.    00   C    CALL HPIN(1),HRE,PARE,XM,ACC,TKRE,YRF,XL,VL,VV)
      5890.    00   C    TRM(110,2,1)=TKRE*1.8-459.67
      5900.    00   C    PRM(110,2,1)=PRE
      5910.    00   C    HR(2,1)=HRE
      5920.    00   C    XRM(110,2,1)=XPE
      5930.    00   C    DTR(1)=TRI-TRM(110,2,1)
      5940.    00   C    DPR(1)=PRI-PRE
      5950.    00   C    DXR(1)=XRI-XRE
      5960.    00   C    IF(XRE.EQ.0.) THEN
      5970.    00   C    VLM(110,2,1)=16.01846*VL/WM
      5980.    00   C    ELSE
      5990.    00   C    IF(XRE.LT.1.) THEN
      6000.    00   C    WMV=W1*(1.-XV)+W2*XV
      6010.    00   C    VGM(110,2,1)=16.01746*VV/WMV
      6020.    00   C    WML=W1*(1.-XL)+W2*XL
      6030.    00   C    VLM(110,2,1)=16.01746*VL/WML
      6040.    00   C    XLS(2,1)=XL
      6050.    00   C    XVS(2,1)=XV
      6060.    00   C    VLS(2,1)=VL
      6070.    00   C    VVS(2,1)=VV
      6080.    00   C    ELSE
      6090.    00   C    VAM(110,2,1)=16.01746*VV/WM
      6100.    00   C    END IF
      6110.    00   C    END IF
      6120.    00   C    JJ=1
      6130.    00   C    TAIR(2,ICT+1)=(TAE+AIRN(ICT))*TAIR(2,ICT+1))/_
      6140.    00   C    &(AIRN(ICT)+1.)
      6150.    00   C    AIRN(ICT)=AIRN(ICT)+1.
      6160.    00   C    GOTO 18
      6170.    00   C    IEN=IEN+1
      6180.    00   C    IEND(IEN)=JJ
      6190.    00   C    86 CONTINUE
      6200.    00   C    ALL TUBES OF COIL COMPUTED. CHECK IF CONVERGENCE OBTAINED
      6210.    00   C    H2=0.
      6220.    00   C    00 CONTINUE
      6230.    00   C    00
      6240.    00   C    00
      6250.    00   C    00
      6260.    00   C    00
      6270.    00   C    00
      6280.    00   C    00
      6290.    00   C    00
      6300.    00   C    00
      6310.    00   C    00
      6320.    00   C    00
      6330.    00   C    00
      6340.    00   C    00
      6350.    00   C    00
      6360.    00   C    00
      90  CONTINUE
      H2=H2*NSECT(110)
      IF(IAIR.EQ.1)GOTO 92
      H2PH2=H2PH-H2
      PRINT 850,H2,H2FH2
      850 FORMAT( H2,H2PH2, ,2F8.2)
      IF(IAIR.LT.3)GOTO 91
      IF(ABS(H2PH2).LT.0.02.AND.ABS(H2PH2).LT..1)GOTO 202
      91 H2PH2=H2FH2
      92 H2F=H2

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***** CONDHX *****

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6370      00      C**** CONVERGENCE NOT OBTAINED
6380      00      C**** PREPARE AIR SIDE DATA FOR NEW LOOP
6390      00      DO 94 I=1, NDEEP
6400      00      J=I+1
6410      00      TAIR'(1,J)=TAIR(2,J)
6420      00      94 TAIR(2,J)=0.
6430      00      NTOT=0
6440      00      NDEEP=NDEP(110)-1
6450      00      DO 149 ICT=1,NDEEP
6460      00      NTOT=NTCT+NTUB(110,ICT)
6470      00      NDIF=NTUB(110,ICT)-NTUB(110,ICT+1)
6480      00      C
6490      00      IF(NDIF.EQ.0) THEN
6500      00      IA=NTOT+1
6510      00      IB=NTOT+NTUB(110,ICT+1)
6520      00      DO 142 I=IA,IB
6530      00      J=JFROM(110,1)
6540      00      TAIR(1,1)=TAIR(2,J)
6550      00      END IF
6560      00      C
6570      00      IF(NDIF.LT.0) THEN
6580      00      IA=NTOT+1
6590      00      ID=NTOT+NTUB(110,ICT)-1
6600      00      DO 143 I=IA,IB
6610      00      J=JFROM(110,1)
6620      00      TAIR(1,1)=0.5*(TAIR(1,1)+TAIR(2,J))
6630      00      IA=NTOT-NTUB(110,ICT)+1
6640      00      IB=NTOT-1
6650      00      T=0.
6660      00      DO 144 I=IA,IB
6670      00      T=T+TAIR(2,I)
6680      00      T=T*(AMSI(ICT)-AMSI(ICT+1))+TAIR(2,NTOT)*AMSI(ICT)
6690      00      SEG=(NTUB(110,ICT+1)-NTUB(110,ICT)+1)*AMSI(ICT+1)
6700      00      T=T/SEG
6710      00      IA=NTOT+NTUB(110,ICT)
6720      00      IB=NTOT+NTUB(110,ICT+1)
6730      00      DO 145 I=IA,IB
6740      00      TAIR(1,1)=0.5*(TAIR(1,1)+T)
6750      00      END IF
6760      00      C
6770      00      IF(NDIF.GT.0) THEN
6780      00      IA=NTOT-NDIF+1
6790      00      TCOR=0.
6800      00      DO 146 I=IA,NTOT
6810      00      J=JFROM(110,1)
6820      00      TCOR=TCOR+NTUB(110,ICT+1)
6830      00      IA=NTOT+1
6840      00      IB=NTOT+NTUB(110,ICT+1)
6850      00      DO 147 I=IA,IB
6860      00      J=JFROM(110,1)
6870      00      TAIR(1,1)=.5*(TAIR(1,1)+(TAIR(2,J)+TCOR)*AMSI(ICT+1))
6880      00      END IF
6890      00      149 CONTINUE
6900      00      100 CONTINUE
6910      00      C***** END OF MAIN LOOP
6920      00      C***** END *****
6930      00      WRITE(6,505)H2P12

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DATE: 072184

***** CONDHX *****

```
6950.          00      202  CONTINUE
6960.          00      P2=0.
6970.          00      DO 206 I=1,1EN
6980.          00      IE=IEND(1)
6990.          00      P2=P2*PRM(110,2,1E)*FLOW(110,1E)
7000.          00      206  CONTINUE
7010.          00      P2=P2*INSECT(110)
7020.          00      PA2=P2/14.6959
7030.          00      CALL HPIN(NO,H2 FA2,X1,ACC,TK2,X2,XL,XV,VL,VV)
7040.          00      T2=TK2*1.8-459.67
7050.          00      500  FORMAT(/2X,'INPUT DATA TO COLDHX: //2X,
7060.          00      & 'T',10X,'P',10X,'TAIR',7X,'RH',9X,'RHSS',/5(1PE11.3))
7070.          00      WRITE(6,501)T1,P1,X1,T2,P2,H2,X2
7080.          00      501  FORMAT(/2X,'COMPENSER ITERATION: //',
7090.          00      & 2X,'T',10X,'P',10X,'H',10X,'X',4(1PE11.3)/4(1PE11.3))
7100.          00      505  FORMAT(' COLDHX DOES NOT CONVERGE, MAX. FRROR= ',1PE11.3,
7110.          00      1. (BTU/LB), )
7120.          00      RETURN
7130.          00

END ELT.  ERRORS: NONE.  TIME: 0.835 SEC. IMAGE COUNT: 713
```

@HDG, P ***** DEBTE ***** .L,0

***** DBUBTE *****

DATE 072184

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@ELT,L DD,DBUBTE
ELT 8R1 S74QIC 07/21/84 15:55:00 (0)
00      C      SUBROUTINE DBUBTE(IG,P,X,T,XV)
20      00      C
30      00      REAL*8 P,T,XV
31      00
40      00      C*** PURPOSE:
50      00      TO CALCULATE IN DOUBLE PRECISION A BUBBLE POINT
60      00      TEMPERATURE OF A NON-ARTICROPIK BINARY MIXTURE FROM GIVEN
70      00      PRESSURE AND COMPOSITION
80      00      C*** INPUT:
90      00      C      IG = 0, IF GUESS OF TEMPERATURE IS NOT GIVEN
100     00      C      = 1, IF GUESS OF TEMPERATURE IS GIVEN
110     00      C      P - PRESSURE (STD ATM)
120     00      C      T - GUESS OF TEMPERATURE, OPTIONAL (K)
130     00      C      X - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
140     00
150     00      C*** OUTPUT:
160     00      C      T - BINARY MIXTURE TEMPERATURE AT BUBBLE POINT (K)
170     00      C      XV - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
180     00      C      IN SAT. VACCR IN EQUILIBRIUM WITH LIQUID (-)
190     00
200     00      C*** SUBPROGRAMS CALLED BY DBUBTE:
210     00      EBUTE,DOLITY
220     00
221     00      REAL*8 SLOPE,TLAST,PLAST,XVLAST,XL,T1,T2,
222     00      *      XDIF1,XDIF2,DT,XQ
230     00      DATA SLOPE/0.0/,PLAST/0.0/,DO/
240     00
250     00      C      IF (ABS(P-PLAST).GT.1.E-4)GOTO 10
260     00      C      IF (ABS(X-XLAST).GT.1.E-3)GOTO 10
270     00      T=TLAST
280     00      XV=XVLAST
290     00      RETURN
300     00
302     00      C      PS=P
310     00      IF (IG.NE.1)T=ERUSTE(PS,X)
320     00      DO 50 I=1,20
330     00      CALL DOLITY(T,P,X,XQ,XV,XL)
340     00      T2=T
350     00      XDIF2=X-XL
360     00      IF (I.NE.1)GOTO 20
370     00      T1=T2
380     00      XDIF1=XDIF2
390     00      IF (SLOPE.NE.0.)THEN
400     00      DT=XDIF2*SLOPE
410     00      IF (ABS(DT).GT.10.)DT=SIGN(10.,DT)
420     00      T=T2-DT
430     00      GO TO 50
440     00
450     00      END IF
460     00      T=T2+5.
470     00      IF (XDIF2.GT.0.)T=T2-5.
480     00      GO TO 50
490     00
500     00      C      20 IF (XDIF1.EQ.XDIF2)GOTO 15
500     00      SLOPE=(T2-T1)/(XDIF2-XDIF1)
500     00      IF (DABS(XDIF1).LT.DABS(XDIF2))GOTO 30
510     00

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DATE 072184

***** DBUBTE *****

```
520.      00          T1=T2
530.      00          XDIF1=XDIF2
540.      00          DT=XDIF1*SLOPE
550.      00          IF( DABS(DT) .LT. 0.000001 ) GOTO 100
560.      00          IF( ABS(DT) .GT. 10. ) DT=SIGN(10.)DT
570.      00          T=T1-DT
580.      00          CONTINUE
590.      00          WRITE(6,600)XDIF2
600.      00          FORMAT(' ERROR 600 IN DBUBTE, XDIF2= ',1PE12.4)
610.      00          100 PLAST=P
620.      00          XLAST=X
630.      00          TLAST=T
640.      00          XVILAST=XV
650.      00          RETURN
660.      00          END

END ELT.  ERRORS: NONE.  TIME: 0.131 SEC.  IMAGE COUNT: 71
@HDDG,P ***** DDENFA ***** .L,0
```

***** DDENFA *****

```

@EELT,L DD.DDENFA
ELT BR1 S7AQ1C 07/21/84 15:55:00 (0)
10.    00      DOUBLE PRECISION FUNCTION DDENFA(XM,P,HO,G3)
20.    00
30.    00      C**** PURPOSE:
40.    00      C      TO CALCULATE IN DOUBLE PRECISION
50.    00      C      DENSITY OF NON-AZOTRIC TWO-PHASE MIXTURE
60.    00      C      IN THE FANNO FLOW FOR A GIVEN PRESSURE
70.    00
80.    00      C**** INPUT DATA:
90.    00      C      HO      - REFRIG. TOTAL ENTHALPY (BTU/LM)
100.   00      C      GG      = G*(64.4*778.104) (BTU*LM/FT**6)
110.   00      C      P      WHERE G = REFRIG. MASS FLUX (LM/(SEC*FT**2))
120.   00      C      XM      - REFRIG. PRESSURE AT WHICH DENSITY IS DESIRED (PSIA)
130.   00      C      XM      - MOLE COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
140.   00      C**** OUTPUT DATA:
150.   00      C      DDENFA - DENSITY (BTU/LM R)
160.   00
170.   00      C**** SUBPROGRAMS CALLED BY DDENFA:
180.   00      C      DVUBTE,DH,DOLITY,DVOL1,FUBTE,VISCON
190.   00
200.   00      C      REAL*8 DH,DVOL1
210.   00      C      REAL*8 SLOPE,TKD,XVB,PA,TK2,YQ,XV,VNL,VML,HL,HFG,
220.   00      C      *VMV,VML,VL,VFG,R,S,C,XQ,DIFXQ2,DIFXQ1,TK1
230.   00      C      COMMON/RDATA2/W1,W2,TC1,TC2
240.   00      C      DATA SLOPE/O.DO/NO,N1/O,1/
250.   00
260.   00      C      IF(P.GT.0.)GOTO 10
270.   00      C      WRITE(6,600)P
280.   00      C      600 FORMAT(' ERROR IN CALLING DDENFA, P=',1PE15.5,' PSIA')
290.   00      C      RETURN
300.   00
310.   00      C      10 PA=P/14.6959
320.   00      C      CALL DVUBTE(NO,PA,XM,TK3,XVB)
330.   00      C      TKD=TKB+9.5-20.*(.55-XM)
340.   00      C      TK2=0.9*TKB+0.1*TKD
350.   00      C      DO 100 I=1,20
360.   00      C      IF (TK2.LT.TKB)THEN
370.   00      C      TK2=TKB
380.   00      C      XL=XM
390.   00      C      XV=XVB
400.   00      C      YQ=0.0D0
410.   00
420.   00      C      CALL DOLITY(TK2,PA,XM,YQ,XV,XL)
430.   00
440.   00      END IF
450.   00      C      VNV=DVOL1(N1,TK2,PA,XV)
460.   00      C      HV=DH(TK2,VNV,XV)
470.   00      C      VNL=DVOL1(N0,TK2,PA,XL)
480.   00      C      HLL=DH(TK2,VNL,XL)
490.   00      C      HFG=HV-HL
500.   00      C      WMV=W1*(1.-XV)*M2*XV
510.   00      C      WML=W1*(1.-XL)*M2*XL
520.   00      C      VV=VNV*16.01846/VNV
530.   00      C      VL=VNL*16.01846/VNL
540.   00      C      VFG=VV-VL
550.   00      C      R=GG*VFC*VFG
560.   00      C      S=2.*GG*VL*VFG+HFG
      C=GG*VL*VL+HL-HL

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DATE 072184

DDENFA *****

```
570.    00      XQQ=(-S+DSQRT(S*S-4.*R*C))/(2.*R)
580.    00      DIFXQ2=XQQ-XQ
590.    00      IF(ABS(XQ).LT.1.E-5.AND.RAS(XQQ).LT.1.E-5)GOTO 105
600.    00      IF(XQ.EQ.0.00.AND.XQQ.LT.0.)GOTO 110
610.    00      IF(DABS(DIFXQ2).LT.5.E-8)GOTO 105
620.    00
C       00      IF(L.GT.1)GOTO 70
      00      TK1=TK2
      00      DIFXQ1=DIFYQ2
      00      IF(SLOPE.NE.0.DO)THEN
          00      TDEL=DIFXQ2*SLOPE
          00      TD=ABS(TDEL)
          00      TD=AMIN1(2.,TD)
          00      TK2=TK1-SIGN(TD,TDEL)
      ELSE
          00      TK2=TK1+SIGN(1.,DIFXQ2)
      END IF
      00      GOTO 100
C       70      SLOPE=(TK2-TK1)/(DIFXQ2-DIFXQ1)
      00      IF(ABS(XQ).LT.1.E-3)GOTO 75
      00      IF(DARS(DIFXQ1).LT.DARS(DIFXQ2))GOTO 80
      75      TK1=TK2
          00      DIFXQ1=DIFXQ2
          00      TK2=TK1-DIFYQ1*SLOPE
          00      CONTINUE
          00      PRINT 602,DIFXQ2,XQ
          00      602 FORMAT('DDENFA DOES NOT CONVERGE, DIFXQ2= ',1PE13.4,
          1,   XQ= ,1PE13.4)
          00      105 XQ=0.5*(XQ+XCQ)
          00      110 CONTINUE
          00      DDENFA=1./(VL+XQ*VFG)
          00      RETURN
          00      END
END ELT.  ERRORS: NONE. TIME: 0.155 SEC. IMAGE COUNT: 90
@HDG,P ***** DDEWTE ***** .L,0
```

***** DDEWTE *****

DATE 072184

```
©ELT,L DD DDEWTE
ELT 8R1 S74Q1C 07/21/84 15:55:00 (0)
10.    00      SUBROUTINE DDEWTE(IG,P,X,T,XL)
20.    00
30.    00      C      REAL*8 P,T,XL
40.    00      C*** PURPOSE:
50.    00      C      TO CALC. IN DOUBLE PRECISION A NEW POINT TEMPERATURE
60.    00      C      OF A NON-AZEOTROPIC MIXTURE FROM GIVEN PRESSURE
70.    00      C      AND COMPOSITION
80.    00
90.    00      C*** INPUT:
100.   00      C      IG = 0,   IF GUESS OF TEMPERATURE IS NOT GIVEN
110.   00      C      = 1,   IF GUESS OF TEMPERATURE IS GIVEN
120.   00
130.   00      C      P - PRESSURE (STD ATM)
140.   00      C      T - GUESS OF TEMPERATURE, OPTIONAL (K)
150.   00      C      X - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
160.   00
170.   00      C*** OUTPUT:
180.   00      C      T - BINARY MIXTURE TEMPERATURE AT DEV POINT (K)
190.   00      C      XL - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
200.   00      C      IN SAT. LIQUID IN EQUILIBRIUM WITH VAPOUR (-)
210.   00
220.   00      C*** SUBPROGRAMS CALLED BY DDFWTE:
230.   00      C      EBUBTE,DCLITY
240.   00
250.   00      C      REAL*8 SLOPE,TLAST,PLAST,XLLAST,XV,T1,T2,
260.   00      C      *      XDIF1,XDIF2,DT,XQ
270.   00
280.   00      C      DATA SLOPE/0.D0/,PLAST/0.D0/
290.   00
300.   00      C      IF(DABS(P-PLAST).GT.1.E-4)GOTO 10
310.   00      C      IF(DABS(X-XLAST).GT.1.E-3)GOTO 10
320.   00      C      T=TLAST
330.   00      C      XL=XLLAST
340.   00      C      RETURN
350.   00
360.   00      C      10 IF(IG.NE.1)THEN
363.   00      PS=P
364.   00      TS=EBUBTE(FS,X)+9.5-20.*(.55-X)
372.   00      T=TS
374.   00      END IF
380.   00      DO 50 I=1,20
390.   00      CALL DCLITY(T,P,X,XQ,XV,XL)
400.   00      T2=T
410.   00      XDIF2=X-XV
420.   00      IF(I.NE.1)GOTO 20
430.   00
440.   00      15      XDIF1=XDIF2
450.   00      IF(SLOPE.NF.0.)THEN
460.   00      DT=XDIF2*SLOPE
470.   00      IF(DABS(DT).GT.10.)DT=SIGN(10.,DT)
480.   00      T=T2-DT
490.   00      GOTO 50
500.   00
510.   00      END IF
520.   00      T=T2+5.
530.   00      IF(XDIF2.LT.0.)T=T2-5.
      GOTO 50
      00
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DATE 072184

***** DDEVENTE *****

```
540.      00      C      20 IF(XDIF1.EQ.XDIF2)GOTO 15
550.      00
560.      00      SLOPE=(T2-T1)/(XDIF2-XDIF1)
570.      00      IF(DABS(XDIF1).LT.DABS(XDIF2))GOTO 30
580.      00      T1=T2
590.      00      XDIF1=XDIF2
600.      00      DT=XDIF1*SLOPE
610.      00      IF(DABS(DT).LT.0.000001)GOTO 100
620.      00      IF(DABS(DT).GT.10.)DT=SIGN(10.,DT)
630.      00      T=T1-DT
640.      00      COUNTINUE
650.      00      WRITE('6,600)IG,P,X,XDIF2
660.      00      600 FORMAT(' DDEVENTE DID NOT CONVERGE ',' 16,P,X,XDIF2: ',14,4F8.3)
670.      00      100 PLAST=P
680.      00      XLAST=X
690.      00      TLAST=T
700.      00      XLLAST=XL
710.      00      RETURN
720.      00      END

END ELT.  ERRORS: NONE. TIME: 0.141 SEC. IMAGE COUNT: 75
@HDG,P ***** DENTRO ***** .L.O
```

***** DENTRO *****

```
©ELT,L DD.DENTRO
ELT 8R1 S74Q1C 07/21/84 15:55:01 (0)
      00  DOUBLE PRECISION FUNCTION DENTRO( T,V,X )
      10.   00
      20.   00
      30.   00
      40.   00
      50.   00
      60.   00
      70.   00
      80.   00
      90.   00
     100.   00
     110.   00
     120.   00
     130.   00
     140.   00
     150.   00
     160.   00
     170.   00
     180.   00
     190.   00
     200.   00
     210.   00
     220.   00
     230.   00
     240.   00
     250.   00
     260.   00
     270.   00
     280.   00
     290.   00
     300.   00
     310.   00
     320.   00
     330.   00
     340.   00
     350.   00
     360.   00
     370.   00
     380.   00
     390.   00
     400.   00
     410.   00
     420.   00
     430.   00
     440.   00
     450.   00
     460.   00
     470.   00

      C*** PURPOSE:
      C   TO CALCULATE IN DOUBLE PRECISION REFICERATEY ENTROPY

      C*** INPUT:
      C   T - REFRIG. TEMPERATURE (K)
      C   V - REFRIG. SPEC. VOLUME (L./MOL)
      C   W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT (G)
      C   W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT (G)
      C   X - MOLECULAR CONCENTRATION OF A LESS VOLATILE REFRIG. (-)
      C   * - CONSTANTS A,B,C1,D1, AS PER COMMON STATEMENT /PARAM/
      C*** OUTPUT:
      C   DENTRO - ENTROPY (BTU/(LB*F))

      C*** SUBPROGRAMS CALLED BY DENTRO:
      C   HPAR

      REAL*8 W1,CONV,S
COMMON/PARAM/A,B,C1,C2,D1,D2
COMMON/RDATA2/W1,W2
DATA R/0.08206/
      C
      WM=(1.-X)*W1+X*W2
      CONV:=453.5924/(1.055056*UM)
      IQ=1
      TK=T
      XM=X
      CALL HPAR(IQ,TK,XM)
      S=(C1*B-A*D1)/B**2*DLOG((V+R)/V)+A*D1/B/(V+B)
      S=S-R*B/A./(V-B/4.)*2*(1.*V-3*B/4.)
      S=S-R*T*D1*V/2./(V-B/4.)*3*(2.*V-B/4.)
      S=S+(1.-X)*0.320937932921*X*0.401655769501
      S=S+R*(X*DLOG(V/0.0632978)+(1.-X))*DLNG(V/0.0776799)
      S=0.101325*S
      S=S+(0.0116393*(1.-X)+0.013956*X)*DLNG(T/233.15)
      S=S+(2.163944E-4*(1.-X)+1.540053E-4*X)*(T-233.15)
      S=S-(3.512035E-8*(1.-X)+1.53352E-9*X)*(T*2-233.15**2)
      IF(X.EQ.1.D0.OR.X.EQ.0.D0)GOTO 1000
      S=S-0.101325*R*(X*DLOG(X)+(1.-X))*DLNG(1.-X)
      1000 DENTRO=S*CONV/1.8
      RETURN
      END

END ELT.  ERRORS: NONE. TIME: 0.09 SEC. IMAGE COUNT: 47
©HDC,P ***** DEPRE ***** L,O
```

***** DEWPRE *****

DATE 072184

```
©ELT,L DD,DEWPRE
ELT 8R1 S74Q1C 07/21/84 15:55:01 (0)
          00      SUBROUTINE DEWPRE(IG,T,X,P,XL)
          00
          00      C
          00      C
          00      C*** PURPOSE:
          00      C      TO CALC. DEW POINT PRESSURE OF BINARY MIXTURE
          00      C      FROM GIVEN TEMPERATURE AND COMPOSITION
          00
          00      C*** INPUT:
          00      C      IG = 0, IF GUESS OF PRESSURE IS NOT GIVEN
          00      C      = 1, IF GUESS OF PRESSURE IS GIVEN
          00      C      P - GUESS OF PRESSURE, OPTIONAL (STD ATM)
          00      C      T - TEMPERATURE (K)
          00      C      X - MOLEAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
          00
          00      C*** OUTPUT:
          00      C      P - BINARY MIXTURE PRESSURE AT BUBBLE POINT (STD ATM)
          00      C      XL - MOLEAR CONCENTRATION OF LESS VOLATILE COMPONENT
          00      C      IN SAT. LIQUID IN EQUILIBRIUM WITH VAPOR (-)
          00
          00      C*** SUBPROGRAMS CALLED BY DEWPRE:
          00      C      EBUBPR, QLITY
          00
          00      DATA SLOPE/0./,TLAST/0./
          00
          00      IF(ABS(T-TLAST).GT.1.E-3)GOTO 10
          00      IF(ABS(X-XLAST).GT.1.E-3)GOTO 15
          00      P=PLAT
          00      XL=XLLAST
          00      RETURN
          00
          00      C      10  IF(IG.NE.1)THEN
          00      P=EBUBPR(T,X)
          00      P=P-(T-255.)*0.16*X*(1.-X)
          00
          00      END IF
          00      DO 50 I=1,20
          00      CALL QLITY(T,P,X,XQ,XV,XL)
          00      P2=P
          00      XDIF2=X-XV
          00      IF(ABS(XDIF2).LT.0.00001)GOTO 100
          00      IF(I.NE.1)GOTO 20
          00      P1=P2
          00      XDIF1=XDIF2
          00      IF(SLOPE.NE.0.)THEN
          00      DP=XDIF2*SLOPE
          00      IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)
          00      P=P2-DP
          00      GOTO 50
          00
          00      END IF
          00      P=P2+0.5
          00      IF(XDIF2.GT.0.)P=P2-0.5
          00      GOTO 50
          00
          00      C      20  IF(XDIF1.EQ.XDIF2)GOTO 15
          00      SLOPE=(P2-P1)/(XDIF2-XDIF1)
          00      IF(ABS(XDIF1).LT.ARS(XDIF2))GOTO 30
          00
          00      P1=P2
```

```

***** DEWPRE *****
      570.      00      XDIF1=XDIF2
      580.      00      DP=XDIF1*SLOPE
      590.      00      IF(ACS(DP).GT.'.')DP=SIGN(1.,DP)
      600.      00      P=P1-DP
      610.      00      CONTINUE
      620.      00      WRITE(6,GRO)XDIF2
      630.      00      600 FORMAT(' ERROR 600 IN DEWPRE, XDIF2= ',1PE12.4)
      640.      00      100 TLAST=T
      650.      00      XLAST=X
      660.      00      PLAST=P
      670.      00      XLLAST=XL
      680.      00      RETURN
      690.      00      END

END ELT.  ERRORS: NONE.  TIME: 0.130 SEC.  IMAGE CCUNT: 69
@HDG,P ***** DEWTEM ***** .L,O

```

***** DEWTEM *****

```
©ELT,L DD.DEWTEM
ELT 8RI S74Q1C 07/21/84 15:55:01 (O)
          00  SUBROUTINE DEWTEM(IG,P,X,T,XL)

20.      00
30.      00
40.      00
50.      00
60.      00
70.      00
80.      00
90.      00
100.     00
110.     00
120.     00
130.     00
140.     00
150.     00
160.     00
170.     00
180.     00
190.     00
200.     00
210.     00
220.     00
230.     00
240.     00
250.     00
260.     00
270.     00
280.     00
290.     00
300.     00
310.     00
320.     00
330.     00
340.     00
350.     00
370.     00
380.     00
390.     00
400.     00
410.     00
420.     00
430.     00
440.     00
450.     00
460.     00
470.     00
480.     00
490.     00
500.     00
510.     00
520.     00
530.     00
540.     00
550.     00
551.     00
560.     00

        C*** PURPOSE:
          C   TO CALC. DEW POINT TEMPERATURE OF BINARY MIXTURE
          C   FROM GIVEN PRESSURE AND COMPOSITION
          C
          C*** INPUT:
          C   IG = 0, IF GUESS OF TEMPERATURE IS NOT GIVEN
          C   = 1, IF GUESS OF TEMPERATURE IS GIVEN
          C   P - PRESSURE (STD ATM)
          C   T - GUESS OF TEMPERATURE, OPTIONAL (K)
          C   X - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)

          C*** OUTPUT:
          C   T - BINARY MIXTURE TEMPERATURE AT DEW POINT (K)
          C   XL - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
          C   IN SAT. LIQUID IN EQUILIBRIUM WITH VAPOR (-)
          C
          C*** SUBPROGRAMS CALLED BY DEWTEM:
          C   EBUBTE, QLITY
          C
          C   DATA SLOPE/0./,PLAST/0./
          C
          C   IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
          C   IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
          T=TLAST
          XL=XLLAST
          RETURN
          C
          C   10 IF((IG.NE.1)T=EBUBTE(P,X):9.5-20.*(.55-X)
          DO 50 I=1,20
          CALL QLITY(T,P,X,XQ,XV,XL)
          T2=T
          XDIF2=X-XV
          IF(I.NE.1)GOTO 20
          15 T1=T2
          XDIF1=XDIF2
          IF(SLOPE.NE.0.)THEN
            DT=XDIF2*SLOPE
            IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
            T=T2-DT
            GOTO 50
          END IF
          T=T2+5.
          IF(XDIF2.LT.0.)T=T2-5.
          GOTO 50
          C
          C   20 IF(XDIF1.EQ.XDIF2)GOTO 15
          SLOPE=(T2-T1)/(XDIF2-XDIF1)
          IF(Abs(XDIF1).LT.AR5(XDIF2))GOTO 30
            T1=12
            XDIF1=XDIF2
          30 DT=XDIF1*SLOPE
            IF(Abs(DT).LT.0.003)GOTO 100
            IF(Abs(DT).GT.10.)DT=SIGN(10.,DT)
```

```

***** DENTEM *****
      570.          00      T=T1-DT
      580.          00      50 CONTINUE
      590.          00      WRITE(6,600)IG,P,X,XDIF2
      600.          00      600 FORMAT(' DEWTEM DID NOT CONVERGE' ,/, 1G,P,X,XDIF2,14,4F8.3)
      610.          00      100 PLAST=P
      620.          00      XLAST=X
      630.          00      TLAST=T
      640.          00      XLLAST=XL
      650.          00      RETURN
      660.          00      END

END ELT.  ERRORS: NONE. TIME: 0.127 SEC. IMAGE COUNT: 66
@HDG,P  ***** DFANNO ***** .L,O

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***** DFANNO *****

DATE 072184

```
@ELT,L DD.DFANNO
ELT 8RI S7401C 07/21/84 15:55:02 (0)
      DOUBLE PRECISION FUNCTION DFANNO(X1,P,HO,GG)

10.    00      C
20.    00      C
30.    00      C*** PURPOSE:
40.    00      C   TO CALCULATE IN DOUBLE PRECISION
50.    00      C   ENTROPY OF NON-AZENTROPIC TWO-PHASE MIXTURE
60.    00      C   IN THE FANNO FLOW FOR A GIVEN PRESSURE
70.    00      C
80.    00      C*** INPUT DATA:
90.    00      HO = REFRIG. TOTAL ENTHALPY (BTU/LM)
100.   00      GG = G*XG/(64.*773.104)^(BTU*LM/FT**6)
110.   00      C   WHERE G = REFRIG. MASS FLUX (LB/(SEC*FT**2))
120.   00      P = REFRIG. PRESSURE AT WHICH ENTROPY IS DESIRED (PSIA)
130.   00      XM = MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
140.   00      C*** OUTPUT DATA:
150.   00      DFANNO = ENTROPY (BTU/LM R)
160.   00      C
170.   00      C*** SUBPROGRAMS CALLED BY DFANNO:
180.   00      DBUBTE,DENTRO,DH,DQLITY,DVOL1,EBUBTE
190.   00      C
200.   00      REAL*8 DH,DVOL1
210.   00      REAL*8 SLOPE,TKB,XVB,PA,TK2,XQ,XV,XL,VML,HL,HFG,
220.   00      *VMV,WML,VV,VL,VFG,R,S,C,XQ,Q,DIFXQ1,DIFXQ2,TK1,SL,SV
230.   00      COMMON/RDATA2/W1,W2,TC1,TC2
240.   00      DATA SLOPE/0.D0/NO,N1/0./1/
250.   00      C
260.   00      IF(P.GT.0.)GOTO 10
270.   00      WRITE(6,600)P
280.   00      600 FORMAT(' ERROR IN CALLING DFANNO, P= ',1PE15.5,' PSIA')
290.   00      RETURN
300.   00      C
310.   00      PA=P/14.6959
320.   00      CALL DQBLTE(NO,PA,XM,TKB,XVB)
330.   00      TKD=TKB+9.5-20.*(.55-XM)
340.   00      TK2=0.9*TKB+0.1*TKD
350.   00      DO 100 I=1,20
360.   00      IF(TK2.LT.TKB)THEN
370.   00      TK2=TKB
380.   00      XL=XM
390.   00      XV=XVB
400.   00      XQ=0.D0
410.   00      ELSE
420.   00      CALL DQBLTY(TKB,PA,XM,XQ,XV,XL)
430.   00      END IF
440.   00      VMV=DVOL1(N1,TK2,PA,XV)
450.   00      HV=DH(TKB,VMV,XV)
460.   00      VML=DVOL1(NO,TK2,PA,XL)
470.   00      HL=DH(TKB,VML,XL)
480.   00      HFG=HV-HL
490.   00      WMV=W1*(1.-XV)+W2*XV
500.   00      WRL=W1*(1.-XL)+W2*XL
510.   00      VV=VMV*16.0184E/W1V
520.   00      VL=VML*16.0184E/W1L
530.   00      VRG=VV-VL
540.   00      RG=GG*VFG*VFG
550.   00      S=2.*GG*VL*V-TG+HFG
560.   00      C=GG*VL*VL+HL-HO
```

DFANNO *****

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570.      00      XQ0=(-S+D5QRT(S*S-4.*R*C))/(2.*R)
580.      00      DIFXQ?=(XQ-Q-XQ)
590.      00      IF(AE S/(XQ).LT.1.E-5.AND.ABS(XQ).LT.1.E-5)GOTO 105
600.      00      IF(XQ.EQ.0.D0.AND.XQ.LT.0.)GOTO 110
610.      00      IF(DABS(DIFXQ2).LT.5.E-8)GOTO 105
620.      00      C
630.      00      IF(I1.GT.1)GOTO 70
640.      00      TK1=TK2
650.      00      DIFXQ1=DIFXQ2
660.      00      IF(SLOPE.NE.0.DO)THEN
670.      00      TDEL=DIFXQ2*SLOPE
680.      00      TD=ABG(TDEL)
690.      00      TD=AFLIN(2.,TD)
700.      00      TK2=TK1-SIGN(TD,TDEL)
710.      00      ELSE
720.      00      TK2=TK1+SIGN(1.,D1FYQ2)
730.      00      END IF
740.      00      GOT0 100
750.      00      C
760.      00      70 SLOPE=(TK2-TK1)/(DIFXQ2-DIFXQ1)
770.      00      IF(ABS(XQ).LT.1.E-3)GOTO 75
780.      00      IF(DABS(DIFXQ1).LT.DABS(DIFXQ2))GOTO 80
790.      00      75 TK1=TK2
800.      00      DI=XQ1=DIFXQ2
810.      00      80 TK2=TK1-DIFXQ1*SLOPE
820.      00      130 CONTINUE
830.      00      PRINT 602,DIFXQ2
840.      00      602 FORMAT(' DFANNO DOES NOT CONVERGE, DIFXQ2=' ,1PE15.5)
850.      00      105 XQ=0.5*(XQ+XQQ)
860.      00      110 CONTINUE
870.      00      SL=DENTRO(TK2,VML,XL)
880.      00      SV=DENTRO(TK2,VMV,XV)
890.      00      DFANNO=(1.-XQ)*SL+XQ*SV
900.      00      RETURN
910.      00      END

END ELT.  ERRORS: NONE.  TIME: 0.140 SEC. IMAGE COUNT: 91
@HDG,P ***** DH **** * .L,0

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***** DH *****

DATE 072184

```
©ELT,L DD.DH
ELT 8R1 S74Q1C 07/21/84 15:55:02 (0)
      00      DOUBLE PRECISION FUNCTION DH(T,V,X)
      20.
      00      C
      30.    00      C REAL*B T,V,X
      40.    00      C **** PURPOSE:
      50.    00      C TO CALCULATE REFRIGERANT ENTHALPY
      60.    00      C IN DOUBLE PRECISION
      70.    00      C
      80.    00      C **** INPUT:
      90.    00      C   T - REFRIG. TEMPERATURE (K)
     100.   00      C   V - REFRIG. SPEC. VOLUME (L/MOL)
     110.   00      C   X - MOLEAR CONCENTRATION (FRACTION OF LESS VOLATILE REFRIG.)
     120.   00      C
     130.   00      C   W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT (G/MOL)
     140.   00      C   W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT (G/MOL)
     150.   00      C   * - CONSTANTS AS PER COMMON STATEMENT /PARAM/
     160.   00      C   A,B,C1,D1 FOR CALC. OF ENTALPY
     170.   00      C
     180.   00      C **** OUTPUT:
     190.   00      C   DH - ENTHALPY (BTU/LB)
     200.   00      C
     210.   00      C COMMON /PARAM/A,B,C1,C2,D1,D2
     220.   00      C COMMON /RDATA2/W1,W2
     230.   00      C REAL*8 WHDL,CONV,T2,T3
     240.   00      C DATA R/O .08206/
     250.   00      C
     260.   00      C **** SUBPROGRAMS CALLED BY HCVCP:
     270.   00      C   HPAR
     280.   00      C
     290.   00      C
     300.   00      C   TS=T
     310.   00      C   XS=X
     320.   00      C   CALL HPAR(1,TS,XS)
     330.   00      C   WHDL=(1.-X)*W1*X*W2
     340.   00      C   CONV=453.5924/(1.055056*MOL)
     350.   00      C   T2=T*T
     360.   00      C   T3=T2*T
     370.   00      C   DH=(C1*B*T-A*D1*T-A*B)/B**2*DI.06((V+B)/V)
     380.   00      C   DH=DH+(A*D1*T-A*B)/(D*(V+B))
     390.   00      C   DH=DH+2.*R*T*V*(2.*V-B/4.)/(V-B/4.)**3*(B/4.-D1*T/4.)
     400.   00      C   DH=0.101325*DH
     410.   00      C   DH=DH+(1.-X)*(0.0199537*(T-233.15)+1.081972E-04*(T2-233.15**2))
     420.   00      C   DH=DH-(1.-X)*(5.67469E-06*(T3-233.15**3))
     430.   00      C   DH=DH+(1.-X)*16.6976530393
     440.   00      C   DH=DH+X*(0.0222804*(T-233.15)+7.700465E-05*(T2-233.15**2))
     450.   00      C   DH=DH+X*(1.0222346E-03*(233.15**3-T3)+21.9460206504)
     460.   00      C   DI=DH*CONV
     470.   00      C   RETURN
     480.   00      C
END ELT.  ERRORS: NONE. TIME: 0.093 SEC. IMAGE COUNT: 48
©HDG,P ***** DPDYN1 ***** L,O
```

***** DP DPDYN1 *****

DATE 072184

```
@ELT,L DD DPDYN1
ELT 8R1 S74Q1C 07/21/84 15:55:02 (0)
      00 FUNCTION DPDYN1(F1,H1,P2,H2,RMS,D)
20.    00
30.    00 C**** PURPOSE:
40.    00   C TO CALCULATE DYNAMIC PRESSURE DROP IN A TUBE
50.    00   C FOR A NON-AZEOTROPIC MIXTURE SINGLE-PHASE FLOW
60.    00
70.    00 C**** INPUT DATA:
80.    00   C   D - TUBE DIAMETER (FT)
90.    00   C   H1 - REFRIG. ENTHALPY AT TUBE INLET (BTU/LBM)
100.   00   C   H2 - REFRIG. ENTHALPY AT TUBE OUTLET (BTU/LBM)
110.   00   C   P1 - REFRIG. PRESSURE AT TUBE INLET (PSIA)
120.   00   C   P2 - REFRIG. PRESSURE AT TUBE OUTLET (PSIA)
130.   00   C   RMS - REFRIG. MASS FLOW RATE (LBIN/H)
140.   00   C   NM - MOLECULAR WEIGHT (G/MOL)
150.   00   C   XM - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
160.
170.   00 C**** OUTPUT DATA:
180.   00   C DPDYN1 - DYNAMIC SINGLE-PHASE PRESSURE DROP (PSI)
190.   00 C**** SUBPROGRAMS CALLED BY DPDYN1:
200.   00   C HPIN
210.   00   C COMMON/RDATA3/XH,XM,WM
220.   00   C DIMENSION VL(2),VV(2)
230.   00
240.   00
250.   00
260.   00   C PA=P1/14.6959
270.   00   C H=H1
280.   00   C IG=0
290.   00   C DO 10 I=1,2
300.   00   C IF(I.EQ.2)THEN
301.   00   C   IG=1
302.   00   C   PA=P2/14.6959
303.   00   C   H=H2
304.   00
310.   00   C END IF
320.   00
330.   00   C 10 CALL HPIN(IG,H,PA,XM,0.005,T,XQ,XL,XV,VL(1),VV(1))
340.   00
350.   00   C IF(XG.GT.0)THEN
360.   00   C   DV=(VL(2)-VL(1))*16.01846/WM
370.   00
380.   00   C END IF
390.   00   C G=RMS/(0.7853982*D*D)
400.   00   C G=G*G/(32.2*144.*3500.*3600.)
410.   00   C DPDYN1=G*D
420.   00
END ELT.  ERRORS: NONE. TIME: 0.097 SEC. IMAGE COUNT: 46
@HDG,P **** DP DPDYN2 **** .L,0
```

***** DP DYN2 *****

DATE 072184

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@ELT,L DD.DPDYN2
ELT 8R1 S7401C 07/21/84 15:55:03 (0)
      00   FUNCTION DPDYN2(P1,T1,P2,T2,RMS,DI)

10.    00
20.    00
30.    00
40.    00
50.    00
60.    00
70.    00
80.    00
90.    00
100.   00
110.   00
120.   00
130.   00
140.   00
150.   00
160.   00
170.   00
180.   00
190.   00
200.   00
210.   00
220.   00
230.   00
240.   00
250.   00
260.   00
270.   00
280.   00
290.   00
300.   00
310.   00
320.   00
330.   00
340.   00
350.   00
360.   00
370.   00
380.   00
390.   00
400.   00
410.   00
420.   00
430.   00
440.   00
450.   00
460.   00
470.   00
480.   00
490.   00
500.   00
510.   00
520.   00
530.   00
540.   00
550.   00

C**** PURPOSE:
C      TO CALCULATE DYNAMIC PRESSURE DROP IN A TUBE
C      FOR A TWO-PHASE FLOW OF NON-AZEOTROPIC MIXTURE
C**** INPUT DATA:
C      DI      - TUBE INNER DIAMETER (FT)
C      PI      - REFRIG. PRESSURE AT TUBE INLET (PSIA)
C      P2      - REFRIG. PRESSURE AT TUBE OUTLET (PSIA)
C      T1      - REFRIG. TEMPERATURE AT TUBE INLET (F)
C      T2      - REFRIG. TEMPERATURE AT TUBE OUTLET (F)
C      RMS     - MASS FLOW RATE (LBIN/H)

C**** OUTPUT DATA:
C      DPDYN2 - DYNAMIC TWO-PHASE PRESSURE DROP (PSIA)

C**** SUBPROGRAMS CALLED BY DPDYN2:
C      QLITY, VISCOS, VOLIT1

COMMON/RDATA2/W1,W2,TC1,TC2
COMMON/RDATA3/XM,X1,WM
DIMENSION END(12)

C
AREA=3.145927*DI*DI/4.
G=RMS/AREA/3600.
PA=P1/14.6359
TK=(T1+459.67)/1.8
T=T1
DO 100 I=1,2
IF(I.EQ.2)THEN
PA=P2/14.6359
TK=(T2+459.67)/1.8
T=T2
END IF
CALL QLITY(TK,PA,XM,XQ,XV,XL)
CALL VOLIT1(0,TK,PA,XL,VM)
WMOL=W1*(1.-XL)+W2*XL
VL=16.01646*VM/WMOL
XWL=XL/(W1/42*(1.-XL)+XL)
VISL=VISCOS(1,T,XW1)
CALL VOLIT1(1,TK,PA,XV,V1)
WHCL=W1*(1.-XV)+W2*XV
VV=16.01646*VM/WMOL
XWV=XV/(W1/W2*(1.-XV)+XV)
VISV=VISCOS(3,T,XWV)
XTT=((1.-XQ)/XQ)**0.9*(VISL/VISV)**0.1
XTT=XTT*(VL/VV)**0.5
VQD=(1.+XTT**0.6)**(-.378)
IF(XTT.GT.10.)VQD=0.823-0.57*LOG(XTT)
END(1)=VV*XQ*XQ/VQD+VL*(1.-XQ)**2/(1.-VQD)
CONTINUE
DPDYN2=G*G*(END(2)-END(1))/144./32.2
RETURN
END

```

***** DOLITY *****

DATE 072184

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@ELT,L DD DOLITY
ELT 8R1 S74Q1C 07/21/84 15:55:03 (O)
10.    00      SURROUNTING DOLITY(T,P,X,XQ,XV,XL)
20.    00
30.    00
40.    00      REAL*X T,P,XQ,XV,XL
50.    00
60.    00      C**** PURPOSE:
70.    00      C TO CALCULATE QUALITY OF A BINARY FLUID
80.    00      C IN DOUBLE PRECISION
90.    00      C**** INPUT:
100.   00      P - PRESSURE (STD ATM)
110.   00      T - TEMPERATURE (K)
120.   00      X - MOLAR CONCENTRATION OF A LESS VOLATILE
130.   00      COMPONENT (-)
140.   00
150.   00      C**** OUTPUT:
160.   00      XL - MOLAR CONCENTRATION AT BUBBLE POINT (-)
170.   00      XQ - FLUID QUALITY (-)
180.   00      XV - MOLAR CONCENTRATION AT DEW POINT (-)
190.   00
200.   00
210.   00      REAL*X8 T2,P1,P2,RP,SEG0,SEG8,SEG9,SEG,Z0,Z1,Z2,Z
220.   00
230.   00
240.   00      T2=T*T
250.   00      P1=10.0522804-2204.5632/T+9636.5313/T2
260.   00      P1=DEXP(F1)
270.   00      P2=10.6410518-2642.8984/T+450.87535/T2
280.   00      P2=DEXP(F2)
290.   00      IF(P.GE.P1)THEN @FLUID IS LIQUID AT ALL CONCENTRATIONS
300.   00      XQ=0. DO
310.   00      XL=0. DO
320.   00      XV=0. DO
330.   00      GOTO 1000
340.   00
350.   00      IF(P.L.E.P2)THEN @FLUID IS VAPOR AT ALL CONCENTRATIONS
360.   00      XL=1. DO
370.   00      XQ=1. DO
380.   00      XV=1. DO
390.   00      GOTO 1000
400.   00
410.   00      RP=(P1-P)/(P1-P2)
420.   00      SEG0=12.58741-0.06165226,T+9.53391E-5*T2
430.   00      SEG8=-43.8799+0.232414*T-4.530495E-4*T2
440.   00      SEG9=47.7509-0.273093*T+4.14487E-4*T2
450.   00      SEG=SEG0+SEG8*RF+SEG9*RF**2
460.   00      Z0=-0.34G65415-3.327532E-3*T+9.66115E-6*T2
470.   00      Z1=-10.3139754+0.0653356*T-9.9829162E-5*T2
480.   00      Z2=10.035917-0.05527259*T+7.6321554E-5*T2
490.   00      Z=1.+Z0*(RF-1.)+Z1*(RF**2-1.)+Z2*(RF**3-1.)
500.   00      XL=(1.+SEG)*RF/(1.+SEG*RF) @SAT. LIQUID COMPOSITION
510.   00      XV=XL*Z
520.   00      XQ=(XL-X)/ (XL-XV)
530.   00      IF(XQ.GE.1.0)XQ=1.0
540.   00      IF(XQ.LT.0.0)XQ=0.0
550.   00      1000 RETURN
560.   00

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***** DVOL1 *****

```

@ELT,L DD,DVOL1
ELT 8R1 S7AQIC 07/21/84 15:55:03 (0) DOUBLE PRECISION FUNCTION DVOL1(N,T,P5,X)
10. 00 C
20. 00 C
30. 00 C
40. 00 C
50. 00 C
60. 00 C
70. 00 C
80. 00 C
90. 00 C
100. 00 C
110. 00 C
120. 00 C
130. 00 C
140. 00 C
150. 00 C
160. 00 C
170. 00 C
180. 00 C
190. 00 C
200. 00 C
210. 00 C
220. 00 C
230. 00 C
240. 00 C
250. 00 C
260. 00 C
270. 00 C
280. 00 C
290. 00 C
300. 00 C
310. 00 C
320. 00 C
330. 00 C
340. 00 C
350. 00 C
360. 00 C
370. 00 C
380. 00 C
390. 00 C
400. 00 C
420. 00 C
430. 00 C
440. 00 C
450. 00 C
460. 00 C
470. 00 C
480. 00 C
490. 00 C
500. 00 C
510. 00 C
520. 00 C
530. 00 C
540. 00 C
550. 00 C
560. 00 C
570. 00 C

C**** PURPOSE:
C TO ITERATE REFRIG. MIXTURE R-13B1/R-152A SPEC. VOL.
C FROM EQUATION OF STATE IN DOUBLE PRECISION
C
C**** INPUT:
C N - OUTPUT QUALIFIER
C = 0, IF SPEC. VOL. OF LIQUID IS REQUIRED
C = 1, IF SPEC. VOL. OF VAFOUR IS REQUIRED
C T - REFRIG. TEMPERATURE (K)
C P5 - REFRIG. SAT. PRESSURE (STD ATM)
C X - MOLAR COMPOSITION (FRACTION OF LEAST VOLATILE COMPONENT)
C * - REFRIG. CONSTANTS A & B (SEE COMMON STATEMENT /PARAM/)

C**** OUTPUT:
C DVOL1 - REFRIG. SPEC. VOLUME (L/MOL)
C
C**** SUBPROGRAMS CALLED BY DVOL1:
C ESVAL, EQPAR
C
REAL*8 Y,Y2,Y3,Y4,P,PO,P6,V6,V7,V
COMMON//PARAM//A,B,C1,C2,D1,D2
DATA R/0.08206/
C
IF(P5.GT.0.)GOTO 10
PRINT 601,P5
601 FORMAT(' DVOL1 CALLED WITH NEG. PRESSURE, P5= ',1PD13.3)
DVOL1=1.D0
GOTO 1000
C
10 IF(T.LT.220.)PRINT 602,T
602 FORMAT(' WARNING, DVOL1 CALLED WITH TEMP.= ',1PD13.3)
C
10 TS=T
P5=P5
XS=X
V=ESVAL(N,TS,P5,XS)
CALL EQPAR(TS,XS)
DO 100 I=1,15
Y=B/(4.*V),
Y2=Y*Y
Y3=Y2*Y
Y4=Y3*Y
P=(R*T*(1.+Y+Y2-Y3)/(1.-Y)**3-N/(V+B))/V
P6=(P5-P)/P5
IF(DABS(P6).LT.1.D-7)GOTO 200
P0=-R*T/V**2*(1.+4.*Y+4.*Y2-4.*Y3+Y4)/(1.-Y)**4
P0=P0+A*(2.*V+B)/(V*(V+B))**2
V6=(P-P5)/P0
V7=V-V6
IF(V7.GT.(B/4.))GOTO 50
V=V-(V-B/4.)/10.
GOTO 100
C

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DATE 072184

V=V-(V-B/A.)/10.
GOTO 100
00
00
560.
570.

```
***** DVQL1 *****  
580.      00      50 V=V7  
590.      00      100 CONTINUE  
600.      00      WRITE(5,600)P6  
610.      00      600 FORMAT(5,600)P6  
620.      00      600 FORMAT(5,600)P6  
630.      00      200 DVOL1=V  
640.      00      1000 RETURN  
          END  
  
END ELT.  ERRORS: NONE.  TIME: 0.119 SEC. IMAGE COUNT: 63  
©Hdg,p  ***** ERUBPR ***** .L,0
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***** EBUBPR *****

```
©ELT_L DD.EBUBPR
ELT 8R1 S74Q1C 07/21/84 15:55:04 (0)
      00 FUNCTION EBUBPR(TK,XM)
10.   00
20.   00 C
30.   00 C
40.   00 C***PURPOSE:
50.   00 C ESTIMATE BUBBLE POINT PRESSURE OF MIXTURE
60.   00 C FROM GIVEN TEMPERATURE AND COMPOSITION
70.   00 C
80.   00 C***INPUT:
90.   00 C TK - TEMPERATURE (K)
100.  00 C XM - COMPOSITION (MOLE FRACTION OF LESS VOLATILE COMPONENT)
110.  00 C
120.  00 C*** OUTPUT:
130.  00 C EBUBPR - ESTIMATE OF BUBBLE POINT PRESSURE (STD ATM)
140.  00 C
150.  00 C COMMON/RDATA/2/W1,W2,TC1,TC2
160.  00 C COMMON/ESDATA/Λ(2,3),R(2,3),C(2,3)
161.  00 C DIMENSION P(2)
170.  00 C
180.  00 C
190.  00 C TK2=TK*TK
200.  00 DO 10 I=1,2
210.  00 P(I)=EXP(A(I,1)+A(I,2)/TK+Λ(I,3)/TK2)
220.  00 C*** WEIGHT COMPOSITION
230.  00 XM=XM/(W1*W2*(1.-XM)+XM)
240.  00 C*** INTERPOLATE
250.  00 EBUBP=P(1)*(1.-XM)+P(2)*XM
260.  00 RETURN
270.  00
END ELT.  ERRORS: NONE.  TIME: 0.080 SEC. IMAGE COUNT: 28
©HDG,P ***** EBUBTE ***** .L,0
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DATE 072184

***** EBUBTE *****

DATE 072184

```
@ELT,L DD EBUBTE
ELT 8R1 S74Q1C 07/21/84 15:55:04 (0)
10.      00      FUNCTION EBUBTE(P,X)
20.      00      C
30.      00      C*** PURPOSE:
40.      00      C   TO ESTIMATE EBUBL E POINT TEMP. OF A MIXTURE
50.      00      C   FROM GIVEN PRESSURE AND COMPOSITION
60.      00      C
70.      00      C*** INPUT:
80.      00      C   P - PRESSURE (STD. ATM)
90.      00      C   X - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
100.     00      C
110.     00      C*** OUTPUT:
120.     00      C   EBUBTE - ESTIMATE OF EBUBL E POINT TEMPERATURE (K)
130.     00      C
140.     00      C
150.     00      C   DIMENSION PS(2), XW(2)
160.     00      C   CCMN/RDATA2/W1,W2,TC1,TC2
161.     00      C   CCMN/ESDATA/A(2,3),R(2,3),C(2,3)
180.     00      C
190.     00      C   XW(2)=W1/W2*(1.-X)+X
200.     00      C   XW(2)=X/XW(2)
210.     00      C   XW(1)=1.-XW(2)
220.     00      C   T=280.
230.     00      C   DO 50 N=1,10
240.     00      C   T2=T*T
250.     00      C   DO 10 I=1,2
260.     00      C   PS(I)=XW(I)*EXP(A(I,1)+A(I,2)/T+A(I,3)/T2)
270.     00      C   PDELT A=PS(1)+PS(2)-P
280.     00      C   IF (ADS(PDELT A).LT.0.1)GOTO 100
290.     00      C   T3=T2*T
300.     00      C   DP=0.
310.     00      C   DO 20 I=1,2
320.     00      C   DP=DP+PS(I)*(-A(I,2)/T2-2.*A(I,3)/T3)
330.     00      C   T=T-PDELT A/DP
340.     00      C   50 CONTINUE
350.     00      C   WRITE(6,600)PDELT A
360.     00      C   600 FORMAT(1, ERROR 600 IN EBUBTE, PDELT A= ', 1PE12.4)
370.     00      C   100 EBUBTE=T
380.     00      C   RETURN
390.     00      C
END ELT.  ERRORS: NONE.  TIME: 0.006 SEC.  IMAGE COUNT: 39
@HDG,P ***** ENTROP ***** .L,0
```

***** ENTROP *****

DATE 07/21/84

```
@ELT,L DD,ENTROP
ELT 8R1 S74Q1C 07/21/84 15:55:04 (O)
10.    00      FUNCTION ENTROP(T,V,X)
20.    00
30.    00
40.    00      C**** PURPOSE:
50.    00      TO CALCULATE REFRIG. ENTROPY
60.    00
70.    00      C**** INPUT:
80.    00      C   T - REFRIG. TEMPERATURE (K)
90.    00      C   V - REFRIG. SPEC. VOLUME (L/MOL)
100.   00      C   W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT (G)
110.   00      C   W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT (G)
120.   00      C   X - MOLE CONCENTRATION OF A LESS VOLATILE REFRIG. (-)
130.   00      C   * - CONSTANTS A,B,C1,D1, AS PER COMMON STATEMENT /PARAM/
140.   00
150.   00      C**** OUTPUT:
160.   00      C   S - ENTROPY (BTU/(LB*F))
170.   00
180.   00      C**** SUBPROGRAMS CALLED BY ENTROP:
190.   00      HFAR
200.   00
210.   00      COMMON /PARAM/A,B,C1,C2,D1,D2
220.   00      COMMON /RDATA2/W1,W2,TC1,TC2
230.   00      DATA R/O.08206/
240.   00
250.   00      C   WM=(1.-X)*W1+X*W2
260.   00      C   CONV=453.5924/(1.0E5056*T/M)
270.   00
280.   00      CALL HPAR(IQ,T,X)
290.   00      C   S=(C1*B*A*D1)/B**2*ALOG((V+B)/V)+A*D1/B/(V+B)
300.   00      C   S=S-R*B/4./((V-B/4.)*2*(A.*V..3*B/4.))
310.   00      C   S=S-R*T*D1*V/2./((V-B/4.)**3*(2.*V-B/4.))
320.   00      C   S=S+(1.-X)*0.320937933924*X*3.401655761501
330.   00      C   S=S+R*(X*ALOG(V/0.0632978)+(1.-X)*ALOG(V/0.0776799))
340.   00      C   S=0.101325*S
350.   00      C   S=S+(0.0116393*(1.-X)+0.013936*X)*ALOG(T/233.15)
360.   00      C   S=S+(2.163944E-4*(1.-X)+1.540093E-4*X)*(T-233.15)
370.   00      C   S=S-(8.512035F-8*(1.-X)+1.533352E-9*X)*(T**2-233.15**2)
380.   00      IF(X,EQ,1.OF,X,EN,O,)GOTO 1000
390.   00      S=S-0.101325*R*(X*ALOG(X)+(1.-X))*ALOG(1.-X)
400.   00      ENTROP=S*CINV/1.8
410.   00      RETURN
420.   00
END ELT.  ERRORS: NONE.  TIME: 0.086 SEC. IMAGE COUNT: 42
@HDG,P **** ENTROP **** .L,0
```

©ELT,L DD.ENTR02
 ELT 8R1 S74Q1C 07/21/84 15:55:05 (0)
 10. 00 C
 20. 00 C
 30. 00 C
 40. 00 C
 50. 00 C
 60. 00 C
 70. 00 C
 80. 00 C
 90. 00 C
 100. 00 C
 110. 00 C
 120. 00 C
 130. 00 C
 140. 00 C
 150. 00 C
 160. 00 C
 170. 00 C
 180. 00 C
 181. 00 C
 182. 00 C
 190. 00 C
 200. 00 C
 210. 00 C
 220. 00 C
 230. 00 C
 240. 00 C
 250. 00 C
 260. 00 C
 270. 00 C
 280. 00 C
 290. 00 C
 300. 00 C
 310. 00 C
 320. 00 C
 330. 00 C
 340. 00 C

 ©ELT,L DD.ENTR02
 SUBROUTINE ENTR02(XM,TF,P,S,XQ)
 C
 C **** PURPOSE:
 C TO CALC. ENTROPY OF NON-AZOTROPIC REFRIGERANT
 C
 C **** INPUT:
 C P - REFRIG. PRESSURE (PSIA)
 C TF - REFRIG. TEMPERATURE (F)
 C XM - WEIGHT CONCENTRATION OF A LESS VOLATILE REFRIG. (-)
 C
 C **** OUTPUT:
 C S - ENTROPY (BTU/(LB*F))
 C XQ - QUALITY (-)
 C
 C **** SUBPROGRAMS CALLED BY ENTR02:
 C ENTR0P,QLITY,VOLIT1
 C
 COMMON/RDATA2/W1,W2,TC1,TC2
 C
 XM=XW/(W2/W1*(1.-XW)+XW)
 TK=(TF+453.67)/1.8
 PA=P/14.6959
 CALL QLITY(TK,PA,XM,XQ,XV,XL)
 IF(XQ.LT..0001.OR.XQ.GT..9999)THEN
 N=1.1*XQ
 CALL VOLIT1(N,TK,PA,XM,V)
 S=ENTROP(TK,V,XM)
 ELSE
 CALL VOLIT1(0,TK,PA,XL,V)
 S=(1.-XQ)*ENTROP(TK,V,XL)
 CALL VOLIT1(1,TK,PA,XV,V)
 S=S+XQ*ENTROP(TK,V,XV)
 END IF
 RETURN
END

END ELT. ERRORS: NONE. TIME: 0.084 SEC. IMAGE COUNT: 36

©HDC,P ***** EQPAR ***** , L,0

***** EQPAR *****

```

@ELT,L DD.EQPAR
ELT 8R1 S74Q1C 07/21/84 15:55:05 (0)
          00      SUBROUTINE EQPAR(T,X)
 10.        00      C
 20.        00      C
 30.        00      C
 40.        00      C
 50.        00      C
 60.        00      C
 70.        00      C
 80.        00      C
 90.        00      C
100.       00      C
110.       00      C
120.       00      C
130.       00      C
140.       00      C
150.       00      C
160.       00      C
170.       00      C
180.       00      C
190.       00      C
200.       00      C
210.       00      C
220.       00      C
230.       00      C
240.       00      C
250.       00      C
260.       00      C
270.       00      C
280.       00      C
290.       00      C
300.       00      C
310.       00      C
320.       00      C
330.       00      C
340.       00      C
350.       00      C
360.       00      C
370.       00      C
380.       00      C
390.       00      C
400.       00      C
410.       00      C
420.       00      C
430.       00      C
440.       00      C
450.       00      C
460.       00      C

      **** PURPOSE:
      TO CALC. REFRIG. PARAMETERS FOR EQUATION OF STATE

      **** INPUT:
      REFRIG. CONSTANTS AS LISTED IN THE CONCN STATEMENT /RDATA1/
      - REFRIG. TEMPERATURE (K)
      X - MOLE CONCENTRATION OF A LESS VOLATILE REFRIG. (-)

      **** OUTPUT:
      * - CONSTANTS A & B FOR EQUATION OF STATE

      COMMON/RDATA1/A3,A4,A5,A6,A7,A8,E3,R4,R5,R6,R7,B8,F0,F1
      COMMON/PARAH/A,D,C1,C2,D1,D2
      COMMON/STORE1/A1,A2,B1,B2,SEG31
      DATA TLAST,XLAST,/2*0./

      IF(ABS(T-TLAST).GT.0.0001)GOTO 10
      IF(ABS(X-XLAST).GT.0.0001)GOTO 10
      RETURN

      10  TLAST=T
      XLAST=X
      X2=X**2
      XX=1.-X
      XX2=XX**2
      XXX=XX**XX
      T2=T**2
      B1=B2*(D4*T+B5*T2
      B2=B7*D7*T+B8*T2
      B=XX2*T1+X2*B2
      SEG31=(D1*(1./3.)+B2*(1./3.))/2.
      SEG32=SEG31**2
      B=B+2.*XXX*SEG31*SEG32
      A1=A3+A4*T+A5*T2
      A2=A5*A7*T+AR*T2
      A1A2S=SQRT(A1*A2)
      SEC1=XXX*A1A2S
      F=F0+F1*T
      SEG2=XXX*(1.-F)*A1A2S
      A=A1*X2+A2*X2+2.*SEG2
      RETURN
      END

END ELT.  ERRORS: NONE.  TIME: 0.089 SEC. IMAGE COUNT: 46
@HDG,P ****ESVOL **** .L,0

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***** ESVAL *****

DATE 072184

```
@ELT,L DD.ESVAL
ELT 8R1 S74Q1C 07/21/84 15:55:05 (0)
          00      FUNCTION ESVAL(N,T,P,X)
10.        00
20.        00      C
30.        00      C
40.        00      C*** PURPOSE: TO ESTIMATE SPEC. VOLUME OF LIQUID OR VAPOR
50.        00      OF A NON-ANETROPIC, BINARY MIXTURE
60.        00
70.        00
80.        00      C*** INPUT:
90.        00      C   N - OUTPUT QUALIFIER
100.       00      C   = 0 FOR LIQUID
110.       00      C   = 1 FOR VAPOR
120.       00      C   P - PRESSURE (REQUIRED FOR N=1 ONLY) (STD ATM)
130.       00      C   T - TEMPERATURE (K)
140.       00      C   X - MOLE COMPOSITION (FRACTION OF LEAST VOLATILE COMPONENT)
150.       00
160.       00      C*** OUTPUT:
170.       00      C   ESVAL - SPECIFIC VOLUME (L/MOL)
180.       00
190.       00
200.       00      C   COMMON/ESDATA/A(2,3),B(2,3),C(2,3)
240.       00      DIMENSION V(2)
250.       00
260.       00      C   T2=T*T
270.       00      IF(N.NE.0)GOTO 10
280.       00      C*** SPEC. VOL. OF SAT. LIQUID
290.       00      DO 5 I=1,2
300.       00      5   V(I)=C(I,1)+C(I,2)*T+C(I,3)*T2
310.       00      VV=(1.-X)*V(1)+X*V(2)
320.       00      GOTO 1000
330.       00      C*** SPEC. VOL. OF SAT. VAPOR
340.       00      10  DO 15 I=1,2
350.       00      15  V(I)=B(I,1)+B(I,2)*T+B(I,3)*T2
360.       00      VV=((1.-X)*V(1)+X*V(2))*T/P
370.       00      C   1000  ESVAL=VV
380.       00      RETURN
390.       00
400.       00
END ELT.  ERRORS: NONE. TIME: 0.100 SEC. IMAGE COUNT: 37
@HDG,P ***** EVAPHX ***** .L,0
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***** EVAPHX *****

@ELT,L DD.EVAPHX
ELT OR1 S74Q1C 07/21/94 15:55:05 (0)
10. 00 SUBROUTINE EVAPHX(I10,RHSS,T1,P1,ATIN,APIN,ARHIN,
20. 00 &
30. 00 X1,T2,P2,H2,X2)

C 00 FEBRUARY 1984

C C*** EVAPORATOR SIMULATION

C C*** PERFORMANCE OF CROSS-FLOW AIR HEATED EVAPORATOR
90. 00 C*** WITH UP TO 130 PLATE FINNED TUBES
100. 00 C*** PLACED IN UP TO 5 DEPTH ROWS.

C C FORWARD SCHEME, TUBE-BY-TUBE LOGIC. INLET TEMPERATURES
OF AIR & REFRIGERANT CALCULATED FOR EACH TUBE INDIVIDUALLY.

C C*** INPUT DATA:
170. 00 C
180. 00 C - AIR MASS FLOW RATE THROUGH COIL (LBM/H)
190. 00 C - ANGLE BETWEEN COIL FACE & AIR STREAMLINES (RAD)
200. 00 C - AIR INLET PRESSURE (PSIA)
210. 00 C - AIR INLET RELATIVE HUMIDITY (-)
220. 00 C - AIR INLET TEMPERATURE (F)
230. 00 C - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION (-)
240. 00 C - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION (-)
250. 00 C - INNER DIAMETER OF TUBES (FT)
260. 00 C - OUTER DIAMETER OF TUBES (FT)
270. 00 C - TUBE DEPTH PITCH (FT)
280. 00 C - FIN TIP DIAMETER (FT)
290. 00 C - FRACTION OF COIL TOTAL REFRIG. MASS FLOW PASSING
300. 00 C - THROUGH TUBE M (-)
310. 00 C - FIN MATERIAL THERMAL CONDUCTIVITY (BTU/FT*H*F)
320. 00 C - FIN PITCH (FT)
330. 00 C - FIN THICKNESS (FT)
340. 00 C - DEPTH IRG OF A TUBE M
350. 00 C - NUMBER OF TUBE TUBE M RECEIVES REFRIG. FROM
360. 00 C - WHEN COIL WORKS AS EVAPORATOR (-)
370. 00 C 110
380. 00 C = 1 FOR INDOOR COIL (-)
390. 00 C = 2 FOR OUTDOOR COIL (-)
400. 00 C - NUMBER OF MERGING TUBES (-)
410. 00 C - NUMBER OF TUBES REFRIG. FLOWS INTO COIL
ISTART(I10,L) - WORKING AS CONDENSER (-)
IMER(I10) - NUMBER OF TUBE REFRIG. FLOWS INTO COIL
IST(I10) - WORKING AS CONDENSER (-)
420. 00 C - NUMBER OF TUBE REFRIG. FLOWS INTO COIL
430. 00 C - WORKING AS CONDENSER, FOUND AS L SUCH TUBE (-)
JFRON(I10,J) - NUMBER OF TUBE POSITIONED AIR UPSTREAM
KFEED(I10,J,N) - NUMBER OF TUBE RECEIVING REFRIGERANT FROM
TUBE J WHEN COIL WORKS AS EVAPORATOR (-)
NOTE THAT TUBE J CAN FEED UP TO 3 TUBES
(N CAN BE 1,2 AND 3) (-)
440. 00 C - NUMBER OF TUBE REFRIGERANT FLOWS INTO COIL
450. 00 C - WORKING AS EVAPORATOR (-)
460. 00 C - NUMBER OF TUBES REFRIGERANT FLOWS INTO COIL
470. 00 C - WORKING AS EVAPORATOR (-)
480. 00 C - NUMBER OF TUBE ROW DEPTHS (-)
490. 00 C - NUMBER OF TUBES PER ROW (-)
500. 00 C - NUMBER OF REPEATING SECTIONS OF COIL (-)
510. 00 C - NUMBER OF TUBES PER SECTION (-)
520. 00 C
530. 00 C
540. 00 C
550. 00 C
560. 00 C

570. 00 C NTUB(110,1) - NUMBER OF TUBES IN ROW 1 OF EACH COIL SECTION (-)
 580. 00 C P1 - REFRIGERANT PRESSURE AT EVAPORATOR OUTLET (PSIA)
 590. 00 C PRMSS - TOTAL REFRIG. MASS FLOW RATE THROUGH COIL (LBM/H)
 600. 00 C RPCH(110) - TUBE ROW PITCH (FT)
 610. 00 C TMK(110) - TUBE MATERIAL THERMAL CONDUCTIVITY (BTU/FT*H*F)
 620. 00 C T1 - REFRIGERANT TEMPERATURE AT EVAPORATOR OUTLET (F)
 630. 00 C WIDTH(110) - COIL WIDTH (FT)
 640. 00 C XM - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
 650. 00 C XW - WEIGHT COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
 660. 00 C WM - MIXTURE MOLECULAR WEIGHT (G/MOL)
 670. 00 C WI - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT (G/MOL)
 680. 00 C W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT (G/MOL)
 690. 00 C
 700. 00 C **** OUTPUT DATA:
 710. 00 C H2 - REFRIGERANT ENTHALPY AT EVAPORATOR INLET (RTU/LBM)
 720. 00 C PRM(2,1,1) - REFRIG. PRESSURE AT 1 TUBE OUTLET (PSIA)
 730. 00 C PRM(2,2,1) - REFRIG. PRESSURE AT 1 TUBE INLET (PSIA)
 740. 00 C P2 - REFRIGERANT PRESSURE AT EVAPORATOR INLET (PSIA)
 750. 00 C TRM(2,1,1) - REFRIG. TEMP. AT 1 TUBE OUTLET (F)
 760. 00 C TRM(2,2,1) - REFRIG. TEMP. AT 1 TUBE INLET (F)
 770. 00 C T2 - REFRIGERANT TEMPERATURE AT EVAPORATOR INLET (F)
 780. 00 C XRM(2,1,1) - REFRIG. QUALITY AT 1 TUBE OUTLET (-)
 790. 00 C XRM(2,2,1) - REFRIG. QUALITY AT 1 TUBE INLET (-)
 800. 00 C XTUBE(2,J) - FRACTION OF TUBE J WITH SUPERHEATED VAPOR
 810. 00 C
 820. 00 C
 830. 00 C
 840. 00 C
 850. 00 C
 860. 00 C OR - FRACTION OF TUBE J WITH 2-PHASE MIXTURE
 870. 00 C WHEN SURCOOLED LIQUID IS IN REST OF TUBE (-)
 880. 00 C - REFRIGERANT QUALITY AT EVAPORATOR INLET (-)
 890. 00 C X1 - REFRIGERANT QUALITY AT EVAPORATOR OUTLET (-)
 900. 00 C VGM(2,1,1) - SPEC. VOL. OF SATURATED REFRIG. VAPOR AT
 910. 00 C VGM(2,2,1) - SAT. TEMP. OF 1 TUBE OUTLET (FT**3/LBM)
 920. 00 C VLM(2,1,1) - SPEC. VOL. OF SATURATED REFRIG. VAPOR AT
 930. 00 C VLM(2,2,1) - SAT. TEMP. OF 1 TUBE INLET (FT**3/LBM)
 940. 00 C - REFRIG. SPEC. VOLUME AT 1 TUBE OUTLET (FT**3/LBM)
 950. 00 C - REFRIG. SPEC. VOLUME AT 1 TUBE INLET (FT**3/LBM)
 960. 00 C **** SUBPROGRAMS CALLED BY EVAPHX:
 970. 00 C AIRHT, AIRTR, BUBTEM, DEVITEM, DYNDP1, DPFDYN2, EBUBTE, ESVOL, FEELIQ,
 980. 00 C FINEFF, HGVCVP, HPIN, HTCIV, OVLTET, PXRQINZ, QLTY, SPIDP1, SPHTC,
 990. 00 C VISCON, VOLITI
 1000. 00 C
 1010. 00 C COMMON//ACCURA/NEAT, ICOMP
 1020. 00 C COMMON//RDATA2/W1, W2, TC1, TC2
 1030. 00 C COMMON//RDATA3/XW, XH, WM
 1040. 00 C COMMON//IPHX/NDEP(2), NROW(2), D1(2), DO(2), DT(2), RPCH(2), DPCH(2),
 &YDEPTH(2), RPCH(2), FTK(2), FRM(2), TMR(2), ANMS(2), ANGLE(2),
 &CONST(2), CPDW(2), NTUB(2,5), IFROM(2,130), NSECT(2), NTPS(2),
 COMMON//MERGE(2,20,2), IMER(2), ISTAR(2,20), ISI(2),
 &DEPTH(2,130), FICW(2,130), JFTOM(2,130), KFTD(2,130),
 &KSTART(2,20), KSR(2)
 1100. 00 C COMMON//MASS/TRM(2,2,130), PRM(2,2,130), XRM(2,2,130),
 1110. 00 C VLM(2,2,130), VGM(2,2,130), XTUBE(2,130), XTT(2,130)
 1120. 00 C DIMENSION TAIR(2,6), AIRN(5), HR(2,130), HRACK(10,2),
 1130. 00 C OMEGA(2,6), DT, IFG(130), MY(130), FEE(5),
 @ EFR(130), CPRS(130), HCO(5), HCOP(5), ILook(15)

DATE 072184

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1150.    00      DIMENSION TPIP(5),TWAT(5),UDI(5),HICE(5),HFCWT(5),TKICE(5),CPAS(5)
1160.    00      DIMENSION TAIRI(2,120),WAIRI(2,130),ANSI(5),XLWS(130)
1170.    00      DATA NO,N1,N3,NA,N5/O,1,3,4,5/
1180.    00      C
1190.    00      C***** DATA PREPARATION
1200.    00      ANGLE=ANGLE(110)
1210.    00      NNDEP=NDEP(110)
1220.    00      DDI=DI(110)
1230.    00      DDO=DO(110)
1240.    00      DDT=DT(110)
1250.    00      RRPCH=RPCH(110)
1260.    00      DDPCH=DPCH(110)
1270.    00      WMIDTH=WIDTH(110)
1280.    00      FFPCH=FPCH(110)
1290.    00      FFTK=FTK(110)
1300.    00      FMK=FMK(110)
1310.    00      TTMK=TMK(110)
1320.    00      AIRMAS=AIRMAS(110)
1330.    00      CCNST=CONST(110)
1340.    00      CCPW=CPW(110)
1350.    00      API=3.1415927*DDI*WMIDTH
1360.    00      APO=3.1415927*(DDI*WMIDTH)
1370.    00      AFM=0.5*(API+APO)
1380.    00      AFO=APU*(FPCH-FTK)/FFCH
1390.    00      AF=1.570796*(DDT+DDG)*(DDT-DDO)
1400.    00      AF=AF*WMIDTH/FFPCH
1410.    00      AC=APO+AF
1420.    00      AFLOW=AFLOW*(FPCH-DDG)/FRCH
1430.    00      AFLOW=AFLOW/FFCH
1440.    00      AFLOW=39.75*AFLOW
1450.    00      WFLW=AO/RRPCH
1460.    00      HDEP=3000.
1470.    00      HP=2.*TTMK/(DDO-DDI)
1480.    00      AIRMS=AIRMAS*WROW(110)
1490.    00      C***** FIND INLET STATE FROM PRESSURE AND TEMPERATURE
1500.    00      PA1=P1/14.6959
1510.    00      TK1=(T1+459.67)/1.8
1520.    00      CALL QLITY(TK1,PA1,X1,X',XV,XL)
1530.    00      IF(X1.GT.0.) THEN
1540.    00          CALL VOLIT1(NO,TK1,PA1,XL,VL)
1550.    00          CALL HCVC(1,TK1,VL,X1,HL,CV,CP)
1560.    00          CALL VOLIT1(N1,TK1,PA1,XV,VL)
1570.    00          CALL HCVC(1,TK1,VL,XV,HV,CP)
1580.    00          H1=(1.-X1)*HL,X1*HV
1590.    00          WML=W1*((1.-XL)+M2*XL)
1600.    00          WNW=W1*((1.-XV)+M2*XV)
1610.    00          VLW=16.01846*VL/WML
1620.    00          VNW=16.01846*VW/WMV
1630.    00          XLW1=XL/(W1/W2*(1.-XL)+XL)
1640.    00      ELSE
1650.    00          CALL VOLIT1(NO,TK1,PA1,XM,VL)
1670.    00          CALL HCVC(1,TK1,VL,XR,HI,CV,CP)
1680.    00          VLW=16.01846*VL/WML
1690.    00          VNW=0.
1700.    00          XLW1=XW
1710.    00      END IF
1720.    00      C

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*****      00      C      WRITE(6,900)T1,P1,X1,ATIN,ARHIN,R1ASS
1730.      00
1740.      00      C      DO 4 IS=1,KST(110)
1750.      00      I=KSTART(110,IS)
1760.      00      TRM(110,1,1)=T1
1770.      00      PRM(110,1,1)=P1
1780.      00      XRM(110,1,1)=X1
1790.      00      HR(1,1)=H1
1800.      00      VGM(110,1,1)=VNW
1810.      00      VLM(110,1,1)=VLW
1820.      00
1830.      00      C 4 CONTINUE
1840.      00      C*** ESTIMATE CHANGE OF AIR T:IMPERATURE
1850.      00      CALL AIRPR(1,ATIN,APIN,ARHIN,WAIR,CPAIR,RAIR,
1860.      00      &AMAIR,AKAIR)
1870.      00      CALI_DEFTEM(NQ,PA1,XM,TKD,XL)
1880.      00      TD2=TKD*1.8-460.
1890.      00      DTAIR=0.85*(ATIN-TD2)/(NNDEP-1)
1900.      00      DTAIR=AMAX1(0.,DTAIR)
1910.      00      DO 6 I=1,NTUB(110,1)
1920.      00      TAIR(1,1)=ATIN
1930.      00      TAIR(2,1)=TAIR(1,1)-DTAIR
1940.      00      WAIR(1,1)=WAIR
1950.      00      WAIR(2,1)=WAIR
1960.      00      IA=NTUB(110,1)+1
1970.      00      DO 7 I=IA,NTPS(110)
1980.      00      J=JFROM(110,1)
1990.      00      TAIR(1,1)=TAIR(2,J)
2000.      00      TAIR(2,1)=TAIR(1,1)-DTAIR
2010.      00      WAIR(1,1)=WAIR(2,J)
2020.      00      WAIR(2,1)=WAIR(2,J)
2030.      00      CC      END IF
2040.      00      O'ECA(1,1)=WAIR
2050.      00      OMEGA(2,1)=WAIR
2060.      00      TAIR(1,1)=ATIN
2070.      00      DO 8 I=1,NNDEP
2080.      00      J=I+1
2090.      00      TAIR(1,J)=TAIR(1,I)-DTAIR
2100.      00      OMEGA(1,J)=OMEGA(1,I)
2110.      00      HICE(1)=1.E+30
2120.      00      HFGBT(1)=0.
2130.      00      TKICE(1)=0.
2140.      00      TWAT(1)=0.
2150.      00      TFIP(1)=0.
2160.      00      HBACK(1,2)=999.
2170.      00      C*** EVALUATE TMC-PLIASE SPEC. HEAT.
2180.      00      TK2=TKD
2190.      00      PA2=PA1
2200.      00      VV=ESVOL(N1,TK2,PA2,XM)
2210.      00      CALL HCVCF(N1,TK2,VV,YM,H2,CV,CP)
2220.      00      CPR=(H2-H1)/(1.8*(TK2-TK1))
2230.      00      DO 12 I=1,NTPS(110)
2240.      00      VLM(110,2,I)=0.0
2250.      00      VGM(110,2,I)=0.0
2260.      00      DPR(I)=0.
2270.      00      CPFS(I)=CPR
2280.      00      DTHFG(I)=0.
2290.      00      HY(I)=0
2300.      00      DO 13 I=1,IMER(110)

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EVAPHX *****

DATE 072184

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2310.          00      J=MERGE(110,1,1)
2320.          00      MY(J)=1
2330.          00      ACC=0.003
2340.          00      HBACK(1,2)=999.
2350.          00      AFIN=3.14159*(DDT-DDO)*(DDT+DDO)/4.
2360.          00      SEGFIN=DDT*3/24.-DDT*DDO/16.+DDO*3/48.
2370.          00      SEGFIN=SEGFIN*2./AFIN*(DDT-DDO)
2380.          00      HTDL=0.003
2390.          00      H2P=0.
2400.          00
2410.          00      C***** START MAIN LOOP
2420.          00      C***** CALC. CHANGE OF AIR MASS FLOW RATE DUE TO WATER/FROST ACCUM.
2430.          00
2440.          00
2450.          00
2460.          00      LAIRN=10
2470.          00      DO 150 LA'R=1,LAIRN
2480.          00      AFEE=0.
2490.          00      DO 16 I=1,NNDEP
2500.          00      AFEE=AFEE*(FFPCH-FFTK-2.*TKICE(I))
2510.          00      AFEE=AFEE/(NNDEP*(FFPCH-FFTK))
2520.          00      AMMAS=AMMAS*AFEE*.56*(530./(460.+ATIN))*0.64
2530.          00      C***** CALC. AIR DATA FOR EACH TUBE
2540.          00      DO 18 I=1,NNDEP
2550.          00      NT=NSECT(110)*NTUB(110,1)
2560.          00      AMS=AMMAS/NT
2570.          00      AMSI(I)=AMS
2580.          00      TAAV=0.5*(TAIR(I,I)+TAIR(I,I+1))
2590.          00      WAIR=0.5*(OMEGA(I,I)+OMEGA(I,I+1))
2600.          00      CALL AIRPR(2,TAAV,APIN,RHA,WAIR,CPA,RA,AMAI,AKA)
2610.          00      FFTK=FFTK+2.*TKICE(I)
2620.          00      HCOD(I)=AIRHT(AMMAS,CPA,AMAI,AKA,IND,DT,WIDTH,
2630.          00      &           RFPCH,FFPCH,FFFTK,CCONST,CCFOW,ANGL,E)
2640.          00      HCO(I)=HCOD(I)*(1.-HFGBT(I))
2650.          00      FEE(I)=FINEFF(110,DDT,DDO,FFTK,FFMK,HCO(I))
2660.          00      UD(I)=HCO(I)*(1.-FEE(I))/AO
2670.          00      CPAS(I)=CPA
2680.          00      AIRN(I)=0.
2690.          00      GOTO 30
2700.          00      ILN=0
2710.          00      ILNEXT=0
2720.          00      DO 110 NUMB=1,KST(110)
2730.          00      I=KSTART(110,NUMB)
2740.          00      TRI=T1
2750.          00      PRI=P1
2760.          00      HRI=H1
2770.          00      XRI=X1
2780.          00      XLWI=XLW1
2790.          00      GOTO 30
2800.          00      ***** ASSIGN INLET PARAMETERS FOR NEXT TUBE
2810.          00      22  CONTINUE
2820.          00      TRI=TRM(110,2,JJ)
2830.          00      PRI=PRM(110,2,JJ)
2840.          00      HRI=HR(2,JJ)
2850.          00      XRI=XFM(110,2,JJ)
2860.          00      VLM(110,1,1)=VLM(110,2,JJ)
2870.          00      VGM(110,1,1)=VGM(110,2,JJ)
2880.          00

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2890.      00      C
2900.      00      C      TUBE SELECTION FOR CALCULATION DONE
2910.      00      C      COMPUTE HEAT TRANSFER & REFRIG. PRESSURE DROP FOR TUBE 1
2920.      00      C      FIND REFRIG. STATE AT OUTLET
2930.      00      C
2940.      00      C      30  TRM(110,1,1)=TRI
2950.      00      PRM(110,1,1)=FRI
2960.      00      HR(1,1)=HRI
2970.      00      XRM(110,1,1)=XRI
2980.      00      TRI1=TRI
2990.      00      TRI2=TRI
3000.      00      HRI1=HRI
3010.      00      HRI2=HRI
3020.      00      HRI3=HRI
3030.      00      XRI1=XRI
3040.      00      XRI2=XRI
3050.      00      RM3=RMASS*FLOW(110,1)
3060.      00      XLIQ=.0
3070.      00      XSLUG=.0
3080.      00      XANNUL=.0
3090.      00      XMIST=.0
3100.      00      TKR1=(TRI+459.67)/1.8
3110.      00      PRE=PRI+DPR(1)
3120.      00      PRAV=0.5*(PRI+FRE)
3130.      00      PARAVAL=PRAV/14.6959
3140.      00      DP1=0.
3150.      00      DP2=0.
3160.      00      DP3=0.
3170.      00      VIX=(1.-XRI)*VLM(110,1,1)+XRI*VCR(110,1,1)
3180.      00      ICT=IDEPHT(110,1)
3190.      00      TAI=TAIR(1,1)
3200.      00      IF(TAI LT. (TRI+0.1))TAI=TRI+0.1
3210.      00      CPA=CPAS(ICT)
3220.      00      AMS=AMSI(ICT)
3230.      00      OMEGI=WAIR(1,1)
3240.      00      OMEGE=WAIR(2,1)
3250.      00      CDE_I(AIR,LQ,1)PRINT 444,IAIR,I,XRI,PRI,TRI,HRI,TAI
3260.      00      444 FORMAT(1,XRI,FRI,TRI,HRI,TAI=,215,F5.2,4F8.2)
3270.      00      C
3280.      00      IF(XRI.GT.0.)GOTO 45
3290.      00      C
3300.      00      C***** CASE 1 ***** QUALITY 0
3310.      00      C
3320.      00      C***** INIT QUALITY 0
3330.      00      C
3340.      00      C
3350.      00      CALL BUDTENC,PARAV,XM,TKB,XV)
3360.      00      CALL VOLIT1(N0,TKB,PARAV,XM,VLB)
3370.      00      CALL HCVCVP(N1,TKB,XM,HD,CV,CP)
3380.      00      TRE=TKB*1.8-459.67
3390.      00      C
3400.      00      DO 36 IT=1,5
3410.      00      TRAV=0.5*(TRI+TRE)
3420.      00      TKRAV=(TRAV+459.67)/1.8
3430.      00      AMR=VISCON(1,TRAV,XW)
3440.      00      AKR=VISCON(2,TRAV,XW)
3450.      00      CALL VOLIT1(N0,TKRAV,PARAV,XM,VL)
3460.      00      CALL HCVCVP(N5,TKRAV,VL,XM,H,CV,CP)

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DATE 072184

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EVAPHX *****

3470.    00      HI=SPHTC(CPR,AMR,AKR,RMS,DDI)
         00      CALL OVLJET(AO,AF1,AFM,II,HDTP,HP,HICE(ICK),UD1(ICK),UD2(UAO,UPO,UPD))
         00      QQ=CPA*11S*(1.-EXP(-UAO/(CPA+AT(S)))/(CPA+AT(S)))
         00      Q=1.-EXP(-QQ)
         00      Q=CPR*RMS*(TAI-TR1)*Q
         00      HRE=HRI+Q/RMS
         00      TR1=TR1+(IRE-HRI)/CPR
         00      IF(IIT.EQ.1)GOTO 34
         00      IF(HRE.CT.HD)THEN
         00      XL1Q=-ALOG(1.-(TB-HRI)/(CPR*(TAI-TR1)))/QQ
         00      AL1=XL1Q*WIDTH
         00      TR1=TK1*1.8-459.67
         00      HRI1=HR
         00      XRI1=0.
         00      TRIX=TR11
         00      HRIX=HRI1
         00      XRIX=0.
         00      VIX=VLB*16.01846/WM
         00      END IF
         00      HDIF:=HRE1-HRE
         00      XRE=0.
         00      XL1Q=0.
         00      IF(ADS(HD1F).LT.HDTL)GOTC 38
         00      34 HRE1=HRE
         00      36 CONTINUE
         00      WRITE(6,F50)AIR,I,ICK,XRI,HDIF
         00      650 FORMAT(' CASE 1 TUBE DOES NOT CONVERGE',/,'AIR,I,ICK,XRI,HDIF=',
         00      @314,F5.2,F10.5)
         00      33 CONTINUE
         C      XLYS(1)=XW
         C      AL1=VW'DTH*20.*DDI
         00      40 VL=VL*16.01846/WM
         00      DF1=$HD1(RMS,AL1,DDI,VL,AIR)
         00      IF(XL1Q.EQ.0.)GOTO 100
         00      45 IF(XRI.GT.0.1)GOTO 58
         C      C***** CASE 2 *****
         C      CASE 2 *****

3480.    00      C*** INLET QUALITY 0.0 - 0.1
         00      C
         00      CALL RUBITEM(NO,PAPAV,XM,TKB,XV)
         00      TB=TKB*1.8-459.67
         00      CALL VOLIT1(NO,TKB,FARAV,X1,VLB)
         00      CALL HCVCP(N5,TKB,VL3,XM,H,CV,CPR)
         00      VISL=VISCON(N1,TB,XW)
         00      CONL=VISCON(N2,TB,XW)
         00      H100=SPHTC(CPR,VISL,CONL,RMS,DDI)
         00      X10=.1
         00      CALL PX01N2(XM,PAPAV,X10,TK10,XL,XV,VL,VN,H10)
         00      TF10=TK10*1.8-459.67
         00      H110=HTCEV(TF10,PRAV,RMS,DDI,XTT(110,I))
         00      TRE=TF10
         00      TKRE=TK10
         00      XRE=0.1
         C      ITE=0

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      ***** EVAPHX *****
      DO 55 IT=1,6
      CPR=CPRS(1)
      TRAV=0.5*(TRII+TFE)
      XRAV=0.5*(XRII+XRE)
      HI=HI10-10.*((1-XRAV)*(HI10-HI00))
      CALL OVLWET(LAO,AP1,APM,HI,HITP,HICE(ICT),UDI(1CT),UAO,UP0,UN0)
      QO=CPR*RM5*(1.-EXP(-UAO/(CPA*AL15)))/(CPR*RS)
      Q=CPA*AM5*(TAI-TRII)*(1.-EXP(-QO*(1.-XL1Q)))
      HRE=HRII+Q/RMS
      CALL HPIN(N1,HRE,PARAV,XM,ACC,TKRE,YRE,XL,YV,VL,VV)
      TRE=TKE*1.8-459.67
      IF(TRE.NE.TRII)GOTO 52
      IF(IT.EQ.0)THEN
        IT=1
        CPRS(1)=3.*CPR
        GOTO 54
      ELSE
        GOTO 77
      END IF
      52 CPRS(1)=(HRE-HR11)/(TRE-TRII)
      IF(IT.EQ.1)GOTO 54
      IF(HRE.GT.H10)THEN
        XSLUG=-ALCG(1-(H10-HR11)/(CPR*(TAI-TRII)))/QO
        AL1=XSLUG*WWIDTH
        HRII=H10
        TRII=TF10
        XRII=-1
        GOTO 60
      END IF
      HDIF=HRE1-HRE
      IF(ABS(HDIF).LT.HTOL)GOTO 77
      54 HRE1=HRE
      55 CONTINUE
      C   WRITE(6,651)IAIR,I,ICT,XRI,HDIF
      651 FORMAT(' CASE 2 TUBE DOES NOT CONVERGE ',/ ' IAIR,I,ICT,XRI,HDIF=',
     @314,F5.2,F10.5)
      GOTO 77
      C   58 IF(XRI.GT..9)GOTO 68
      C*** CASE 3 *****
      C*** INLET QUANTITY 0.1 - 0.9
      C
      60 TRE=TRII
      TKRE=(TRE+459.67)/1.8
      XRE=XRII
      IT=0
      DO 65 IT=1,6
      CPR=CPRS(1)
      TRAV=0.5*(TRII+TFE)
      XRAV=0.5*(XRII+XRE)
      HI=HTCEV('RAV,FRAV,RM5,DD1,XTT(110,1))
      CALL OVLWET(LAO,AP1,APM,HI,HITP,HICE(ICT),UDI(1CT),UAO,UP0,UN0)
      QO=CPR*RM5*(1.-EXP(-UAO/(CPA*AL15)))/(CPR*RS)
      Q=CPA*AM5*(TAI-TRII)*(1.-EXP(-QO*(1.-XL1Q*XSLUG)))
      HRE=HRII+Q/RMS
      65

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***** EVAPIX *****

DATE 072184

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4630.      00 CALL HFIN(N1,HRE,PARAV,XM,ACC,TKRF,XRE,XL,XV,VL,VV)
4640.      00 TRIE=TKRF*1.8-459.67
4650.      00 IF(TRE.NE.TRII)GOTO 62
4660.      00 IF(ITE.EQ.0)THEN
4670.      00 ITE=1
4680.      00 CPRS(1)=3.*CPR
4690.      00 GOTO 64
4700.      00 ELSE
4710.      00 GOTO 77
4720.      00 END IF
4730.      00 62 CPRS(1)=(HRE-HRI1)/(TRE-TRII)
4740.      00 1F(1T,EQ,1)GOTO 54
4750.      00 IF(XRE.GT..9)THEN
4760.      00 X90=.9
4770.      00 XAHNU=-ALOG(1.-(H90-HRI1)/(CPR*(TAI-TRII)))/60
4780.      00 HRI1=H90
4790.      00 TRII=TK90*1.8-459.67
4800.      00 XRI1=.9
4810.      00 XRI1=.9
4820.      00 GOTO 70
4830.      00 END IF
4840.      00 IF(ABS(HRE-HRE1).LT.HTOI)GOTO 77
4850.      00 64 1F(XRE.GT.0.9)THEN
4860.      00 X90=0.9
4870.      00 CALL PXQIN2(XM,PARAV,X90,TK90,XL,XV,VL,VV,H90)
4880.      00 TRE=TK90*1.8-459.67
4890.      00 END IF
4900.      00 HRE1=HRE
4910.      00 65 CONTINUE
4920.      00 C
4930.      00 68 1F(XRI.GT..999)GOTO 82
4940.      00 C*** CASE 4 ****
4950.      00 C
4960.      00 C*** INLET QUALITY 0.9 - 1.0
4970.      00 C
4980.      00 C
4990.      00 C
5000.      00 C
5010.      00 C
5020.      00 C
5030.      00 C
5040.      00 CAL1_PXQIN(XM,PARAV,X90,TK90,XL,XV)
5050.      00 TF90=TK90*1.8-459.67
5060.      00 H190=HTCF(V(TF90,P,AV,RMS,DDI,XTT(110,I)))
5070.      00 CALL DEWTEM(NO,PARAV,XM,TKD,XID)
5080.      00 TD=TKD*1.0-459.67
5090.      00 CALL VOLIT1(N1,TKD,PARAV,XM,VVD)
5100.      00 CALL HCVCN(N3,TKD,VVD,XM,HD,CV,CPR)
5110.      00 PRINT 708,TD,HD
5120.      00 708 FORMAT( TD,HD='2F14.5)
5130.      00 VISV=VISCON(N3,TD,XW)
5140.      00 CONV=VISCON(N4,TD,XW)
5150.      00 H11=SPHTC(CPR,VISV,CONV,RMS,DDI)
5160.      00 TRE=TD
5170.      00 TRE=TKD
5180.      00 XRE=1.
5190.      00 C
5200.      00 ITE=0

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5210.      00      DO 75 IT=1,6
5220.      00      CXC      IF(I.EQ.14)PRINT 710,XRE
5230.      00      710      FORMAT(' XRE=' ,F12.6)
5240.      00      CPR=CPRS(1)
5250.      00      TRAV=0.5*(TRII+TRE)
5260.      00      XRAV=0.5*(XRII+XRE)
5270.      00      HI=HI-10.*((1.-XRAV)*(HI1-HI30))
5280.      00      CXC      IF(I.EQ.14)PRINT 707,HI
5290.      00      707      FORMAT(' HI=' ,F12.5)
5300.      00      CALL OVLWETTAO,APO,APM,HI,HOEP,HP,HICE(1CT),UDI(1CT),UAQ,UPO,UWO)
5310.      00      QQ=CPA*AMS*(1.-EXP(-UAQ/(CPA*AMS)))/(CPR*RIS)
5320.      00      Q=CPF*RMS*(TAI-TRII)*(1.-EXP(-QQ*(1.-XLI0-XSLUG-XANNUL)))
5330.      00      HRE=IRII+Q/EMS
5340.      00      IF(I.EQ.14)PRINT 709,HRE,PARAV,TKRE
5350.      00      709      FORMAT(' HRE,PARAV,TKRE=' ,4F14.6)
5360.      00      CALL 'PINON1,HRE,FARAV,XM1,ACC,TKRE,XRE,XL,XV,VL,VV'
5370.      00      TRE=TKRE*1.5-459.57
5380.      00      CXC      IF(I.EQ.14)PRINT 711,HRE,HD,TRII,TRE
5390.      00      711      FORMAT(' HRE,HD,TRII,TRE*' ,4F10.5)
5400.      00      IF(TRE.NE.TRII)GOTO 72
5410.      00      IF(I.EQ.0)THEN
5420.      00      ITE=1
5430.      00      CPRS(1)=3.*CPR
5440.      00      GOTO 74
5450.      00      ELSE
5460.      00      GOTO 77
5470.      00      END IF
5480.      00      CPRS(1)=(HRE*HRII)/(TRE-TRII)
5490.      00      72      IF(ITE.EQ.1)GOTO 74
5500.      00      IF(HRE.GT.HD)THEN
5510.      00      CXC      IF(I.EQ.14)PRINT 765,HD,HRII,TAI,TRII
5520.      00      765      FORMAT(' HD,HRII,TAI,TRII=' ,4F12.4)
5530.      00      XRE=1.
5540.      00      XMIST=-ALOG(1.-(HD-HRII)/(CPR*(TAI-TRII)))/QQ
5550.      00      HRII=HD
5560.      00      TRII=TD
5570.      00      XRII=1.
5580.      00      XV=XM
5590.      00      VV=VVD
5600.      00      XL=XLD
5610.      00      CALL V2LIT1(NQ,TKD,PARAV,XLD,VL)
5620.      00      XTURE(110,1)=XSLUG+XMIST
5630.      00      AL1=XTURE(110,1)*WWIDTH
5640.      00      TRAV=0.5*(TRIX+TRII)
5650.      00      XRE=1.
5660.      00      HRE=HRII
5670.      00      GOTO 80
5680.      00      END IF
5690.      00      HDIF=HRE1-HRE
5700.      00      IF(ABS(HDIF).LT.HTOL)GOTO 77
5710.      00      HRE1=HRE
5720.      00      75      CONTINUE
5730.      00      C      WRITE(6,653)AIR,I,ICT,XRI,HDIF
5740.      00      653      FORMAT(' CASE 4 TUBE DOES NOT CONVERGE' ,/
@314,F5.2,F10.5)
5750.      00      C      **** COMPUTE FRICTIONAL, 2-PHASE PRESSURE DROP
5760.      00
5770.      00
5780.      00

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EVAPHX *****

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5790.      00      C    77 AL1=(1.-XL1Q)*WMIDTH+20.,'CDI
5800.      00      C    TRAV=0.5*(TRIX,TRIE)
5810.      00      C    XREX=XRE
5820.      00      C    HREX=HRE
5830.      00      C    XRAY=0.5*(XRIX*XREX)
5840.      00      C    IF(I.EQ.14)PRINT 720,XRI,XRII,XRE
5850.      00      C    FORMAT(' ',XRI,XRII,XRE,' ','FG.2)
5860.      00      C    WML=W1*(1.-XL)+V2*XL
5870.      06      C    VLW=VL*16.0134G/WML
5880.      00      C    WIV=H1*(1.-XV)+WC*YV
5890.      00      C    VVW=VV*16.01846/WMV
5900.      00      C    VMIX=(1.-XREX)*VLW+XREX*VVW
5910.      00      C    VMIX=0.5*(VH1X+VIX)
5920.      00      C    XIWS(L)=XL/(V1/V2*(1.-XL)+XL)
5930.      00      C    XWL=.5*(XLW1+XLWS(1))
5940.      00      C    ELSE
5950.      00      C    IF(I.EQ.14)PRINT 843,HRI,HREX
5960.      00      C    VISL=VISCON(1,TRAV,XWL)
5970.      00      C    IF(HRI.NE.HREX)THEN
5980.      00      C    DP2=1.4*EVDF(FMS,HRI,IIREX,VMS,XL1,DD1)
5990.      00      C    ELSE
6000.      00      C    F=FEELIO(XRAV,TRAV,XL,XV,VL,VV,XT)
6010.      00      C    RMSX=(1.-XRAV)*RMS
6020.      00      C    DP2=F*SPHDF1(RMSX,XL1,D1),VLW,VISL)
6030.      00      C    END IF
6040.      00      C
6050.      00      C    IF(XRII.NE.1.)GOTO 100
6060.      00      C
6070.      00      C    CASE 5 *****
6080.      00      C
6090.      00      C    INLET QUALITY 1
6100.      00      C
6110.      00      C
6120.      00      C    DO 86 IS=1,5
6130.      00      C    TRAV=0.5*(TRII,TRE)
6140.      00      C    TKRAV=(TRAV+459.67)/1.8
6150.      00      C    AMR=VISCON(3,TRAV,XW)
6160.      00      C    AKR=VISCON(4,TRAV,XW)
6170.      00      C    CALL VOLITI(N1,TKRAV,PARAV,XM,VV)
6180.      00      C    CALL HCVCPC(N5,TKRAV,VV,XM,H,CV,CPR)
6190.      00      C    HI=SPHTC(CPR,AMR,AKR,RMS,DD1)
6200.      00      C    CALL CYLMET(AN,AP1,APM,HI,HDCP,HP,HICE,ICT),UNI(CT),UAO,UPO,UMO
6210.      00      C    QQ=CPA*MS*(1.-EXP(-UAQ/(CPA*MS)))/(CPR*RS)
6220.      00      C    Q=1.-EXP(-QQ*(1.-XL1Q-XSLUG-XANNU-X1ST))
6230.      00      C    O=C'R*RMS*(TAI-TRII)*O
6240.      00      C    HRE=IRI:+O/RMS
6250.      00      C    IF(I.EQ.14)PRINT 740
6260.      00      C    FORMAT(' ',HRE=' ',F10.4)
6270.      00      C    TRE=TRII+(HRE-HRII)/CPR
6280.      00      C    IF((IS.EQ.1)GOTO 84
6290.      00      C    HDIF=IRE1-HRE
6300.      00      C    IF(ABS(HDIF).LT.HTOL)GOTO 83
6310.      00      C    HRE1=HRE
6320.      00      C    CONTINUE
6330.      00      C
6340.      00      C    WRITE(6,654)AIR,I,ICT,XRI,HDIF
6350.      00      C    FORMAT(' ',CASE 5 TUBE Does NOT CONVERGE','AIR,I,ICT,XRI,HDIF',',
@314,F5.2,F10.5),
6360.      00      C

```

***** EVAPHX *****

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6370.    00      C      XTUBF(110,1)=1.-XL10-XSL1G-XANNUL-XH11ST
6380.    00      C      AL1=XTUBE(110,1)*WIDHTH*20.*DDI
6390.    00      C      VV=VV*16.01815/WM
6400.    00      C      AL1=KWIDTH+20.*DDI
6410.    00      C      DF3=SHPD?1(RMS,AL1,DDI,VV,AMR)
6420.    00      C      750 FORMAT(' PRE= ', F10.5)
6430.    00      C      100 PRE=PRI-DP1-DP2-DP3
6440.    00      C      PRE=AMAX1(3.,PRE)
6450.    00      C      PRE=AMAX1(3.,PRE)
6460.    00      C      IF(1.EQ.14)PRINT 750,PRE
6470.    00      C      Q=(HRE-HRI)*RMS
6480.    00      C      TAE=TAIR(1,1)-Q/(CFA*AMR)
6490.    00      C      TAE=TAE+DTI*FG(1)
6500.    00      C      CC*** FOLLOWING STATEMENTS FOR CALC. OF DYNAMIC PRESSURE DROP ARE
6510.    00      C      SKIPPED. THEY PROVIDE LITTLE CORRECTION FOR PRESSURE DROP
6520.    00      C      AT EXPENSE OF A LOT OF COMPUTING.
6530.    00      C      IF(XRI.LT.1..AND.XRE.GT.0.)THEN
6540.    00      C      DIX=DYNDP1(PRI,TRI,PFE,TRE,RMS,DDI)
6550.    00      C      ELSE
6560.    00      C      DIX=DYNDP2(PRI,TRI,PFE,TRE,RMS,DDI)
6570.    00      C      END IF
6580.    00      C      PRE=PRE+DIX
6590.    00      C
6600.    00      C
6610.    00      C      **** END OF HEAT TRANSFER AND PRESSURE DROP CALCULATIONS*****
6620.    00      C
6630.    00      C      **** ENTHALPY & PRESSURE AT TUBE 1 OUTLET ARE KNOWN
6640.    00      C      **** FIND TEMP., QUALITY & SPEC. VOLUME
6650.    00      C      TKRE=(TRE+459.67)/1.8
6660.    00      C      PARE=PRE/14.6959
6670.    00      C      CALL HPIN(N1,HRE,PARE,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
6680.    00      C      TRM(110,2,1)=TKRE*1.8-459.67
6690.    00      C      PRM(110,2,1)=PRE
6700.    00      C      HR(2,1)=HRE
6710.    00      C      XRM(110,2,1)=XRE
6720.    00      C      DFR(1)=PRI-PRE
6730.    00      C      IF(XRE.EQ.0.)THEN
6740.    00      C      VLM(110,2,1)=16.01816*VL/WM
6750.    00      C
6760.    00      C      IF(XRE.LT.1.)THEN
6770.    00      C      WMV=W1*(1.-XV)+V2*XV
6780.    00      C      VGM(110,2,1)=16.0154*GV*VV/WMV
6790.    00      C      WML=W1*(1.-XL)+V2*VL
6800.    00      C      VLM(110,2,1)=16.01516*VL/WML
6810.    00      C
6820.    00      C      VGM(110,2,1)=16.01816*VV/WM
6830.    00      C
6840.    00      C
6850.    00      C      **** REFRIGERANT SIDE CALCULATIONS FOR TUBE 1 COMPLETED.
6860.    00      C      **** FIND AIR STATE PAST TUBE
6870.    00      C      GEGE=OMEGI
6880.    00      C      WATHFG=0.
6890.    00      C      IF(Q.LE.0.)THEN
6900.    00      C      TAIA=TRI
6910.    00      C      TP1PE=TRI
6920.    00      C      GOTO 104
6930.    00      C
6940.    00      C

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EVAPHX *****

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6950.    00      C      OMECHF=0.
6960.    00      C      TWATAI=TRI+Q/UWD
6970.    00      C      TWATAE=TRE+Q/UWD
6980.    00      C      TWATAE=S*(TWATAI+TWATE)
6990.    00      C      TP1PA=0. S*(TRI+TRE)*Q/UFO
7000.    00      C      IF(I.EQ.14)PRINT 755, TWATA
7010.    00      C      FORMAT(.,TWATA='F12.5')
7020.    00      C      CALL AIRPR(1,TWATAI,APIN,1.,OMEGWI,CPW,RW,AMW,AKW)
7030.    00      C      CALL AIRPR(1,TWATE,APIN,1.,OMEGWE,CPW,RW,AMW,AKW)
7040.    00      C      IF(OMEGI.LE.OMEGI1)GOTO 704
7050.    00      C      XCOND=(OMEGI-OMEGI1)/(OMEGWE-OMEGWI)
7060.    00      C      XCUND=AMIN1(1.,XCOND)
7070.    00      C      TWATA=TWATAI+0.5*XCOND*(TWATAE-TWATAI)
7080.    00      C      CALL AIRPR(1,TWATA,APIN,1.,OMEGWI,CPW,RW,AMW,AKW)
7090.    00      C      OMECHP=(OMEGI-OMEGW)*(1.-EXP(-ICT)*(CT)*AP0/(CPA*AMS))
7100.    00      C      TTAIR=TAEE+0.5*XCOND*(TAI-TAEE)
7110.    00      C      TFM=TTAIR-FFEE(1CT)*(TTAIR-TWATA)
7120.    00      C      TEND=TWATA+(TFM-TWATA)/SEG*1N
7130.    00      C      IF(TEND.GT.TAEE)TEND=TAEE
7140.    00      C      CALL AIRPR(1,TEND,APIN,1.,OMEGIS,CPW,RW,AMW,AKW)
7150.    00      C      IF(OMEGIS.LE.OMEGW)THEN
7160.    00      C      OMEGSF=OMEGW
7170.    00      C      GOTO 101
7180.    00      C      END 1F
7190.    00      C      DDT3=DDO*(DDT-DDO)*(OIEGI-OMEGW)/(OMEGI-S-OMEGW)
7200.    00      C      DDT5=AMIN1(DDTS,DDT)
7210.    00      C      IF(DDTS.EQ.DDO)GOTO 103
7220.    00      C      AFIN=3.14159*(DDTS-DDO)*(DDTS+DDO)/4.
7230.    00      C      AFS=AF1N*2.*WIDTH/FPCH
7240.    00      C      SEG=DDTS*3/24.-DDTS*DDO/16.+DDO*3/18.
7250.    00      C      SEG=SEG*2./((AFIN*(DDTS-DDO))
7260.    00      C      OMEGIS=AMIN1(OMEGI,OMEGI1)
7270.    00      C      OMEGFI=OMEGI4*(OMEGIS-(MECH))*SEG
7280.    00      C      ONECHF=(OMEGI-OMEGFI)*(1.-EXP(-1C0D(1CT)*AFS/(CPA*AM1S)))
7290.    00      C      101   ONECHF=OMEGI-OMEGF
7300.    00      C      103   ONECH=XCOND*(OMECHP+OMECHF)
7310.    00      C      OMEGE=OMEGI-OMECH
7320.    00      C      CXC   IF(I.EQ.14)PRINT 760, OMEGE
7330.    00      C      760   FORMAT(.,OMEGE='F14.6')
7340.    00      C      TWATAE=S*(TWATAI+TWATE)
7350.    00      C      TP1FA=.5*(TRI+TRE)+Q/UFO
7360.    00      C      104   TTAIR=0.5*(TAI+TAAE)
7370.    00      C      VFLA=AMAS*(450.+TTAIR)/(AFLOW*(FFPCH-F1K-2.*TKICE(1CT)))
7380.    00      C      CALL WATPR(TWATA,TPIPA,VFLA,OMEGI,WATRO,WATK,
7390.    00      C      &WATM,WATIFG,WATCF)
7400.    00      C      DTHFG(1)=WATHFC*(OMEGI-OMEGE)/CPA
7410.    00      C      TAIE=TAE+DTHFG(1)
7420.    00      C      TAIR(2,1)=TAE
7430.    00      C      WAIR(2,1)=OMEGE
7440.    00      C      AM1=1./AIRN(1CT)+1.
7450.    00      C      AA2=AM1*AIRN(1CT)
7460.    00      C      TAIR(2,1CT+1)=AM1*TAE+AM2*TAIR(2,1CT+1)
7470.    00      C      OMEGA(2,1CT+1)=AM1*OMEGE:AM2*OMEGA(2,1CT+1)
7480.    00      C      TWAT(1CT)=AM1*TWATA+AM2*TWAT(1CT)
7490.    00      C      TP1P(1CT)=AM1*TPIPA+AM2*TP1P(1CT)
7500.    00      C      AIRN(1CT)=AIRN(1CT)+1.
7510.    00      C      7520.

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***** EVAPHX *****

DATE 072184

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7530.      00      C**** SELECT NEXT TURE FOR CALCULATIONS
7540.      00      106 IF(MY(1).EQ.1)THEN
7550.      00      DO 108 N=2,3
7560.      00      NN=KFEED(110,1,N)
7570.      00      IF(NN.EQ.0)GOTO 109
7580.      00      ILN=ILN+1
7590.      00      ILPOK(ILN)=NN
7600.      00      108 CONTINUE
7610.      00      END IF
109      JJ=1
    00      I=KFEED(110,JJ,1)
    00      IF(I.IE.-1)GOTO 22
    00      IF(ILN.EQ.ILNEXT)GOTO 110
    00      ILNEXT=ILNEXT+1
    00      I=1LOOK(ILNEXT)
    00      JJ=1FROM(110,1)
    00      GOTO 22
110      CONTINUE
C      ALL TUBES OF COIL COMPUTED. CHECK IF CONVERGENCE OBTAINED
C
C      H2=0.
C      DO 111 IT=1,1ST(110)
C      I=1START(110,IT)
111      H2=H2+HR(2,I)*FLCW(110,I)
C      H2=H2*NSECT(110)
C      H2PH2=H2P-H2
C      IF(LAIR.LT.3)GOTO 114
C      IF(ABS(H2P12).LT.0.06)GOTO 160
112      H2P=H2
C      HBACK(LAIR,1)=H2
C      HBACK(LAIR,2)=H2FH2
C      CONVERGENCE NOT OBTAINED
C      PREPARE AIR SIDE DATA FOR NEW LOOP
DO 124 I=1,NINDEP
J=I+1
TAIR(1,J)=0.5*(TAIR(1,J)+TAIR(2,J))
124      OMEGA(1,J)=OMEGA(2,J)
      00      124 OMEGA(2,J)=0.
DO 140 I=1,NHDEP
TWATA=TWAT(I)
      00      TAIR=0.5*(TAIR(1,I+1)+TAIR(2,I+1))
      00      TAIR(2,I+1)=0.
      00      WHAIR=OMEGA(1,I)
      00      CALL APPR(TWATA,APIN,1,WATER,CCPA,RFA,
      00      &AANA,AAKA)
      00      TPipe=TPIP(I)
      00      VELA=KAMAS*(460.+TTAIR)/AFLW
      00      VELA=VELA/(FFPCH-FFTK-2.*TKICE(I))
      00      CALL WATER(TWATA,TPipe,VELA,WPAIR,WATR,WATK,
      00      &WATH,WATFC,WATCP)
      00      IF(C*OMEGA(1,I).GT.WATER)GOTO 125
      00      NICE(I)=1.E+30
      00      HFWT(I)=0.
      00      TKICE(I)=0.
      00      GOTO 140
125      IF(OMEGA(1,I+1).LT.OMEGA(1,I))GOTO 126
      00      OMEGA(1,I+1)=OMEGA(1,I)

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EVAPEX

DATE 072184

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00 HICE(1)=1.E+30
00 HFGBT(1)=0.
00 TKICE(1)=0.
00 GOTO 140
126 VMAS=AMMAS*(OMEGA(1,1)-OMEGA(1,1+1))
HFGBT(1)=TAITG*(OMEGA(1,1)-WWATER)
CALL AIRPR(2,TTAIR,APIN,PRL,WAIR,PPA,PPA,AMMA,AMKA)
HFGBT(1)=HFGBT(1)/(CPA*(TAIR(1,1)-TWATA))
IF(TWATA.GT.32.)GOTO 128
TKICE(1)=0.125*VMAS/(AO*HYROM(110)*WATRO)
TKMAX=0.5*(FFPCH-FPTK)
IF(TKICE(1).GE.TKMAX)TKICE(1)=0.9*TKMAX
GOTO 132
128 VAV=VMAS/VFLW
WW=WATH*VWH/WMATC*WATRO
TKICE(1)=1.49E-02*VW/1*VU .333
132 HICE(1)=WATK/TKICE(1)
IF(HICE(1).LT.0.)HICE(1)=0.
IF(TKICE(1).LT.0.)TKICE(1)=0.
IF(HFGBT(1).LT.0.)HFGBT(1)=0.
140 CONTINUE
NTOT=0
NDEEP=NDEP(110)-1
DO 149 ICT=1,NDEEP
NTOT=NTOT+NTUB(110,ICT)
NDIF=NTUB(110,ICT)-NTUB(110,ICT+1)

C
IF(NDIF.EQ.0)THEN
IA=NTOT+1
IB=NTOT+NTUB(110,ICT+1)
DO 142 I=IA,IB
J=JFROM(110,1)
TAIRI(1,1)=TAIRI(2,J)
WAIRI(1,1)=WAIRI(2,J)
142 WAIRI(1,1)=WAIRI(2,J)
END IF
C
IF(NDIF.LT.0)THEN
IA=NTOT+1
IB=NTOT+NTUB(110,ICT)-1
DO 143 I=IA,IB
J=JFROM(110,1)
TAIRI(1,1)=0.5*(TAIRI(1,1)+TAIRI(2,J))
WAIRI(1,1)=0.5*(WAIRI(1,1)+WAIRI(2,J))
143 IA=NTOT-NTUB(110,ICT)+1
IB=NTOT-1
T=0.
WW=0.
DO 144 I=IA,IB
T=T+TAIRI(2,I)
WW=WW+WAIRI(2,I)
144 T=T*(AMSI(1CT)-AMSI(1CT+1))+TAIRI(2,NTOT)*AMSI(1CT)
WW=WW*(AMSI(1CT)-AMSI(1CT+1))+WAIRI(2,NTOT)*AMSI(1CT)
SEG=(NTUB(110,ICT-1)-NTUB(110,ICT)+1)*AMSI(1CT)
T=T/SEG
WW=WW/SEG
IA=NTOT+NTUB(110,1CT)
IB=NTOT+NTUB(110,1CT+1)
DO 145 I=IA,IB
00

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***** EVAPHX *****
      00          TAIRI(1,1)=0.5*(TAIRI(1,1)+T)
      00          WAIRI(1,1)=0.5*(WAIRI(1,1)+WW)
      00          IF (NDIF.GT.0) THEN
      00          IA=NTOT-NDIF+1
      00          TCFR=R.
      00          NCOR=0.
      00          DO 146 I=IA,NTOT
      00          TCFR=TCOR+TAIRI(2,1)
      00          NCOR=WCOR+TAIRI(2,1)
      00          TCFR=TCOR/NTUB(110,ICT+1)
      00          NCOR=WCOR/NTUB(110,ICT+1)
      00          IA=NTOT+1
      00          IB=NTOT+NTUB(110,ICT+1)
      00          DO 147 I=IA,IB
      00          J=JFROM(110,1)
      00          TAIRI(1,1)=.5*(TAIRI(1,1)+(TAIRI(2,J)*AMSI((ICT+1))
      00          WAIRI(1,1)=.5*(WAIRI(1,1)+(WAIRI(2,J)*VCOR)*AMSI((ICT+1))
      00          END IF
      00          149 CONTINUE
      00          PRINT 858,H2
      00          858 FORMAT(' H2=',F8.4)
      00          150 CONTINUE
      C          ***** END OF MAIN LOOP *****
      C          ***** END *****
      00          I=5
      00          DO 151 IEV=6,IAIRN
      00          IF (AES(HBACK(1,2)).GT.ABS(HBACK(IEV,2))) I=IEV
      00          H2=HBACK(1,2)
      00          H2=HBACK(1,1)+H2PH2
      00          Q=ADS(H2*H2*RMASS)
      00          WRITE(6,1021)H2FH2,Q
      00          160 CONTINUE
      00          DO 162 I=1,NTPS(110)
      00          T=TRM(110,1,1)
      00          TRM(110,1,1)=TRM(110,2,1)
      00          TRM(110,2,1)=T
      00          T=PRM(110,1,1)
      00          PRM(110,1,1)=PRM(110,2,1)
      00          PRM(110,2,1)=T
      00          T=XRM(110,1,1)
      00          XRM(110,1,1)=XRM(110,2,1)
      00          XRM(110,2,1)=T
      00          T=VLM(110,1,1)
      00          VLM(110,1,1)=VLM(110,2,1)
      00          VLM(110,2,1)=T
      00          T=VGM(110,1,1)
      00          VGM(110,1,1)=VGM(110,2,1)
      00          VGM(110,2,1)=T
      00          P2=0.
      00          DO 164 I=1,1ST(110)
      00          IE=ISTART(110,1)
      00          P2=P2+PRM(110,2,IE)*FLOW(110,IE)
      00          164 CONTINUE

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***** EVAPHX *****

DATE 072184

```
P2=P2*NSECT(110)
PA2=P2/1.4.GS59
CALL HF1N(NO,H2,PA2,XM,ACC,TK2,X2,XL,XV,VL,VV)
T2=TK2*1.8-459.67
IF(X2.LT.-999)THEN
  TSUP2=0.
ELSE
  CALL DEVENT(M1,PA2,XM,TKD,XL)
  TD=TKD*1.8-459.67
  TSUP2=T2-TD
END IF
QT=RNASS*(H2-H1)
QL=WATHFG*AAMAS*(MFGA(1,1)-OMEGA(1,NODEP+1))
QS=QT-QL
PRINT 880,QT,QS
FORMAT('QT,QS=',3(1PE11.3))
880 WRITE(6,1012)T1,P1,H1,X1,T2,P2,H2,X2,TSUP2
900 FORMAT(/2X,'INPUT DATA TO EVAPIX://2X','T',
  &10X,'P',10X,'X',10X,'RH',9X,'RMASS',/6(1PE11.3))
1021 FORMAT('EVAPIX DOES NOT CONVERGE',/
  &'CONVERGENCE OBTAINED = ',F6.2,'BTU/LB',F11.1,'BTU/H')
1012 FORMAT(/2X,'EVAPORATOR ITERATION://2X',
  &'T',10X,'P',10X,'X',10X,'TSUP',/4(1PE11.3)/5(1PE11.3))
RETURN
END
```

```
END ELT.  ERRORS: NONE. TIME: :.071 SEC. IMAGE COUNT: 951
©HDG,P ***** EVDP ***** .L,O
```

***** EVDP *****

DATE 07/21/84

```
@ELT,L DD.EVDP
ELT 8R1 S74Q1C 07/21/84 15:55:06 (0)
      00      FUNCTION EVDP(RMS, H1, H2, VMIX, VISM, AL, D)
      00      C
      00      C*** PURPOSE:
      00      C   TO COMPUTE FRICTIONAL EVAPORATION PRESSURE DROP
      00      C FOR FLOW IN A TUBE
      00      C
      00      C*** INPUT DATA:
      00      C   AL   - TUBE LENGTH (FT)
      00      C   VISM - LIQUID DYNAMIC VISCOSITY (LBM/H*FT)
      00      C   D    - TUBE INSIDE DIAMETER (FT)
      00      C   RMS  - REFRIG. MASS FLOW RATE (LBM/H)
      00      C   H1   - REFRIG. ENTHALPY AT TUBE INLET (BTU/LBM)
      00      C   H2   - REFRIG. ENTHALPY AT TUBE OUTLET (BTU/LBM)
      00      C   VMIX - REFRIG. AVERAGE SPEC. VOLUME IN A TUBE (FT**3/LBM)
      00      C
      00      C*** OUTPUT DATA:
      00      C   EVDP - FRICTIONAL EVAPORATION PRESSURE DROP (PSI)
      00      C
      00      AC=1.6654E-11          @32.174*144.*3600.**2
      00      G=RMS/(0.78539316*D*D)
      00      RE=G*D/VISM
      00      AKF=778.26*(H2-H1)/AL
      00      RATIO=RE/AKF
      00      IF (RATIO.LT.1.) RATIO=1.
      00      F=0.0185/RATIO**.25
      00      EVDP=AC*F*AL*G*G*VMIX/D
      00      RETURN
      00      END

END ELT.  ERRORS: NONE.  TIME: 0.080 SEC. IMAGE COUNT: 28

@HDG,P ***** FANNO ***** .L,0
```

***** FANNO *****

DATE 072184

```

@EELT,L DD.FANNO
ELT 8R1 S74Q1C 07/21/84 15:55:07 (O)
          00   FUNCTION FANNO(XM,P,H0,GG)
          20.
          00
          C**** PURPOSE:
          C    TO CALCULATE ENTROPY OF NON-AZENTROPIC
          C    TWO-PHASE MIXTURE IN THE FANNO FLOW
          C    FOR A GIVEN PRESSURE
          C
          C**** INPUT DATA:
          C    HO      - REFRIG. TOTAL ENTHALPY (BTU/LM)
          C    GG      = G*G/(64.4*78.104) (BTU*LM/FT**6)
          C    WHERE G - REFRIG. MASS FLUX (LM/(SEC*FT**2))
          C    P        - REFRIG. PRESSURE AT WHICH ENTROPY IS DESIRED (PSIA)
          C    XM      - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
          C
          C**** OUTPUT DATA:
          C    FANNO - ENTROPY (BTU/LM R)
          C
          C**** SUBPROGRAMS CALLED BY FANNO:
          C    EBUTE,ENTROP,HCVCP,QLITY,VOLIT1
          C
          COMMON/RDATA2/W1,W2,TC1,TC2
          DATA SLOPE/0./NO,N1/O,1/
          C
          IF(P.GT.0.)GOTO 10
          WRITE(6,600)P
          600 FORMAT(' ERROR IN CALLING FANNO, P= ',1PE15.5,' PSIA')
          RETURN
          C
          10 PA=P/14.6959
          TKB=EBUTE(PA,XM)
          TKD=TKB+9.5-20.*(.55-XM)
          TB=TKB*1.8-459.67
          TD=TKD*1.8-459.67
          TK2=0.5*(TKB+TKD)
          D0J 100 I=1,20
          CALL QLITY(TK2,PA,XM,XG,XV,XL)
          CALL VOLIT1(N1,TK2,PA,XV,VNV)
          CALL HCVCP(N1,TK2,VN1,XV,HV,CV,CP)
          CALL VOLIT1(NO,TK2,PA,XL,VNL)
          CALL HCVCP(N1,TK2,VML,XL,CV,CP)
          HFQ=HV-HL
          WNV=W1*(1.-XV)+W2*XV
          WNL=W1*(1.-XL)+W2*XL
          VV=VN1*16.01845^NMV
          VL=VNL*16.01845^WNL
          VFG=VV-VL
          R=GG*VFG*VFG
          S=2.*GG*VV*VFG*HFQ
          C=GG*VL*VL+HL-H0
          XQN=(-S*SQRT(S*S-4.*R*C))/(2.*R)
          DIFXQ2=XQN-XQ
          TF=TK2*1.8-450.
          PRINT 800,P,TF,XQN,DIFXQ2
          800 FORMAT(' P,TF,XQN,DIFXQ2')
          IF(ABS(DIFXQ2).LT.0.000001)GOTO 110
          C
          IF(I.GT.1)GOTO 70

```

***** FANNO *****

```

570.      00      TK1=TK2
      00      DIFXQ1=DIFXQ2
      00      IF(SLOPE.NE.0.) THEN
      00      TDEL=DIFXQ2*SL/R/E
      00      TD=ABS(TDEL)
      00      TD=AMIN1(4.,TD)
      00      TK2=TK1-SIGN(TD,TDEL)
      00      ELSE
      00      TK2=TK1+SIGN(1.,DIFXQ2)
      00      END IF
      00      GOTO 100
      00
      C      70      SLOPE=(TK2-TK1)/(DIFXQ2-DIFXQ1)
      00      IF(ABS(DIFXQ1).LT.ABS(DIFXQ2))GOTO 80
      00      TK1=TK2
      00      DIFXQ1=DIFXQ2
      00      80      TK2=TK1-DIFXQ1*SLOPE
      00      100     COUNTINUE
      00      PRINT EO2,DIFXQ2
      00      602     FORMAT(' FANNO DOFS NOT CONVERGE, DIFXQ2=',1PE15.5)
      00      110     CONTINUE
      00      SL=ENTROP(TK2,VNL,XL)
      00      SV=ENTROP(TK2,VMV,XV)
      00      FANNO=(1.-XQQ)*SL+XQQ*SV
      00      RETURN
      00      END
      00
      END ELT.  ERRORS: NONE.  TIME: 0.135 SEC.  IMAGE COUNT: 82
@HDG,P ***** FEELIQ ***** .L,O

```

***** FEELIQ *****

DATE: 072184

@ELT,L DD.FEELIQ
ELT 8R1 S74Q1C 07/21/84 15:55:07 (O)
10. 00 FUNCTION FEELIQ(X,T,XML,XMV,VMV,VMV,XTT)

20. 00
30. 00 C**** PURPOSE:
40. 00 C COMPUTE FOR A NON-AZOTROPIC MIXTURE TWO-PHASE FLOW
50. 00 C LOCKHART-MARTINELLI CORRECTION PRESSURE DROP FACTOR
60. 00 C
70. 00 C**** INPUT DATA:
80. 00 C T - REFRIG. AVERAGE TEMPERATURE (F)
90. 00 C VML - LIQUID SPECIFIC VOLUME (L/MOL)
100. 00 C VMV - VAPOUR SPECIFIC VOLUME (L/MOL)
110. 00 C X - REFRIG. AVERAGE QUALITY (-)
120. 00 C XL - LIQUID MOLEAR COMPOSITION
130. 00 C (FRACTION OF LESS VOLATILE COMPONENT)
140. 00 C XV - VAPOUR MOLEAR COMPOSITION
150. 00 C (FRACTION OF LESS VOLATILE COMPONENT)
160. 00 C W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT (G/MOL)
170. 00 C W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT (G/MOL)
180. 00 C
190. 00 C**** OUTPUT DATA:
200. 00 C FEELIQ - PRESSURE DROP CORRECTION FACTOR (-)
210. 00 C XTT - LOCKHART-MARTINELLI PARAMETER (-)
220. 00 C
230. 00 C**** SUBPROGRAMS CALLED BY FEELIQ:
240. 00 C VISCON
250. 00 C
260. 00 C COMMON/RDATA2/W1,W2,TC1,TC2
270. 00 C
280. 00 C A0=-.418956
290. 00 C A1=1.47330
300. 00 C A2=.668583
310. 00 C A3=-.321168
320. 00 C A4=0.0408167
330. 00 C XML=XFL/(W1/W2*(1.-XML)+XML)
340. 00 C VISM=VISCON(1,T,XML)
350. 00 C XMV=XMV/(W1/W2*(1.-XML)+XML)
360. 00 C VISV=VISCON(3,T,XMV)
370. 00 C WML=W1*(1.-XML)+W2*XML
380. 00 C VL=16.01846*VML/WML
390. 00 C WMV=W1*(1.-XML)+W2*XML
400. 00 C VV=16.01846*VMV/WMV
410. 00 C XTT=((1.-X)/X)*.9*(VL/V')**.5*(VISM/VISV)**.1
420. 00 C H4=1./XTT
430. 00 C H1=H4*.25
440. 00 C H2=H1*H1
450. 00 C H3=H2*xH1
460. 00 C FEELIQ=EXP(A0+A1*H1+A2*H2+A3*xH3+A4*xH4)
462. 00 C FEELIQ=FEELIQ**2
470. 00 C
END ELT. ERRORS: NONE. TIME: 0.098 SEC. IMAGE COUNT: 48

@HDG,P ***** FGIBBS ***** .L,0

***** FGIBBS *****

```
@ELT,L DD FGIBBS
ELT 8R1 S74Q1C 07/21/84 15:55:07 (0)
10.    00      FUNCTION FGIBBS(T,P,X,V)
20.    00      C
30.    00      C
40.    00      C*** PURPOSE:
50.    00      C TO EVALUATE GIBBS FREE ENERGY
60.    00      C
70.    00      C*** INPUT:
80.    00      C P - REFRIG. PRESSURE (ATM)
90.    00      C T - REFRIG. TEMPERATURE (K)
100.   00      C V - REFRIG. SPEC. VOLUME (L/MOL)
110.   00      C X - MOLE CONCENTRATION OF A LESS VOLATILE REFRIG.
120.   00      C * - CONSTANTS A @ B AS PER COMMON STATEMENT PARAM
130.   00      C
140.   00      C*** OUTPUT:
150.   00      C G - GIBBS FREE ENERGY (KJ)
160.   00      C
170.   00      C COMMON/PARAM/A,B,C1,C2,D1,D2
180.   00      C DATA R/0.0R206/
190.   00      C
200.   00      C
210.   00      C
220.   00      C G=R*T*ALOG(R*T/(P*V))
230.   00      C G=G-2.*R*T/(V-B/4.)*(V-B/2.)
240.   00      C G=G+A/B*( ALOG(V/(V+B))-R/(V+B) )
250.   00      C G=G+R*T/(V-B/4.)*2*(2.*V**3/(V-B/4.) +B**2/16.)
260.   00      C IF(X.EQ.0.OR.X.EQ.1.)GOTO 10
270.   00      C G=G+R*T*(X*ALOG(X)+(1.-X)*ALOG(1.-X))
280.   00      C 10 FGIBBS=G
290.   00      C RETURN
300.   00      C END

END ELT.  ERRORS: NONE. TIME: 0.081 SEC. IMAGE COUNT: 30
```

```
@HDG,P ***** HCVCP ***** .L,0
```

***** HCVCP *****

DATE 072184

```

@ELT,L DD.HCVCP
ELT 9R1 S7401C 07/21/84 15:55:07 (0)
          00      SUBROUTINE HCVCP(IQ,T,V,X,H,CV,CF)
          20.
          30.
          40.      00      PURPOSE:
          50.      00      TO CALCULATE REFRIG. THERMODYNAMIC PROPERTIES
          60.
          70.      00      INPUT:
          80.      00      IQ - OUTPUT QUALIFIER
          90.      00      C = 1 FOR ENTHALPY ONLY
          100.     00      C = 2 FOR ENTHALPY AND SPEC. HEAT AT CONST. VOL.
          110.     00      C = 3 FOR ENTHALPY, SPEC. HEAT AT CONST. VOL. @
          120.     00      C = SPEC. HEAT AT CONST. PRESSURE
          130.     00      C = 4 FOR SPEC. HEAT AT CONST. VOL. ONLY
          140.     00      C = 5 FOR SPEC. HEAT AT CONST. VOL. @ SPEC. HEAT
          150.     00      C = AT CONST. PRESSURE
          160.     00      C T - REFRIG. TEMPERATURE (K)
          170.     00      C V - REFRIG. SPEC. VOLUME (L/MOL)
          180.     00      C X - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE REFRIG.)
          190.     00      C W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT (G/MOL)
          200.     00      C W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT (G/MOL)
          210.     00      C * - CONSTANTS AS PER COMMON STATEMENT /PARAM/
          220.     00      C A,B,C1,D1 FOR CALC. OF ENTHALPY
          230.     00      C A,B,C1,C2,D1,D2 FOR CALC. OF EITHER OF SPEC. HEAT
          240.     00      C
          250.     00      C **** OUTPUT:
          260.     00      C CP - SPEC. HEAT AT CONST. PRESSURE (BTU/(LB*F))
          270.     00      C CV - SPEC. HEAT AT CONST. VOLUME (BTU/(LB*F))
          280.     00      C H - ENTHALPY (BTU/LB)
          290.     00      C
          300.     00      C COMMON/PARAM/A,B,C1,C2,D*,D2
          310.     00      C COMMON/RDATA2/Y1,W2
          320.     00      C DATA R/O. 08206/
          330.     00      C
          340.     00      C **** SUBPROGRAMS CALLED BY HCVCP:
          350.     00      C HPAR
          360.     00      C
          370.     00      C CALL HPAR(IQ,T,X)
          380.     00      C WML=(1.-X)*W1+)*W2
          390.     00      C CONV=453.5924/(1.0E5036*1/MOL)
          400.     00      C T2=T*T
          410.     00      C
          420.     00      C T3=T2*T
          430.     00      C IF(IQ,GT,3)GOTO 10
          440.     00      C **** CALC. OF ENTHALPY
          450.     00      C H=(C1*B*T-A*D1*T-A*B)/B**2*ALOG((V+B)/V)
          460.     00      C H=H+(A*D1*T-A*B)/(B*(V+B))
          470.     00      C H=H+2.*R*T*V*(2.*V-B/A.)/(V-B/4.)*3*(B/4.-D1*T/4.)
          480.     00      C H=0.101325*H
          490.     00      C H=H+(1.-X)*(9.0190537*(T-233.15)+1.091972E-04*(T2-233.15**2))
          500.     00      C H=-((1.-X)*(5.6746E-03*(T3-233.15**3)))
          510.     00      C H=H+(1.-X)*16.8376E30893
          520.     00      C H=H+X*(0.0222804*(T-233.15)+7.700165E-05*(T2-233.15**2))
          530.     00      C H=H+X*(1.022234E-09*(233.15**3-T3)+21.9460206504)
          540.     00      C H=H%CCNV
          550.     00      C
          560.     00      C IF(IQ,EQ,1)GOTO 1000

```

***** HCVCP *****

```

570.    00      10 D12=D1**D1
          CV=(C2*B**2*T-2.*C1*D1*B*T+2.*A*D12*T-A*D2*B*T)/B**3
          CV=CV*ALOG((V+B)/V)
          CV=CV*T/B/(V+B)**((A*D2*B**2.*C1*D1*B-2.*A*D12)/B)
          CV=CV-T/B/(V+B)**D12/(V+B)
          CV=CV+2.*R*T*V/(V-B/A.)**3*((D2/4.*T+D1/2.)*(B/4.-2.*V)+D12/16.*T)
          CV=CV+6.*R*T2*V*D12/16.*((B/4.-2.*V)/(V-B/4.))**4
          CV=CV+(1.-X)*(0.0116293+2.16394E-9*T-1.702407E-7*T2)
          CVM=CVM*(0.013966+1.540093E-04*T-3.0667045E-9*T2)
          CV=CV*CONV/1.8
          IF(IQ.EQ.2.OR.IQ.EQ.4)GOTO 1000
          Y=B/V/4.
          Y2=Y*Y
          Y3=V2*Y
          Y4=Y3*Y
          P0=-R/(1.-Y)*4*(1+4.*Y+4.*Y2-4.*Y3+Y4)+A*(2.*V+B)/T/(V+B)**2
          T0=R/(1.-Y)**3*(1+Y+Y2-Y3+D1*T*(4.+4.*Y-2.*V2)/V/A./((1.-Y))
          T0=T0-C1/(V+B)+A*D1/(V+B)**2
          CP=-0.101325*T0**2/P0
          CP=CONV*(CP+CVM)/1.8
          1000 RETURN
          END
END ELT.  ERRORS: NONE.  TIME: 0.134 SEC. IMAGE COUNT: 79
@HDG,P ***** HPAR ***** .L,0

```

***** HPAR *****

DATE 072184

```

EELT,L DD,HPAR
ELT 8R1 S74Q1C 07/21/84 15:55:08 (0)
      SUBROUTINE HPAR(IQ,T,X)

10.    00
20.    00
30.    00
40.    00
50.    00
60.    00
70.    00
80.    00
90.    00
100.   00
110.   00
120.   00
130.   00
140.   00
150.   00
160.   00
170.   00
180.   00
190.   00
200.   00
210.   00
220.   00
230.   00
240.   00
250.   00
260.   00
270.   00
280.   00
290.   00
300.   00
310.   00
320.   00
330.   00
340.   00
350.   00
360.   00
370.   00
380.   00
390.   00
400.   00
410.   00
420.   00
430.   00
440.   00
450.   00
460.   00
470.   00
480.   00
490.   00
500.   00
510.   00
520.   00
530.   00
540.   00
550.   00
560.   00

      C*** PURPOSE:
      C   TO CALC. PARAMETERS FOR CALCULATIONS OF REFRIG.
      C   ENTHALPY , SPEC. HEAT AND ENTROPY REQUIRED
      C   (CONSTANTS A @ B FOR EQ. OF STATE ARE INCLUDED)

      C*** INPUT:
      C   REFRIG. CONSTANTS AS LISTED IN THE COMMON STATEMENT /RDATA1/
      C   IQ - OUTPUT QUALIFIER
      C     = 1, IF CONSTANTS FOR CALC. OF ENTHALPY OR ENTROPY REQUIRED
      C     > 1, IF ALSO CONSTANTS FOR SPEC. HEAT REQUIRED
      C   T - REFRIG. TEMPERATURE (K)
      C   X - MOLE CONCENTRATION OF A LESS VOLATILE REFRIG. (-)

      C*** OUTPUT:
      C   * - CONSTANTS FOR EVALUATION OF REFRIG.
      C     ENTHALPY , A,B,C1,D1
      C     ENTROPY, A,B,C1,D1
      C     SPEC. HEAT, A,B,C1,C2,D1,D2

      C*** PROGRAMS CALLED BY HPAR:
      C   EQPAR

      COMMON/RDATA1/A3,A4,A5,A6,A7,A8,B3,B4,B5,B6,B7,B8,F0,F1
      COMMON/PARAM/A,B,C1,C2,D1,D2
      COMMON/STORE1/A1,A2,B1,B2,SEG31
      DATA TLAST,XLAST/2*0./

      CALL EQPAR(T,X)
      IF(ABS(T-TLAST).GT.0.0001)GOTO 10
      IF(ABS(X-XLAST).GT.0.0001)GOTO 10
      IF(IQ.NE.1)GOTO 10
      RETURN

      C   10  TLAST=T
      XLAST=X
      X2=X**2
      XX=1.-X
      XX2=XX**2
      XXX=X*XX
      T2=T**2
      A1A2S=SQRT(A1*A2)
      SEG1=XXX*A1A2S
      F=F0+F1*T
      SEG2=XXX*(1.-F)*A1A2S
      SEG32=SEG31**2
      SEG5=R4+2.*B5*T
      SEG6=B7+2.*B8*T
      SEG7=A4+2.*A5*T
      SEG8=A7+2.*A8*T
      SEG9=B1*(2./3.)
      SEG10=B2*(2./3.)
      D1=XX2*SEG5+Y/2*SEG6
      00

```

```

***** HPAR *****
570.    00      D4=SEG5/SEG9+SEG6/SEG10
580.    00      D4=D4*XXX*SEG32
590.    00      D1=D1*D4
600.    00      C1=XX2*SEG7*X2*SEG8
610.    00      C1=C1+SEG1*((1.-F)*SEG7/A1)
620.    00      C1=C1+SEG1*((1.-F)*SEG8/A2)
630.    00      C1=C1-2.*XXX*F1*A1A2S
640.    00      IF((IQ.EQ.1)RETURN
650.    00
660.    00      C   D2=SEG5**2/B1**((5./3.)*SEG6**2/B2**((5./3.))
670.    00      D2=-2./3.*D2+2.*((5./SEG9*B8/SEG10)
680.    00      D2=D2*XXX*SEG32
690.    00      D3=SEG5/SEG9+SEG6/SEG10
700.    00      D3=D3**2*XXX*SEG31/3.
710.    00      D2=D2+D3+2.*((XX2*D5+X2*B8)
720.    00      C2=2.*((XX2*A5+X2*A8)
730.    00      C2=C2-2.*SEG1*F1*(SEG7/A1+SEG8/A2)
740.    00      C2=C2+SEG2*(2.*A5/A1**2.*A8/A2)
750.    00      C2=C2+SEG2*(SEG7*SEG8/A1/A2)
760.    00      C3=(SEG7/A1)**2+(SEG2/A2)**2
770.    00      C2=C2-XXX*((1.-F)*(A1*A)**0.5*C3/2.
780.    00      RETURN
790.    00      END

END ELT.  ERRORS: NONE. TIME: 0.125 SEC. IMAGE COUNT: 79
@Hdg,P ***** HPIN ***** .L,0

```

***** HPIN *****

DATE 072184

```
@ELT,L DD,HPIN
ELT OR1 S74Q1C 07/21/84 15:55:08 (0)
          00      SUBROUTINE HPIN(IG,H,P,X,ACUR,T,XQ,XL,XV,VL,VV)
20.        00
30.        00
40.        00
50.        00
60.        00
70.        00
80.        00
90.        00
100.       00
110.       00
120.       00
130.       00
140.       00
150.       00
160.       00
170.       00
180.       00
190.       00
200.       00
210.       00
220.       00
230.       00
240.       00
250.       00
260.       00
270.       00
280.       00
290.       00
300.       00
310.       00
320.       00
330.       00
340.       00
350.       00
360.       00
370.       00
380.       00
390.       00
400.       00
410.       00
420.       00
430.       00
440.       00
450.       00
460.       00
470.       00
480.       00
490.       00
500.       00
510.       00
520.       00
530.       00
540.       00
550.       00
      00
      C
      C
      C*** PURPOSE:
      C   TO CALC. TEMPERATURE OF BINARY MIXTURE FROM GIVEN
      C   ENTHALPY AND PRESSURE
      C
      C*** INPUT:
      C   ACCUR - REQUIRED ACCURACY OF CONVERGENCE (BTU/LB)
      C   IG    = 0, IF GUESS OF TEMPERATURE IS NOT GIVEN
      C         = 1, IF GUESS OF TEMPERATURE IS GIVEN
      C
      C   H    - ENTHALPY (BTU/LB)
      C   P    - PRESSURE (STD ATM)
      C   T    - GUESS OF TEMPERATURE, OPTIONAL (K)
      C   X    - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
      C
      C*** OUTPUT:
      C   T    - BINARY MIXTURE TEMPERATURE (K)
      C   VL   - SPEC. VOLUME OF SURCONED OR SAT. LIQUID AT T TEMP.
      C   P    - AND P PRESSURE, IF MIXTURE IS SUBCOOLED
      C         OR IN TWO-PHASE, RESPECTIVELY. (L/MOL)
      C
      C   VV   - SPEC. VOLUME OF SUPERICATED OR SAT. VAPOR AT T TEMP.
      C         AND P PRESSURE, IF MIXTURE IS SUPERHEATED
      C         OR IN TWO-PHASE, RESPECTIVELY. (L/MOL)
      C
      C   XL   - MOLAR COMPOSITION OF SAT. LIQUID
      C
      C   XV   - MOLAR COMPOSITION OF LESS VOLATILE COMPONENT
      C
      C   XQ   - QUALITY (-)
      C
      C*** SUBPROGRAMS CALLED BY HPIN:
      C   DBUTE, DDEWTE, DQALITY, ERUBTE, HCVCPL, QLITY, VOLIT1
      C
      REAL*8 TDD, PDD, XQDD, XVDD, XLDD
      C
      COMMON/RDATA2/W1,W2,TC1,TC2
      DATA SLOPE/0./,PLAST/0./
      C
      IF(P.LE.0.)THEN
      PRINT 590,P
      590 FORMAT(' HPIN CALLED WITH NON-POSITIVE PRESSURE, P@TM= ',1PE15.6)
      RETURN
      END IF
      C
      TT=T
      IF(ABS(P-PLAST).GT.1.E-4)GOTO 2
      IF(ABS(H-HLAST).GT.ACUR)GOTO 2
      IF(ABS(X-XLAST).GT.1.E-4)GOTO 2
      T=TLAST
      XQ=XQLAST
      XL=XLLAST
      XV=XVLAST
      VL=VLLAST
      VV=VVLAST
      RETURN
      C
      2 IF(IG.NE.1)T=EBUBTE(P,X)-3.
```

```

***** HPIN *****
      570.          00
      580.          00
      590.          00
      600.          00
      610.          00
      620.          00
      630.          00
      640.          00
      650.          00
      660.          00
      670.          00
      680.          00
      690.          00
      700.          00
      710.          00
      720.          00
      730.          00
      740.          00
      750.          00
      760.          00
      770.          00
      780.          00
      790.          00
      800.          00
      810.          00
      820.          00
      830.          00
      840.          00
      850.          00
      860.          00
      870.          00
      880.          00
      890.          00
      900.          00
      910.          00
      920.          00
      930.          00
      940.          00
      950.          00
      960.          00
      970.          00
      980.          00
      990.          00
     1000.          00
     1010.          00
     1020.          00
     1030.          00
     1040.          00
     1050.          00
     1060.          00
     1070.          00
     1080.          00
     1090.          00
     1100.          00
     1110.          00
     1120.          00
     1130.          00
     1140.          00

      XQX=.5
      IDD=1.0029-ACCUR
      DO 50 I=1,20
      IF(I.EQ.1)GOTO 8
      IF(XQ.EQ.0..AND.HDIF2.LT.0.)GOTO 11
      IF(XQ.EQ.1..AND..HDIF2.GT.0.)GOTO 12
  8 IF(T.EQ.TC1)THEN
      XQ=1.
      GOTO 12
  END IF
  IF( IDD.EC.0 )THEN
    CALL QLITY(T,F,X,XQ,XV,XL)
  ELSE
    TDD=T
    FDD=P
    CALL DQLITY(TDD,PDD,X,XQDD,XVDD,XLDD)
    XQ=:XQND
    XV=XVDD
    XL=XLDD
  END IF
  IF(XQ.EQ.1.)GOTO 12
  11 XX=X
  IF(XQ.NE.0.)XX=XL
  CALL VOLIT1(0,T,P,XX,VL)
  CALL HCVCR(1,T,VL,XX,HL,CV,CP)
  IF(XQ.EQ.0.)GOTO 14
  12 XX=X
  IF(XQ.NE.1.)XX=XV
  CALL VOLIT1(1,T,P,XX,VW)
  CALL HCVCP(1,T,VW,XX,HW,CV,CP)
  14 HH=(1.-XQ)*HL+XQ*HV
  T2=T
  HDIF2=H-HH
  IF(ABS(HDIF2).LT.ACUR)GOTO 100
  IF(L.NE.1)GOTO 20
  15 T1=T2
  HDIF1=HDIF2
  IF(SLOPE.NE.0.)THEN
    DT=HDIF2*SLOPE
    IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
    T=T2-DT
    GOTO 48
  END IF
  T=T2+8.
  IF(HDIF2.LT.0.)T=T2-8.
  GOTO 48
  C 20 IF(XQ.EQ.0..AND..HDIF2.GT.0.)THEN
    IF(XQX.EQ.0.)GOTO 22
    IDD=1
    TDD=T2
    PDD=P
    CALL DBURTE(1,FDD,X,TDD,XVDD)
    TB=TDD
    CALL VOLIT1(0,TB,P,X,VL)
    CALL HCVCP(1,TE,VL,X,HB,CV,CP)
    IF(H.GT.HD)THEN
      HDIF2=H-HB

```

```

***** HPIN *****
      1150.      00      T2=TB
      1160.      00      ELSE
      1170.      00      HDIF1=H-HB
      1180.      00      T1=TB
      1190.      00      END IF
      1200.      00      GOTO 22
END IF
      1210.      00
      1220.      00      IF(XQ.EQ.1..AND.HDIF2.LT.0.)THEN
      1230.      00      1F(XQ,XEQ.1.)GOTO 22
      1240.      00      IDD=1
      1250.      00      TD=PDD
      1260.      00      PDD=P
      1270.      00      CALL DDEWTE(1,PDD,X,TND,YLDD)
      1280.      00      TD=TDD
      1290.      00      CALL VOLIT1(1,TD,P,X,VV)
      1300.      00      CALL HCVCP(1,TD,VV,X,HV,CV,CP)
      1310.      00      IF(H.LT.HV)THEN
      1320.      00      T2=TD
      1330.      00      HDIF2=H-HV
      1340.      00      ELSE
      1350.      00      T1=TD
      1360.      00      HDIF1=H-HV
      1370.      00      END IF
END IF
      1380.      00      22 IF(HDIF1.EQ.HDIF2)THEN
      1390.      00      WRITE(6,601)XQ,DT,HDIF2
      1400.      00      GOTO 60
      1410.      00
      1420.      00      END IF
      1430.      00      SLOPE=(T2-T1)/(HDIF2-HDIF1)
      1440.      00      IF(ABS(HDIF1).LT.ABS(HDIF2))GOTO 30
      1450.      00      T1=T2
      1460.      00      HDIF1=HDIF2
      1470.      00      DT=HDIF1*SLOPE
      1480.      00      IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
      1490.      00      T=T1-DT
      1500.      00      48 XQ=XQ
      1510.      00      50 CONTINUE
      1520.      00      60 WRITE(6,600)IG,HDIF2,H,P,X,ACCUR,TT,XQ,XQX
      1530.      00      600 FORMAT(' ERROR GOO IN HPIN, IG,HDIF2= ',I3,1PE12.4,
      1540.      00      & ' . H, P, X, ACCUR, TT, XQ, XQX= ',7(1PE12.4))
      1550.      00      601 FIRMAT(' HPIN DOES NOT CONVERGE ANY FURTHER, XC,DT,HDIF2= ',3F8.4)
      1560.      00      100 PLAST=P
      1570.      00      HALST=H
      1580.      00      XLAST=X
      1590.      00      TLAST=T
      1600.      00      XQLAST=XQ
      1610.      00      XLLAST=XL
      1620.      00      XVLAST=XV
      1630.      00      VLLAST=VL
      1640.      00      VVLAST=VV
      1650.      00      RETURN
      1660.      00      END

END ELT.    ERRORS: NONE. TIME: 0.221 SEC. IMAGE COUNT: 166
@HNG, P ***** HPROP ***** .L, O

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***** HPPROP *****

ELT,L DD.HPPROP
 ELT 8R1 S74Q1C 07/21/84 15:55:08 (0)
 10. 00
 20. 00
 30. 00
 40. 00
 50. 00
 60. 00
 70. 00
 80. 00
 90. 00
 100. 00
 110. 00
 120. 00
 130. 00
 140. 00
 150. 00
 160. 00
 170. 00
 180. 00
 190. 00
 200. 00
 210. 00
 220. 00
 230. 00
 240. 00
 250. 00
 260. 00
 270. 00
 280. 00
 290. 00
 300. 00
 310. 00
 320. 00
 330. 00
 340. 00
 350. 00
 360. 00
 370. 00
 380. 00
 390. 00
 400. 00
 410. 00
 420. 00
 430. 00
 440. 00
 450. 00
 460. 00
 470. 00
 480. 00
 490. 00
 500. 00
 510. 00
 520. 00
 530. 00
 540. 00
 550. 00
 560. 00

ELT,V,CP,CV,AM,AK)
 @ VM,V,CP,CV,AM,AK)

C*** PURPOSE:
 C TO CALC. THERMODYNAMIC AND TRANSPORT AND PROPERTIES
 C OF BINARY MIXTURE FROM GIVEN PRESSURE AND ENTHALPY

C*** INPUT DATA:
 C IG = 0, IF GUESS OF REFRIG. TEMP. IS NOT GIVEN
 C = 1, IF GUESS OF REFRIG. TEMP. IS GIVEN
 C ACC - ACCURACY OF CONVERGENCE REQUIRED (BTU/LB)
 C H - ENTHALPY (BTU/LB)
 C PA - PRESSURE (STD. ATM)
 C TK - GUESS OF REFRIG. TEMPERATURE, OPTIONAL (K)
 C XM - MOLE COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)

C*** OUTPUT DATA:
 C AK - THERMAL CONDUCTIVITY (BTU/(H*FT*F))
 C AM - ABSOLUTE VISCOSITY (LB/(H*FT))
 C CP - SPEC. HEAT AT CONSTANT PRESSURE (BTU/(LB*F))
 C CV - SPEC. HEAT AT CONSTANT VOLUME (BTU/(LB*xF))
 C TK - TEMPERATURE (K)
 C V - SPEC. VOLUME OF MIXTURE (FT**3/LB)
 C VLM - SPEC. VOLUME OF SAT. LIQUID AT TK TEMP. AND PA PRESSURE
 C IF MIXTURE IS IN TWO-PHASE (L/mol)
 C VM - SPEC. VOLUME OF MIXTURE (L/mol)
 C VVM - SPEC. VOLUME OF SAT. VAPOR AT TK TEMP. AND PA PRESSURE
 C IF MIXTURE IS IN TWO-PHASE (L/mol)
 C XM - COMPOSITION OF SAT. LIQUID AT TK TEMP. AND PA PRESSURE
 C (MOLE FRACTION OF LESS VOLATILE COMPONENT)
 C XMV - COMPOSITION OF SAT. VAPOR AT TK TEMP. AND PA PRESSURE
 C (MOLE FRACTION OF LESS VOLATILE COMPONENT)
 C XQ - QUALITY (-)

C*** SURROGRAMS CALLED BY HPPROP:
 C HCVC,P,HPIN,VISCCN

C COMMON/RDATA2/W1,W2,TG1,TG2
 DATA N1,N2,N3,N4,N5/1,2,3,4,5/

C WM=(1.-XM)*W1+X1*W2
 XV=XM/(W1/W2*(1.-XM)+XM)
 CALL HPIN(H,PA,XM,ACC,TK,XQ,XML,VLM,VVM)
 T=TK*1.8-459.67
 IF(XQ.EQ.0.) THEN
 VM=VLM
 VM=VM*16.01845/VM
 AM=VISCCN(N1,T,XW)
 AK=VISCCN(N2,T,XW)
 CALL HCVC(P(NS,TK,VLM,XM,DUM,CV,CP)
 GOTO 1000
 END IF

C IF(XQ.NE.1.) THEN
 XL=XML/(W1/W2*(1.-XM))+XM) @TWO-PHASE

***** HPPROP *****

DATE 072184

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      00      XV=XMV/(W1/W2*((1.-XMV)*XWV)
570.    00      AM=(1.-XO)*VISCON(N1,T,XL)
      00      AM=AM+XO*VISCON(N3,T,XV)
      00      AK=(1.-XO)*VISCON(N2,T,XL)
      00      AK=AK+XO*VISCON(N4,T,XV)
      00      WML=(1.-XML)*W1+XML*XW2
      00      WMV=(1.-XMV)*W1*XW1*XW2
      00      V=16.01845*((1.-XO)*VLM/XML+XO*VMN/WMV)
      00      VM=V*WM/16.01846
      00      CALL HCVCP(N5,T,VLM,XNL,DUM,CVL,CPL)
      00      CALL HCVCP(N5,T,VVI,XIV,D'II,CVV,CPV)
      00      CP=(1.-XO)*CFL+XO*CPV
      00      CV=(1.-XO)*CVL+XO*CVV
      ELSE
      VM=VVM
      V=VM*13.01846/WM
      AM=VISCON(N3,T,XW)
      AK=VISCON(N4,T,XW)
      CALL HCVCP(N5,T,VVM,XM,DUM,CV,CP)
      END IF
      1000 RETURN
      END.
```

END ELT. ERRORS: NONE. TIME: 0.161 SEC. IMAGE COUNT: 78

@HDG, P ***** HTC CON **** .L, 0

***** HTCCON *****

DATE 072184

```

@ELT,L DD.HTCCON
ELT 8R1 S7AQ1C 07/21/84 15:55:09 (0)
          00      FUNCTION HTCCON(T,P,RMAS,D)

10.      00
20.      00
30.      00      C**** PURPOSE:
40.      00      C TO COMPUTE CONDENSATION HEAT TRANSFER COEFFICIENT
50.      00      C FOR NON-AZOTROPIC MIXTURE FLOW INSIDE A TUBE
60.      00
70.      00      C**** INPUT DATA:
80.      00      C      D - TUBE DIAMETER (FT)
90.      00      C      P - REFRIG. AVERAGE PRESSURE (PSIA)
100.     00      C      RMAS - REFRIG. MASS FLOW RATE (LBM/H)
110.     00      C      T - REFRIG. AVERAGE TEMPERATURE (F)
120.     00      C      XW - MIXTURE WEIGHT COMPOSITION
130.     00      C      XM - (FRACTION OF LESS VOLATILE COMPONENT)
140.     00      C      XM - MIXTURE MOLAR COMPOSITION
150.     00      C      W1 - (FRACTION OF LESS VOLATILE COMPONENT)
160.     00      C      W2 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT
170.     00      C      W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT
180.     00
190.     00      C**** SUBPROGRAMS CALLED BY HTCCON:
200.     00      C      BUBTEM,DEWTEM,HCVCP,QLITY,SPTHc,VISCON,VOLIT1
210.     00
220.     00
230.     00
240.     00
250.     00
260.     00
270.     00
280.     00
290.     00
300.     00
310.     00
320.     00
330.     00
340.     00
350.     00
360.     00
370.     00
380.     00
390.     00
400.     00
410.     00
420.     00
430.     00
440.     00
450.     00
460.     00
470.     00
480.     00
490.     00
500.     00
510.     00
520.     00
530.     00
540.     00
550.     00
560.     00

          00      C      D - TUBE DIAMETER (FT)
          00      C      P - REFRIG. AVERAGE PRESSURE (PSIA)
          00      C      RMAS - REFRIG. MASS FLOW RATE (LBM/H)
          00      C      T - REFRIG. AVERAGE TEMPERATURE (F)
          00      C      XW - MIXTURE WEIGHT COMPOSITION
          00      C      XM - (FRACTION OF LESS VOLATILE COMPONENT)
          00      C      XM - MIXTURE MOLAR COMPOSITION
          00      C      W1 - (FRACTION OF LESS VOLATILE COMPONENT)
          00      C      W2 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT
          00      C      W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT
          00
          00      C**** SUBPROGRAMS CALLED BY HTCCON:
          00      C      BUBTEM,DEWTEM,HCVCP,QLITY,SPTHc,VISCON,VOLIT1
          00
          00      C      COMMON/RDATA2/W1,W2,TC1,TC2
          00      C      COMMON/RDATA3/XW,XM,WM
          00
          00      C      TK=(T+459.67)/1.8
          00      C      PA=P/14.6959
          00      C      CALL QLITY(TK,PA,XM,X,XV,XL)
          00      C      X1=X
          00      C      IF(X.LT.0.1)X1=0.1
          00      C      IF(X.GT.0.95)X1=0.95
          00      C      G=0.7853981*D*D
          00      C      G=RMAS/G

          00      C      CALL VOLIT1(0,TK,PA,XL,VL)
          00      C      CALL HCVCP(5,TK,VL,XL,H,CV,CPL)
          00      C      WM*DL=M1*(1.-XL)+W2*XL
          00      C      VL=16.01846*VL/WMOL
          00      C      XL=XL/(W1/W2*(1.-XL)+XL)
          00      C      VISL=VISCON(1,T,XL)
          00      C      CONL=VISCON(2,T,XL)
          00      C      CALL VOLIT1(1,TK,PA,XV,VL)
          00      C      WMOL=W1*(1.-XV)+W2*XV
          00      C      VV=16.01845*VV/WMOL
          00      C      XV=XV/(W1/W2*(1.-XV)+XV)
          00      C      VISV=VISCON(3,T,XV)
          00      C      PEF=VISL*CPL/CONL
          00      C      RETP=G*(1.-X1)*D/VISL
          00      C      XTT=((1.-X1)/X1)*X0.9*SQRT(VL/VV)*(VISL/VISV)**0.1
          00      C      F1=0.15*(1.+2.85*XTT*X0.524)/XTT
          00      C      F2=0.707*PRF*SQRT(RETP)
          00      C      IF((RETP.GT.50. AND. RETP.LT.1125.)F2=5.*PRF+.5.*ALOG(1.+PRF)*(80.09636*RETP**0.535-1.))
          00      C      IF((RETP.GE.1125.)F2=5.*PRF*.5.*ALOG(1.+5.*PRF)+2.5*ALOG(0.0031*RETP
          00      C      8**0.812)
          00      C      ALF=1.
          00      C      IF((F1.GT.1.)ALF=1.15

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***** HTCCON *****

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570.    00  HTCCON=CONL*PRF*xF1**ALF*RETP**0.9/(D*xF2)
      00  IF(X.GE.0.1)GOTO10
      00  CALL DUDTEM(1,PA,XM,TK,XV)
      00  CALL VOLIT1(0,TK,PA,XM,VL)
      00  CALL HCVCFC(5,TK,VL,XM,H,CV,CPL)
      00  TFB=TK*1.8-459.67
      00  VISL=VISCON(1,TFB,XW)
      00  CONI=VISCON(2,TFB,XW)
      00  HL=SPHTC(CPL,VISL,CONI,RMAS,D)
      00  HTCCON=HL+10.*X*(HTCCON-IL)
      00  GOTC20
10  CONTINUE
      00  IF(X.LE.0.95)GOT020
      00  CALL DEWTEM(1,PA,XM,TK,XL.)
      00  CALL VOLIT1(1,TK,PA,XM,VL)
      00  CALL HCVCFC(5,TK,VL,XM,H,CV,CPL)
      00  TFD=TK*1.8-459.67
      00  VISV=VISCON(3,TFD,XW)
      00  CONV=VISCON(4,TFD,XW)
      00  HV=SPHTC(CPV,VISV,CONV,RMAS,D)
      00  HTCCON=HTCCON-20.* (X-0.95)*(HTCCON-HV)
      00  20 RETURN
      00  END

END ELT.  ERRORS: NONE. TIME: 0.125 SEC. IMAGE COUNT: 79
@HDG,P ***** HTCEV ***** .L,0

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***** HTCEV *****

DATE 072184

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@ELT,L DD.HTCEV
ELT 8R1 S74Q1C 07/21/84 15:55:09 (O)
          FUNCTION HTCEV(TF,PSIA,RMS,DDI,XTT)

10.      00
20.      00
30.      00
40.      00
50.      00
60.      00
70.      00
80.      00
90.      00
100.     00
110.     00
120.     00
130.     00
140.     00
150.     00
160.     00
170.     00
180.     00
190.     00
200.     00
210.     00
220.     00
230.     00
240.     00
250.     00
260.     00
270.     00
280.     00
290.     00
291.     00
300.     00
310.     00
320.     00
330.     00
340.     00
350.     00
360.     00
370.     00
380.     00
390.     00
400.     00
410.     00
420.     00
430.     00
440.     00
450.     00
460.     00
470.     00
480.     00
490.     00
500.     00
510.     00
520.     00
530.     00
540.     00

C*** PURPOSE:
C   TO COMPUTE EVAPORATION HEAT TRANSFER COEFFICIENT
C   FOR NON-AZEOTROPIC FIXTURE FLOW INSIDE A TUBE

C*** INPUT DATA:
C   DDI    - TUBE DIAMETER (FT)
C   PSIA   - REFRIG. AVERAGE PRESSURE (PSIA)
C   RMS    - REFRIG. MASS FLOW RATE (LBM/H)
C   TF     - REFRIG. AVERAGE TEMPERATURE (F)
C   XM     - MIXTURE MOLE COMPOSITION
C           (FRACTION OF LESS VOLATILE COMPONENT)
C   W1     - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT (G/MOL)
C   W2     - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT (G/MOL)

C*** OUTPUT DATA:
C   HTCEV - EVAPORATIVE HEAT TRANSFER COEFF. (BTU/(H*FT**2))
C   XTT   - LOCKHART-MARTINELLI PRESSURE DROP PARAMETER

C*** SUBPROGRAMS CALLED BY HTCEV:
C   HCVCVP, QLITY, SPHTC, VISCON, VOLIT1
C   COMMON/RDATA2/W1,W2,TC1,TC2
C   COMMON/RDATA3/XW,XM,WM
C
C   PA=PSIA/14.6959
C   TK=(TF+159.67)/1.8
C   CALL QLITY(TK,PA,XM,XQ,XV,XL)
C
C   IF(XQ.EQ.0..OR.XQ.EQ.1.)THEN
C     PRINT 10,XQ
C   10 FORMAT(' ',ERROR IN CALLING HTCEV, XQ=' ,F4.1)
C   HTCEV=200.
C   RETURN
C   END IF
C
C   XLW=XL/(W1/W2*(1.-XL)+XL)
C   XVM=XV/(W1/W2*(1.-XV)+XV)
C   Y1SL=VISCON(1,TF,XLM)
C   CONL=VISCON(2,TF,XLM)
C   VISV=VISCON(3,TF,XVN)
C   CALL VOLIT1(O,TK,PA,XL,VL)
C   CALL HCYCP(5,TK,VL,XL,IL,CV,CPL)
C   CALL VOLIT1(1,TK,PA,XV,VL)
C   WML=W1*(1.-XL)+W2*XL_
C   WMV=W1*(1.-XV)+W2*XV_
C   VL_4=VL*16.01846/WML
C   VVM=VV*16.01846/WIV
C   XTT=((1.-XQ)/XQ)**.9*(VLH/VVN)**.5*(VISL/VISV)**.1
C   HL=SPHTC(CPL,VISL,CONL,RMS,DDI)
C   HTCEV=2.12*HL*(1./XTT)**0.866
C   HTCEV=3.23*HL*XTT**(-0.3)
C   RETURN
C
C

```

***** HXCODE *****

DATE 072184

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@ELT,L DD.HXCODE
ELT 8R1 S74Q1C 07/21/84 15:55:09 (0)
      00   SUBROUTINE HXCODE(110)

      20.
      30.          C
      40.          C**** THIS PROGRAM DETERMINES REFRIGERANT & AIR FLOW
      50.          C**** DISTRIBUTION FOR HEAT EXCHANGER TUBES
      60.          C
      70.          C**** INPUT DATA:
      80.          C   IFROM(110,J)    - NUMBER OF TUBE J RECEIVES REFRIG. FROM
      90.          C   WHEN COIL WORKS AS EVAPORATOR (-)
      100.         C   110           = 1 FOR INDOOR COIL (-)
      110.         C   00            = 2 FOR OUTDOOR COIL (-)
      120.         C   NDFP(110)     - NUMBER OF COIL TUBE ROW DEPTHS (-)
      130.         C   NFFECT(110)   - NUMBER OF REPEATING SECTIONS (-)
      140.         C   NTUB(110,N)  - NUMBER OF TUBES IN ROW N FOR EACH SECTION
      150.         C   00            OF TUBE J (-)
      160.         C
      170.         C**** OUTPUT DATA:
      180.         C   FLOW(110,J)   - FRACTION OF COIL TOTAL REFRIG. MASS FLOW
      190.         C   00            PASSING THROUGH TUBE J (-)
      200.         C   IDEPTH(110,J) - DEPTH ROW OF A TUBE J (-)
      210.         C   IMER(110)    - NUMBER OF MERGING TUBES (-)
      220.         C   IST(110)     - NUMBER OF TUBES REFRIG. FLOWS INTO COIL
      230.         C   00            WORKING AS CONDENSER (-)
      240.         C   ISTART(110,L) - NUMBER OF TUBE REFRIG. FLOWS INTO COIL
      250.         C   WORKING AS CONDENSER, FOUND AS L SUCH TUBE (-)
      260.         C   JFROM(110,J)  - NUMBER OF TUBE POSITIONED AIR UPSTREAM
      270.         C   KFEED(110,J,N) - NUMBER OF TUBE RECEIVING REFRIGERANT FROM
      280.         C   TUBE J WHEN COIL WORKS AS EVAPORATOR.
      290.         C   NOTE THAT TUBE J CAN FEED UP TO 3 TUBES
      300.         C   00            (N CAN BE 1,2 AND 3) (-)
      310.         C   KSTART(110,N) - NUMBER OF TUBE REFRIGERANT FLOWS INTO COIL
      320.         C   00            WORKING AS EVAPORATOR (-)
      330.         C   KST(110)     - NUMBER OF TUBES REFRIGERANT FLOWS INTO COIL
      340.         C   00            WORKING AS EVAPORATOR
      350.         C   MERGE(110,K,1) - NUMBER OF TUBE FOUND AS K MERGING TUBE (-)
      360.         C   MERGE(110,K,2) - NUMBER OF TUBES MERGING INTO TUBE K (-)
      370.         C   NTPS(110)    - NUMBER OF TUBES PER SECTION (-)
      380.         C
      390.         C   COMMON/HPX/NDEP(2),NROW(2),DT(2),RPCH(2),DPCH(2),
      400.         C   & WIDTH(2),FPCH(2),FTK(2),FMK(2),THK(2),AMAC(2),ANGLE(2),
      410.         C   & CONST(2),CPW(2),NTUB(2,5),IFROM(2,130),NSECT(2),NTPS(2),
      420.         C   COMMON/MENG/MERGE(2,20,2),IMER(2),ISTART(2,20),1ST(2),
      430.         C   & IDEPTH(2,130),FLOW(2,130),JFROM(2,130),KFEED(2,130,3),
      440.         C   & KSTART(2,20),KST(2)
      450.         C   DIMENSION IMC(20),IDID(130)
      460.         C
      470.         C**** FIND NUMBER TUBES PER SECTION
      480.         C   NTPS(110)=0
      490.         C   DO 1 1=1,5
      500.         C   510.         C   1 NTPS(110)=NTPS(110)+NTUB(110,1)
      520.         C
      530.         C   DO 2 I=1,NTPS(110)
      540.         C   550.         C   2 FLOW(110,I)=0.
      560.         C   DO 4 I=1,20
      570.         C   4 MERGE(110,I,1)=0
      580.         C

```

***** HXCONE *****

```

570.    00      C**** FIND TUBES REFRIGERANT ENTERS CONDENSER
580.    00      C**** FIND TUBES REFRIGERANT MERGES
590.    00      IS=0
600.    00      IM=0
610.    00      DO 10 J=1,NTPS(110)
620.    00      N1=0
630.    00      DO 6 I=1,NTPS(110)
640.    00      IF(I=FROM(110,I).NE.J)GOTO 6
650.    00      NP=NM+1
660.    00      6 CONTINUE
670.    00      IF(NM.EQ.0)GOTO 8
680.    00      IF(NM.EQ.1)GOTO 10
690.    00      IM=IM+1
700.    00      MERGE(110,IM,2)=NM
710.    00      MERGE(110,IM,1)=J
720.    00      GOTO 10
730.    00      IS=IS+1
740.    00      ISTART(110,IS)=J
750.    00      10 CONTINUE
760.    00      IST(110)=IS
770.    00      IMER(110)=IM
780.    00      C**** FIND REFRIGERANT FLOW DISTRIBUTION
790.    00      DO 12 L=1,IM
800.    00      IMC(L)=MERGE(110,L,2)
810.    00      12 CONTINUE
820.    00      SECFLW=1./FLOAT(INSECT(110))
830.    00      STFLOW=SECFLW/FLOAT(IS)
840.    00      DO 20 IB=1,IS
850.    00      I=ISTART(110,IB)
860.    00      FLOW(110,I)=STFLOW
870.    00      14 J=IFROM(110,I)
880.    00      IF(J.EQ.0)GOTO 20
890.    00      DO 16 IC=1,IM
900.    00      IF(MERGE(110,IC,1).EQ.J)GOTO 18
910.    00      I=J
920.    00      16 CONTINUE
930.    00      FLOW(110,J)=FLOW(110,I)
940.    00      I=J
950.    00      GOTO 14
960.    00      18 FLOW(110,J)=FLCW(110,J)+FLOW(110,I)
970.    00      IMC(IC)=IMC(IC)-1
980.    00      IF(IMC(IC).NE.0)GOTO 20
990.    00      I=J
1000.   00      GOTO 14
1010.   00      20 CONTINUE
1020.   00      C**** FIND DEPTH ROW FOR EACH TUBE
1030.   00      NNDEP=NDEP(110)
1040.   00      ILAST=0
1050.   00      DC 22 J=1,NNDEP
1070.   00      IFIRST=ILAST+1
1080.   00      ILAST=IL/ST+NTUR(110,J)
1090.   00      DO 22 I=IFIRST,ILAST
1100.   00      IDEPTH(110,I)=J
1110.   00      22 CONTINUE
1120.   00      C**** FIND AIR FLOW DISTRIBUTION
1130.   00      DO 40 I=1,NTUB(110,1)
1140.   00

```

***** HXCCDE *****

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1150.    00      40 JFROM(110,1)=999
1160.    00      N=1:NTUB(110,1)
1170.    00      DC 44 I=N,NTPS(110)
1180.    00      ICT=IDEPTH(110,1)
1190.    00      J=I-NTUB(110,ICT-1)
1200.    00      ICTJ=IDEPTH(110,J)
1210.    00      IF(ICTJ.EQ.ICT)THEN
1220.    00      IB=ICT-1
1230.    00
1240.    00      DO 42 K=1,IB
1250.    00      J=J+NTUB(110,K)
1260.    00
1270.    00      END IF
1280.    00      JFRCH(110,1)=J
1290.    00      44 CONTINUE
1300.    00      C**** FIND RE-RIG. FLOW PATH IN EVAPORATOR COIL
1310.    00      DO 50 I=1,NTPS(110)
1320.    00      DO 48 IK=1,IMER(110)
1330.    00      IF(I.I.NE.MERGE(110,IK,1))GOTO 48
1340.    00      IDID(I)=MERGE(110,IK,2)
1350.    00      GOTO 50
1360.    00      48 CONTINUE
1370.    00      IDID(I)=1
1380.    00      50 CONTINUE
1390.    00      C
1400.    00      KS=0
1410.    00      DO 60 IS=1,IST(110)
1420.    00      I=ISTART(110,IS)
1430.    00      KFEED(110,I,1)=-1
1440.    00
1450.    00      J=I
1460.    00      I=IFROM(110,J)
1470.    00      IF(I.EQ.0)THEN
1480.    00      KS=KS+1
1490.    00      KSTART(110,KS)=J
1500.    00      KST(110)=KS
1510.    00      GOTO 60
1520.    00      END IF
1530.    00      IF(IDID(I).EQ.0)GOTO 60
1540.    00      N=IDID(I)
1550.    00      KFEED(110,1,N)=J
1560.    00      IDID(I)=IDID(I)-1
1570.    00      GOTO 54
1580.    00      60 CONTINUE
1590.    00      RETURN
END ELT.  ERRORS: NONE. TIME: 0.225 SEC. IMAGE COUNT: 159
@HDG,P ***** MVAL4 **** L,0

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***** MVAL4 *****

DATE 072184

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@ELT,L DD.MVAL4
ELT 8R1 S74Q1C 07/21/84 15:55:10 (0)
          00      SUBROUTINE MVAL4(XW,RMASS,V2,AM2,AK2,CP2,
20.        00      @ V7,AM7,AK7,CP7,V11,AM11,AK11,CP11,V71,AM71,AK71,CP71)
30.        00
40.        00      C**** PURPOSE:
50.        00      C      TO SIMULATE PERFORMANCE OF 4-WAY VALVE
60.        00      C      (BINARY MIXTURE REFRIGERANT)
70.        00
80.        00      C**** INPUT DATA:
90.        00      C      RMASS   - REFRIG. MASS FLOW RATE (LB/II)
100.       00      C      XW      - COMPOSITION (WEIGHT FRACTION OF LESS VOLATILE COMPONENT)
110.       00      C      * REFRIG. PARAMETERS & PROPERTIES:
120.       00      C      AK2,AK7  - THERMAL CONDUCTIVITY (BTU/H*F*FT)
130.       00      C      AM2,AM7  - DYNAMIC VISCOSITY (LB/H*FT)
140.       00      C      CP2,CP7  - SPECIFIC HEAT AT CONST. PRESSURE (BTU/LB*F)
150.       00      C      H2,H7   - ENTHALPY (BTU/LB)
160.       00      C      P2,P7   - PRESSURE (PSIA)
170.       00      C      T2,T7   - TEMPERATURE (F)
180.       00      C      V2,V7   - SPEC. VOLUME (FT**3/LB)
190.       00      C      WHERE IN ABOVE SYMBOLS NUMBERS DENOTE LOCATION:
200.       00      C      2      4-WAY VALVE LOW PRESSURE OUTLET
210.       00      C      7      4-WAY VALVE HIGH PRESSURE INLET
220.       00      C      * 4-WAY VALVE PARAMETERS:
230.       00      C      CPDR   - PARAMETER FOR PRESSURE DROP (LBF*H**2/LB*IN**2*FT**3)
240.       00      C      CG     - PARAMETER FOR HEAT TRANSFER (FT**.2)
250.       00
260.       00      C**** OUTPUT DATA:
270.       00      C      * REFRIG. PARAMETERS & PROPERTIES:
280.       00      C      AK11,AK71 - THERMAL CONDUCTIVITY (BTU/H*F*FT)
290.       00      C      AM11,AM71 - DYNAMIC VISCOSITY (LB/H*FT)
300.       00      C      CP11,CP71 - SPECIFIC HEAT AT CONST. PRESSURE (BTU/LB*F)
310.       00      C      H11,H71  - ENTHALPY (BTU/LB)
320.       00      C      P11,P71  - PRESSURE (PSIA)
330.       00      C      T11,T71  - TEMPERATURE (F)
340.       00      C      X11     - QUALITY (-)
350.       00      C      V11,V71  - SPECIFIC VOLUME (LB/FT**3)
360.       00      C      WHERE IN ABOVE SYMBOLS NUMBERS DENOTE LOCATION:
370.       00      C      11     4-WAY VALVE LOW PRESSURE INLET
380.       00      C      71     4-WAY VALVE HIGH PRESSURE OUTLET
390.       00
400.       00      C      * SUBPROGRAMS CALLED BY MVAL4:
410.       00      C      HFFROP
420.       00
430.       00      COMMON/RDATA2/W1,W2,TC1,TC2
440.       00      COMMON/COND2/P11,T11,H11,X11,S11
450.       00      COMMON/COND3/P2,T2,H2,S2
460.       00      COMMON/COND3/P7,T7,H7,S7
470.       00      COMMON/COND9/P71,T71,H71,S71
480.       00      COMMON/WAY4/CQ,CPDR
490.       00      NO=0
500.       00      N1=1
510.       00      ACCUR=0.0003
520.       00      PDRF=CPDR*RMASS*RMASS
530.       00      XM=XW/(W2/W1*(1.-XW)+XW)
540.       00
550.       00
560.       00
570.       00

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***** MVAL4 *****

DATE 072184

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      580.          00      WM=(1-XM)*W1+XM*W2
      590.          00      TK2=(T2+459.67)/1.8
      600.          00      PA2=P2/14.6959
      610.          00      TK7=(T7+459.67)/1.8
      620.          00      PA7=P7/14.6959
      630.          00      RMASSR=RMASS**0.8
      640.          00      T11=T2
      650.          00      V11=V2
      660.          00      AM11=AM2
      670.          00      AK11=AK2
      680.          00      CP11=CP2
      690.          00      T71=T7
      700.          00      V71=V7
      710.          00      AM171=AM7
      720.          00      AK71=AK7
      730.          00      CP71=CP7
      740.          00      C
      750.          00      DO 100 I=1,10
      810.          00      VS=(V11+V2)/2.
      820.          00      AMS=(AM11+AM2)/2.
      830.          00      AKS=(AK11+AK2)/2.
      840.          00      CPS=(CP11+CP2)/2.
      850.          00      VH=(V7+V71)/2.
      860.          00      AMH=(AM7+AK71)/2.
      870.          00      AKH=(AK71+AK7)/2.
      880.          00      CPH=(CP7+CP71)/2.
      890.          00      P11=F2+FDRF*VS
      900.          00      PA11=P11/14.6959
      910.          00      P71=P7-PDRF*VH
      920.          00      PA71=P71/14.6959
      930.          00      HCS=RMASS8*AKS**0.667*CPS**0.333/AMS**0.467
      940.          00      HCH=RMASS2*AKH**0.657*CPII**0.333/AMII**0.467
      950.          00      DTA=T71-T11
      960.          00      DTB=T7-T2
      970.          00      IF(ABS(DTA-DTB),LT.0.01)GOTO20
      980.          00      TF=(DTA-DTB)/(ALOG(DTA/DTB))
      990.          00      GOTO 21
      1000.         00      20  TF=T7-T2
      1010.         00      Q=CC*TF/(1./HCS+1./HCH)
      1020.         00      H71=H7-Q/RMASS
      1030.         00      T71=T7-Q/(RMASS*CPH)
      1040.         00      TK71=(T71+459.67)/1.8
      1060.         00      CMLL_HPROP(N1,H71,PA71,XM,ACCUR,TK71,XQ,XL,XV,VL11,VM11,
      1061.         00      @ VM11,V71,CP71,CV,AM71,AK71)
      1090.         00      T71=TK71*.8-453.67
      1100.         00      C
      1110.         00      H11=H2-Q/RMASS
      1120.         00      T11=T2-Q/(RMASS*CPS)
      1130.         00      TK11=(T11+459.67)/1.8
      1150.         00      CMLL_HPROP(N1,H11,PA11,XM,ACCUR,TK11,XL,XV,VL11,VM11,
      1151.         00      @ VM11,V11,CP11,CV,AM11,AK11)
      1160.         00      T11=TK11*.8-453.67
      1180.         00      IF(I.EQ.1)GOTO51
      1290.         00      IF(ABS(H71-H71A).LT.0.001)GOTO101
      1291.         00      H71D=H71A
      1300.         00      51  H71A=H71
      1310.         00      100  CONTINUE
      1320.         00      WRITE(6,600)H71A,H71B

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PAGE DATE 072184

00 WRITE FOR GOOD H71A, H71B
00 1320.
00 1330. 00 FORMAT: MVAL4 DOES NOT CONVERGE, H71A, H71B= ' ,2(1PE16.6)
00 1340. 00 101 CONTINUE
00 RETURN
00 END
00
1350.
1360.

END ELT. ERRORS: NONE. TIME: 0.161 SEC. IMAGE COUNT: 118

@HDG, P ***** OVLWET ***** .L, 0

***** OVLWET *****

@ELT,L DD.OVLWET
ELT 8R1 S74Q1C 07/21/84 15:55:10 (0)
10. 00 SURROUNGE OVLWET(AO,API,APM,HI,HD,HP,HL,HO,UAQ,UPO,UWO)

DATE 072184

20. 00 C*** PURPOSE:
30. 00 C TO COMPUTE OVERALL HEAT TRANSFER COEFFICIENT
40. 00 C FOR A WET FINNED TUBE
50. 00 C
60. 00 C
70. 00 C*** INPUT DATA:
80. 00 C AO - TOTAL OUTSIDE SURFACE AREA (FT**2)
90. 00 C API - TUBE INSIDE SURFACE AREA (FT**2)
100. 00 C APM - SURFACE AREA BASED ON TUBE MEAN DIAMETER (FT**2)
110. 00 C HD - TUBE INSIDE SURFACE DEPOSIT HEAT TRANSFER COEFF. (BTU/H*F*FT**2)
120. 00 C HI - TUBE INSIDE SURFACE HEAT TRANSFER COEFF. (BTU/H*F*FT**2)
130. 00 C HL - HEAT TRANSFER COEFF. FOR WATER (FROST) LAYER (BTU/H*F*FT**2)
140. 00 C HP - TUBE WALL HEAT TRANSFER COEFFICIENT (BTU/H*F*FT**2)
150. 00 C HO - AIR-SIDE HEAT TRANSFER COEFF. FOR WET FINNED TUBE (BTU/H*F*FT**2)
160. 00 C
170. 00 C*** OUTPUT DATA:
180. 00 C AO - OVERALL HEAT TRANSFER COEFF. FOR WET FINNED TUBE (BTU/H*F*FT**2)
190. 00 C UPO - HEAT CONDUCTANCE FROM REFRIGERANT TO TUBE SURFACE (BTU/H*F)
200. 00 C UWO - HEAT CONDUCTANCE FROM REFRIGERANT TO WATER (FROST) SURFACE (BTU/H*F)
210. 00 C
220. 00 C $U = AO / (API * HI) + AO / (API * HD) + AO / (APM * HP)$
230. 00 C $UPO = AO / U$
240. 00 C $U = U + 1 / HL$
250. 00 C $UWO = AO / U$
260. 00 C $U = U + 1 / HO$
270. 00 C $UAQ = AO / U$
280. 00 C RETURN
290. 00 C END
END ELT. ERRORS: NONE. TIME: 0.073 SEC. IMAGE COUNT: 29
@Hdg,P ***** PFLASH ***** .L,0

***** PFLASH *****

```

@ELT,L DD.PFLASH
ELT 8R1 S74Q1C 07/21/84 15:55:10 (0)
10.    00      SUBROUTINE PFLASH(XM,H1,GN,TIN,TFLASH,PFLA,VL)
20.    00
30.    00      C**** PURPOSE:
40.    00      C        TO CALCULATE FLASHING PRESSURE & TEMPERATURE
50.    00      C        FOR GIVEN CONSTANT ENERGY FLOW OF NON-AZEOTROPIC MIXTURE
60.    00
70.    00      C**** INPUT DATA:
80.    00      C        GN = G*G/(64.4*778.104) (BTU*LB/FT**6)
90.    00      C        WHERE G - REFRIG. MASS FLUX (LB/(SEC*FT**2))
100.   00      C        H1           - REFRIG TOTAL ENTHALPY (BTU/LB)
110.   00      C        TIN          - PFLASHING TEMPERATURE ( GUESS ) (F)
120.   00
130.   00      C**** OUTPUT DATA:
140.   00      C        PFLASH - FLASHING PRESSURE (PSIA)
150.   00      C        TFLASH - FLASHING TEMPERATURE (F)
160.   00      C        VL            - SPEC. VOLUME OF LIQ. REFRIG. (FT**3/LB)
170.   00      C        XM            - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
180.   00
190.   00      C**** SUBPROGRAMS CALLED BY PFLASH:
200.   00      C        BUBPRE, HCVCP, VOLIT1
210.   00
220.   00      COMMON/RDATA2/W1,W2,TC1,TC2
230.   00      DATA NO, N1/0, 1/
240.   00      WM=W1*(1-XM)+W2*X'M
250.   00      TKIN=(TIN-459.67)/1.8
260.   00      DO 3 I=1,10
270.   00      TKIN=TKIN*1.8-459.67
280.   00      CALL BUBPRE(NO,TKIN,XM,PAFL,XV)
290.   00      CALL VOLIT1(NO,TKIN,PAFL,XM,VML)
300.   00      VL=VML*16.01846/WM
310.   00      PAFL3=PAFL+3.
320.   00      CALL VOLIT1(NO,TKIN,PAFL3,XM,VML3)
330.   00      VL3=VML3*16.01846/WM
340.   00      PFL=PAFL*14.6959
350.   00      PFL3=PAFL3*14.6959
360.   00      HIN=H1-GN*VL*VL
370.   00      CALL HCVCP(N1,TKIN,VML,XM,HF,CV,CP)
380.   00      HDIF=HIN-HF
390.   00      IF(ABS(HDIF).LT..0003)GOTO 5
400.   00      IF(I.EQ.1)GOTO 1
410.   00      TK=TKIN-HDIF*(TK(NP-TK;N)/(HDIF-HDIF))
420.   00      GOTO 2
430.   00      1 TK=TKIN+SIGN(1.,HDIF)
440.   00      2 IF((TK.GT.TC1)TK=TC1-2.
450.   00      TKINF=TKIN
460.   00      TKIN=TK
470.   00      HDIFP=HDIF
480.   00      3 CONTINUE
490.   00      4 FORMAT(' PFLASH DOES NOT CONVERGE, HDIF=',1PE15.5)
500.   00
510.   00      5 CONTINUE
520.   00      PFLA=PAFL*14.6959
530.   00      TFLASH=TKIN*1.8-459.67
540.   00      RETURN
550.   00

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PIPE *****

DATE 072164

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EELT,L DD,PIPE
ELT 8RI S74Q1C 07/21/84 15:55:11 (0)
      00 SURROUTINE PIPE((BACK,XW,TAIR,RMASS,T1,P1,V1,H1,AM1,AK1,CP1,
     20. 00 & T2,P2,H2,XO2,PL,PD1,PK1,PD2,PK3,PK4),
     30. 00
     40. 00
     50. 00
     60. 00
     70. 00
     80. 00
     90. 00
    100. 00
    110. 00
    120. 00
    130. 00
    140. 00
    150. 00
    160. 00
    170. 00
    180. 00
    190. 00
    200. 00
    210. 00
    220. 00
    230. 00
    240. 00
    250. 00
    260. 00
    270. 00
    280. 00
    290. 00
    300. 00
    310. 00
    320. 00
    330. 00
    340. 00
    350. 00
    360. 00
    370. 00
    380. 00
    390. 00
    400. 00
    410. 00
    420. 00
    430. 00
    440. 00
    450. 00
    460. 00
    470. 00
    480. 00
    490. 00
    500. 00
    510. 00
    520. 00
    530. 00
    540. 00
    550. 00
    560. 00

C**** PURPOSE:
C TO COMPUTE PARAMETERS OF SUPERHEATED OR WET REFRIG. VAPOR
C (BINARY MIXTURE) FLOWING THROUGH A PIPE FOR OUTLET
C OR INLET CONDITIONS KNOWN
C
C**** ASSUMPTIONS:
C SINGLE PHASE HEAT TRANSFER INSIDE PIPE
C FREE CONVECTION OUTSIDE PIPE
C
C**** INPUT DATA:
C AK1 - REFRIG. THERMAL CONDUCTIVITY AT PIPE INLET (OUTLET)
C 'BTU/H*F*FT)
C AM1 - REFRIG. DYNAMIC VISCOSITY AT PIPE INLET (OUTLET) (LBM/H*FT)
C CP1 - REFRIG. SPEC. HEAT AT PIPE INLET (OUTLET) (BTU/LB(1*F))
C H1 - REFRIG. ENTHALPY AT PIPE INLET (OUTLET) (BTU/LBM)
C IBACK = 0 IF INLET REFRIG. STATE KNOWN, OUTLET IS CALCULATED
C = 1 IF OUTLET REFRIG. STATE KNOWN, INLET IS CALCULATED
C PD1 - PIPE INSIDE DIAMETER (FT)
C PD2 - PIPE OUTSIDE DIAMETER (FT)
C PD3 - OUTER DIAMETER OF INSIDE INSULATION (FT)
C PD4 - OUTER DIAMETER OF OUTSIDE INSULATION (FT)
C PK1 - THERMAL CONDUCTIVITY OF PIPE MATERIAL (BTU/H*F*FT)
C PK2 - THERMAL CONDUCTIVITY OF INSIDE INSULATION MATERIAL
C (BTU/H*F*FT)
C PK3 - THERMAL CONDUCTIVITY OF OUTSIDE INSULATION MATERIAL
C (BTU/H*F*FT)
C PL - PIPE LENGTH (FT)
C P1 - REFRIG. PRESSURE AT PIPE INLET (OUTLET) (PSIA)
C RMASS - REFRIG. MASS FLOW RATE (LBM/H)
C TAIR - AMBIENT AIR TEMPERATURE (F)
C T1 - REFRIG. TEMPERATURE AT PIPE INLET (OUTLET) (F)
C V1 - REFRIG. SPEC. VOLUME AT PIPE INLET (OUTLET) (FT**3/LBM)
C XW - MIXTURE COMPOSITION (WEIGHT FRACTION OF LESS VOLATILE COMPONENT)
C
C**** OUTPUT DATA:
C H2 - REFRIG. ENTHALPY AT PIPE OUTLET (INLET) (BTU/LBM)
C P2 - REFRIG. PRESSURE AT PIPE OUTLET (INLET) (PSIA)
C T2 - REFRIG. TEMPERATURE AT PIPE OUTLET (INLET) (F)
C XQ2 - REFRIG. QUALITY AT PIPE OUTLET (INLET) (-)
C
C**** SUBPROGRAMS CALLED BY PIPE:
C ESEVOL,HCVCVP,HPIH,GLITY,SPHDF1,SPHTC,VISCON
C
COMMON/RDATA2/W1,W2,TC1,TC2
DATA NO,N1,N2,N3,N1,N5/0,1,2,3,4,5/
C
ACCUR=0.0005
XM:=XW/(W2/W1*(1.-XW)+XW)
JM=(1.-XM)*W1+XM*W2
AREA=3.1415927*FD1*PL
RUP=PD1*ALOG(FD2/FD1)/(2.*FK1)
P02=PD2

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***** PIPE *****

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570.    00 IF (PK2.LT.1.E-08) GOTO 5
      00 RUP=RUP+PD1*ALOG(FD3/PD2)/(2.*PK2)
      00 PDO=PD3
      00 IF (PK3.LT.1.E-08) GOTO 5
      00 RUF=RUF+PD1*ALOG(PD4/PD3)/(2.*PK3)
      00 PDO=PD4
      00
      5 CONTINUE
      TK1=(T1+459.67)/1.8
      PA1=P1/14.6959
      CALL QLITY(TK1,PA1,XM,XQ1,XV1,XL1)
      T2=T1
      TR2=TK1
      PA2=PA1
      CP2=CP1
      AM2=AM1
      AK2=AK1
      V2=V1
      TF=T1
      DO 50 I=1,10
      00 T=0.5*(T1+T2)
      00 CP=0.5*(CP1+CP2)
      00 AM=0.5*(AM1+AM2)
      00 AK=0.5*(AK1+AK2)
      00 V=0.5*(V1+V2)
      C***** CALC. PRESSURE DROP
      IF (XQ1.NE.1..AND.XQ2.NE.1.) THEN
      XL=0.5*(XL1+XL2)
      XV=0.5*(XV1+XV2)
      AML=V1*SCON(N1,T,XL)
      AMV=V1*SCON(N3,T,XV)
      WL=(1.-XL)*W1+XL*W2
      PA=0.5*(PA1+PA2)
      TK=0.5*(TK1+TK2)
      VL=ESVOL(NO,TK,PA,XL)
      VL=VL*16.01846/WL
      WV=(1.-XV)*W1+XV*W2
      VV=FSVOL(N1,TK,PA,XV)
      YV=VV*16.01846/WV
      XQ=0.5*(XQ1+XQ2)
      XTT=(AML/AMV)**1*(VL/VV)**.5*((1.-XQ)/XQ)**.9
      F1=1.+2.35*XTT*.523
      RMS=XQ*RMASS
      PCROP=F1*SPHDP1(RMS,PL,PD1,VV,AMV)
      ELSE
      PDROP=SPHDP1(RMASS,PL,PD1,V,AM)
      END IF
      P2=P1-PCROP
      IF (BACK.EQ.1) P2=P1+PDROP
      C*****
      CALC. HEAT TRANSFER, SINGLE PHASE FLOW ASSUMED
      U1=SPHTC(CP,AM,AK,RMASS,PD1)
      UO=0.27*(ABS(TAIR-TP)/PD1)**0.25
      RU1=1./U1
      RUO=PD1/(PDO*UO)
      UG1=1. / (RUI+RUF+RUO)
      UO1=1. / (RUI+RUP)
      Q=UG1*AREA*(TAIR-T)
      TP=T+Q/(UO1*AREA)
      H2=H1+Q/RMASS

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***** PIPE *****

DATE 072184

PAGE

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PA2=P2/14.6959
CALL HPIN(N1,H2,P&2,0M,ACCUR,TK2,XN2,XL2,XV2,VL2,VV2)
T2=TK2*1.8-459.67
IF(XQ2.NE.1.) THEN
  WL=(1.-XL2)*V1+XL2*W2
  WV=(1.-XV2)*V1+XV2*W2
  VL2=YL2*16.01846/WL
  VV2=VV2*16.01846/WV
  V2=(1.-XQ2)*VL2+XQ2*VV2
  XL2W=XL2/(W1/W2*(1.-XL2)+XL2)
  XV2W=XV2/(W1/W2*(1.-XV2)+XV2)
  AM2=(1.-XQ2)*VISCON(N1,T2,XL2W)
  AM2=AM2+XQ2*VISCON(N3,T2,XV2W)
  AK2=(1.-XQ2)*VISCON(N2,T2,XL2W)
  AK2=AK2+XQ2*VISCON(N4,T2,XV2W)
  VV2=V2*WM/16.01846
  CALL HCVCP(N5,TK2,VV2,XV2,DUM,CV,CP2),
  CP2=XQ2*CP2+(1.-XQ2)*VISCON(N5,T2,XL2W)
ELSE
  V2=VV2*16.01846/WM
  AM2=VISCON(N3,T2,XM)
  AK2=VISCON(N4,T2,XM)
  CALL HCVCP(N5,TK2,VV2,XM,DUM,CV,CP2)
END IF
IF(I.EQ.1)GOTO 40
IF(ABS(H2-H2A).LT.0.003.AND.ARS(P2-F2A).LT.0.005)GOT0 60
H2A=H2
P2A=P2
50 CONTINUE
WRITE(5,600)H2,H2A
600 FORMAT('PIPE DOES NOT CONVERGE, H2, H2A=',2(1PE16.6))
60 CONTINUE
RETURN
END
END ELT.  ERRORS: NONE.  TIME: 0.212 SEC. IMAGE COUNT: 148
©HDG,P ***** PXQIN ***** .L,O
```

```

@ELT,L DD.PXQIN
ELT 8R1 S74Q1C 07/21/84 15:55:11 (O)
10.    00      C
20.    00      C
30.    00      C
40.    00      C
50.    00      C*** PURPOSE:
60.    00      C TO CALC. TEMPERATURE OF NON-AZOTROPIC MIXTURE
70.    00      C FORM GIVEN PRESSURE, COMPOSITION AND QUALITY
80.    00      C
90.    00      C*** INPUT:
100.   00      C P - PRESSURE (STD ATM)
110.   00      C X - COMPOSITION (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
120.   00      C XQ - QUALITY (-)
130.   00      C
140.   00      C*** OUTPUT:
150.   00      C T - TEMPERATURE OF MIXTURE (K)
160.   00      C XL - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
170.   00      C (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
180.   00      C XV - COMPOSITION OF SAT. VAPOR AT TEMP. TK AND PRESSURE PA
190.   00      C (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
200.   00      C
210.   00      C*** SUBPROGRAMS CALLED BY PXQIN:
220.   00      C DBUBTE,DDEBUTE,DALITY,ERBUTE,QLITY
230.   00      C
240.   00      C REAL*8 TDD,PDD,XQDD,XLDD,XVDD
250.   00      C
260.   00      C DATA SLOPE/0./,PLAST/0./
270.   00      C
280.   00      C IF(XQ.LE.0..OR.XQ.GE.1.) THEN
290.   00      C PRINT 666,XQ
300.   00      C 666 FORMAT(' ERROR IN CALLING PXQIN, XQ= ',1PE16.6)
310.   00      C RETURN
320.   00      C END IF
330.   00      C
340.   00      C IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
350.   00      C IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
360.   00      C IF(ABS(XQ-XQLAST).GT.1.E-4)GOTO 10
370.   00      C T=TLAST
380.   00      C XL=XLLAST
390.   00      C XV=XVLAST
400.   00      C RETURN
410.   00      C
420.   00      C 10 XQDIF1=0.
430.   00      C DT=1.
440.   00      C T=EBUBTE(P,X)-XQ*SLOPE
450.   00      C DO 50 I=1,20
460.   00      C IF((XQ.LT..01.OR.XQ.GT..99)THEN
470.   00      C TDD=T
480.   00      C PDD=P
490.   00      C CALL DQILITY(TDD,PDD,X,XQDIF1,XVDD,XLD)
500.   00      C XQN=XQDD
510.   00      C XV=XVDD
520.   00      C XL=XLDD
530.   00      C ELSE
540.   00      C CALL QLITY(T,P,X,XQN,XV,XL)
550.   00      C END IF
560.   00      C IF(XQN.EQ.0..AND.XQDIF1.LT.0.)THEN

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570.    00 PDD=P
      00 TDD=T
      00 CALL DBUBTE(1,PDD,X,TDD,XVDD)
      00 T=TDD
      00 XV=XVDD
END IF
IF(XQN.EQ.1..AND.XQDIF1.GT.0.)THEN
  PDD=P
  TDD=T
  CALL DDEWTE(1,PDD,X,TDD,XLDD)
  T=TDD
  XL=XLDD
END IF
T2=T
XQDIF2=XQ-XQN
IF(ABS(DT).LT.0.005.AND.ABS(XQDIF2).LT..0001)GOTO 100
IF(I.NE.1)GOTO 20
T1=T2
XQDIF1=XQDIF2
IF(SLOPE.NE.0.)THEN
  IF(XQN.EQ.1..OR.XQN.EQ.0.)GOTO 15
  DT=XQDIF2*SLOPE
  IF(ABS(DT).GT.5.)DT=SIGN(5.,DT)
  T=T2-DT
  GOTO 50
END IF
15 T=T2+.5.
IF(XQDIF2.LT.0.)T=T2-.5.
GOTO 50
C
20 IF(XQDIF1.EQ.XQDIF2)GOTO 15
Slope=(T2-T1)/(XQDIF2-XQDIF1)
T1=T2
XQDIF1=XQDIF2
DT=XQDIF1*SLOPE
IF(A3S(DT).GT.10.)DT=SIN(10.,DT)
T=T1-DT
50 CONTINUE
WRITE(6,500)X,P,XQ,DT,XQDIF2
500 FORMAT('PXQIN DID NOT CONVERGE; X,P,XQ,DT,XQDIF2=' ,5(1PE12.4))
100 PLAST=P
XLAST=X
XQLAST=XQ
TLAST=T
XL LAST=XL
XVLAST=XV
RETURN
END

END ELT.  ERRORS: NONE.  TIME: 0.154 SEC.  IMAGE COUNT: 104
@HDG,P ***** PXQIN2 ***** .L,0

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@ELT,L DD.PXQIN2
ELT 8R1 S74Q1C 07/21/84 15:55:11 (0)
      SUBROUTINE PXQIN2(X,P,YQ,T,XL,XV,VL,VV,H)

10.    00      C
20.    00      C
30.    00      C*** PURPOSE:
40.    00      C   TO CALC. TEMPERATURE & ENTHALPY OF 2-PHASE NON-AZEOTROPIC MIXTURE
50.    00      C   FORM GIVEN PRESSURE, COMPOSITION AND QUALITY
60.    00      C
70.    00      C*** INPUT:
80.    00      C   P - PRESSURE (STD ATM)
90.    00      C   X - MOLE FRACTION OF LESS VOLATILE COMPONENT
100.   00      C   XQ - QUALITY (-)
110.   00      C
120.   00      C*** OUTPUT:
130.   00      C   H - MIXTURE ENTHALPY (BTU/LB)
140.   00      C   T - TEMPERATURE OF MIXTURE (K)
150.   00      C   XL - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
160.   00      C   (MOLE FRACTION OF LESS VOLATILE COMPONENT)
170.   00      C   XV - COMPOSITION OF SAT. VAPOR AT TEMP. TK AND PRESSURE PA
180.   00      C   (MOLE FRACTION OF LESS VOLATILE COMPONENT)
190.   00      C   VL - SPECIFIC VOLUME OF SAT. LIQUID OF XL COMPOSITION
200.   00      C   AT TEMPERATURE TK (L/MOL)
210.   00      C   VV - SPECIFIC VOLUME OF SAT. VAPOR OF XV COMPOSITION
220.   00      C   AT TEMPERATURE TK (L/MOL)
230.   00      C
240.   00      C*** SUBPROGRAMS CALLED BY PXQIN2:
250.   00      C   HCVCP, PXQIN, VOLIT1
260.   00      C
270.   00      C
280.   00      C
290.   00      C   IF(XQ.LE.Q.OR.XQ.GE.1.)THEN
300.   00      C   PRINT 666,XQ
310.   00      C   666 FORMAT(' ERROR IN CALLING PXQIN2, XQ= ',1PE16.6)
320.   00      C   RETURN
      .
      END IF
330.   00      C
340.   00      C   IF(ANS(P-PLAST).GT.1.E-4)GOTO 10
350.   00      C   IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
360.   00      C   IF(ABS(XQ-XQLAST).GT.1.E-4)GOTO 10
370.   00      C   T=TLAST
      .
      XL=XLLAST
      XV=XVLAST
      VL=VLLAST
      VV=VVLAST
      H=HLLAST
      RETURN
380.   00      C
390.   00      C
400.   00      C
410.   00      C
420.   00      C
430.   00      C
440.   00      C
450.   00      C   10  CALL PXQIN(X,P,XQ,T,XL,XV)
460.   00      C   CALL VOLIT1(0,T,P,XL,VL)
470.   00      C   CALL HCVCP(1,T,VL,XL,HL,CV,CR)
480.   00      C   CALL VOLIT1(1,T,P,XV,VV)
490.   00      C   CALL HCVCP(1,T,VL,XV,HV,CV,CP)
500.   00      C   H=(1.-XQ)*HL+XQ*HV
510.   00      C   PLAST=P
520.   00      C   XLLAST=X
530.   00      C   XQLAST=XQ
540.   00      C   TLAST=T
550.   00      C   XLLAST=XL
560.   00      C   XVLAST=XV

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DATE 072184

***** PXQIN2 *****
570. 00 VLLAST=VL
580. 00 VVLAST=VV
590. 00 HLAST=H
600. 00 RETURN
610. 00 END
END ELT. ERRORS: NONE. TIME: 0.124 SEC. IMAGE COUNT: 61
©HDG,P ***** QLITY ***** .L,0

 QLITY DD.QLITY
 ELT,L 07/21/84 15:55:12 (0)
 ELT 8R1 S74Q1C 07/21/84 15:55:12 (0)

```

10.      00      C
20.      00      C
30.      00      C
40.      00      C
50.      00      C
60.      00      C
70.      00      C
80.      00      C
90.      00      C
100.     00      C
110.     00      C
120.     00      C
130.     00      C
140.     00      C
150.     00      C
160.     00      C
170.     00      C
180.     00      C
190.     00      C
200.     00      C
210.     00      C
220.     00      C
230.     00      C
240.     00      C
250.     00      C
260.     00      C
270.     00      C
280.     00      C
290.     00      C
300.     00      C
310.     00      C
311.     00      C
312.     00      C
320.     00      C
330.     00      C
340.     00      C
350.     00      C
360.     00      C
370.     00      C
380.     00      C
390.     00      C
400.     00      C
410.     00      C
420.     00      C
430.     00      C
440.     00      C
450.     00      C
460.     00      C
470.     00      C
480.     00      C
490.     00      C
500.     00      C
510.     00      C
511.     00      C
512.     00      C

      **** PURPOSE:  

      **** TO CALCULATE QUALITY OF A BINARY FLUID  

      **** INPUT:  

      IA - QUALIFIER OF PRECISION OF CALCULATIONS (-)  

      = 0, SIMPLIFIED CORRELATIONS TO BE USED  

      = POSITIVE INTEGER, COMPLETE SET EQUATIONS TO BE USED  

      P - PRESSURE (STD ATM)  

      T - TEMPERATURE (K)  

      X - MOLAR CONCENTRATION OF A LESS VOLATILE  

      COMPONENT (-)

      **** OUTPUT:  

      XL - MOLAR CONCENTRATION AT BUBBLE POINT (-)  

      XQ - FLUID QUALITY (-)  

      XV - MOLAR CONCENTRATION AT DEW POINT (-)

      **** SUBPROGRAMS CALLED BY QLITY:  

      SATCOM

      COMMON/ACCURA/ IA
      IF(IA.EQ.0)THEN
        T2=T*T
        P1=10.0522804-2204.5632/T+9636.5313/T2
        P1=EXP(P1)
        P2=10.6410518-2642.8904/T+460.87585/T2
        P2=EXP(P2)
        GOTO 10
      END IF
      CALL SATCOM(T,P1,V1,P2,V2,VL2)
      10 IF(P.GE.P1)THEN
        @FLUID IS LIQUID AT ALL CONCENTRATIONS
        XQ=0.
        XL=0.
        XV=0.
        GOTO 1000
      END IF
      IF(P.LE.P2)THEN
        @FLUID IS VAPOR AT ALL CONCENTRATIONS
        XL=1.
        XQ=1.
        XV=1.
        GOTO 1000
      END IF
      T2=T*T
      RP=(P1-P)/(P1-P2)
      SE60=12.58711-0.06465226*T+9.56391E-5*T2
      SE68=-48.9799+0.289414*T-4.504215E-4*T2
      SF68=SE60*SFC8*RP+SE69*RP**2
      Z0=-0.34065415-3.337532E-3*T+9.66115E-6*T2
      Z1=-10.3139754+0.06533556*T-9.9099162E-5*T2
      Z2=10.035917-0.05527259*T+7.68215541E-5*T2

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DATE 072184

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***** QLITY *****
540.      00      Z=1.+Z0*(RP-1.)+Z1*(RP**2-1.)+Z2*(RP**3-1.)
550.      00      XL=(1.+SEG)*RP/(1.+SEG*RP)    @SAT. LIQUID COMPOSITION
560.      00      XV=XL*Z                      @3SAT. VAPOR COMPOSITION
570.      00      XQ=(XL-X)/(XL-XV)
580.      00      IF(XQ GE. 1.)XQ=1.
590.      00      IF(XQ LT.0.)XQ=0.
600.      00      1000 RETURN
610.      00      END

END ELT.  ERRORS: NONE. TIME: 0.125 SEC. IMAGE COUNT: 64
@HDG,P ***** ROFANN ***** .L,O
```

©ELT,L DD.ROFANN
 ELT 8R1 S74Q1C 07/21/84 15:55:12 (O)
 FUNCTION ROFANN(XM,P,HO,GG)

```

***** C***** PURPOSE:
      C TO CALCULATE DENSITY OF NON-AZEOTROPIC TWO-PHASE MIXTURE
      C FOR ANY PRESSURE ON A AND FLOW PATH
 10.   C***** INPUT DATA:
      C HO - REFRIG. TOTAL ENTHALPY (BTU/LB)
 20.   C GG = G*G/(64.4*73.104) (BTU*LBS/FT**6)
      C WHERE G = REFRIG. MASS FLUX (LB/(SEC*FT**2))
 30.   C P - REFRIG. PRESSURE AT WHICH ENTROPY IS DESIRED (PSIA)
      C XM - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
 40.   C***** OUTPUT DATA:
      C ROFAIN - ENTROPY (BTU/LB R)
 50.   C***** SUBPROGRAMS CALLED BY ROFANN:
      C EBUBTE, ENTROP, HCVCP, QLITY, VOLITI
 60.   COMMON/RDATA2/W1,W2,TG1,TG2
 70.   DATA SLOPE/O./NO,N1/0,1/
 80.   IF(P.GT.0.)GOTO 10
 90.   WRITE(6,600)P
 100.  600 FORMAT(' ERROR IN CALLING ROFANN, P=: ',1FE15.5,' PSIA')
 110.  RETURN
 120.  C 10 PA=P/14.6959
 130.  TK3=ERUBTE(PA,XM)
 140.  TKD=TKB+9.5-20.*(.55-XM)
 150.  TB=TKB*.8-459.67
 160.  TD=TKD*.8-459.67
 170.  TK2=0.5*(TKB+TKD)
 180.  DO 100 I=1,20
 190.  CALL QLITY(TK2,PA,XM,XQ,XV,XL)
 200.  CALL VOLIT1(N1,TK2,PA,XV,VMV)
 210.  CALL HCVCP(N1,TK2,VMV,XV,HV,CV,CP)
 220.  CALL VOLIT1(N0,TK2,PA,XL,VML)
 230.  CALL HCVCP(N1,TK2,V1L,XL,HL,CV,CP)
 240.  HFG=HV-HL
 250.  WML=W1*(1.-XV)+W2*XV
 260.  VML=V1*(1.-XL)+W2*XL
 270.  VMV=V1*16.01646/VML
 280.  VV=V1*16.01846/VML
 290.  VFG=VV-VL
 300.  R=GG*VFG*VFG
 310.  S=2.*GG*VV*VFG+HFG
 320.  C=GG*VL*VL+HL-HO
 330.  XQQ=(-S+SQR(S*S-4.*R*C))/(2.*R)
 340.  DIFXQ1=DIFXQ2
 350.  IF(SLOPE.NE.0.)THEN
 360.  TK2=TK1-DIFXQ2*SLOPE
 370.  IF(ABS(DIFXQ2).LT.0.00001)GOTO 110
 380.  IF(I.GT.1)GOTO 70
 390.  TK1=TK2
 400.  DIFXQ1=DIFXQ2
 410.  IF(SLOPE.NE.0.)THEN
 420.  TK2=TK1-DIFXQ2*SLOPE
 430.  70
 440.  00
 450.  00
 460.  00
 470.  00
 480.  00
 490.  00
 500.  00
 510.  00
 520.  00
 530.  00
 540.  00
 550.  00
 560.  00

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DATE 072184

```
***** ROFANN *****  
570.    00      ELSE  
580.    00      TK2=TK1+SIGN(1.,DIFXQ2)  
590.    00      END IF  
600.    00      GOTO 100  
610.    00      C  
620.    00      70  SLOPE=(TK2-TK1)/(DIFXQ2-DIFXQ1)  
630.    00      IF(ABS(DIFXQ1).LT.ABS(DIFXQ2))GOTO 80  
640.    00      TK1=TK2  
650.    00      DIFXQ1=DIFXQ2  
660.    00      80  TK2=TK1-DIFXQ1*SLOPE  
670.    00      100 CONTINUE  
680.    00      PRINT 602,DIFXQ2  
690.    00      602 FORMAT('ROFANN DOES NOT CONVERGE, DIFXQ2= ',1PE15.5)  
700.    00      110 CONTINUE  
710.    00      RCFANN=1./(VL+XQQ*VFG)  
720.    00      RETURN  
730.    00      END  
  
END ELT.  ERRORS: NONE. TIME: 0.129 SEC. IMAGE COUNT: 73  
@Hdg,P ***** SATCOM ***** .L,0
```

```

@ELT,L DD.SATCOM
ELT 8R1 S74Q1C 07/21/84 15:55:12 (0)
          SUBROUTINE SATCOM(T,P1,V1,VL1,P2,V2,VL2)

10.      00      C
20.      00      C
30.      00      C
40.      00      C
50.      00      C
60.      00      C
70.      00      C
80.      00      C
90.      00      C
100.     00      C
110.     00      C
120.     00      C
130.     00      C
140.     00      C
150.     00      C
160.     00      C
170.     00      C
180.     00      C
190.     00      C
200.     00      C
210.     00      C
220.     00      C
230.     00      C
240.     00      C
250.     00      C
251.     00      C
260.     00      C
270.     00      C
280.     00      C
290.     00      C
299.     00      C
300.     00      C
310.     00      C
320.     00      C
330.     00      C
340.     00      C
350.     00      C
360.     00      C
370.     00      C
380.     00      C
390.     00      C
400.     00      C
410.     00      C
420.     00      C
430.     00      C
440.     00      C
450.     00      C
460.     00      C
470.     00      C
480.     00      C
490.     00      C
500.     00      C
510.     00      C
520.     00      C

C*** PURPOSE:
C   TO CALC. FOR PURE MIXTURE COMPONENTS AT SATURATION:
C   PRESSURE, SPEC. VOLUME OF LIQUID, SPEC. VOLUME OF VAPOUR

C*** INPUT:
C   T      - TEMPERATURE (K)
C   P1    - SAT. PRESSURE OF MORE VOLATILE REFRIGERANT (ATM)
C   P2    - SAT. PRESSURE OF LESS VOLATILE REFRIGERANT (ATM)
C   V(1)  - SPEC. VOLUME OF VAPOUR OF MORE VOLATILE REFRIG. AT SATURATION
C           (L/MOL)
C   V(2)  - SPEC. VOLUME OF VAPOUR OF LESS VOLATILE REFRIG. AT SATURATION
C           (L/MOL)
C   VL(1) - SPEC. VOLUME OF LIQUID OF MORE VOLATILE REFRIG. AT SATURATION
C           (L/MOL)
C   VL(2) - SPEC. VOLUME OF LIQUID OF LESS VOLATILE REFRIG. AT SATURATION

C*** SUBPROGRAMS CALLED BY SATCOM:
C   FGIBBS, SATLIB, VOLIT

C COMMON/RDATA2/W1,W2,TC1,TC2
C DIMENSION P(2),X(2),V(2),VL(2)
C DATA X(1),X(2)/0.,1./

C CALL SATLIB(T,P(1),V(1),VL(1),P(2),V(2),VL(2))
C IF(T.GT.(TC1-10.))GOTO 100
C
C DO 100 I=1,2
C DO 90 J=1,20
C   VOLIT(T,P(1),X(J),V(J))
C   GV=FGIBBS(T,P(1),X(J),V(J))
C   CALL VOLIT(T,P(1),X(J),V(J))
C   GL=FGIBBS(T,P(1),X(J),VL(J))
C   P7=(GL-GV)/(VL(J)-V(J))
C   F(1)=F(1)-P7/3.
C   P7=P7/P(1)
C   IF(ABS(P7).LT.1E-04)GOTO 100
C
C 90 CONTINUE
C   PRINT 600,1,P(1),P7
C   600 FORMAT(' ERROR 600 IN SATCOM, 1,P,P7= ',13,2(1PE14.6))
C   100 CONTINUE
C   P1=F(1)
C   V1=V(1)
C   VL1=VL(1)
C   P2=F(2)
C   V2=V(2)
C   VL2=VL(2)
C   RETURN
C END
```

***** SATLIB *****

DATE 072184

```
©ELT L DD.SATLIB
ELT 8R1 S74Q1C 07/21/84 15:55:13 (0) SUBROUTINE SATLIB(T,P1,Y1,VL1,P2,V2,VL2)
 00 C
 20. 00 C
 30. 00 C
 40. 00 C
 50. 00 C
 60. 00 C
 70. 00 C
 80. 00 C
 90. 00 C
100. 00 C
110. 00 C
120. 00 C
130. 00 C
140. 00 C
150. 00 C
160. 00 C
170. 00 C
180. 00 C
190. 00 C
200. 00 C
210. 00 C
220. 00 C
230. 00 C
240. 00 C
250. 00 C
260. 00 C
270. 00 C
280. 00 C
290. 00 C
300. 00 C
310. 00 C
320. 00 C
330. 00 C
340. 00 C
350. 00 C

C**** PURPOSE:
C FOR GIVEN T, ESTIMATE SAT. PRESSURE, SPEC. VOLUME OF VAPOR,
C AND SPEC. VOLUME OF LIQUID. OF MIXTURE. PURE COMPONENTS

C**** INPUT:
C      T - TEMPERATURE (K)
C**** OUTPUT:
C      P1 - SAT. PRESSURE OF MORE VOLATILE COMPONENT (ATM)
C      P2 - SAT. PRESSURE OF LESS VOLATILE COMPONENT (ATM)
C      VL1 - SPEC. VOLUME OF MORE VOLATILE COMPONENT SAT. VAPOR
C             (L/MOL)
C      V2 - SPEC. VOLUME OF LESS VOLATILE COMPONENT SAT. VAPOR
C             (L/MOL)
C      VL1 - SPEC. VOLUME OF MORE VOLATILE COMPONENT SAT. LIQUID
C             (L/MOL)
C      VL2 - SPEC. VOLUME OF LESS VOLATILE COMPONENT SAT. LIQUID
C             (L/MOL)

COMMON//ESDATA/A(2,3),B(2,3),C(2,3)
C      T2=T*T
C**** MORE VOLATILE COMPONENT
P1=EXP(A(1,1)+A(1,2)/T+A(1,3)/T2)
V1=(B(1,1)+B(1,2)*T+B(1,3)*T2)*T/P1
VL1=C(1,1)+C(1,2)*T+C(1,3)*T2
C**** LESS VOLATILE COMPONENT
P2=EXP(A(2,1)+A(2,2)/T+A(2,3)/T2)
V2=(B(2,1)+B(2,2)*T+B(2,3)*T2)*T/P2
VL2=C(2,1)+C(2,2)*T+C(2,3)*T2
RETURN
END

END ELT. ERRORS: NONE. TIME: 0.064 SEC. IMAGE COUNT: 35
EHDG,P ***** SPHDP1 ***** .L,0
```

***** SPHDP1 *****

@ELT,L DD.SPHDP1
ELT 8RI S74Q1C 07/21/84 15:55:13 (0)
FUNCTION SPHDP1(AM,AL,D,VSP,AMU)

10. 00 C
20. 00 C
30. 00 C*** PURPOSE:
40. 00 C TO COMPUTE FRICTIONAL PRESSURE DROP
50. 00 C FOR SINGLE PHASE FLOW IN A TUBE
60. 00 C
70. 00 C*** INPUT DATA:
80. 00 C AL - TUBE LENGTH (FT)
90. 00 C AM - FLUID MASS FLOW RATE (LBM/H)
100. 00 C AMU - FLUID DYNAMIC VISCOSITY (LBM/H*FT)
110. 00 C D - TUBE DIAMETER (FT)
120. 00 C VSP - FLUID SPECIFIC VOLUME (FT**3/LBM)
130. 00 C
140. 00 ACC=3.3309E-11
150. 00 G=0.78539816*D*D
160. 00 G=AM/G
170. 00 RE=G*D/AMU
180. 00 F=0.046/RE**0.2
190. 00 SPHDP1=ACC*F*VSP*AL*G*G/D
200. 00 RETURN
210. 00 END

END ELT. ERRORS: NONE. TIME: 0.059 SEC. IMAGE COUNT: 21

@HDG,P ***** SPHTC ***** .L,0

DATE 072184

***** SPHTC *****

DATE 072184

```
@ELT,L DD.SPHTC
ELT 8R1 S74Q1C 07/21/84 15:55:13 (0)
      00   FUNCTION SPHTC(CP,AM,AK,RMASS,D)
      00   C
      20.  C
      30.  C*** PURPOSE:
      40.  C   TO COMPUTE SINGLE PHASE HEAT TRANSFER COEFFICIENT
      50.  C   FOR FLOW INSIDE TUBE
      60.  C
      70.  C*** INPUT DATA:
      80.  C   AM - FLUID DYNAMIC VISCOSITY (LBM/FT*SEC)
      90.  C   AK - FLUID THERMAL CONDUCTIVITY (BTU/IN*F*FT)
     100. C   CP - FLUID SPECIFIC HEAT AT CONST. PRESSURE (BTU/LBM*F)
     110. C   D - TUBE DIAMETER (FT)
     120. C   RMASS - FLUID MASS FLOW RATE (LBM/H)
     130. C
     140. C*** OUTPUT DATA:
     150. C   SPHTC - SINGLE PHASE HEAT TRANSFER COEFF. (BTU/H*F*FT**2)
     160. C
     170. C   G=RMASS/(0.7853982*D*D)
     180. C   RE=D*G/AM
     190. C   IF(REF.GE.2000.)GOTO10
     200. C   SPHTC=4.3E*AK/D
     210. C   GOTO20
     220. C   10 PR=(AM*CP/AK)**0.4
     230. C   RE=RE**0.8
     240. C   SPHTC=0.023*AK*FR*RE/D
     250. C   20 RETURN
     260. C
END ELT.  ERRORS: NONE. TIME: 0.071 SEC. IMAGE COUNT: 26
@HDG,P ***** SPIN ***** .L,0
```

***** SPIN *****

DATE 072184

```

@ELT,L DD,SPIN
ELT 8R1 S74Q1C 07/21/84 15:55:13 (0)
      00      SUBROUTINE SPIN(IG,S,P,X,ACCUR,T,V)
      20.
      30.
      40.      00      C*** PURPOSE: TO CALC. TEMPERATURE OF BINARY MIXTURE VAPOR
      50.      00      FROM GIVEN ENTROPY AND PRESSURE
      60.      00
      70.      00
      80.      00      C*** INPUT: ACCUR - ACCURACY OF CONVERGANCE (BTU/LB)
      90.      00      IG   = 0, IF GUESS OF TEMPERATURE IS NOT GIVEN
     100.      00      C   = POSITIVE INTEGER, IF GUESS OF TEMPERATURE IS GIVEN
     110.      00
     120.      00      P   - PRESSURE (STD ATM)
     130.      00      S   - ENTROPY (BTU/LB*F)
     140.      00      T   - GUESS OF TEMPERATURE, OPTIONAL (K)
     150.      00      X   - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
     160.      00
     170.      00      C*** OUTPUT: T   - BINARY MIXTURE TEMPERATURE (K)
     180.      00      V   - SPEC. VOLUME (L/MOL)
     190.
     200.
     210.      00      C*** SUBPROGRAMS CALLED BY SPIN:
     220.      00      DEWTEM,ENTROP,ESVOL,VOLIT
     230.
     240.
     250.
     260.      00      C   IF (ABS(P-PLAST).GT.1.E-4) GOTO 10
     270.      00      IF (ABS(S-SLAST).GT.ACCUR) GOTO 10
     280.      00      IF (ABS(X-XLAST).GT.1.E-4) GOTO 10
     290.      00      T=TLAST
     300.      00      V=VLAST
     310.      00      RETURN
     320.
     330.
     340.      00      C   10 N1=1
     350.      00      CALL DEWTEM(0,P,X,TD,XL)
     360.      00      IF (IG.EQ.0) T=TD+20.
     370.      00      DO 50 I=1,15
     380.      00      T=MAY1(TD,T)
     390.      00      V=ESVOL(N1,T,P,X)
     400.      00      CALL VOLIT(T,P,X,V)
     410.      00      SS=ENTROP(T,V,X)
     420.      00      T2=T
     430.      00      SDIF2=S-SS
     440.      00      IF (ABS(SDIF2).LT.ACCUR) GOTO 100
     450.      00      IF (SDIF1.EQ.SDIF2) THEN
     460.      00      WRITE(6,601)
     470.      00      GOTO 60
     480.
     490.
     500.      00      END IF
     510.      00      IF (SL.OFC.NE.0.) THEN
     520.      00      DT=SDIF2*SLOPE
     530.      00      IF (ABS(DT).GT.15.) DT=SIGN(15.,DT)
     540.      00      T=T2-DT
     550.      00      GOTO 50
     560.      00

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DATE 072184

```
***** SPIN *****
      570.    00   T=T2+10.
      580.    00   IF(SDIF2.LT.0.) T=T2-10.
      590.    00   GOTO 50
      600.    00
      610.    00   SDIF2=(T2-T1)/(SDIF2-SDIF1)
      620.    00   IF(ABS(SDIF1).LT.ABS(SDIF2))GOTO 30
      630.    00   T1=T2
      640.    00   SDIF1=SDIF2
      650.    00   DT=SDIF1*SLOPE
      660.    00   IF(ABS(DT).GT.15.)DT=SIGN(15.,DT)
      670.    00   T=T1-DT
      680.    00   50 CONTINUE
      690.    00   C) WRITE(6,600)SDIF2
      700.    00   600 FORMAT('' ERROR 600 IN SPIN, SDIF2=''',1PE12.4)
      710.    00   601 FORMAT('' SPIN DOES NOT CONVERGE ANY FURTHER='')
      720.    00   100 PLAST=P
      730.    00   SLAST=S
      740.    00   XLAST=X
      750.    00   TLAST=T
      760.    00   VLAST=V
      770.    00   RETURN
      780.    00   END

END ELT.  ERRORS: NONE.  TIME: 0.142 SEC. IMAGE COUNT: 78
@HDG,P ***** TPPROP ***** .L,0
```

***** TPPROP *****

```
©ELT,L DD.TPPROP
ELT 8R1 S74Q1C 07/21/84 15:55:14 (O) SUBROUTINE TPPROP(TF,PSIA,XW,XQ,H,V)
20. 00
30. 00
40. 00
50. 00
60. 00
70. 00
80. 00
90. 00
100. 00
110. 00
120. 00
130. 00
140. 00
150. 00
160. 00
170. 00
180. 00
190. 00
200. 00
210. 00
220. 00
230. 00
240. 00
250. 00
260. 00
270. 00
280. 00
290. 00
300. 00
310. 00
320. 00
330. 00
340. 00
350. 00
360. 00
370. 00
380. 00
390. 00
400. 00
410. 00
420. 00
      C **** PURPOSE:
      C   TO CALCULATE NON-AZEOTROPIC MIXTURE THERMODYNAMIC PROPERTIES
      C   FROM GIVEN TEMPERATURE, PRESSURE AND COMPOSITION
      C **** INPUT:
      C   TF   - TEMPERATURE (F)
      C   PSIA - PRESSURE (PSIA)
      C   XW   - WEIGHT COMPOSITION (FRACTION OF LEAST VOLATILE COMPONENT)
      C **** OUTPUT:
      C   H   - ENTHALPY (BTU/LB)
      C   V   - SPEC. VOLUME (FT**3/LB)
      C   XQ  - QUALITY (-)
      C
      COMMON/RDATA2/W1,W2,TC1,TC2
      C
      TK=(TF+459.67)/1.8
      PA=PSIA/14.6959
      XM=XW/(W2/W1*(1.-XW)+XW)
      WM=(1.-XM)*W1+XM*W2
      CALL QLITY(TK,PA,XM,XQ,XV,XL)
      IF(XQ.NE.0.0.AND.XQ.NE.1.)GOTO 10
      N=1.0001*XQ
      CALL VOLIT1(N,TK,PA,XM,V)
      CALL HCVCP(1,TK,V,XM,H,CV,CP)
      V=V*16.01845/WM
      GOTO 1000
      C
      10 CALL VOLIT1(0,TK,PA,XL,V)
      CALL HCVCP(1,TK,VL,XL,HL,CV,CP)
      CALL VOLIT1(1,TK,PA,XV,V)
      CALL HCVCF(1,TK,VL,XV,HV,CV,CP)
      H=(1.-XQ)*HL+XQ*HV
      WML=(1.-XL)*W1+XL*W2
      WMV=(1.-XV)*W1+XV*W2
      VL=VL*16.01846/WML
      VVW=VV*16.01845/WMV
      V=(1.-XQ)*VL*W+XQ*VVW
      1000 RETURN
      00
END ELT.  ERRORS: NONE.  TIME: 0.095 SEC.  IMAGE COUNT: 42
©HOG,P ***** TPPROP ***** L,0
```

***** TPPRO2 *****

```
©ELT,L DD.TPPRO2
ELT 2R1 S74Q1C 07/21/84 15:55:14 (0)
      00          SUBROUTINE TPPRO2(TF,PS1^,XM,XQ,H,V,XL,XV,VL,VV)
      20.
      30.          C
      40.          C **** PURPOSE:
      50.          C TO CALCULATE NON-AZOTROPIC MIXTURE THERMODYNAMIC PROPERTIES
      60.          C FROM GIVEN TEMPERATURE, PRESSURE AND COMPOSITION
      70.          C
      80.          C **** INPUT:
      90.          C   TF - TEMPERATURE (F)
     100.         C   PSIA - PRESSURE (PSIA)
     110.         C   XM - WEIGHT COMPOSITION (FRACTION OF LIQS VOLATILE COMPONENT)
     120.         C
     130.         C **** OUTPUT:
     140.         C   H - ENTHALPY (BTU/LB)
     150.         C   V - SPEC. VOLUME (FT^3/LB)
     160.         C   XQ - QUALITY (-)
     170.         C COMMON/RDATA2/W1,W2,TC1,TC2
     180.         C
     190.         C TK=(TF+459.67)/1.8
     200.         C PA=PSIA/14.6959
     210.         C XM=XW/(W2/W1*(1.-X1)+XW)
     220.         C WM=(1.-XM)*W1+XM*W2
     230.         C CALL QLTY(TK,PA,XN,XQ,XV,XL)
     240.         C IF(XQ.NE.0..AND.XQ.NE.-1.)GOTO 10
     250.         C N=1.0001*XQ
     260.         C CALL VOLIT1(N,TK,P^,XM,V)
     270.         C CALL HCVCP(1,TK,V,XM,H,CV,CP)
     280.         C V=V*16.0184E/W1
     290.         C GOTO 1000
     300.         C
     310.         C 10 CALL VOLIT1(0,TK,PA,XL,VL)
     320.         C CALL HCVCP(1,TK,VL,XL,HL,CV,CP)
     330.         C CALL VOLIT1(1,TK,PA,XV,VV)
     340.         C CALL HCVCP(1,TK,VV,XV,HV,CV,CP)
     350.         C H=(1.-XQ)*HL+XQ*HV
     360.         C WM1=(1.-XL)*W1+XL*W2
     370.         C WMV=(1.-XV)*W1+XV*W2
     380.         C VLW=VL*16.0184E/HML
     390.         C VVM=VV*16.0184E/HMV
     400.         C V=((1.-XQ)*VLW+XQ*VVM
     410.         C 1000 RETURN
     420.         C END

END ELT.  ERRCRS: NONE. TIME: 0.087 SEC. IMAGE COUNT: 42
©HDG,P ***** TXQIN ***** .L.0
```

DATE 07/21/84

* * * * * TXQIN

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@ELT,L DD.TXQIN
ELT 8R1 S740IC 07/21/84 15:55:14 (0)
10.    00      C
20.    00      C
30.    00      C*** PURPOSE:
40.    00      C   TO CALC. PRESSURE OF NON-AZEOTROPIC MIXTURE
50.    00      C   FORM GIVEN COMPOSITION, TEMPERATURE AND QUALITY
60.    00      C
70.    00      C
80.    00      C*** INPUT:
90.    00      C   T - TEMPERATURE (F,
100.   00      C   X - COMPOSITION (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
110.   00      C   XQ - QUALITY (-)
120.   00      C
130.   00      C*** OUTPUT:
140.   00      C   P - PRESSURE OF MIXTURE (STD ATM)
150.   00      C   XL - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
160.   00      C   (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
170.   00      C   XV - COMPOSITION OF SAT. VAPOR AT TEMP. TK AND PRESSURE PA
180.   00      C   (MOLAR FRACTION OF LFSS VOLATILE COMPONENT)
190.   00      C
200.   00      C*** SUBPROGRAMS CALLED BY TXQIN:
210.   00      C   EBUBPR, QLITY
220.   00      C
230.   00      C   DATA SLOPE/0., TLAST/0./
240.   00      C
250.   00      C   IF(XQ.LE.0..OR.XQ.GE.1.) THEN
260.   00      C   PRINT 677,XQ
270.   00      C   677 FORMAT(' ERROR IN CALLING TXQIN, XQ= ',1PE16.6)
280.   00      C   RETURN
290.   00      C   END IF
300.   00      C
310.   00      C   IF(ABS(T-TLAST).GT.1.E-3)GOTO 10
320.   00      C   IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
330.   00      C   IF(ABS(XQ-XQLAST).GT.1.E-4)GOTO 10
340.   00      C   P=PLAST
350.   00      C   XL=XLLAST
360.   00      C   XV=XVLAST
370.   00      C   RETURN
380.   00      C
390.   00      C   10 P=EBUBPR(T,X)-XQ*3LCPE
400.   00      C   DO 50 I=1,20
410.   00      C   CALL QLITY(T,P,X,XQN,XV,XL)
420.   00      C   P2=P
421.   00      C   IF(XQN.EQ.0.)CALL BUPPRE(0,T,X,P2,XV)
422.   00      C   IF(XQN.EQ.1.)CALL DEWPRE(0,T,X,P2,XL)
430.   00      C   XQDIF2=XQ-XQN
460.   00      C   IF(I.NE.1)GOTO 20
470.   00      C   P1=F2
480.   00      C   XQDIF1=XQDIF2
490.   00      C   IF(SLOPE.NE.0.)THEN
500.   00      C   DP=XQDIF2*SLOPE
510.   00      C   IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)
520.   00      C   P=P2-DP
530.   00      C   GOTO 50
540.   00      C
550.   00      C   P=P2- DP
560.   00      C

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```

***** TXQIN *****
570.    00      C      GOTO 50
580.    00      C      20 IF(XQDIF1.NE.XQDIF2)GOTO 25
590.    00      C      WRITE(6,610)XQDIF1
640.    00      C      610 FORMAT(' TXQIN DOES NOT CONVERGE ANY FURTHER, XQDIF1=' ,1PE14.5)
650.    00      C      GOTO 110
660.    00      C
670.    00      C      25 SLOPE=(P2-P1)/(XQDIF2-XQDIF1)
680.    00      C      IF(ABS(XQDIF1).LT.ABS(XQDIF2))GOTO 30
690.    00      C      P1=P2
700.    00      C      XQDIF1=XQDIF2
710.    00      C      30 DP=XQDIF1+SLOPE
720.    00      C      IF(ABS(DP).LT.0.002.AND.ABS(XQDIF2).LT.0.0001)GOTO 100
730.    00      C      IF(ABS(DP).GT.2.)DP=SIGN(2.,DF)
740.    00      C      P=P1-DP
750.    00      C      50 CONTINUE
760.    00      C      WRITE(6,600)XQDIF2
770.    00      C      600 FORMAT(' ERROR 600 IN TXQIN, XQDIF2=' ,1PE12.4)
780.    00      C      100 PLAST=P
790.    00      C      XLAST=X
800.    00      C      XQLAST=XQ
810.    00      C      TLAST=T
820.    00      C      XLLAST=XL
830.    00      C      XVLAST=XV
840.    00      C      110 RETURN
850.    00      C      END
860.    00      C

END ELT.  ERRORS: NONE. TIME: 0.135 SEC. IMAGE COUNT: 82
@HDG,P ***** TXQIN2 ***** .L,O

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***** TXQIN2 *****

@ELT,L DD,TXQIN2
ELT 8R1 S74Q1C 07/21/84 15:55:14 (0)
10. 00 C SUBROUTINE TXQIN2(X,T,XQ,P,XL,XV,VL,VV,H)
20. 00 C
30. 00 C
40. 00 C*** PURPOSE:
50. 00 C TO CALC. PRESSURE & ENTHALPY OF 2-PHASE NON-AZOTROPIC MIXTURE
60. 00 C FORM GIVEN COMPOSITION, TEMPERATURE AND QUALITY
70. 00 C
80. 00 C*** INPUT:
90. 00 C   H - MIXTURE ENTHALPY (BTU/LB)
100. 00 C   P - PRESSURE (STD ATM)
110. 00 C   XL - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
120. 00 C   (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
130. 00 C
140. 00 C*** OUTPUT:
150. 00 C   T - TEMPERATURE (K)
160. 00 C   X - COMPOSITION (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
170. 00 C   XQ - QUALITY (-)
180. 00 C
190. 00 C
200. 00 C
210. 00 C
220. 00 C
230. 00 C
240. 00 C
250. 00 C
260. 00 C
270. 00 C
280. 00 C
290. 00 C
300. 00 C
310. 00 C
320. 00 C
330. 00 C
340. 00 C
350. 00 C
360. 00 C
370. 00 C
380. 00 C
390. 00 C
400. 00 C
410. 00 C
420. 00 C
430. 00 C
440. 00 C
450. 00 C
460. 00 C
470. 00 C
480. 00 C
490. 00 C
500. 00 C
510. 00 C
520. 00 C
530. 00 C
540. 00 C
550. 00 C
560. 00 C

C*** PURPOSE:
C TO CALC. PRESSURE & ENTHALPY OF 2-PHASE NON-AZOTROPIC MIXTURE
C FORM GIVEN COMPOSITION, TEMPERATURE AND QUALITY
C
C*** INPUT:
C   H - MIXTURE ENTHALPY (BTU/LB)
C   P - PRESSURE (STD ATM)
C   XL - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
C   (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
C   X - COMPOSITION OF SAT. VAPOR AT TEMP. TK AND PRESSURE PA
C   (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
C   VL - SPECIFIC VOLUME OF SAT. LIQUID OF XL COMPOSITION
C   AT TEMPERATURE TK (L/MOL)
C   VW - SPECIFIC VOLUME OF SAT. VAPOR OF XV COMPOSITION
C   AT TEMPERATURE TK (L/MOL)

C*** SUBPROGRAMS CALLED BY TXQIN2:
C   HCVCVP, TXQIN1, VOLIT1
C
C IF(XQ.LE.0.0R.XQ.GE.1.) THEN
C   PRINT 666,XQ
C   666 FORMAT(' ERROR IN CALLING TXQIN2, XQ=',IPE16.6)
C   RETURN
C END IF
C
C IF(ABS(T-TLAST).GT.1.E-4)GOTO 10
C IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
C IF(ABS(XQ-XQLAST).GT.1.E-4)GOTO 10
C P=PLAST
C XL=XLLAST
C XV=XVLAST
C VL=VLLAST
C VW=VVLAST
C H=HLLAST
C RETURN
C
C 10 CALL TXQIN1(X,T,XQ,P,XL,XV)
C   CALL VOLIT1(0,T,P,XL,VL)
C   CALL HCVCVP(1,T,VL,XL,H1,CV,CP)
C   CALL VOLIT1(1,T,P,XV,VV)
C   CALL HCVCVP(1,T,VV,XV,HV,CV,CR)
C   H=(1.-XQ)*H1+XQ*HV
C
C 100 PLAST=P
C   XL,VST=X
C   XQLAST=XQ
C   TLAST=T
C   XLLAST=XL
C   XVLAST=XV
C

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DATE 072184

***** TXQIN2 *****
570. 00 VL LAST=VL
580. 00 VV LAST=VV
590. 00 HL AST=H
600. 00 RETURN
610. 00
END ELT. ERRORS: NONE. TIME: 0.115 SEC. IMAGE COUNT: 61
@HDG,P ***** VALVPA ***** .L,O

***** VALVPA *****

DATE 072184

ELT,L DD,VALVPA
ELT 8R1 S74Q1C 07/21/84 15:55:15 (0)
10. 00 SUBROUTINE VALVPA
20. 00
30. 00
40. 00
50. 00
60. 00
70. 00
80. 00

```

C*** PURPOSE:  
C   TO EVALUATE 4-WAY VALVE PERFORMANCE PARAMETERS  
C   FROM TEST UNDER ONE OPERATION CONDITION  
C   (BINARY MIXTURE REFRIGERANT)  
  
C*** INPUT DATA:  
C [1] REFRIGERANT CONSTANTS  
C LISTED IN COMMON STATEMENTS RDATA1 & RDATA2  
C [2] TEST DATA AS EXPLAINED BELOW:  
C     P2,T2 - REFRIG. PRESSURE & TEMP. AT VALVE LOW PRESSURE INLET  
C     (PSIA), (F)  
C     P3,T3 - REFRIG. PRESSURE & TEMP. AT VALVE LOW PRESSURE OUTLET  
C     (PSIA), (F)  
C     P8,T8 - REFRIG. PRESSURE & TEMP. AT VALVE HIGH PRESSURE INLET  
C     (PSIA), (F)  
C     P9,T9 - REFRIG. PRESSURE & TEMP. AT VALVE HIGH PRESSURE OUTLET  
C     (PSIA), (F)  
C     RMASS - REFRIG. MASS FLOW RATE (LBMM/H)  
C     XW - MIXTURE COMPOSITION  
C           - WEIGHT FRACTION OF MORE VOLATILE COMPONENT  
  
C*** OUTPUT DATA:  
C     CPD - PARAMETER FOR 4-WAY VALVE PRESSURE DROP  
C           (LBF*H**2/LBM*N**2*FT**3)  
C     CPDH - PARAMETER FOR PRESSURE DROP ON HIGH PRESSURE SIDE  
C           (LBF*H**2/LB11*N**2*FT**3)  
C     CPDS - PARAMETER FOR PRESSURE DROP ON LOW PRESSURE SIDE  
C           (LBF*H**2/LBM*N**2*FT**3)  
C     CQ - PARAMETER FOR 1-WAY VALVE HEAT TRANSFER (FT**2)  
C     Q - HEAT TRANSFER RATE BETWEEN HIGH & LOW PRESSURE REFRIG.  
C           (BTU/H)  
C     QS - LOW PRESSURE REFRIG. VAPOR HEAT GAIN (BTU/H)  
C     QH - HIGH PRESSURE REFRIG. VAPOR HEAT LOSS (BTU/H)  
  
C*** SUBPROGRAMS CALLED BY VALVPA:  
C   ESVOL,HCVCP,VISCON,VOLIT  
  
C COMMON/RDATA1/A3,A4,A5,A6,A7,A8,B3,B4,B5,B6,B7,B8,F0,F1  
C COMMON/RDATA2/W1,W2,TC1,TC2  
C DIMENSION TK(4),PA(4),VM(4),H(4),CP(4),AK(4),AM(4)  
C  
400. 00  
410. 00  
420. 00  
430. 00  
440. 00  
450. 00  
460. 00  
470. 00  
480. 00  
490. 00  
500. 00  
510. 00  
520. 00  
530. 00  
540. 00  
550. 00  
560. 00  
  
C WRITE(6,19)  
15 WRITE(6,20)  
READ(5,777)T11,P11,T2,P2  
WRITE(6,21)  
READ(5,777)T7,P7,T71,P71  
WRITE(6,22)  
READ(5,777)RMASS,XW  
XW=1.-XW  
XM=W2/W1*(1.-XW)+XW
```

***** VALVPA *****

DATE 072184

```

      570.      00      XM=XM//XM
      580.      00      W1=(1.-XM)*W1+XM*W2
      590.      00      PA(1)=P1/14.6959
      600.      00      PA(2)=P2/14.6959
      610.      00      PA(3)=P7/14.6959
      620.      00      PA(4)=P71/14.6959
      630.      00      TK(1)=(T11+459.67)/1.8
      640.      00      TK(2)=(T2+459.67)/1.8
      650.      00      TK(3)=(T7+459.67)/1.8
      660.      00      TK(4)=(T71+459.67)/1.8
      670.      00      C*** FIND TRANSPORT AND THERMODYNAMIC PROPERTIES AT EACH POINT
      680.      00      DO 18 I=1,4
      690.      00      V1(I)=ESVOL(1,TK(I),PA(I),XM)
      700.      00      CALL VOLIT(TK(I),PA(I),XM,VM(I))
      710.      00      CALL HCVCVP(N3,TK(I),VM(I),XM,H(I),CV,CP(I))
      720.      00      AM(I)=VISCON(3,TK(I),XW)
      730.      00      AK(I)=VISCON(4,TK(I),XW)
      740.      00      18 CONTINUE
      750.      00      C
      760.      00      AMS=(AM(1)+AM(2))/2.
      770.      00      AKS=(AK(1)+AK(2))/2.
      780.      00      CPS=(CP(1)+CP(2))/2.
      790.      00      AM1=(AM(4)+AM(3))/2.
      800.      00      AKH=(AK(4)+AK(3))/2.
      810.      00      CFH=(CP(4)+CP(3))/2.
      820.      00      VS=0.5*(V1(I)+VM(2))*16.01846./WM
      830.      00      VH=0.5*(VM(4)+VM(3))*16.01846./WM
      840.      00      RMASS8=RMASS**0.8
      850.      00      HCS=RMASS8*AKS**0.667*CP8**0.333/AMS**0.467
      860.      00      HCH=RMASS8*AKH**0.667*CP11**0.333/AMH**0.467
      870.      00      RHT=1./HCS+1./HCH
      880.      00      DTA=DTA-DTB/(ALOG(DTA/DTB))
      890.      00      OS=RMASS*(H(2)-H(1))
      900.      00      OH=(OS+QH)/2.
      910.      00      DTA=T7-T2
      920.      00      DTB=T7-T1
      930.      00      TF=(DTA-DTB)/(ALOG(DTA/DTB))
      940.      00      CQ=Q*RHT/TF
      950.      00      CPDS=(P11-P2)/(RMASS*RMASS*VS)
      960.      00      CPDH=(P7-P71)/(RMASS*RMASS*VH)
      970.      00      CPD=(CPDS+CPDH)/2.
      980.      00      WFLTE(5,31)Q,OS,OH
      990.      00      WFLTE(6,32)CPDS,CPDH
      1000.      00      WFLTE(6,34)CQ,CPD
      1010.      00      C
      1020.      00      WRITE(6,36)
      1030.      00      READ(5,777)
      1040.      00      IF(I,NE,999)GOTO 15
      1050.      00      19 FORMAT(' EVALUATION OF FOUR-WAY VALVE PARAMETERS ')
      1060.      00      20 FORMAT(' ENTER: T2,F2,T3,P3=')
      1070.      00      21 FORMAT(' ENTER: T0,F8,T9,P9=')
      1080.      00      22 FORMAT(' ENTER: RMASS,XW=')
      1090.      00      31 FORMAT(' Q,OS,OH= ',3(1PE10.3))
      1100.      00      32 FORMAT(' CPDS,CPDH= ',2(1PE10.3))
      1110.      00      34 FORMAT(' CQ,CPD ',2(1PE10.3))
      1120.      00      36 FORMAT(' I=999 TO STOP, I=?')
      1130.      00      777 FORMAT( )
      1140.      00
  
```

DATE 072184

***** VALVPA *****
1150. 00 RETURN
1160. 00 END
END ELT. ERRORS: NONE. TIME: 0.188 SEC. IMAGE COUNT: 116
@HDG,P ***** VISCON ***** .L,0

***** VISCON *****

```

@ELT_L DD.VISCON
ELT 8R1 S74Q1C 07/21/84 15:55:15 (0)
10. 00 FUNCTION VISCON(IQ,T,XW)
20. 00
30. 00
40. 00
50. 00
60. 00
70. 00
80. 00
90. 00
100. 00
110. 00
120. 00
130. 00
140. 00
150. 00
160. 00
170. 00
180. 00
190. 00
200. 00
210. 00
220. 00
230. 00
240. 00
250. 00
260. 00
270. 00
280. 00
290. 00
300. 00
310. 00
320. 00
330. 00
340. 00
350. 00
360. 00
370. 00
380. 00
390. 00
400. 00
410. 00
420. 00
430. 00
440. 00
450. 00
460. 00
470. 00
480. 00
490. 00
500. 00
510. 00
520. 00
530. 00
540. 00
550. 00
560. 00

C*** PURPOSE:
C   TO CALCULATE ABS. VISCOSITY OR THERMAL CONDUCTIVITY
C   OF LIQUID OR VAPOR, OR SPEC. HEAT OF SAT. LIQUID
C   OF R-13B1/R-152A MIXTURE

C*** INPUT:
C   IQ   - OUTPUT QUALIFER
C   C   = 1, IF LIQUID ABS. VISCOSITY REQUIRED
C   C   = 2, IF LIQUID THERMAL CONDUCTIVITY REQUIRED
C   C   = 3, IF VAPOR ABS. VISCOSITY REQUIRED
C   C   = 4, IF VAPOR THERMAL CONDUCTIVITY REQUIRED
C   C   = 5, IF SPEC. HEAT OF SAT. LIQUID REQUIRED
C   T   - TEMPERATURE (F)
C   XW  - WEIGHT COMPOSITION (FRACTION OF R-152A)

C*** OUTPUT:
C   VISCON - LIQ. ABS. VISCOSITY (IQ=1) (LD/(H*FT))
C   C   - LIQ. THERMAL CONDUCTIVITY (IQ=2) (BTU/(H*FT*F))
C   C   - VAP. ADS. VISCOSITY (IQ=3) (LB/(H*FT))
C   C   - VAP. THERMAL CONDUCTIVITY (IQ=4) (BTU/(H*FT*F))
C   C   - SAT. LIQUID SPEC. HEAT (IQ=5) (BTU/(LB*F))

DATA W1,W2/148.93,66.05/,TB1,TB2/215.4,248.15/
DATA R/0.125885/,
```

GOTO (10,20,30,30,50)IQ

C*** LIQ. ABS. VISCOSITY
10 TK=(T+459.68)/1.8
TK2=TK*TK

VL1=0.2749422-0.001702569*TK+3.71008313E-G*TK2

VL1=VL1*16.01845/W1

VL2=0.1023688715-4.0752759E-4*TK

VL2=VL2+1.0409447E-6*TK2

VL2=VL2*16.01846/W2

VLM=(1.-XW)*VL1+XW*VL2

VI1=2419.09*EXP(-4.22529+710.843/TK)*1.E-3

VI1=VI1*VL1

VI2=2419.09*EXP(-4.28224-753.013/TK)*1.E-3

VI2=VI2*VL2

FIA=(1.-XW)*VL1/VLM

FIB=1.-FIA

SEG=ALOG(VL2/VL1)

ALFA=-1.7*SEG

ALFAB=0.27*SEG+SQRT(1.3*SFC)

VISCON=FIA*VI1*EXP(FIB*ALFAB)+FIB*VI2*EXP(FIA*ALFAA)

VISCON=VISCON/VLM

GOTO 1000

C*** LIQ. THERMAL CONDUCTIVITY
20 C1=0.035-1.5E-4*T

C2=0.577778*(0.1165-1.97E-4*(T-32.)/1.8)
VISCON=C1+(C2-C1)*XW*(0.72*XW+0.28),

***** VISCON *****

570. 00 C GOT0 1000
580. 00 C*** VAP. ABS. VISCOSITY
590. 00 3.0 TK=(T+459.67)/1.8
600. 00 TK2=TK*TK
610. 00 X=W2/W1*(1.-XW)+XW
620. 00 X=XW/X
630. 00 V11=-0.67329*7.60593E-3*TK-2.81108E-5*TK2
640. 00 V11=2.41909*(V11+3.4741E-8*TK**TK2)
650. 00 C2=0.1*(-0.08357+6.32E-4*TK+4.257E-7*TK2)
660. 00 CP=-7.33704+0.093433*TK-3.61094E-4*TK2+4.80149E-7*TK2*TK
670. 00 FE=0.115+0.354*CF/R
680. 00 V12=2.41909*0.03205*C2*V12/FC
690. 00 IF(IQ,NE,3)GOTO 40
700. 00 F12=(1.+SQR((V11/V12)*(W2/W1)**0.25))**2
710. 00 F12=F12/SQR((8+8*W1/W2)
720. 00 F21=F12*V12*W1/(V11*W2)
730. 00 VISCON=(1.-X)*V11/(1.-X+X*F12)
740. 00 VISCON=VISCON+X*V12/(X+(1.-X)*F21)
750. 00 GOTO 1000
760. 00 C*** VAP. THERMAL CONDUCTIVITY
770. 00 40 C1=8.2982E-3-5.1971E-5*TK+1.8413E-7*TK2
780. 00 S1=1.5*TB1
790. 00 S2=1.5*TB2
800. 00 S12=0.73*SQRT(S1*S2)
810. 00 SEG=SQRT(V11*(TK+S1)*(W2/W1)**0.75/(V12*(TK+S2)))
820. 00 A12=.25*(1.+SEG)**2*(TK+S12)/(TK+S1)
830. 00 A21=.25*(1.+1./SEC)**2*(TK+S12)/(TK+S2)
840. 00 VISCON=(1.-X)*C1/(1.-X*A12)
850. 00 VISCON=0.577789*(VISCON+X*C2/((1.-X)*A21+X))
860. 00 GOTO 1000
870. 00 C*** SPEC. HEAT OF SAT. LIQUID
880. 00 50 TK=(T+459.67)/1.8
890. 00 TK2=TK*TK
900. 00 C1=-1.42637+0.0276024*TK-1.23753E-4*TK2+1.92012E-7*TK*TK2
910. 00 C2=-1.7E539+0.0252241*TK-8.71975E-5*TK2+1.39262E-7*TK*TK2
920. 00 VISCON=0.23902*((1.-XW)*C1+XW*C2)
930. 00 1000 RETURN
940. 00
950. 00 END

END ELT. ERRORS: NONE. TIME: 0.171 SEC. IMAGE COUNT: 95

©HDG, P ***** VOLIT1 ***** .L., 0

***** VOLITI *****

©ELT,L DD.VOLITI
ELT 8R1 S74Q1C 07/21/84 15:55:15 (0)

```

00      SUBROUTINE VOLITI(N,T,P5,X,V)
20.
00
C***** PURPOSE:
C      TO ITERATE REFRIG. MIXTURE R-13B1/R-152A SPEC. VOL.
30.      FROM EQUATION OF STATE
00
C***** INPUT:
C      N - OUTPUT QUALIFIER
00      C   = 0, IF SPEC. VOL. OF LIQUID IS REQUIRED
00      C   = 1, IF SPEC. VOL. OF VAPOR IS REQUIRED
00
00      T - REFRIG. TEMPERATURE (K)
00      P5 - REFRIG. SAT. PRESSURE (STD ATM)
00      X - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
00      * - REFRIG. CONSTANTS A & B (SEE COMMON STATEMENT /PARAM/ )
00
00      C***** OUTPUT:
00      C   V - REFRIG. SPEC. VOLUME (L/MOL)
00
00      C***** SUBPROGRAMS CALLED BY VOLITI:
00      C   FSVCL, EQPAR
00
00      COMMON/PARAM/A,B,C1,C2,D1,D2
00      DATA R/0.08206/
00
00      C   IF(P5.GT.0.)GOTO 10
00
00      PRINT 601,P5
00
00      601 FORMAT(' VOLITI CALLED WITH NEG. PRESSURE, P5= ',1PE13.3)
00
00      RETURN
00
00      C   10 IF(T.LT.150.)PRINT 602,T
00      602 FORMAT(' WARNING, VOLITI CALLED WITH TEMP.= ',1PE11.3)
00
00      C   V=FSVCL(N,T,P5,X)
00      CALL EQPAR(T,X)
00      D0 100 I=1,25
00      Y=B/(4.*V)
00      Y2=Y*Y
00      Y3=Y2*Y
00      Y4=Y3*Y
00      P=(R*T*(1.+Y+Y2-Y3)/(1.-Y)**3-A/(V+B))/V
00      P6=(P5-P)/P5
00      1F(AE.S(P5).LT.1.E-04)GOT1 1000
00      P0=-R*T/V**2*(1.+4.*Y+4.*Y2-4.*Y3+Y4)/(1.-Y)**4
00      P0=P0+A*(2.*V+B)/(V*(V+B))**2
00      V6=(P-F5)/P0
00
00      V7=V-V6
00      IF(V7.GT.(B/4.) )GOTO 50
00      V=V-(V-B/4.)/10.
00
00      GOT1 100
00      V=V7
00
00      50 CONTINUE
00      WRITE(6,600)P6
00      600 FORMAT(' ERROR 600 IN VOLITI, P6 = ',1PE12.4)
00
00      1000 RETURN
00
00      END

```

***** VOLITI *****
END ELT. ERRORS: NONE. TIME: 0.121 SEC. IMAGE COUNT: 55
@HDG,P ***** WACCUM ***** .L,O

DATE 072184

***** WACCUM *****

DATE 072184

```

@ELT,L DD WACCUM
ELT,8R1 S74Q1C 07/21/84 15:55:16 (O)
10.    00      SUBROUTINE WACCUM(T,P,RMSS,WACC,XWA)
20.    00
30.    00      C**** PURPOSE:
40.    00      C    TO CALCULATE MASS OF NON-AZOTROPIC REFRIGERANT
50.    00      C    IN AN ACCUMULATOR
60.    00
70.    00
80.    00      C**** INPUT DATA:
90.    00      C    AHGT   - ACCUMULATOR HEIGHT (FT)
100.   00      C    DACC   - INNER DIAMETER OF ACCUMULATOR (FT)
110.   00      C    DHOLE(1) - INNER DIA. OF THE OIL RETURN HOLE (FT)
120.   00      C    DHOLE(2) - INNER DIA. OF THE UPPER HOLE (FT)
130.   00      C    CTUBE  - INNER DIA. OF ACCUMULATOR TUBE (FT)
140.   00      C    HDIS   - VERTICAL DISTANCE BETWEEN HOLES (FT)
150.   00      C    P      - REFRIG. PRESSURE (PSIA)
160.   00      C    RMASS  - REFRIG. MASS FLOW RATE (LB/H)
170.   00      C    T      - REFRIG. TEMPERATURE (F)
180.   00
190.   00      C**** OUTPUT DATA:
200.   00      C    XWA   - WEIGHT COMPOSITION OF MIXTURE IN ACCUMULATOR
210.   00      C    (FRACTION OF LESS VOLATILE COMPONENT)
220.   00      C    WACC   - MASS OF REFRIG. IN THE ACCUMULATOR (LB)
230.   00
240.   00      C**** SUBPROGRAMS CALLED BY WACCUM:
250.   00      C    QLITY, VOLIT1
260.   00
270.   00      C    COMMON/RDATA2/W1,W2,TC1,TC2
280.   00      C    COMMON/ACCDIM/AHGT,DACC,DHOLE(2),DTUBE,HDIS
290.   00
300.   00      C    DIMENSION AHCLE(2)
310.   00      C    REAL*8 WL,AHCL,PD,HL(2),HLL,HLDI1A,HLDI1B,HLLA,ZZ,Y1,Y2,
320.   00      C    HLLB,Z1,Z2,DP,RM,RMT,DIFF1,DIFF2,SLOPE,ALFA,AT
330.   00      C    REAL*8 RO,PDYN,AHOLE(2),RMSL
340.   00      C    DATA PI/3.1415927/
350.   00
360.   00      C    AACCC=PI*DACC*DACC/4.
370.   00      PA=P/14.6959
380.   00      TK=(T+459.67)/1.8
390.   00      CALL QLITY(TK,PA,XM,X,XV,XL)
400.   00      XMW=XL/(W1/W2*(1.-XL)+XL)
410.   00      XVW=XV/(W1/W2*(1.-XV)+XV)
420.   00
430.   00      IF(X.GT..999) THEN
440.   00      CALL VOLIT1(1,TK,PA,XM,V) @VAPOR ONLY IN ACCUMULATOR
450.   00      V=V*16.0184E/WM
460.   00      WACC=AACC*AHGT/V
470.   00      XMW=XW
480.   00      GOTO 100
490.   00
500.   00      END IF
510.   00      CALL VOLIT1(0,TK,PA,XL,V) @LIQUID PRESENT IN ACCUMULATOR
520.   00      WM=V1*(1.-XL)+W2*XW
530.   00      RO=V1M/(V*16.0184E)
540.   00      CALL VOLIT1(1,TK,PA,XV,V)
550.   00      WMV=V1*(1.-XV)+W2*XV
560.   00      V=V*16.0164E/WMV

```

WACCUM *****

```

570.      00
580.      00 RMS=RMS/3600.
590.      00 RMS'=(1.-X)*RMS
600.      00 AHOLE(1)=PI*DHOLE(1)*DHOLE(1)/4.
610.      00 ATUBE=PI*DTUBE*DTUBE/4.
620.      00 AHOL=AHOLE(1)
630.      00 HLL=DHOLE(1)
640.      00 PDYN=0.5*(X*RMS/ATUBE)**2*v
650.      00 D0 10 I=1,20
660.      00 WL=RMSL/AHOL
670.      00 PD=WL*WL/(.585*.585*2.*RO)
680.      00 HL((1))=(PD-PDYN)/(RO*.32.2)
690.      00 IF(I.EQ.1.AND.HL((1)).GT.DHOLE((1)))GOTO 12
700.      00 IF(.ABS((HL((1))-HLL))/DHOLE((1)).LT.0.01)GOTO 12
710.      00 IF(I.EQ.1)THEN
720.      00 HLL=DHOLE((1))/2.
730.      00 HLLA=DHOLE((1))
740.      00 HLDIFA=HL((1))-DHOLE((1))
750.      00 ELSE
760.      00 HLDIFB=HL((1))-HLL
770.      00 HLLB=HLL
780.      00 HLLA=HLLA*(HLLA-HLLB)/(HLDIFA-HLDIFB)
790.      00 HLLB=HLLB
800.      00 HLDIFA=HLDIFB
810.      00 IF(HLL.LT.0.)HLL=.9*HLLA
820.      00 END IF
830.      00 R=0.5*DHOLE((1))
840.      00 Z1=HLL-R
850.      00 Z2=DSQRT(R*R-Z1*Z1)
860.      00 AT=Z1*Z2
870.      00 ALFA=2.*ARCCOS(ABS(Z1/R))
880.      00 IF((HL((1)).LE.HDIS.OR.HDIS.EQ.0.)GOTO 40
890.      00 AHOL=AHOLE((1))*ALFA/(2.*PI)+AT
900.      00 10 CONTINUE
910.      00 WRITE(6,90)
920.      00 90 FORMAT(' WACCUM LOOP 10 DID NOT CONVERGE ')
930.      00 GOTO 10
940.      00 C
950.      00 12 VHGT=AHGT-HL((1))
960.      00 VHGT=AAMAX1(0.,VHGT)
970.      00 AMASS2=AACC*(HL((1))*RO+VHGTV/V)
980.      00 IF((HL((1)).LE.HDIS.OR.HDIS.EQ.0.)GOTO 40
990.      00 AHOLE((2))=PI*DHOLE((2)*DHOLE((2))/4.
1000.      00 Z1=HL((1))
1010.      00 HL((2))=HL((1))-HDIS
1020.      00 DP=HL((2))*RO*.32.2+PDYN
1030.      00 RM=0.585*AHOLE((2))*DSQRT((2.*RO*DP)
1040.      00 DIFF1=RM
1050.      00 VHGT=AAMAX1(0.,VHGT)
1060.      00 AMASS1=AACC*(Z2*RO+VHGTV/V)
1070.      00 Z2=HDIS
1080.      00 DO 30 J=1,20
1090.      00 HL((1))=Z2
1100.      00 HL((2))=Z2-HDIS
1110.      00 RMT=0. DO
1120.      00 DO 16 I=1,2
1130.      00 DP=HL((1))*RO*.32.2DO+PDYN
1140.      00

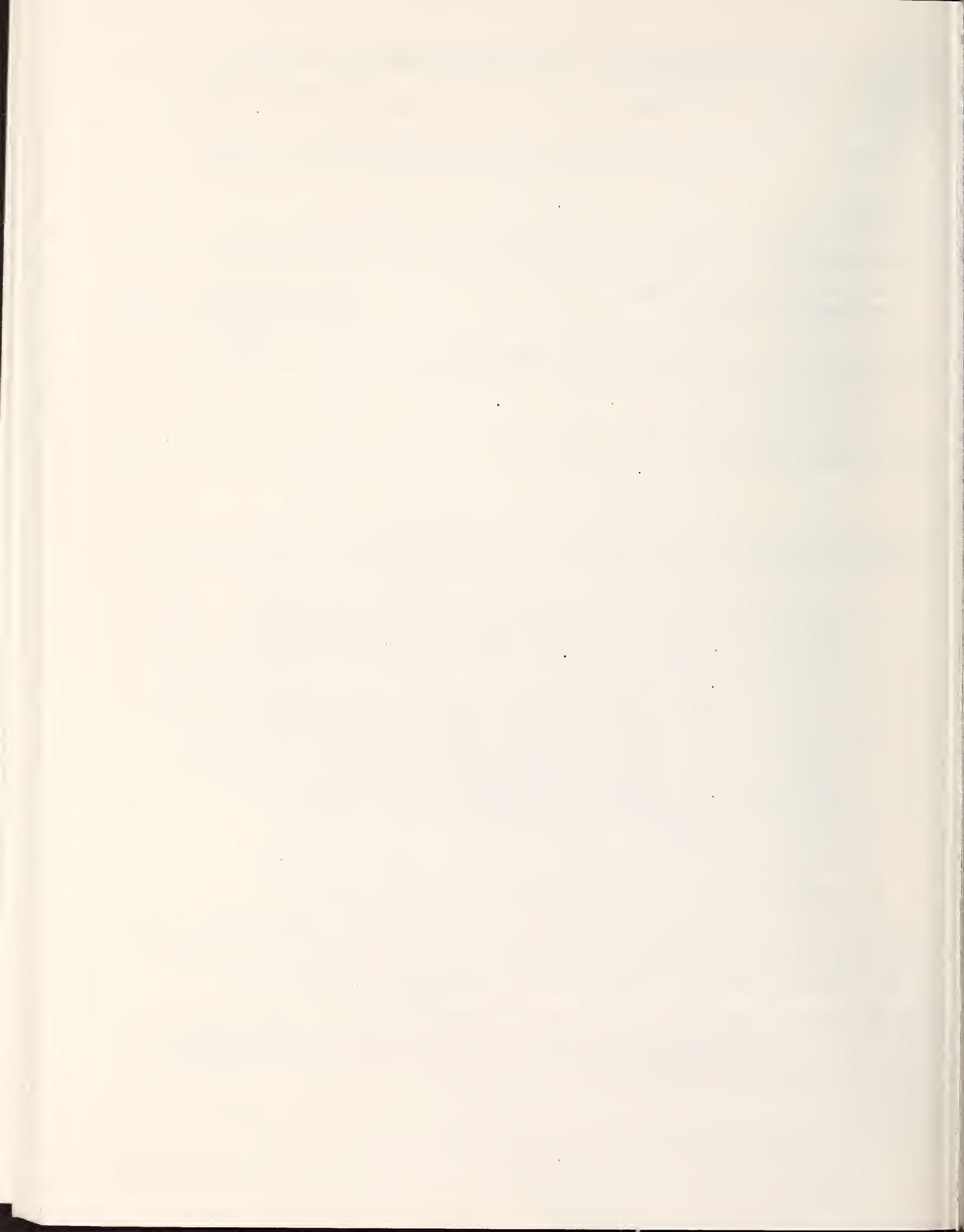
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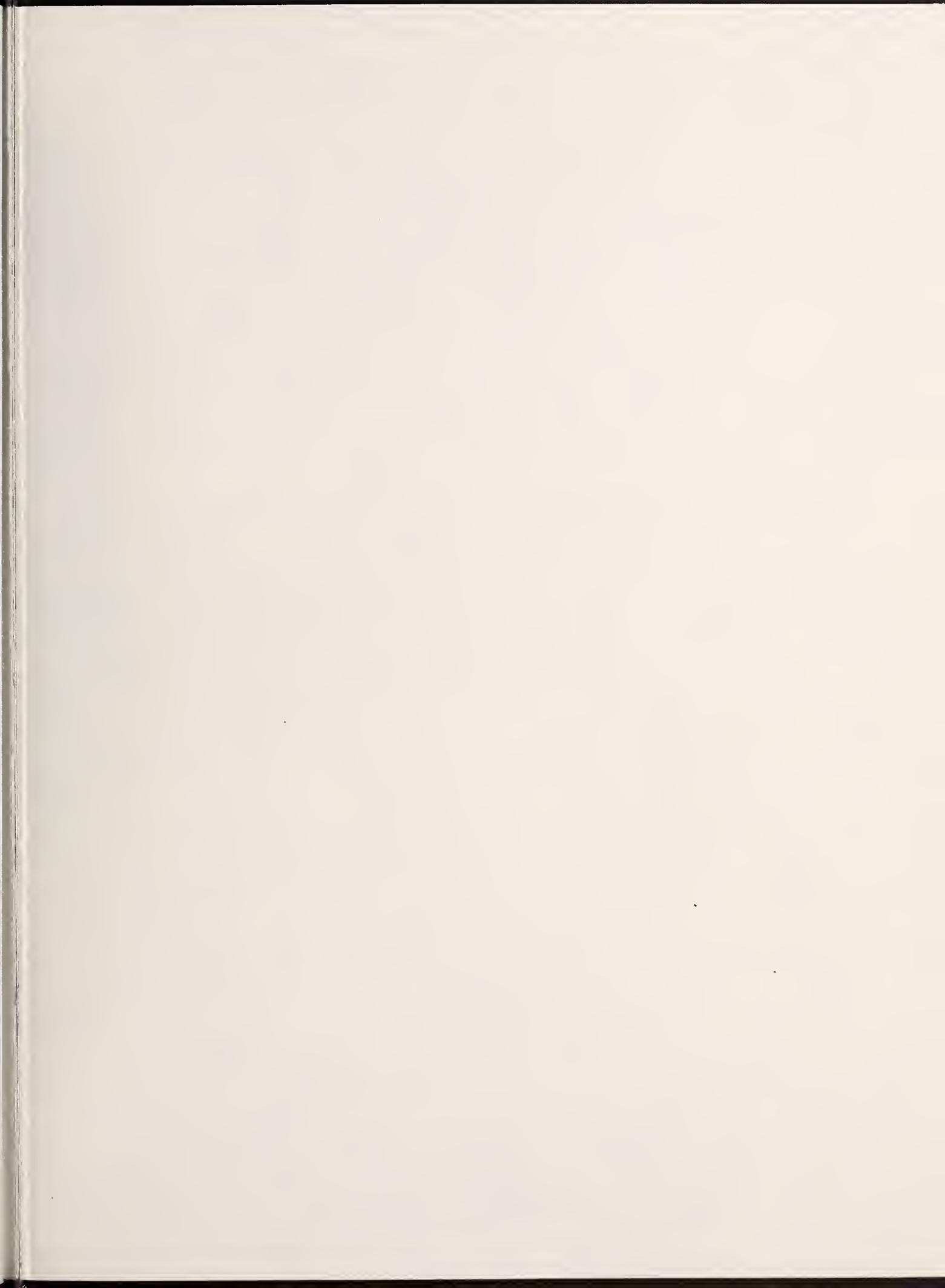
***** WACCUM *****

DATE 072184

```
1150.      00      IF(HL(1).EQ.0.D0)DP=0.D0
1160.      00      AHOL=1.
1170.      00      IF(I.EQ.2)THEN
1180.      00          IF(HL(2).GT.DHOLE(2))GOTO 15
1190.      00          IF(HL(2).EQ.0.D0)GOTO 15
1200.      00          R=.5*DHOLE(2)
1210.      00          Y1=HL(2)-R
1220.      00          Y2=DSQRT(R*R-Y1*Y1)
1230.      00          AT=Y1*Y2
1240.      00          ALFA=2.*ARCCOS(DABS(Y1/R))
1250.      00          IF(HL(2).GT.R)ALFA=2.*PI-ALFA
1260.      00          AHOL=AHOLE(2)*ALFA/(2.*PI)+AT
1270.      00          AHOL=AHOLE(2)/AHOL
1280.      00      END IF
1290.      00          R1=.585*AHOLE(1)*DSQRT(2.*R0*DP)/AHOL
1300.      00          RM=FMT+7H
1310.      00          DIFF2=RMT-FMSL
1320.      00          VHGT=AHGT-HL(1)
1330.      00          VIGT=AMAX1(0.,VHGT)
1340.      00          AMASS2=AACC*(HL(1)*R0+VHGT/V)
1350.      00          IF(ABS(AMASS1-AMASS2).LT.0.01)GOTO 40
1360.      00          SLOPE=(Z1-Z2)/(DIFF1-DIFF2)
1370.      00          Z2=Z2-DIFF2*SLOPE
1380.      00          IF(ABS(DIFF1).LT.ABS(DIFF2))GOTO 20
1390.      00          AMASS1=AMASS2
1400.      00          DIFF1=DIFF2
1410.      00          Z1=Z2
1420.      00          Z2=DMAX1(Z2,HDIS)
1430.      00          20 Z2=Z2
1440.      00          30 CONTINUE
1450.      00          ERROR=AACC*ARS(Z2-Z1)*R0
1460.      00          WRITE(6,602)ERROR
1470.      00          40 CONTINUE
1480.      00          IF(VHGT.EQ.0.)WRITE(6,600)
1490.      00          WACC=AMASS2
1500.      00          W152A=AACC*(HL(1)*R0*XWL+VHGT/V*VW)
1510.      00          XWA=W152A/WACC
1520.      00          XB=1.-XWA
1530.      00          WRITE(6,604)XB,WACC
1540.      00          600 FORMAT('ACCUMULATOR OVERFILLED')
1550.      00          602 FORMAT('WACCUM DOES NOT CONVERGE, MAX.ERROR = ',1PE10.3,' (LB)')
1560.      00          604 FORMAT('COMPOSITION OF REFRIG. IN ACCUMULATOR = ',F6.3,/,'
@ 'WEIGHT FRACTION OF MORE VOLATILE COMPONENT) ',/
@ 'REFRIG. IN ACCUMULATOR = ',F8.3,' LB')
1570.      00          RETURN
1580.      00
1590.      00
1600.      00      END
END ELT.    ERRORS. NONE. TIME: 0.217 SEC. IMAGE COUNT: 160
@HDG,N
@OFFSEND,S
☆U.S. GOVERNMENT PRINTING OFFICE: 1986-491-070-20342
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				NBS/TN-1218		January 1986
<p>4. TITLE AND SUBTITLE</p> <p>MODELING OF A HEAT PUMP CHARGED WITH A NON-AZEOTROPIC REFRIGERANT MIXTURE</p>						
<p>5. AUTHOR(S)</p> <p>Piotr Domanski</p>						
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<p>9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)</p> <p>Electric Power Research Institute 3412 Hillview Avenue P.O. Box 10412 Palo Alto, California 94303</p>						
<p>10. SUPPLEMENTARY NOTES</p> <p><input type="checkbox"/> Document describes a computer program; SF-185, FIPS Software Summary, is attached.</p>						
<p>11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)</p> <p>An analysis of the vapor compression cycle and the main components of an air-to-air heat pump charged with a binary non-azeotropic mixture has been performed for steady-state operation. The general heat pump simulation model HPBI has been formulated which is based on independent, analytical models of system components and the logic linking them together. The logic of the program requires an iterative solution of refrigerant pressure and enthalpy balances, and refrigerant mixture and individual mixture component mass inventories.</p> <p>The modeling effort emphasis was on the local thermodynamic phenomena which were described by fundamental heat transfer equations and equation of state relationships among material properties. In the compressor model several refrigerant locations were identified and the processes taking place between these locations accounted for all significant heat and pressure losses. Evaporator and condenser models were developed on a tube-by-tube basis where performance of each coil tube is computed separately by considering the cross-flow heat transfer with the external air stream and the appropriate heat and mass transfer relationships. A capillary tube model was formulated with the aid of Fanno flow theory. Equation of state for mixtures is described and equation constants for R13B1/R152a mixture are given.</p> <p>The developed heat pump model was validated by checking computer results against laboratory tests data of one heat pump at two cooling and two heating rating points.</p> <p>Program HPBI can be used to evaluate potentials of non-azeotropic mixtures working in a heat pump. User's Manual and listing of the program is included in the report.</p>						
<p>12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)</p> <p>air conditioner; capillary tube; coil; compressor; condenser; expansion device; heat pump; modeling; mixture; non-azeotropic refrigerant; vapor modeling cycle</p>						
<p>13. AVAILABILITY</p> <p><input checked="" type="checkbox"/> Unlimited <input type="checkbox"/> For Official Distribution. Do Not Release to NTIS <input checked="" type="checkbox"/> Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. <input type="checkbox"/> Order From National Technical Information Service (NTIS), Springfield, VA. 22161</p>					14. NO. OF PRINTED PAGES	391
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