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

Piotr Domanski

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

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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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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 Z210.1).

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

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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

Cp = specific heat at constant pressure

Cv = 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 = $\frac{h_{c,o}}{h_{D,o} Cp_a}$, 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 = $\frac{\mu \cdot Cp}{k}$, 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

Vs = compressor swept volume

$\forall$ = 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

XL = molar composition of liquid phase

XM = molar composition of mixture

XV = molar composition of vapor phase

XW = 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 effiiency

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

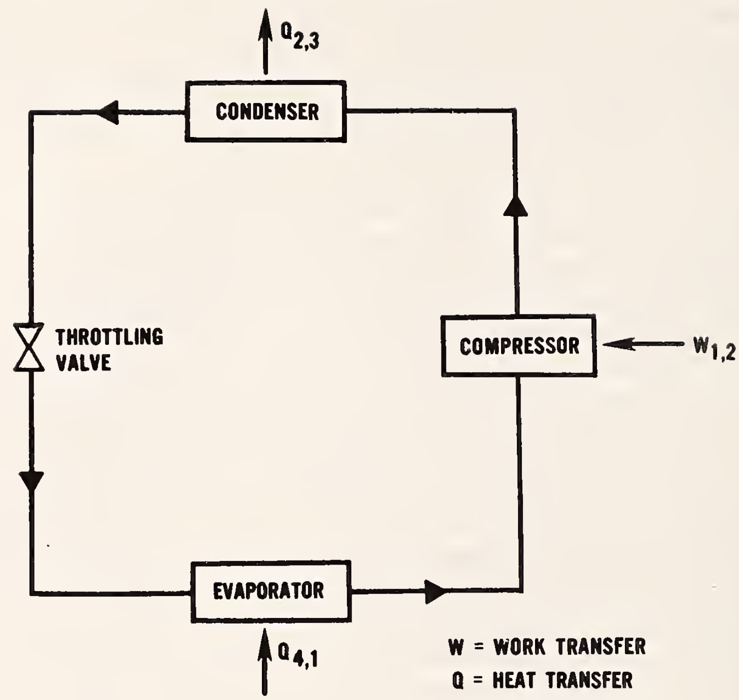
Among equipment providing thermal comfort for indoor spaces, the heat pump has gained in recent years substantial popularity for residential applications. The heat pump is unique since it is the only device, which can provide both heating and cooling. Heat pumps have become very competitive economically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



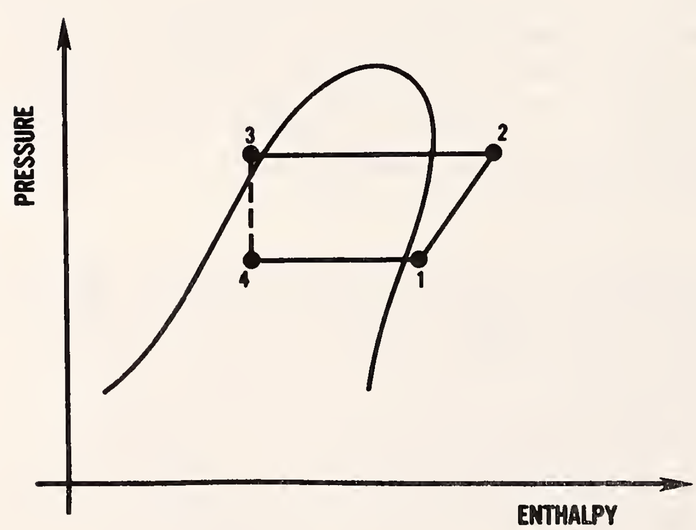
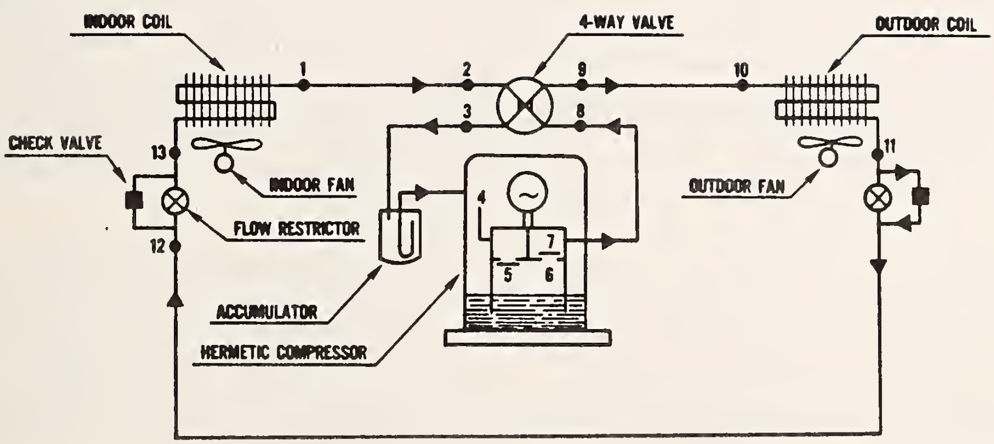


Figure 1. Oversimplified thermodynamic cycle of a heat pump.



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.

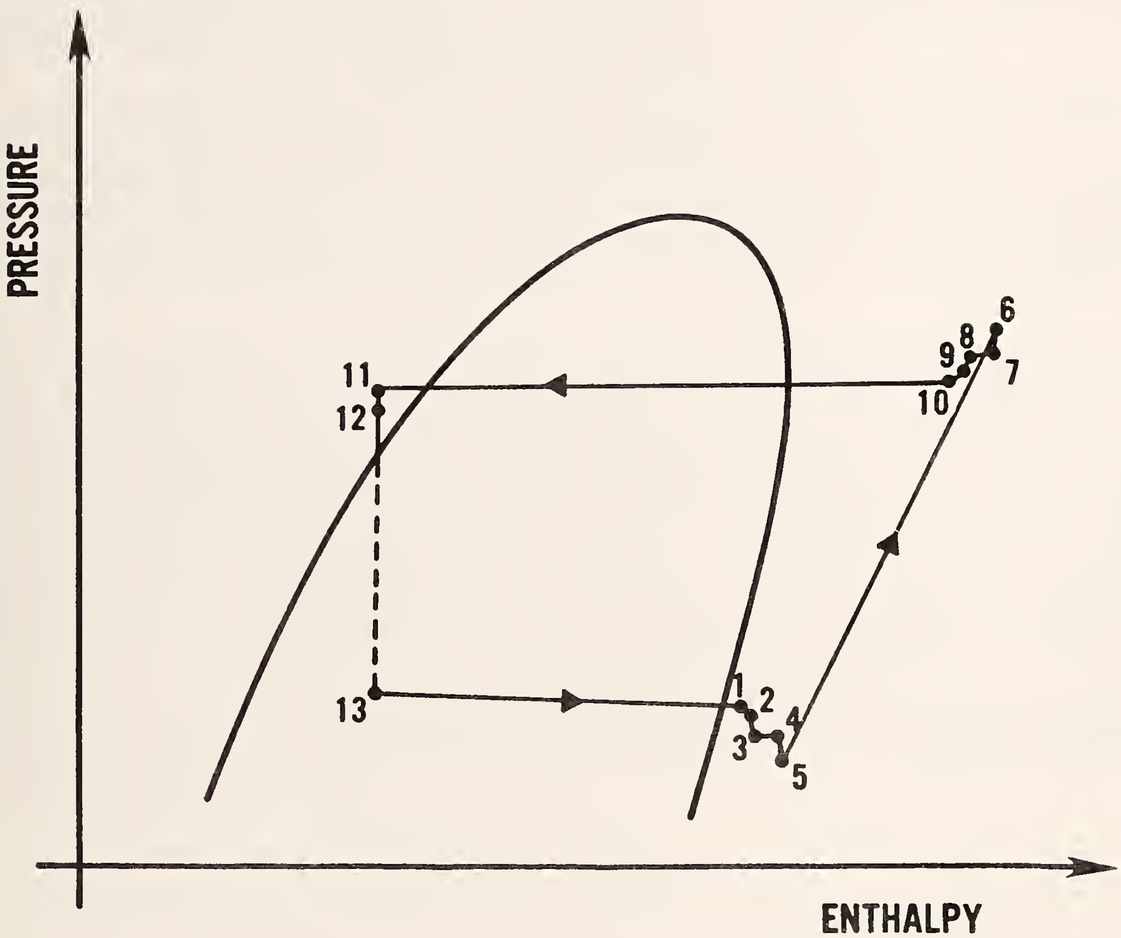


Figure 3. Thermodynamic cycle realized by a heat pump (for number location refer to figure 2).

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:

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

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

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

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

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

ere a_0, a_1, a_2, b_0, b_1, and b_2 are constants which are based on empirical ta for a given refrigerant. For mixtures, these parameters may be etermined 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_o	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	

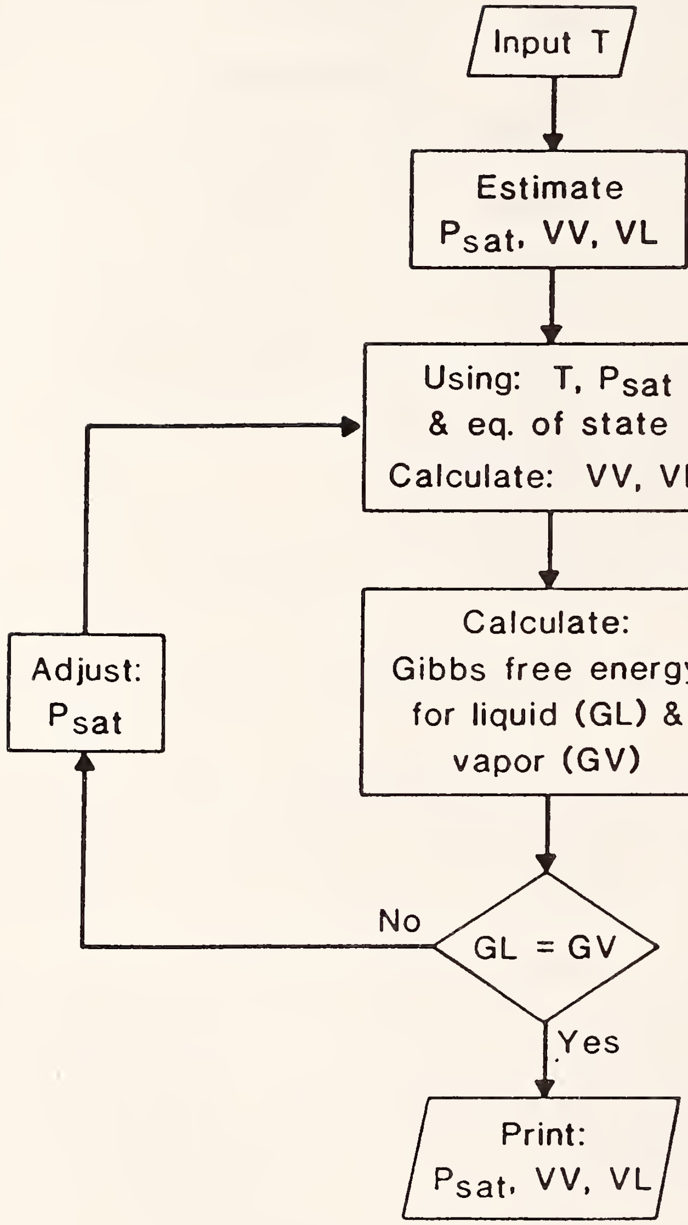


Figure 4. Flow chart for calculating the saturation pressure of single component refrigerant

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:

$$RP = \frac{P1 - P}{P1 - P2}$$

$$S1 = 12.58741 - 0.06465226 * TK \quad 9.56391 * 10^{-5} * TK^2$$

$$S2 = -48.9799 - 0.289414 * TK - 4.504945 * 10^{-4} * TK^2$$

$$S3 = 47.7509 - 0.273993 * TK + 4.14487 * 10^{-4} * TK^2$$

$$S = S1 + S2 * RP + S3 * RP^2$$

$$Z1 = -0.34065414 - 3.337532 * 10^{-3} * TK + 9.66115 * 10^{-6} * TK^2$$

$$Z2 = -10.3139754 + 0.0653856 * TK - 9.9899162 * 10^{-5} * TK^2$$

$$Z3 = 10.035917 - 0.05527259 * TK + 7.6821554 * 10^{-5} * TK^2$$

$$Z = 1 + Z1 * (RP - 1) + Z2 * (RP^2 - 1) + Z3 * (RP^3 - 1)$$

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

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

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:

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

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 (XL) is equal to a known mixture composition (XM). 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:

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

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.

$$h^{pg} = \int_{T_{ref}}^{T} Cpdt = \int_{-40F}^{T} (w_I Cp_I + w_{II} Cp_{II}) dT \quad (12)$$

where Cp_I and Cp_{II} are perfect gas heat capacities of the respective components, functions of temperature, whose coefficients are determined empirically.

$$Cp_I = C_I(1) + C_I(2) \cdot T + C_I(3) T^2 \quad (13)$$

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

Specific entropy can be calculated by the following expression:

$$S_m = w_I \int_{-40}^{T} \frac{Cv_I}{T} dT + R \ln \frac{v}{w_I \cdot v_I^*} - \Delta S_I^{pg} (v_I^*, -40^\circ C)$$

$$+ w_{II} \int_{40}^{T} \frac{C_{vII}}{T} dT + R \ln \frac{v}{w_{II} \cdot v_{II}^*} - \Delta S_{II}^{pg} (v_{II}^*, - 40^\circ C)$$

$$+ \Delta S_m^{pg}(v,T) \quad (15)$$

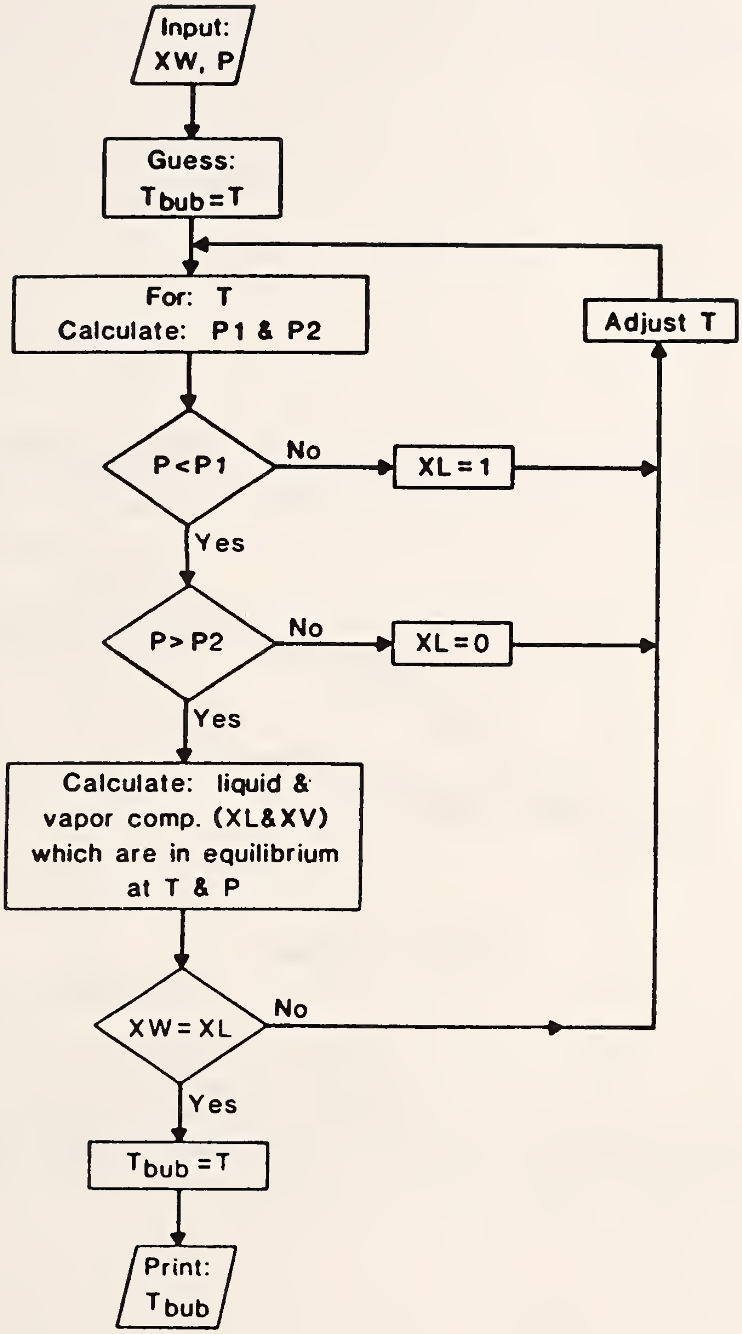


Figure 5. Flow chart for calculating the bubble point temperature of a non-azeotropic binary mixture.

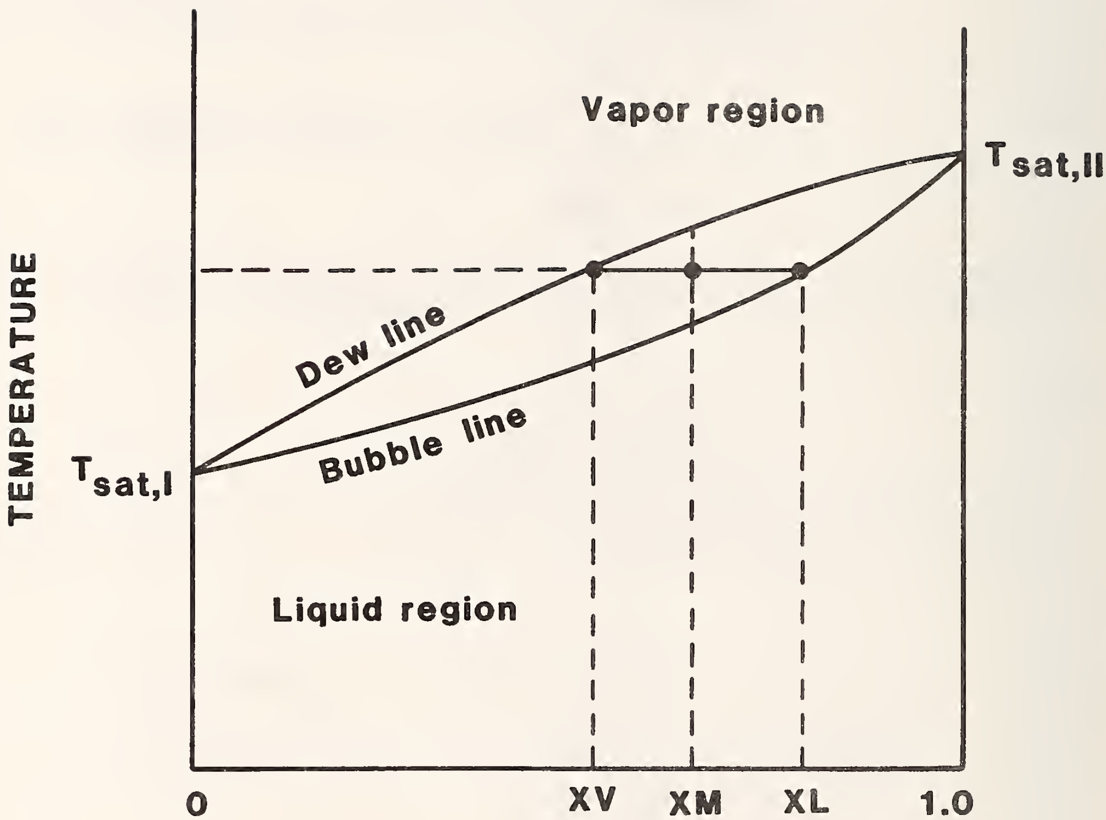


Figure 6. Temperature-composition diagram for a non-azeotropic binary mixture

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 ΔS_{II}^{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.

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

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:

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

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

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

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 - ^{o}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].)

$$k = k1 + (k2 - k1) * XW * (0.72 * XW + 0.28) \tag{20}$$

where: k1, k2 = thermal conductivity of the pure components of R13B1 and R152a, respectively.

k1 =	$0.35 - 1.5 * 10^{-4} \cdot TF$	(Btu/h ft F) [8]
k2 =	$0.11650 - 0.000497 \cdot TC$	(w/m · K) [8]
TC =	temperature	(C)
TF =	temperature	(F)
XW =	weight composition	(fraction of R152a)

Vapor Thermal Conductivity, k

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

$$k = \frac{(1 - XM) \cdot k1}{(1 - XM) \cdot A_{11} + XM \cdot A_{12}} + \frac{XM \cdot k2}{(1 - XM) \cdot A_{21} + XM \cdot A_{22}} \tag{21}$$

where: k1, k2 = thermal conductivity of the pure components of R13B1 and R152a, respectively.

$k1 = 8.2982 * 10^{-3} - 5.1971 * 10^{-5} \cdot TK + 1.8413 * 10^{-7}\, TK^2$ [w/m · K] [8]

$k2 = -8.357 * 10^{-3} + 6.32 * 10^{-5} \cdot TK + 4.257 * 10^{-8} * TK^2$ [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} = normal boiling point of 'i' component (K)
$S_{ij} = 0.73 \cdot (S_i \cdot S_2)^{0.5}$
XM = composition (mole fraction of R152a)

Liquid Absolute Viscosity, μ

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

$$\mu = \frac{1}{v_m} (\phi_1 \cdot \gamma_1 e^{\phi_2 \alpha_2^*} + \phi_2 \gamma_2 e^{\phi_1 \alpha_1^*}) \qquad (22)$$

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)
$\mu_1 = (e^{-4.22529 + 710.843/TK}) * 10^{-3}$ $(N \cdot s/m^2)$ [10]
$\mu_2 = (e^{-4.28224 + 753.013/TK}) * 10^{-3}$ $(N \cdot s/m^2)$ [10]

$$\alpha_1^* = 1.7 \ln \frac{\gamma_2}{\gamma_1}$$

$$\alpha_2^* = 0.27 \ln \frac{\gamma_2}{\gamma_1} + \left(1.3 * \ln \frac{\gamma_2}{\gamma_1}\right)^{0.5}$$

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].)

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

where

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

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

XM = composition (mole fraction of R152a)

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

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

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

k2 = thermal conductivity of pure R152a vapor (w/m · 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.

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

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 subcooled 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 spproximation, 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 refrigeant 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

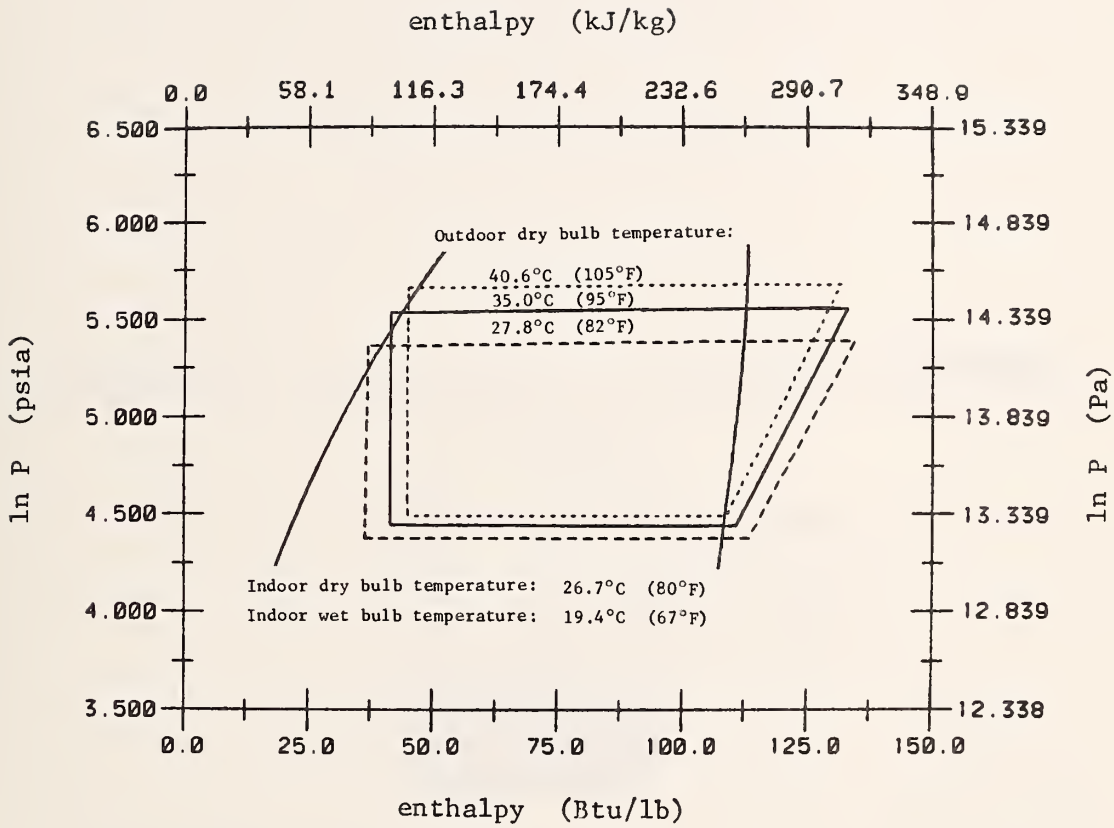


Figure 7. Simplified thermodynamic cycles realized by a heat pump charged with refrigerant 22 in the cooling mode at different outdoor temperatures.

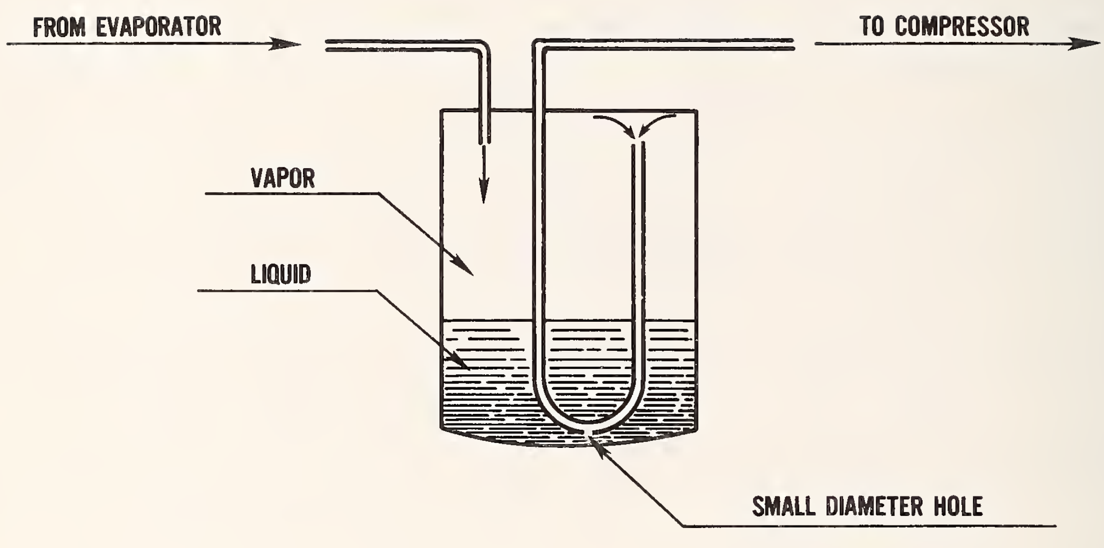


Figure 8. Schematic of an accumulator.

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:

$$\frac{D}{Dt} \int_{V} \rho_m dV = 0 \qquad (24)$$

$$\frac{D}{Dt} \int_{V} \rho_i dV = 0 \qquad (25)$$

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

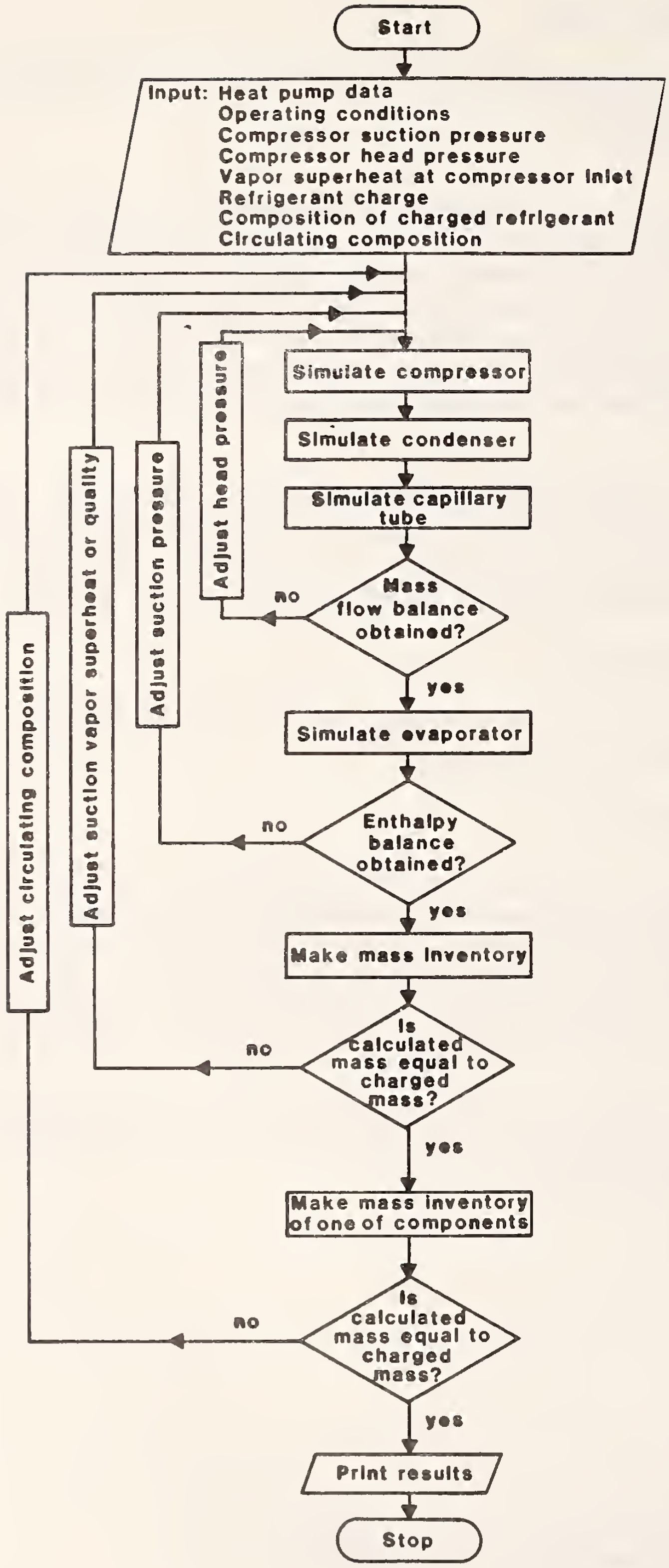


Figure 9. Overall logic of a program simulating performance of a heat pump employing a constant flow area expansion device and charged with a non-azeotropic binary refrigerant mixture.

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 compresor, 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.

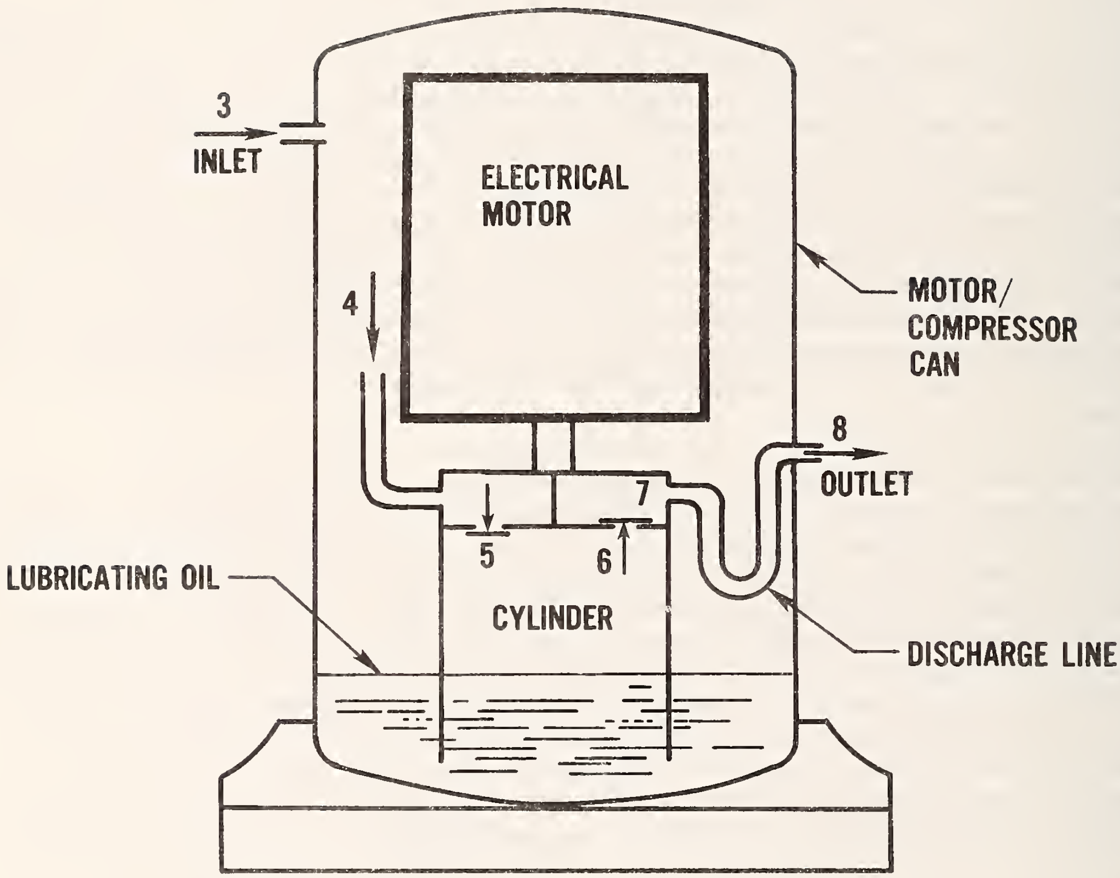
Flow of the refrigerant is from location 3 to location 8, as marked in figure 10. Low pressure refrigerant enters the compressor can and is directed towards the electric motor to cool motor windings. The enthalpy of the refrigerant changes due to this and other heat transfer with other surrounding surfaces, 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.

<u>Conversion of Electrical to Mechanical Energy</u>

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

$$\eta_e = \frac{W_e}{E} \tag{26}$$

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

$$\eta_m = \frac{W_c}{W_e} \tag{27}$$

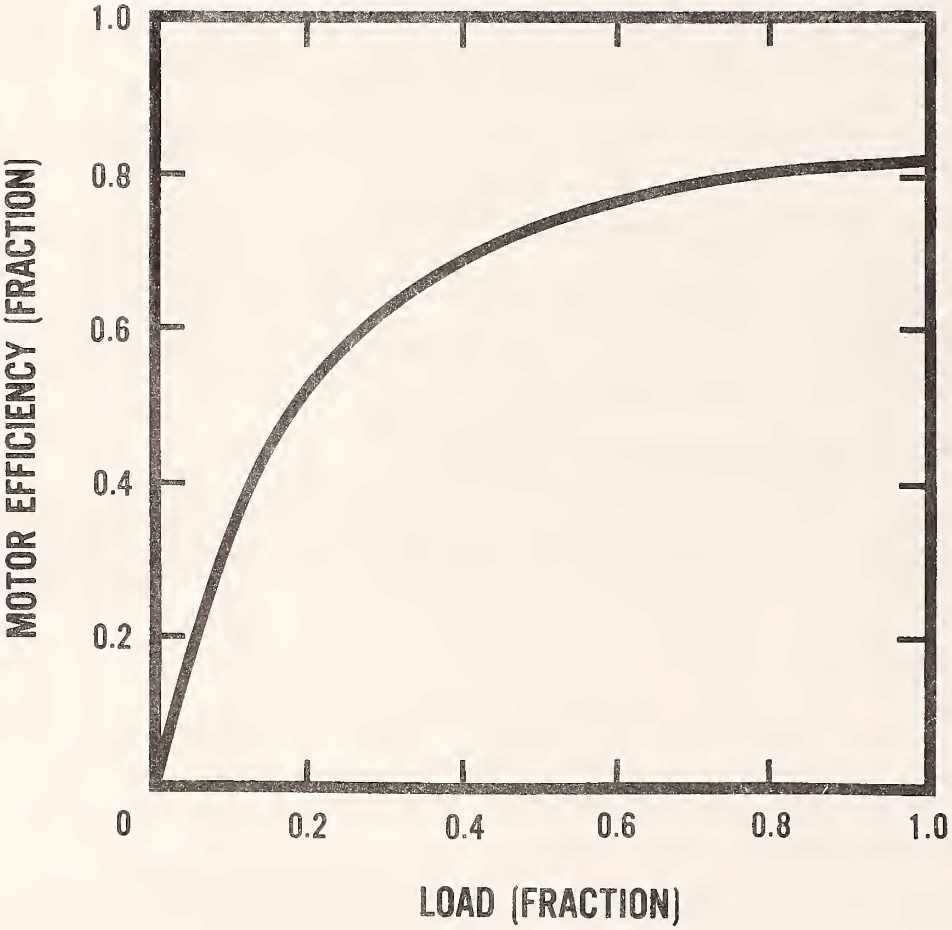


Figure 11. Typical speed (RPM) versus load curve for a permanent split-capacitor 2 pole electrical motor [15].

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]:

$$P \cdot v^n = \text{const} \tag{28}$$

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:

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

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:

$$\eta_p = \frac{\dfrac{\gamma - 1}{\gamma}}{\dfrac{n-1}{n}} \tag{30}$$

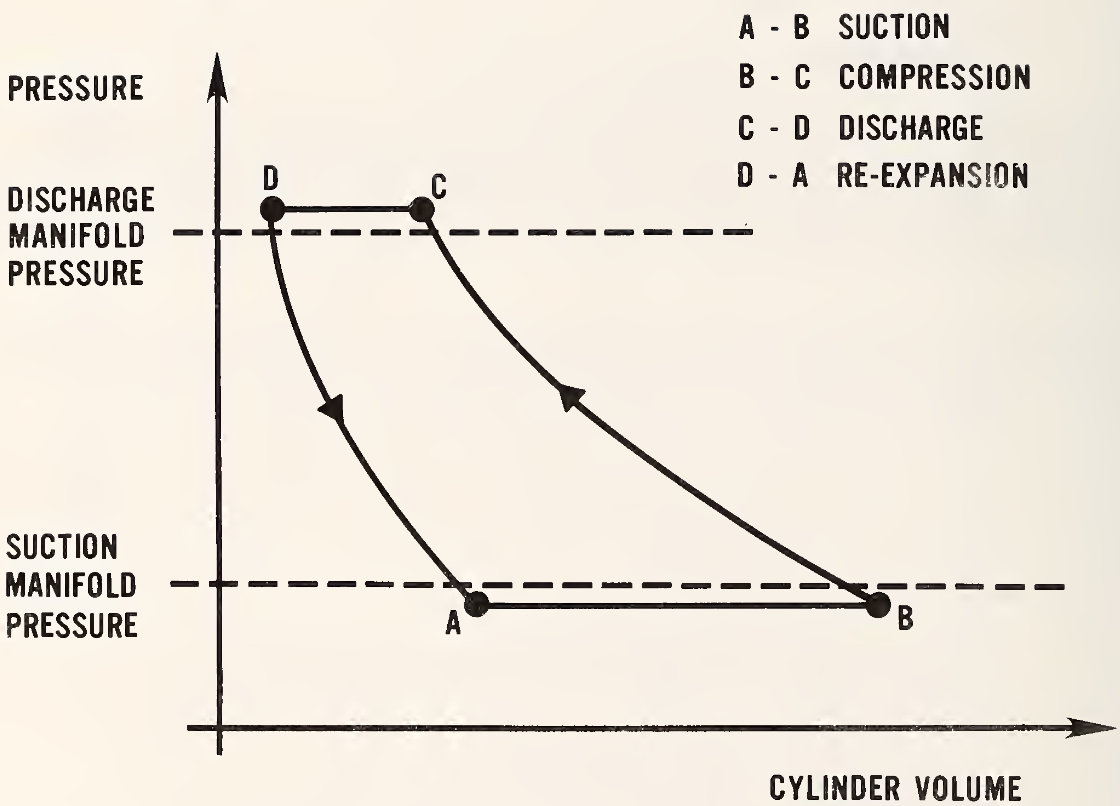


Figure 12. Simplified indicator diagram for a reciprocating compressor.

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

$$\gamma = \frac{Cp}{Cv} \tag{31}$$

where Cp = specific heat at constant pressure
Cv = 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:

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

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:

$$m_r = \frac{60 \cdot RPM \cdot Vs}{v_5} \eta_v \tag{33}$$

where m_r = refrigerant mass flow rate
RPM = compressor speed (revolutions per minute)
Vs = 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.

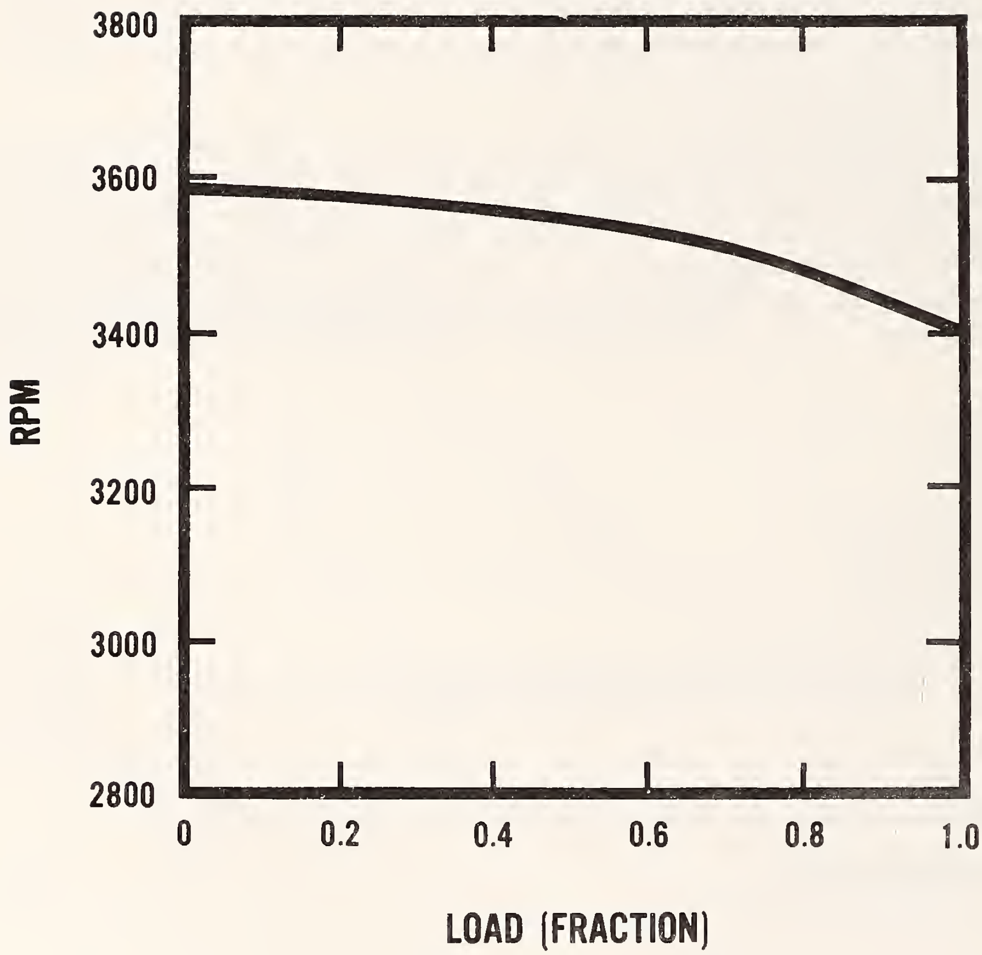


Figure 13. Typical efficiency versus load curve for a permanent split-capacitor 2 pole electric motor [15].

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]:

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

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

<u>Heat Transfer Relations</u>

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:

$$E + \dot{m}_r \; (i_3 - i_8) - Q_{C,A} = 0 \qquad (35)$$

where E = electric energy input

i_3, i_8 = refrigerant enthalpy at respective locations (refer to figure 10)

$\dot{m}_r$ = 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. Respetive heat transfer coefficients, h_c and h_r, are calculated by the following equations [19]:

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

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

where T_a = ambient air temperature (F)
T_c = compressor shell temperature (F)
$\sigma = 0.1714 \times 10^{-4} \frac{Btu}{h \cdot ft \cdot R^4}$ = 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:

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

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]:

$$Nu \propto Re^{0.8} \cdot Pr^{0.333} \tag{39}$$

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

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

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

$G = \frac{m_r}{A}$ = 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:

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

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]:

$$Q_{7,8} = CQ_{7,8} \cdot m_r^{0.8} \frac{a1}{a2 + a3} (T_7 - T_8)/\ln \frac{T_7 - T_4}{T_8 - T_4} \quad (45)$$

where $a1 = (Cp_4 \cdot Cp_{7,8})^{0.333}(k_4 \cdot k_{7,8})^{0.667}$

$a2 = \mu_4^{0.467} \cdot Cp_{7,8}^{0.333} \cdot k_{7,8}^{0.667}$

$a3 = \mu_{7,8}^{0.467} \cdot Cp_4^{0.333} \cdot k_4^{0.667}$

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:

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

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

$$i_7 - i_8 = CQ_{6,7} \frac{a1}{a2 + a3}(T_7 - T_8)/(m_r{}^{0.2} \cdot \ln \frac{T_7 - T_4}{T_8 - T_4} \tag{49}$$

where a1, a2, a3 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.,

$$\Delta P_{tot} = \Delta P_{friction} + \Delta P_{accel} + \Delta P_{gravity} \tag{50}$$

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.,

$$\Delta P_{accel} \propto \rho \cdot V^2 \tag{51}$$

which can be written, using the continuity equation:

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

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:

$$\Delta P_{friction} = 2f \cdot \rho \cdot V^2 \cdot L/D \tag{53}$$

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:

$$\Delta P_{friction} = CP \cdot \mu^{0.2} \cdot m_r^{0.8}/\rho \tag{54}$$

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:

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

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

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

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

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 accompained by a corresponding drop in temperature, the

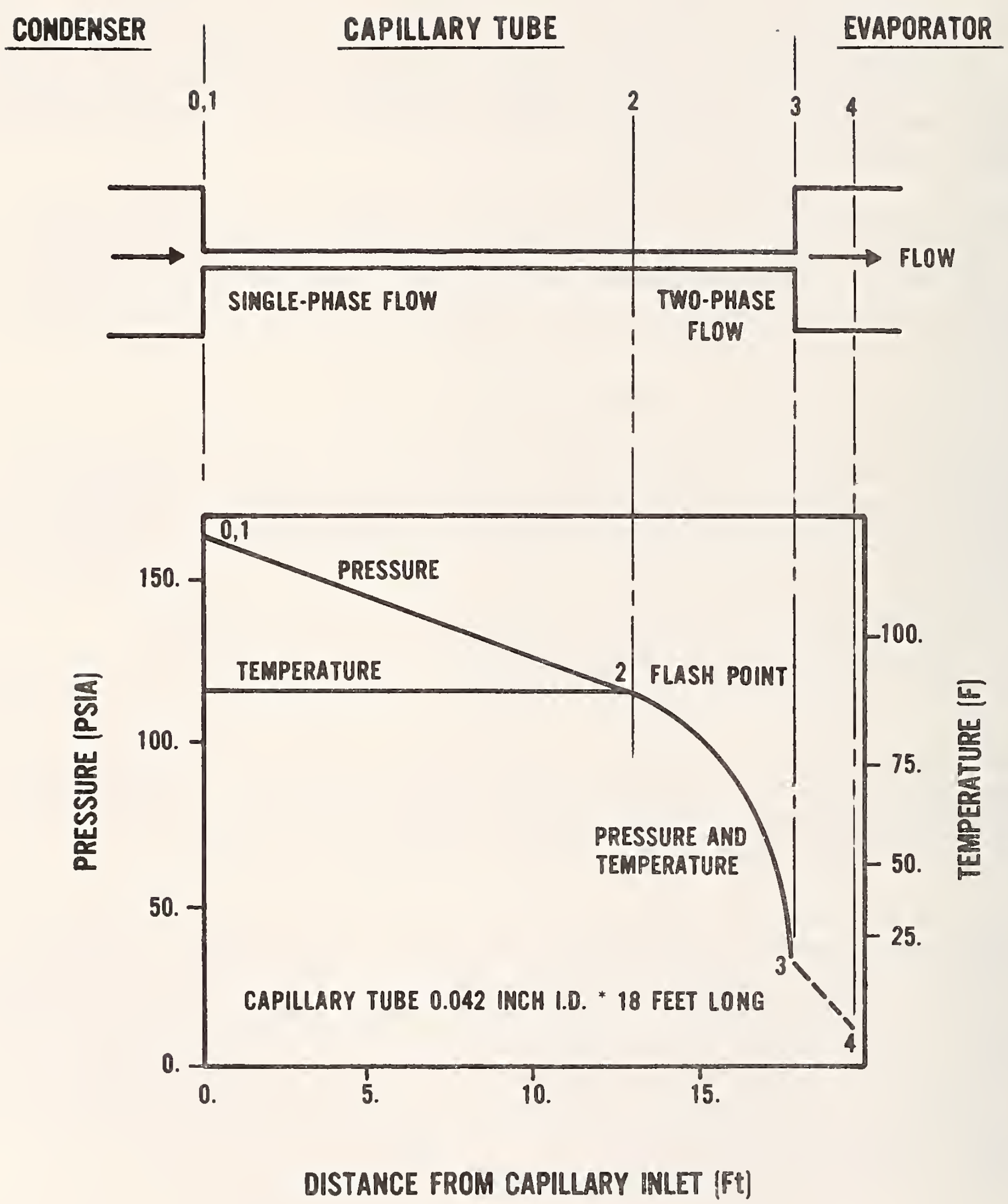


Figure 14. Pressure and temperature distribution along typical capillary tube [23].

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, persistance 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

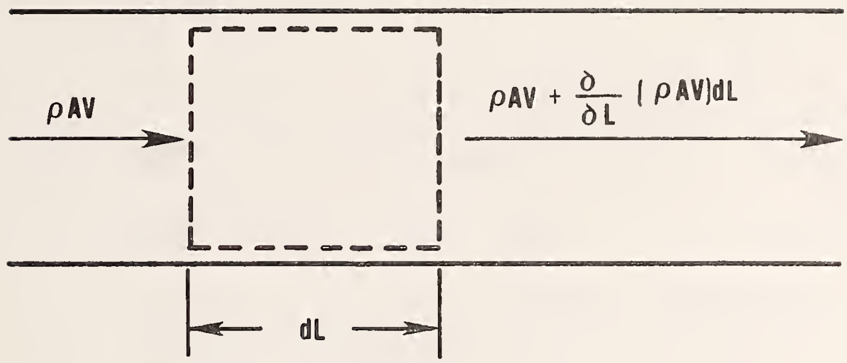
An experimental study on the flow of refrigerant 12 through short tubes was performed by Pasqua [28]. From his visual observations he found that the refrigerant flowed through the restrictor in the form of a metastable liquid core surrounded by a vapor annulus. Based on his experiment, Pasqua also determined 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 rations 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

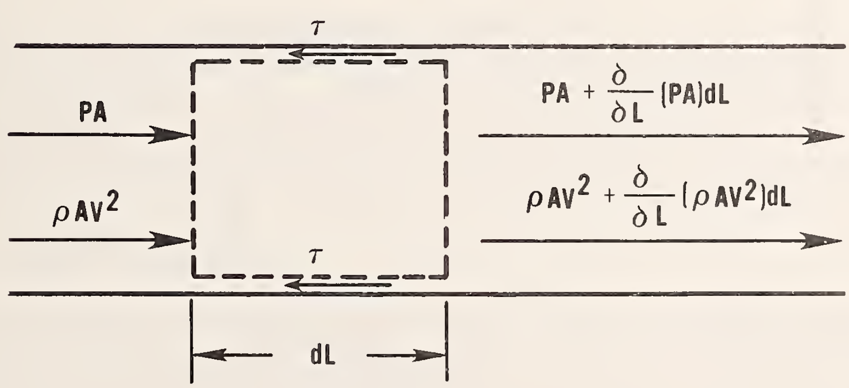
Refrigerant mass flow rate through a given flow restrictor will depend on the inlet refrigerant state and on the pressure that will be established at the tube outlet. This pressure may equal the evaporator pressure or may have a higher value if the flow is choked. Since pressure at the tube exit is one 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.



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.



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.

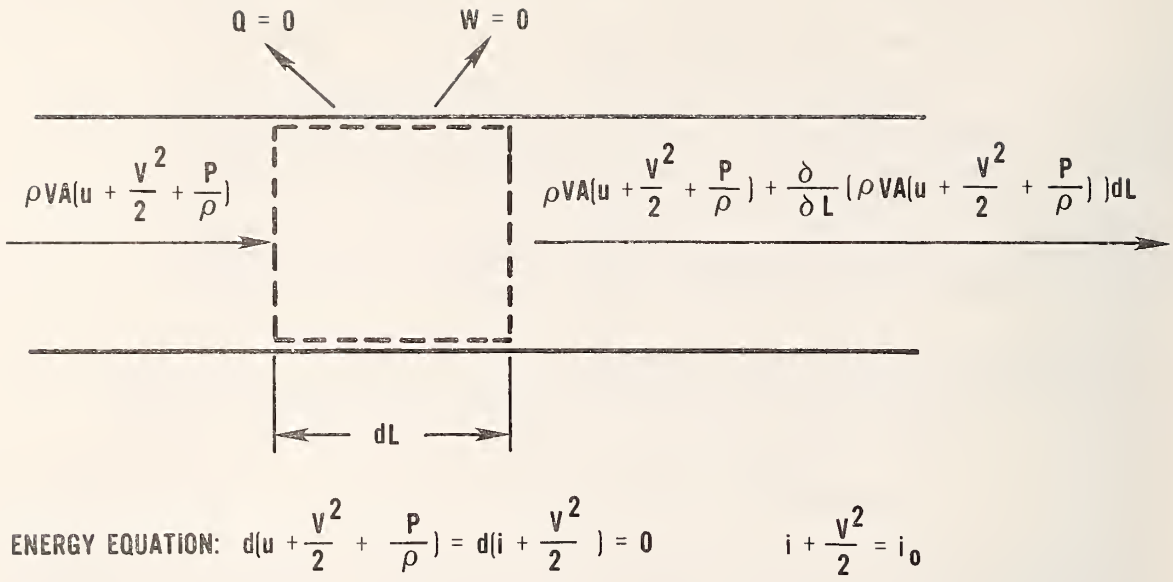


Figure 17. Energy balance for an element of fluid in one-dimensional adiabatic, steady flow in a horizontal, constant area duct.

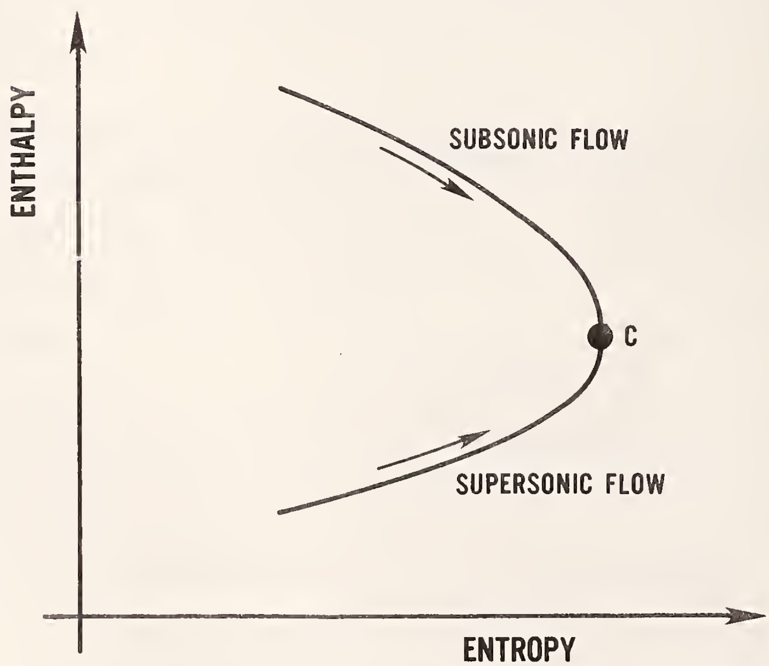


Figure 18. Fanno line.

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:

$$di + V \cdot dV = 0 \qquad \text{or} \qquad i_o = i + V^2/2 = \text{const} \tag{59}$$

which, when combined with the equation of continuity yields:

$$i_o = i + \left(\frac{m_r}{A}\right)^2 \cdot v^2/2 = i + G^2 \cdot v^2/2 \tag{60}$$

where A = tube cross-sectional area

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

i = refrigerant enthalpy
i_o = refrigerant stagnation enthalpy
m_r = refrigerant mass flow rate
V = flow velocity
v = refrigerant specific volume

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:

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

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

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

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:

$$\rho \cdot A \cdot V \cdot dV + A \cdot dP + \tau \cdot S \cdot dL = 0 \tag{63}$$

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

$$\tau = \frac{1}{2} f \cdot \rho \cdot V^2 \tag{64}$$

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

$$d(V \cdot \rho) = 0 \tag{65}$$

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

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

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:

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

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

$$f = 0.046 \cdot Re^{-0.2} \tag{68}$$

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:

$$v = v_L + x(v_V - v_L) \tag{69}$$

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:

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

where x_i = quality of refrigerant entering capillary tube

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

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

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

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:

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

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]:

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

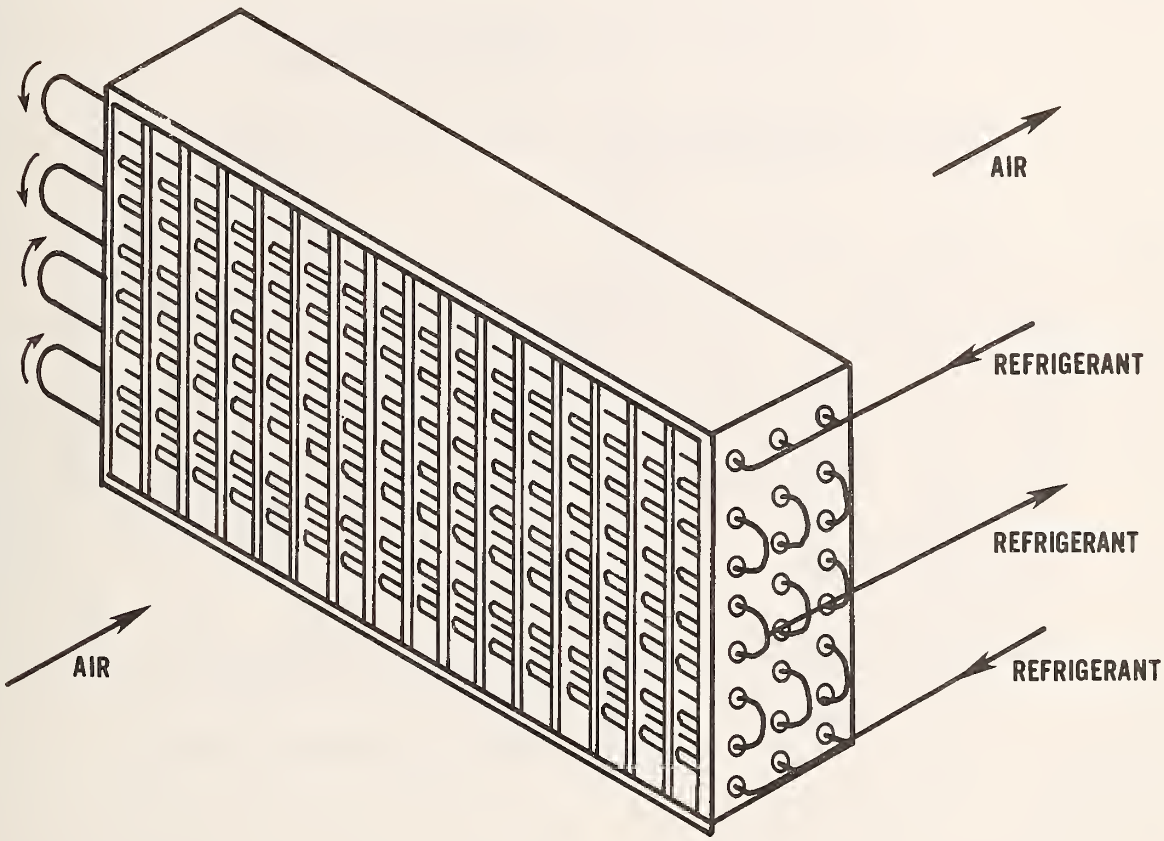
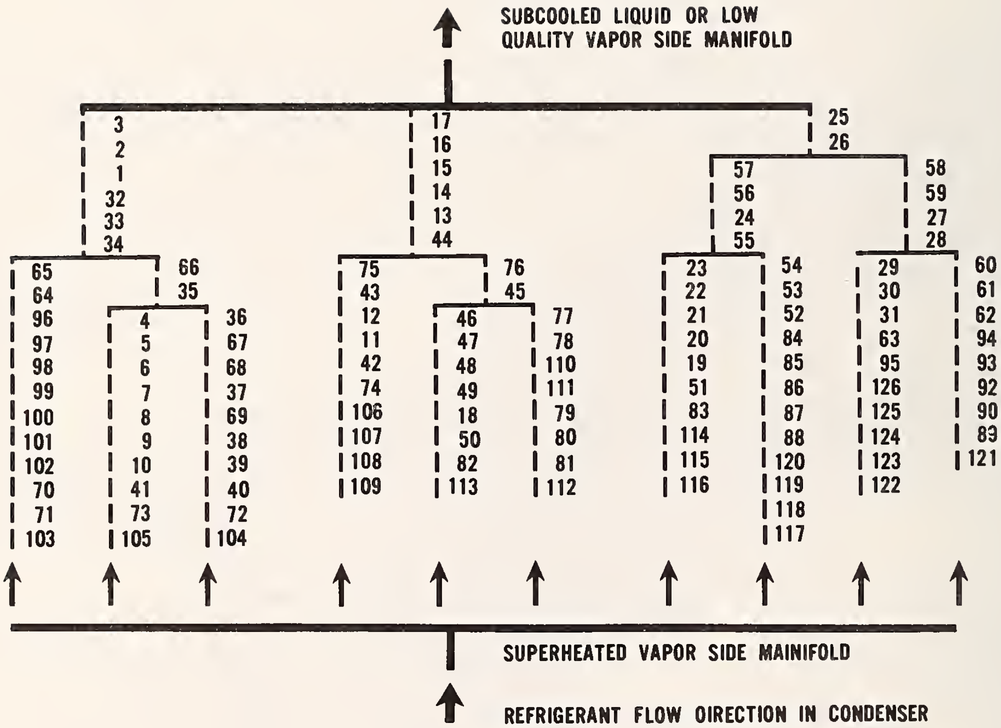


Figure 19. Schematic of a heat pump heat exchanger.



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.

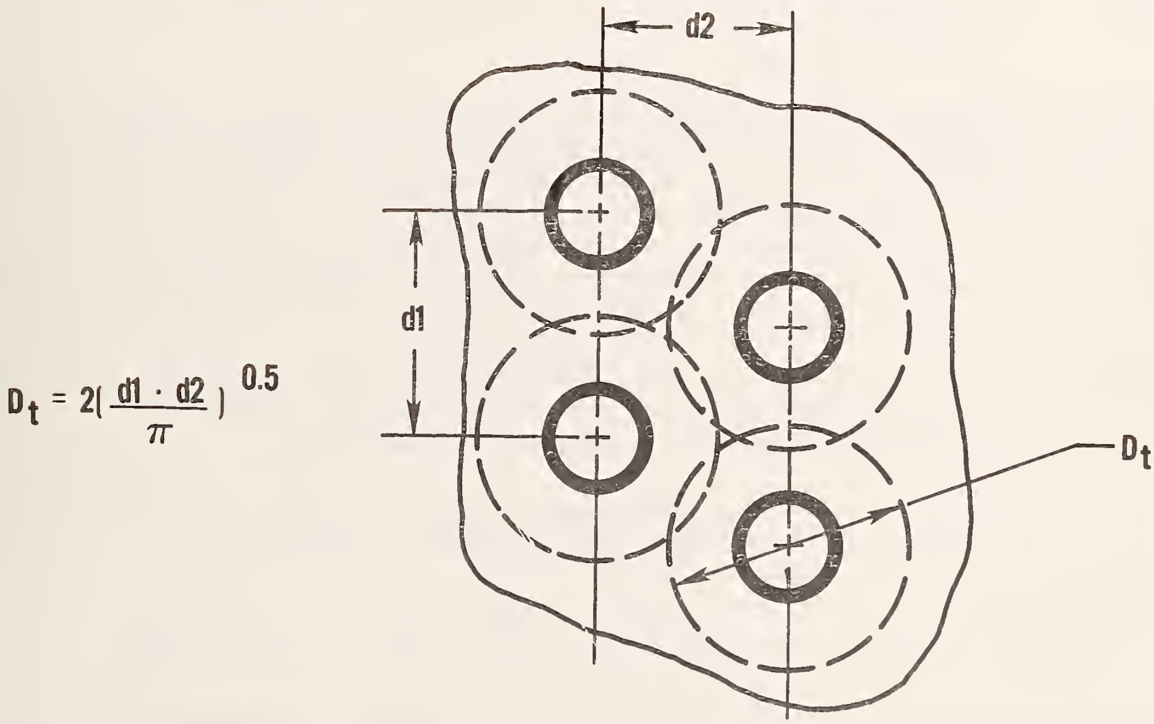


Figure 21. Approximation method for treating a rectangular-plate fin of uniform thickness in terms of a flat circular-plate fin of equal area.

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

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

where Cp = 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

$$Q = Cpr \cdot m_r(T_{r,i} - T_{a,i})(1 - \exp(-\frac{Cp_a \cdot m_a}{Cp_r \cdot m_r}(1 - \exp(\frac{-U \cdot A_o}{Cp_a \cdot m_a})))) \quad (76)$$

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

$$Q = m_r(i_{r,i} - i_{r,V}) + Cp_r \cdot m_r \cdot (T_{r,V} - T_{a,i}) \quad (77)$$

$$(1 - \exp(\frac{Cp_a \cdot m_a(1 - Z_V)}{Cp_r \cdot m_r}(1 - \exp(-\frac{U \cdot A_o}{Cp_a \cdot m_a})))$$

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

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

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

$$Q = Cp_r \cdot m_r (T_{r,L} - T_{a,i}) \left(1 - \exp\left(- \frac{Cp_a \cdot m_a (1 - Z_{tp})}{Cp_r \cdot m_r}\right.\right.$$

$$\left.\left.\left(1 - \exp\left(- \frac{U \cdot A_o}{Cp_a \cdot m_a}\right)\right)\right)\right) + m_r (i_{r,i} - i_{r,L}) \tag{79}$$

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

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

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

<u>Refrigerant Mass Flow Rate</u>

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 calcuations. 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]:

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

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]:

$$Nu = 0.023 \cdot Re^{0.8} \cdot Pr^{\alpha} \qquad (82)$$

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

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

$Re = \frac{G \cdot D}{\mu}$ = 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

<u>Two-Phase Forced Convection with Condensation</u>

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 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-Matinelli method [22], and the momentum and heat transfer analogy was applied. The proposed correlation has the following form:

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

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

$$Pr_L = \frac{\mu_L \cdot Cp_L}{k_L}$$

$\beta = 1$ for $F1 \leq 1$, $\beta = 1.15$ for $F1 > 1$

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

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

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

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

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

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:

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

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.,:

$$X_{tt} = \left[\frac{\left(\frac{dP}{dL}\right)_L}{\left(\frac{dP}{dL}\right)_V}\right]^{0.5} \tag{85}$$

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:

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

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, , 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:

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

where D_o = outside tube diameter

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

k_a = air thermal conductivity

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

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

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 equilivalent 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.

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

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

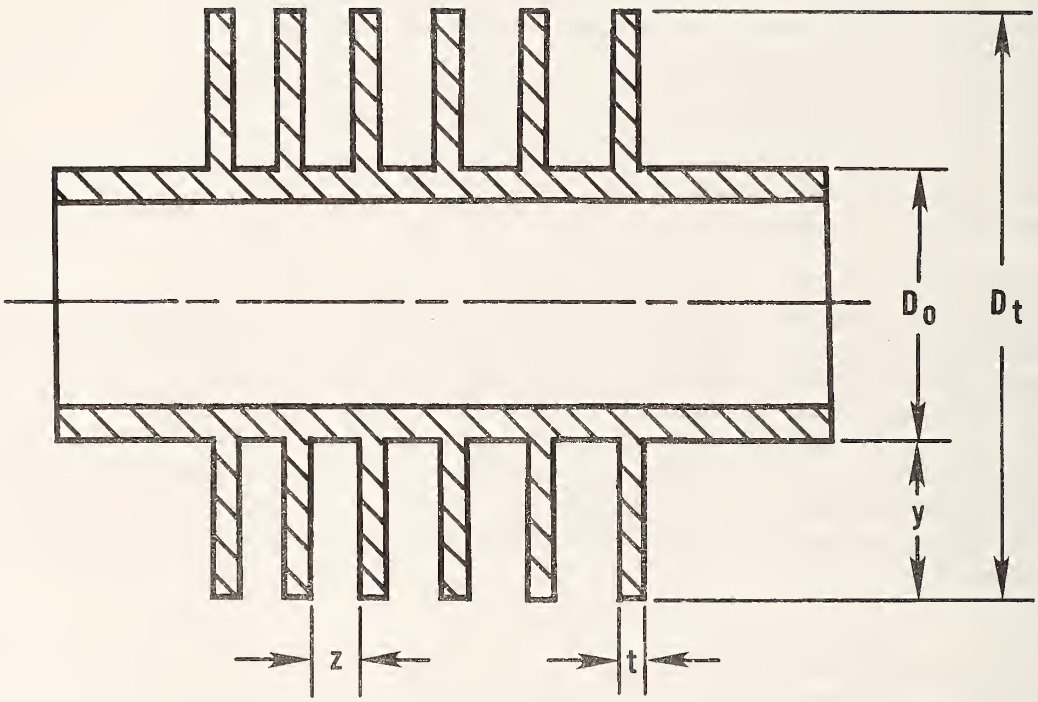
$$\phi = \sum_{i=1}^{8} (A_{1,i} + A_{2,i}\frac{D_o}{D_t} + A_{3,i}\frac{D_o}{D_t}^2)(y(\frac{2 \cdot h_c}{k_f \cdot t})^{0.5\ i-1}) \qquad (89)$$

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.

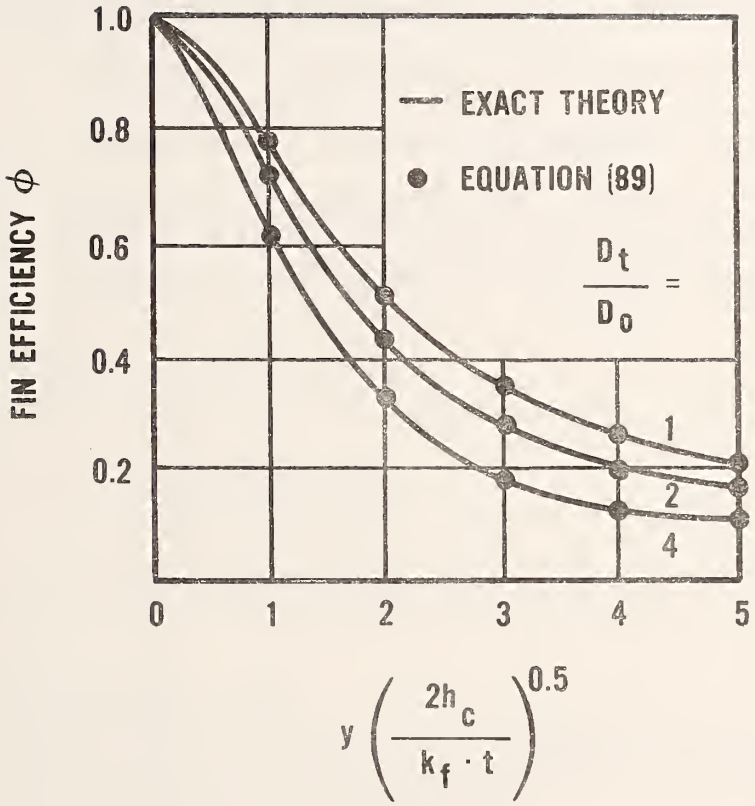


Figure 23. Efficiency for a circular-plate fin of uniform thickness. Comparison of exact theory results with those obtained by equation (89).

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:

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

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,

$$Le = \frac{h_{c,o}}{h_{D,o} Cp_a} , \qquad (91)$$

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

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

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

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

A_f = fin area
A_o = total external area
Cp_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

$\phi = \frac{T_{w,m} - T_a}{T_{w,b} - T_a}$, 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:

$$dQ = h_L \cdot \Delta T_L \cdot dA_o \tag{93}$$

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.

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

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:

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

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

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

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

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

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]:

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

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:

$$m(z) = \rho \int_{o}^{\delta} V_z \, dy \tag{101}$$

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:

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

where
- g = gravitational acceleration
- R' = condensation rate per unit width of a fin
- μ_m = 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):

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

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

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

$$\frac{dP}{dL} = - G^2 \frac{dv}{dL} \tag{105}$$

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.,:

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

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:

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

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

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:

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

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:

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

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

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

where x = quality
v_L = specific volume of liquid
v_V = specific volume of vapor
α = void fraction

Void fraction, α, 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:

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

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:

$$\alpha = 0.823 - 0.157 \cdot \ln X_{tt} \tag{113}$$

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:

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

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 $Re/K_f > 1$:

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

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

$Re = \frac{G \cdot D}{\mu_L}$, 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]:

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

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:

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

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

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 throught 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, $\forall$, may be determined by:

$$M = \int_{\forall} \rho \cdot d\forall \qquad (119)$$

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:

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

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

where M_i = mass of refrigerant in particular component i
$\forall_i$ = 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, XW, of the considered refrigerant:

$$M_{i,I} = M_i \cdot XW \qquad (121)$$

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,

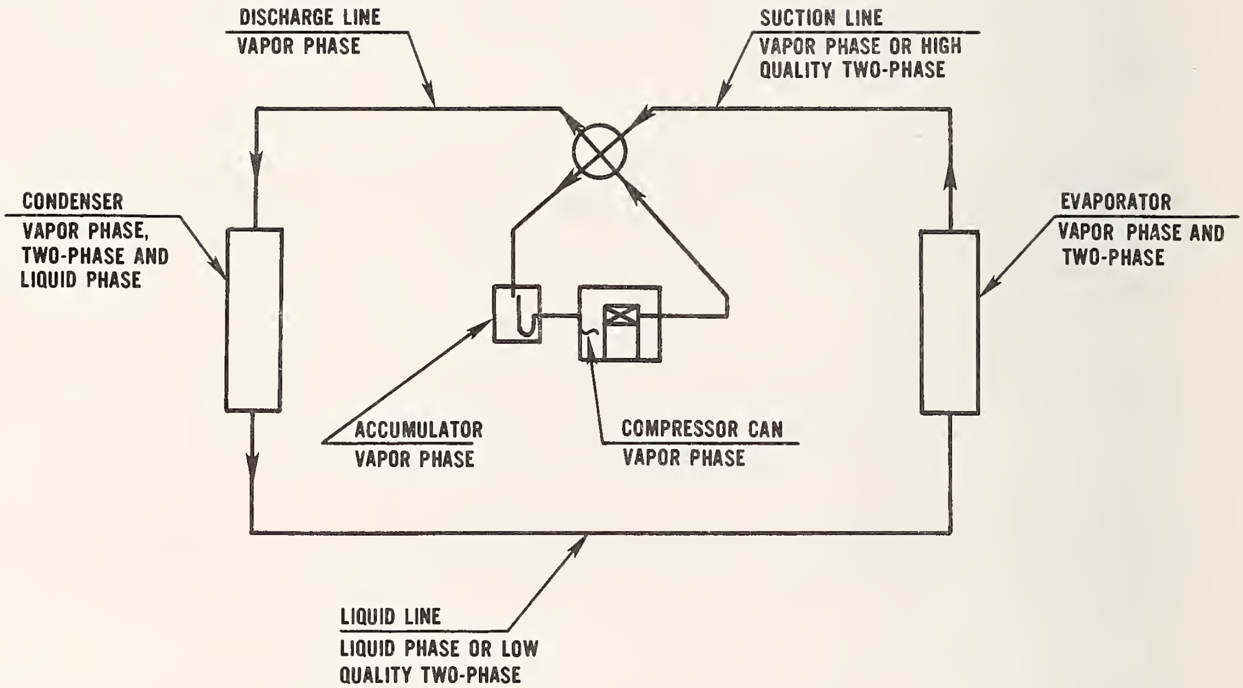


Figure 24. Refrigerant phase in the heat pump components.

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:

$$\rho_m = \frac{\rho_L \cdot \text{¥}_L + \rho_V \cdot \text{¥}_V}{\text{¥}_t} = \rho_L(1 - \alpha) + \rho_V \cdot \alpha \qquad (122)$$

where M = mass
¥ = occupied volume
ρ = density
α = $\text{¥}_V/\text{¥}_t$, 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:

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

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)).

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

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

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 easy 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°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°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 occured.

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	Data Source	Circulating Mixture Compositon	Capacity	Energy Consumption Rate	EER	Refrigerant Mass Flow Rate	Evaporator Outlet Dew Point Temperature	Superheat Leaving Evaporator	Compressor Discharge Pressure	Compressor Discharge Temperature	Condenser Outlet Pressure	Condenser Outlet Temperature
°F		Weight Fraction of R13B1	Btu/h	Watt	Btu/(h · Watt)	lb/h	°F	°F	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	Capacity	Energy Consumption	COP	Evaporator Outlet Temperature	Compressor Discharge		Condenser Outlet	
							Pressure	Temperature	Pressure	Temperature
		Weight Fraction of R13B1	Btu/h	Watt	--	°F	psia	°F	psia	°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]:

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

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]:

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

For 32 ≤ to < 180°F
$$PSAT = \exp(13.4353 - 5.0988z - 1.6896z^2 + 0.17829z^3)$$

For T ≥ 180°F
$$PSAT = \exp(16.8255 - 14.213z + 7.5568z^2 - 4.01506z^3 + 0.17692z^4)$$

where
$$z = \frac{1000}{460 + T} \tag{A2}$$

The specific heat at constant pressure is [16]:

$$Cp = (Cp_{dry} + 0.444)/(1 + w) \tag{A3}$$

where Cp = specific heat at constant pressure of moist air (Btu/(lb moist air · F))
Cp_{dry} = specific heat at constant pressure of dry air (Btu/(lb · 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]:

$$Cp_{dry} = 0.2478786 - 0.4204563 \cdot 10^{-4} \cdot TR + 0.567857 \cdot 10^{-7} \cdot TR^2 - 0.14936056\ TR^3 \tag{A4}$$

where $TR = T + 460^{o}F$ 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 = moist air gas constant $\frac{lbf \cdot ft}{lb \quad R}$

w = humidity ratio (lb water/lb dry air)

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

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

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

where k = moist air thermal conductivity (Btu/(h · F · ft))
$TR = 460 + T$ = 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]:

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

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 $Cp = 1 \frac{Btu}{lb \cdot F}$

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

$$\rho_f = \exp(b1 + b2 \cdot (TW - TP)) \tag{B2}$$

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:

$$k_f = 0.012138 + 3.8909\ 10^{-3} \cdot \rho_f + 5.1409\ 10^{-6} \cdot \rho_f \tag{B3}$$

where k_f = frost conductivity ($Btu/(h \cdot F \cdot ft)$)
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]:

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

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

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

Calculated Property A(I)	Density lb/ft^3	Dynamic viscosity lb/(h · ft)	Thermal conductivity Btu/(h · F · ft)	Latent heat of condensation Btu/lb
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:

$$s = s_L + x(s_V - s_L) \qquad \text{(C1)}$$

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:

$$i_o = i + \frac{G^2}{2} \cdot v^2 \qquad \text{(C2)}$$

where G = mass flux
i = enthalpy
i_o = stagnation enthalpy
v = specific volume

Two-phase specific enthalpy and specific volume are:

$$i = i_L + x(i_V - i_L) \qquad \text{(C3)}$$

$$v = v_L + x(v_V - v_L) \qquad \text{(C4)}$$

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

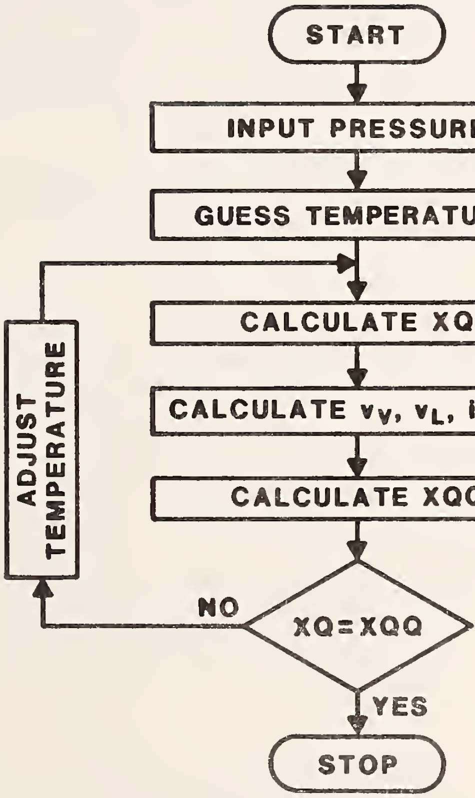
$$x^2 + x \cdot b + c = 0 \qquad \text{(C5)}$$

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

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

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

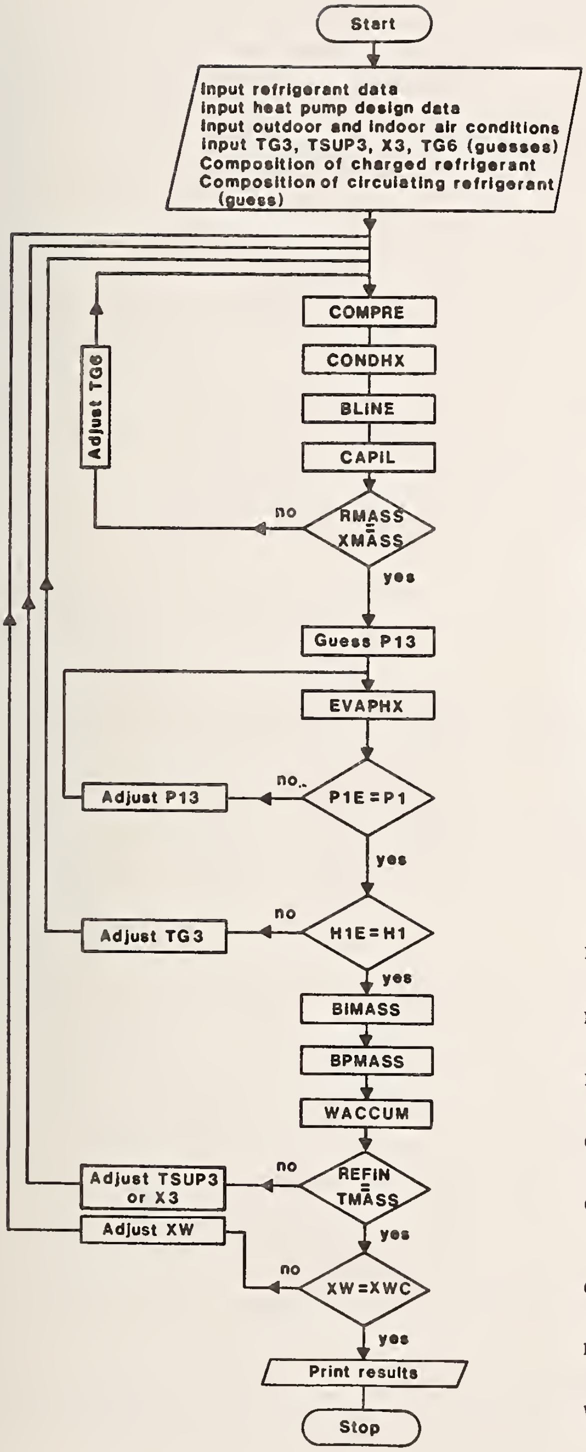
The thermodynamic processes shown in figure D1 are covered by five subroutines: COMPRE, CONDHX, BLINE, CAPIL, and EVAPHX. The iteration process starts with an estimated refrigerant pressure, superheat or quality at the compressor can inlet, and an estimated compressor discharge pressure (points 3 and 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:

H1	- refrig. enthalpy at evaporator outlet calculated by COMPRE
H1E	- refrig. enthalpy at evaporator outlet caluclated by EVAPHX
H12	- refrig. enthalpy at point 12
H13	- refrig. enthalpy at point 13
P1	- refrig. pressure at evaporator outlet calculated by COMPRE
P1E	- refrig. pressure at evaporator outlet calculated by EVAPHX
REFIN	- mass of refrig. charged into a machine
RMASS	- refrig. mass flow rate through a compressor
TG3	- refrig. dew point temp. at point 3
TG6	- refrig. dew point temp. at point 6
TMASS	- total mass of refrig. calculated by inventory program
TSUP3	- refrig. superheat at point 3
XMASS	- refrig. mass flow rate throuth 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	- refrig. quality at point 3

BIMASS - calculates mass of refrigerant in a coil
Input: refrig. state at each coil tube end
Output: mass of refrig. in a coil

BLINE - calculates pressure drop in a liquid line
Input: RMASS and refrig. state at point 11
Output: refrig. state at point 12

BPMASS - Calculates mass of refrig. in a tube
Input: refrig. state at tube ends
Output: mass of refrig. in a tube

CAPIL - calculates performance of an expansion device
Input: refrig state at point 12 and pressure at point 13
Output: XMASS

COMPRE - calculates performance of a compressor with a 4-way valve and tubing connecting compresor with both coils
Input: refrig. state at point 3 and pressure at point 6
Output: RMASS and refrig. state at points 1 through 10

CONDHX - calculates performance of a condenser
Input: RMASS and refrig. state at point 10
Output: refrig. state at point 11

EVAPHX - calculates performance of an evaporator
Input: RMASS and refrig. state at point 13
Output: refrig. state at point 1

WACCUM - calculates mass of refrigerant in an accumulator
Input: refrig. state in an accumulator
Output: mass of refrig. in an accumulator and mean refrig. 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.

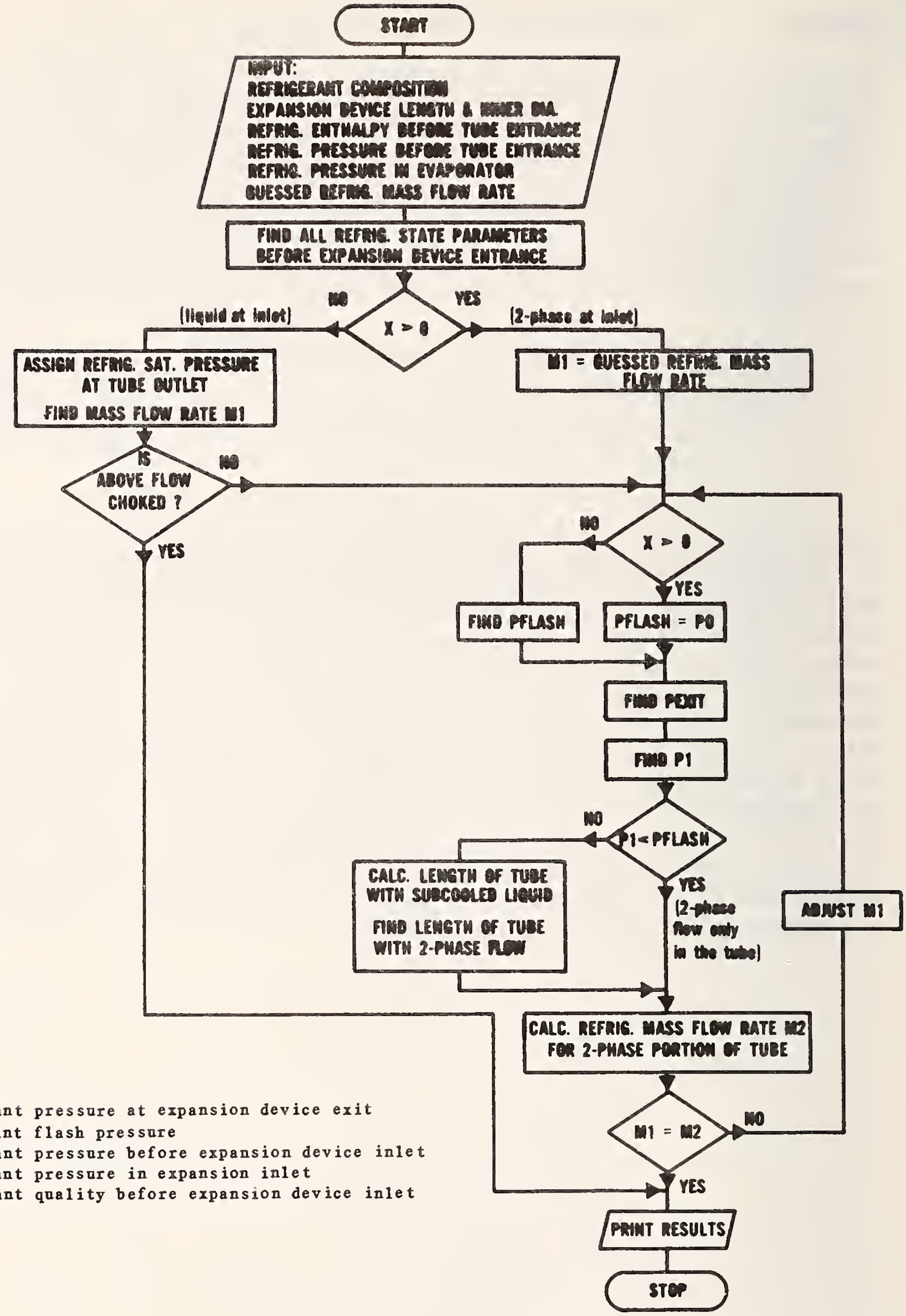
APPENDIX F. CONSTANT FLOW AREA EXPANSION DEVICE SUBROUTINE, CAPIL

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.



PEXIT = refrigerant pressure at expansion device exit
PFLASH = refrigerant flash pressure
P0 = refrigerant pressure before expansion device inlet
P1 = refrigerant pressure in expansion inlet
X = refrigerant quality before expansion device inlet

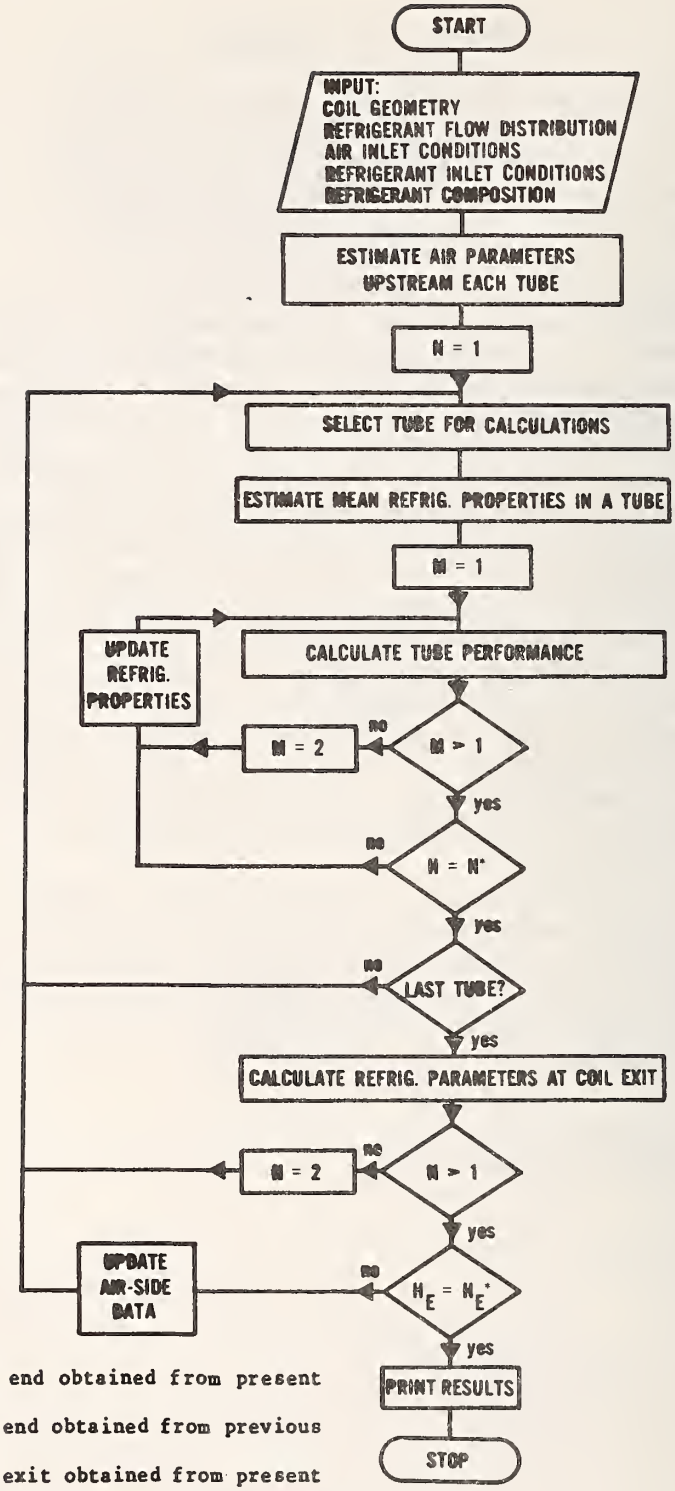
Figure F1. Logic of a constant flow area expansion device simulation program, CAPIL

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.

<u>Evaluation of Compressor Parameters</u>

The following is the sequence of program requests and explanation of reponses 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 (in^3)
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 characteric (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 PARAMETRS (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) OR HEAT PUMP PERFORMANCE (3)
   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/(lb · 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 tranfer 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

```
25.4145,-0.063368,4.140051E-05
0.1353977,-1.50409E-04,-1.354434E-07
27.392729669,-0.0594211671,3.317695607E-5
0.1239878,-1.445514007E-4,-1.90223806E-8
0.1466,-2.241E-04
148.93,66.05
340.15,386.65
10.0522804,-2204.5632,9636.5313
-0.05060051,1.1455764E-03,-2.56392871E-06
0.2749422,-1.702569E-03,3.71008313E-06
10.6410518,-2642.8994,460.87585
0.0218192958,5.416820778E-04,-1.24731336E-06
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.

<u>Line 1</u>: ATITLE
ATITLE = title, maximum 80 characters

<u>Line 2</u>: EMETA(I), I = 1,5
EMETA(I) = compressor motor effiiency in fraction at fraction of full load specified by EMOPT(I), I = 1,5 (-)

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

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

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

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

<u>Line 7</u>: ELEFUL, SWPVOL, ETAPLY, 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 (-)

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

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

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

<u>Line 11</u>: 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 (-)

<u>Line 39</u>: 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 (-)

<u>Line 40</u>: 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 (-)

<u>Line 41</u>: IFROM(2,I), I = 21,30
<u>Line 42</u>: IFROM(2,I), I = 31,40
<u>Line 43</u>: IFROM(2,I), I = 41,50
<u>Line 44</u>: IFROM(2,I), I = 51,60
<u>Line 45</u>: IFROM(2,I), I = 61,70
<u>Line 46</u>: IFROM(2,I), I = 71,80
<u>Line 47</u>: IFROM(2,I), I = 81,90
<u>Line 48</u>: IFROM(2,I), I = 91,100
<u>Line 49</u>: IFROM(2,I), I = 101,110
<u>Line 50</u>: IFROM(2,I), I = 111,120
<u>Line 51</u>: 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 (-)

<u>Line 52</u>: 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 (-)

<u>Line 53</u>: 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

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


         COMPRESSOR PARAMETERS(1), FOUR WAY VALVE PARAMETERS(2)
         OR HEAT PUMP PERFORMANCE(3), IPTP=
         3

         ANSWER 1 FOR YES OR 0 FOR NO
         DO YOU WANT ANY INPUT DATA PRINTED ? LPR=
         0

         OUTDOOR & INDOOR AIR CONDITIONS
         POA,TOA,RHOA,PRA,TRA,RHRA=?
         14.7,47.,0.73,14.7,70.,0.56

         NSYS=1 FOR HEATING,  NSYS=2 FOR COOLING MODE    NSYS=?
         1

         IS ITERATION OF SUPERHEAT/QUALITY REQUESTED ?
         ITER=0 FOR NO, ITER=1 FOR YES,    ITER=
         1

         IS ITERATION OF MIXTURE COMPOSITION REQUESTED ?
         ITERXW=0 FOR NO, ITERXW=1 FOR YES,    ITERXW=
         1

         COMPOSITION OF CHARGED REFRIGERANT =
         (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
         .65

         COMPOSITION OF CIRCULATING REFRIGERANT =
         (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
         .65

         REFRIGERANT STATE GUESSES: TG3,X3,TSUP3,TG6=
         33.,1.,0.,110.


         INPUT DATA TO COMPR:

         P3         T3         H3         XQ3        TG6        TRA        TOA
         6.697+001  3.300+001  8.929+001  1 000+000  1.100+002  7.000+001  4.700+001

         COMPRESSOR ITERATION:

         EI         ETAE       ETAC       ETAV       CPRPM      RMASS
         2.663+000  7.552-001  9.498-001  8.620-001  3.550+003  4.827+002

         I  T          P          H          X
         1  3.828+001  7.458+001  8.778+001  9.771-001
         2  3.766+001  7.372+001  8.773+001  9.773-001
         3  3.300+001  6.697+001  8.929+001  1.000+000
         4  6.995+001  9.688+001  9.536+001  1.000+000
         5  7.348+001  6.407+001  9.606+001  1.000+000
         6  1.808+002  2.343+002  1.097+002  1.000+000
         7  1.738+002  2.118+002  1.090+002  1.000+000
         8  1.559+002  2.107+002  1.055+002  1.000+000
```

```
 9  1.475+002  2.081+002  1.040+002  1.000+000
10  1.498+002  2.080+002  1.038+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.468+002  2.080+002  7.000+001  5.600-001  4.827+002
H2,H2PH2=   40.91      .01
H2,H2PH2=   41.12     -.21
H2,H2PH2=   41.38     -.26
H2,H2PH2=   41.52     -.13
H2,H2PH2=   41.59     -.07
H2,H2PH2=   41.62     -.03
H2,H2PH2=   41.63     -.01

 CONDENSER ITERATION:

 T          P          H          X
 1.468+002  2.080+002  1.038+002  1.000+000
 8.412+001  1.962+002  4.163+001  1.369-001


 LIQUID LINE:
 INPUT  -   PIN = 1.962+002   TIN = 8.412+001   XIN = 1.369-001   HIN = 4.163+001
 OUTPUT -   POUT= 1.779+002   TOUT= 7.737+001   XOUT= 1.692-001


 EXPANSION DEVICE:
 INPUT  -   P12  =1.779+002   H12 =4.163+001   P13 =8.258+001
 OUTPUT -   POUT =1.221+002   XMASS =3.186+002

 INPUT DATA TO COMPR:

 P3         T3         H3         XQ3        TG6        TRA        TOA
 6.697+001  3.300+001  8.929+001  1.000+000  1.125+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.719+000  7.576-001  9.483-001  8.580-001  3.549+003  4.796+002

 I  T          P          H          X
 1  3.820+001  7.448+001  8.772+001  9.766-001
 2  3.758+001  7.263+001  8.767+001  9.768-001
 3  3.300+001  6.697+001  8.929+001  1.000+000
 4  7.069+001  6.688+001  9.548+001  1.000+000
 5  7.437+001  6.410+001  9.620+001  1.000+000
 6  1.849+002  2.426+002  1.103+002  1.000+000
 7  1.781+002  2.212+002  1.096+002  1.000+000
 8  1.597+002  2.202+002  1.059+002  1.000+000
 9  1.511+002  2.177+002  1.043+002  1.000+000
10  1.503+002  2.176+002  1.042+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.503+002  2.176+002  7.000+001  5.600-001  4.796+002
H2,H2PH2=   35.34     -.62
```

```
H2,H2PH2=   35.44    -.10
H2,H2PH2=   35.92    -.48
H2,H2PH2=   36.09    -.17
H2,H2PH2=   36.17    -.08
H2,H2PH2=   36.21    -.03
H2,H2PH2=   36.23    -.03
H2,H2PH2=   36.25    -.01

 CONDENSER ITERATION:

 T           P           H           X
 1.503+002   2.178+002   1.042+002   1.000+000
 8.739+001   2.089+002   3.625+001   5.989-003


 LIQUID LINE:
 INPUT  -    PIN = 2.089+002   TIN = 8.739+001   XIN = 5.989-003   HIN = 3.625+001
 OUTPUT -    POUT= 2.025+002   TOUT= 8.515+001   XOUT= 1.811-002


 EXPANSION DEVICE:
 INPUT  -    P12  =2.025+002   H12 =3.625+001   P13 =8.248+001
 OUTPUT -    POUT =1.540+002   XMASS =4.513+002

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TGS         TRA         TOA
 6.697+001   3.300+001   8.929+001   1.000+000   1.130+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:

 EI          ETAE        ETAC        ETAV        CPRPM       RMASS
 2.730+000   7.581-001   9.430-001   8.572-001   3.549+003   4.790+002

 I  T           P           H           X
 1  3.818+001   7.446+001   8.771+001   9.765-001
 2  3.757+001   7.362+001   8.766+001   9.767-001
 3  3.300+001   6.697+001   8.929+001   1.000+000
 4  7.087+001   6.688+001   9.551+001   1.000+000
 5  7.453+001   6.411+001   9.624+001   1.000+000
 6  1.857+002   2.443+002   1.104+002   1.000+000
 7  1.790+002   2.232+002   1.097+002   1.000+000
 8  1.605+002   2.222+002   1.060+002   1.000+000
 9  1.519+002   2.197+002   1.044+002   1.000+000
10  1.511+002   2.196+002   1.042+002   1.000+000

 INPUT DATA TO CONDHX:

 T           P           TAIR        RH          RMASS
 1.511+002   2.196+002   7.000+001   5.600-001   4.790+002
H2,H2PH2=   34.33    -.01
H2,H2PH2=   34.52    -.19
H2,H2PH2=   35.10    -.58
H2,H2PH2=   35.35    -.25
H2,H2PH2=   35.40    -.05
H2,H2PH2=   35.41    -.01

 CONDENSER ITERATION:
```

```
 T            P            H            X
 1.511+002    2.196+002    1.042+002    1.000+000
 8.528+001    2.116+002    3.541+001     .000


 LIQUID LINE:
 INPUT  -     PIN = 2.116+002   TIN = 8.528+001   XIN =   .000        HIN = 3.541+001
 OUTPUT -     POUT= 2.061+002   TOUT= 8.525+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -     P12  =2.061+002   H12 =3.541+001   P13 =8.246+001
 OUTPUT -     POUT =1.593+002   XMASS =4.802+002

 INPUT DATA TO EVAPHX:

 T            P            X            TAIR         RH           RMASS
 2.834+001    8.246+001    2.548-001    4.700+001    7.300-001    4.790+002
H2= 92.6812
H2= 92.6334
QT,QS=  2.739+004  1.894+004

 EVAPORATOR ITERATION:

 T            P            H            X            TSUP
 2.834+001    8.246+001    3.541+001    2.548-001
 4.672+001    4.255+001    9.259+001    1.000+000    3.659+001

 INPUT DATA TO EVAPHX:

 T            P            X            TAIR         RH           RMASS
 4.742+001    1.144+002    1.799-001    4.700+001    7.300-001    4.790+002
H2= 37.7119
H2= 37.0321
H2= 36.8217
QT,QS=  6.995+002  6.994+002

 EVAPORATOR ITERATION:

 T            P            H            X            TSUP
 4.742+001    1.144+002    3.541+001    1.799-001
 4.645+001    1.119+002    3.687+001    2.110-001     .000

 INPUT DATA TO EVAPHX:

 T            P            X            TAIR         RH           RMASS
 3.770+001    9.715+001    2.190-001    4.700+001    7.300-001    4.790+002
H2= 85.2274
H2= 77.3103
H2= 75.9824
QT,QS=  1.942+004  1.854+004

 EVAPORATOR ITERATION:

 T            P            H            X            TSUP
 3.770+001    9.715+001    3.541+001    2.190-001
 3.915+001    8.021+001    7.596+001    8.362-001     .000
```

```
 INPUT DATA TO EVAPHX:

 T            P            X            TAIR         RH           RMASS
 3.580+001    9.403+001    2.264-001    4.700+001    7.300-001    4.790+002
H2= 91.0432
H2= 89.3153
H2= 87.1500
H2= 87.0712
H2= 86.9629
QT,QS=  2 470+004  2.147+004

 EVAPORATOR ITERATION:

 T            P            H            X            TSUP
 3 580+001    9.403+001    3.541+001    2.264-001
 3.691+001    7.293+001    8.597+001    9.697-001     .000

 INPUT DATA TO EVAPHX:

 T            P            X            TAIR         RH           RMASS
 3.620+001    9.469+001    2.248-001    4.700+001    7.300-001    4.790+002
H2= 90.6913
H2= 87.0221
H2= 84.6521
H2= 84.5449
QT,QS=  2.353+004  2.022+004

 EVAPORATOR ITERATION:

 T            P            H            X            TSUP
 3.620+001    9.469+001    3.541+001    2.248-001
 3.752+001    7.459+001    8.454+001    9.412-001     .000
P1,P1E,P1EP1,DENT2=    74.4634    74.5945     .1311    -3.1760

 INPUT DATA TO COMPR:

P3           T3           H3           XQ3          TG6          TRA          TOA
6.447+001    3.100+001    8.909+001    1.000+000    1.120+002    7.000+001    4.700+001

 COMPRESSOR ITERATION:

EI           ETAE         ETAC         ETAV         CPRPM        RMASS
2.679+000    7.559-001    9.477-001    6.536-001    3.549+003    4.584+002

I   T            P            H            X
1   3.615+001    7.161+001    8.780+001    9.800-001
2   3.554+001    7.080+001    8.774+001    9.799-001
3   3.100+001    6.447+001    8.909+001    1.000+000
4   7.048+001    6.436+001    9 555+001    1.000+000
5   7.433+001    6.174+001    9.629+001    1.000+000
6   1.870+002    2.410+002    1.108+002    1.000+000
7   1.804+002    2.214+002    1.101+002    1.000+000
8   1.615+002    2.204+002    1.063+002    1.000+000
9   1.543+002    2.181+002    1.049+002    1.000+000
10  1.534+002    2.180+002    1.048+002    1.000+000
```

```
 T            P            TAIR         RH           RMASS
 1.534+002    2.180+002    7.000+001    5.600-001    4.584+002
H2,H2PH2=     34.10      -.39
H2,H2PH2=     34.16      -.05
H2,H2PH2=     34.61      -.45
H2,H2PH2=     34.76      -.16
H2,H2PH2=     34.82      -.06
H2,H2PH2=     34.82       .00

 CONDENSER ITERATION:

 T            P            H            X
 1.534+002    2.180+002    1.048+002    1.000+000
 8.300+001    2.110+002    3.482+001     .000


 LIQUID LINE:
 INPUT  -     PIN = 2.110+002    TIN = 8.300+001    XIN =   .000        HIN = 3.482+001
 OUTPUT -     POUT= 2.059+002    TOUT= 8.298+001    XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -     P12  =2.059+002    H12 =3.482+001   P13 =9.183+001
 OUTPUT -     POUT =1.612+002    XMASS =4.940+002

 INPUT DATA TO COMPR:

 P3           T3           H3           XQ3          TG6          TRA          TOA
 6.447+001    3.100+001    8.909+001    1.000+000    1.114+002    7.000+001    4.700+001

 COMPRESSOR ITERATION:

 EI           ETAE         ETAC         ETAV         CPRPM        RMASS
 2.665+000    7.553-001    9.481-001    8.547-001    3.550+003    4.592+002

 I  T            P            H            X
 1  3.617+001    7.164+001    8.782+001    9.801-001
 2  3.555+001    7.083+001    8.775+001    9.800-001
 3  3.100+001    6.447+001    8.909+001    1.000+000
 4  7.029+001    6.438+001    9.551+001    1.000+000
 5  7.410+001    6.174+001    9.625+001    1.000+000
 6  1.859+002    2.388+002    1.106+002    1.000+000
 7  1.793+002    2.189+002    1.099+002    1.000+000
 8  1.605+002    2.160+002    1.062+002    1.000+000
 9  1.534+002    2.156+002    1.048+002    1.000+000
10  1.525+002    2.156+002    1.047+002    1.000+000

 INPUT DATA TO CONDHX:

 T            P            TAIR         RH           RMASS
 1.525+002    2.156+002    7.000+001    5.600-001    4.592+002
H2,H2PH2=     34.79      -.51
H2,H2PH2=     34.74       .05
H2,H2PH2=     35.19      -.45
H2,H2PH2=     35.46      -.27
H2,H2PH2=     35.57      -.11
H2,H2PH2=     35.58      -.01
```

```
H2,H2PH2=   35.58      .00

 CONDENSER ITERATION:

 T           P           H           X
 1.525+002   2.156+002   1.047+002   1.000+000
 8.591+001   2.077+002   3.558+001    .000


 LIQUID LINE:
 INPUT  -    PIN = 2.077+002   TIN = 8.591+001   XIN =   .000        HIN = 3.558+001
 OUTPUT -    POUT= 2.023+002   TOUT= 8.504+001   XOUT= 4.725-003


 EXPANSION DEVICE:
 INPUT  -    P12  =2.025+002   H12 =3.558+001   P13 =9.186+001
 OUTPUT -    POUT =1.556+002   XMASS =4.644+002

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TG6         TRA         TOA
 6.447+001   3.100+001   8.909+001   1.000+000   1.113+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:

 EI          ETAE        ETAC        ETAV        CPRPM       RMASS
 2.662+000   7.552-001   9.481-001   8.549-001   3.550+003   4.593+002

 I  T           P           H           X
 1  3.617+001   7.164+001   8.782+001   9.801-001
 2  3.550+001   7.083+001   8.775+001   9.800-001
 3  3.100+001   6.447+001   8.909+001   1.000+000
 4  7.025+001   6.438+001   9.551+001   1.000+000
 5  7.405+001   6.173+001   9.624+001   1.000+000
 6  1.857+002   2.384+002   1.106+002   1.000+000
 7  1.791+002   2.185+002   1.099+002   1.000+000
 8  1.603+002   2.175+002   1.052+002   1.000+000
 9  1.532+002   2.152+002   1.048+002   1.000+000
10  1.523+002   2.151+002   1.047+002   1.000+000

 INPUT DATA TO CONDHX:

 T           P           TAIR        RH          RMASS
 1.523+002   2.151+002   7.000+001   5.600-001   4.593+002
H2,H2PH2=   35.09     -.44
H2,H2PH2=   35.04      .05
H2,H2PH2=   35.47     -.43
H2,H2PH2=   35.75     -.28
H2,H2PH2=   35.83     -.08
H2,H2PH2=   35.84     -.01

 CONDENSER ITERATION:

 T           P           H           X
 1.523+002   2.151+002   1.047+002   1.000+000
 8.671+001   2.072+002   3.584+001   9.987-004
```

```
LIQUID LINE:
INPUT  -    PIN = 2.072+002   TIN = 8.671+001   XIN = 9.987-004   HIN = 3.584+001
OUTPUT -    POUT= 2.016+002   TOUT= 3.477+001   XOUT= 1.179-002


EXPANSION DEVICE:
INPUT  -    P12  =2.016+002   H12 =3.584+001   P13 =9.186+001
OUTPUT -    POUT =1.537+002   XMASS =4.558+002

INPUT DATA TO EVAPHX:

T           P           X           TAIR        RH          RMASS
3.454+001   9.186+001   2.372-001   4.700+001   7.300-001   4.592+002
H2= 91.4649
H2= 91.2135
H2= 90.9388
H2= 90.8369
QT,QS=  2.530+004  2.185+004

EVAPORATOR ITERATION:

T           P           H           X           TSUP
3.454+001   9.186+001   3.574+001   2.372-001
4.301+001   6.873+001   9.084+001   1.000+000   8.535+000

INPUT DATA TO EVAPHX:

T           P           X           TAIR        RH          RMASS
3.532+001   9.311+001   2.342-001   4.700+001   7.300-001   4.592+002
H2= 91.2289
H2= 90.4051
H2= 89.6060
H2= 89.0465
H2= 88.9463
QT,QS=  2.445+004  2.132+004

EVAPORATOR ITERATION:

T           P           H           X           TSUP
3.532+001   9.311+001   3.573+001   2.342-001
3.687+001   7.223+001   8.897+001   9.921-001    .000

INPUT DATA TO EVAPHX:

T           P           X           TAIR        RH          RMASS
3.518+001   9.290+001   2.347-001   4.700+001   7.300-001   4.592+002
H2= 91.2820
H2= 90.6518
H2= 89.9340
H2= 89.6312
H2= 89.4731
QT,QS=  2.468+004  2.146+004

EVAPORATOR ITERATION:

T           P           H           X           TSUP
3.518+001   9.290+001   3.573+001   2.347-001
3.661+001   7.172+001   8.948+001   9.980-001    .000
```

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

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TG6         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       RMASS
 2.687+000   7.563-001   9.481-001   8.556-001   3.549+003   4.650+002

 I  T           P           H           X
 1  3.689+001   7.260+001   8.789+001   9.800-001
 2  3.623+001   7.178+001   8.783+001   9.801-001
 3  3.169+001   6.532+001   8.916+001   1.000+000
 4  7.045+001   6.523+001   9.551+001   1.000+000
 5  7.423+001   6.254+001   9.624+001   1.000+000
 6  1.858+002   2.405+002   1.105+002   1.000+000
 7  1.791+002   2.202+002   1.093+002   1.000+000
 8  1.604+002   2.192+002   1.061+002   1.000+000
 9  1.533+002   2.168+002   1.048+002   1.000+000
10  1.525+002   2.168+002   1.046+002   1.000+000

 INPUT DATA TO CONDHX:

 T           P           TAIR        RH          RMASS
 1.525+002   2.168+002   7.000+001   5.600-001   4.560+002
H2,H2PH2=    34.50        .12
H2,H2PH2=    35.23      -.73
H2,H2PH2=    34.95        .28
H2,H2PH2=    35.30      -.36
H2,H2PH2=    35.45      -.15
H2,H2PH2=    35.53      -.07
H2,H2PH2=    35.52        .01

 CONDENSER ITERATION:

 T           P           H           X
 1.525+002   2.168+002   1.046+002   1.000+000
 8.569+001   2.088+002   3.552+001    .000


 LIQUID LINE:
 INPUT  -    PIN = 2.088+002   TIN = 8.569+001   XIN =  .000        HIN = 3.552+001
 OUTPUT -    POUT= 2.035+002   TOUT= 6.537+001   XOUT= 1.694-003


 EXPANSION DEVICE:
 INPUT  -    P12  =2.035+002   H12 =3.552+001   P13 =9.386+001
 OUTPUT -    POUT =1.566+002   XMASS =4.690+002

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TG6         TRA         TOA
 6.532+001   3.169+001   8.916+001   1.000+000   1.118+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:
```

```
EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.686+000   7.562-001   9.481-001   8.557-001   3.549+003   4.560+002

I  T           P           H           X
1  3.689+001   7.260+001   8.789+001   9.801-001
2  3.628+001   7.178+001   8.783+001   9.801-001
3  3.169+001   6.532+001   8.916+001   1.000+000
4  7.044+001   6.523+001   9.551+001   1.000+000
5  7.422+001   6.254+001   9.624+001   1.000+000
6  1.857+002   2.404+002   1.105+002   1.000+000
7  1.791+002   2.201+002   1.098+002   1.000+000
8  1.604+002   2.191+002   1.061+002   1.000+000
9  1.533+002   2.167+002   1.048+002   1.000 000
10 1.524+002   2.166+002   1.046+002   1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.524+002   2.166+002   7.000+001   5.600-001   4.560+002
H2,H2PH2=   34.60       .12
H2,H2PH2=   34.67      -.06
H2,H2PH2=   35.18      -.52
H2,H2PH2=   35.50      -.32
H2,H2PH2=   35.61      -.11
H2,H2PH2=   35.61       .00
H2,H2PH2=   35.61       .00

CONDENSER ITERATION:

T           P           H           X
1.524+002   2.166+002   1.046+002   1.000+000
8.604+001   2.033+002   3.561+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.085+002   TIN = 8.604+001   XIN =  .000        HIN = 3.561+001
OUTPUT -    POUT= 2.033+002   TOUT= 8.531+001   XOUT= 3.958-003


EXPANSION DEVICE:
INPUT  -    P12  =2.033+002   H12 =3.561+001   P13 =9 386+001
OUTPUT -    POUT =1.560+002   XMASS =4.666+002

INPUT DATA TO EVAPHX:

T           P           X           TAIR        RH          RMASS
3.575+001   9.386+001   2.303-001   4.700+001   7.300-001   4.660+002
H2= 91.0376
H2= 89.3069
H2= 87.2842
H2= 86.8236
QT,QS=  2.389+004  2.114+004

EVAPORATOR ITERATION:

T           P           H           X           TSUP
3 575+001   9.386+001   3.561+001   2.303-001
```

```
 3.735+001  7.356+001  8.689+001  9.682-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.554+001  9.352+001  2.311-001  4.700+001  7.300-001  4.660+002
H2= 91.1463
H2= 89.8963
H2= 88.5308
H2= 88.0712
QT,QS=  2.445+004  2.152+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.554+001  9.352+001  3.561+001  2.311-001
 3.701+001  7.270+001  8.808+001  9.821-001   .000
P1,P1E,P1EP1,DENT2=    72.5026   72.6990     .0965      .1938
INTERM,INTERE,POUT,P13=    0    0  156.00    93.52
 COMPOSITION OF REFRIG. IN ACCUMULATOR =  .650
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =     .181 LB

 REFRIG. IN INDOOR COIL =   2.311 LB

 REFRIG. IN OUTDOOR COIL=    .848 LB

 TMASS =  4.434+000     REFIN =  4.968+000

**********************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA        RHOA       TRA        RHRA
 4.700+001  7.300-001  7.000+001  5.600-001

 CFMIND     CFMOUT
 1.118+003  2.284+003


 RESULTS:

 I  T          P          H          S          X
 1  3.689+001  7.260+001  8.789+001  1.921-001  9.801-001
 2  3.623+001  7.178+001  8.789+001  1.921-001  9.801-001
 3  3.169+001  6.532+001  8.916+001  1.965-001  1.000+000
 4  7.044+001  6.523+001  9.551+001  2.039-001  1.000+000
 5  7.422+001  6.254+001  9.624+001  2.110-001  1.000+000
 6  1.857+002  2.404+002  1.105+002  2.122-001  1.000+000
 7  1.791+002  2.201+002  1.098+002  2.126-001  1.000+000
 8  1.604+002  2.191+002  1.061+002  2.068-001  1.000+000
 9  1.533+002  2.167+002  1.048+002  2.043-001  1.000+000
10  1.524+002  2.166+002  1.046+002  2.045-001  1.000+000
11  8.604+001  2.086+002  3.561+001  8.132-002   .000
12  8.531+001  2.033+002  3.561+001  8.135-002  3.958-003
13  3.554+001  9.352+001  3.561+001  8.335-002  2.311-001

 TG3        TSUP3      TGS        RMASS      TMASS
```

```
3.169+001    .000     , 1.118+002  4.660+002  4.434+000

QLOAD       ELUSE      COP
3.381+004   3.551+000  2.790+000

REFRIG. COMPOSITION =    .650
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.657+001   3.226+001   8.740+001   9.800-001   1.138+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.749+000   7.589-001   9.461-001   8.563-001   3.543+003   4.823+002

 I  T          P          H          X
 1  3.756+001  7.407+001  8.622+001  9.904-001
 2  3.692+001  7.320+001  8.617+001  9.606-001
 3  3.226+001  6.657+001  8.740+001  9.800-001
 4  6.457+001  6.648+001  9.448+001  1.000+000
 5  6.829+001  6.369+001  9.521+001  1.000+000
 6  1.812+002  2.471+002  1.094+002  1.000+000
 7  1.744+002  2.263+002  1.087+002  1.000+000
 8  1.558+002  2.253+002  1.050+002  1.000+000
 9  1.492+002  2.229+002  1.037+002  1.000+000
10  1.485+002  2.228+002  1.036+002  1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.485+002   2.228+002   7.000+001   5.600-001   4.823+002
H2,H2PH2=   33.96      -.42
H2,H2PH2=   33.90       .06
H2,H2PH2=   34.44      -.54
H2,H2PH2=   34.20       .24
H2,H2PH2=   34.47      -.27
H2,H2PH2=   34.53      -.06
H2,H2PH2=   34.58      -.05
H2,H2PH2=   34.56       .01

CONDENSER ITERATION:

T           P           H           X
1.485+002   2.228+002   1.036+002   1.000+000
8.205+001   2.152+002   3.456+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.152+002   TIN = 8.205+001   XIN =   .000       HIN = 3.456+001
OUTPUT -    POUT= 2.095+002   TOUT= 8.291+001   XOUT=   .000
```

```
EXPANSION DEVICE:
INPUT  -    P12  =2.096+002    H12 =3.456+001    P13 =9.499+001
OUTPUT -    POUT =1.668+002    XMASS =5.173+002

INPUT DATA TO COMPR:

P3           T3           H3           XQ3          TG6          TRA          TOA
6.657+001    3.226+001    8.740+001    9.800-001    1.134+002    7.000+001    4.700+001

COMPRESSOR ITERATION:

EI           ETAE         ETAC         ETAV         CPRPM        RMASS
2.738+000    7.584-001    9.463-001    8.571-001    3.548+003    4.828+002

 I  T           P           H           X
 1  3.757+001   7.409+001   8.623+001   9.605-001
 2  3.693+001   7.321+001   8.618+001   9.607-001
 3  3.226+001   6.657+001   8.740+001   9.800-001
 4  6.443+001   6.642+001   9.446+001   1.000+000
 5  6.812+001   6.369+001   9.518+001   1.000+000
 6  1.804+002   2.456+002   1.093+002   1.000+000
 7  1.736+002   2.246+002   1.086+002   1.000+000
 8  1.551+002   2.236+002   1.049+002   1.000+000
 9  1.486+002   2.211+002   1.037+002   1.000+000
10  1.478+002   2.210+002   1.025+002   1.000+000

INPUT DATA TO CONDHX:

T            P            TAIR         RH           RMASS
1.478+002    2.210+002    7.000+001    5.600-001    4.828+002
H2,H2PH2=    34.11      -.04
H2,H2PH2=    34.26      -.25
H2,H2PH2=    34.99      -.64
H2,H2PH2=    34.73       .27
H2,H2PH2=    34.97      -.24
H2,H2PH2=    35.06      -.09
H2,H2PH2=    35.11      -.05
H2,H2PH2=    35.10       .00

CONDENSER ITERATION:

T            P            H            X
1.478+002    2.210+002    1.035+002    1.000+000
8.411+001    2.128+002    3.510+001     .000


LIQUID LINE:
INPUT  -    PIN = 2.128+002    TIN = 8.411+001    XIN =   .000        HIN = 3.510+001
OUTPUT -    POUT= 2.072+002    TOUT= 8.408+001    XOUT=   .000


EXPANSION DEVICE:
INPUT  -    P12  =2.072+002    H12 =3.510+001    P13 =9.501+001
OUTPUT -    POUT =1.612+002    XMASS =4.916+002

INPUT DATA TO EVAPHX:

T            P            X            TAIR         RH           RMASS
```

```
 3.636+001  9.501+001  2.220-001  4.700+001  7.300-001  4.830+002
H2= 90.4425
H2= 85.9278
H2= 83.4042
H2= 83.3173
QT,QS=  2.321+004  2.072+004

 EVAPORATOR ITERATION:

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

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.613+001  9.463+001  2.229-001  4.700+001  7.300-001  4.839+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
 3.732+001  7.419+001  8.491+001  9.457-001   .000
P1,P1E,P1EP1,DENT2=   74.0893   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  4.775+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  6.588+001  8.734+001  9.800-001
 4  6.422+001  6.579+001  9.445+001  1.000+000
 5  6.794+001  6.303+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  1.548+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 CONDHX:

 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
```

```
H2,H2PH2=   35.42    -.27
H2,H2PH2=   34.83     .59
H2,H2PH2=   35.01    -.18
H2,H2PH2=   35.14    -.12
H2,H2PH2=   35.21    -.07
H2,H2PH2=   35.20     .01

 CONDENSER ITERATION:

 T          P          H          X
 1.475+002  2.192+002  1.035+002  1.000+000
 8.445+001  2.108+002  3.520+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.108+002   TIN = 8.445+001   XIN =  .000      HIN = 3.520+001
 OUTPUT -   POUT= 2.053+002   TOUT= 8.444+001   XOUT=  .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.053+002   H12 =3.520+001   P13 =9.385+001
 OUTPUT -   POUT =1.594+002   XMASS =4.826+002

 INPUT DATA TO COMPR:

 P3         T3         H3         XQ3        TG6        TRA        TOA
 6.588+001  3.172+001  8.734+001  9.800-001  1.127+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.714+000  7.574-001  9.465-001  8.568-001  3.549+003  4.776+002

 I  T          P          H          X
 1  3.700+001  7.332+001  8.617+001  9.606-001
 2  3.636+001  7.245+001  8.611+001  9.607-001
 3  3.172+001  6.588+001  8.734+001  9.800-001
 4  6.420+001  6.579+001  9.445+001  1.000+000
 5  6.791+001  6.303+001  9.517+001  1.000+000
 6  1.801+002  2.432+002  1.093+002  1.000+000
 7  1.732+002  2.224+002  1.086+002  1.000+000
 8  1.547+002  2.214+002  1.049+002  1.000+000
 9  1.481+002  2.190+002  1.037+002  1.000+000
10  1.474+002  2.189+002  1.035+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.474+002  2.189+002  7.000+001  5.600-001  4.776+002
H2,H2PH2=   34.40    -.02
H2,H2PH2=   34.61    -.21
H2,H2PH2=   35.33    -.71
H2,H2PH2=   34.98     .35
H2,H2PH2=   35.22    -.24
H2,H2PH2=   35.35    -.13
H2,H2PH2=   35.42    -.08
H2,H2PH2=   35.42     .01
```

```
CONDENSER ITERATION:

T            P            H            X
1.474+002    2.189+002    1.035+002    1.000+000
8.529+001    2.194+002    3.542+001     .000


LIQUID LINE:
INPUT  -     PIN = 2.104+002    TIN = 8.529+001    XIN =   .000        HIN = 3.542+001
OUTPUT -     POUT= 2.049+002    TOUT= 8.528+001    XOUT=   .000


EXPANSION DEVICE:
INPUT  -     P12  =2.049+002    H12 =3.542+001    P13 =9.385+001
OUTPUT -     POUT =1.576+002    XMASS =4.751+002

INPUT DATA TO EVAPHX:

T            P            X            TAIR         RH           RMASS
3.567+001    9.385+001    2.258-001    4.700+001    7.300-001    4.776+002
H2= 91.0917
H2= 89.5983
H2= 87.5974
H2= 87.4747
H2= 87.3638
QT,QS=  2.484+004  2.154+004

EVAPORATOR ITERATION:

T            P            H            X            TSUP
3.567+001    9.385+001    3.535+001    2.258-001
3.683+001    7.269+001    8.737+001    9.742-001     .000

INPUT DATA TO EVAPHX:

T            P            X            TAIR         RH           RMASS
3.581+001    9.403+001    2.252-001    4.700+001    7.300-001    4.776+002
H2= 90.9892
H2= 89.0026
H2= 86.7588
H2= 86.6626
H2= 86.5777
QT,QS=  2.447+004  2.135+004

EVAPORATOR ITERATION:

T            P            H            X            TSUP
3.581+001    9.408+001    3.534+001    2.252-001
3.706+001    7.326+001    8.659+001    9.652-001     .000
P1,PIE,PIEP1,DENT2=    73.3157    73.2571     -.0586      .4132
INTERM,INTERE,POUT,P13=    1    0   157.55    94.03

INPUT DATA TO COMPR:

P3           T3           H3           XQ3          TG6          TRA          TOA
6.588+001    3.172+001    8.734+001    9.800-001    1.127+002    7.000+001    4.700+001

COMPRESSOR ITERATION:
```

```
 EI           ETAE         ETAC         ETAV         CPRPM        RMASS
 2.715+000    7.575-001    9.465-001    8.567-001    3.549+003    4.776+002

 I  T            P            H            X
 1  3.700+001    7.331+001    8.617+001    9.606-001
 2  3.635+001    7.245+001    8.611+001    9.607-001
 3  3.172+001    5.588+001    8.734+001    9.800-001
 4  6.420+001    6.579+001    9.445+001    1.000+000
 5  6.791+001    6.303+001    9.518+001    1.000+000
 6  1.301+002    2.433+002    1.093+002    1.000+000
 7  1.733+002    2.225+002    1.086+002    1.000+000
 8  1.547+002    2.215+002    1.042+002    1.000+000
 9  1.482+002    2.191+002    1.037+002    1.000+000
10  1.474+002    2.190+002    1.035+002    1.000+000

 INPUT DATA TO CONDHX:

 T            P            TAIR         RH           RMASS
 1.474+002    2.190+002    7.000+001    5.600-001    4.776+002
H2,H2PH2=     34.33          .04
H2,H2PH2=     34.55         -.22
H2,H2PH2=     35.27         -.72
H2,H2PH2=     34.91          .36
H2,H2PH2=     35.15         -.23
H2,H2PH2=     35.27         -.13
H2,H2PH2=     35.35         -.08
H2,H2PH2=     35.34          .01

 CONDENSER ITERATION:

 T            P            H            X
 1.474+002    2.190+002    1.035+002    1.000+000
 8.502+001    2.105+002    3.534+001     .000


 LIQUID LINE:
 INPUT  -     PIN = 2.105+002    TIN = 8.502+001    XIN =   .000        HIN = 3.534+001
 OUTPUT -     POUT= 2.050 002    TOUT= 8.500+001    XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -     P12  =2.050+002    H12 =3.534+001    P13 =9.40?+001
DDENFA DOES NOT CONVERGE, DIFXQ2=    -8.01178-006
 OUTPUT -     POUT =1.534+002    XMASS =4.730+002

 INPUT DATA TO EVAPHX:

 T            P            X            TAIR         RH           RMASS
 3.581+001    9.408+001    2.252-001    4.700+001    7.300-001    4.776+002
H2= 90.9994
H2= 89.0039
H2= 86.7603
H2= 86.6943
H2= 86.5792
QT,QS=   2.447+004   2.135+004

 EVAPORATOR ITERATION:
```

```
   T            P            H            X            TSUP
   3.581+001    9.408+001    3.534+001    2.252-001
   3.706+001    7.326+001    8.659+001    9.052-001     .000
 P1,P1E,P1EP1,DENT2=    73.3148    73.2557     -.0591        .4153
 INTERM,INTERE,POUT,P13=     0    0   158.40    94.08
 WACCUM DOES NOT CONVERGE, MAX.ERROR = 2.982-002   (LB)
  COMPOSITION OF REFRIG. IN ACCUMULATOR =   .333
  (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

  REFRIG. IN ACCUMULATOR =    2.740 LB

  REFRIG. IN INDOOR COIL =    2.361 LB

  REFRIG. IN OUTDOOR COIL=     .885 LB

  TMASS =  7.110+000      REFIN =  4.968+000

 ******************************************************
 **SYST4 WITH ACCUM., 13B1/152A 6-22-84***

  TOA          RHOA         TRA          RHRA
  4.700+001    7.300-001    7.000+001    5.600-001

  CFMIND       CFMOUT
  1.118+003    2.284+003


  RESULTS:

  I   T            P            H            S            X
  1   3.700+001    7.331+001    8.617+001    1.884-001    9.606-001
  2   3.636+001    7.245+001    8.611+001    1.885-001    9.607-001
  3   3.172+001    6.588+001    8.734+001    1.926-001    9.800-001
  4   6.420+001    6.579+001    9.445+001    2.068-001    1.000+000
  5   6.791+001    6.303+001    9.518+001    2.089-001    1.000+000
  6   1.801+002    2.433+002    1.093+002    2.101-001    1.000+000
  7   1.733+002    2.225+002    1.086+002    2.104-001    1.000+000
  8   1.547+002    2.215+002    1.049+002    2.046-001    1.000+000
  9   1.482+002    2.191+002    1.037+002    2.028-001    1.000+000
 10   1.474+002    2.190+002    1.035+002    2.025-001    1.000+000
 11   8.502+001    2.105+002    3.534+001    8.082-002     .000
 12   8.500+001    2.050+002    3.534+001    8.085-002     .000
 13   3.581+001    9.408+001    3.534+001    8.278-002    2.252-001

  TG3          TSUP3        TG6          RMASS        TMASS
  3.214+001     .000        1.127+002    4.776+002    7.110+000

  QLOAD        ELUSE        COP
  3.422+004    3.560+000    2.801+000

  REFRIG. COMPOSITION =    .650
  (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




  INPUT DATA TO COMPR:
```

```
P3          T3          H3          XQ3         TGG         TRA         TOA
6.543+001   3.157+001   8.823+001   9.900-001   1.120+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.694+000   7.566-001   9.474-001   8.562-001   3.549+003   4.705+002

I  T          P          H          X
1  3.681+001  7.277+001  8.702+001  9.704-001
2  3.618+001  7.193+001  8.696+001  9.704-001
3  3.157+001  6.543+001  8.823+001  9.900-001
4  6.720+001  6.534+001  9.493+001  1.000+000
5  7.102+001  6.262+001  9.571+001  1.000+000
6  1.828+002  2.410+002  1.099+002  1.000+000
7  1.760+002  2.205+002  1.092+002  1.000+000
8  1.574+002  2.197+002  1.035+002  1.000+000
9  1.506+002  2.170+002  1.042+002  1.000+000
10 1.498+002  2.170+002  1.041+002  1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.498+002   2.170+002   7.000+001   5.600-001   4.705+002
H2,H2PH2=   34.65       .08
H2,H2PH2=   34.75      -.10
H2,H2PH2=   35.33      -.58
H2,H2PH2=   35.65      -.32
H2,H2PH2=   35.76      -.11
H2,H2PH2=   35.76       .00
H2,H2PH2=   35.76       .00

CONDENSER ITERATION:

T           P           H           X
1.498+002   2.170+002   1.041+002   1.000+000
8.660+001   2.080+002   3.576+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.088+002   TIN = 8.660+001   XIN =  .000        HIN = 3.576+001
OUTPUT -    POUT= 2.033+002   TOUT= 8.533+001   XOUT= 6.996-003


EXPANSION DEVICE:
INPUT  -    P12  =2.033+002   H12 =3.576+001   P13 =9.353+001
OUTPUT -    POUT =1.560+002   XMASS =4.632+002

INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.543+001   3.157+001   8.823+001   9.900-001   1.121+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.696+000   7.567-001   9.474-001   8.561-001   3.543+003   4.704+002
```

```
     I   T          P          H          X
     1   3.681+001  7.277+001  8.702+001  9.703-001
     2   3.618+001  7.192+001  8.696+001  9.704-001
     3   3.157+001  6.543+001  8.823+001  9.900-001
     4   6.731+001  6.534+001  9.498+001  1.000+000
     5   7.106+001  6.263+001  9.571+001  1.000+000
     6   1.829+002  2.413+002  1.099+002  1.000+000
     7   1.752+002  2.208+002  1.092+002  1.000+000
     8   1.575+002  2.198+002  1.055+002  1.000+000
     9   1.507+002  2.174+002  1.043+002  1.000+000
    10   1.499+002  2.173+002  1.041+002  1.000+000

     INPUT DATA TO CONDHX:

     T          P          TAIR       RH         RMASS
     1.499+002  2.173+002  7.000+001  5.600-001  4.704+002
    H2,H2PH2=   34.43       .07
    H2,H2PH2=   35.21      -.78
    H2,H2PH2=   35.21      -.01
    H2,H2PH2=   35.29      -.07
    H2,H2PH2=   35.46      -.17
    H2,H2PH2=   35.55      -.09
    H2,H2PH2=   35.56      -.01

     CONDENSER ITERATION:

     T          P          H          X
     1.499+002  2.173+002  1.041+002  1.000+000
     8.584+001  2.092+002  3.556+001   .000


     LIQUID LINE:
     INPUT  -   PIN = 2.092+002   TIN = 8.584+001   XIN =  .000        HIN = 3.556+001
     OUTPUT -   POUT= 2.038+002   TOUT= 8.549+001   XOUT= 1.859-003


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

     INPUT DATA TO EVAPHX:

     T          P          X          TAIR       RH         RMASS
     3.553+001  9.353+001  2.302-001  4.700+001  7.300-001  4.704+002
    H2= 91.1647
    H2= 89.3796
    H2= 88.6931
    H2= 88.3154
    Q1,QS=  2.480+004  2.173+004

     EVAPORATOR ITERATION:

     T          P          H          X          TSUP
     3.553+001  9.353+001  3.556+001  2.302-001
     3.679+001  7.234+001  8.828+001  9.846-001   .000

     INPUT DATA TO EVAPHX:
```

```
 T           P           X           TAIR        RH          RMASS
 3.562+001   9.368+001   2.298-001   4.700+001   7.300-001   4.794+002
H2= 91.1296
H2= 89.7738
H2= 88.1679
H2= 87.8335
QT,QS=  2.457+004  2.157+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.562+001   9.368+001   3.556+001   2.298-001
 3.696+001   7.272+001   8.780+001   9.790-001    .000
P1,P1E,P1EP1,DENT2=   72.7675    72.7228     -.0447      .7846

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TG6         TRA         TOA
 6.584+001   3.189+001   8.827+001   9.900-001   1.124+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:

 EI          ETAE        ETAC        ETAV        CPRPM       RMASS
 2.707+000   7.571-001   9.474-001   8.565-001   3.549+003   4.736+002

 I  T           P           H           X
 1  3.715+001   7.223+001   8.705+001   9.703-001
 2  3.652+001   7.238+001   8.699+001   9.704-001
 3  3.189+001   6.584+001   8.827+001   9.900-001
 4  6.740+001   6.575+001   9.498+001   1.000+000
 5  7.114+001   6.301+001   9.571+001   1.000+000
 6  1.829+002   2.422+002   1.099+002   1.000+000
 7  1.761+002   2.215+002   1.092+002   1.000+000
 8  1.576+002   2.205+002   1.055+002   1.000+000
 9  1.508+002   2.181+002   1.042+002   1.000+000
10  1.500+002   2.180+002   1.041+002   1.000+000

 INPUT DATA TO CONDHX:

 T           P           TAIR        RH          RMASS
 1.500+002   2.180+002   7.000+001   5.600-001   4.736+002
H2,H2PH2=    34.29      .04
H2,H2PH2=    35.11     -.82
H2,H2PH2=    35.12     -.01
H2,H2PH2=    35.18     -.06
H2,H2PH2=    35.35     -.17
H2,H2PH2=    35.44     -.09
H2,H2PH2=    35.46     -.02

 CONDENSER ITERATION:

 T           P           H           X
 1.500+002   2.180+002   1.041+002   1.000+000
 8.545+001   2.099+002   3.546+001    .000


 LIQUID LINE:
```

```
 INPUT  -    PIN = 2.099+002   TIN = 8.545+001   XIN =   .000        HIN = 3.546+001
 OUTPUT -    POUT= 2.044+002   TOUT= 8.513+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -    P12  =2.044+002   H12 =3.546+001   P13 =9.414+001
 OUTPUT -    POUT =1.572+002   XMASS =4.727+002

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          RMASS
 3.588+001   9.414+001   2.270-001   4.700+001   7.300-001   4.736+002
H2= 90.9402
H2= 88.7216
H2= 86.4685
H2= 86.2656
QT,QS=  2.405+004  2.122+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.588+001   9.414+001   3.546+001   2.270-001
 3.728+001   7.368+001   8.623+001   9.609-001    .000

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          RMASS
 3.578+001   9.398+001   2.274-001   4.700+001   7.300-001   4.736+002
H2= 91.0247
H2= 89.2156
H2= 87.0729
H2= 86.8743
H2= 86.8123
QT,QS=  2.433+004  2.127+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.578+001   9.390+001   3.546+001   2.274-001
 3.712+001   7.327+001   8.682+001   9.678-001    .000
P1,P1E,P1EP1,DENT2=   73.2274   73.2701     .0427     -.2317
INTERM,INTERE,POUT,P13=   0   0  157.22   93.98
 COMPOSITION OF REFRIG. IN ACCUMULATOR =  .365
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =   1.083 LB

 REFRIG. IN INDOOR COIL =   2.340 LB

 REFRIG. IN OUTDOOR COIL=    .878 LB

 TMASS =  5.419+000     REFIN =  4.968+000

*************************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA         RHOA        TRA         RHRA
 4.700+001   7.300-001   7.000+001   5.600-001
```

```
CFMIND     CFMOUT
1.118+003  2.234+003


RESULTS:

 I   T          P          H          S          X
 1  3.715+001  7.323+001  8.705+001  1.902-001  9.703-001
 2  3.652+001  7.238+001  8.699+001  1.903-001  9.704-001
 3  3.180+001  6.584+001  8.827+001  1.945-001  9.900-001
 4  6.740+001  6.575+001  9.498+001  2.078-001  1.000+000
 5  7.114+001  6.301+001  9.571+001  2.099-001  1.000+000
 6  1.829+002  2.422+002  1.099+002  2.111-001  1.000+000
 7  1.761+002  2.215+002  1.092+002  2.115-001  1.000+000
 8  1.576+002  2.205+002  1.055+002  2.057-001  1.000+000
 9  1.508+002  2.181+002  1.042+002  2.038-001  1.000+000
10  1.500+002  2.180+002  1.041+002  2.035-001  1.000+000
11  8.545+001  2.099+002  3.546+001  8.104-002   .000
12  8.543+001  2.044+002  3.546+001  8.106-002   .000
13  3.578+001  9.398+001  3.546+001  8.302-002  2.274-001

TG3        TSUP3      TG6        RMASS      TMASS
3.210+001   .000      1.124+002  4.736+002  5.412+000

QLOAD      ELUSE      COP
3.415+004  3.572+000  2.802+000

REFRIG. COMPOSITION =    .650
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




INPUT DATA TO COMPR:

P3         T3         H3         XQ3        TG6        TRA        TOA
6.582+001  3.199+001  8.873+001  9.950-001  1.123+002  7.000+001  4.700+001

COMPRESSOR ITERATION:

EI         ETAE       ETAC       ETAV       CPRPM      RMASS
2.702+000  7.569-001  9.477-001  8.563-001  3.549+003  4.717+002

 I   T          P          H          X
 1  3.723+001  7.319+001  8.749+001  9.752-001
 2  3.661+001  7.236+001  8.743+001  9.753-001
 3  3.199+001  6.582+001  8.873+001  9.950-001
 4  6.899+001  6.573+001  9.524+001  1.000+000
 5  7.273+001  6.301+001  9.597+001  1.000+000
 6  1.843+002  2.419+002  1.102+002  1.000+000
 7  1.779+002  2.213+002  1.095+002  1.000+000
 8  1.590+002  2.203+002  1.059+002  1.000+000
 9  1.520+002  2.179+002  1.045+002  1.000+000
10  1.512+002  2.178+002  1.043+002  1.000+000

INPUT DATA TO CONDHX:
```

```
 T           P           TAIR        RH          RMASS
 1.512+002   2.178+002   7.000+001   5.600-001   4.717+002
H2,H2PH2=   34.33       .06
H2,H2PH2=   35.12      -.80
H2,H2PH2=   34.88       .25
H2,H2PH2=   35.21      -.34
H2,H2PH2=   35.36      -.15
H2,H2PH2=   35.44      -.08
H2,H2PH2=   35.44       .00

 CONDENSER ITERATION:

 T           P           H           X
 1.512+002   2.173+002   1.043+002   1.000+000
 8.538+001   2.097+002   3.544+001    .000


 LIQUID LINE:
 INPUT  -    PIN = 2.097+002   TIN = 8.538+001   XIN =   .000       HIN = 3.544+001
 OUTPUT -    POUT= 2.043+002   TOUT= 8.536+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -    P12  =2.043+002   H12 =3.544+001   P13 =9.394+001
 OUTPUT -    POUT =1.573+002   XMASS =4.729+002

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          RMASS
 3.575+001   9.394+001   2.271-001   4.700+001   7.300-001   4.717+002
H2= 91.0172
H2= 89.1768
H2= 87.0406
H2= 86.8044
QT,QS=  2.421+004  2.132+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.575+001   9.394+001   3.544+001   2.271-001
 3.720+001   7.339+001   8.276+001   9.669-001    .000
P1,P1E,P1EP1,DENT2=   73.1945   73.3925     .1981    -.7351

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TG6         TRA         TOA
 6.545+001   3.168+001   8.870+001   9.950-001   1.120+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:

 EI          ETAE        ETAC        ETAV        CPRPM       RMASS
 2.692+000   7.565-001   9.477-001   8.559-001   3.549+003   4.687+002

 I  T           P           H           X
 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
 3  3.168+001   6.545+001   8.870+001   9.950-001
 4  6.890+001   6.536+001   9.524+001   1.000+000
```

```
 5  7.266+001  6.265+001  9.598+001  1.000+000
 6  1.843+002  2.410+002  1.102+002  1.000+000
 7  1.776+002  2.206+002  1.095+002  1.000+000
 8  1.583+002  2.196+002  1.058+002  1.000+000
 9  1.520+002  2.172+002  1.045+002  1.000+000
10  1.512+002  2.171+002  1.044+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.512+002  2.171+002  7.000+001  5.600-001  4.687+002
H2,H2PH2=   34.46       .09
H2,H2PH2=   35.21     -.75
H2,H2PH2=   34.96       .25
H2,H2PH2=   35.32     -.35
H2,H2PH2=   35.47     -.15
H2,H2PH2=   35.54     -.08
H2,H2PH2=   35.54       .01

 CONDENSER ITERATION:

 T          P          H          X
 1.512+002  2.171+002  1.044+002  1.000+000
 8.575+001  2.091+002  3.554+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.091+002   TIN = 8.575+001   XIN =  .000        HIN = 3.554+001
 OUTPUT -   POUT= 2.037+002   TOUT= 8.546+001   XOUT= 1.539-003


 EXPANSION DEVICE:
 INPUT  -   P12  =2.037+002   H12 =3.554+001   P13 =9.351+001
 OUTPUT -   POUT =1.566+002   XMASS =4.695+002

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.551+001  9.351+001  2.298-001  4.700+001  7.300-001  4.697+002
H2= 91.1552
H2= 89.9336
H2= 88.6044
H2= 88.2019
QT,QS=  2.458+004  2.165+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.551+001  9.351+001  3.554+001  2.298-001
 3.688+001  7.249+001  8.818+001  9.834-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.557+001  9.361+001  2.296-001  4.700+001  7.300-001  4.697+002
H2= 91.1332
H2= 89.8058
H2= 88.2652
```

```
H2= 87.8343
QT,QS=  2.453+004  2.156+004

 EVAPORATOR ITERATION:

 T            P            H            X            TSUP
 3.557+001   9.361+001   3.554+001   2.296-001
 3.698+001   7.273+001   8.788+001   9.798-001    .000
P1,P1E,P1EP1,DENT2=    72.7637    72.7340     -.0297      .4190
INTERM,INTERE,POUT,P13=    0    0  156.59    93.61
 COMPOSITION OF REFRIG. IN ACCUMULATOR =   .625
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =     .196 LB

 REFRIG. IN INDOOR COIL =   2.324 LB

 REFRIG. IN OUTDOOR COIL=     .854 LB

 TMASS =  4.482+000     REFIN =  4.968+000

************************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA          RHOA         TRA          RHRA
 4.700+001   7.300-001   7.000+001   5.600-001

 CFMIND      CFMOUT
 1.118+003   2.284+003


 RESULTS:

 I   T            P            H            S            X
 1   3.691+001   7.276+001   8.746+001   1.912-001   9.752-001
 2   3.629+001   7.193+001   8.740+001   1.912-001   9.753-001
 3   3.168+001   6.545+001   8.870+001   1.955-001   9.950-001
 4   6.890+001   6.536+001   9.524+001   2.084-001   1.000+000
 5   7.266+001   6.263+001   9.598+001   2.105-001   1.000+000
 6   1.843+002   2.410+002   1.102+002   2.117-001   1.000+000
 7   1.776+002   2.206+002   1.095+002   2.120-001   1.000+000
 8   1.589+002   2.196+002   1.053+002   2.062-001   1.000+000
 9   1.520+002   2.172+002   1.045+002   2.043-001   1.000+000
10   1.512+002   2.171+002   1.044+002   2.040-001   1.000+000
11   8.575+001   2.091+002   3.554+001   8.118-002    .000
12   6.546+001   2.037+002   3.554+001   8.121-002   1.539-003
13   3.557+001   9.361+001   3.554+001   8.319-002   2.296-001

 TG3          TSUP3        TG6          RMASS        TMASS
 3.179+001    .000        1.120+002   4.687+002   4.482+000

 QLOAD        ELUSE        COP
 3.391+004   3.557+000   2.794+000

 REFRIG. COMPOSITION =    .650
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
```

```
INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.565+001   3.179+001   8.848+001   9.925-001   1.122+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.699+000   7.568-001   9.475-001   8.562-001   3.549+003   4.712+002

 I  T          P           H           X
 1  3.703+001  7.300+001   8.726+001   9.728-001
 2  3.641+001  7.216+001   8.720+001   9.729-001
 3  3.179+001  6.565+001   8.848+001   9.925-001
 4  6.814+001  6.556+001   9.511+001   1.000+000
 5  7.189+001  6.284+001   9.584+001   1.000+000
 6  1.836+002  2.416+002   1.100+002   1.000+000
 7  1.768+002  2.211+002   1.093+002   1.000+000
 8  1.592+002  2.201+002   1.057+002   1.000+000
 9  1.513+002  2.177+002   1.044+002   1.000+000
10  1.505+002  2.176+002   1.042+002   1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.505+002   2.176+002   7.000+001   5.600-001   4.712+002
H2,H2PH2=   34.37        .06
H2,H2PH2=   35.16       -.79
H2,H2PH2=   34.92        .23
H2,H2PH2=   35.26       -.34
H2,H2PH2=   35.41       -.15
H2,H2PH2=   35.49       -.08
H2,H2PH2=   35.49        .00

CONDENSER ITERATION:

T           P           H           X
1.505+002   2.176+002   1.042+002   1.000+000
8.557+001   2.095+002   3.549+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.095+002   TIN = 8.557+001   XIN =  .000       HIN = 3.549+001
OUTPUT -    POUT= 2.041+002   TOUT= 8.555+001   XOUT=  .000


EXPANSION DEVICE:
INPUT  -    P12  =2.041+002   H12 =3.549+001   P13 =9.385+001
OUTPUT -    POUT =1.571+002   XMASS =4.712+002

INPUT DATA TO EVAPHX:

T           P           X           TAIR        RH          RMASS
3.571+001   9.385+001   2.282-001   4.700+001   7.300-001   4.712+002
H2= 91.0547
H2= 89.4687
```

```
H2= 87.4577
H2= 87.1759
QT,QS=  2.433+004  2.139+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.571+001   9.385+001   3.549+001   2.282-001
 3.711+001   7.315+001   8.713+001   9.712-001    .000
P1,P1E,P1EP1,DENT2=    73.0043    73.1545      .1503      -.1317
INTERM,INTERE,POUT,P13=    0    0  157.13    93.85
 COMPOSITION OF REFRIG. IN ACCUMULATOR =  .615
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =     .204 LB

 REFRIG. IN INDOOR COIL =   2.333 LB

 REFRIG. IN OUTDOOR COIL=     .872 LB

 TMASS =  4.525+000      REFIN =  4.968+000

******************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA         RHOA        TRA         RHRA
 4.700+001   7.300-001   7.000+001   5.600-001

 CFMIND      CFMOUT
 1.118+003   2.284+003


 RESULTS:

 I  T          P          H          S          X
 1  3.703+001  7.300+001  8.726+001  1.907-001  9.728-001
 2  3.641+001  7.216+001  8.720+001  1.908-001  9.729-001
 3  3.179+001  6.565+001  8.848+001  1.950-001  9.925-001
 4  9.814+001  6.556+001  9.511+001  2.081-001  1.000+000
 5  7.189+001  6.284+001  9.584+001  2.102-001  1.000+000
 6  1.836+002  2.416+002  1.100+002  2.114-001  1.000+000
 7  1.768+002  2.211+002  1.093+002  2.117-001  1.000+000
 8  1.582+002  2.201+002  1.057+002  2.059-001  1.000+000
 9  1.513+002  2.177+002  1.044+002  2.040-001  1.000+000
10  1.505+002  2.176+002  1.042+002  2.038-001  1.000+000
11  8.557+001  2.095+002  3.549+001  8.109-002   .000
12  8.555+001  2.041+002  3.549+001  8.112-002   .000
13  3.571+001  9.385+001  3.549+001  8.308-002  2.282-001

 TG3         TSUP3       TG6         RMASS       TMASS
 3.195+001    .000       1.122+002   4.712+002   4.525+000

 QLOAD       ELUSE       COP
 3.404+004   3.564+000   2.799+000

 REFRIG. COMPOSITION =    .650
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
```

```
INPUT DATA TO COMPR:

P3          T3          H3          XO3         TG6         TRA         TOA
6.777+001   3.344+001   8.854+001   9.912-001   1.141+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.765+000   7.596-001   9.471-001   8.577-001   3.548+003   4.881+002

 I  T          P          H          X
 1  3.876+001  7.540+001  8.732+001  9.714-001
 2  3.813+001  7.453+001  8.727+001  9.717-001
 3  3.344+001  6.777+001  8.854+001  9.912-001
 4  6.837+001  6.767+001  9.506+001  1.000+000
 5  7.205+001  6.485+001  9.579+001  1.000+000
 6  1.838+002  2.479+002  1.099+002  1.000+000
 7  1.769+002  2.265+002  1.092+002  1.000+000
 8  1.585+002  2.254+002  1.055+002  1.000+000
 9  1.518+002  2.229+002  1.043+002  1.000+000
10  1.510+002  2.228+002  1.041+002  1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.510+002   2.228+002   7.000+001   5.600-001   4.881+002
H2,H2PH2=   33.92       -.26
H2,H2PH2=   34.60       -.68
H2,H2PH2=   34.59        .01
H2,H2PH2=   34.78       -.20
H2,H2PH2=   34.88       -.10
H2,H2PH2=   34.95       -.06
H2,H2PH2=   34.95        .00

CONDENSER ITERATION:

T           P           H           X
1.510+002   2.228+002   1.041+002   1.000+000
8.350+001   2.151+002   3.495+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.151+002   TIN = 8.350+001   XIN =  .000       HIN = 3.495+001
OUTPUT -    POUT= 2.093+002   TOUT= 8.348+001   XOUT=  .000


EXPANSION DEVICE:
INPUT  -    P12  =2.093+002   H12 =3.495+001   P13 =9.625+001
OUTPUT -    POUT =1.643+002   XMASS =5.049-002

INPUT DATA TO COMPR:

P3          T3          H3          XO3         TG6         TRA         TOA
6.777+001   3.344+001   8.854+001   9.912-001   1.139+002   7.000+001   4.700+001
```

```
COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.760+000   7.594-001   9.472-001   8.580-001   3.543+003   4.853+002

I  T          P          H          X
1  3.876+001  7.541+001  8.732+001  9.715-001
2  3.813+001  7.454+001  8.723+001  9.717-001
3  3.344+001  6.777+001  8.854+001  9.912-001
4  6.830+001  6.767+001  9.505+001  1.000+000
5  7.197+001  6.485+001  9.577+001  1.000+000
6  1.834+002  2.472+002  1.098+002  1.000+000
7  1.763+002  2.257+002  1.091+002  1.000+000
8  1.582+002  2.247+002  1.055+002  1.000+000
9  1.515+002  2.221+002  1.042+002  1.000+000
10 1.507+002  2.221+002  1.041+002  1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.507+002   2.221+002   7.000+001   5.600-001   4.883+002
H2,H2PH2=   34.20      -.11
H2,H2PH2=   34.44      -.25
H2,H2PH2=   34.58      -.14
H2,H2PH2=   34.82      -.23
H2,H2PH2=   34.98      -.17
H2,H2PH2=   35.02      -.04
H2,H2PH2=   35.03      -.01

CONDENSER ITERATION:

T           P           H           X
1.507+002   2.221+002   1.041+002   1.000+000
8.383+001   2.140+002   3.503+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.140+002   TIN = 8.383+001   XIN =  .000      HIN = 3.503+001
OUTPUT -    POUT= 2.083+002   TOUT= 8.380+001   XOUT=  .000


EXPANSION DEVICE:
INPUT  -    P12  =2.083+002   H12 =3.503+001   P13 =9.626+001
OUTPUT -    POUT =1.631+002   XMASS =4.383+002

INPUT DATA TO EVAPHX:

T           P           X           TAIR        RH          RMASS
3.709+001   9.626+001   2.167-001   4.700+001   7.300-001   4.887+002
H2= 88.2819
H2= 80.8385
H2= 78.9247
QT,QS=  2.140+004  1.974+004

EVAPORATOR ITERATION:

T           P           H           X           TSUP
3.709+001   9.626+001   3.515+001   2.167-001
```

```
 3.831+001  7.777+001  7.894+001  8.742-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.658+001  9.542+001  2.187-001  4.700+001  7.300-001  4.887+002
H2= 89.9611
H2= 84.2842
H2= 81.9661
H2= 81.8844
QT,QS=  2 286+004  2.053+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.658+001  9.542+001  3.515+001  2.187-001
 3.773+001  7.581+001  8.193+001  9.107-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.647+001  9.525+001  2.191-001  4.700+001  7.300-001  4.887+002
H2= 90.1903
H2= 85.0249
H2= 82.5664
QT,QS=  2.319+004  2.091+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.647+001  9.525-001  3.515+001  2.191-001
 3.760+001  7.539+001  8.260+001  9.187-001   .000
P1,P1E,P1EP1,DENT2=    75.4106    75.3918    -.0188    -4.7252

 INPUT DATA TO COMPR:

 P3         T3         H3         X33        TG6        TRA        TOA
 6.531+001  3.149+001  8.834+001  9.912-001  1.119+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.690+000  7.564-001  9.475-001  8.561-001  3.549+003  4.690+002

 I  T          P          H          X
 1  3.672+001  7.262+001  8.712+001  9.716-001
 2  3.610+001  7.178+001  8.706+001  9.716-001
 3  3.149+001  6.531+001  8.834+001  9.912-001
 4  6.765+001  6.521+001  9.504+001  1.000+000
 5  7.140+001  6.251+001  9.577+001  1 000+000
 6  1.831+002  2.409+002  1.100+002  1 000+000
 7  1.764+002  2.202+002  1.093+002  1.000+000
 8  1.578+002  2.192+002  1.056+002  1.000+000
 9  1.509+002  2.168+002  1.043+002  1.000+000
10  1.501+002  2.167+002  1.042+002  1.000+000

 INPUT DATA TO CONDHX:
```

```
T           P           TAIR        RH          RMASS
 1.501+002  2.167+002   7.000+001   5.600-001   4.690+002
H2,H2PH2=   34.86     -.61
H2,H2PH2=   34.89     -.02
H2,H2PH2=   35.39     -.51
H2,H2PH2=   35.66     -.27
H2,H2PH2=   35.78     -.11
H2,H2PH2=   35.79     -.01
H2,H2PH2=   35.79      .00

CONDENSER ITERATION:

T           P           H           X
1.501+002   2.167+002   1.042+002   1.000+000
8.671+001   2.086+002   3.579+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.086+002   TIN = 8.671+001   XIN =  .000        HIN = 3.579+001
OUTPUT -    POUT= 2.030+002   TOUT= 8.525+001   XOUT= 8.115-003


EXPANSION DEVICE:
INPUT  -    P12  =2.030+002   H12 =3.579+001   P13 =9.246+001
OUTPUT -    POUT =1.553+002   XMASS =4.615+002

INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.531+001   3.149+001   8.834+001   9.912-001   1.121+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.695+000   7.566-001   9.474-001   8.557-001   3.549+003   4.688+002

I  T          P          H          X
1  3.672+001  7.261+001  8.711+001  9.715-001
2  3.609+001  7.177+001  8.705+001  9.716-001
3  3.149+001  6.531+001  8.834+001  9.912-001
4  6.771+001  6.521+001  9.505+001  1.000+000
5  7.147+001  6.251+001  9.579+001  1.000+000
6  1.835+002  2.413+002  1.100+002  1.000+000
7  1.768+002  2.210+002  1.093+002  1.000+000
8  1.581+002  2.200+002  1.056+002  1.000+000
9  1.512+002  2.176+002  1.043+002  1.000+000
10 1.504+002  2.175+002  1.042+002  1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
 1.504+002  2.175+002   7.000+001   5.600-001   4.683+002
H2,H2PH2=   34.72     -.48
H2,H2PH2=   34.80     -.08
H2,H2PH2=   34.85     -.05
H2,H2PH2=   34.96     -.12
H2,H2PH2=   35.18     -.22
H2,H2PH2=   35.27     -.09
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```
H2,H2PH2=    35.28     -.01

 CONDENSER ITERATION:

 T            P            H            X
 1.504+002    2.175+002    1.042+002    1.000+000
 8.477+001    2.096+002    3.528+001     .000


 LIQUID LINE:
 INPUT  -     PIN = 2.096+002   TIN = 8.477+001   XIN =   .000        HIN = 3.528+001
 OUTPUT -     POUT= 2.042+002   TOUT= 8.475+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -     P12  =2.042+002   H12 =3.528+001   P13 =9.245+001
DDENFA DOES NOT CONVERGE, DIFXQ2=    -5.66260-006
 OUTPUT -     POUT =1.580+002   XMASS =4.766+002

 INPUT DATA TO COMPR:

 P3           T3           H3           XQ3          TG6          TRA          TOA
 6.531+001    3.149+001    8.834+001    9.912-001    1.120+002    7.000+001    4.700+001

 COMPRESSOR ITERATION:

 EI           ETAE         ETAC         ETAV         CPRPM        RMASS
 2.692+000    7.565-001    9.475-001    8.559-001    3.549+003    4.689+002

 I  T            P            H            X
 1  3.672+001    7.262+001    8.712+001    9.716-001
 2  3.610+001    7.178+001    8.705+001    9.716-001
 3  3.149+001    6.531+001    8.834+001    9.912-001
 4  6.768+001    6.521+001    9.505+001    1.000+000
 5  7.144+001    6.251+001    9.578+001    1.000+000
 6  1.833+002    2.410+002    1.100+002    1.000+000
 7  1.766+002    2.206+002    1.093+002    1.000+000
 8  1.579+002    2.195+002    1.056+002    1.000+000
 9  1.511+002    2.172+002    1.043+002    1.000+000
10  1.503+002    2.171+002    1.042+002    1.000+000

 INPUT DATA TO CONDHX:

 T            P            TAIR         RH           RMASS
 1.503+002    2.171+002    7.000+001    5.600-001    4.689+002
H2,H2PH2=    34.44      .08
H2,H2PH2=    35.20     -.76
H2,H2PH2=    34.97      .23
H2,H2PH2=    35.32     -.35
H2,H2PH2=    35.47     -.15
H2,H2PH2=    35.55     -.08
H2,H2PH2=    35.54      .01

 CONDENSER ITERATION:

 T            P            H            X
 1.503+002    2.171+002    1.042+002    1.000+000
 8.577+001    2.091+002    3.554+001     .000
```

```
LIQUID LINE:
INPUT  -   PIN = 2.091+002   TIN = 8.577+001   XIN =  .000        HIN = 3.554+001
OUTPUT -   POUT= 2.037+002   TOUT= 8.544+001   XOUT= 1.716-003


EXPANSION DEVICE:
INPUT  -   P12  =2.037+002   H12 =3.554+001   P13 =3.245+001
OUTPUT -   POUT =1.562+002   XMASS =4.692+002

INPUT DATA TO EVAPHX:

T          P          X          TAIR       RH         RMASS
3.486+001  9.245+001  2.325-001  4.700+001  7.300-001  4.689+002
H2= 91.4095
H2= 91.0235
H2= 90.6844
H2= 90.4082
H2= 90.3057
QT,QS=  2.567+004  2.190+004

EVAPORATOR ITERATION:

T          P          H          X          TSUP
3.486+001  9.245+001  3.554+001  2.325-001
3.988+001  6.970+001  9.028+001  1.000+000  4.700+000

INPUT DATA TO EVAPHX:

T          P          X          TAIR       RH         RMASS
3.561+001  9.367+001  2.295-001  4.700+001  7.300-001  4.689+002
H2= 91.1227
H2= 89.7332
H2= 88.0675
H2= 87.7171
QT,QS=  2.441+004  2.148+004

EVAPORATOR ITERATION:

T          P          H          X          TSUP
3.561+001  9.367+001  3.554+001  2.295-001
3.703+001  7.287+001  8.766+001  9.773-001   .000

INPUT DATA TO EVAPHX:

T          P          X          TAIR       RH         RMASS
3.555+001  9.357+001  2.298-001  4.700+001  7.300-001  4.689+002
H2= 91.1433
H2= 89.8641
H2= 88.4274
H2= 88.0450
QT,QS=  2.461+004  2.161+004

EVAPORATOR ITERATION:

T          P          H          X          TSUP
3.555+001  9.357+001  3.554+001  2.298-001
```

```
 3.693+001  7.261+001  8.803+001  9.815-001   .000
P1,P1E,P1EP1,DENT2=   72.6171   72.6117    -.0054     .9032

 INPUT DATA TO COMPR:

 P3         T3         H3         XQ3        TG6        TRA        TOA
 6.570+001  3.181+001  8.837+001  9.912-001  1.123+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.702+000  7.569-001  9.474-001  8.563-001  3.549+003  4.720+002

 I  T          P          H          X
 1  3.705+001  7.306+001  8.715+001  9.716-001
 2  3.643+001  7.222+001  8.709+001  9.716-001
 3  3.181+001  6.570+001  8.837+001  9.912-001
 4  6.776+001  6.561+001  9.505+001  1.000+000
 5  7.150+001  6.238+001  9.578+001  1.000+000
 6  1.832+002  2.418+002  1.100+002  1.000+000
 7  1.765+002  2.212+002  1.093+002  1.000+000
 8  1.579+002  2.202+002  1.056+002  1.000+000
 9  1.511+002  2.178+002  1.043+002  1.000+000
10  1.503+002  2.177+002  1.041+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.503+002  2.177+002  7.000+001  5.600-001  4.720+002
H2,H2PH2=   34.34      .06
H2,H2PH2=   35.14     -.80
H2,H2PH2=   34.92      .23
H2,H2PH2=   35.25     -.34
H2,H2PH2=   35.41     -.15
H2,H2PH2=   35.49     -.08
H2,H2PH2=   35.48      .01

 CONDENSER ITERATION:

 T          P          H          X
 1.503+002  2.177-002  1.041+002  1.000+000
 8.554+001  2.096+002  3.548+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.096+002   TIN = 8.554+001   XIN =   .000       HIN = 3.548+001
 OUTPUT -   POUT= 2.042+002   TOUT= 8.552+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.042+002   H12 =3.548+001   P13 =9.402+001  .
 OUTPUT -   POUT =1.568+002   XMASS =4.714+002

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.581+001  9.402+001  2.277-001  4.700+001  7.300-001  4.720+002
H2= 90.9949
```

```
H2= 89.0392
H2= 86.8653
H2= 86.6291
QT,QS=  2.413+004  2.127+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.581+001  9.402+001  3.543+001  2.277-001
 3.723+001  7.350+001  8.659+001  9.650-001   .000

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          RMASS
 3.570+001  9.385+001  2.281-001  4.700+001  7.300-001  4.720+002
H2= 91.0722
H2= 89.5154
H2= 87.5181
H2= 87.2596
H2= 87.1924
QT,QS=  2.441+004  2.131+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.570+001  9.385+001  3.548+001  2.281-001
 3.706+001  7.306+001  8.720+001  9.721-001   .000
P1,P1E,P1EP1,DENT2=    73.0641    73.0637    -.0004     .0495
INTERM,INTERE,FOUT,P13=    0    0  156.78   93.85
 COMPOSITION OF REFRIG  IN ACCUMULATOR =   .570
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =     .240 LB

 REFRIG. IN INDOOR COIL =   2.336 LB

 REFRIG. IN OUTDOOR COIL=    .871 LB

 TMASS =  4.563+000     REFIN =  4.963+000

*****************************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA         RHOA        TRA         RHRA
 4.700+001  7.200-001  7.000+001  5.600-001

 CFMIND      CFMOUT
 1.118+003  2.284+003


 RESULTS:

 I  T           P           H           S           X
 1  3.705+001  7.306+001  8.715+001  1.905-001  9.716-001
 2  3.643+001  7.222+001  8.709+001  1.905-001  9.716-001
 3  3.181+001  6.570+001  8.837+001  1.947-001  9.912-001
 4  6.776+001  6.561+001  9.505+001  2.079-001  1.000+000
 5  7.150+001  6.288+001  9.578+001  2.101-001  1.000+000
```

```
  6  1.832+002  2.418+002  1.100+002  2.113-001  1.000+000
  7  1.765+002  2.212+002  1.093+002  2.116-001  1.000+000
  8  1.579+002  2.202+002  1.056+002  2.058-001  1.000+000
  9  1.511+002  2.178+002  1.043+002  2.039-001  1.000+000
 10  1.503+002  2.177+002  1.041+002  2.037-001  1.000+000
 11  8.551+001  2.096+002  3.548+001  8.108-002   .000
 12  8.552+001  2.042+002  3.548+001  8.111-002   .000
 13  3.570+001  9.985+001  3.543+001  8.307-002  2.281-001

  TG3        TSUP3      TG6        RMASS      TMASS
  3.199+001   .000      1.123+002  4.720+002  4.563+000

  QLOAD      ELUSE      COP
  3.407+004  3.567+000  2.799+000

  REFRIG. COMPOSITION =    .650
  (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




  INPUT DATA TO COMPR:

  P3         T3         H3         XQ3        TG6        TRA        TOA
  6.622+001  3.221+001  8.836+001  9.906-001  1.128+002  7.000+001  4.700+001

  COMPRESSOR ITERATION:

  EI         ETAE       ETAC       ETAV       CPRPM      RMASS
  2.721+000  7.577-001  9.472-001  8.565-001  3.549+003  4.762+002

  I  T          P          H          X
  1  3.747+001  7.366+001  8.714+001  9.709-001
  2  3.685+001  7.280+001  8.708+001  9.710-001
  3  3.221+001  6.622+001  8.836+001  9.906-001
  4  6.776+001  6.613+001  9.502+001  1.000+000
  5  7.149+001  6.338+001  9.575+001  1.000+000
  6  1.834+002  2.437+002  1.099+002  1.000+000
  7  1.766+002  2.230+002  1.092+002  1.000+000
  8  1.580+002  2.219+002  1.056+002  1.000+000
  9  1.512+002  2.195+002  1.043+002  1.000+000
 10  1.504+002  2.194+002  1.041+002  1.000+000

  INPUT DATA TO CONDHX:

  T          P          TAIR       RH         RMASS
  1.504+002  2.194+002  7.000+001  5.600-001  4.762+002
 H2,H2PH2=   34.17      .00
 H2,H2PH2=   34.90     -.72
 H2,H2PH2=   34.95     -.05
 H2,H2PH2=   35.07     -.12
 H2,H2PH2=   35.20     -.12
 H2,H2PH2=   35.26     -.07
 H2,H2PH2=   35.27     -.01

  CONDENSER ITERATION:

  T          P          H          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        HIN = 3.527+001
OUTPUT -    POUT= 2.061+002   TOUT= 8.472+001   XOUT=  .000


EXPANSION DEVICE:
INPUT  -    P12  =2.061+002   H12 =3.527+001   P13 =9.444+001
OUTPUT -    POUT =1.597+002   XMASS =4.835+002

INPUT DATA TO COMPR:

P3         T3         H3         XQ3        TG6        TRA        TOA
6.622+001  3.221+001  8.836+001  9.906-001  1.127+002  7.000+001  4.700+001

COMPRESSOR ITERATION:

EI         ETAE       ETAC       ETAV       CPRPM      RMASS
2.719+000  7.576-001  9.473-001  8.567-001  3.549+003  4.763+002

I  T          P          H          X
1  3.748+001  7.366+001  8.714+001  9.709-001
2  3.685+001  7.281+001  8.708+001  9.710-001
3  3.221+001  6.622+001  8.836+001  9.906-001
4  6.773+001  6.610+001  9.502+001  1.000+000
5  7.115+001  6.338+001  9.575+001  1.000+000
6  1.832+002  2.434+002  1.099+002  1.000+000
7  1.764+002  2.226+002  1.092+002  1.000+000
8  1.579+002  2.219+002  1.055+002  1.000+000
9  1.511+002  2.191+002  1.043+002  1.000+000
10 1.503+002  2.190+002  1.041+002  1.000+000

INPUT DATA TO CONDHX:

T          P          TAIR       RH         RMASS
1.503+002  2.190+002  7.000+001  5.600-001  4.763+002
H2,H2PH2=  34.38     .01
H2,H2PH2=  34.56    -.18
H2,H2PH2=  35.32    -.76
H2,H2PH2=  35.35    -.03
H2,H2PH2=  35.42    -.08
H2,H2PH2=  35.45    -.02
H2,H2PH2=  34.62     .63
H2,H2PH2=  34.98    -.16
H2,H2PH2=  35.08    -.11
CONDHX DOES NOT CONVERGE, MAX. ERROR= -1.059-001  (BTU/LB)

CONDENSER ITERATION:

T          P          H          X
1.503+002  2.190+002  1.041+002  1.000+000
8.401+001  2.110+002  3.508+001   .000


LIQUID LINE:
```

```
INPUT  -   PIN = 2.110+002   TIN = 8.401+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 =9.444+001
OUTPUT -   POUT =1.600+002   XMASS =4.861-002

INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.615+001  9.444+001  2.322-001  4.700+001  7.300-001  4.758+002
H2= 90.8930
H2= 88.4190
H2= 86.1198
H2= 85.9054
QT,QS=  2.383+004  2.110+004

EVAPORATOR ITERATION:

T          P          H          X          TSUP
3.615+001  9.444+001  3.581+001  2.322-001
3.733+001  7.386+001  8.589+001  9.569-001   .000

INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.610+001  9.436+001  2.324-001  4.700+001  7.300-001  4.758+002
H2= 90.9397
H2= 88.6861
H2= 86.4198
H2= 86.2107
QT,QS=  2.397+004  2.118+004

EVAPORATOR ITERATION:

T          P          H          X          TSUP
3.610+001  9.436+001  3.581+001  2.324-001
3.725+001  7.366+001  8.618+001  9.603-001   .000
P1,P1E,P1EP1,DENT2=   73.6589   73.6608     .0019     -.9602

INPUT DATA TO COMPR:

P3         T3         H3         XQ3        TG6        TRA        TOA
6.581+001  3.158+001  8.832+001  9.906-001  1.129+002  7.000+001  4.700+001

COMPRESSOR ITERATION:

EI         ETAE       ETAC       ETAV       CPRPM      RMASS
2.717+000  7.575-001  9.471-001  8.556-001  3.549+003  4.725+002

I  T          P          H          X
1  3.712+001  7.317+001  8.710+001  9.709-001
2  3.649+001  7.222+001  8.704+001  9.710-001
3  3.188+001  6.581+001  8.832+001  9.906-001
4  6.774+001  6.571+001  9.504+001  1.000+000
5  7.151+001  6.299+001  9.577+001  1.000+000
6  1.839+002  2.408+002  1.100+002  1.000+000
```

```
 7  1.772+002  2.234+002  1.093+002  1.000+000
 8  1.585+002  2.224+002  1.056+002  1.000+000
 9  1.517+002  2.200+002  1.043+002  1.000+000
10  1.508+002  2.199+002  1.042+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.508+002  2.199+002  7.000+001  5.600-001  4.725+002
H2,H2PH2=   34.04       .00
H2,H2PH2=   34.22     -.18
H2,H2PH2=   34.86     -.64
H2,H2PH2=   34.93     -.08
H2,H2PH2=   34.45      .48
H2,H2PH2=   34.63     -.18
H2,H2PH2=   34.74     -.11
H2,H2PH2=   34.78     -.04
H2,H2PH2=   34.77      .01

 CONDENSER ITERATION:

 T          P          H          X
 1.508+002  2.139+002  1.042+002  1.000+000
 8.280+001  2.123+002  3.477+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.123+002   TIN = 8.280+001   XIN =   .000       HIN = 3.477+001
 OUTPUT -   POUT= 2.039+002   TOUT= 8.278+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.069+002   H12 =3.477+001   P13 =9.387+001
 OUTPUT -   POUT =1.626+002   XMASS =4.999+002

 INPUT DATA TO COMPR:

 P3         T3         H3         XQ3        TG6        TRA        TOA
 6.581+001  3.188+001  8.832+001  9.906-001  1.149+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.742+000  7.586-001  9.464-001  8.539-001  3.548+003  4.711+002

 I  T          P          H          X
 1  3.708+001  7.313+001  8.708+001  9.707-001
 2  3.645+001  7.229+001  8.702+001  9.708-001
 3  3.188+001  6.581+001  8.832+001  9.906-001
 4  6.898+001  6.571+001  9.309+001  1.000+000
 5  7.191+001  6.300+001  9.584+001  1.000+000
 6  1.857+002  2.475+002  1.103+002  1.000+000
 7  1.791+002  2.275+002  1.096+002  1.000+000
 8  1.602+002  2.265+002  1.058+002  1.000+000
 9  1.533+002  2.242+002  1.045+002  1.000+000
10  1.524+002  2.241+002  1.043+002  1.000+000

 INPUT DATA TO CONDHX:
```

```
     T           P           TAIR        RH          RMASS
     1.524+002   2.241+002   7.000+001   5.600-001   4.711+002
    H2,H2PH2=    33.54       -.28
    H2,H2PH2=    33.62       -.08
    H2,H2PH2=    33.87       -.26
    H2,H2PH2=    33.73        .14
    H2,H2PH2=    33.89       -.15
    H2,H2PH2=    33.95       -.06
    H2,H2PH2=    33.94        .01

     CONDENSER ITERATION:

     T           P           H           X
     1.524+002   2.241+002   1.043+002   1.000+000
     7.962+001   2.176+002   3.394+001    .000


     LIQUID LINE:
     INPUT  -    PIN = 2.176+002   TIN = 7.962+001   XIN =   .000      HIN = 3.394+001
     OUTPUT -    POUT= 2.122+002   TOUT= 7.959+001   XOUT=   .000


     EXPANSION DEVICE:
     INPUT  -    P12  =2.122+002   H12 =3.394+001   P13 =9.383+001
     OUTPUT -    POUT =1.820+002   XMASS =5.922+002

     INPUT DATA TO COMPR:

     P3          T3          H3          XQ3         TG6         TRA         TOA
     6.581+001   3.188+001   8.832+001   9.906-001   1.125+002   7.000+001   4.700+001

     COMPRESSOR ITERATION:

     EI          ETAE        ETAC        ETAV        CPRPM       RMASS
     2.710+000   7.572-001   9.473-001   8.561-001   3.549+003   4.729+002

     I  T           P           H           X
     1  3.713+001   7.318+001   8.710+001   9.709-001
     2  3.650+001   7.233+001   8.704+001   9.710-001
     3  3.188+001   6.581+001   8.832+001   9.906-001
     4  6.765+001   6.571+001   9.502+001   1.000+000
     5  7.139+001   6.296+001   9.575+001   1.000+000
     6  1.834+002   2.427+002   1.100+002   1.000+000
     7  1.766+002   2.222+002   1.093+002   1.000+000
     8  1.580+002   2.211+002   1.056+002   1.000+000
     9  1.512+002   2.187+002   1.043+002   1.000+000
    10  1.504+002   2.187+002   1.041+002   1.000+000

     INPUT DATA TO CONDHX:

     T           P           TAIR        RH          RMASS
     1.504+002   2.187+002   7.000+001   5.600-001   4.729+002
    H2,H2PH2=    34.31        .03
    H2,H2PH2=    34.47       -.16
    H2,H2PH2=    35.22       -.75
    H2,H2PH2=    35.26       -.04
    H2,H2PH2=    35.33       -.07
```

```
H2,H2PH2=   35.35    -.02
H2,H2PH2=   35.37    -.02

 CONDENSER ITERATION:

 T          P          H          X
 1.504+002  2.187+002  1.041+002  1.000+000
 8.513+001  2.108+002  3.537+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.108+002   TIN = 3.513+001   XIN =  .000       HIN = 3.537+001
 OUTPUT -   POUT= 2.054+002   TOUT= 3.510+001   XOUT=  .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.054+002   H12 =3.537+001   P13 =9.388+001
DDENFA DOES NOT CONVERGE, DIFXQ2=   -9.61527-006
 OUTPUT -   POUT =1.588+002   XMASS =4.789+002

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.572+001  9.388+001  2.274-001  4.700+001  7.000-001  4.730+002
H2= 91.0375
H2= 89.4232
H2= 87.3639
H2= 87.1429
H2= 87.0711
QT,QS=  2.442+004  2.132+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3 572+001  9.388+001  3.544+001  2.274-001
 3.707+001  7.311+001  3.708+001  9.707-001   .000
P1,P1E,P1EP1,DENT2=   73.1819   73.1082    -.0737    -.0226
INTERM,INTERE,POUT,P13=   1   0  158.83   93.88

 INPUT DATA TO COMPR:

 P3         T3         H3         XQ3        TG6        TRA        TOA
 6.581+001  3.188+001  8 832+001  9.906-001  1.125+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.708+000  7.572-001  9.473-001  8.563-001  3.549+003  4.730+002

 I  T          P          H          X
 1  3.713+001  7.318+001  8.710+001  9.709-001
 2  3.650+001  7.234+001  8.704+001  9.710-001
 3  3.188+001  6.581+001  8.832+001  9.906-001
 4  6.763+001  6.571+001  9.502+001  1.000+000
 5  7.137+001  6.298+001  9.575+001  1.000+000
 6  1.833+002  2.425+002  1.100+002  1.000+000
 7  1.765+002  2.219+002  1.093+002  1.000+000
 8  1.579+002  2.209+002  1.056+002  1.000+000
```

```
  9  1.511+002  2.184+002  1.043+002  1.000+000
 10  1.503+002  2.184+002  1.041+002  1.000+000

  INPUT DATA TO CONDHX:

  T           P          TAIR       RH         RMASS
  1.503+002   2.184+002  7.000+001  5.600-001  4.730+002
 H2,H2PH2=    34.60       -.54
 H2,H2PH2=    34.71       -.10
 H2,H2PH2=    34.75       -.04
 H2,H2PH2=    34.86       -.11
 H2,H2PH2=    35.08       -.21
 H2,H2PH2=    35.17       -.09
 H2,H2PH2=    35.18       -.01

  CONDENSER ITERATION:

  T           P          H          X
  1.503+002   2.184+002  1.041+002  1.000+000
  8.439+001   2.104+002  3.518+001   .000


  LIQUID LINE:
  INPUT  -    PIN = 2.104+002   TIN = 8.439+001   XIN =  .000      HIN = 3.518+001
  OUTPUT -    POUT= 2.049+002   TOUT= 8.437+001   XOUT=  .000


  EXPANSION DEVICE:
  INPUT  -    P12  =2.049+002   H12 =3.518+001   P13 =9.389+001
  OUTPUT -    POUT =1.583+002   XMASS =4.814+002

  INPUT DATA TO COMPR:

  P3          T3          H3          XQ3         TG6         TRA         TOA
  6.581+001   3.188+001   8.932+001   9.906-001   1.124+002   7.000+001   4.700+001

  COMPRESSOR ITERATION:

  EI          ETAE        ETAC        ETAV        CPRPM       RMASS
  2.706+000   7.571-001   9.474-001   8.564-001   3.549+003   4.731+002

  I  T          P          H          X
  1  3.713+001  7.319+001  8.710+001  9.709-001
  2  3.650+001  7.234+001  8.705+001  9.710-001
  3  3.188+001  6.531+001  8.832+001  9.906-001
  4  6.759+001  5.571+001  9.501+001  1.000+000
  5  7.133+001  6.293+001  9.574+001  1.000+000
  6  1.831+002  2.421+002  1.099+002  1.000+000
  7  1.763+002  2.215+002  1.092+002  1.000+000
  8  1.577+002  2.205+002  1.055+002  1.000+000
  9  1.509+002  2.180+002  1.043+002  1.000+000
 10  1.501+002  2.180+002  1.041+002  1.000+000

  INPUT DATA TO CONDHX:

  T           P          TAIR       RH         RMASS
  1.501+002   2.180+002  7.000+001  5.600-001  4.731+002
 H2,H2PH2=    34.82       -.50
```

```
H2,H2PH2=   34.92    -.10
H2,H2PH2=   34.77     .16
H2,H2PH2=   35.16    -.39
H2,H2PH2=   35.36    -.21
H2,H2PH2=   35.44    -.07
H2,H2PH2=   35.43     .01

 CONDENSER ITERATION:

 T           P           H           X
 1.501+002   2.180+002   1.041+002   1.000+000
 8.534+001   2.099+002   3.543+001    .000


 LIQUID LINE:
 INPUT  -    PIN = 2.099+002   TIN = 8.534+001   XIN =   .000        HIN = 3.543+001
 OUTPUT -    POUT= 2.044+002   TOUT= 8.532+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -    P12  =2.044+002   H12 =3.543+001   P13 =9.389+001
 OUTPUT -    POUT =1.576+002   XMASS =4.737+002

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          FMASS
 3.572+001   9.389+001   2.271-001   4.700+001   7.300-001   4.731+002
H2= 91.0529
H2= 89.3913
H2= 87.3205
H2= 87.1003
H2= 87.0362
QT,QS=  2.442+004  2.132+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.572+001   9.389+001   3.543+001   2.271-001
 3.707+001   7.313+001   8.704+001   9.703-001    .000
P1,P1E,P1EP1,DENT2=    73.1884    73.1278     -.0607     -.0620
INTERM,INTERE,POUT,P13=    0    0  157.59   93.89
 COMPOSITION OF REFRIG. IN ACCUMULATOR =  .404
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =     .649 LB

 REFRIG. IN INDOOR COIL =   2.344 LB

 REFRIG. IN OUTDOOR COIL=    .875 LB

 TMASS =  4.984+000     REFIN =  4.968+000

************************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA         RHOA        TRA         RHRA
 4.700+001   7.300-001   7.000+001   5.600-001
```

```
CFMIND     CFMOUT
1.118+003  2.284+003


RESULTS:

 I  T          P          H          S          X
 1  3.713+001  7.319+001  8.710+001  1.903-001  9.709-001
 2  3.650+001  7.234+001  8.705+001  1.904-001  9.710-001
 3  3.188+001  6.581+001  8.832+001  1.946-001  9.906-001
 4  6.759+001  6.571+001  9.501+001  2.078-001  1.000+000
 5  7.133+001  6.298+001  9.574+001  2.100-001  1.000+000
 6  1.831+002  2.421+002  1.099+002  2.112-001  1.000+000
 7  1.763+002  2.215+002  1.092+002  2.115-001  1.000+000
 8  1.577+002  2.205+002  1.055+002  2.057-001  1.000+000
 9  1.509+002  2.180+002  1.043+002  2.033-001  1.000+000
10  1.501+002  2.180+002  1.041+002  2.036-001  1.000+000
11  8.534+001  2.099+002  3.543+001  8.093-002   .000
12  8.532+001  2.044+002  3.543+001  8.101-002   .000
13  3.572+001  9.339+001  3.543+001  8.296-002  2.271-001

TG3        TSUP3      TG6        RMASS      TMASS
3.208+001   .000      1.124+002  4.731+002  4.934+000

QLOAD      ELUSE      COP
3.415+004  3.571+000  2.802+000

REFRIG. COMPOSITION =    .650
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)





FOR THE AMOUNT OF REFRIGERANT STORED IN THE ACCUMULATOR
CIRCULATING COMPOSITION SHOULD BE    .687

NEW CALCULATED COMPOSITION FOR THE NEXT LOOP IS    .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

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

INPUT DATA TO COMPR:

P3         T3         H3         XO3        TG6        TRA        TOA
6.773+001  3.187+001  8.642+001  9.906-001  1.124+002  7.000+001  4.700+001

COMPRESSOR ITERATION:

EI         ETAE       ETAC       ETAV       CPRPM      RMASS
2.763+000  7.595-001  9.470-001  8.577-001  3.548+003  4.985+002

I  T          P          H          X
1  3.722+001  7.547+001  8.524+001  9.708-001
2  3.658+001  7.459+001  8.518+001  9.709-001
3  3.187+001  6.773+001  8.642+001  9.906-001
4  6.722+001  6.764+001  9.295+001  1.000+000
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
  7  1.757+002  2.253+002  1.068+002  1.000+000
  8  1.573+002  2.249+002  1.033+002  1.000+000
  9  1.506+002  2.223+002  1.020+002  1.000+000
 10  1.498+002  2.222+002  1.019+002  1.000+000

  INPUT DATA TO CONDHX:

  T          P          TAIR       RH         RMASS
  1.498+002  2.222+002  7.000+001  5.600-001  4.965+002
 H2,H2PH2=   34.64      -.09
 H2,H2PH2=   35.39      -.75
 H2,H2PH2=   35.80      -.41
 H2,H2PH2=   35.95      -.15
 H2,H2PH2=   36.02      -.07
 H2,H2PH2=   36.07      -.05
 H2,H2PH2=   36.10      -.03
 H2,H2PH2=   36.11      -.01

  CONDENSER ITERATION:

  T          P          H          X
  1.498+002  2.222+002  1.019+002  1.000+000
  8.773+001  2.130+002  3.611+001  1.170-002


  LIQUID LINE:
  INPUT  -   PIN = 2.130+002   TIN = 8.773+001   XIN = 1.170-002   HIN = 3.611+001
  OUTPUT -   POUT= 2.058+002   TOUT= 8.524+001   XOUT= 2.552-002


  EXPANSION DEVICE:
  INPUT  -   P12  =2.058+002   H12 =3.611+001   P13 =9 617+001
  OUTPUT -   POUT =1.549+002   XMASS =4.529+002

  INPUT DATA TO COMPR:

  P3         T3         H3         XQ3        TG6        TRA        TOA
  6.773+001  3.187+001  8.642+001  9.906-001  1.129+002  7.000+001  4.700+001

  COMPRESSOR ITERATION:

  EI         ETAE       ETAC       ETAV       CPRPM      RMASS
  2.775+000  7.600-001  9.467-001  8.568-001  3.548+003  4.558+002

  I  T          P          H          X
  1  3.720+001  7.545+001  8.523+001  9.707-001
  2  3.657+001  7.457+001  8.518+001  9.709-001
  3  3.187+001  6.773+001  8.642+001  9.906-001
  4  6.739+001  6.764+001  9.298+001  1.000+000
  5  7.107+001  6.477+001  9.370+001  1.000+000
  6  1.831+002  2.496+002  1.076+002  1.000+000
  7  1.766+002  2.280+002  1.070+002  1.000+000
  8  1.582+002  2.269+002  1.033+002  1.000+000
  9  1.514+002  2.244+002  1.021+002  1.000+000
 10  1.506+002  2.243+002  1.019+002  1.000+000

  INPUT DATA TO CONDHX:
```

```
 T            P            TAIR         RH           RMASS
 1.506+002    2.243+002    7.000+001    5.600-001    4.958+002
H2,H2PH2=     34.14        -.10
H2,H2PH2=     34.41        -.27
H2,H2PH2=     34.94        -.53
H2,H2PH2=     34.59         .35
H2,H2PH2=     34.81        -.22
H2,H2PH2=     34.92        -.11
H2,H2PH2=     34.99        -.07
H2,H2PH2=     34.98         .01

 CONDENSER ITERATION:

 T            P            H            X
 1.506+002    2.243+002    1.019+002    1.000+000
 8.545+001    2.153+002    3.498+001     .000


 LIQUID LINE:
 INPUT  -     PIN = 2.158+002    TIN = 8.545+001    XIN =   .000        HIN = 3.498+001
 OUTPUT -     POUT= 2.099+002    TOUT= 8.543+001    XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -     P12  =2.099+002    H12 =3.498+001    P13 =9.615+001
 OUTPUT -     POUT =1.627+002    XMASS =4.909+002

 INPUT DATA TO COMPR:

 P3           T3           H3           XQ3          TG6          TRA          TOA
 6.773+001    3.187+001    8.642+001    9.906-001    1.130+002    7.000+001    4.700+001

 COMPRESSOR ITERATION:

 EI           ETAE         ETAC         ETAV         CPRPM        RMASS
 2.777+000    7.601-001    9.466-001    8.567-001    3.543+003    4.957+002

 I  T            P            H            X
 1  3.720+001    7.545+001    8.523+001    9.707-001
 2  3.657+001    7.457+001    8.517+001    9.708-001
 3  3.187+001    6.773+001    8.642+001    9.906-001
 4  6.740+001    6.764+001    9.298+001    1.000+000
 5  7.109+001    6.477+001    9.370+001    1.000+000
 6  1.835+002    2.498+002    1.076+002    1.000+000
 7  1.767+002    2.282+002    1.070+002    1.000+000
 8  1.582+002    2.272+002    1.034+002    1.000+000
 9  1.515+002    2.245+002    1.021+002    1.000+000
10  1.507+002    2.245+002    1.020+002    1.000+000

 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
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```
H2,H2PH2=   35.11    -.05
H2,H2PH2=   35.12    -.01

 CONDENSER ITERATION:

 T          P          H          X
 1.507+002  2.246+002  1.020+002  1.000+000
 8.602+001  2.162+002  3.512+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.162+002   TIN = 8.602+001   XIN =  .000       HIN = 3.512+001
 OUTPUT -   POUT= 2.104+002   TOUT= 8.593+001   XOUT=  .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.104+002   H12 =3.512+001   P13 =9.615+001
 OUTPUT -   POUT =1.624+002   XMASS =4.885+002

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.576+001  9.615+001  2.212-001  4.700+001  7.300-001  4.960+002
H2= 89.0996
H2= 87.5662
H2= 85.5736
QT,QS=  2.522+004  2.238+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.576+001  9.615+001  3.467+001  2.212-001
 3.685+001  7.485+001  8 552+001  9.745-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.591+001  9.639+001  2.206-001  4.700+001  7.300-001  4.990+002
H2= 88.9841
H2= 86.9319
H2= 84.7277
QT,QS=  2.482+004  2.210+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.591+001  9.639+001  3.467+001  2.206-001
 3.707+001  7.546+001  8.471+001  9.648-001   .000
P1,P1E,P1EP1,DENT2=   75.4489   75.4558     .0068    -.5204
INTERM,INTERE,POUT,P13=   1   0  162.35   96.39

 INPUT DATA TO COMPR:

 P3         T3         H3         XO3        TG6        TRA        TOA
 6.773+001  3.187+001  8.642+001  9.906-001  1.128+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

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```
EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.772+000   7.599-001   9.468-001   8.571-001   3.548+003   4.960+002

I  T           P           H           X
1  3.721+001   7.546+001   8.523+001   9.708-001
2  3.657+001   7.457+001   8.519+001   9.709-001
3  3.187+001   6.773+001   8.642+001   9.906-001
4  6.734+001   6.764+001   9.297+001   1.000+000
5  7.101+001   6.477+001   9.369+001   1.000+000
6  1.832+002   2.491+002   1.076+002   1.000+000
7  1.763+002   2.274+002   1.069+002   1.000+000
8  1.579+002   2.263+002   1.033+002   1.000+000
9  1.512+002   2.238+002   1.021+002   1.000+000
10 1.504+002   2.237+002   1.019+002   1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.504+002   2.237+002   7.000+001   5.600-001   4.960+002
H2 H2PH2=   34.09      -.10
H2,H2PH2=   34.97      -.88
H2,H2PH2=   34.77       .20
H2,H2PH2=   35.10      -.33
H2,H2PH2=   35.25      -.15
H2,H2PH2=   35.33      -.08
H2,H2PH2=   35.32       .00

CONDENSER ITERATION:

T           P           H           X
1.504+002   2.237+002   1.019+002   1.000+000
8.677+001   2.150+002   3.532+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.150+002   TIN = 8.677+001   XIN =  .000        HIN = 3.532+001
OUTPUT -    POUT= 2.091+002   TOUT= 8.626+001   XOUT= 2.741-003


EXPANSION DEVICE:
INPUT  -    P12  =2.091+002   H12 =3.532+001   P13 =3.640+001
OUTPUT -    POUT =1.603+002   XMASS =4.795+002

INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.773+001   3.187+001   8.642+001   9.906-001   1.123+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.760+000   7.594-001   9.471-001   8.578-001   3.548+003   4.965+002

I  T           P           H           X
1  3.722+001   7.548+001   8.524+001   9.708-001
2  3.659+001   7.459+001   8.519+001   9.710-001
3  3.187+001   6.773+001   8.642+001   9.906-001
4  6.720+001   6.764+001   9.295+001   1.000+000
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```
  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

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.497+002  2.218+002  7.000+001  5.600-001  4.966+002
H2,H2PH2=   34.99     -.08
H2,H2PH2=   35.62     -.63
H2,H2PH2=   35.95     -.33
H2,H2PH2=   36.13     -.18
H2,H2PH2=   36.23     -.09
H2,H2PH2=   36.29     -.06
H2,H2PH2=   36.32     -.03
H2,H2PH2=   36.33     -.02

 CONDENSER ITERATION:

 T          P          H          X
 1.497+002  2.218+002  1.019+002  1.000+000
 8.756+001  2.124+002  3.633+001  1.752-002


 LIQUID LINE:
 INPUT  -   PIN = 2.124+002   TIN = 8.756+001   XIN = 1.752-002   HIN = 3.633+001
 OUTPUT -   POUT= 2.047+002   TOUT= 8.491+001   XOUT= 3.220-002


 EXPANSION DEVICE:
 INPUT  -   P12  =2.047+002   H12 =3.633+001   P13 =9.641+001
 OUTPUT -   POUT =1.536+002   XMASS =4.455+002

 INPUT DATA TO COMPR:

 P3         T3         H3         XQ3        TG6        TRA        TOA
 6.773+001  3.187+001  8.642+001  9.906-001  1.130+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.777+000  7.601-001  9.466-001  8.567-001  3.548+003  4.957+002

 I  T          P          H          X
 1  3.720+001  7.545+001  8.523+001  9.707-001
 2  3.656+001  7.457+001  8.517+001  9.703-001
 3  3.187+001  6.773+001  8.642+001  9.906-001
 4  6.741+001  6.764+001  9.299+001  1.000+000
 5  7.109+001  6.477+001  9.370+001  1.000+000
 6  1.835+002  2.499+002  1.077+002  1.000+000
 7  1.767+002  2.283+002  1.070+002  1.000+000
 8  1.583+002  2.273+002  1.034+002  1.000+000
 9  1.515+002  2.247+002  1.021+002  1.000+000
10  1.507+002  2.247+002  1.020+002  1.000+000
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```
 INPUT DATA TO CONDHX:

 T           P           TAIR        RH          RMASS
 1.507+002   2.247+002   7.000+001   5.600-001   4.957+002
H2,H2PH2=    33.97      -.11
H2,H2PH2=    34.23      -.26
H2,H2PH2=    34.79      -.55
H2,H2PH2=    35.03      -.24
H2,H2PH2=    35.08      -.05
H2,H2PH2=    35.09      -.01

 CONDENSER ITERATION:

 T           P           H           X
 1.507+002   2.247+002   1.020+002   1.000+000
 8.588+001   2.163+002   3.509+001    .000


 LIQUID LINE:
 INPUT  -    PIN = 2.163+002   TIN = 8.588+001   XIN =  .000       HIN = 3.509+001
 OUTPUT -    POUT= 2.105+002   TOUT= 8.534+001   XOUT=  .000


 EXPANSION DEVICE:
 INPUT  -    P12  =2.105+002   H12 =3.509+001   P13 =9.639+001
DDENFA DOES NOT CONVERGE, DIFXQ2=    -8.00648-006
 OUTPUT -    POUT =1.626+002   XMASS =4.904+002

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TGS         TRA         TOA
 6.773+001   3.187+001   8.642+001   9.906-001   1.131+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:

 EI          ETAE        ETAC        ETAV        CPRPM       RMASS
 2.779+000   7.602-001   9.466-001   8.566-001   3.548+003   4.956+002

 I  T           P           H           X
 1  3.720+001   7.544+001   8.523+001   9.707-001
 2  3.656+001   7.456+001   8.517+001   9.708-001
 3  3.187+001   6.773+001   8.642+001   9.906-001
 4  6.744+001   6.764+001   9.299+001   1.000+000
 5  7.113+001   6.478+001   9.371+001   1.000+000
 6  1.837+002   2.502+002   1.077+002   1.000+000
 7  1.769+002   2.286+002   1.070+002   1.000+000
 8  1.584+002   2.276+002   1.034+002   1.000+000
 9  1.516+002   2.251+002   1.021+002   1.000+000
10  1.509+002   2.250+002   1.020+002   1.000+000

 INPUT DATA TO CONDHX:

 T           P           TAIR        RH          RMASS
 1.509+002   2.250+002   7.000+001   5.600-001   4.956+002
H2,H2PH2=    33.80      -.12
H2,H2PH2=    34.57      -.77
H2,H2PH2=    34.47       .10
H2,H2PH2=    34.78      -.31
```

```
H2,H2PH2=   34.88     -.10
H2,H2PH2=   34.94     -.06
H2,H2PH2=   34.94      .00

 CONDENSER ITERATION:

 T          P          H          X
 1.509+002  2.250+002  1.020+002  1.000+000
 8.530+001  2.167+002  3.494+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.167+002   TIN = 8.530+001   XIN =. .000       HIN = 3.494+001
 OUTPUT -   POUT= 2.109+002   TOUT= 8.527+001   XOUT=  .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.109+002   H12 =3.494+001   P13 =9.638+001
 OUTPUT -   POUT =1.638+002   XMASS =4.954+002

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.597+001  9.638+001  2.253-001  4.700+001  7.300-001  4.956+002
H2= 89.0563
H2= 87.3074
H2= 85.2126
H2= 85.1421
H2= 85.0411
QT,QS=  2.483+004  2.153+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.597+001  9.638+001  3.494+001  2.253-001
 3.698+001  7.520+001  8.505+001  9.689-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.603+001  9.648+001  2.251-001  4.700+001  7.300-001  4.956+002
H2= 89.0079
H2= 87.0411
H2= 84.8757
H2= 84.8077
H2= 84.7199
QT,QS=  2.468+004  2.145+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.603+001  9.648+001  3.494+001  2.251-001
 3.707+001  7.544+001  8.473+001  9.651-001   .000
P1,P1E,P1EP1,DENT2=   75.4447   75.4423    -.0024    -.4981
INTERM,INTERE,POUT,P13=   0   0  163.83   96.48
 COMPOSITION OF REFRIG. IN ACCUMULATOR =  .414
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
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REFRIG. IN ACCUMULATOR =      .796 LB

REFRIG. IN INDOOR COIL =    2.492 LB

REFRIG. IN OUTDOOR COIL=      .915 LB

TMASS =  5.350+000      REFIN =  4.968+000

*******************************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

TOA         RHOA        TRA         RHRA
4.700+001   7.300-001   7.000+001   5.600-001

CFMIND      CFMOUT
1.118+003   2.284+003


RESULTS:

 I  T           P           H           S           X
 1  3.720+001   7.544+001   8.523+001   1.862-001   9.707-001
 2  3.656+001   7.456+001   8.517+001   1.863-001   9.703-001
 3  3.187+001   6.773+001   8.642+001   1.905-001   9.906-001
 4  6.744+001   6.764+001   9.259+001   2.035-001   1.000+000
 5  7.113+001   6.478+001   9.371+001   2.056-001   1.000+000
 6  1.837+002   2.502+002   1.077+002   2.067-001   1.000+000
 7  1.769+002   2.286+002   1.070+002   2.071-001   1.000+000
 8  1.534+002   2.276+002   1.034+002   2.014-001   1.000+000
 9  1.516+002   2.251+002   1.021+002   1.996-001   1.000+000
10  1.509+002   2.250+002   1.020+002   1.993-001   1.000+000
11  8.530+001   2.167+002   3.494+001   7.987-002    .000
12  8.527+001   2.109+002   3.494+001   7.989-002    .000
13  3.603+001   9.648+001   3.494+001   8.179-002   2.251-001

TG3         TSUP3       TG6         RMASS       TMASS
3.208+001    .000       1.131+002   4.956+002   5.350+000

QLOAD       ELUSE       COP
3.487+004   3.644+000   2.804+000

REFRIG. COMPOSITION =    .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.713+001   3.151+001   8.723+001   1.000+000   1.121+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.750+000   7.589-001   9.475-001   8.562-001   3.548+003   4.877+002

 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  1.082+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

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.527+002  2.221+002  7.000+001  5.600-001  4.877+002
H2,H2PH2=   34.66      -.68
H2,H2PH2=   34.60       .06
H2,H2PH2=   35.22      -.62
H2,H2PH2=   35.47      -.25
H2,H2PH2=   35.57      -.10
H2,H2PH2=   35.57       .00
H2,H2PH2=   35.57       .00

 CONDENSER ITERATION:

 T          P          H          X
 1.527+002  2.221+002  1.024+002  1.000+000
 8.772+001  2.135+002  3.557+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.135+002   TIN = 8.772+001   XIN =  .000        HIN = 3.557+001
 OUTPUT -   POUT= 2.074+002   TOUT= 8.571+001   XOUT= 1.127-002


 EXPANSION DEVICE:
 INPUT  -   P12  =2.074+002   H12 =3.557+001   P13 =9.577+001
 OUTPUT -   POUT =1.582+002   XMASS =4.691+002

 INPUT DATA TO COMPR:

 P3         T3         H3         XQ3        TG6        TRA        TOA
 6.713+001  3.161+001  8.723+001  1.000+000  1.124+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.756+000  7.592-001  9.473-001  8.558-001  3.548+003  4.873+002

 I  T          P          H          X
 1  3.688+001  7.473+001  8.599+001  9.798-001
 2  3.626+001  7.387+001  8.593+001  9.799-001
 3  3.161+001  6.713+001  8.723+001  1.000+000
 4  7.026+001  6.704+001  9.348+001  1.000+000
 5  7.399+001  6.423+001  9.420+001  1.000+000
 6  1.863+002  2.480+002  1.083+002  1.000+000
 7  1.796+002  2.268+002  1.076+002  1.000+000
 8  1.610+002  2.258+002  1.039+002  1.000+000
```

```
 9  1.540+002  2.233+002  1.026+002  1.000+000
10  1.531+002  2.232+002  1.025+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.531+002  2.232+002  7.000+001  5.600-001  4.873+002
H2,H2PH2=   34.30      -.58
H2,H2PH2=   34.33      -.03
H2,H2PH2=   34.32      -.59
H2,H2PH2=   34.49       .43
H2,H2PH2=   34.71      -.22
H2,H2PH2=   34.82      -.11
H2,H2PH2=   34.89      -.07
H2,H2PH2=   34.88       .01

CONDENSER ITERATION:

T          P          H          X
1.531+002  2.232+002  1.025+002  1.000+000
8.504+001  2.149+002  3.488+001   .000


LIQUID LINE:
INPUT  -   PIN = 2.149+002   TIN = 8.504+001   XIN =   .000        HIN = 3.488+001
OUTPUT -   POUT= 2.093+002   TOUT= 8.502+001   XOUT=   .000


EXPANSION DEVICE:
INPUT  -   P12  =2.093+002   H12 =3.488+001   P13 =9.576+001
OUTPUT -   POUT =1.620+002   XMASS =4.908+002

 INPUT DATA TO COMPR:

P3         T3         H3         XQ3        TG6        TRA        TOA
6.713+001  3.161+001  8.723+001  1.000+000  1.124+002  7.000+001  4.700+001

COMPRESSOR ITERATION:

EI         ETAE       ETAC       ETAV       CPRPM      RMASS
2.755+000  7.592-001  9.474-001  8.559-001  3.548+003  4.874+002

I  T          P          H          X
1  3.688+001  7.473+001  8.599+001  9.798-001
2  3.626+001  7.388+001  8.593+001  9.799-001
3  3.161+001  6.713+001  8.723+001  1.000+000
4  7.025+001  6.704+001  9.347+001  1.000+000
5  7.393+001  6.423+001  9.419+001  1.000+000
6  1.862+002  2.478+002  1.083+002  1.000+000
7  1.795+002  2.267+002  1.076+002  1.000+000
8  1.609+002  2.256+002  1.039+002  1.000+000
9  1.539+002  2.231+002  1.026+002  1.000+000
10 1.531+002  2.230+002  1.025+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.531+002  2.230+002  7.000+001  5.600-001  4.874+002
```

```
H2,H2PH2=   34.40    -.56
H2,H2PH2=   34.42    -.03
H2,H2PH2=   35.00    -.58
H2,H2PH2=   34.60     .41
H2,H2PH2=   34.83    -.23
H2,H2PH2=   34.93    -.11
H2,H2PH2=   34.99    -.06
H2,H2PH2=   34.98     .01

 CONDENSER ITERATION:

 T           P           H           X
 1.531+002   2.230+002   1.025+002   1.000+000
 8.546+001   2.147+002   3.498+001    .000


 LIQUID LINE:
 INPUT  -    PIN = 2.147+002   TIN = 8.546+001   XIN =   .000       HIN = 3.498+001
 OUTPUT -    POUT= 2.091+002   TOUT= 8.544+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -    P12  =2.091+002   H12 =3.498+001   P13 =9.576+001
DDENFA DOES NOT CONVERGE, DIFXQ2=    -3.49636-006
 OUTPUT -    POUT =1.612+002   XMASS =4.867+002

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          RMASS
 3.560+001   9.576+001   2.276-001   4.700+001   7.300-001   4.874+002
H2= 89.2099
H2= 88.1069
H2= 86.9356
H2= 86.5808
QT,QS=  2.513+004  2.190+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.560+001   9.576+001   3.499+001   2.276-001
 3.676+001   7.436+001   8.655+001   9.864-001    .000

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          RMASS
 3.569+001   9.591+001   2.273-001   4.700+001   7.300-001   4.874+002
H2= 89.1770
H2= 87.9079
H2= 86.4846
H2= 86.1747
QT,QS=  2.493+004  2.177+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.569+001   9.591+001   3 499+001   2.273-001
 3.691+001   7.472+001   8.614+001   9.815-001    .000
P1,P1E,P1EP1,DENT2=    74.7282    74.7190    -.0091     .1507
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INTERM,INTERE,POUT,P13=    0    0  161.18    95.91
 COMPOSITION OF REFRIG. IN ACCUMULATOR =   .668
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =      .190 LB

 REFRIG. IN INDOOR COIL =    2.392 LB

 REFRIG. IN OUTDOOR COIL=     .882 LB

 TMASS =  4.602+000      REFIN =  4.968+000

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**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA         RHOA        TRA         RHRA
 4.700+001   7.300-001   7.000+001   5.600-001

 CFMIND      CFMOUT
 1.118+003   2.284+003


 RESULTS:

 I  T           P           H           S           X
 1  3.688+001   7.473+001   8.599+001   1.879-001   9.798-001
 2  3.626+001   7.388+001   8.593+001   1.880-001   9.799-001
 3  3.161+001   6.713+001   8.723+001   1.923-001   1.000+000
 4  7.025+001   6.704+001   9.347+001   2.045-001   1.000+000
 5  7.398+001   6.423+001   9.419+001   2.066-001   1.000+000
 6  1.862+002   2.478+002   1.083+002   2.078-001   1.000+000
 7  1.795+002   2.267+002   1.076+002   2.082-001   1.000+000
 8  1.609+002   2.256+002   1.039+002   2.025-001   1.000+000
 9  1.539+002   2.231+002   1.026+002   2.005-001   1.000+000
10  1.531+002   2.230+002   1.025+002   2.003-001   1.000+000
11  8.546+001   2.147+002   3.498+001   7.996-002    .000
12  8.514+001   2.091+002   3.496+001   7.998-002    .000
13  3.569+001   9.591+001   3.498+001   8.191-002   2.273-001

 TG3         TSUP3       TG6         RMASS       TMASS
 3.161+001    .000       1.124+002   4.874+002   4.602+000

 QLOAD       ELUSE       COP
 3.455+004   3.620+000   2.796+000

 REFRIG. COMPOSITION =    .668
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TG6         TRA         TOA
 6.743+001   3.173+001   8.683+001   9.953-001   1.127+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:
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EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2 767+000   7.597-001   9.470-001   8.562-001   3.548+003   4.914+002

I  T           P           H           X
1  3.703+001   7.508+001   8.561+001   9.753-001
2  3.641+001   7.421+001   8.555+001   9.754-001
3  3.173+001   6.743+001   8.683+001   9.953-001
4  6.884+001   6.733+001   9.323+001   1.000+000
5  7.255+001   6.449+001   9.395+001   1.000+000
6  1.850+002   2.490+002   1.080+002   1.000+000
7  1.782+002   2.278+002   1.073+002   1.000+000
8  1.597+002   2.266+002   1.037+002   1.000+000
9  1.528+002   2.241+002   1.024+002   1.000+000
10 1.520+002   2.240+002   1.022+002   1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.520+002   2.240+002   7.000+001   5.600-001   4.914+002
H2,H2PH2=   34.03       -.07
H2,H2PH2=   34.28       -.25
H2,H2PH2=   34.78       -.51
H2,H2PH2=   35.03       -.25
H2,H2PH2=   35.08       -.05
H2,H2PH2=   35.09       -.01

CONDENSER ITERATION:

T           P           H           X
1.520+002   2.240+002   1.022+002   1.000+000
8.589+001   2.158+002   3.509+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.158+002   TIN = 8.589+001   XIN =  .000      HIN = 3.509+001
OUTPUT -    POUT= 2.100+002   TOUT= 8.586+001   XOUT=  .000


EXPANSION DEVICE:
INPUT  -    P12  =2.100+002   H12 =3.509+001   P13 =9.626+001
OUTPUT -    POUT =1.518+002   XMASS =4.878+002

INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.743+001   3.173+001   8.683+001   9.953-001   1.128+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.769+000   7.597-001   9.469-001   8.561-001   3.548+003   4.914+002

I  T           P           H           X
1  3.703+001   7.508+001   8.561+001   9.753-001
2  3.641+001   7.421+001   8.555+001   9.754-001
3  3.173+001   6.743+001   8.683+001   9.953-001
4  6.883+001   6.733+001   9.323+001   1.000+000
5  7.254+001   6.450+001   9.395+001   1.000+000
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   6  1.850+002  2.491+002  1.080+002  1.000+000
   7  1.783+002  2.278+002  1.073+002  1.000+000
   8  1.597+002  2.268+002  1.037+002  1.000+000
   9  1.529+002  2.242+002  1.024+002  1.000+000
  10  1.520+002  2.242+002  1.022+002  1.000+000

   INPUT DATA TO CONDHX:

   T          P          TAIR       RH         RMASS
   1.520+002  2.242+002  7.000+001  5.300-001  4.914+002
  H2,H2PH2=   33.94     -.07
  H2,H2PH2=   34.18     -.24
  H2,H2PH2=   34.70     -.52
  H2,H2PH2=   34.94     -.24
  H2,H2PH2=   34.99     -.05
  H2,H2PH2=   35.01     -.01

   CONDENSER ITERATION:

   T          P          H          X
   1.520+002  2.242+002  1.022+002  1.000+000
   8.556+001  2.160+002  3.501+001   .000


   LIQUID LINE:
   INPUT  -   PIN = 2.160+002   TIN = 8.556+001   XIN =   .000      HIN = 3.501+001
   OUTPUT -   POUT= 2.102+002   TOUT= 8.552+001   XOUT=   .000


   EXPANSION DEVICE:
   INPUT  -   P12  =2.102+002   H12 =3.501+001   P13 =9.626+001
   OUTPUT -   POUT =1.628+002   XMASS =4.915+002

   INPUT DATA TO EVAPHX:

   T          P          X          TAIR       RH         RMASS
   3.591+001  9.626+001  2.268-001  4.700+001  7.300-001  4.914+002
  H2= 89.0907
  H2= 87.5102
  H2= 85.5433
  H2= 85.3556
  H2= 85.2817
  QT,QS=  2.471+004  2.146+004

   EVAPORATOR ITERATION:

   T          P          H          X          TSUP
   3.591+001  9.626+001  3.501+001  2.268-001
   3.704+001  7.520+001  8.529+001  9.716-001   .000
  P1,P1E,P1EP1,DENT2=    75.0783    75.2007      .1225     -.3170
  INTERM,INTERE,POUT,P13=    0    0   162.77    96.26
   COMPOSITION OF REFRIG. IN ACCUMULATOR =   .645
   (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

   REFRIG. IN ACCUMULATOR =     .205 LB

   REFRIG. IN INDOOR COIL =   2.475 LB
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REFRIG. IN OUTDOOR COIL=     .903 LB

TMASS =  4.726+000      REFIN =  4.968+000

*******************************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

TOA          RHOA         TRA          RHRA
4.700+001    7.300-001    7.000+001    5.600-001

CFMIND       CFMOUT
1.118+003    2.204+003


RESULTS:

 I   T           P           H           S           X
 1   3.703+001   7.503+001   8.561+001   1.871-001   9.753-001
 2   3.641+001   7.421+001   8.555+001   1.872-001   9.754-001
 3   3.173+001   6.743+001   8.633+001   1.914-001   9.953-001
 4   6.883+001   6.733+001   9.323+001   2.040-001   1.000+000
 5   7.254+001   6.450+001   9.395+001   2.061-001   1.000+000
 6   1.850+002   2.491+002   1.080+002   2.073-001   1.000+000
 7   1.783+002   2.278+002   1.073+002   2.076-001   1.000+000
 8   1.597+002   2.265+002   1.037+002   2.019-001   1.000+000
 9   1.528+002   2.242+002   1.024+002   2.001-001   1.000+000
10   1.520+002   2.242+002   1.022+002   1.998-001   1.000+000
11   8.556+001   2.160+002   3.501+001   8.000-002    .000
12   8.552+001   2.102+002   3.501+001   8.002-002    .000
13   3.591+001   9.626+001   3.501+001   8.194-002   2.263-001

TG3          TSUP3        TG6          RMASS        TMASS
3.184+001     .000        1.123+002    4.914+002    4.726+000

QLOAD        ELUSE        COP
3.469+004    3.634+000    2.797+000

REFRIG. COMPOSITION =    .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




INPUT DATA TO COMPR:

P3           T3           H3           XQ3          TG6          TRA          TOA
6.800+001    3.213+001    8.606+001    9.930-001    1.135+002    7.000+001    4.700+001

COMPRESSOR ITERATION:

EI           ETAE         ETAC         ETAV         CPRPM        RMASS
2.792+000    7.607-001    9.465-001    8.563-001    3.548+003    4.965+002

 I   T           P           H           X
 1   3.745+001   7.573+001   8.545+001   9.729-001
 2   3.682+001   7.485+001   8.539+001   9.731-001
 3   3.213+001   6.800+001   8.666+001   9.930-001
 4   6.834+001   6.791+001   9.313+001   1.000+000
```

```
 5  7.204+001   6.504+001   9.385+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  1.596+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   2.266+002   1.021+002   1.000+000

 INPUT DATA TO CONDHX:

 T           P           TAIR        RH          RMASS
 1.519+002   2.266+002   7.000+001   5.600-001   4.965+002
H2,H2PH2=    33.58       -.25
H2,H2PH2=    33.83       -.25
H2,H2PH2=    34.28       -.45
H2,H2PH2=    34.53       -.25
H2,H2PH2=    34.57       -.04
H2,H2PH2=    34.57        .00

 CONDENSER ITERATION:

 T           P           H           X
 1.519+002   2.266+002   1.021+002   1.000+000
 8.385+001   2.187+002   3.457+001    .000


 LIQUID LINE:
 INPUT  -    PIN = 2.187+002   TIN = 8.385+001   XIN =  .000        HIN = 3.457+001
 OUTPUT -    POUT= 2.129+002   TOUT= 8.383+001   XOUT=  .000


 EXPANSION DEVICE:
 INPUT  -    P12  =2.129+002   H12 =3.457+001   P13 =9.691+001
 OUTPUT -    POUT =1.675+002   XMASS =5.131+002

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TG6         TRA         TOA
 6.800+001   3.213+001   8.666+001   9.930-001   1.133+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:

 EI          ETAE        ETAC        ETAV        CPRPM       RMASS
 2.787+000   7.605-001   9.467-001   8.566-001   3.546+003   4.968+002

 I  T           P           H           X
 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
 4  6.828+001   6.791+001   9.312+001   1.000+000
 5  7.196+001   6.504+001   9.383+001   1.000+000
 6  1.845+002   2.509+002   1.078+002   1.000+000
 7  1.777+002   2.294+002   1.071+002   1.000+000
 8  1.592+002   2.283+002   1.035+002   1.000+000
 9  1.524+002   2.257+002   1.022+002   1.000+000
10  1.516+002   2.257+002   1.021+002   1.000+000

 INPUT DATA TO CONDHX:
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```
 T            P            TAIR         RH           RMASS
 1.516+002    2.257+002    7.000+001    5.600-001    4.938+002
H2,H2PH2=     34.03        -.58
H2,H2PH2=     34.25        -.22
H2,H2PH2=     34.19         .06
H2,H2PH2=     34.54        -.35
H2,H2PH2=     34.70        -.16
H2,H2PH2=     34.74        -.04
H2,H2PH2=     34.74         .00

 CONDENSER ITERATION:

 T            P            H            X
 1.516+002    2.257+002    1.021+002    1.000+000
 8.452+001    2.175+002    3.474+001     .000


 LIQUID LINE:
 INPUT  -     PIN = 2.175+002    TIN = 8.452+001    XIN =   .000        HIN = 3.474+001
 OUTPUT -     POUT= 2.117+002    TOUT= 8.448+001    XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -     P12  =2.117+002    H12 =3.474+001    P13 =9.692+001
 OUTPUT -     POUT =1.656+002    XMASS =5.038+002

 INPUT DATA TO EVAPHX:

 T            P            X            TAIR         RH           RMASS
 3.627+001    9.692+001    2.227-001    4.700+001    7.300-001    4.970+002
H2= 83.7629
H2= 85.5637
H2= 83.2565
QT,QS=   2.403+004   2.155+004

 EVAPORATOR ITERATION:

 T            P            H            X            TSUP
 3.627+001    9.692+001    3.486-001    2.227-001
 3.741+001    7.649+001    8.322+001    9.469-001     .000

 INPUT DATA TO EVAPHX:

 T            P            X            TAIR         RH           RMASS
 3.610+001    9.662+001    2.234-001    4.700+001    7.300-001    4.970+002
H2= 88.9210
H2= 86.5753
H2= 84.3140
QT,QS=   2.456+004   2.193+004

 EVAPORATOR ITERATION:

 T            P            H            X            TSUP
 3.610+001    9.662+001    3.486+001    2.234-001
 3.717+001    7.574+001    8.429+001    9.598-001     .000
P1,P1E,P1EP1,DENT2=    75.7395    75.7413      .0017    -1.1637

 INPUT DATA TO COMPR:
```

```
P3          T3          H3          XQ3         TG6         TRA         TOA
6.749+001   3.173+001   8.662+001   9.930-001   1.128+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.770+000   7.598-001   9.468-001   8.563-001   3.548+003   4.928+002

I   T           P           H           X
1   3.704+001   7.516+001   8.541+001   9.730-001
2   3.641+001   7.428+001   8.505+001   9.731-001
3   3.173+001   6.749+001   8.662+001   9.930-001
4   6.810+001   6.739+001   9.311+001   1.000+000
5   7.180+001   6.434+001   9.383+001   1.000+000
6   1.843+002   2.493+002   1.078+002   1.000+000
7   1.775+002   2.279+002   1.071+002   1.000+000
8   1.590+002   2.268+002   1.035+002   1.000+000
9   1.522+002   2.243+002   1.023+002   1.000+000
10  1.514+002   2.242+002   1.021+002   1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.514+002   2.242+002   7.000+001   5.600-001   4.928+002
H2,H2PH2=   33.99     -.08
H2,H2PH2=   34.24     -.25
H2,H2PH2=   34.77     -.53
H2,H2PH2=   35.01     -.24
H2,H2PH2=   35.07     -.05
H2,H2PH2=   35.08     -.01

CONDENSER ITERATION:

T           P           H           X
1.514+002   2.242+002   1.021+002   1.000+000
8.583+001   2.160+002   3.508+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.160+002   TIN = 8.533+001   XIN =   .000       HIN = 3.508+001
OUTPUT -    POUT= 2.102+002   TOUT= 8.510+001   XOUT=   .000


EXPANSION DEVICE:
INPUT  -    P12  =2.102+002   H12 =3.508+001   P13 =9.604+001
DDENFA DOES NOT CONVERGE, DIFXQ2=    -5.18214-006
OUTPUT -    POUT =1.628+002   XMASS =4.897+002

INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.749+001   3.173+001   8.662+001   9.930-001   1.129+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.772+000   7.599-001   9.467-001   8.562-001   3.548+003   4.927+002
```

```
 I  T          P          H          X
 1  3.704+001  7.515+001  8.541+001  9.730-001
 2  3.641+001  7.428+001  8.525+001  9.731-001
 3  3.173+001  6.749+001  8.662+001  9.930-001
 4  6.813+001  6.739+001  9.311+001  1.000+000
 5  7.183+001  6.455+001  9.383+001  1.000+000
 6  1.844+002  2.495+002  1.078+002  1.000+000
 7  1.776+002  2.281+002  1.072+002  1.000+000
 8  1.591+002  2.271+002  1.035+002  1.000+000
 9  1.523+002  2.246+002  1.023+002  1.000+000
10  1.515+002  2.245+002  1.021+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.515+002  2.245+002  7.000+001  5.600-001  4.927+002
H2,H2PH2=   33.35     -.09
H2,H2PH2=   34.09     -.25
H2,H2PH2=   34.65     -.55
H2,H2PH2=   34.88     -.24
H2,H2PH2=   34.93     -.05
H2,H2PH2=   34.94     -.01

 CONDENSER ITERATION:

 T          P          H          X
 1.515+002  2.245+002  1.021+002  1.000+000
 8.530+001  2.163+002  3.494+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.163+002   TIN = 8.530+001   XIN =   .000       HIN = 3.494+001
 OUTPUT -   POUT= 2.105+002   TOUT= 8.527+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.105+002   H12 =3.494+001   P13 =9.604+001
 OUTPUT -   POUT =1.635+002   XMASS =4.942+002

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.576+001  9.604+001  2.262-001  4.700+001  7.300-001  4.927+002
H2= 89.1718
H2= 87.8456
H2= 86.2838
H2= 86.0935
H2= 86.0077
QT,QS=  2.516+004  2.170+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.576+001  9.604+001  3.494+001  2.262-001
 3.679+001  7.459+001  8.601+001  9.802-001   .000

 INPUT DATA TO EVAPHX:
```

```
 T           P           X            TAIR        RH          RMASS
 3.589+001   9.626+001   2.257-001    4.700+001   7.300-001   4.927+002
H2= 89.0866
H2= 87.4873
H2= 85.5003
H2= 85.3471
H2= 85.2596
QT,QS=  2.479+004  2.150+004

 EVAPORATOR ITERATION:

 T           P           H            X           TSUP
 3.589+001   9.626+001   3.494+001    2.257-001
 3.700+001   7.515+001   8.527+001    9.714-001    .000
P1,P1E,P1EP1,DENT2=    75.1531    75.1549      .0019     -.1412
INTERM,INTERE,POUT,P13=    0    0  163.49    96.26
 COMPOSITION OF REFRIG. IN ACCUMULATOR =   .637
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =     .212 LB

 REFRIG. IN INDOOR COIL =   2.487 LB

 REFRIG. IN OUTDOOR COIL=    .905 LB

 TMASS =  4.749+000     REFIN =  4.938+000

****************************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA         RHOA        TRA          RHRA
 4.700+001   7.300-001   7.000+001    5.600-001

 CFMIND      CFMOUT
 1.118+003   2.284+003


 RESULTS:

 I  T            P            H            S            X
 1  3.704+001    7.513+001    8.541+001    1.867-001    9.730-001
 2  3.641+001    7.428+001    8.535+001    1.868-001    9.731-001
 3  3.173+001    6.749+001    8.662+001    1.909-001    9.930-001
 4  6.813+001    6.739+001    9.311+001    2.038-001    1.000+000
 5  7.183+001    6.455+001    9.383+001    2.059-001    1.000+000
 6  1.844+002    2.495+002    1.078+002    2.070-001    1.000+000
 7  1.776+002    2.281+002    1.072+002    2.074-001    1.000+000
 8  1.591+002    2.271+002    1.035+002    2.017-001    1.000+000
 9  1.523+002    2.246+002    1.023+002    1.998-001    1.000+000
10  1.515+002    2.245+002    1.021+002    1.996-001    1.000+000
11  8.530+001    2.163+002    3.494+001    7.987-002     .000
12  8.527+001    2.105+002    3.494+001    7.989-002     .000
13  3.589+001    9.626+001    3.494+001    8.130-002    2.257-001

 TG3         TSUP3       TG6          RMASS       TMASS
 3.188+001    .000       1.129+002    4.927+002   4.749+000
```

```
QLOAD        ELUSE        COP
3.475+004    3.637+000    2.800+000

REFRIG. COMPOSITION =     .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




INPUT DATA TO COMPR:

P3           T3           H3           XQ3          TG6          TRA          TOA
6.805+001    3.214+001    8.655+001    9.918-001    1.139+002    7.000+001    4.700+001

COMPRESSOR ITERATION:

EI           ETAE         ETAC         ETAV         CPRPM        RMASS
2.801+000    7.611-001    9.462-001    8.558-001    3.547+003    4.969+002

I   T            P            H            X
1   3.745+001    7.577+001    8.534+001    9.717-001
2   3.682+001    7.489+001    8.529+001    9.719-001
3   3.214+001    6.805+001    8.655+001    9.918-001
4   6.807+001    6.795+001    9.308+001    1.000+000
5   7.178+001    6.508+001    9.280+001    1.000+000
6   1.851+002    2.530+002    1.079+002    1.000+000
7   1.783+002    2.316+002    1.072+002    1.000+000
8   1.597+002    2.306+002    1.035+002    1.000+000
9   1.529+002    2.280+002    1.023+002    1.000+000
10  1.521+002    2.280+002    1.021+002    1.000+000

INPUT DATA TO CONDHX:

T            P            TAIR         RH           RMASS
1.521+002    2.280+002    7.000+001    5.600-001    4.969+002
H2,H2PH2=    33.61     -.28
H2,H2PH2=    33.54      .07
H2,H2PH2=    33.99     -.45
H2,H2PH2=    34.20     -.20
H2,H2PH2=    33.85      .34
H2,H2PH2=    33.98     -.13
H2,H2PH2=    34.06     -.08
H2,H2PH2=    34.11     -.05
H2,H2PH2=    34.09      .02

CONDENSER ITERATION:

T            P            H            X
1.521+002    2.280+002    1.021+002    1.000+000
8.202+001    2.204+002    3.409+001     .000


LIQUID LINE:
INPUT  -     PIN = 2.204+002    TIN = 8.202+001    XIN =   .000        HIN = 3.409+001
OUTPUT -     POUT= 2.146+002    TOUT= 8.198+001    XOUT=   .000


EXPANSION DEVICE:
```

```
INPUT  -    P12  =2.146+002    H12 =3.409+001    P13 =9.688+001
OUTPUT -    POUT =1.712+C02    XMASS =5.341+002

INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TPA         TOA
6.805+001   3.214+001   8.655+001   9.918-00    1.130+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPH       RMASS
2.781+000   7.603-001   9.468-001   8.572-C01   3.548+003   4.980+002

 I  T          P           H           X
 1  3.748+001  7.581+001   8.506+001   9.719-001
 2  3.685+001  7.492+C01   8.530+001   9.720-001
 3  3.214+001  6.805+001   8.655+001   9.919-001
 4  6.782+001  6.795+C01   9.304+001   1.000+000
 5  7.148+001  6.507+001   9.375+001   1.000+000
 6  1.836+002  2.500+002   1.077+002   1.000+000
 7  1.768+002  2.282+002   1.070+002   1.000+000
 8  1.584+002  2.271+002   1.034+002   1.000+000
 9  1.516+002  2.246+002   1.021+002   1.000+000
10  1.508+002  2.245+002   1.020+002   1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.508+C02   2.245+002   7.000+001   5.600-001   4.980+002
H2,H2PH2=   34.37     -.67
H2,H2PH2=   34.59     -.23
H2,H2PH2=   35.06     -.47
H2,H2PH2=   34.67      .39
H2,H2PH2=   34.91     -.24
H2,H2PH2=   35.03     -.12
H2,H2PH2=   35.09     -.07
H2,H2PH2=   35.08      .01

CONDENSER ITERATION:

T           P           H           X
1.508+002   2.245+002   1.020+002   1.000+000
8.584+001   2.159+002   3.508+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.159+002    TIN = 8.584+001   XIN =   .000       HIN = 3.508+001
OUTPUT -    POUT= 2.100+002    TOUT= 8.582+001   XOUT=   .000


EXPANSION DEVICE:
INPUT  -    P12  =2.100+002    H12 =3.508+001    P13 =9.691+001
OUTPUT -    POUT =1.619+002    XMASS =4.880+002

INPUT DATA TO EVAPHX:

T           P           X           TAIR        RH          RMASS
3.627+001   9.691+001   2.230-C01   4.700+001   7.300-001   4.977+002
```

```
H2= 88.7753
H2= 85.6629
H2= 83.3127
QT,QS=  2.412+004  2.161+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.627+001  9.691+001  3.487+001  2.230-001
 3.737+001  7.639+001  8.333+001  9.483-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.613+001  9.668+001  2.235-001  4.700+001  7.300-001  4.977+002
H2= 88.8993
H2= 86.4500
H2= 84.1672
QT,QS=  2.453+004  2.190+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.613+001  9.668+001  3.487+001  2.235-001
 3.718+001  7.581+001  8.415+001  9.582-001   .000
P1,P1E,P1EP1,DENT2=   75.8052   75.8075      .0023   -1.2055

 INPUT DATA TO COMPR:

 P3         T3         H3         XQ3        TG6        TRA        TOA
 6.751+001  3.172+001  8.651+001  9.918-001  1.129+002  7.000+001  4.700+001

 COMPRESSOR ITERATION:

 EI         ETAE       ETAC       ETAV       CPRPM      RMASS
 2.772+000  7.599-001  9.467-001  8.564-001  3.548+003  4.934+002

 I  T          P          H          X
 1  3.704+001  7.519+001  8.531+001  9.719-001
 2  3.640+001  7.431+001  8.525+001  9.720-001
 3  3.172+001  6.751+001  8.651+001  9.918-001
 4  6.774+001  6.741+001  9.305+001  1.000+000
 5  7.144+001  6.456+001  9.377+001  1.000+000
 6  1.840+002  2.495+002  1.078+002  1.000+000
 7  1.772+002  2.281+002  1.071+002  1.000+000
 8  1.587+002  2.270+002  1.034+002  1.000+000
 9  1.519+002  2.245+002  1.022+002  1.000+000
10  1.511+002  2.244+002  1.020+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.511+002  2.244+002  7.000+001  5.600-001  4.934+002
H2,H2PH2=   33.93     -.09
H2,H2PH2=   34.18     -.25
H2,H2PH2=   34.73     -.55
H2,H2PH2=   34.97     -.24
H2,H2PH2=   35.02     -.05
```

```
H2,H2PH2=   35.03    -.01

 CONDENSER ITERATION:

 T          P          H          X
 1.511+002  2.244+002  1.020+002  1.000+000
 8.565+001  2.162+002  3.503+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.162+002   TIN = 8.565+001   XIN =   .000       HIN = 3.503+001
 OUTPUT -   POUT= 2.104+002   TOUT= 8.561+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.104+002   H12 =3.503+001   P13 =9.606+001
 OUTPUT -   POUT =1.630+002   XMASS =4.915+002

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.530+001  9.606+001  2.277-001  4.700+001  7.300-001  4.934+002
H2= 89.1784
H2= 87.8766
H2= 86.3823
H2= 86.1836
H2= 86.0991
QT,QS=  2.520+004  2.172+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.580+001  9.606+001  3.503+001  2.277-001
 3.674+001  7.449+001  8.610+001  9.813-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.596+001  9.634+001  2.270-001  4.700+001  7.300-001  4.934+002
H2= 89.0790
H2= 87.4363
H2= 85.4180
H2= 85.2754
H2= 85.1920
QT,QS=  2.475+004  2.148+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.596+001  9.634+001  3.503+001  2.270-001
 3.701+001  7.519+001  8.520+001  9.706-001   .000
P1,P1E,P1EP1,DENT2=   75.1867   75.1382      .0014     -.1117
INTERM,INTERE,POUT,P13=   0   0  163.04   96.34
 COMPOSITION OF REFRIG. IN ACCUMULATOR =  .631
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =    .216 LB
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REFRIG. IN INDOOR COIL =   2.475 LB

REFRIG. IN OUTDOOR COIL=    .905 LB

TMASS =  4.740+000     REFIN =  4.963+000

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**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

TOA          RHOA         TRA          RHRA
4.700+001    7.500-001    7.000+001    5.600-001

CFMIND       CFMOUT
1.118+003    2.284+003


RESULTS:

I   T            P            H            S            X
1   3.704+001    7.519+001    8.531+001    1.865-001    9.719-001
2   3.640+001    7.431+001    8.525+001    1.865-001    9.720-001
3   3.172+001    6.751+001    8.651+001    1.907-001    9.918-001
4   6.774+001    6.741+001    9.305+001    2.036-001    1.000+000
5   7.144+001    6.456+001    9.377+001    2.057-001    1.000+000
6   1.840+002    2.495+002    1.078+002    2.069-001    1.000+000
7   1.772+002    2.281+002    1.071+002    2.073-001    1.000+000
8   1.587+002    2.270+002    1.034+002    2.016-001    1.000+000
9   1.519+002    2.245+002    1.022+002    1.937-001    1.000+000
10  1.511+002    2.244+002    1.020+002    1.995-001    1.000+000
11  8.565+001    2.162+002    3.503+001    8.004-002     .000
12  8.561+001    2.104+002    3.503+001    8.006-002     .000
13  3.596+001    9.634+001    3.503+001    8.198-002    2.270-001

TG3          TSUP3        TG6          RMASS        TMASS
3.190+001     .000        1.129+002    4.931+002    4.740+000

QLOAD        ELUSE        COP
3.472+004    3.637+000    2.797+000

REFRIG. COMPOSITION =    .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




INPUT DATA TO COMPR:

P3           T3           H3           XQ3          TG6          TRA          TOA
6.686+001    3.120+001    8.641+001    9.912-001    1.132+002    7.000+001    4.700+001

COMPRESSOR ITERATION:

EI           ETAE         ETAC         ETAV         CPRPM        RMASS
2.774+000    7.590-001    9.462-001    8.545-001    3.543+003    4.871+002

I   T            P            H            X
1   3.647+001    7.442+001    8.519+001    9.712-001
2   3.584+001    7.356+001    8.513+001    9.712-001
```

```
   3  3.120+001  6.686+001  8.641+001  9.912-001
   4  6.764+001  6.677+001  9.306+001  1.000+000
   5  7.141+001  6.396+001  9.379+001  1.000+000
   6  1.852+002  2.506+002  1.080+002  1.000+000
   7  1.784+002  2.299+002  1.073+002  1.000+000
   8  1.597+002  2.288+002  1.036+002  1.000+000
   9  1.529+002  2.264+002  1.023+002  1.000+000
  10  1.520+002  2.263+002  1.022+002  1.000+000

  INPUT DATA TO CONDHX:

  T           P           TAIR        RH          RMASS
  1.520+002   2.263+002   7.000+001   5.600-001   4.874+002
 H2,H2PH2=    33.58     -.34
 H2,H2PH2=    33.57      .01
 H2,H2PH2=    33.99     -.42
 H2,H2PH2=    34.18     -.19
 H2,H2PH2=    33.83      .35
 H2,H2PH2=    33.97     -.13
 H2,H2PH2=    34.05     -.08
 H2,H2PH2=    34.09     -.04
 H2,H2PH2=    34.08      .02

  CONDENSER ITERATION:

  T           P           H           X
  1.520+002   2.263+002   1.022+002   1.000+000
  8.194+001   2.190+002   3.408+001    .000


  LIQUID LINE:
  INPUT  -    PIN = 2.190+002    TIN = 8.194+001    XIN =   .000        HIN = 3.408+001
  OUTPUT -    POUT= 2.134+002    TOUT= 8.191+001    XOUT=   .000


  EXPANSION DEVICE:
  INPUT  -    P12  =2.134+002    H12 =3.408+001    P13 =9.557+001
  OUTPUT -    POUT =1.699+002    XMASS =5.295+002

  INPUT DATA TO COMPR:

  P3          T3          H3          XQ3         TG6         TRA         TOA
  6.686+001   3.120+001   8.641+001   9.912-001   1.124+002   7.000+001   4.700+001

  COMPRESSOR ITERATION:

  EI          ETAE        ETAC        ETAV        CPRPM       RMASS
  2.754+000   7.591-001   9.467-001   8.558-001   3.548+003   4.881+002

  I  T           P           H           X
  1  3.640+001   7.445+001   8.521+001   9.713-001
  2  3.586+001   7.358+001   8.515+001   9.714-001
  3  3.120+001   6.686+001   8.641+001   9.912-001
  4  6.740+001   6.677+001   9.302+001   1.000+000
  5  7.113+001   6.395+001   9.374+001   1.000+000
  6  1.838+002   2.480+002   1.078+002   1.000+000
  7  1.770+002   2.269+002   1.071+002   1.000+000
  8  1.585+002   2.258+002   1.035+002   1.000+000
```

```
 9  1.517+002  2.233+002  1.022+002  1.000+000
10  1.509+002  2.233+002  1.020+002  1.000+000

 INPUT DATA TO CONDHX:

 T           P          TAIR       RH         RMASS
 1.509+002  2.233+002  7.000+001  5.600-001  4.804+002
H2,H2PH2=   34.24     -.62
H2,H2PH2=   34.41     -.18
H2,H2PH2=   34.89     -.47
H2,H2PH2=   34.47      .42
H2,H2PH2=   34.70     -.23
H2,H2PH2=   34.82     -.12
H2,H2PH2=   34.88     -.07
H2,H2PH2=   34.87      .01

 CONDENSER ITERATION:

 T           P          H          X
 1.509+002  2.233+002  1.020+002  1.000+000
 8.503+001  2.150+002  3.487+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.150+002   TIN = 8.503+001   XIN =   .000        HIN = 3.487+001
 OUTPUT -   POUT= 2.093+002   TOUT= 8.501+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.093+002   H12 =3.487+001   P13 =9.560+001
 OUTPUT -   POUT =1.624+002   XMASS =4.910+002

 INPUT DATA TO EVAPHX:

 T           P          X          TAIR       RH         RMASS
 3.549+001  9.560+001  2.270-001  4.700+001  7.300-001  4.884+002
H2= 89.2513
H2= 88.3391
H2= 87.3552
H2= 86.9869
QT,QS=  2.542+004  2.207+004

 EVAPORATOR ITERATION:

 T           P          H          X          TSUP
 3.549+001  9.560+001  3.493+001  2.270-001
 3.655+001  7.393+001  8.696+001  9.914-001   .000

 INPUT DATA TO EVAPHX:

 T           P          X          TAIR       RH         RMASS
 3.562+001  9.581+001  2.265-001  4.700+001  7.300-001  4.884+002
H2= 89.1969
H2= 88.0232
H2= 86.7563
H2= 86.4446
QT,QS=  2.514+004  2.190+004
```

```
EVAPORATOR ITERATION:

T           P           H           X           TSUP
3.562+001   9.581+001   3.493+001   2.265-001
3.678+001   7.445+001   8.640+001   9.846-001    .000
P1,P1E,P1EP1,DENT2=    74.4542    74.4459     -.0083     1.1886

INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.739+001   3.161+001   8.645+001   9.912-001   1.127+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.766+000   7.596-001   9.467-001   8.564-001   3.548+003   4.927+002

I  T           P           H           X
1  3.693+001   7.505+001   8.525+001   9.713-001
2  3.630+001   7.418+001   8.519+001   9.714-001
3  3.161+001   6.739+001   8.645+001   9.912-001
4  6.751+001   6.729+001   9.302+001   1.000+000
5  7.121+001   6.445+001   9.373+001   1.000+000
6  1.837+002   2.489+002   1.077+002   1.000+000
7  1.769+002   2.275+002   1.070+002   1.000+000
8  1.584+002   2.265+002   1.034+002   1.000+000
9  1.516+002   2.240+002   1.022+002   1.000+000
10 1.508+002   2.239+002   1.020+002   1.000+000

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.508+002   2.239+002   7.000+001   5.600-001   4.927+002
H2,H2PH2=   34.12      -.08
H2,H2PH2=   34.38      -.25
H2,H2PH2=   34.90      -.52
H2,H2PH2=   34.55       .35
H2,H2PH2=   34.76      -.21
H2,H2PH2=   34.87      -.11
H2,H2PH2=   34.94      -.07
H2,H2PH2=   34.93       .01

CONDENSER ITERATION:

T           P           H           X
1.508+002   2.239+002   1.020+002   1.000+000
8.525+001   2.155+002   3.493+001    .000


LIQUID LINE:
INPUT  -    PIN = 2.155+002   TIN = 8.525+001   XIN =   .000       HIN = 3.493+001
OUTPUT -    POUT= 2.097+002   TOUT= 8.523+001   XOUT=   .000


EXPANSION DEVICE:
INPUT  -    P12  =2.097+002   H12 =3.493+001   P13 =9.641+001
OUTPUT -    POUT =1.626+002   XMASS =4.911+002
```

```
 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.598+001  9.641+001  2.252-001  4.700+001  7.300-001  4.927+002
H2= 89.0122
H2= 87.0705
H2= 84.9381
H2= 84.8139
H2= 84.7435
QT,QS=  2.455+004  2.138+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.598+001  9.641+001  3.493+001  2.252-001
 3.715+001  7.554+001  8.475+001  9.653-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.587+001  9.622+001  2.256-001  4.700+001  7.300-001  4.927+002
H2= 89.0816
H2= 87.5769
H2= 85.6249
H2= 85.4721
H2= 85.3758
QT,QS=  2.486+004  2.154+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.587+001  9.622+001  3.493+001  2.256-001
 3.697+001  7.506+001  8.538+001  9.728-001   .000
P1,P1E,P1EP1,DENT2=    75.0545    75.0616      .0071      .1320
INTERM,INTERE,POUT,P13=    0    0  162.61    96.22
 COMPOSITION OF REFRIG. IN ACCUMULATOR =  .508
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =    .368 LB

 REFRIG. IN INDOOR COIL =   2.407 LB

 REFRIG. IN OUTDOOR COIL=    .903 LB

 TMASS =  4.822+000     REFIN =  4.968+000

***********************************************************
**SYST4 WITH ACCUM , 13B1/152A 6-22-84***

 TOA        RHOA       TRA        RHRA
 4.700+001  7.300-001  7.000+001  5.600-001

 CFMIND     CFMOUT
 1.118+003  2.284+003


 RESULTS:
```

```
 I  T          P          H          S          X
 1  3.693+001  7.505+001  8.525+001  1.864-001  9.713-001
 2  3.630+001  7.418+001  8.519+001  1.865-001  9.714-001
 3  3.161+001  6.739+001  8.645+001  1.906-001  9.912-001
 4  6.751+001  6.729+001  9.302+001  2.036-001  1.000+000
 5  7.121+001  6.445+001  9.373+001  2.057-001  1.000+000
 6  1.837+002  2.489+002  1.077+002  2.069-001  1.000+000
 7  1.769+002  2.275+002  1.070+002  2.072-001  1.000+000
 8  1.584+002  2.265+002  1.034+002  2.016-001  1.000+000
 9  1.516+002  2.240+002  1.022+002  1.997-001  1.000+000
10  1.508+002  2.239+002  1.020+002  1.994-001  1.000+000
11  8.525+001  2.155+002  3.493+001  7.985-002   .000
12  8.523+001  2.097+002  3.493+001  7.988-002   .000
13  3.587+001  9.622+001  3.493+001  8.179-002  2.256-001

TG3        TSUP3      TG6        RMASS      TMASS
3.181+001   .000      1.127+002  4.927+002  4.822+000

QLOAD      ELUSE      COP
3.470+004  3.631+000  2.800+000

REFRIG. COMPOSITION =    .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




INPUT DATA TO COMPR:

P3         T3         H3         XQ3        TG6        TRA        TOA
6.717+001  3.144+001  8.641+001  9.909-001  1.124+002  7.000+001  4.700+001

COMPRESSOR ITERATION:

EI         ETAE       ETAC       ETAV       CPRPM      RMASS
2.758+000  7.593-001  9.468-001  8.564-001  3.548+003  4.912+002

 I  T          P          H          X
 1  3.675+001  7.481+001  8.521+001  9.710-001
 2  3.612+001  7.394+001  8.515+001  9.711-001
 3  3.144+001  6.717+001  8.641+001  9.909-001
 4  6.732+001  6.708+001  9.299+001  1.000+000
 5  7.102+001  6.424+001  9.371+001  1.000+000
 6  1.834+002  2.480+002  1.077+002  1.000+000
 7  1.765+002  2.266+002  1.070+002  1.000+000
 8  1.581+002  2.256+002  1.034+002  1.000+000
 9  1.513+002  2.230+002  1.021+002  1.000+000
10  1.505+002  2.230+002  1.020+002  1.000+000

INPUT DATA TO CONDHX:

T          P          TAIR       RH         RMASS
 1.505+002 2.230+002  7.000+001  5.600-001  4.912+002
H2,H2PH2=  34.11     -.06
H2,H2PH2=  34.96     -.85
H2,H2PH2=  34.75      .21
H2,H2PH2=  35.08     -.34
H2,H2PH2=  35.24     -.15
```

```
  H2,H2PH2=   35.31    -.08
  H2,H2PH2=   35.31     .00

   CONDENSER ITERATION:

   T          P          H          X
   1.505+002  2.230+002  1.020+002  1.000+000
   8.670+001  2.144+002  3.531+001   .000


   LIQUID LINE:
   INPUT  -   PIN = 2.144+002   TIN = 8.670+001   XIN =  .000       HIN = 3.531+001
   OUTPUT -   POUT= 2.086+002   TOUT= 8.607+001   XOUT= 3.445-003


   EXPANSION DEVICE:
   INPUT  -   P12  =2.086+002   H12 =3.531+001   P13 =9.598+001
   OUTPUT -   POUT =1.600+002   XMASS =4.785+002

   INPUT DATA TO COMPR:

   P3         T3         H3         XQ3        TG6        TRA        TOA
   6.717+001  3.144+001  8.641+001  9.909-001  1.127+002  7.000+001  4.700+001

   COMPRESSOR ITERATION:

   EI         ETAE       ETAC       ETAV       CPRPM      RMASS
   2.763+000  7.595-001  9.466-001  8.560-00'  3.548+003  4.909+002

   I  T          P          H          X
   1  3.674+001  7.481+001  8.521+001  9.710-001
   2  3.611+001  7.393+001  8.515+001  9.711-001
   3  3.144+001  6.717+001  8.641+001  9.909-001
   4  6.740+001  6.708+001  9.301+001  1.000+000
   5  7.111+001  6.424+001  9.372+001  1.000+000
   6  1.838+002  2.488+002  1.077+002  1.000+000
   7  1.770+002  2.276+002  1.070+002  1.000+000
   8  1.585+002  2.265+002  1.034+002  1.000+000
   9  1.517+002  2.240+002  1.022+002  1.000+000
  10  1.509+002  2.240+002  1.020+002  1.000+000

   INPUT DATA TO CONDHX:

   T          P          TAIR       RH         RMASS
   1.509+002  2.240+002  7.000+001  5.600-001  4.909+002
  H2,H2PH2=   33.95    -.08
  H2,H2PH2=   34.19    -.24
  H2,H2PH2=   34.74    -.55
  H2,H2PH2=   34.98    -.24
  H2,H2PH2=   35.03    -.05
  H2,H2PH2=   35.04    -.01

   CONDENSER ITERATION:

   T          P          H          X
   1.509+002  2.240+002  1.020+002  1.000+000
   8.569+001  2.158+002  3.504+001   .000
```

```
 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


 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

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          RMASS
 3.574+001   9.597+001   2.281-001   4.700+001   7.300-001   4.909+002
H2= 89.1871
H2= 87.9454
H2= 86.5718
H2= 86.3075
H2= 86.2429
QT,QS=  2.513+004  2.169+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.574+001   9.597+001   3.504+001   2.281-001
 3.677+001   7.448+001   8.624+001   9.828-001    .000

 INPUT DATA TO EVAPHX:

 T           P           X           TAIR        RH          RMASS
 3.582+001   9.610+001   2.278-001   4.700+001   7.300-001   4.909+002
H2= 89.1628
H2= 87.7873
H2= 86.1445
H2= 85.9260
H2= 85.8617
QT,QS=  2.494+004  2.158+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.582+001   9.610+001   3.504+001   2.278-001
 3.690+001   7.480+001   8.584+001   9.781-001    .000
P1,P1E,P1EP1,DENT2=    74.8051    74.8045    -.0006      .6326

 INPUT DATA TO COMPR:

 P3          T3          H3          XQ3         TG6         TRA         TOA
 6.745+001   3.166+001   8.643+001   9.909-001   1.129+002   7.000+001   4.700+001

 COMPRESSOR ITERATION:

 EI          ETAE        ETAC        ETAV        CPRPM       RMASS
 2.770+000   7.598-001   9.466-001   8.563-001   3.548+003   4.932+002

 I  T          P          H          X
 1  3.697+001  7.512+001  8.523+001  9.710-001
```

```
 2  3.634+001  7.425+001  8.517+001  9.711-001
 3  3.166+001  6.745+001  8.643+001  9.909-001
 4  6.746+001  6.736+001  9.300+001  1.000+000
 5  7.116+001  6.451+001  9.372+001  1.000+000
 6  1.837+002  2.494+002  1.077+002  1.000+000
 7  1.769+002  2.280+002  1.070+002  1.000+000
 8  1.584+002  2.270+002  1.034+002  1.000+000
 9  1.517+002  2.245+002  1.021+002  1.000+000
10  1.509+002  2.244+002  1.020+002  1.000+000

 INPUT DATA TO CONDHX:

 T          P          TAIR       RH         RMASS
 1.509+002  2.244+002  7.000+001  5.600-001  4.932+002
H2,H2PH2=   33.91    -.09
H2,H2PH2=   34.16    -.25
H2,H2PH2=   34.71    -.56
H2,H2PH2=   34.95    -.24
H2,H2PH2=   35.00    -.05
H2,H2PH2=   35.01    -.01

 CONDENSER ITERATION:

 T          P          H          X
 1.509+002  2.244+002  1.020+002  1.000+000
 8.559+001  2.162+002  3.501+001   .000


 LIQUID LINE:
 INPUT  -   PIN = 2.162+002   TIN = 8.559+001   XIN =   .000        HIN = 3.501+001
 OUTPUT -   POUT= 2.104+002   TOUT= 8.555+001   XOUT=   .000


 EXPANSION DEVICE:
 INPUT  -   P12  =2.104+002   H12 =3.501+001   P13 =9.642+001
 OUTPUT -   POUT =1.632+002   XMASS =4.919+002

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.601+001  9.642+001  2.266-001  4.700+001  7.300-001  4.932+002
H2= 89.0363
H2= 87.1973
H2= 85.0951
H2= 84.9684
H2= 84.8924
QT,QS=  2.461+004  2.141+004

 EVAPORATOR ITERATION:

 T          P          H          X          TSUP
 3.601+001  9.642+001  3.501+001  2.266-001
 3.710+001  7.542+001  8.490+001  9.670-001   .000

 INPUT DATA TO EVAPHX:

 T          P          X          TAIR       RH         RMASS
 3.594+001  9.630+001  2.268-001  4.700+001  7.300-001  4.932+002
```

```
H2= 89.0900
H2= 87.5004
H2= 85.5169
H2= 85.3627
H2= 85.2751
QT,QS=  2.479+004  2.150+004

 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.594+001  9.630+001  3.501+001  2.268-00'
 3.699+001  7.513+001  8.528+001  9.716-00:    .000
P1,P1E,P1EP1,DENT2=   75.1244   75.1281     .0037      .0523
INTERM,INTERE,POUT,P13=   0   0  163.24   96.30
 COMPOSITION OF REFRIG. IN ACCUMULATOR =  .445
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =     .571 LB

 REFRIG. IN INDCOR COIL =   2.477 LB

 REFRIG. IN OUTDOOR COIL=    .904 LB

 TMASS =  5.097+000     REFIN =  4.968+000

*****************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA         RHOA        TRA         RHRA
 4.700+001  7.300-001  7.000+001  5.600-001

 CFMIND      CFMOUT
 1.118+003  2.284+003


 RESULTS:

 I  T           P           H           S           X
 1  3.697+001  7.512+001  8.523+001  1.863-001  9.710-001
 2  3.634+001  7.425+001  8.517+001  1.864-001  9.711-001
 3  3.166+001  6.745+001  8.643+001  1.906-001  9.909-001
 4  6.746+001  6.735+001  9.300+001  2.036-001  1.000+000
 5  7.116+001  6.451+001  9.372+001  2.057-001  1.000+000
 6  1.837+002  2.494+002  1.077+002  2.068-001  1.000+000
 7  1.769+002  2.280+002  1.070+002  2.072-001  1.000+000
 8  1.584+002  2.270+002  1.034+002  2.015-001  1.000+000
 9  1.517+002  2.245+002  1.021+002  1.996-001  1.000+000
10  1.509+002  2.244+002  1.020+002  1.994-001  1.000+000
11  8.559+001  2.162+002  3.501+001  8.001-002   .000
12  8.555+001  2.104+002  3.501+001  8.003-002   .000
13  3.594+001  9.630+001  3.501+001  8.195-002  2.268-001

 TG3         TSUP3       TG6         RMASS       TMASS
 3.186+001   .000       1.129+002  4.932+002  5.097+000

 QLOAD       ELUSE       COP
 3.469+004  3.635+000  2.796+000
```

```
REFRIG. COMPOSITION =    .668
(WEIGHT FRACTION OF MORE VOLATILE COMPONENT)




INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
6.742+001   3.164+001   8.644+001   9.911-001   1.128+002   7.000+001   4.700+001

COMPRESSOR ITERATION:

EI          ETAE        ETAC        ETAV        CPRPM       RMASS
2.769+000   7.597-001   9.467-001   8.564-001   3.548+003   4.930+002

I  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   1.000+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

INPUT DATA TO CONDHX:

T           P           TAIR        RH          RMASS
1.508+002   2.242+002   7.000+001   5.600-001   4.930+002
H2,H2PH2=   34.01     -.09
H2,H2PH2=   34.26     -.25
H2,H2PH2=   34.80     -.54
H2,H2PH2=   35.04     -.24
H2,H2PH2=   35.10     -.05
H2,H2PH2=   35.11     -.01

CONDENSER ITERATION:

T           P           H           X
1.508+002   2.242+002   1.020+002   1.000+000
8.593+001   2.159+002   3.511+001     .000


LIQUID LINE:
INPUT  -    PIN = 2.159+002   TIN = 8.593+001   XIN =   .000       HIN = 3.511+001
OUTPUT -    POUT= 2.101+002   TOUT= 8.591+001   XOUT=   .000


EXPANSION DEVICE:
INPUT  -    P12  =2.101+002   H12 =3.511+001   P13 =9.627+001
OUTPUT -    POUT =1.618+002   XMASS =4.878+002

INPUT DATA TO COMPR:

P3          T3          H3          XQ3         TG6         TRA         TOA
```

```
6.742+001  3.164+001  8.644+001  9.911-001  1.129+002  7.000+001  4.700+001

COMPRESSOR ITERATION:

EI         ETAE       ETAC       ETAV       CPRPM      RMASS
2.771+000  7.598-001  9.466-001  8.562-001  3.548+003  4.928+002

 I  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  6.752+001  6.733+001  9.302+001  1.000+000
 5  7.122+001  6.448+001  9.373+001  1.000+000
 6  1.839+002  2.495+002  1.077+002  1.000+000
 7  1.771+002  2.282+002  1.070+002  1.000+000
 8  1.586+002  2.271+002  1.034+002  1.000+000
 9  1.518+002  2.246+002  1.022+002  1.000+000
10  1.510+002  2.246+002  1.020+002  1.000+000

INPUT DATA TO CONDHX:

T          P          TAIR       RH         RMASS
1.510+002  2.246+002  7.000+001  5.600-001  4.928+002
H2,H2PH2=  33.81    -.10
H2,H2PH2=  34.57    -.76
H2,H2PH2=  34.46     .11
H2,H2PH2=  34.77    -.32
H2,H2PH2=  34.87    -.10
H2,H2PH2=  34.93    -.06
H2,H2PH2=  34.93     .00

CONDENSER ITERATION:

T          P          H          X
1.510+002  2.246+002  1.020+002  1.000+000
8.525+001  2.164+002  3.493+001   .000


LIQUID LINE:
INPUT  -   PIN = 2.164+002   TIN = 8.525+001   XIN =  .000      HIN = 3.493+001
OUTPUT -   POUT= 2.106+002   TOUT= 8.522+001   XOUT=  .000


EXPANSION DEVICE:
INPUT  -   P12  =2.106+002   H12 =3.493+001   P13 =9.626+001
OUTPUT -   POUT =1.637+002   XMASS =4.946+002

INPUT DATA TO EVAPHX:

T          P          X          TAIR       RH         RMASS
3.589+001  9.626+001  2.254-001  4.700+001  7.300-001  4.928+002
H2= 89.0827
H2= 87.4651
H2= 85.4580
H2= 85.3255
H2= 85.2310
QT,QS=  2.480+004  2.151+004
```

```
 EVAPORATOR ITERATION:

 T           P           H           X           TSUP
 3.589+001   9.626+001   3.493+001   2.254-001
 3.700+001   7.517+001   8.524+001   9.711-001    .000
P1,P1E,P1EP1,DENT2=    75.0878    75.1672      .0795      .0004
INTERM,INTERE,POUT,P13=    0    0  163.71    96.26
 COMPOSITION OF REFRIG. IN ACCUMULATOR =   .470
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)

 REFRIG. IN ACCUMULATOR =     .469 LB

 REFRIG. IN INDOOR COIL =   2.490 LB

 REFRIG. IN OUTDOOR COIL=    .905 LB

 TMASS =  5.009+000     REFIN =  4.968+000

*****************************************************************
**SYST4 WITH ACCUM., 13B1/152A 6-22-84***

 TOA         RHOA        TRA         RHRA
 4.700+001   7.300-001   7.000+001   5.600-001

 CFMIND      CFMOUT
 1.118+003   2.284+003


 RESULTS:

 I  T           P           H           S           X
 1  3.695+001   7.509+001   8.524+001   1.863-001   9.711-001
 2  3.632+001   7.421+001   8.518+001   1.864-001   9.712-001
 3  3.164+001   6.742+001   8.644+001   1.906-001   9.911-001
 4  6.752+001   6.733+001   9.302+001   2.036-001   1.000+000
 5  7.122+001   6.448+001   9.373+001   2.057-001   1.000+000
 6  1.839+002   2.495+002   1.077+002   2.069-001   1.000+000
 7  1.771+002   2.282+002   1.070+002   2.072-001   1.000+000
 8  1.586+002   2.271+002   1.034+002   2.015-001   1.000+000
 9  1.518+002   2.246+002   1.022+002   1.997-001   1.000+000
10  1.510+002   2.246+002   1.020+002   1.994-001   1.000+000
11  8.525+001   2.164+002   3.493+001   7.985-002    .000
12  8.522+001   2.106+002   3.493+001   7.987-002    .000
13  3.589+001   9.626+001   3.493+001   8.178-002   2.254-001

 TG3         TSUP3       TG6         RMASS       TMASS
 3.183+001    .000       1.129+002   4.928+002   5.009+000

 QLOAD       ELUSE       COP
 3.472+004   3.636+000   2.798+000

 REFRIG. COMPOSITION =    .668
 (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)
```

```
FOR THE AMOUNT OF REFRIGERANT STORED IN THE ACCUMULATOR
CIRCULATING COMPOSITION SHOULD BE    .669



 I=999 FOR DISCONTINUATION
 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 8R1 S74Q1C 07/21/84 15:54:51 (0)
   00          FUNCTION AIRHT(AMASS,ACP,AMU,AK,DO,DT,NROW,WIDTH,
   00         & RPCH,FPCH,FTK,CONST,CPOW,ANGLE)
   00    C
   00    C**** PURPOSE:
   00    C       TO CALCULATE AIR-SIDE FINNED-TUBE
   00    C       HEAT TRANSFER COEFFICIENT
   00    C
   00    C**** INPUT DATA:
   00    C       ACP   - AIR SPEC. HEAT AT CONSTANT PRESSURE   (BTU/LBM*F)
   00    C       AK    - AIR THERMAL CONDUCTIVITY   (BTU/H*FT*F)
   00    C       AMASS - AIR MASS FLOW RATE   (LBM/H)
   00    C       AMU   - AIR DYNAMIC VISCOSITY   (LBM/FT*H)
   00    C       ANGLE - ANGLE BETWEEN COIL FACE & AIR STREAMLINES   (RAD)
   00    C       CONST - COEFFICIENT FOR NUSSELT NUMBER   (-)
   00    C       CPOW  - POWER FOR REYNOLDS NUMBER   (-)
   00    C       DO    - TUBE OUTSIDE DIAMETER   (FT)
   00    C       DT    - FIN TIP DIAMETER   (FT)
   00    C       FPCH  - FIN PITCH   (FT)
   00    C       FTK   - FIN THICKNESS   (FT)
   00    C       NROW  - NUMBER OF TUBES PER ROW   (-)
   00    C       RPCH  - TUBE ROW PITCH   (FT)
   00    C       WIDTH - HEAT EXCHANGER WIDTH   (FT)
   00    C
   00    C**** OUTPUT DATA:
   00    C       AIRHT - AIR-SIDE HEAT TRANSFER COEFFICIENT   (BTU/H*F*FT**2)
   00    C
   00          APR=AMU*ACP/AK
   00          FS=FPCH-FTK
   00          FL=0.5*(DT-DO)
   00          HGT=NROW*RPCH
   00          TA=DO*WIDTH*NROW
   00          FN=WIDTH/FPCH
   00          FA=(RPCH-DO)*FTK*FN
   00          FA=NROW*FA
   00          EA=(WIDTH*HGT-TA-FA)*SIN(ANGLE)
   00          G=AMASS/EA
   00          RE=G*DO/AMU
   00          ANU=CONST*RE**CPOW*APR**0.333*(FS/FL)**0.2*(FS/FTK)**0.1134
   00          AIRHT=ANU*AK/DO
   00          RETURN
   00          END

END ELT.  ERRORS: NONE. TIME:  0.098 SEC. IMAGE COUNT: 41

@HDG,P  ******  AIRPR  ****** .L,0
```

```
@ELT,L DD.AIRPR
ELT 8R1 S74Q1C 07/21/84 15:54:51 (0)
 00          SUBROUTINE AIRPR(I,T,PATM,RH,W,CP,R,AM,AK)
 00     C
 00     C**** PURPOSE:
 00     C        TO CALCULATE AIR PROPERTIES
 00     C
 00     C**** INPUT DATA:
 00     C        I    = 1   IF RELATIVE HUMIDITY IS GIVEN   (-)
 00     C             = 2   IF HUMIDITY RATIO IS GIVEN   (-)
 00     C        T    - AIR TEMPERATURE   (-)
 00     C        PATH - AIR PRESSURE   (PSIA)
 00     C        RH   - RELATIVE HUMIDITY IN FRACTION (IF I=1)   (-)
 00     C        W    - HUMIDITY RATIO (IF I=2)   (LBM H2O/LBM DRY AIR)
 00     C
 00     C**** OUTPUT DATA:
 00     C        AK   - AIR THERMAL CONDUCTIVITY   (BTU/H*F*FT)
 00     C        AM   - AIR DYNAMIC VISCOSITY   (LBM/FT*H)
 00     C        CP   - AIR SPEC. HEAT AT CONSTANT PRESSURE   (BTU/LBM*F)
 00     C        R    - GAS CONSTANT OF AIR   (LBF*FT/LBM*R)
 00     C        RH   - RELATIVE HUMIDITY IN FRACTION (FOR I=2)   (-)
 00     C        W    - HUMIDITY RATIO (FOR I=1)   (LBM H2O/LBM DRY AIR)
 00     C
 00     C
 00          IF(I.EQ.1)GOTO100
 00          P=W*PATM/(0.622+W)
 00      100 CONTINUE
 00          TR=T+460.
 00          Z=1000./TR
 00          IF(TR.GE.492.)GOTO10
 00          PSAT=EXP(0.03940*Z**3-0.2755*Z*Z-10.431*Z+19.509)
 00          GOTO30
 00       10 IF(TR.GE.672.)GOTO20
 00          PSAT=EXP(0.17829*Z*Z*Z-1.6895*Z*Z-5.0988*Z+13.4353)
 00          GOTO30
 00       20 PSAT=EXP(0.71692*Z**4-4.01506*Z**3+7.5568*Z*Z-14.2131*Z+16.8255)
 00       30 IF(I.EQ.1)GOTO110
 00          RH=P/PSAT
 00      110 CONTINUE
 00          IF(RH.GE.0.00001)GOTO40
 00          W=0.
 00          GOTO50
 00       40 PW=RH*PSAT
 00          W=0.622*PW/(PATM-PW)
 00       50 CONTINUE
 00          CP=0.2478786-0.4204563E-04*TR+0.5767657E-07*TR**2
 00         & -0.1493056E-10*TR**3
 00          CP=(CP+0.444*W)/(1.+W)
 00          R=(53.34+85.76*W)/(1.+W)
 00          AM=5.5029E-03+8.7157E-05*TR-2.9464E-08*TR**2
 00         & +6.250E-12*TR**3
 00          AK=-2.853E-04+3.268E-05*TR-8.253E-09*TR*TR
 00         & +1.239E-12*TR**3
 00          RETURN
 00          END

END ELT.  ERRORS: NONE.  TIME:  0.093 SEC.  IMAGE COUNT: 53
```

```
@ELT,L DD.BCONST
ELT 8R1 S7401C 07/21/84 15:54:52 (0)
          00         SUBROUTINE BCONST
          00   C
          00   C
          00   C**** PURPOSE:
          00   C        TO READ CONSTANTS FOR PURE COMPONENTS OF MIXTURE.
          00   C
          00         COMMON/RDATA1/A3,A4,A5,A6,A7,A8,B3,B4,B5,
          00        &  B6,B7,B8,F0,F1
          00         COMMON/RDATA2/WMOL1,WMOL2,TC1,TC2
          00         COMMON/ESDATA/AA(2,3),BB(2,3),CC(2,3)
          00   C
          00   C
          00   C**** READ EQ. OF STATE CONSTANTS
          00   C     MORE VOLATILE COMPONENT
          00   C     A0,A1,A2,B0,B1,B2
          00         READ(7,777)A3,A4,A5
          00         READ(7,777)B3,B4,B5
          00   C
          00   C     LESS VOLATILE COMPONENT
          00   C     A0,A1,A2,B0,B1,B2
          00         READ(7,777)A6,A7,A8
          00         READ(7,777)B6,B7,B8
          00   C
          00   C     INTERACTION COEFFICIENTS; C,D
          00         READ(7,777)F1,F0
          00   C
          00   C**********************************************
          00   C
          00   C     READ MOLECULAR WEIGHTS
          00   C     MORE & LESS VOLATILE COMPONENT
          00         READ(7,777)WMOL1,WMOL2
          00   C
          00   C     READ CRITICAL TEMPERATURES
          00   C     MORE & LESS VOLATILE COMPONENT
          00         READ(7,777)TC1,TC2
          00   C**********************************************
          00   C
          00   C**** READ CONSTANTS FOR ESTIMATING EQUATIONS
          00   C     PSAT=EXP(AA1+AA2/T+AA3/T**2)
          00   C     VVAPOR=T*(BB1+BB2*T+BB3*T**2)/P
          00   C     VLIQUID=CC1+CC2*T+CC3*T**2
          00   C**** MORE VOLATILE COMPONENT
          00         READ(7,777)AA(1,1),AA(1,2),AA(1,3)
          00         READ(7,777)BB(1,1),BB(1,2),BB(1,3)
          00         READ(7,777)CC(1,1),CC(1,2),CC(1,3)
          00   C
          00   C**** LESS VOLATILE COMPONENT
          00         READ(7,777)AA(2,1),AA(2,2),AA(2,3)
          00         READ(7,777)BB(2,1),BB(2,2),BB(2,3)
          00         READ(7,777)CC(2,1),CC(2,2),CC(2,3)
          00     777 FORMAT()
          00         RETURN
          00         END

END ELT.  ERRORS: NONE.  TIME:  0.101 SEC.  IMAGE COUNT: 53
```

```
@ELT,L DD.BIMASS
ELT 8R1 S74Q1C 07/21/84 15:54:52 (0)
00          FUNCTION BIMASS(N)
00    C
00    C**** PURPOSE:
00    C        TO COMPUTE MASS OF A NON-AZEOTROPIC REFRIGERANT
00    C        IN A COIL
00    C
00    C**** INPUT DATA:
00    C        DI(N)         - INNER DIAMETER OF COIL TUBES    (FT)
00    C        N             = 1   FOR AN INDOOR COIL    (-)
00    C                      = 2   FOR AN OUTDOOR COIL    (-)
00    C        NSECT(N)      - NUMBER OF REPEATING SECTIONS IN COIL    (-)
00    C        NTPS(N)       - NUMBER OF TUBES PER COIL SECTION    (-)
00    C        TRM(N,1,I)    - REFRIG. TEMP. AT TUBE I END OF HIGHER REFRIG. ENTHALPY    (F)
00    C        TRM(N,2,I)    - REFRIG. TEMP. AT TUBE I END OF LOWER REFRIG. ENTHALPY    (F)
00    C        VGM(N,1,I)    - SPEC. VOL. OF REFRIG. VAPOR IN TUBE I END OF HICHER REFRIG. ENTHALPY
00    C                        (FT**3/LB)
00    C        VGM(N,2,I)    - SPEC. VOL. OF REFRIG. VAPOR IN TUBE I END OF LOWER REFRIG. ENTHALPY
00    C                        (FT**3/LB)
00    C        VLM(N,1,K)    - SPEC. VOL. OF REFRIG. LIQUID IN TUBE I END OF HIGHER REFRIG. ENTHALPY
00    C                        (FT**3/LB)
00    C        VLM(N,2,K)    - SPEC. VOL. OF REFRIG. LIQUID IN TUBE I END OF LOWER REFRIG. ENTHALPY
00    C                        (FT**3/LB)
00    C        XRM(N,1,K)    - REFRIG. QUALITY AT TUBE K END OF HIGHER REFRIG. ENTHALPY    ( -)
00    C        XRM(N,2,K)    - REFRIG. QUALITY AT TUBE K END OF LOWER REFRIG. ENTHALPY    (-)
00    C        XTUBE(N,K)    - FRACTION OF TUBE K WITH SUPERHEATETD VAPOR
00    C                        (WHEN 2-PHASE FLOW IS IN REST OF TUBE)    (-)
00    C                        OR
00    C                      - FRACTION OF TUBE K WITH 2-PHASE FLOW
00    C                        (WHEN SUBCOOLED LIQUID IS IN REST OF TUBE)    (-)
00    C        XTT(N,K)      - LOCKHART-MARTINELLI PARAMETER FOR REFRIG. IN TUBE K    (-)
00    C        XW            - WEIGHT COMPOSITION    (FRACTION OF LESS VOLATILE COMPONENT)
00    C        WIDTH(N)      - LENGTH OF COIL TUBES    (FT)
00    C
00    C**** OUTPUT DATA:
00    C        BIMASS        - MASS OF REFRIGERANT IN COIL    (LB)
00    C
00    C**** SUBPROGRAMS CALLED BY BIMASS:
00    C        BUBTEM,DEWTEM,VISCON
00    C
00          COMMON/RDATA3/XW,XM,WM
00          COMMON/HPHX/NDEP(2),NROW(2),DI(2),DO(2),DT(2),RPCH(2),DPCH(2),
00         &WIDTH(2),FPCH(2),FTK(2),FMK(2),TMK(2),AMAS(2),ANGLE(2),
00         &CONST(2),CPOW(2),NTUB(2,5),IFROM(2,130),NSECT(2),NTPS(2)
00          COMMON/MASS/TRM(2,2,130),PRM(2,2,130),XRM(2,2,130),
00         &   VLM(2,2,130),VGM(2,2,130),XTUBE(2,130),XTT(2,130)
00    C
00          AREA=3.14159*DI(N)*DI(N)/4.
00          VTUBE=AREA*WIDTH(N)
00          VBEND=AREA*20.0*DI(N)
00          BIMASS=0.
00    C
00          DO 100 I=1,NTPS(N)
00          IF(XRM(N,2,I).GT..9999)THEN        @SUPERHEATED VAPOR ONLY
00             CM=VTUBE/(.5*(VGM(N,1,I)+VGM(N,2,I)))
00             CM=CM+VBEND/VGM(N,2,I)
00             GOTO 210
```

```
00         END IF
00     C
00         IF(XRM(N,1,I).GT..9999)THEN      @SUPERHEATED VAPOR AND 2-PHASE
00         VSAT=VGM(N,1,I)+XTUBE(N,I)*(VGM(N,2,I)-VGM(N,1,I))
00         TM1=VTUBE*XTUBE(N,I)/(.5*(VSAT+VGM(N,1,I)))
00         PDEW=PRM(N,1,I)+XTUBE(N,I)*(PRM(N,2,I)-PRM(N,1,I))
00         PA=PDEW/14.6959
00         TKDEW=(TRM(N,2,I)+460.)/1.8
00         CALL DEWTEM(1,PA,XM,TKDEW,XL)
00         TDEW=TKDEW*1.8-459.67
00         XRAV=0.5*(1.+XRM(N,2,I))
00         TRAV=.5*(TDEW+TRM(N,2,I))
00         VISL=VISCON(1,TRAV,XW)
00         VISV=VISCON(3,TRAV,XW)
00         XTTT=((1.-XRAV)/XRAV)**.9*(VISL/VISV)**.1
00         XTTT=XTTT*(VLM(N,2,I)/VGM(N,2,I))**.5
00         IF(XTTT.LT.10.)VOID=(1.+XTTT**.8)**(-.378)
00         IF(XTTT.GE.10.)VOID=.823-.157*ALOG(XTTT)
00         TM2=VTUBE*(1.-XTUBE(N,I))*VOID/(0.5*(VSAT+VGM(N,2,I)))
00         TM3=VTUBE*(1.-XTUBE(N,I))*(1.-VOID)/VLM(N,2,I)
00         TM4=VBEND*((1.-VOID)/VLM(N,2,I)+VOID/VGM(N,2,I))
00         CM=TM1+TM2+TM3+TM4
00         GOTO 210
00         END IF
00     C
00         IF(XRM(N,2,I).GT.0.9)THEN
00            XRAV=.5*(XRM(N,1,I)+XRM(N,2,I))
00            TRAV=.5*(TRM(N,1,I)+TRM(N,2,I))
00            VISL=VISCON(1,TRAV,XW)
00            VISV=VISCON(3,TRAV,XW)
00            XTTT=((1.-XRAV)/XRAV)**.9*(VISL/VISV)**.1
00            XTTT=XTTT*(VLM(N,2,I)/VGM(N,2,I))**.5
00            IF(XTTT.LT.10.)VOID=(1.+XTTT**.8)**(-.378)
00            IF(XTTT.GE.10.)VOID=.823-.157*ALOG(XTTT)
00            TM1=VTUBE*VOID/(0.5*(VGM(N,1,I)+VGM(N,2,I)))
00            TM2=VTUBE*(1.-VOID)/(.5*(VLM(N,2,I)+VLM(N,1,I)))
00            TM3=VBEND*(VOID/VGM(N,2,I)+(1.-VOID)/VLM(N,2,I))
00            CM=TM1+TM2+TM3
00            GOTO 210
00         END IF
00     C
00         IF(XRM(N,2,I).GT..1)THEN
00            IF(XTT(N,I).LT.10.)VOID=(1.+XTT(N,I)**.8)**(-.378)
00            IF(XTT(N,I).GE.10.)VOID=.823-.157*ALOG(XTT(N,I))
00            TM1=VTUBE*VOID/(0.5*(VGM(N,1,I)+VGM(N,2,I)))
00            TM2=VTUBE*(1.-VOID)/(.5*(VLM(N,2,I)+VLM(N,1,I)))
00            TM3=VBEND*(VOID/VGM(N,2,I)+(1.-VOID)/VLM(N,2,I))
00            CM=TM1+TM2+TM3
00            GOTO 210
00         END IF
00     C
00         IF(XRM(N,2,I).GT.0.0001)THEN
00            XRAV=.5*(XRM(N,1,I)+XRM(N,2,I))
00            TRAV=.5*(TRM(N,1,I)+TRM(N,2,I))
00            VISL=VISCON(1,TRAV,XW)
00            VISV=VISCON(3,TRAV,XW)
00            XTTT=((1.-XRAV)/XRAV)**.9*(VISL/VISV)**.1
00            XTTT=XTTT*(VLM(N,2,I)/VGM(N,2,I))**.5
```

```
00              IF(XTTT.LT.10.)VOID=(1.+XTTT**.8)**(-.378)
00              IF(XTTT.GE.10.)VOID=.823-.157*ALOG(XTTT)
00              TM1=VTUBE*VOID/(0.5*(VGM(N,1,I)+VGM(N,2,I)))
00              TM2=VTUBE*(1.-VOID)/(.5*(VLM(N,2,I)+VLM(N,1,I)))
00              TM3=VBEND*(VOID/VGM(N,2,I)+(1.-VOID)/VLM(N,2,I))
00              CM=TM1+TM2+TM3
00              GOTO 210
00           END IF
00     C
00           IF(XRM(N,1,I).GT.0.0001)THEN    @2-PHASE AND SUBCOOLED LIQUID
00           XRAV=0.5*XRM(N,1,I)
00           PA=PRM(N,1,I)+XTUBE(N,I)*(PRM(N,2,I)-PRM(N,1,I))
00           PA=PA/14.6959
00           CALL BUBTEM(0,PA,XM,TK,XV)
00           TRAV=.5*(TK*1.8-459.67+TRM(N,1,I))
00           VISL=VISCON(1,TRAV,XW)
00           VISV=VISCON(3,TRAV,XW)
00           XTTT=((1.-XRAV)/XRAV)**.9*(VISL/VISV)**.1
00           XTTT=XTTT*(VLM(N,1,I)/VGM(N,1,I))**.5
00           IF(XTTT.LT.10.)VOID=(1.+XTTT**.8)**(-.378)
00           IF(XTTT.GE.10.)VOID=.823-.157*ALOG(XTTT)
00           TM1=XTUBE(N,I)*VOID*VTUBE/VGM(N,1,I)
00           TM2=XTUBE(N,I)*(1.-VOID)*VTUBE/VLM(N,1,I)
00           TM3=((1.-XTUBE(N,I))*VTUBE+VBEND)/VLM(N,2,I)
00           CM=TM1+TM2+TM3
00           GOTO 210
00           END IF
00     C
00           CM=VTUBE/(.5*(VLM(N,1,I)+VLM(N,2,I)))
00           CM=CM+VBEND/VLM(N,2,I)
00       210 CONTINUE
00           BIMASS=BIMASS+CM
00       100 CONTINUE
00           BIMASS=BIMASS*NSECT(N)
00           IF(N.EQ.1)THEN
00           WRITE(6,220)BIMASS
00       220 FORMAT(/2X,'REFRIG. IN INDOOR COIL =',F8.3,' LB')
00                 ELSE
00           WRITE(6,222)BIMASS
00       222 FORMAT(/2X,'REFRIG. IN OUTDOOR COIL=',F8.3,' LB')
00           END IF
00           RETURN
00           END

END ELT.  ERRORS: NONE. TIME:  0.237 SEC. IMAGE COUNT: 157

@HDG,P  ******  BISYS1  ****** .L,0
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```
@ELT,L DD.BLINE
ELT 8R1 S74Q1C 07/21/84 15:54:53 (0)
      SUBROUTINE BLINE(D,TL,RMASS)
C
C**** PURPOSE:
C       TO CALCULATE FRICTIONAL PRESSURE DROP
C       OF A NON-AZEOTROPIC MIXTURE IN A LIQUID LINE
C
C**** INPUT DATA:
C       D     - INNER LIQUID LINE DIAMETER   (FT)
C       H11   - REFRIG. ENTHALPY AT INLET   (BTU/LBM)
C       P11   - REFRIG. PRESSURE AT INLET   (PSIA)
C       RMASS - REFRIG. MASS FLOW RATE   (LBM/H)
C       TL    - LIQUID LINE LENGTH   (FT)
C       T11   - REFRIG. TEMPERATURE AT INLET   (F)
C       XM    - MOLAR COMPOSITION   (FRACTION OF LESS VOLATINE COMPONENT)
C       XW    - WEIGHT COMPOSITION   (FRACTION OF LESS VOLATILE COMPONENT)
C       X11   - REFRIG. QUALITY AT INLET   (-)
C       WM    - MIXTURE MOLECULAR WEIGHT   (G/MOL)
C
C**** OUTPUT DATA:
C       H12   - REFRIG. ENTHALPY AT OUTLET   (BTU/LBM)
C       P12   - REFRIG. PRESSURE AT OUTLET   (PSIA)
C       T12   - REFRIG. TEMPERATURE AT OUTLET   (F)
C       X12   - REFRIG. QUALITY AT OUTLET   (-)
C
C**** SUBPROGRAMS CALLED BY BLINE:
C
      COMMON/RDATA2/W1,W2,TC1,TC2
      COMMON/RDATA3/XW,XM,WM
      COMMON/COND11/P11,T11,H11,X11
      COMMON/COND12/P12,T12,H12,X12
      DATA NO,N1/0,1/
C
      WRITE(6,100)P11,T11,X11,H11
      H12=H11
      IF(X11.GT.999)THEN
         X12=X11
         P12=P11
         T12=T11
         WRITE(6,99)
 99      FORMAT(' ERROR IN CALLING BLINE, X11=0.')
         GOTO 50
      END IF
      TLL=TL
      TK11=(T11+459.67)/1.8
      PA11=P11/14.6959
      ACCUP=0.003
      IF(X11.GT.0.)GOTO 10
C
C**** SUBCOOLED LIQUID AT ENTRANCE
      CALL VOLIT1(0,TK11,PA11,XM,VL)
      VL=VL*16.01846/WM
      VISL=VISCON(1,T11,XW)
      PD1=SPHDP1(RMASS,TL,D,VL,VISL)
      P12=P11-PD1
      PA12=P12/14.6959
      TK12=TK11
```

```
00          CALL HPIN(N1,H12,PA12,XM,ACCUR,TK12,X12,XL,XV,VL,VV)
00          T12=TK12*1.8-459.67
00          IF(X12.LT.0.0001)GOTO 50
00    C
00    C     PRESSURE DROPS BELOW SAT. PRESSURE
00          CALL BUBPRE(NO,TK11,XM,PARI,XVIN)
00          XLIN=XM
00          CALL VOLIT1(NO,TK11,PARI,XLIN,VLIN)
00          CALL VOLIT1(N1,TK11,PARI,XVIN,VVIN)
00          TRI=T11
00          PRI=PARI*14.6959
00          XRI=0.
00          TLL=TL*(PRI-P12)/PD1
00          GOTO 20
00    C
00    C**** 2-PHASE AT INLET
00       10 CALL QLITY(TK11,PA11,XM,XQ11,XVIN,XLIN)
00          CALL VOLIT1(NO,TK11,PA11,XLIN,VLIN)
00          CALL VOLIT1(N1,TK11,PA11,XVIN,VVIN)
00          XRI=X11
00          TRI=T11
00          PRI=P11
00       20 X12=XRI+0.02
00          PRE=PRI
00          T12=TRI
00          TK12=(T12+459.67)/1.8
00          XLE=XLIN
00          XVE=XVIN
00          VLE=VLIN
00          VVE=VVIN
00          DO 40 I=1,15
00          XRAV=0.5*(XRI+X12)
00          TRAV=0.5*(TRI+T12)
00          VL=0.5*(VLIN+VLE)
00          VV=0.5*(VVIN+VVE)
00          XL=0.5*(XLIN+XLE)
00          XV=0.5*(XVIN+XVE)
00          WML=W1*(1.-XL)+W2*XL
00          VLW=VL*16.04816/WML
00          XLW=XL/(W1/W2*(1.-XL)+XL)
00          WMV=W1*(1.-XV)+W2*XV
00          VVW=VV*16.04816/WMV
00          VMIX=VLW*(1.-XRAV)+VVW*XRAV
00          VISL=VISCON(1,TRAV,XLW)
00          PD1=SPHDP1(RMASS,TLL,D,VMIX,VISL)
00          P12=PRI-PD1
00          IF(P12.LE.0.)THEN
00             WRITE(6,98)
00       98 FORMAT(' CALC. OUTLET. PRESSURE BELOW ZERO, LIQ. LINE BY-PASSED')
00             X12=X11
00             T12=T11
00             P12=P11
00             GOTO 50
00          END IF
00    C
00          PA12=P12/14.6959
00          CALL HPIN(N1,H12,PA12,XM,ACCUR,TK12,X12,XLE,XVE,VLE,VVE)
00          T12=TK12*1.8-459.67
```

```
00          DELP=PRE-P12
00          IF(ABS(DELP).LT.0.001)GOTO 50
00          PRE=P12
00       40 CONTINUE
00          WRITE(5,105)DELP
00       50 WRITE(6,110)P12,T12,X12
00      100 FORMAT(//'  LIQUID LINE:',/
00         @ '   INPUT  -    PIN =',1PE10.3,3X,'TIN =',1PE10.3,3X,
00         @  'XIN =',1PE10.3,3X,'HIN =',1PE10.3)
00      105 FORMAT(' BLINE DOES NOT CONVERGE, DELP=',1PE14.5)
00      110 FORMAT('  OUTPUT -   POUT=',1PE10.3,3X,'TOUT=',1PE10.3,3X,
00         @       'XOUT=',1PE10.3)
00          RETURN
00          END
```

END ELT. ERRORS: NONE. TIME: 0.195 SEC. IMAGE COUNT: 128

@HDG,P ****** BMAIN ****** .L,0

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@ELT,L DD.BMAIN
ELT 8R1 S74Q1C 07/21/84 15:54:54 (0)
 00     C
 00     C**** THIS IS THE MAIN PROGRAM OF  ** HPBI **
 00     C      PROGRAM FOR SIMULATION OF VAPOR COMPRESSION CYCLE
 00     C      WITH CONSTANT FLOW AREA EXPANSION DEVICE,
 00     C      WORKING WITH NON-AZEOTROPIC, BINARY REFRIGERANT.
 00     C
 00     C**** THIS PROGRAM HAS BEEN DEVELOPED AT NATIONAL BUREAU OF STANDARDS,
 00     C      WASHINGTON, D.C.,
 00     C      UNDER THE CONTRACT FROM ELETRIC POWER RESEARCH INSTITUTE,
 00     C      PALO ALTO, CA.
 00     C      FEBRUARY, 1984.
 00     C
 00     C
 00     C**** THIS PROGRAM PROVIDES LOGIC AND ITERATION PROCEDURES
 00     C      FOR EVALUATION OF PERFORMANCE OF VAPOR COMPRESSION CYCLE
 00     C      WITH CONSTANT FLOW AREA EXPANSION DEVICE
 00     C
 00     C**** THIS PROGRAM PROVIDES ALSO LOGIC FOR EVALUATION
 00     C      OF PERFORMANCE PARAMETERS OF RECIPROCATING, HERMETIC COMPRESSOR.
 00     C
 00     C**** INPUT DATA:
 00     C [1] REFRIGERANT CONSTANTS - CONTANED IN PROGRAM BCONST
 00     C [2] HEAT PUMP DATA - READ FROM FILE 8
 00     C      REFER TO********************
 00     C [3] RUN CONTROLLING DATA - READ FROM A TERMINAL
 00     C [4] INDOOR/OUTDOOR AIR CONDITIONS DATA - READ FROM A TERMINAL
 00     C [5] REFRIGERANT PARAMETERS (GUESS) - READ FROM A TERMINAL
 00     C
 00     C      [2],[3],[4] & [5] ARE EXPLAINED IN ALPHABETIC ORDER BELOW
 00     C        AHGT          - DISTANCE BETWEEN ACCUMULATOR TOP AND OIL RETURN HOLE   (FT)
 00     C        AMAS(IIO)     - AIR MASS FLOW RATE THROUGH COIL   (LBM/H)
 00     C        ANGLE(IIO)    - ANGLE BETWEEN COIL FACE & AIR STREAMLINES   (RAD)
 00     C        CAPL1         - LENGTH OF COOLING OPERATION EXPANSION DEVICE   (IN)
 00     C        CAPL2         - LENGTH OF HEATING OPERATION EXPANSION DEVICE   (IN)
 00     C        CAPID1        - INNER DIA. OF COOLING OPERATION EXPANSION DEVICE   (IN)
 00     C        CAPID2        - INNER DIA. OF HEATING OPERATION EXPANSION DEVICE   (IN)
 00     C        CONST(IIO)    - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION   (-)
 00     C        CPOW(IIO)     - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION   (-)
 00     C        CLREFF        - COMPRESSOR CLEARANCE VOLUME AS FRACTION OF STROKE VOLUME   (-)
 00     C        CPC34         - PRESSURE DROP PARAMETER AT COMPRESSOR CAN INLET
 00     C                        (LBF*H**2/LBM*IN**2*FT**3)
 00     C        CPC45         - PRESSURE DROP PARAMETER AT COMPRESSOR SUCTION VALVE
 00     C                        (LBF*H**2/LBM*IN**2*FT**3)
 00     C        CPC67         - PRESSURE DROP PARAMETER AT COMPRESSOR DISCHARGE VALVE
 00     C                        (LBF*H**2/LBM*IN**2*FT**3)
 00     C        CPC78         - PRESSURE DROP PARAMETER AT COMPRESSOR CAN EXIT
 00     C                        (LBF*H**2.2/LBM*IN**2*FT**2.3)
 00     C        CPDR          - PRESSURE DROP PARAMETER FOR 4-WAY VALVE
 00     C                        (LBF*H**2/LBM*IN**2*FT**3)
 00     C        CQ            - PARAMETER FOR 4-WAY VALVE HEAT TRANSFER   (FT**.2)
 00     C        CQCCOA        - PARAMETER FOR COMPRESSOR CAN WALL-AMBIENT AIR HEAT TRANSFER   (BTU/H*F**1.333
 00     C        CQC4C         - PARAMETER FOR COMPRESSOR CAN WALL-REFRIG. VAPOR HEAT TRANSFER   (FT**.2)
 00     C        CQC45         - SUCTION VALVE HEAT TRANSFER PARAMETER   (FT**.2)
 00     C        CQC67         - DISCHARGE VALVE HEAT TRANSFER PARAMETER   (FT**.2)
 00     C        CQC78         - CAN EXIT HEAT TRANSFER PARAMETER   (FT**.2)
 00     C        DACC          - ACCUMULATOR INNER DIAMETER   (FT)
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00   C   DHOLE(I)       - DIA. OF A HOLE IN ACCUMULATOR TUBE   (FT)
00   C                    I=1  - OIL RETURN HOLE
00   C                    I=2  - UPPER HOLE
00   C   DI(IIO)        - INNER DIAMETER OF COIL TUBES   (IN)
00   C   DO(IIO)        - OUTER DIAMETER OF COIL TUBES   (IN)
00   C   DPCH(IIO)      - DEPTH PITCH FOR COIL TUBES   (IN)
00   C   DT(IIO)        - FIN TIP DIAMETER   (IN)
00   C   DTUBE          - INNER DIA. OF ACCUMULATOR TUBE   (FT)
00   C   EIDFAN         - INDOOR FAN ENERGY INPUT RATE   (KW)
00   C   ELEFUL         - COMPRESSOR MOTOR ENERGY INPUT RATE AT FULL LOAD   (KW)
00   C   EMETA(K)       - COMPRESSOR MOTOR EFFICIENCY IN FRACTION AT FRACTION
00   C                    OF FULL LOAD SPECIFIED BY EMOPT(K)   (-)
00   C   EMOPT(K)       - COMPRESSOR MOTOR FULL LOAD FRACTION   (-)
00   C   ENRPM(M)       - COEFFICIENT FOR COMPRESSOR MOTOR RPM CALCULATION   (-)
00   C   EODFAN         - OUTDOOR FAN ENERGY INPUT RATE   (KW)
00   C   ETAPLY         - COMPRESSOR POLYTROPIC EFFICIENCY   (-)
00   C   FMK(IIO)       - FIN MATERIAL THERMAL CONDUCTIVITY   (BTU/FT*H*F)
00   C   FPCH(IIO)      - FIN PITCH   (IN)
00   C   FTK(IIO)       - FIN THICKNESS   (IN)
00   C   HDIS           - VERTICAL DISTANCE BETWEEN HOLES IN AN ACCUMULATOR   (FT)
00   C   IFROM(IIO,M)   - NUMBER OF TUBE FROM WHICH TUBE M RECEIVES REFRIG.
00   C                    WHEN COIL WORKS AS EVAPORATOR   (-)
00   C   IIO            = 1   FOR INDOOR COIL   (-)
00   C                  = 2   FOR OUTDOOR COIL   (-)
00   C   IPTP           = 1   FOR EVALUATION OF COMPRESSION CYCLE PERFORMANCE   (-)
00   C                  = 2   FOR EVALUATION OF COMPRESSOR CYCLE PERFORMANCE   (-)
00   C   ITER           = 1   FOR ENTHALPY & REF. FLOW BALANCE   (-)
00   C                  = 2   FOR ABOVE + REFRIG. CHARGE BALANCE   (-)
00   C   LPR            = 0   FOR NO INPUT DATA PRINTOUT   (-)
00   C                  = 1   FOR INPUT DATA PRINTOUT REQUEST   (-)
00   C   NCPL1          - NUMBER OF COOLING OPERATION EXPANSION DEVICES   (-)
00   C   NCPL2          - NUMBER OF HEATING OPERATION EXPANSION DEVICES   (-)
00   C   NDEP(IIO)      - NUMBER OF COIL TUBE ROW DEPTHS   (-)
00   C   NSECT(1)       - NUMBER OF REPEATING SECTIONS IN INDOOR COIL   (-)
00   C   NSECT(2)       - NUMBER OF REPEATING SECTION IN OUTDOOR COIL   (-)
00   C   NROW(IIO)      - NUMBER OF TUBES PER ROW   (-)
00   C   NTUB(IIO,I)    - NUMBER OF TUBES IN ROW I FOR EACH SECTION OF COIL (-)
00   C   NSYS           = 1  FOR HEATING OPERATION   (-)
00   C                  = 2  FOR COOLING OPERATION   (-)
00   C   POA            - OUTDOOR AIR PRESSURE   (PSIA)
00   C   PRA            - INDOOR AIR PRESSURE   (PSIA)
00   C   REFIN          - REFRIGERANT CHARGE (REQUIRED FOR ITER=1 ONLY) (LBM)
00   C   RD             - INNER DIAMETER COMPRESSOR-INDOOR COIL TUBING   (IN)
00   C   RD1            - OUTER DIAMETER COMPRESSOR INDOOR COIL TUBING   (IN)
00   C   RD2            - OUTER DIAMETER OF COMPRESSOR-INDOOR COIL TUBING
00   C                    INSULATION   (IN)
00   C   RHOA           - OUTDOOR AIR REL HUMIDITY   (-)
00   C   RHRA           - INDOOR AIR REL. HUMIDITY   (-)
00   C   RK1            - THERMAL CONDUCTIVITY OF COMPRESSOR-INDOOR COIL TUBING
00   C                    MATERIAL   (BTU/FT*H*F)
00   C   RK2            - THERMAL CONDUCTIVITY OF COMPRESSOR-INDOOR COIL TUBING
00   C                    INSULATION   (BTU/FT*H*F)
00   C   RL             - LENGTH OF COMPRESSOR-INDOOR COIL TUBING   (IN)
00   C   RPCH(IIO)      - PITCH BETWEEN TUBES OF THE SAME DEPTH   (IN)
00   C   RYD            - LIQUID LINE DIAMETER   (IN)
00   C   RYL            - LIQUID LINE LENGTH   (IN)
00   C   SWPVOL         - COMPRESSOR SWEPT VOLUME PER REVOLUTION   (IN**3)
00   C   TMK(IIO)       - TUBE MATERIAL THERMAL CONDUCTIVITY   (BTU/FT*H*F)
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00   C       TG3          - REFRIG. SAT. TEMP. AT COMPRESSOR CAN INLET   (F)   (GUESS)
00   C       TG6          - REFRIG. SAT. TEMP. AT COMPRESSOR DISCHARGE VALVE   (F)   (GUESS)
00   C       TOA          - OUTDOOR AIR TEMPERATURE   (F)
00   C       TRA          - INDOOR AIR TEMPERATURE   (F)
00   C       TSUP3        - REFRIG. SUPERHEAT AT COMPRESSOR CAN INLET   (F)   (GUESS)
00   C       VCAN         - VOLUME OF COMPRESSOR CAN FILLED BY REFRIG.   (FT**3)
00   C       WIDTH(110)   - COIL WIDTH   (IN)
00   C       X3           - REFRIG. QUALITY AT COMPRESSOR CAN INLET   (-)
00   C       YD           - INNER DIAMETER COMPRESSOR-OUTDOOR COIL TUBING   (IN)
00   C       YD1          - OUTER DIAMETER OF COMPRESSOR-OUTDOOR COIL TUBING   (IN)
00   C       YD2          - OUTER DIAMETER OF COMPRESSOR-OUTDOOR COIL TUBING INSULATION   (IN)
00   C       YK1          - THERMAL CONDUCTIVITY OF COMPRESSOR-OUTDOOR COIL TUBING
00   C                      MATERIAL   (BTU/FT*H*F)
00   C       YK2          - THERMAL CONDUCTIVITY OF COMPRESSOR-OUTDOOR COIL TUBING
00   C                      INSULATION   (BTU/FT*H*F)
00   C       YL           - LENGTH OF COMPRESSOR-OUTDOOR COIL TUBING   (IN)
00   C
00   C**** OUTPUT DATA:
00   C       CFMIND       - VOLUMETRIC AIR FLOW THROUGH INDOOR COIL   (FT**3/MIN)
00   C       CFMOUT       - VOLUMETRIC AIR FLOW THROUGH OUTDOOR COIL   (FT**3/MIN)
00   C       COP          - COEFFICIENT OF PERFORMANCE   (-)
00   C       ELUSE        - TOTAL HEAT PUMP ENERGY CONSUMPSION   (KW)
00   C       RMASS        - REFRIG. MASS FLOW RATE   (LBM/H)
00   C       TG3          - REFRIG. SAT. TEMP. AT COMPRESSOR CAN INLET   (F)
00   C       TG6          - REFRIG. SAT. TEMP. AT COMPRESSOR DISCHARGE VALVE   (F)
00   C       TMASS        - REFRIGERANT CHARGE   (LBM)
00   C       TSUP3        - REFRIG. SUPERHEAT AT COMPRESSOR CAN INLET   (F)
00   C       QLOAD        - NET CAPACITY OF A HEAT PUMP   (BTU/H)
00   C       REFRIG. PARAMETERS  H,P,S,T,X FOR SYSTEM LOCATIONS FROM 1 TO 13
00   C       WHERE:
00   C                    H - ENTHALPY   (BTU/LBM)
00   C                    P - PRESSURE   (PSIA)
00   C                    S - ENTROPY   (BTU/LBM*F)
00   C                    T - TEMPERATURE   (F)
00   C                    X - QUALITY   (-)
00   C
00   C                    1 - EVAPORATOR EXIT
00   C                    2 - LOW PRESSURE 4-WAY VALVE INLET
00   C                    3 - COMPRESSOR INLET
00   C                    4 - INSIDE COMPRESSOR CAN
00   C                    5 - CYLINDER AT SUCTION
00   C                    6 - CYLINDER AT DISCHARGE
00   C                    7 - DISCHARGE MANIFOLD
00   C                    8 - COMPRESSOR CAN EXIT
00   C                    9 - HIGH PRESSURE 4-WAY VALVE EXIT
00   C                   10 - CONDENSER INLET
00   C                   11 - CONDENSER OUTLET
00   C                   12 - EXPANSION DEVICE INLET
00   C                   13 - EVAPORATOR INLET
00   C
00   C**** SUBPROGRAMS CALLED BY THIS MAIN PROGRAM:
00   C       AIRPR,BIMASS,BLINE,BPMASS,CAPIL,COMPAR,COMPRE,CONDHX,DEWPRE,
00   C       ENTRO2,EVAPHX,HCVCP,PXQIN2,VALVPA,VOLIT1,WACCUM
00   C
00   C
00          COMMON/RDATA1/A3,A4,A5,A6,A7,A8,B3,B4,B5,B6,B7,B8,F0,F1
00          COMMON/RDATA2/W1,W2,TC1,TC2
00          COMMON/RDATA3/XW,XM,WM
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00          COMMON/PARAM/A,B,C1,C2,D1,D2
00          COMMON/STORE1/A1,A2,B1,B2,SFG31
00          COMMON/ESDATA/AA(2,3),BB(2,3),CC(2,3)
00          COMMON/ACCURA/IACC,ITM
00    C
00          COMMON/COND1/P1,T1,H1,X1
00          COMMON/COND2/P2,T2,H2,X2
00          COMMON/COND3/P3,T3,H3,X3
00          COMMON/COND47/P4,T4,H4,X4,P5,T5,H5,X5,S5,P6,T6,H6,X6,
00         @  P7,T7,H7,X7
00          COMMON/COLD8/P8,T8,H8,X8
00          COMMON/COND9/P9,T9,H9,X9
00          COMMON/COND10/P10,T10,H10,X10
00          COMMON/COND11/P11,T11,H11,X11
00          COMMON/COND12/P12,T12,H12,X12
00          COMMON/COND13/P13,T13,H13,X13
00          COMMON/COMP/CPC34,COC4C,COCCDA,CPC45,COC45,
00         & EMETA(11),EMOPT(11),EMRPM(6),ELEFUL,SWPVOL,
00         & ETAPLY,CLREFF,CPC67,COC67,CPC78,COC78
00          COMMON/WAY4/CQ,CPDR
00          COMMON/HPHX/NDEP(2),NROW(2),DI(2),DO(2),DT(2),RPCH(2),DPCH(2),
00         & WIDTH(2),FPCH(2),FTK(2),FMK(2),THK(2),AMAS(2),ANGLE(2),
00         & CONST(2),CPOW(2),NTUB(2,5),IFROM(2,130),NSECT(2),NTPS(2)
00          COMMON/CFIN/CHX(2,8)
00          COMMON/MERG/MERGE(2,20,2),IMER(2),ISTART(2,20),IST(2),
00         &IDEPTH(2,130),FLOW(2,130),JFROM(2,130),KFEED(2,130,3),
00         &KSTART(2,20),KST(2)
00          COMMON/MASS/TRM(2,2,130),PRM(2,2,130),XRM(2,2,130),
00         &    VRM(2,2,130),VGM(2,2,130),XTUBE(2,130),XTT(2,130)
00          COMMON/RLINE/RL,RD,RK1,RD1,RK2,RD2
00          COMMON/YLINE/YL,YD,YK1,YD1,YK2,YD2
00          COMMON/ACCDIM/AHGT,DACC,DHOLE(2),DTUBE,HDIS
00          DIMENSION ATITLE(20),CEFF(8,3)
00          DATA X6,X7,X8,X9,X10/5*1./
00          DATA CEFF(1,1),CEFF(1,2),CEFF(1,3)/1.,0.,0./
00         *CEFF(2,1),CEFF(2,2),CEFF(2,3)/-.02282,  -.13755,     .20130E-01/
00         *CEFF(3,1),CEFF(3,2),CEFF(3,3)/ .16106,   .8182E-01, -.1144E-01/
00         *CEFF(4,1),CEFF(4,2),CEFF(4,3)/-.64075,  -.555E-01,  -.28753E-01/
00         *CEFF(5,1),CEFF(5,2),CEFF(5,3)/ .53491,   .1804E-01,  .42477E-01/
00         *CEFF(6,1),CEFF(6,2),CEFF(6,3)/-.19286,   .3094E-03,-.20335E-01/
00         *CEFF(7,1),CEFF(7,2),CEFF(7,3)/ .03564, -.1066E-02,  .40947E-02/
00         *CEFF(8,1),CEFF(8,2),CEFF(8,3)/-.0020972, .1241E-03, -.29673E-03/
00          DATA NO,N1/0,1/
00    C
00    C*******************************************************************************
00    C**** INPUT REFRIGERANT DATA
00          CALL BCONST
00    C
00          WRITE(6,894)
00          READ(5,777)IPTP
00          IF(IPTP.EQ.2)GOTO 340
00    C
00    C**** INPUT HEAT PUMP DATA
00    C**** INPUT MOTOR/COMPRESSOR DATA
00          READ(8,800)ATITLE
00          READ(8,777)(EMETA(I),I=1,5)
00          READ(8,777)(EMETA(I),I=6,11)
00          READ(8,777)(EMOPT(I),I=1,5)
```

```
00           READ(8,777)(EMOPT(I),I=6,11)
00           READ(8,777)(EMRPM(I),I=1,6)
00           IF(IPTP.EQ.1)GOTO 301
00           READ(8,777)FLEFUL,SWPVOL,ETAPLY,CLREFF
00           READ(8,777)CPC34,CPC45,CPC67,CPC78
00           READ(8,777)COC4C,COCCOA,COC45,COC67,COC78
00           READ(8,777)CO,CPDR,VCAN,IEFIN
00           READ(8,777)AHGT,DACC,DHOLE(1),DHOLE(2),DTUBE,HDIS
00     C**** INPUT INDOOR COIL DATA
00           READ(8,777)NDEP(1),NROW(1)
00           READ(8,777)DI(1),DO(1),DT(1),RPCH(1),DPCH(1),WIDTH(1)
00           READ(8,777)FPCH(1),FTK(1),FMK(1),TMK(1),AMAS(1)
00           READ(8,777)CONST(1),CPOW(1),ANGLE(1)
00           READ(8,777)EIDFAN
00           READ(8,777)NSECT(1)
00           READ(8,777)(NTUB(1,I),I=1,5)
00           DO 12 I=1,13
00           N=10*I
00           M=N-9
00        12 READ(8,777)(IFROM(1,J),J=M,N)
00     C**** INPUT OUTDOOR COIL DATA
00           READ(8,777)NDEP(2),NROW(2)
00           READ(8,777)DI(2),DO(2),DT(2),RPCH(2),DPCH(2),WIDTH(2)
00           READ(8,777)FPCH(2),FTK(2),FMK(2),TMK(2),AMAS(2)
00           READ(8,777)CONST(2),CPOW(2),ANGLE(2)
00           READ(8,777)EODFAN
00           READ(8,777)NSECT(2)
00           READ(8,777)(NTUB(2,I),I=1,5)
00           DO13I=1,13
00           N=10*I
00           M=N-9
00        13 READ(8,777)(IFROM(2,J),J=M,N)
00     C**** INPUT EXPANSION DEVICE DATA
00           READ(8,777)CAPID1,CAPL1,NCPL1,CAPID2,CAPL2,NCPL2
00     C**** INPUT CONNECTING TUBING DATA
00           READ(8,777)YL,YD,YK1,YD1,YK2,YD2
00           READ(8,777)RL,RD,RK1,RD1,RK2,RD2
00           READ(8,777)RYL,RYD
00     C
00     C*********************************************************************
00     C**** EVALUATION OF PERFORMANCE
00     C**** OF VAPOR COMPRESSION CYCLE
00     C*********************************************************************
00     C**** WRITE INPUT DATA
00           LPR1=1
00           LPR2=1
00           LPR3=1
00           WRITE(6,851)
00           READ(5,777)LPR
00           IF(LPR.EQ.0)GOTO 32
00           WRITE(6,852)
00           READ(5,777)LPR1
00           WRITE(6,853)
00           READ(5,777)LPR2
00           WRITE(6,854)
00           READ(5,777)LPR3
00           WRITE(6,855)
00           READ(5,777)LPR4
```

```
00         IF(LPR1.EQ.0)GOTO 22
00         WRITE(6,905)
00         WRITE(6,856)ELEFUL,SHPVOL,ETAPLY,CLREFF
00         WRITE(6,899)
00         WRITE(6,856)(EMETA(I),I=1,5)
00         WRITE(6,856)(EMETA(I),I=6,11)
00         WRITE(6,901)
00         WRITE(6,856)(EMOPT(I),I=1,5)
00         WRITE(6,856)(EMOPT(I),I=6,11)
00         WRITE(6,900)
00         WRITE(6,856)(EMRPM(I),I=1,6)
00         WRITE(6,906)
00         WRITE(6,856)CPC34,CPC45,CPC67,CPC78
00         WRITE(6,907)
00         WRITE(6,856)COC4C,COCCOA,COC45,COC67,COC78
00         WRITE(6,951)
00         WRITE(6,856)CQ,CPDR,VCAN,REFIN
00         WRITE(6,952)
00         WRITE(6,856)AHGT,DACC,DHOLE(1),DHOLE(2),DTUBE,HDIS
00      22 CONTINUE
00         IF(LPR2.EQ.0)GOTO 28
00         WRITE(6,911)
00         WRITE(6,912)NDEP(1),NROW(1)
00         WRITE(6,913)
00         WRITE(6,856)DI(1),DO(1),DT(1),RPCH(1),DPCH(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),CPOW(1),ANGLE(1)
00         WRITE(6,935)EIDFAN
00         WRITE(6,915)NSECT(1)
00         WRITE(6,916)(NTUB(1,I),I=1,5)
00         DO 24 I=1,13
00         N=10*I
00         M=N-9
00      24 WRITE(6,917)(IFROM(1,J),J=M,N)
00         WRITE(6,919)
00         WRITE(6,920)NDEP(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),CPOW(2),ANGLE(2)
00         WRITE(6,936)EODFAN
00         WRITE(6,915)NSECT(2)
00         WRITE(6,924)(NTUB(2,I),I=1,5)
00         DO 26 I=1,13
00         N=10*I
00         M=N-9
00      26 WRITE(6,917)(IFROM(2,J),J=M,N)
00      28 CONTINUE
00         IF(LPR3.EQ.0)GOTO 30
00         WRITE(6,946)CAPID1,CAPL1,NCPL1,CAPID2,CAPL2,NCPL2
00      30 CONTINUE
00         IF(LPR4.EQ.0)GOTO 32
00         WRITE(6,903)
00         WRITE(6,929)
```

```
00          WRITE(6,856)RL,RD,RK1,RD1,RK2,RD2
00          WRITE(6,909)
00          WRITE(6,910)
00          WRITE(6,856)YL,YD,YK1,YD1,YK2,YD2
00          WRITE(6,948)
00          WRITE(6,949)
00          WRITE(6,856)RYL,RYD
00       32 CONTINUE
00    C***********************************************************************
00    C**** PREPARE DATA FOR CALCULATIONS
00    C**** INDOOR @ OUTDOOR COIL
00          DO 34 I=1,2
00          DI(I)=DI(I)/12.
00          DO(I)=DO(I)/12.
00          DT(I)=DT(I)/12.
00          RPCH(I)=RPCH(I)/12.
00          DPCH(I)=DPCH(I)/12.
00          WIDTH(I)=WIDTH(I)/12.
00          FPCH(I)=FPCH(I)/12.
00       34 FTK(I)=FTK(I)/12.
00          CALL HXCODE(1)
00          CALL HXCODE(2)
00          DO 40 I=1,2
00          CRR=DT(I)/DO(I)
00          DO 40 J=1,8
00          CHX(I,J)=0.
00          DO 40 K=1,3
00          L=K-1
00       40 CHX(I,J)=CHX(I,J)+CEFF(J,K)*CRR**L
00    C**** EXPANSION DEVICE
00          CAPID1=CAPID1/12.
00          CAPL1=CAPL1/12.
00          CAPID2=CAPID2/12.
00          CAPL2=CAPL2/12.
00    C**** CONNECTING TUBING
00          RL=RL/12.
00          RD=RD/12.
00          RD1=RD1/12.
00          RD2=RD2/12.
00          YL=YL/12.
00          YD=YD/12.
00          YD1=YD1/12.
00          YD2=YD2/12.
00          RYL=RYL/12.
00          RYD=RYD/12.
00    C
00    C***********************************************************************
00       50 WRITE(6,926)
00          READ(5,777)POA,TOA,RHOA,PRA,TRA,RHRA
00          WRITE(6,940)
00          READ(5,777)NSYS
00          IF(NSYS.EQ.1)THEN
00             CAPID=CAPID2
00             CAPL=CAPL2
00             NCPL=NCPL2
00             PAIRC=PRA
00             TAIRC=TRA
00             RHC=RHRA
```

```
00            PAIRE=POA
00            TAIRE=TOA
00            RHE=RHOA
00         ELSE
00            CAPID=CAPID1
00            CAPL=CAPL1
00            NCPL=NCPL1
00            PAIRE=PRA
00            TAIRE=TRA
00            RHE=RHRA
00            PAIRC=POA
00            TAIRC=TOA
00            RHC=RHOA
00         END IF
00         WRITE(6,941)
00         READ(5,777)ITER
00         WRITE(6,954)
00         READ(5,777)ITERXW
00         IF(ITER.EQ.0)ITERXW=0
00         WRITE(6,927)
00         READ(5,777)XWORG
00         WRITE(6,928)
00         READ(5,777)XWW
00         WRITE(6,908)
00         READ(5,777)TG3,X3,TSUP3,TG6
00         XW=1.-XWW
00         CALL AIRPR(1,TRA,PRA,RHRA,W,CT,R,AM,AT)
00         V=R*(459.67+TRA)/144./PRA
00         CFM1=AMAS(1)*V/60.
00         CALL AIRPR(1,TOA,POA,RHOA,W,CT,R,AM,AT)
00         V=R*(459.67+TOA)/144./POA
00         CFM2=AMAS(2)*V/60.
00         IACC=0
00         RTGG=0.
00         PDR113=8.
00         FITER=0.
00         SPAD=0.
00   C**********************************************************************
00   C**** MAIN ITERATION PROCESS
00   C**********************************************************************
00   C
00   C**** START MIXTURE COMPOSITION LOOP
00         DO 250 NXW=1,4
00         X3MIN=0.8
00         X3MAX=1.
00         XM=XW/(W2/W1*(1.-XW)+XW)
00         WM=W1*(1.-XM)+W2*XM
00   C
00   C**** START REFRIGERANT MASS CONSERVATION LOOP
00         DO 200 NMASS=1,12
00   C
00   C**** START ENTHALPY LOOP
00         DO 130 ITH=1,8
00         TKG3=(TG3+459.67)/1.8
00         CALL DEWPRE(NO,TKG3,XM,PA3,XL)
00         P3=PA3*14.6959
00         IF(X3.LT.1.)THEN
00            CALL PXQIN2(XM,PA3,X3,TK3,XL,XV,VL,VV,H3)
```

```
00             T3=TK3*1.8-459.67                                 @
00          ELSE                                                 @
00             T3=TG3+TSUP3                                      @
00             TK3=(T3+459.67)/1.8                               @
00             CALL VOLIT1(N1,TK3,PA3,XM,V)                      @
00             CALL HCVCP(N1,TK3,V,XM,H3,CV,CP)                  @
00          END IF                                               @
00    C
00    C**** START REFRIGERANT FLOW RATE LOOP
00          INTERM=1
00          INTERE=1
00          DO 120 ICLAR=1,3
00          DO 112 ITM=1,8
00          IF(INTERM.EQ.0)GOTO 114
00          CALL COMPRE(NSYS,TG6,TRA,TOA,EI,RMASS)
00    C
00          CALL CONDHX(NSYS,RMASS,T10,P10,TAIRC,PAIRC,RHC,T11,P11,H11,X11)
00    C
00          X12A=X12
00          CALL BLINE(RYD,RYL,RMASS)
00    C
00          P13=P1+PDR113
00          POUT=P13
00          XMASS=RMASS
00          CALL CAPIL(XW,XMASS,P12,H12,POUT,CAPL,CAPID,NCPL)
00    C
00          DRMS2=RMASS-XMASS
00          INTERM=0
00          IF(ABS(DRMS2/RMASS).LT.0 005)GOTO 114
00          INTERM=1
00    C
00          IF(ITM.EQ.1)THEN
00             TG6X=TG6
00             IF(FITER.NE.0.)THEN
00                TG6CH=-FITER*DRMS2
00                IF(ABS(TG6CH).GT.8.)TG6CH=SIGN(8,TG6CH)
00             ELSE
00                TG6CH=SIGN(2.5,DRMS2)
00             END IF
00             TG6=TG6X+TG6CH
00             GOTO 108
00          END IF
00    C
00          FITER=(TG6X-TG6)/(DRMS21-DRMS2)
00          DDR=DRMS2/(DRMS21-DRMS2)
00          IF((X12+X12A).EQ.0..OR.(X12*X12A).NE.0.)THEN
00             IF(ABS(DRMS2/RMASS).GT..05)GOTO 105
00             TG6=TG6-DDR*(TG6X-TG6)
00             RMASS=RMASS-DDR*(RMASS1-RMASS)
00             H12=H12-DDR*(H121-H12)
00             IF(ICLAR.NE.1)GOTO 112
00             GOTO 114
00          END IF
00    C
00      105 TG6Y=TG6
00          TG6CH=-DDR*(TG6X-TG6)
00          IF(ABS(TG6CH).GT.8.)TG6CH=SIGN(8.,TG6CH)
00          TG6=TG6+TG6CH
```

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```
00          TG6X=TG6Y
00      108 RMASS1=RMASS
00          H121=H12
00          DRMS21=DRMS2
00      112 CONTINUE @@@@@@@@@@@@@@@@@@
00          WRITE(6,113)DRMS2,TG6CH
00      113 FORMAT(//' ITM LOOP DID NOT CONVERGE, DRMS2=',F6.2,' TG6CH=',F6.2)
00      114 CONTINUE
00          H13=H12
00          TK13=(T1+459.67)/1.8
00     C
00     C**** ITERATE EVAPORATOR TO CLOSE ENTHALPY LOOP
00          DO 116 ITE=1,6
00          PA13=P13/14.6959
00          CALL HPIN(N1,H13,PA13,XM,0.003,TK13,X13,XL,XV,VL,VV)
00          T13=TK13*1.8-459.67
00          NSY=2/NSYS
00          CALL EVAPHX(NSY,RMASS,T13,P13,TAIRE,PAIRE,RHE,X13,T1E,P1E,H1E,X1E)
00          P1EP1=P1E-P1
00          INTERE=0
00          IF(ABS(P1EP1).LT.0.2)GOTO 118
00          INTERE=1
00          TV=P13
00          IF(ITE.EQ.1)THEN
00             P13=P13-P1EP1
00             IF(SPAD.NE.0.)P13=TV-P1EP1*SPAD
00          ELSE
00             SPAD=(P13-P13F)/(P1EP1-P1EP1F)
00             P13=P13-P1EP1*SPAD
00             H1EE=H1E-P1EP1*(H1E-H1F)/(P1EP1-P1EP1F)
00          END IF
00          P13F=TV
00          P1EP1F=P1EP1
00          H1F=H1E
00      116 CONTINUE
00          WRITE(6,117)
00      117 FORMAT(//' ITE LOOP FAILED TO CONVERGE=')
00          INTERE=1
00          H1E=H1EE
00     C
00      118 PDR113=P13-P1
00          DENT2=H1E-H1
00          PRINT 640,P1,P1E,P1EP1,DENT2
00      640 FORMAT(' P1,P1E,P1EP1,DENT2=',4F10.4)
00          IF(ABS(DENT2).GT.0.6)GOTO 123
00          PRINT 3020,INTERM,INTERE,POUT,P13
00     3020 FORMAT(' INTERM,INTERE,POUT,P13=',2I4,2F8.2)
00             IF(INTERM.NE.0)GOTO 120
00             IF(INTERE.NE.0)GOTO 120
00             IF((POUT-P13).LT.-0.5)GOTO 120
00             GOTO 140
00      120 CONTINUE
00          WRITE(6,642)
00      642 FORMAT(' LOOP 120 DID NOT CONVERGE, RUN TERMINATED')
00          GOTO 999
00     C
00     C**** ITERATE INPUT DATA FOR NEXT LOOP (ITH)
00      123 IF(ITH.EQ.1)THEN
```

```
00              DENT1=DENT2
00              TG3A=TG3
00              TG6A=TG6
00              IF(RTG6.NE.0.)THEN
00                 TG3=TG3-DENT2*RTG3
00                 TG6=TG6-DENT2*RTG6
00              ELSE
00                 TCH=SIGN(2.,DENT2)
00                 TG3=TG3+TCH
00                 TG6=TG6+TCH/2.
00              END IF
00           ELSE
00              RTG3=(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       124    TG3=TG3A-DENT1*RTG3
00              TG6=TG6A-DENT1*RTG6
00           END IF
00       130 CONTINUE
00           WRITE(6,133)DENT2
00       133 FORMAT(//' ITH LOOP DID NOT CONVERGE, DENT2=',F8.3)
00       140 CONTINUE
00     C*************************************************************************
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           PMASS4=BPMASS(1.128,VCAN,P4,T4,P4,T4)
00           PMASS5=BPMASS(RYD,RYL,P11,T11,P12,T12)
00           PMASST=PMASS1+PMASS2+PMASS3+PMASS4+PMASS5
00           TMASS=PMASST+BIMASS(1)+BIMASS(2)
00     C**** 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,P9,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(6,934)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          WRITE(6,933)INN,T2,P2,H2,S2,X2
00          INN=3
00          WRITE(6,933)INN,T3,P3,H3,S3,X3
00          INN=4
00          WRITE(6,933)INN,T4,P4,H4,S4,X4
00          INN=5
00          WRITE(6,933)INN,T5,P5,H5,S5,X5
00          INN=6
00          WRITE(6,933)INN,T6,PC,HG,S6,X6
00          INN=7
00          WRITE(6,933)INN,T7,P7,H7,S7,X7
00          INN=8
00          WRITE(6,933)INN,T8,P8,H8,S8,X8
00          INN=9
00          WRITE(6,933)INN,T9,P9,H9,S9,X9
00          INN=10
00          WRITE(6,933)INN,T10,P10,H10,S10,X10
00          INN=11
00          WRITE(6,933)INN,T11,P11,H11,S11,X11
00          INN=12
00          WRITE(6,933)INN,T12,P12,H12,S12,X12
00          INN=13
00          WRITE(6,933)INN,T13,P13,H13,S13,X13
00          QLOAD=RMASS*(H10-H11)+3412.66*EIDFAN
00          IF(NSYS.EQ.2)QLOAD=RMASS*(H1-H13)-3412.66*EIDFAN
00          ELUSE=EI+EODFAN+EIDFAN
00          COP=QLOAD/(3412.66*ELUSE)
00          WRITE(6,942)TG3,TSUP3,TG6,RMASS,TMASS
00          WRITE(6,943)QLOAD,ELUSE,COP
00          WRITE(6,945)XWW
00          IF(ITER.EQ.0)GOTO 260
00    C
00    C***  CHECK ON REFRIG. CHARGE REQUESTED
00          DMASS=TMASS-REFIN
00    C***  REFRIG. BALANCE NOT OBTAINED
00    C***  ITERATE INPUT DATA FOR THE NEXT LOOP (NMASS)
00          IF(ABS(DMASS/REFIN).LT.0.015)GOTO 202
00          IF(NMASS.NE.1)GOTO 164
00      158 DMASS1=DMASS
00          TSUP31=TSUP3
00          X31=X3
00          TG31=TG3
00          TG61=TG6
00    CC+++
00          X3MAX=X3
00          X3MIN=X3
00          TG3MAX=TG3
00          TG3MIN=TG3
00          TG6MIN=TG6
00          TG6MAX=TG6
00          DMMAX=DMASS1
00          DMMIN=DMASS1
00    CC+++
00          IF(DMASS.GT.0.)GOTO 160
00          IF(TSUP3.GT.0.)THEN            @MOVE TOWARDS SMALLER TSUP3 OR X3
00             TSUP3=TSUP31-4.
00             TSUP3=AMAX1(0.,TSUP3)
00             TG3=TG31+(TSUP31-TSUP3)/4.
```

```
            TG6=TG61+(TSUP31-TSUP3)/2.
         ELSE
            X3=X31-0.02
            TG3=TG31+1.
            TG6=TG61+2.
            X3MAX=X31
            DMMAX=DMASS1
            TG3MAX=TG31
            TG6MAX=TG61
         END IF
         GOTO 193
     160 IF(X3.LT.1.)THEN        @MOVE TOWARDS HIGHER TSUP3 OF X3
            X3MIN=X31
            DMMIN=DMASS1
            TG3MIN=TG31
            TG6MIN=TG61
            X3=X31+0.02
            X3=AMIN1(1.,X3)
            TG3=TG31-(X3-X31)/0.02
            TG6=TG61-(X3-X31)/0.01
         ELSE
         IF(NXW.NE.1)THEN
            WRITE(6,956)
            GOTO 202
         END IF
            TSUP3=TSUP31+4.
            TG3=TG31-1.
            TG6=TG61-2.
         END IF
         GOTO 196
C**********  INTERPOLATION  *****************************
     164 DMASS2=DMASS
         TSUP32=TSUP3
         X32=X3
         TG32=TG3
         TG62=TG6
         FACT=-DMASS2/(DMASS1-DMASS2)
C
         IF(DMASS.GT.0.)GOTO 166
         IF(TSUP3.GT.0.)THEN             @MOVE TOWARDS SMALLER TSUP3 OR X3
            TSUPCH=(TSUP31-TSUP32)*FACT
            IF(TSUPCH.LT.-10.)THEN
               TSUPCH=-10.
               FACT=-10./(TSUP31-TSUP32)
            END IF
            TSUP3=TSUP3+TSUPCH
            IF(TSUP3.LT.0.)THEN
               TSUP3=0.
               X3=1.
               FACT=-TSUP32/(TSUP31-TSUP32)
            END IF
         ELSE
            X3MAX=X3
            TG3MAX=TG3
            TG6MAX=TG6
            DMMAX=DMASS
            IF(X3MIN.LT.X3MAX)THEN
               X3=0.5*(X3MIN+X3MAX)
```

```
00                TG3=0.5*(TG3MIN+TG3MAX)
00                TG6=0.5*(TG6MIN+TG6MAX)
00             ELSE
00                X3=X3MAX-0.015
00             END IF
00   C+          IF((ABS(DMASS1-DMASS2)/REFIN).LT.0.005)THEN
00   C+             XCH=-0.01
00   C+             IF(X3MIN.EQ..8)GOTO 165
00   C+             X3=X3MIN+0.00199
00   C+             X31=X3MIN
00   C+             TG31=TG3MIN
00   C+             TG61=TG6MIN
00   C+             DMASS1=DMMIN
00   C+             TG3=TG3MIN
00   C+             TG6=TG6MIN
00   C+             GOTO 198
00   C+          END IF
00   C+          XCH=(X31-X32)*FACT
00   C+          IF(XCH.LT.-0.06)THEN
00   C+             XCH=-0.06
00   C+             FACT=-0.06/(X31-X32)
00   C+          END IF
00   C+  165     X3=X32+XCH
00   C+          IF(X3.LT.X3MIN)THEN
00   C+             FACT=-DMASS2/(DMMIN-DMASS2)
00   C+             X3=X32+(X3MIN-X32)*FACT
00   C+          END IF
00          END IF
00          GOTO 170
00   C
00     166 IF(X3.LT.1.)THEN                 @MOVE TOWARDS HIGHER TSUP3 OR X3
00             X3MIN=X3
00             TG6MIN=TG6
00             TG3MIN=TG3
00             DMMIN=DMASS
00             IF(X3MAX.GT.X3MIN)THEN
00                X3=0.5*(X3MIN+X3MAX)
00                TG3=0.5*(TG3MIN+TG3MAX)
00                TG6=0.5*(TG6MIN+TG6MAX)
00             ELSE
00                X3=X3MIN+0.015
00             X3=AMIN1(1.,X3)
00             END IF
00   C+          X3=X32+(X31-X32)*FACT
00   C+          IF(X3.GT.1.)THEN
00   C+             X3=1.0001
00   C+             FACT=(1.-X32)/(X31-X32)
00   C+          END IF
00   C+          IF(X3.GT.X3MAX)THEN
00   C+             FACT=-DMASS2/(DMMAX-DMASS2)
00   C+             X3=X32+(X3MAX-X32)*FACT
00   C+          END IF
00          ELSE
00             IF(NXW.NE.1)THEN
00             WRITE(6,956)
00                GOTO 202
00                END IF
00             IF(TSUP31.EQ.0..AND.TSUP32.EQ.0.)GOTO 158
```

```
00              TSUPCH=(TSUP31-TSUP32)*FACT
00              IF(TSUPCH.GT.10.)THEN
00                 TSUPCH=10.
00                 FACT=10./(TSUP31-TSUP32)
00              END IF
00           TSUP3=TSUP3+TSUPCH
00           END IF
00       170 TG3=TG32+(TG31-TG32)*FACT
00           TG6=TG62+(TG61-TG62)*FACT
00           DMASS1=DMASS2
00           TSUP31=TSUP32
00           X31=X32
00           TG31=TG32
00           TG61=TG62
00       196 IF(X3.LT.0.80.OR.TSUP3.GT.55.)THEN
00              WRITE(6,944)
00              GOTO 202
00       198 END IF
00     C+   198 IF((X3MAX-X3MIN).LT..002)THEN
00     C+          WRITE(6,950)X3MAX,X3MIN
00     C+          GOTO 202
00     C+       END IF
00       200 CONTINUE
00           WRITE(6,201)DMASS
00       201 FORMAT(//' NMASS LOOP DID NOT CONVERGE, DMASS=',F9.3)
00     C**** END OF REFRIGERANT MASS CONSERVATION LOOP
00     C
00     C*********************************************************************
00       202 IF(ITERXW.EQ.0)GOTO 260
00           XWCIR=(TMASS*(1.-XWORG)-PMASS3*XWA)/(TMASS-PMASS3)
00           XWCIRW=1.-XWCIR
00           PRINT 957,XWCIRW
00           XWDIF=XW-XWCIR
00           IF(ABS(XWDIF).LT.0.01)GOTO 250
00           IF(NXW.EQ.1)THEN
00              XW1=XW
00              XW=XW-.5*(XW-XWCIR)
00              XWDIF1=XWDIF
00           ELSE
00              POCH=(XW-XW1)/(XWDIF-XWDIF1)
00              XWO=XW-XWDIF*POCH
00              XW1=XW
00              XW=XWO
00              XW=AMIN1(XW,.95)
00              XW=AMAX1(XW,.05)
00              IF(XW.EQ.XW1)GOTO 260
00              XWDIF1=XWDIF
00           END IF
00           XWW-1.-XW
00           PRINT 958,XWW
00       250 CONTINUE
00     C**** END OF MIXTURE COMPOSITION LOOP
00     C
00           WRITE(6,955)
00       260 CONTINUE
00     C**** END OF EVALUATION OF PERFORMANCE
00     C**** OF VAPOR COMPRESSION CYCLE
00           WRITE(6,893)
```

```
00          READ(5,777)I
00          IF(I.NE.999)GOTO 50
00          GOTO 999
00    C
00    C**********************************************************************
00    C**** EVALUATION OF PARAMETERS
00    C**** OF VAPCR COMPRESSOR
00    C**********************************************************************
00    CW     WRITE(6,899)
00    CW     WRITE(6,856)(EMETA(I),I=1,5)
00    CW     WRITE(6,856)(EMETA(I),I=6,11)
00    CW     WRITE(6,901)
00    CW     WRITE(6,856)(EMOPT(I),I=1,5)
00    CW     WRITE(6,856)(EMOPT(I),I=6,11)
00    CW     WRITE(6,900)
00    CW     WRITE(6,856)(EMRPM(I),I=1,6)
00      301 CALL COMPAR
00          GOTO 999
00    C
00    C**********************************************************************
00    C     EVALUATION OF FOUR-VALVE PARAMETERS
00    C**********************************************************************
00    C
00      340 CALL VALVPA
00    C
00      777 FORMAT( )
00      800 FORMAT( 20A4)
00      851 FORMAT(/2X,'ANSWER 1 FOR YES OR 0 FOR NO',
00         *  /2X,'DO YOU WANT ANY INPUT DATA PRINTED ? LPR=')
00      852 FORMAT(/2X,'MOTOR/COMPRESSOR DATA ?')
00      853 FORMAT(/2X,'INDOOR COIL DATA',
00         & /2X,'OUTDOOR COIL DATA ?')
00      854 FORMAT(/2X,' EXPANSION DEVICE DATA ?')
00      855 FORMAT(/2X,' CONNECTING TUBING DATA ?')
00      856 FORMAT(6(1PE11.3))
00      858 FORMAT(/' RMASS=',1PE11.3)
00      860 FORMAT(/2X,'TG1,TG3,RMASS,P13=',4(1PE11.3))
00      862 FORMAT(/2X,'TMASS =',1PE11.3,5X,'REFIN =',1PE11.3)
00      864 FORMAT(/'*************************************************************')
00      893 FORMAT(///2X,'I=999 FOR DISCONTINUATION')
00      894 FORMAT(//2X,'COMPRESSOR PARAMETERS(1), FOUR WAY VALVE PARAMETERS'
00         1'(2)', //'  OR HEAT PUMP PERFORMANCE(3), IPTP=')
00      899 FORMAT(/2X,'EMETA(11):')
00      900 FORMAT(/2X,'EMRPM(6):')
00      901 FORMAT(/2X,'EMOPT(11):')
00      903 FORMAT(//2X,'TUBING CONNECTING COMPRESSOR @ IND. COIL')
00      905 FORMAT(//2X,'MOTOR/COMPRESSOR DATA',//
00         & 2X,'ELEFUL',5X,'SWPVOL',5X,'ETAPLY',5X,'CLREFF')
00      906 FORMAT(/2X,'CPC34',6X,'CPC45',6X,'CPC67',6X,'CPC78')
00      907 FORMAT(/2X,'COC4C',6X,'COCC0A',6X,'COC45',6X,'COC67',6X,'COC78')
00      908 FORMAT(/2X,'REFRIGERANT STATE GUESSES: TG3,X3,TSUP3,TG6=')
00      909 FORMAT(//2X,'TUBING CONNECTING COMPRESSOR @ OUT. COIL')
00      910 FORMAT(/2X,'YL',7X,'YD',6X,'YK1',6X,
00         &'YD1',6X,'YK2',6X,'YD2')
00      911 FORMAT(//2X,'INDOOR COIL DATA:')
00      912 FORMAT(/2X,'NDEP(1)',4X,'NROW(1)'/I4,I11)
00      913 FORMAT(/2X,'DI(1)',6X,'DO(1)',6X,'DT(1)'6X,'RPCH(1)',4X,
00         & 'DPCH(1)',4X,'WIDTH(1)')
```

```
00   914 FORMAT(/2X,'FPCH(1)',4X,'FTK(1)',5X,'FMK(1)',5X,
00      &'TMK(1)',5X,'AMAS(1)')
00   915 FORMAT(/2X,'NO. OF REPEATING SECTIONS:',I3)
00   916 FORMAT(/2X,'NTUB(1):'/5I5//2X,'IFROM(1):')
00   917 FORMAT(10I5)
00   918 FORMAT(/2X,'CONST(1)',3X,'CPOW(1)',4X,'ANGLE(1)')
00   919 FORMAT(//2X,'OUTDOOR COIL DATA:')
00   920 FORMAT(/2X,'NDEP(2)',4X,'NROW(2)'/I4,I11)
00   921 FORMAT(/2X,'DI(2)',6X,'DO(2)',6X,'DT(2)',6X,'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,'CPOW(2)',4X,'ANGLE(2)')
00   924 FORMAT(/2X,'NTUB(2):'/5I5//2X,'IFROM(2):')
00   926 FORMAT(/2X,'OUTDOOR & INDOOR AIR CONDITIONS',
00      @       /2X,'POA,TOA,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(I3,5(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,'TSUP3',6X,'TG6',8X,'RMASS',6X,'TMASS'/
00      &  5(1PE11.3))
00   943 FORMAT(/2X,'QLOAD',6X,'ELUSE',6X,'COP'/3(1PE11.3))
00   944 FORMAT(' QUALITY OR SUPERHEAT LIMIT EXEEDED')
00   945 FORMAT(/1X,' REFRIG. COMPOSITION =',F7.3,/
00      & '  (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)',///)
00   946 FORMAT(/2X,'EXP. DEVICE:',8X,'ID',5X,'LENGTH     #'/
00      @  '  AT INDOOR COIL',F10.4,F8.2,I6,/
00      @  '  AT OUTDOOR COIL',F9.4,F8.2,I6)
00   947 FORMAT(/2X,'CFMIND',5X,'CFMOUT'/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,'CQ',11X,'CPDR',7X,'VCAN',7X,'REFIN')
00   952 FORMAT(/2X,'AHGT',7X,'DACC',7X,'DHOLE(1)',3X,'DHOLE(2)',
00      @  3X,'DTUBE',6X,'HDIS')
00   954 FORMAT(/2X,'IS ITERATION OF MIXTURE COMPOSITION REQUESTED ?',/
00      &      2X,'ITERXW=0 FOR NO, ITERXW=1 FOR YES,    ITERXW=')
00   955 FORMAT(/2X,' CONVERGENCE NOT OBTAINED IN COMPOSITION LOOP')
00   956 FORMAT(/2X,'GUESSED COMPOSITION TO RICH IN MORE VOLATILE',
00      &' COMPONENT')
00   957 FORMAT(//' FOR THE AMOUNT OF REFRIGERANT STORED IN THE ACCUMULA'
00      & 'TOR',/' CIRCULATING 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)'//,
```

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******  BMAIN  ******                                                          DATE 072184

 9860.          00        & ' **************************************************')
 9870.          00     999 STOP
 9880.          00         END

END ELT.  ERRORS: NONE. TIME:  1.146 SEC. IMAGE COUNT: 987

@HDG,P  ******  BPMASS  ****** .L,0
```

```
@ELT,L DD.BPMASS
ELT 8R1 S74Q1C 07/21/84 15:54:55 (0)
        00          FUNCTION BPMASS(DI,DL,P1,T1,P2,T2)
        00     C
        00     C**** PURPOSE
        00     C        TO COMPUTE MASS OF A NON-AZEOTROPIC REFRIGERANT
        00     C        IN A TUBE
        00     C        (HOMOGENOUS FLOW ASSUMED)
        00     C
        00     C**** INPUT DATA:
        00     C        DI     - INNER DIAMETER OF TUBE    (FT)
        00     C        DL     - LENGTH OF TUBE    (FT)
        00     C        P1     - REFRIG. INLET PRESSURE    (PSIA)
        00     C        P2     - REFRIG. OUTLET PRESSURE    (PSIA)
        00     C        T1     - REFRIG. INLET TEMPERATURE    (F)
        00     C        T2     - REFRIG. OUTLET TEMPERATURE    (F)
        00     C        XW     - WEIGHT COMPOSITION    (FRACTION OF LESS VOLATILE COMPONENT)
        00     C
        00     C**** OUTPUT DATA:
        00     C        BPMASS - REFRIG. MASS IN TUBE    (LB)
        00     C
        00     C**** SUBPROGRAMS CALLED BY BPMASS:
        00     C        TPPROP
        00     C
        00          COMMON/RDATA3/XW,XM,WM
        00     C
        00          AREA=3.14159*DI*DI/4.
        00          VTUBE=AREA*DL
        00          CALL TPPROP(T1,P1,XW,XQ,H,V1)
        00          CALL TPPROP(T2,P2,XW,XQ,H,V2)
        00          BPMASS=2.*VTUBE/(V1+V2)
        00          RETURN
        00          END

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)
    00          FUNCTION BSIMP(FX,A1,A2,E,MAXIT,H1,GN,XM)
    00    C-----------------------------------------------------------------------
    00    C     NUMERICAL INTEGRATION USING SIMPSON-S 1/3 RULE
    00    C-----------------------------------------------------------------------
    00    C     INITIALIZATIONS
    00          REAL*8 FX
    00    C
    00          S1=0.
    00          PR=0.
    00          X=A2
    00          H=A1-A2
    00          M=2
    00    C     LOOP TO COUNT THE MAXIMUM NUMBER OF ITERATIONS
    00          DO 6 J=0,MAXIT
    00          S=0.
    00    C     LOOP TO COUNT THE NUMBER OF FUNCTION EVALUATIONS
    00          DO 1 I=1,M
    00    C     SUM THE FUNCTION EVALUATIONS
    00          S=S+FX(XM,X,H1,GN)
    00    C     INCREMENT X
    00        1 X=X+H
    00    C     OBTAIN NEW VALUE OF INTEGRATION
    00          BSIMP=(2.*S+S1)*H/3.
    00          IF(J-1) 2,4,3
    00    C     FIRST LOOP. SET M TO 1 AND DIVIDE THE FUNCTION EVALUATIONS
    00    C     BY 2
    00        2 M=1
    00          S1=-S/2.
    00          GO TO 5
    00    C     CHECK ERROR CONTROL
    00        3 PR=PR-BSIMP
    00          PR=PR/BSIMP
    00    C     EVALUATION WITHIN ERROR LIMITS. FINISH
    00          IF(ABS(PR).LT.E) GO TO 7
    00    C     SECOND ITERATION.  HALVE H AND DOUBLE M
    00        4 H=H*.5
    00          M=2*M
    00    C     OBTAIN NEW LOWER FOR FUNCTION EVALUATIONS
    00        5 X=A2+.5*H
    00    C     PREVIOUS VALUE OF INTEGRATION
    00          PR=BSIMP
    00        6 S1=S1+S
    00        7 RETURN
    00          END

END ELT.  ERRORS: NONE. TIME:  0.096 SEC. IMAGE COUNT: 44

@HDG,P  ******  BUBPRE  ****** .L,0
```

```
@ELT,L DD.BUBPRE
ELT 8R1 S74Q1C 07/21/84 15:54:56 (0)
      SUBROUTINE BUBPRE(IG,T,X,P,XV)
C
C
C**** PURPOSE:
C        TO CALC. BUBBLE POINT PRESSURE OF BINARY MIXTURE
C        FROM GIVEN TEMPERATURE AND COMPOSITION
C
C**** INPUT:
C        IG = 0,  IF GUESS OF PRESSURE IS NOT GIVEN
C           = 1,  IF GUESS OF PRESSURE IS GIVEN
C        T  - TEMPERATURE    (K)
C        P  - GUESS OF PRESSURE, OPTIONAL  (STD ATM)
C        X  - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
C
C**** OUTPUT:
C        P  - BINARY MIXTURE PRESSURE AT BUBBLE POINT   (STD ATM)
C        XV - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
C             IN SAT. VAPOR IN EQUILIBRIUM WITH LIQUID   (-)
C
C**** SUBPROGRAMS CALLED BY BUBPRE:
C        EBUBPR,QLITY
C
      DATA SLOPE/0./,TLAST/0./
C
      IF(ABS(T-TLAST).GT.1.E-3)GOTO 10
      IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
      P=PLAST
      XV=XVLAST
      RETURN
C
   10 IF(IG.NE.1)P=EBUBPR(T,X)
      DO 50 I=1,20
      CALL QLITY(T,P,X,XQ,XV,XL)
      P2=P
      XDIF2=X-XL
      IF(ABS(XDIF2).LT.0.00001)GOTO 100
      IF(I.NE.1)GOTO 20
   15    P1=P2
         XDIF1=XDIF2
         IF(SLOPE.NE.0.)THEN
            DP=XDIF2*SLOPE
            IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)
            P=P2-DP
            GOTO 50
         END IF
         P=P2+0.5
         IF(XDIF2.GT.0.)P=P2-0.5
         GOTO 50
C
   20 IF(XDIF1.EQ.XDIF2)GOTO 15
      SLOPE=(P2-P1)/(XDIF2-XDIF1)
      IF(ABS(XDIF1).LT.ABS(XDIF2))GOTO 30
         P1=P2
         XDIF1=XDIF2
   30 DP=XDIF1*SLOPE
      IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)
```

```
      00            P=P1-DP
      00         50 CONTINUE
      00            WRITE(6,600)XDIF2
      00        600 FORMAT(' ERROR 600 IN BUBPRE, XDIF2=',1PE12.4)
      00        100 TLAST=T
      00            XLAST=X
      00            PLAST=P
      00            XVLAST=XV
      00            RETURN
      00            END

END ELT.  ERRORS: NONE. TIME:  0.128 SEC. IMAGE COUNT: 66

@HDG,P  ******  BUBTEM  ****** .L,0
```

```
@ELT,L DD.BUBTEM
ELT 8R1 S74Q1C 07/21/84 15:54:56 (0)
     00          SUBROUTINE BUBTEM(IG,P,X,T,XV)
     00    C
     00    C
     00    C**** PURPOSE:
     00    C        TO CALC. BUBBLE POINT TEMPERATURE OF BINARY MIXTURE
     00    C        FROM GIVEN PRESSURE AND COMPOSITION
     00    C
     00    C**** INPUT:
     00    C        IG = 0,  IF GUESS OF TEMPERATURE IS NOT GIVEN
     00    C           = 1,  IF GUESS OF TEMPERATURE IS GIVEN
     00    C        P  - PRESSURE    (STD ATM)
     00    C        T  - GUESS OF TEMPERATURE, OPTIONAL  (K)
     00    C        X  - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
     00    C
     00    C**** OUTPUT:
     00    C        T  - BINARY MIXTURE TEMPERATURE AT BUBBLE POINT    (K)
     00    C        XV - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
     00    C             IN SAT. VAPOR IN EQUILIBRIUM WITH LIQUID    (-)
     00    C
     00    C**** SUBPROGRAMS CALLED BY BUBTEM:
     00    C        EBUBTE,QLITY
     00    C
     00          DATA SLOPE/0./,PLAST/0./
     00    C
     00          IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
     00          IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
     00          T=TLAST
     00          XV=XVLAST
     00          RETURN
     00    C
     00       10 TIN=T
     00          IF(IG.NE.1)T=EBUBTE(P,X)
     00          DO 50 I=1,20
     00          CALL QLITY(T,P,X,XQ,XV,XL)
     00          T2=T
     00          XDIF2=X-XL
     00          IF(I.NE.1)GOTO 20
     00       15    T1=T2
     00             XDIF1=XDIF2
     00             IF(SLOPE.NE.0.)THEN
     00                DT=XDIF2*SLOPE
     00                IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
     00                T=T2-DT
     00                GOTO 50
     00             END IF
     00             T=T2+5.
     00             IF(XDIF2.GT.0.)T=T2-5.
     00             GOTO 50
     00    C
     00       20 IF(XDIF1.EQ.XDIF2)GOTO 15
     00          SLOPE=(T2-T1)/(XDIF2-XDIF1)
     00          IF(ABS(XDIF1).LT.ABS(XDIF2))GOTO 30
     00             T1=T2
     00             XDIF1=XDIF2
     00       30 DT=XDIF1*SLOPE
     00          IF(ABS(DT).LT.0.003)GOTO 100
```

```
      00                IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
      00                T=T1-DT
      00             50 CONTINUE
      00                WRITE(6,600)IG,P,X,TIN,XDIF2,DT
      00            600 FORMAT(' ERROR 600 IN BUBTEM, IG,P,X,TIN,XDIF2,DT=',I2,5F10.6)
      00            100 PLAST=P
      00                XLAST=X
      00                TLAST=T
      00                XVLAST=XV
      00                RETURN
      00                END

END ELT.  ERRORS: NONE. TIME:  0.138 SEC. IMAGE COUNT: 67

@HDG,P  ******  CAPIL  ****** .L,0
```

```
@ELT,L DD.CAPIL
ELT 8R1 S74Q1C 07/21/84 15:54:56 (0)
00          SUBROUTINE CAPIL(XW,XMASS,P1,H1,P2,TL,D,NC)
00    C
00    C
00    C**** PURPOSE:
00    C        TO COMPUTE MASS FLOW RATE OF NON-AZEOTROPIC MIXTURE
00    C        THROUGH EXPANSION DEVICE OF CONSTANT FLOW AREA
00    C
00    C**** INPUT DATA:
00    C        D       - EXPANSION DEVICE DIAMETER    (FT)
00    C        NC      - NUMBER OF EXPANSION DEVICES    (-)
00    C        H1      - REFRIG. ENTHALPY BEFORE EXP. DEVICE    (BTU/LBM)
00    C        P1      - REFRIG. PRESSURE BEFORE EXP. DEVICE    (PSIA)
00    C        P2      - EVAPORATOR INLET PRESSURE    (PSIA)
00    C        TL      - EXPANSION DEVICE LENGTH    (FT)
00    C        XMASS   - MASS FLOW RATE THROUGH NC EXP. DEVICES (GUESS)  (LB/HR)
00    C        XW      - COMPOSITION    (WEIGHT FRACTION OF LESS VOLATILE COMPONENT)
00    C
00    C**** OUTPUT DATA:
00    C        P2      - REFRIG. PRESSURE AT OUTLET OF EXP. DEVICE    (PSIA)
00    C        XMASS   - MASS FLOW RATE THROUGH NC EXP. DEVICES    (LB/HR)
00    C
00    C**** SUBPROGRAMS CALLED BY CAPIL:
00    C        BSIMP,CHOKE,DDENFA,DFANNO,HPPROP,PFLASH,VISCON
00    C
00          COMMON/RDATA2/W1,W2,TC1,TC2
00          EXTERNAL DDENFA
00          REAL*8 DFANNO,S1,S2,DDENFA
00    C
00          NO=0
00          PRINT 44, P1,H1,P2
00          IF(P1.LE.P2)GOTO 50          @ERROR IN CALLING CAPIL
00    C**** PRELIMINARY CALCULATIONS
00          PA1=P1/14.6959
00          XM=XW/(W2/W1*(1.-XW)+XW)
00          AREA=3.141593*D*D/4.
00          G=XMASS/AREA/3600./FLOAT(NC)
00          IF(G.LT.200.)G=200.
00          IF(TL.LT.0.2.AND.G.LT.1000.)G=1000.
00          GMIN=0.
00          GMAX=5.E4
00    C**** FIND REFRIG. COND. BEFORE EXPANSION DEVICE
00          ACC=0.0005
00          CALL HPPROP(NO,H1,PA1,XM,ACC,TK1,XIN,XML,XMV,VLM,VVM,
00         @ VM,V,CP,CV,AM,AK)
00          TIN=TK1*1.8-459.67
00          IF(XIN.GT.0.)THEN
00             VL=V
00             FVL=TL
00             PFLA=P1
00             TFLA=TIN
00             GOTO 20
00          END IF
00          E=G
00          DO 4 LIQ=1,15
00          EE=E*E
00          EN=EE/(64.4*778.104)
```

```
00            CALL PFLASH(XM,H1,EN,TIN,TFLA,PFLA,VL)
00            POUT=AMAX1(PFLA,P2)
00            ZF=VISCON(1,TIN,XW)
00            RE=3900.*E*D/ZF
00            FF=16./RE
00            IF(RE.GT.2000.)FF=0.046/RE**0.2
00            PDL=EE*FF*TL*VL*2./(32.2*144.*D)
00            PDE=1.15*EE*VL/(64.4*144.)
00            P1A=POUT+PDL+PDE
00            P1P1A=P1-P1A
00            IF(ABS(P1P1A).LT.0.02)GOTO 6
00            IF(LIQ.EQ.1)GOTO 2
00            EY=E-P1P1A*(EB-E)/(P1P1B-P1P1A)
00            EB=E
00            E=EY
00            GOTO 3
00          2 EB=E
00            E=.8*E
00            IF(P1P1A.GT.0.)E=1.5*E
00          3 P1P1B=P1P1A
00          4 CONTINUE
00            PRINT 5
00          5 FORMAT(' CAPIL*ERROR 5')
00      C
00          6 CONTINUE
00            G2=E
00            IF(POUT.EQ.P2)GOTO 1000
00            S1=DFANHO(XM,PFLA,H1,EN)
00            S2=DFANHO(XM,PFLA-0.1,H1,EN)
00            IF(S2.LT.S1)GOTO 1000
00            GMIN=G2
00            G=1.05*GMIN
00            IF((P1-POUT).LT.1.)G=20.*G
00      C**** START THE LOOP
00         20 DO 40 IA=1,25
00            DO 30 II=1,10
00            GG=G*G
00            GN=GG/(64.4*778.104)
00      C**** FIND FLASHING PRESSURE
00            IF(XIN.EQ.0.)CALL PFLASH(XM,H1,GN,TIN,TFLA,PFLA,VL)
00      C**** FIND PRESSURE AT EXIT
00            POUT=CHOKE(XW,PFLA,P2,H1,GN)
00            IF(POUT.EQ.PFLA)GOTO 32
00      C**** FIND PRESSURE IN  ENTRANCE
00            PINN=0.
00            DO 35 IEN=1,5
00            PIN=P1-1.15*GG*VL/(64.4*144.)
00               IF(PIN.GE.PFLA)GOTO 22
00            IF(PIN.LT.POUT)GOTO 32
00            VL=1./DDENFA(XM,PIN,H1,GN)
00            IF(ABS(PIN-PINN).LT.0.01)GOTO 21
00            PINN=PIN
00         35 CONTINUE
00         21 P2PH=PIN
00            FVL=TL
00            GOTO 23
00      C**** CALC. LENGHT OF SUBCOOLED LIQUID
00         22 P2PH=PFLA
```

```
00        ZF=VISCON(1,TFLA,XW)
00        RE=3600.*G*D/ZF
00        FF=16./RE
00        IF(RE.GT.2000.)FF=0.046/RE**0.2
00        FL=(32.2*144.)*(PIN-PFLA)*D/(2.*FF*GG*VL)
00        FVL=TL-FL
00        IF(FVL.LT.0.)THEN
00              G2=G
00              IF((FVL/TL).LT.-0.01)GOTO 41
00              GOTO 1000
00        END IF
00  C**** CALC. 2-PHASE FRICTION FACTOR
00     23 ZF=VISCON(1,TFLA,XW)
00        ZG=VISCON(3,TFLA,XW)
00        ZU=ZG*XIN+ZF*(1.-XIN)
00        RE=3600.*G*D/ZU
00        FF=0.775/SQRT(RE)*EXP((1.-XIN**.25)/2.4)
00  C**** EVALUATE DENSITY-PRESSURE INTEGRAL
00        Y=BSIMP(DDENFA,P2PH,POUT,0.002,10,H1,GN,XM)
00  C**** CALCULATE MASS FLOW RATE
00        RO1=1./VL
00        RO2=DDENFA(XM,POUT,H1,GN)
00        G2=SQRT(4636.8*Y/(2.*FF*FVL/D+ALOG(RO1/RO2)))
00        GD=G-G2
00        IF(ABS(GD/G).LT..005)THEN
00           G2=0.5*(G+G2)
00           GOTO 1000
00        END IF
00        IF(II.EQ.1)GOTO 24
00        IF(ABS(GD1-GD).LT..001.AND.(G-GMIN ).LT.0.01)THEN
00           G2=G
00           GOTO 1000
00        END IF
00        G3=G-GD*(G1-G)/(GD1-GD)
00        GOTO 25
00     24 G3=0.1*G+0.9*G2
00     25 G1=G
00        GD1=GD
00        IF(G3.LT.GMIN)G3=G-(G-GMIN)*(GMIN-G3)/(G-G3)
00        IF(G3.GT.GMAX)G3=G+(GMAX-G)*(G3-GMAX)/(G3-G)
00        G=G3
00     30 CONTINUE
00        G2=G
00        PRINT 31,G,GD
00     31 FORMAT(' CAPIL DOES NOT CONVERGE,RG,GD=,'2(1PE14.6))
00        GOTO 1000
00     32 GMAX=G
00        G=0.5*(GMIN+GMAX)
00     40 CONTINUE
00     41 PRINT 42,GD
00     42 FORMAT(' CAPIL DID NOT CONVERGE, GD =',F10.4)
00   1000 XMASS=3600.*G2*AREA*FLOAT(NC)
00        P2=POUT
00     44 FORMAT(//'  EXPANSION DEVICE:'/
00       @'  INPUT  -   P12  =',1PE9.3,3X,'H12 =',1PE9.3,3X,'P13 =',1PE9.3)
00        PRINT 46, POUT,XMASS
00     46 FORMAT( '  OUTPUT -   POUT =',1PE9.3,3X,'XMASS =',1PE9.3)
00        RETURN
```

```
****** CAPIL ******
                                                                   DATE 072184

        00        50 XMASS=0.
        00           PRINT 52,P1,P2
        00        52 FORMAT(//' ***ERROR IN CALLING CAPIL,  P1 LE.P2***',//
        00          &4X,'P1=',1PE11.3,'    P2=',1PE11.3,'     XMASS=0.0')
        00           RETURN
        00           END

END ELT.  ERRORS: NONE.  TIME:  0.236 SEC.  IMAGE COUNT: 178

@HDG,P  ******  CHOKE  ****** .L,0
```

```
@ELT,L DD.CHOKE
ELT 8R1 S74Q1C 07/21/84 15:54:57 (0)
00          FUNCTION CHOKE(XW,PF,PEVAP,HO,GG)
00    C
00    C**** PURPOSE:
00    C          TO CALCULATE THE THERMODYNAMIC CRITICAL PRESSURE
00    C          OF NON-AZEOTROPIC BINARY MIXTURE IN TWO-PHASE FANNO FLOW
00    C
00    C**** NOTE: EVAPORATOR PRESSURE IS RETURNED AS CHOKING PRESSURE
00    C             IF CHOKING PRESSURE IS SMALLER THEN PRESSURE
00    C             IN THE EVAPORATOR
00    C
00    C**** INPUT DATA:
00    C          GG       = G*G/(64.4*778.104)    (BTU*LBM/FT**3)
00    C                     WHERE G - REFRIG. MASS FLUX    (LBM/(SEC*FT**2))
00    C          HO       - REFRIG. TOTAL ENTHALPY    (BTU/LBM)
00    C          PEVAP    - EVAPORATOR PRESSURE    (PSIA)
00    C          PF       - FLASH PRESSURE   (PSIA)
00    C          XW       - COMPOSITION    (WEIGHT FRACTION OF LESS VOLATILE COMPONENT)
00    C**** OUTPUT DATA:
00    C          CHOKE    - CRITICAL PRESSURE   (PSIA)
00    C
00    C**** SUBPROGRAMS CALLED BY CHOKE:
00    C          DFANNO
00    C
00    C
00          COMMON/RDATA2/W1,W2,TC1,TC2
00          DIMENSION P(3),S(3),DS(3),LN(2),LP(2)
00    C
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    C
00       10 XM=XW/(W2/W1*(1.-XW)+XW)
00    C
00    C**** CHECK,IF CHOKING PRESSURE IS BELOW PEVAP
00          P(1)=PEVAP
00          S(1)=DFANNO(XM,P(1),HO,GG)
00          SS=DFANNO(XM,P(1)-.1,HO,GG)
00          DS(1)=S(1)-SS
00          IF(DS(1).LT.0.)GOTO 1000
00    C
00    C**** SELECT PRESSURE STEP
00          IDO=8
00          DPEND=PF-PEVAP
00          DP=40.
00          DO 12 I=1,6
00          DP=0.5*DP
00          IDO=IDO-1
00          IF(DPEND.GT.DP)GOTO 14
00       12 CONTINUE
00       14 CONTINUE
00    C
00    C**** SEARCH FOR SONIC AND SUBSONIC POINT
00          DO 20 I=1,20
```

```
      P(2)=P(1)+20.
      IF(P(2).GT.PF)THEN
         P(1)=PF
         S(1)=DFANNO(XM,P(1),HO,GG)
         DS(1)=S(1)-DFANNO(XM,P(1)-.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)-.1,HO,GG)
         GOTO 30
      END IF
      S(2)=DFANNO(XM,P(2),HO,GG)
      SS=DFANNO(XM,P(2)-.1,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)
   20 CONTINUE
C
   30 CONTINUE
      DO 50 ID=1,IDO
      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
      NNDS=0
      DO 35 I=1,3
      IF(DS(I).GT.0.)GOTO 32
      NDS=NDS+1
      LN(NDS)=I
      GOTO 35
   32 NNDS=NNDS+1
      LP(NNDS)=I
   35 CONTINUE
C**** ASSIGG VALUE OF SINGLE DS POINT FOR FUTURE USE
      IF(NNDS.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)
   45 PS=P(ITO)
      SS=S(ITO)
      DSS=DS(ITO)
C**** PICK UP THE POINT WITH BIGGER ENTROPY
      IBIG=IT2
      IF(S(IT1).GT.S(IT2))IBIG=IT1
C**** ASSIGG VALUES TO POINTS 1 AND 2
      P(1)=P(IBIG)
      S(1)=S(IBIG)
      DS(1)=DS(IBIG)
      P(2)=PS
```

```
00          S(2)=SS
00          DS(2)=DSS
00       50 CONTINUE
00     C
00          DO 60 N=1,2
00          IL=1
00          IF(S(2).LT.S(1))IL=2
00          IF(S(3).LT.S(IL))IL=3
00          DO 55 I=1,2
00          IF(I.NE.IL)GOTO 55
00          P(I)=P(3)
00          S(I)=S(IL)
00       55 CONTINUE
00          P(3)=0.5*(P(1)+P(2))
00          S(3)=DFANNO(XM,P(3),HO,GG)
00       60 CONTINUE
00          IL=1
00          IF(S(2).GT.S(1))IL=2
00          IF(S(3).GT.S(IL))IL=3
00          CHOKE=P(IL)
00          RETURN
00     C
00     1000 CHOKE=P(1)
00          RETURN
00     C
00     1010 CHOKE=P(3)-.05
00          RETURN
00          END

END ELT.  ERRORS: NONE. TIME:  0.182 SEC. IMAGE COUNT: 142

@HDG,P  ******  COMPAR  ****** .L,0
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```
@ELT,L DD.COMPAR
ELT 8R1 S74QIC 07/21/84 15:54:57 (0)
      00          SUBROUTINE COMPAR
      00      C
      00      C**** PURPOSE:
      00      C       TO DETERMINE PERFORMANCE PARAMETERS OF A HERMETIC COMPRESSOR
      00      C       WORKING WITH A NON-AZEOTROPIC MIXTURE FROM TEST UNDER
      00      C       ONE OPERATING CONDITION
      00      C
      00      C**** INPUT DATA:
      00      C     * STANDART ELECTRIC MOTOR CHARACTERISTICS:
      00      C       EMETA(K) - COMPRESSOR MOTOR EFFICIENCY IN FRACTION AT FRACTION
      00      C                  OF FULL LOAD SPECIFIED BY EMOPT(K)   (-)
      00      C       EMOPT(K) - COMPRESSOR MOTOR FULL LOAD FRACTION   (-)
      00      C       EMRPM(L) - COEFFICIENT FOR COMPRESSOR MOTOR RPM CALCULATION   (-)
      00      C     * COMPRESSOR DESIGN DATA:
      00      C       ELEFUL   - COMPRESSOR MOTOR ENERGY INPUT RATE AT FULL LOAD   (KW)
      00      C       SWPVOL   - TOTAL COMPRESSOR SWEPT 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   (LBM/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 LESS 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
      00      C**** OUTPUT DATA:
      00      C       CLREFF   - CLEARANCE VOLUME, IN FRACTION OF STROKE VOLUME   (-)
      00      C       CPC34    - PRESSURE DROP PARAMETER AT COMPRESSOR CAN INLET
      00      C                  (LBF*H**2/LBM*IN**2*FT**3)
      00      C       CPC45    - PRESSURE DROP PARAMETER AT COMPRESSOR SUCTION VALVE
      00      C                  (LBF*H**2/LBM*IN**2*FT**3)
      00      C       CPC67    - PRESSURE DROP PARAMETER AT COMPRESSOR DELIVERY VALVE
      00      C                  (LBF*H**2/LBM*IN**2*FT**3)
      00      C       CPC78    - PRESSURE DROP PARAMETER AT COMPRESSOR CAN EXIT
      00      C                  (LBF*H**2/LBM*IN**2*FT**3)
      00      C       CQCCOA   - PARAMETER FOR CAN WALL-AMBIENT AIR HEAT TRANSFER   (FT**.2)
      00      C       CQC4C    - PARAMETER FOR CAN WALL-REFRIG. VAPOR HEAT TRANSFER   (FT**.2)
      00      C       CQC45    - SUCTION VALVE HEAT TRANSFER PARAMETER   (FT**.2)
      00      C       CQC67    - DELIVERY VALVE HEAT TRANSFER PARAMETER   (FT**.2)
      00      C       CQC78    - CAN EXIT HEAT TRANSFER PARAMETER   (FT**.2)
      00      C       EFFYM    - COMPRESSOR MOTOR EFFICIENCY AT TEST   (-)
      00      C       EFFYV    - COMPRESSOR VOLUMETRIC EFFICIENCY AT TEST   (-)
      00      C       EMETA(K) - COMPRESSOR MOTOR EFFICIENCY IN FRACTION AT FRACTION
      00      C                  OF FULL LOAD SPECIFIED BY EMOPT(K)   (-)
      00      C       EMRPM(L) - COEFFICIENT FOR COMPRESSOR MOTOR RPM CALCULATION   (-)
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C        ETAPLY    - COMPRESSOR POLITROPIC EFFICIENCY    (-)
C        GAMMA     - REFRIG. AVE. SPECICIF HEAT RATIO AT COMPRESSION    (-)
C        RPM       - COMPRESSOR MOTOR RPM    (1/MIN)
C        V5        - REFRIG. SPECIFIC VOLUME AT SUCTION    (FT**3/LBM)
C        WM        - REFRIG. MOLECULAR WEIGHT    (G/MOL)
C        XM        - MOLAR COMPOSITION    (FRACTION OF LESS VOLATILE COMPONENT)
C
C**** SUBPROGRAMS CALLED BY COMPAR:
C         DEWTEM,ENTROP,HCVCP,HPIN,SPIN,VISCON,VOLIT1
C
C**** NOTE: NUMBERS AT DIFFERENT SYMBOLS INDICATING LOCATION USED IN THIS SUBROUTINE
C****         CORRESPOND TO NUMBERS GREATER BY 1 USED IN MAIN PROGRAM & PROGRAM DOCUMENTATION
C
      COMMON/RDATA2/W1,W2,TC1,TC2
      COMMON/RDATA3/XW,XM,WM
      COMMON/COND3/P2,T2,H2,XQ2
      COMMON/COND47/P3,T3,H3,XQ3,P4,T4,H4,XQ4,S4,P5,T5,H5,XQ5,
     @ P6,T6,H6,XQ6
      COMMON/COND8/P7,T7,H7,XQ7
      COMMON/COND9/P8,T8,H8,XQ8
      COMMON/COMP/CPC23,CQC3C,CQCCOA,CPC34,CQC34,
     & EMETA(11),EMOPT(11),EMRPM(6),ELEFUL,SWPVOL,
     & ETAPLY,CLREFF,CPC56,CQC56,CPC67,CQC67
      DATA NO,N1,N3,N5/0,1,3,5/
C
C
    5 CONTINUE
      WRITE(6,290)
      READ(5,777)XW
      XW=1.-XW
      XM=XW/(W2/W1*(1.-XW)+XW)
      WM=W1*(1.-XM)+W2*XM
      WRITE(6,300)
      READ(5,295)ILONG
      IF(ILONG.EQ.1)GOTO  20
C**** INPUT SHORT FORM COMPRESSOR DATA
      WRITE(6,301)
      READ(5,777)ELEFUL,ELEIPT,RPMCP,SWPVOL,RMASS,TOA
      EBTUI=3414.*ELEIPT
      EBTUF=3414.*ELEFUL
      WRITE(6,302)
      READ(5,777)T2,P2
      WRITE(6,303)
      READ(5,777)T7,P7
C
      TK2=(T2+459.67)/1.8                          @POINT 2
      PA2=P2/14.6959
      CALL VOLIT1(N1,TK2,PA2,XM,VM2)
      CALL HCVCP(N1,TK2,VM2,XM,H2,CP2,CV2)
      TK7=(T7+459.67)/1.8                          @POINT 7
      PA7=P7/14.6959
      CALL VOLIT1(N1,TK7,PA7,XM,VM7)
      CALL HCVCP(N3,TK7,VM7,XM,H7,CP7,CV7)
      V7=VM7*16.01846/WM
      QCAN=EBTUI-RMASS*(H7-H2)
      T6=T7+20.                                    @POINT 6
      P6=P7+1.
      TK6=(T6+459.67)/1.8
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```
00          PAS=P6/14.6959
00          CALL VOLIT1(N1,TK6,PAS,XM,VM6)
00          CALL HCVCP(N3,TK6,VM6,XM,H6,CV6,CP6)
00          V6=VM6*16.01846/WM
00          P5=P6+20.                              @POINT 5
00          H5=H6+0.2*(H6-H7)
00          TK5=TK6
00          PA5=P5/14.6959
00          ACC=0.001
00          CALL HPIN(N1,H5,PA5,XM,ACC,TK5,XQ5,XL,XV,VL,VM5)
00          T5=TK5*1.8-459.67
00          S5=ENTROP(TK5,VM5,XM)
00          CALL HCVCP(N5,TK5,VM5,XM,DUM,CV5,CP5)
00          GA5=CP5/CV5
00          GG5=(GA5-1.)/GA5
00          P3=P2-0.1                              @POINTS 3, 4 & 5
00          P4=P3-3.
00          PA4=P4/14.6959
00          CALL DEWTEM(NO,PA4,XM,TKD1,XL)
00          CALL VOLIT1(N1,TKD4,PA4,XM,VD4)
00          SD4=ENTROP(TKD4,VD4,XM)
00          S4=S5+0.1
00          DS4=0.1
00          P5P4=P5/P4
00          P4P5=P4/P5
00          INT=5
00          JNT=11
00          EMFRN=ELEIPT/ELEFUL
00          DO 16 I=1,INT
00          DO 12 J=1,JNT
00          S4=S4-DS4
00          IF(S4.GT.SD4)GOTO 10
00          INT=INT+1
00          JNT=2*JNT-1
00          S4=S4+DS4
00          DS4=0.5*DS4
00          GOTO 16
00       10 CONTINUE
00          TK4=TK5*P4P5**GG5
00          IF(TK4.LT.TKD4)TK4=TKD4+0.01
00          ACC=0.000001
00          CALL SPIN(N1,S4,PA4,XM,ACC,TK4,VM4)
00          CALL HCVCP(N3,TK4,VM4,XM,H4,CV4,CP4)
00          GA4=CP4/CV4
00          TK5S=TK5
00          ACC=0.001
00          CALL SPIN(N1,S4,PA5,XM,ACC,TK5S,VM5S)
00          CALL HCVCP(N3,TK5S,VM5S,XM,H5S,CV5S,CP5S)
00          GA5S=CP5S/CV5S
00          GGA=0.5*(GA4+GA5S)
00          GG=(GGA-1.)/GGA
00          GN=GG/0.76
00          CETA=(P5P4**GG-1.)/(0.76*(P5P4**GN-1.))
00          H55=H4+(H5S-H4)/CETA
00          IF(H55.LE.H5)GOTO 14
00       12 CONTINUE
00       14 IF(I.EQ.5)GOTO 16
00          S4=S4+DS4
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```
00            DS4=0.1*DS4
00         16 CONTINUE
00            CBTUI=RMASS*(H5-H4)
00            H3=H2+(H6-H7)+(EBTUI-CBTUI-QCAN)/RMASS
00            TK3=TK4
00            PA3=P3/14.6959
00            ACC=0.001
00            CALL HPIN(N1,H3,PA3,XM,ACC,TK3,XQ,XL,XV,VL,VM3)
00            V3=VM3*16.01846/WM
00            T3=TK3*1.8-459.67
00            CALL HCVCP(N5,TK3,VM3,XM,DUM,CV3,CP3)
00            TCAN=(TOA+2.*T3)/3.
00            T4=TK4*1.8-459.67
00            GOTO  22
00      C**** ENTER LONG FORM COMPRESSOR DATA
00         20 WRITE(6,304)
00            READ(5,777)ELEFUL,ELEIPT,RPMCP,SWPVOL,RMASS,TCAN,TOA
00            I=2
00            WRITE(6,305)
00            WRITE(6,306)I
00            READ(5,777)T2,P2
00            I=I+1
00            WRITE(6,306)I
00            READ(5,777)T3,P3
00            I=I+1
00            WRITE(6,306)I
00            READ(5,777)T4,P4
00            I=I+1
00            WRITE(6,306)I
00            READ(5,777)T5,P5
00            I=I+1
00            WRITE(6,306)I
00            READ(5,777)T6,P6
00            I=I+1
00            WRITE(6,306)I
00            READ(5,777)T7,P7
00      C
00      C**** CALCULATE REFRIGERANT STATE
00            TK2=(T2+459.67)/1.8
00            TK3=(T3+459.67)/1.8
00            TK4=(T4+459.67)/1.8
00            TK5=(T5+459.67)/1.8
00            TK6=(T6+459.67)/1.8
00            TK7=(T7+459.67)/1.8
00            PA2=P2/14.6959
00            PA3=P3/14.6959
00            PA4=P4/14.6959
00            PA5=P5/14.6959
00            PA6=P6/14.6959
00            PA7=P7/14.6959
00            CALL VOLITI(N1,TK2,PA2,XM,VM2)
00            CALL VOLITI(N1,TK3,PA3,XM,VM3)
00            CALL VOLITI(N1,TK4,PA4,XM,VM4)
00            CALL VOLITI(N1,TK5,PA5,XM,VM5)
00            CALL VOLITI(N1,TK6,PA6,XM,VM6)
00            CALL VOLITI(N1,TK7,PA7,XM,VM7)
00            CALL HCVCP(N3,TK2,VM2,XM,H2,CV2,CP2)
00            CALL HCVCP(N3,TK3,VM3,XM,H3,CV3,CP3)
```

```
00        CALL HCVCP(N3,TK4,VM4,XM,H4,CV4,CP4)
00        CALL HCVCP(N3,TK5,VM5,XM,H5,CV5,CP5)
00        CALL HCVCP(N3,TK6,VM6,XM.H6,CV6,CP6)
00        CALL HCVCP(N3,TK7,VM7,XM,H7,CV7,CP7)
00        S4=ENTROP(TK4,VM4,XM)
00        S5=ENTROP(TK5,VM5,XM)
00  C**** CALCALATE COMPRESSOR PERFORMANCE PARAMETERS
00     22 S2=ENTROP(TK2,VM2,XM)
00        S3=ENTROP(TK3,VM3,XM)
00        S6=ENTROP(TK6,VM6,XM)
00        S7=ENTROP(TK7,VM7,XM)
00        SWPV=SWPVOL/1728.
00        GA4=CP4/CV4
00        GA5=CP5/CV5
00        GA=0.5*(GA4+GA5)
00        DUM=(GA-1.)/GA
00        TK5S=TK4*P5P4**DUM
00        S5S=S4
00        ACC=0.000001
00        CALL SPIN(N1,S5S,PA5,XM,ACC,TK5S,VM5S)
00        T5S=TK5S*1.8-459.67
00        CALL HCVCP(N3,TK5S,VM5S,XM,H5S,CV5S,CP5S)
00        GA5S=CP5S/CV5S
00        AM2=VISCON(3,T2,XW)                 @VISCOSITY
00        AM3=VISCON(3,T3,XW)
00        AM4=VISCON(3,T4,XW)
00        AM5=VISCON(3,T5,XW)
00        AM6=VISCON(3,T6,XW)
00        AM7=VISCON(3,T7,XW)
00        AK2=VISCON(4,T2,XW)                 @CONDUCTIVITY
00        AK3=VISCON(4,T3,XW)
00        AK4=VISCON(4,T4,XW)
00        AK5=VISCON(4,T5,XW)
00        AK6=VISCON(4,T6,XW)
00        AK7=VISCON(4,T7,XW)
00        WRITE(6,310)
00        WRITE(6,297)T2,P2,H2,S2
00        WRITE(6,297)T3,P3,H3,S3
00        WRITE(6,297)T4,P4,H4,S4
00        WRITE(6,297)T5,P5,H5,S5
00        WRITE(6,298)T5S,P5,H5S,S5S
00        WRITE(6,297)T6,P6,H6,S6
00        WRITE(6,297)T7,P7,H7,S7
00        EMFRN=ELEIPT/ELEFUL
00        EBTUI=3414.*ELEIPT
00        EBTUF=3414.*ELEFUL
00  C**** DETERMINE CAN HEAT LOSS COEFFICIENTS CQC3C AND CQCCOA
00        QCAN=EBTUI-RMASS*(H7-H2)
00        CQCCOA=QCAN/(TCAN-TOA)**1.333
00        CQC3C=QCAN*AM3**0.467/(RMASS**0.8*CP3**0.333*AK3**0.667*
00       & (T3-TCAN))
00        V3=VM3*16.01846/WM
00        CPC23=1./(V3*RMASS**2)
00        CPC23=(P2-P3)*CPC23
00  C**** DETERMINE SUCTION VALVE HEAT TRANSFER COEFFICIENT
00        QSUCV=RMASS*(H4-H3)
00        T34=0.5*(T3+T4)
00        AM34=0.5*(AM3+AM4)
```

```
00         CP34=0.5*(CP3+CP4)
00         AK34=0.5*(AK3+AK4)
00         CQC34=AM134**0.467/(RMASS**0.8*CP34**0.333
00        & *AK34**0.667*(T5-T3))
00         CQC34=QSUCV*CQC34
00         V4=VM4*16.01846/WM
00         CPC34=1./(V4*RMASS**2)
00         CPC34=(P3-P4)*CPC34
00   C**** DETERMINE COMPRESSION AND MOTOR COEFFICIENTS
00         RPMEM=0.
00         ETAEM=0.
00         EMFFF=RMASS*(H5-H4)/(0.96*EBTUF)
00         DO 23 I=1,6
00         J=I-1
00         AA=EMFFF**J
00         RPMEM=RPMEM+AA*EMRPM(I)
00      23 CONTINUE
00         J=12
00         DO 25 I=1,11
00         J=J-1
00         IF(EMFFF.LE.EMOPT(J))GOTO 24
00         ETAEM=EMETA(J)+(EMETA(J+1)-EMETA(J))*(EMFFF-EMOPT(J))
00        & /(EMOPT(J+1)-EMOPT(J))
00         GOTO 28
00      24 IF(I.NE.11)GOTO 25
00         ETAEM=EMFFF*EMETA(J)/EMOPT(J)
00      25 CONTINUE
00      28 CONTINUE
00         RPMRT=1.
00         IF(RPMCP.GE.100.)RPMRT=RPMCP/RPMEM
00         CPOPT=RMASS*(H5-H4)
00         CPIPT=CPOPT/0.96
00         ETART=CPIPT
00         ETART=ETART/(ETAEM*EBTUI)
00         DO 30 I=1,11
00         IF(I.GT.6)GOTO 30
00         EMRPM(I)=RPMRT*EMRPM(I)
00      30 EMETA(I)=ETART*EMETA(I)
00         CETA=(H5S-H4)/(H5-H4)
00         ETAPLY=1.1
00         DE=0.1
00         P5P4=P5/P4
00         GGA=0.5*(GA4+GA5S)
00         GG=(GGA-1.)/GGA
00         P5P4=P5P4**GG
00         DO 36 I=1,3
00         DO 32 J=1,11
00         POLY=1./ETAPLY
00         CC=(P5P4-1.)/(ETAPLY*(P5P4**POLY-1.))
00         IF(CC.LE.CETA)GOTO 34
00      32 ETAPLY=ETAPLY-DE
00      34 IF(I.EQ.3)GOTO 38
00         ETAPLY=ETAPLY+DE
00         DE=0.1*DE
00      36 CONTINUE
00      38 CONTINUE
00         CRPM=0.
00         DO 40 I=1,6
```

```
00         J=I-1
00         AA=ENFFF**J
00      40 CRPM=CRPM+AA*EMRPM(I)
00         TVOL=60.*CRPM*SWPV
00         AVOL=RMASS*V4
00         VETA=AVOL/TVOL
00         AN=ETAPLY*GGA
00         AN=AN/(1.+AN-GGA)
00         ANR=1./AN
00         CLREFF=1.-1.0417*VETA
00         CLREFF=CLREFF/((P5/P4)**ANR-1.)
00         WRITE(6,323)
00         WRITE(6,297)(EMETA(I),I=1,5)
00         WRITE(6,297)(EMETA(I),I=6,11)
00         WRITE(6,324)
00         WRITE(6,297)(EMRPM(I),I=1,6)
00         WRITE(6,325)
00         WRITE(6,297)ELEFUL,SWPVOL,ETAPLY,CLREFF
00         WRITE(6,307)
00         WRITE(6,297)CRPM,ETAEM,VETA,V4,GGA,SWPV
00   C**** DETERMINE DISCHARGE VALVE HEAT TRANSFER & PRESSURE COEFFICIENT
00         QDISV=RMASS*(H5-H6)
00         IF(QDISV.LE.0.0)QDISV=0.
00         T56=0.5*(T5+T6)
00         AM56=0.5*(AM5+AM6)
00         AK56=0.5*(AK5+AK6)
00         CP56=0.5*(CP5+CP6)
00         CQC56=AM56**0.467/(RMASS**0.8*CP56**0.333*AK56**0.667*
00        & (T6-T4))
00         CQC56=CQC56*QDISV
00         V6=VM6*16.01846/WM
00         CPC56=1./(V6*RMASS**2)
00         CPC56=CPC56*(P5-P6)
00   C**** DETERMINE DISCHARGE LINE HEAT TRANSFER COEFFICIENT
00         AM67=0.5*(AM6+AM7)
00         AK67=0.5*(AK6+AK7)
00         CP67=0.5*(CP6+CP7)
00         DD1=AM67**0.467*CP3**0.333*AK3**0.667
00         DD2=1.5*AM3**0.467*CP67**0.333*AK67**0.667
00         QDISC=RMASS*(H6-H7)
00         IF(QDISC.LE.0.01)GOTO 42
00         ALOG67=(T7-T6)/ALOG((T7-T3)/(T6-T3))
00         CQC67=QDISC*(DD1+DD2)/(ALOG67*RMASS**0.8)
00         CQC67=CQC67/((CP3*CP67)**0.333*(AK3*AK67)**0.667)
00         GOTO 44
00      42 CQC67=0.
00         V7=VM7*16.01846/WM
00      44 CPC67=1./(0.5*(V6+V7)*RMASS**1.8*AM67**0.2)
00         CPC67=CPC67*(P6-P7)
00         WRITE(6,327)
00         WRITE(6,297)CPC23,CPC34,CPC56,CPC67
00         WRITE(6,326)
00         WRITE(6,297)CQC3C,CQCCOA,CQC34,CQC56,CQC67
00         WRITE(6,330)
00         READ(5,777)ICON
00         IF(ICON.NE.999)GOTO 5
00   C
00     290 FORMAT(/' WEIGHT COMPOSITION OF MIXTURE IN FRACTION '
```

```
00          @  / ' OF MORE VOLATILE COMPONENT, XW= ')
00       295 FORMAT(I10)
00       297 FORMAT(6(1PE11.3))
00       298 FORMAT(4(1PE11.3),2X,'ISENTROPIC 6')
00       300 FORMAT(///2X,'DETERMINE COMPRESSOR PERFORMANCE PARAMENTERS'//
00          & 2X,'ENTER:ILONG EQUAL TO 0 OR 1 FOR SHORT OR LONG TEST DATA=')
00       301 FORMAT(/2X,'ENTER:ELEFUL,ELEIPT,RPMCP,SWPVOL,RMASS,TOA='/)
00       302 FORMAT(/2X,'ENTER:T3,P3='/)
00       303 FORMAT(/2X,'ENTER:T8,P8='/)
00       304 FORMAT(/2X,'ENTER:ELEFUL,ELEIPT,RPMCP,SWPVOL,RMASS,TCAN,TOA:'
00          & /)
00       305 FORMAT(/2X,'ENTER T AND P AT DIFFERENT STATIONS:'/)
00       306 FORMAT(2X,'STATION',I2,':')
00       307 FORMAT(/2X,'RPM',8X,'EFFYM',6X,'EFFYV',6X,'V5',
00          & 9X,'GAMMA',6X,'SWPV')
00       310 FORMAT(//2X,'T',10X,'P',10X,'H',10X,'S')
00       323 FORMAT(/2X,'EMETA(11):')
00       324 FORMAT(/2X,'EMRPM(6):')
00       325 FORMAT(/2X,'ELEFUL',5X,'SWPVOL',5X,'ETAPLY',5X,'CLREFF')
00       327 FORMAT(/2X,'CPC34',6X,'CPC45',6X,'CPC67',6X,'CPC78')
00       326 FORMAT(/2X,'COC4C',6X,'COCCOA',5X,'COC45',6X,'COC67',6X,'COC78')
00       330 FORMAT(/' PUT ICON=999 TO STOP, ICON=?')
00       777 FORMAT ( )
00           RETURN
00           END
```

END ELT. ERRORS: NONE. TIME: 0.518 SEC. IMAGE COUNT: 429

@HDG,P ****** COMPRE ****** .L,0

```
@ELT,L DD.COMPRE
ELT 8R1 S74Q1C 07/21/84 15:54:58 (0)
      00            SUBROUTINE COMPRE(NSYS,TG5,TRA,TA,EI,RMASS)
      00      C
      00      C
      00      C**** SIMULATION OF A HERMETIC COMPRESSOR
      00      C     WORKING WITH A NON-AZEOTROPIC MIXTURE
      00      C     MAY 27 1983
      00      C
      00      C**** CALCULATIONS PERFORMED BY THIS PROGRAM INCLUDE SIMULATION
      00      C**** OF HERMETIC COMPRESSOR, FLOW THROUGH 4-WAY VALVE AND TUBING
      00      C**** CONNECTING COMPRESSOR WITH BOTH HEAT EXCHANGERS.
      00      C
      00      C**** INPUT DATA:
      00      C       CLREFF    - CLEARANCE OF VOLUME AS FRACTION OF STROKE VOLUME   (-)
      00      C       CPC23     - PRESSURE DROP PARAMETER AT COMPRESSOR CAN INLET
      00      C                   (LBF*H**2.2/LBM*IN**2*FT**2.8)
      00      C       CPC34     - PRESSURE DROP PARAMETER AT COMPRESSOR SUCTION VALVE
      00      C                   (LBF*H**2/LBM*IN**2*FT**3)
      00      C       CPC56     - PRESSURE DROP PARAMETER AT COMPRESSOR DELIVERY VALVE
      00      C                   (LBF*H**2/LBM*IN**2*FT**3)
      00      C       CPC67     - PRESSURE DROP PARAMETER AT COMPRESSOR CAN EXIT
      00      C                   (LBF*H**2/LBM*IN**2*FT**3)
      00      C       CQCCOA    - PARAMETER FOR CAN WALL-AMBIENT AIR HEAT TRANSFER   (BTU/H*F**1.333)
      00      C       CQC3C     - PARAMETER FOR REFRIG. VAPOR-CAN WALL HEAT TRANSFER   (FT**.2)
      00      C       CQC34     - SUCTION VALVE HEAT TRANSFER PARAMETER   (FT**.2)
      00      C       CQC56     - DELIVERY VALVE HEAT TRANSFER PARAMETER   (FT**.2)
      00      C       CQC67     - CAN EXIT HEAT TRANSFER PARAMETER   (FT**.2)
      00      C       ELEFUL    - COMPRESSOR MOTOR ENERGY INPUT RATE AT FULL LOAD   (KW)
      00      C       EMETA(K)  - COMPRESSOR MOTOR EFFICIENCY IN FRACTION AT FRACTION
      00      C                   OF FULL LOAD SPECIFIED BY EMOPT(K)   (-)
      00      C       EMOPT(L)  - COMPRESSOR MOTOR FULL LOAD FRACTION   (-)
      00      C       EMRPM(M)  - COEFFICIENT FOR COMPRESSOR MOTOR RPM CALCULATION   (-)
      00      C       ETAPLY    - COMPRESSOR POLYTROPIC EFFICIENCY   (-)
      00      C       H2        - REFRIG. ENTHALPY AT COMPRESSOR CAN INLET   (BTU/LBM)
      00      C       NSYS      = 1  FOR HEATING OPERATION   (-)
      00      C                 = 2  FOR COOLING OPERATION   (-)
      00      C       P2        - REFRIG. PRESSURE AT COMPRESSOR CAN INLET   (PSIA)
      00      C       RD        - INNER DIAMETER COMPRESSOR-INDOOR COIL TUBING   (FT)
      00      C       RD1       - OUTER DIAMETER COMPRESSOR-INDOOR COIL TUBING   (FT)
      00      C       RD2       - OUTER DIAMETER OF COMPRESSOR-INDOOR COIL TUBING
      00      C                   INSULATION   (FT)
      00      C       RK1       - THERMAL CONDUCTIVITY OF COMPRESSOR-INDOOR COIL TUBING
      00      C                   MATERIAL   (BTU/FT*H*F)
      00      C       RK2       - THERMAL CONDUCTIVITY OF COMPRESSOR-INDOOR COIL TUBING
      00      C                   INSULATION   (BTU/FT*H*F)
      00      C       RL        - LENGTH OF COMPRESSOR-INDOOR COIL TUBING   (FT)
      00      C       SWPVOL    - COMPRESSOR SWEPT VOLUME PER REVOLUTION   (IN**3)
      00      C       TA        - OUTDOOR AIR TEMPERATURE   (F)
      00      C       TG5       - REFRIG. SAT. TEMP. AT COMPRESSOR DELIVERY VALVE   (F)
      00      C       TRA       - INDOOR AIR TEMPERATURE   (F)
      00      C       YD        - INNER DIAMETER COMPRESSOR-OUTDOOR COIL TUBING   (FT)
      00      C       YD1       - OUTER DIAMETER COMPRESSOR-OUTDOOR COIL TUBING   (FT)
      00      C       YD2       - OUTER DIAMETER OF COMPRESSOR-OUTDOOR COIL TUBING
      00      C       YK1       - THERMAL CONDUCTIVITY OF COMPRESSOR-OUTDOOR COIL TUBING
      00      C                   MATERIAL   (BTU/FT*H*F)
      00      C       YK2       - THERMAL CONDUCTIVITY OF COMPRESSOR-OUTDOOR COIL TUBING
      00      C                   INSULATION   (BTU/FT*H*F)
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00    C        YL        - LENGTH OF COMPRESSOR-OUTDOOR COIL TUBING    (FT)
00    C
00    C**** OUTPUT DATA:
00    C        CPRPM     - COMPRESSOR MOTOR RPM    (1./MIN)
00    C        EI        - COMPRESSOR ENERGY CONSUMPSION RATE    (KW)
00    C        ETAC      - COMPRESSION EFFICIENCY    (-)
00    C        ETAE      - ELECTRIC MOTOR EFFICIENCY    (-)
00    C        ETAV      - VOLUMETRIC EFFICIENCY    (-)
00    C        RMASS     - REFRIG. MASS FLOW RATE    (LBM/H)
00    C        REFRIG. THERMODYNAMIC STATE AT KEY LOCATIONS:
00    C        H0,P0,T0,XQ0      - AT LOW PRESSURE VAPOR LINE INLET
00    C        H1,P1,T1,XQ1      - AT LOW PRESSURE 4-WAY VALVE INLET
00    C        H2,P2,T2,XQ2      - AT LOW PRESSURE 4-WAY VALVE OUTLET
00    C        H3,P3,T3,XQ3      - AT SUCTION VALVE
00    C        H4,P4,T4,XQ4,S4   - AT PISTON BEFORE COMPRESSION
00    C        H5,P5,T5,XQ5      - AT PISTON AFTER COMPRESION
00    C        H6,P6,T6,XQ6      - PAST DELIVERY VALVE
00    C        H7,P7,T7,XQ7      - AT COMPRESSOR CAN EXIT
00    C        H8,P8,T8,XQ8      - AT HIGH PRESSURE 4-WAY VALVE INLET
00    C        H9,P9,T9,XQ9      - HIGH  PRESSURE VAPOR LINE OUTLET
00    C        WHERE NUMBERS IN ABOVE SYMBOLS STAY FOR LOCATION AND LETTERS DENOTE:
00    C                    H  - REFRIG. ENTHALPY    (BTU/LBM)
00    C                    P  - REFRIG. PRESSURE    (PSIA)
00    C                    S  - REFRIG. ENTROPY    (BTU/LBM*F)
00    C                    XQ - REFRIG. QUALITY    (-)
00    C
00    C**** SUBPROGRAMS CALLED BY COMPRE:
00    C        DEWPRE,ENTROP,HCVCP,HPIN,HPPROP,MVAL4,PIPE,SPIN,VISCON
00    C
00    C
00    C**** NOTE: NUMBERS AT DIFFERENT SYMBOLS INDICATING LOCATION
00    C            USED IN THIS SUBROUTINE CORRESPOND TO NUMBERS GRRATER BY 1
00    C            USED IN THE MAIN PROGRAM MAIN AND PROGRAM DOCUMENTATION
00    C
00    C
00          COMMON/RDATA3/XW,XM,WM
00          COMMON/COND1/P0,T0,H0,XQ0
00          COMMON/COND2/P1,T1,H1,XQ1
00          COMMON/COND3/P2,T2T,H2,XQ2Q
00          COMMON/COND47/P3,T3,H3,XQ3,P4,T4,H4,XQ4,S4,P5,T5,H5,XQ5,
00         & P6,T6,H6,XQ6
00          COMMON/COND8/P7,T7,H7,XQ7
00          COMMON/COND9/P8,T8,H8,XQ8
00          COMMON/COND10/P9,T9,H9,XQ9
00          COMMON/COMP/CPC23,CQC3C,CQCCQA,CPC34,CQC34,EMETA(11),EMOPT(11),
00         & EMRPM(6),ELEFUL,SWPVOL,ETAPLY,CLREFF,CPC55,CQC56,CPC67,CQC67
00          COMMON/RLINE/RL,RD,RK1,RD1,RK2,RD2
00          COMMON/YLINE/YL,YD,YK1,YD1,YK2,YD2
00          DATA N0,N1,N3,N4,N5/0,1,3,4,5/
00          DATA XQ5,XQ6,XQ7,XQ8/4*1./
00    C
00          PA2=P2/14.6959
00          ACC=0.0005
00          CALL HPPROP(N0,H2,PA2,XM,ACC,TK2,XQ2,XML2,XMV2,VML2,VMV2,
00         @ VM2,V2,CP2,CV2,AM2,AK2)
00          T2=TK2*1.8-459.67
00          WRITE(6,200)P2,T2,H2,XQ2,TG5,TRA,TA
00    C**** PRELIMINARY CALCULATIONS
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```
00          BTUFO=3413.*ELEFUL
00          SWPV=SWPVOL/1728.
00          P4=P2-2.
00          H4=H2+9.
00          TK4=TK2
00          TGK5=(TG5+459.67)/1.8
00          CALL DEWPRE(NO,TGK5,XM,PA5,XL)
00          P5=PA5*14.6959
00          SLOPE=0.
00    C*********************************************************************
00    C**** ITERATE THERMODYNAMIC STATE OF REFRIGERANT
00    C**** WITHIN COMPRESSOR CAN
00    C*********************************************************************
00    C**** START ENTHALPY LOOP
00          DO 60 MH=1,15
00          ROB=0.
00    C**** START PRESSURE LOOP
00          DO 50 MP=1,10
00          PA4=P4/14.6959
00    CC
00          ACC=0.0005
00          CALL HPPROP(N1,H4,PA4,XM,ACC,TK4,XQ4,XML4,XMV4,VML4,VMV4,
00         @ VM4,V4,CP4,CV4,AM4,AK4)
00          T4=TK4*1.8-459.67
00          GA4=CP4/CV4
00          IF(XQ4.LT.1.)THEN
00             S4=(1.-XQ4)*ENTROP(TK4,VML4,XML4)
00             S4=S4+XQ4*ENTROP(TK4,VMV4,XMV4)
00          ELSE
00             S4=ENTROP(TK4,VM4,XM)
00          END IF
00    C**** CALCULATE POINT 5
00          P5P4=P5/P4
00          T5S=(T4+460)*P5P4**0.15-460.
00          TK5S=(T5S+460.)/1.8
00          ACC=0.00002
00          CALL SPIN(N1,S4,PA5,XM,ACC,TK5S,VM5S)
00          CALL HCVCP(N3,TK5S,VM5S,XM,H5S,CV5S,CP5S)
00          GA5S=CP5S/CV5S
00          GA45=0.5*(GA4+GA5S)
00          GGA45=(GA45-1.)/GA45
00          ANA45=GGA45/ETAPLY
00          AN=(1.+ETAPLY*GA45-GA45)/(ETAPLY*GA45)
00          ETAV=0.96*(1.-CLREFF*(P5P4**AN-1.))
00          ETAC=(P5P4**GGA45-1.)/(P5P4**ANA45-1.)
00          ETAC=ETAC/ETAPLY
00          UCPIPT=(H5S-H4)/ETAC
00          H5=H4+UCPIPT
00          T5=T4+2.*UCPIPT/(CP4+CP5S)
00          TK5=(T5+459.67)/1.8
00          ACC=0.0005
00          CALL HPPROP(N1,H5,PA5,XM,ACC,TK5,XQ5,XML,XMV,VLM,VVM,
00         @ VM5,V5,CP5,CV5,AM5,AK5)
00          T5=TK5*1.8-459.67
00    C**** CALCULATE REFRIGERANT MASS FLOW RATE
00          FCPT=-0.0998
00          DOPT=0.10
00          DO 16 IC=1,4
```

```
00          DO 12 JC=1,11
00          FOPT=FOPT+DOPT
00          CPRPM=0.
00          DO 10 KC=1,6
00          LC=KC-1
00          AA=FOPT**LC
00       10 CPRPM=CPRPM+AA*EMRPM(KC)
00          RMASS=60.*CPRPM*ETAV*SWPV/V4
00          WE=BTUFO*FOPT
00          WC=0.96*WE
00          RMACP=WC/UCPIPT
00          IF(RMACP.GE.RMASS)GOTO 14
00       12 CONTINUE
00       14 IF(IC.EQ.4)GOTO 16
00          FOPT=FOPT-DOPT
00          DOPT=0.1*DOPT
00       16 CONTINUE
00          RMASS2=RMASS*RMASS
00          RMASS8=RMASS**0.8
00          JJ=12
00          DO 20 II=1,11
00          JJ=JJ-1
00          IF(FOPT.LE.EMOPT(JJ))GOTO 18
00          ETAE=EMETA(JJ)+(EMETA(JJ+1)-EMETA(JJ))*
00         & (FOPT-EMOPT(JJ))/(EMOPT(JJ+1)-EMOPT(JJ))
00          GOTO 22
00       18 IF(II.NE.11)GOTO 20
00          ETAE=FOPT*EMETA(JJ)/EMOPT(JJ)
00       20 CONTINUE
00       22 EI=WC/(0.96*ETAE)
00          IF(NP.GT.1.OR.MH.GT.1)GOTO 24
00     C**** CALCULATE POINTS 3,6,7
00          T3=T4
00          P3=P4
00          V3=V4
00          VM3=VM4
00          AM3=AM2
00          AK3=AK2
00          CP3=CP2
00          T6=T5
00          P6=P5
00          V6=V5
00          VM6=VM5
00          AM6=AM5
00          AK6=AK5
00          CP6=CP5
00          T7=T5
00          P7=P5
00          V7=V5
00          VM7=VM5
00          AM7=AM5
00          AK7=AK5
00          CP7=CP5
00       24 CONTINUE
00          DO 40 K=1,12
00          IF(K.EQ.1)GOTO 26
00          AM3=VISCON(N3,T3,XW)                    @POINT 3
00          AK3=VISCON(N4,T3,XW)
```

```
00          TK3=(T3+459.67)/1.8
00          CALL HCVCP(N5,TK3,VM3,XM,DUM,CV3,CP3)
00    C
00          AM6=VISCON(N3,T6,XW)                   @POINT 6
00          AK6=VISCON(N4,T6,XW)
00          TK6=(T6+459.67)/1.8
00          CALL HCVCP(N5,TK6,VM6,XM,DUM,CV6,CP6)
00    C
00          AM7=VISCON(N3,T7,XW)                   @POINT 7
00          AK7=VISCON(N4,T7,XW)
00          TK7=(T7+459.67)/1.8
00          CALL HCVCP(N5,TK7,VM7,XM,DUM,CV7,CP7)
00       26 CP34=0.5*(CP3+CP4)
00          CP56=0.5*(CP5+CP6)
00          CP67=0.5*(CP6+CP7)
00          AM34=0.5*(AM3+AM4)
00          AM56=0.5*(AM5+AM6)
00          AM67=0.5*(AM6+AM7)
00          AK34=0.5*(AK3+AK4)
00          AK56=0.5*(AK5+AK6)
00          AK67=0.5*(AK6+AK7)
00          V67=0.5*(V6+V7)
00          QM3=EI-WC
00          Q34=CQC34*RMASS8*CP34**0.333*AK34**0.667
00         & *(T5-T3)/(AM34**0.467)
00          Q56=CQC56*RMASS8*CP56**0.333*AK56**0.667
00         & *(T6-T4)/(AM56**0.447)
00          Q67=RMASS8*(CP3*CP67)**0.333*(AK3*AK67)**0.667
00          Q67=Q67/(CP3**0.333*AK3**0.667*AM67**0.467+
00         & 1.5*CP67**0.333*AK67**0.667*AM3**0.467)
00          Q67=CQC67*Q67
00          IF(ABS(T6-T7).GT.0.01)GOTO 28
00          T673=0.5*(T6+T7)-T3
00          GOTO 30
00       28 T673=(T6-T7)/ALOG((T6-T3)/(T7-T3))
00       30 Q67=Q67*T673
00          AAX=CQC3C*RMASS8*CP3**0.333*AK3**0.667/AM3**0.467
00          BBX=CQCCOA
00          TC=(4.*T3+TA)/5.
00          SAA=1.
00          DO 32 ITR=1,20
00          IF(T3.LT.TC)SAA=-1.
00          QQ=SAA*AAX*(T3-TC)-BBX*ABS(TC-TA)**1.333
00          DQDT=SAA*(-AAX-1.333*BBX*ABS(TC-TA)**0.333)
00          TCC=TC-QQ/DQDT
00          IF(ABS(TCC-TC).LT.0.001)GOTO 34
00          TC=TCC
00       32 CONTINUE
00       34 TC=TCC
00          CQA=AAX*(T3-TC)
00          H3=H4-Q34/RMASS
00          H6=H5-Q56/RMASS
00          H7=H5-Q67/RMASS
00          H2A=H7-(EI-Q3A)/RMASS
00          P3=P4+CPC34*V4*RMASS2
00          P2A=P3+CPC23*V3*RMASS2
00          P6=P5-CPC56*V6*RMASS2
00          P7=P6-CPC67*V67*AM67**0.2*RMASS*RMASS8
```

```
      T3=T4-(H4-H3)/CP34
      T6=T5+(H6-H5)/CP56
      T7=T6+(H7-H6)/CP67
CC
      ACC=0.001
      TK3=(T3+459.67)/1.8
      PA3=P3/14.6959
      CALL HPIN(N1,H3,PA3,XM,ACC,TK3,XQ3,XL,XV,VL,VM3)
      T3=TK3*1.8-459.67
      V3=VM3*16.01846/WM
      PA6=P6/14.6959
      TK6=(T6+459.67)/1.8
C
      CALL HPIN(N1,H6,PA6,XM,ACC,TK6,XQ,XL,XV,VL,VM6)
      T6=TK6*1.8-459.67
C
      V6=VM6*16.01846/WM
      PA7=P7/14.6959
      TK7=(T7+459.67)/1.8
      CALL HPIN(N1,H7,PA7,XM,ACC,TK7,XQ,XL,XV,VL,VM7)
      T7=TK7*1.8-459.67
      V7=VM7*16.01346/WM
      IF(K.EQ.1)GOTO 36
      IF(ABS(H2B-H2A).LT.ACC.AND.ABS(H7B-H7).LT.ACC)GOTO 42
   36 H2B=H2A
      H7B=H7
   40 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=P3+CPC23*V3*RMASS2
      ROA=P2-P2A
      SAA=0.002
      IF(ABS(H2-H2A).LT.5.)SAA=0.001
      IF(ABS(ROA).LT.SAA)GOTO 52
      IF(ABS(ROB).GT..0)GOTO 44
      IF(SLOPE.NE..0)GOTO 45
      P4B=P4
      P4=P4+ROA
      ROB=ROA
      GOTO 50
   44 SLOPE=(P4B-P4)/(ROB-ROA)
      IF(ABS(ROB).LT.ABS(ROA))GOTO 46
   45 ROB=ROA
      P4B=P4
   46 P4=P4B-ROB*SLOPE
   50 CONTINUE
      WRITE(6,204)
C**** END OF PRESSURE LOOP
C*********************************************************************
   52 CONTINUE
      RHA=H2-H2A
      IF(ABS(RHA).LT.0.005)GOTO 62
      IF(MH.GT.1)GOTO 54
      P4Y=P4
      P4=P4+0.1
```

```
00          H4B=H4
00          H4=H4+2.
00          IF(RHA.LT.0.0)H4=H4-4.
00          IF(RHA.LT.0.0)P4=P4-0.2
00          RHB=RHA
00          GOTO 60
00       54 SLOPH=(H4B-H4)/(RHB-RHA)
00          SLOPP=(P4Y-P4)/(RHB-RHA)
00          IF(ABS(RHB).LT.ABS(RHA))GOTO 56
00          RHB=RHA
00          H4B=H4
00          P4Y=P4
00       56 H4=H4B-RHB*SLOPH
00          P4=P4Y-RHB*SLOPP
00       60 CONTINUE
00          WRITE(6,206)RHA
00    C**** END OF ENTHALPY LOOP
00    C*****************************************************************
00    C**** END OF ITERATION PROCCESS
00    C*****************************************************************
00    C**** REFRIG. STATE INSIDE COMPRESSOR CAN
00    C**** AND REFRIGERANT MASS FLOW RATE ARE KNOWN
00    C**** CALC. REFRIG. STATE AT 4-WAY VALVE AND CONNECTIG TUBING
00       62 CALL MVAL4(XW,RMASS,V2,AM2,AK2,CP2,V7,AM7,AK7,CP7,
00         & V1,AM1,AK1,CP1,V8,AM8,AK8,CP8)
00          IF(NSYS.EQ.2)GOTO 64
00          CALL PIPE(NO,XW,TRA,RMASS,T8,P8,V8,H8,AM8,AK8,CP8,
00         & T9,P9,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         & T0,P0,H0,XQ0,YL,YD,YK1,YD1,YK2,YD2,0.,0.)
00          GOTO 66
00       64 CALL PIPE(N1,XW,TRA,RMASS,T1,P1,V1,H1,AM1,AK1,CP1,
00         & T0,P0,H0,XQ0,RL,RD,RK1,RD1,RK2,RD2,0.,0.)
00          CALL PIPE(NO,XW,TA,RMASS,T8,P8,V8,H8,AM8,AK8,CP8,
00         & T9,P9,H9,XQ9,YL,YD,YK1,YD1,YK2,YD2,0.,0.)
00       66 EI=EI/3412.7
00    C*****************************************************************
00    C**** PRINT RESULTS
00          WRITE(6,207)
00          WRITE(6,208)EI,ETAE,ETAC,ETAV,CPRPM,RMASS
00          WRITE(6,210)
00          I=1
00          WRITE(6,212)I,T0,P0,H0,XQ0
00          I=I+1
00          WRITE(6,212)I,T1,P1,H1,XQ1
00          I=I+1
00          WRITE(6,212)I,T2,P2,H2,XQ2
00          I=I+1
00          WRITE(6,212)I,T3,P3,H3,XQ3
00          I=I+1
00          WRITE(6,212)I,T4,P4,H4,XQ4
00          I=I+1
00          WRITE(6,212)I,T5,P5,H5,XQ5
00          I=I+1
00          WRITE(6,212)I,T6,P6,H6,XQ6
00          I=I+1
00          WRITE(6,212)I,T7,P7,H7,XQ7
00          I=I+1
```

```
00             WRITE(6,212)I,T8,P8,H8,XQ8
00             I=I+1
00             WRITE(6,212)I,T9,P9,H3,XQ9
00       C
00         200 FORMAT(/2X,'INPUT DATA TO COMPR:'//2X,'P3',9X,'T3',9X,'H3',
00            & 9X,'XQ3',8X,'TG6',8X,'TRA',9X,'TOA'/7(1PE11.3))
00         204 FORMAT(' COMPRE*ERROR PRESSURE LOOP')
00         205 FORMAT(' COMPRE DOES NOT CONVERGE, RHA='1PE16.6)
00         207 FORMAT(/2X,'COMPRESSOR ITERATION:')
00         208 FORMAT(/2X,'EI',9X,'ETAE',7X,'ETAC',7X,'FTAV',7X,
00            & 'CPRPM',6X,'RMASS'/6(1PE11.3))
00         210 FORMAT(/2X,'I',2X,'T',10X,'P',10X,'H',10X,'X')
00         212 FORMAT(I3,4(1PE11.3))
00             RETURN
00             END

END ELT.  ERRORS: NONE. TIME:  0.506 SEC. IMAGE COUNT: 419

@HDG,P  ******  CONDHX  ****** .L,0
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```
@ELT,L DD.CONDHX
ELT 8R1 S74Q1C 07/21/84 15:54:59 (0)
00        SUBROUTINE CONDHX(IIO,RMASS,T1,P1,ATIN,APIN,ARHIN,
00       &                  T2,P2,H2,X2)
00  C
00  C     AUGUST 1983
00  C
00  C**** SIMULATION OF A CONDENSER WORKING WITH A NON-AZEOTROPIC MIXTURE
00  C**** AS REFRIGERANT
00  C
00  C**** THIS PROGRAM COMPUTES IN TUBE-BY-TUBE SCHEME
00  C**** PERFORMANCE OF CROSS-FLOW AIR COOLED CONDENSER
00  C**** WITH UP TO 130 PLATE FINNED TUBES
00  C**** PLACED IN UP TO 5 DEPTH ROWS.
00  C
00  C**** INPUT DATA:
00  C        AMAS(IIO)       - AIR MASS FLOW RATE THROUGH COIL    (LBM/H)
00  C        ANGLE(IIO)      - ANGLE BETWEEN COIL FACE & AIR STREAMLINES    (RAD)
00  C        APIN            - AIR INLET PRESSURE    (PSIA)
00  C        ARHIN           - AIR INLET RELATIVE HUMIDITY    (-)
00  C        ATIN            - AIR INLET TEMPERATURE    (F)
00  C        CONST(IIO)      - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION    (-)
00  C        CPOW(IIO)       - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION    (-)
00  C        DI(IIO)         - INNER DIAMETER OF TUBES    (FT)
00  C        DO(IIO)         - OUTER DIAMETER OF TUBES    (FT)
00  C        DPCH(IIO)       - TUBE DEPTH PITCH    (FT)
00  C        DT(IIO)         - FIN TIP DIAMETER    (FT)
00  C        FLOW(IIO,M)     - FRACTION OF COIL TOTAL REFRIG. MASS FLOW PASSING
00  C                          THROUGH TUBE M    (-)
00  C        FMK(IIO)        - FIN MATERIAL THERMAL CONDUCTIVITY    (BTU/FT*H*F)
00  C        FPCH(IIO)       - FIN PITCH    (FT)
00  C        FTK(IIO)        - FIN THICKNESS    (FT)
00  C        IDEPTH(IIO,M)   - DEPTH ROW OF A TUBE M    (-)
00  C        IFROM(IIO,M)    - NUMBER OF TUBE FROM WHICH TUBE M RECEIVES REFRIG.
00  C                          WHEN COIL WORKS AS EVAPORATOR    (-)
00  C        IIO             = 1    FOR INDOOR COIL    (-)
00  C                        = 2    FOR OUTDOOR COIL    (-)
00  C        IMER(IIO)       - NUMBER OF MERGING TUBES    (-)
00  C        IST(IIO)        - NUMBER OF TUBES REFRIG. FLOWS INTO COIL
00  C                          WORKING AS CONDENSER    (-)
00  C        ISTART(IIO,L)   - NUMBER OF TUBE REFRIG. FLOWS INTO COIL
00  C                          WORKING AS CONDENSER, FOUND AS L SUCH TUBE    (-)
00  C        MERGE(IIO,K,1)  - NUMBER OF TUBE FOUND AS K MERGING TUBE    (-)
00  C        MERGE(IIO,K,2)  - NUMBER OF TUBES MERGING INTO TUBE K    (-)
00  C        NDEP(IIO)       - NUMBER OF TUBE ROW DEPTHS    (-)
00  C        NROW(IIO)       - NUMBER OF TUBES PER ROW    (-)
00  C        NSECT(IIO)          - NUMBER OF REPEATING SECTIONS OF COIL    (-)
00  C        NTPS(I)         - NUMBER OF TUBES PER SECTION    (-)
00  C        NTUB(IIO,I)     - NUMBER OF TUBES IN ROW I OF EACH SECTION    (-)
00  C        P1              - REFRIGERANT PRESSURE AT CONDENSER INLET    (PSIA)
00  C        RMASS           - TOTAL REFRIG. MASS FLOW RATE THROUGH COIL    (LBM/H)
00  C        RPCH(IIO)       - PITCH BETWEEN TUBES OF THE SAME DEPTH    (FT)
00  C        TMK(IIO)        - TUBE MATERIAL THERMAL CONDUCTIVITY    (BTU/FT*H*F)
00  C        T1              - REFRIGERANT TEMPERATURE AT CONDENSER INLET    (F)
00  C        WIDTH(IIO)      - COIL WIDTH    (FT)
00  C        XM              - MOLAR COMPOSITION
00  C                          (FRACTION OF LESS VOLATILE COMPONENT)
00  C        XW              - WEIGHT COMPOSITION
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00   C                          (FRACTION OF LESS VOLATILE COMPONENT)
00   C         WM               - MIXTURE MOLECULAR WEIGHT   (G/MOL)
00   C         W1               - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT   (G/MOL)
00   C         W2               - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT   (G/MOL)
00   C
00   C**** OUTPUT DATA:
00   C         H2               - REFRIGERANT ENTHALPY AT CONDENSER OUTLET   (BTU/LBM)
00   C         PRM(IIO,1,I)     - REFRIG. PRESSURE AT I TUBE INLET   (PSIA)
00   C         PRM(IIO,2,I)     - REFRIG. PRESSURE AT I TUBE OUTLET   (PSIA)
00   C         P2               - REFRIGERANT PRESSURE AT CONDENSER OUTLET   (PSIA)
00   C         TRM(IIO,1,I)     - REFRIG. TEMP. AT I TUBE INLET   (F)
00   C         TRM(IIO,2,I)     - REFRIG. TEMP. AT I TUBE OUTLET   (F)
00   C         T2               - REFRIGERANT TEMPERATURE AT CONDENSER OUTLET   (F)
00   C         XRM(IIO,1,I)     - REFRIG. QUALITY AT I TUBE INLET   (-)
00   C         XRM(IIO,2,I)     - REFRIG. QUALITY AT I TUBE OUTLET   (-)
00   C         XTUBE(IIO,J)     - FRACTION OF TUBE J WITH SUPERHEATED VAPOR
00   C                          (WHEN 2-PHASE FLOW IS IN REST OF TUBE)   (-)
00   C                          OR
00   C                          - FRACTION OF TUBE J WITH 2-PHASE FLOW
00   C                          (WHEN SUPCOOLED LIQUID IS IN REST OF TUBE)   (-)
00   C         XTT(IIO,K)       - LOCKHART-MARTINELLI PARAMETER FOR REFRIG.
00   C                          IN TUBE K   (-)
00   C         X2               - REFRIGERANT QUALITY AT CONDENSER OUTLET   (-)
00   C         VGM(IIO,1,I)     - SPEC. VOLUME OF SATURATED REFRIG. VAPOR AT
00   C                          SAT. TEMP. OF I TUBE INLET   (FT**3/LBM)
00   C         VGM(IIO,2,I)     - SPEC. VOLUME OF SATURATED REFRIG. VAPOR AT
00   C                          SAT. TEMP. OF I TUBE OUTLET   (FT**3/LBM)
00   C         VLM(IIO,1,I)     - REFRIG. SPEC VOLUME AT I TUBE INLET   (FT**3/LBM)
00   C         VLM(IIO,2,I)     - REFRIG. SPEC. VOLUME AT I TUBE OUTLET   (FT**3/LBM)
00   C
00   C**** SUBPROGRAMS CALLED BY CONDHX:
00   C         AIRHT,AIRPR,BUBTEM,DEWTEM,DYNDP1,DPDYN2,EBUBTE,ESVOL,FEELIQ,
00   C         FINEFF,HCVCP,HPIN,HTCCON,SPHDP1,SPHTC,VISCON,VOLIT1
00   C
00         COMMON/RDATA2/W1,W2,TC1,TC2
00         COMMON/RDATA3/XW,XM,WM
00         COMMON/HPHX/NDEP(2),NROW(2),DI(2),DO(2),DT(2),RPCH(2),DPCH(2),
00        &WIDTH(2),FPCH(2),FTK(2),FMK(2),TMK(2),AMAS(2),ANGLE(2),
00        &CONST(2),CPOW(2),NTUB(2,5),IFROM(2,130),NSECT(2),NTPS(2)
00         COMMON/MERG/MERGE(2,20,2),IMER(2),ISTART(2,20),IST(2),
00        &IDEPTH(2,130),FLOW(2,130),JFROM(2,130),KFEED(2,130,3),
00        &KSTART(2,20),KST(2)
00         COMMON/MASS/TRM(2,2,130),PRM(2,2,130),XRM(2,2,130),
00        &   VLM(2,2,130),VGM(2,2,130),XTUBE(2,130),XTT(2,130)
00         DIMENSION TAIR(2,6),AIRN(5),HR(2,130),INC(20),IEND(10),MY(130),
00        @ DTR(130),DPR(130),DHR(130),DXR(130),CPRS(130),HCO(5),FFEE(5)
00         DIMENSION XLS(2,130),XVS(2,130),VLS(2,130),VVS(2,130)
00         DIMENSION TAIRI(2,130),AMSI(5),CPAS(5)
00         DATA NO,N1,N3,N4,N5/0,1,3,4,5/
00   C
00         WRITE(6,500)T1,P1,ATIN,ARHIN,RMASS
00   C
00   C**** DATA PREPARATION
00         NNDEP=NDEP(IIO)
00         DDi=DI(IIO)
00         DDO=DO(IIO)
00         DDT=DT(IIO)
00         RRPCH=RPCH(IIO)
```

```
00          DDPCH=DPCH(IIO)
00          WWIDTH=WIDTH(IIO)
00          FFPCH=FPCH(IIO)
00          FFTK=FTK(IIO)
00          FFMK=FMK(IIO)
00          TTMK=TMK(IIO)
00          AAM^S=AMAS(IIO)
00          AANCLF=ANGLE(IIO)
00          CCONST=CONST(IIO)
00          CCPOW=CPOW(IIO)
00          API=3.1415927*DDI*WWIDTH
00          APO=3.1415927*DDO*WWIDTH
00          APM'=0.5*(API+APO)
00          APO=APO*(FFPCH-FFTK)/FFPCH
00          AF=1.570796*(DDT+DDO)*(DDT-DDO)
00          AF=AF*WWIDTH/FFPCH
00          AO=APO+AF
00          HD=5000.
00          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 VOLITI(N1,TK1,PA1,XM,VM1)
00          V1=16.01846*VM1/WM
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 AIRPR(1,ATIN,APIN,ARHIN,WAIR,CPAIR,RAIR,
00         &AMAIR,AKAIR)
00          TAIR(1,1)=ATIN
00          DTAIR=RMASS*(H1-H2)/(CPAIR*AAMAS*NNDEP)
00          DO10I=1,NNDEP
00          J=I+1
00       10 TAIR(1,J)=TAIR(1,I)+DTAIR
00          DO 11 I=1,NTPS(IIO)
00          ICT=IDEPTH(IIO,I)
00          TAIRI(1,I)=ATIN+(ICT-1.)*DTAIR
00       11 TAIRI(2,I)=TAIRI(1,I)+DTAIR
00    C**** EVALUATE 'TWO-PHASE SPEC. HEAT'
00          CALL DEWTEM(NO,PA1,XM,TKD,XL)
00          CALL VOLITI(N1,TKD,PA1,XM,VV)
00          CALL HCVCP(N1,TKD,VV,XM,HGV,CV,CP)
00          CPR=(HGV-H2)/(1.8*(TKD-TK2))
00          DO 12 I=1,NTPS(IIO)
00          VLM(IIO,2,I)=0.0
00          VGM(IIO,2,I)=0.0
00          DTR(I)=0.
00          DPR(I)=0.
00          DHR(I)=0.
00          DXR(I)=0.
00          CPRS(I)=CPR
00       12 MY(I)=0
00          NIST=IST(IIO)
00          NIMER=IMER(IIO)
```

```
00            DO 13 I=1,NIMER
00            J=MERGE(IIO,I,1)
00         13 MY(J)=1
00            ACC=0.005
00      C*****************************************************************
00      C**** START MAIN LOOP
00      C*****************************************************************
00            DO 100 IAIR=1,10
00      CXZ      PRINT 805,IAIR
00        805 FORMAT(' IAIR=',I4)
00      CAA      IF(IAIR.EQ.1)PRINT 803,TAIR(1,1),TAIR(1,2),TAIR(1,3),TAIR(1,4)
00        803 FORMAT(' TAIR 1,2,3,4=',4F10.3)
00            DO 14 I=1,NNDEP
00            NT=NSECT(IIO)*NTUB(IIO,I)
00            AMS=AAMAS/NT
00            TAAV=0.5*(TAIR(1,I)+TAIR(1,I+1))
00            CALL AIRPR(2,TAAV,APIN,RHA,WAIR,CPA,RA,AMA,AKA)
00            NNROW=NTUB(IIO,I)
00            HCO(I)=AIRHT(AAMAS,CPA,AMA,AKA,DDO,DDT,NNROW,WWIDTH,
00           &RRPCH,FFPCH,FFTK,CCONST,CCPOW,AANGLE)
00            FFEE(I)=FINEFF(IIO,DDT,DDO,FFTK,FFMK,HCO(I))
00            AMSI(I)=AMS
00            CPAS(I)=CPA
00         14 AIRN(I)=0.
00            DO 16 IA=1,NIMER
00            I=MERGE(IIO,IA,1)
00            HR(1,I)=0.
00            PRM(IIO,1,I)=0.
00            IMC(IA)=MERGE(IIO,IA,2)
00         16 CONTINUE
00            IEN=0
00      C**** FIND TUBE REFRIG. FLOWS INTO CONDENSER
00            DO 86 NUMB=1,NIST
00            I=ISTART(IIO,NUMB)
00            TRM(IIO,1,I)=T1
00            PRM(IIO,1,I)=P1
00            HR(1,I)=H1
00            XRM(IIO,1,I)=1.
00            VGM(IIO,1,I)=V1
00            TRI=T1
00            PRI=P1
00            HRI=H1
00            XRI=1.
00            GOTO 34
00      C**** FIND NEXT TUBE
00         18 CONTINUE
00            I=IFROM(IIO,JJ)
00            IF(I.EQ.0)GOTO 85
00            IF(MY(I).EQ.1)GOTO 22
00            TRI=TRM(IIO,2,JJ)
00            PRI=PRM(IIO,2,JJ)
00            HRI=HR(2,JJ)
00            XRI=XRM(IIO,2,JJ)
00            VLM(IIO,1,I)=VLM(IIO,2,JJ)
00            VGM(IIO,1,I)=VGM(IIO,2,JJ)
00            XLS(1,I)=XLS(2,JJ)
00            XVS(1,I)=XVS(2,JJ)
00            VLS(1,I)=VLS(2,JJ)
```

```
      VVS(1,I)=VVS(2,JJ)
      GOTO 32
C**** REFRIG. MERGES IN TUBE I. FIND INLET STATE
   22 HR(1,I)=HR(1,I)+HR(2,JJ)*FLOW(IIO,JJ)
      PRM(IIO,I,I)=PRM(IIO,1,I)+PRM(IIO,2,JJ)*FLOW(IIO,JJ)
      DO 23 IP=1,NIMER
   23 IF(MERGE(IIO,IP,1).EQ.I)GOTO 24
   24 IMC(IP)=IMC(IP)-1
      IF(IMC(IP).NE.0)GOTO 86
      HR(1,I)=HR(1,I)/FLOW(IIO,I)
      PRM(IIO,1,I)=PRM(IIO,1,I)/FLOW(IIO,I)
      HRI=HR(1,I)
      PRI=PRM(IIO,1,I)
      PARI=PRI/14.6959
      CALL HPIN(N1,HRI,PARI,XM,ACC,TKRI,XRI,XL,XV,VL,VV)
      TRI=TKRI*1.8-459.67
      IF(XRI.EQ.0.)THEN
         VLM(IIO,1,I)=16.01846*VL/WM
      ELSE
         IF(XRI.LT.1.)THEN
            WMV=W1*(1.-XV)+W2*XV
            VGM(IIO,1,I)=16.01846*VV/WMV
            WML=W1*(1.-XL)+W2*XL
            VLM(IIO,1,I)=16.01846*VL/WML
            XLS(1,I)=XL
            XVS(1,I)=XV
            VLS(1,I)=VL
            VVS(1,I)=VV
         ELSE
            VGM(IIO,1,I)=16.01846*VV/WM
         END IF
      END IF
   32 CONTINUE
      TRM(IIO,1,I)=TRI
      PRM(IIO,1,I)=PRI
      HR(1,I)=HRI
      XRM(IIO,1,I)=XRI
C
C**** TUBE I SELECTION FOR CALCULATION DONE
C**** COMPUTE HEAT TRANSFER & REFRIG. PRESSURE DROP FOR TUBE I
C**** FIND REFRIG. STATE AT OUTLET
   34 CONTINUE
      TKRI=(TRI+459.67)/1.8
      RMS=RMASS*FLOW(IIO,I)
      TRE=TRI-DTR(I)
      PRE=PRI-DPR(I)
      HRE=HRI-DHR(I)
      XRE=XRI-DXR(I)
      PRAV=0.5*(PRI+PRE)
      PARAV=PRAV/14.6959
      ICT=IDEPTH(IIO,I)
      AMS=AMSI(ICT)
      CPA=CPAS(ICT)
      TAI=TAIRI(1,I)
      IF((TAI-.1).GE.TRI)TAI=TRI-0.1
CDE      PRINT 806,I,ICT,XRI,PRI,TRI,HRI,TAI
CDE  806 FORMAT(' I,ICT,XRI,PRI,TRI,HRI,TAI=',2I4,F6.2,5F6.1)
      IF(XRI.EQ.1.)GOTO 42
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00            IF(XRI.GT.0.0001)GOTO 58
00      C
00      C**** CASE 1
00      C**** SUBCOOLED LIQUID AT TUBE I INLET
00            DO 36 IS=1,5
00            TRAV=0.5*(TRI+TRE)
00            TKRAV=(TRAV+459.67)/1.8
00            AMR=VISCON(1,TRAV,XW)
00            AKR=VISCON(2,TRAV,XW)
00            CALL VOLITI(NO,TKRAV,PARAV,XM,VL)
00            CALL HCVCP(N5,TKRAV,VL,XM,H,CV,CPR)
00            HI=SPHTC(CPR,AMR,AKR,RMS,DDI)
00            UAO=OVLHTC(AO,API,APM,APO,AF,HI,HD,HP,HCO(ICT),FFEE(ICT))
00            QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
00            Q1=1.-EXP(-QQ/(CPR*RMS))
00            Q1=CPR*RMS*(TRI-TAI)*Q1
00            HRE=HRI-Q1/RMS
00            TRE=TRI+(HRE-HRI)/CPR
00            IF(TRE.GT.TAI)GOTO 38
00         36 CONTINUE
00         38 XRE=0.
00            AL1=WWIDTH+20.*DDI
00            VL=VL*16.01846/WM
00            PRE=PRI-SPHDP1(RMS,AL1,DDI,VL,AMR)
00            TAE=TAI+Q1/(CPA*AMS)
00            GOTO 78
00      C
00      C**** CASE 2 & 3
00      C**** SUPERHEATED VAPOR AT TUBE I INLET
00         42 CONTINUE
00            DO 46 ISUP=1,6
00      CXZ       PRINT 807,PARAV,TKRAV
00        807 FORMAT(' PARAV,TKRAV=', 2F8.2)
00            TRAV=0.5*(TRI+TRE)
00            TKRAV=(TRAV+459.67)/1.8
00            CALL VOLITI(N1,TKRAV,PARAV,XM,VV)
00            CALL HCVCP(N5,TKRAV,VV,XM,H,CV,CPR)
00            AMR=VISCON(N3,TRAV,XW)
00            AKR=VISCON(N4,TRAV,XW)
00            HI=SPHTC(CPR,AMR,AKR,RMS,DDI)
00            UAO=OVLHTC(AO,API,APM,APC,AF,HI,HD,HP,HCC(ICT),FFEE(ICT))
00            QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
00            Q1=1.-EXP(-QQ/(CPR*RMS))
00            Q1=CPR*RMS*(TRI-TAI)*Q1
00            HRE=HRI-Q1/RMS
00            TRE=TRI-(HRI-HRE)/CPR
00            IF(ISUP.EQ.1)GOTO 44
00            HDIF=HRE1-HRE
00            IF(ABS(HDIF).LT.0.01)GOTO 48
00         44 HRE1=HRE
00         46 CONTINUE
00            WRITE(6,650)I,HDIF
00        650 FORMAT(' CASE 2 TUBE DOES NOT CONVERGE, I,HDIF=',I4,1PE14.4)
00         48 CONTINUE
00      CXZ       PRINT 808,HRE
00        808 FORMAT(' HRE=',F6.2)
00            CALL DEWTEM(NO,PARAV,XM,TKD,XLD)
00            CALL VOLITI(N1,TKD,PARAV,XM,VVD)
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00            CALL HCVCP(N1,TKD,VVD,XM,HGV,CV,CP)
00      CVX      PRINT 809,HGV
00        809 FORMAT(' HGV=',F8.2)
00            IF(HRE.GE.HGV)THEN
00               XRE=1.
00               Q2=0.
00               XSUP=1.
00               VW=VVD*16.01846/WM
00               GOTO 52
00            END IF
00      C
00      C**** CASE 3
00      C**** 2-PHASE FLOW AT OUTLET OF A TUBE WITH SUPERHEATED VAPOR AT INLET
00      C**** COMPUTE HEAT TRANSFERED BY PART OF A TUBE WITH SUPERHEATED VAPOR
00            TKRAV=0.5*(TKRI+TKD)
00            TRAV=TKRAV*1.8-459.67
00            TD=TKD*1.8-459.67
00            VMAV=0.5*(VVD+VCM(IIO,1,I)*WM/16.01846)
00            VW=VMAV*16.0846/WM
00            CALL HCVCP(N5,TKRAV,VMAV,XM,H,CV,CPR)
00            AMR=VISCON(3,TRAV,XW)
00            AKR=VISCON(4,TRAV,XW)
00            HI=SPHTC(CPR,AMR,AKR,RMS,DDI)
00            UAO=OVLHTC(AO,API,APM,APO,AF,HI,HD,HP,HCO(ICT),FFEE(ICT))
00            Q1=RMS*(HRI-HGV)
00            QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
00            XSUP=-CPR*RMS*ALOG(1.-Q1/(RMS*CPR*(TRI-TAI)))/QQ
00      CVX      PRINT 811,XSUP
00        811 FORMAT(' XSUP=',F6.2)
00            IF(XSUP.GT.1.)THEN
00               HRE=HGV
00               Q2=0.
00               XRE=1.
00               XSUP=1.
00               GOTO 52
00            END IF
00      C**** COMPUTE HEAT TRANSFERED BY PART OF A TUBE WITH 2-PHASE
00            TKRE=(TRE+459.67)/1.8
00            DO 50 IQ=1,6
00            CPR=CPRS(I)
00            IF(TRE.GT.TD)TRE=TD-2.
00            TRAV=0.5*(TD+TRE)
00            HI=HTCCON(TRAV,PRAV,RMS,DDI)
00            UAO=OVLHTC(AO,API,APM,APO,AF,HI,HD,HP,HCO(ICT),FFEE(ICT))
00            QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
00      CVX      PRINT 813,CPR
00        813 FORMAT(' CPR=',1PE15.6)
00            Q2=(1.-XSUP)*CPR*RMS*(TD-TAI)*(1.-EXP(-QQ/(CPR*RMS)))
00            HRE=HGV-Q2/RMS
00            CALL HPIN(N1,HRE,PARAV,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
00            TRE=TKRE*1.8-459.67
00      CVX      PRINT 812,HGV,HRE,TD,TRE,XRE
00        812 FORMAT(' HGV,HRE,TD,TRE,XRE=',4F12.6,F6.2)
00            IF(TRE.EQ.TD)THEN
00               IF(IQ.GT.1)GOTO 52
00               CPRS(I)=2.*CPR
00               GOTO 49
00            END IF
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00          CPRS(I)=(HGV-HRE)/(TD-TRE)
00          IF(IQ.EQ.1)GOTO 49
00          HDIF=HRE-HRE1
00          IF(ABS(HDIF).LT.0.01)GOTO 52
00       49 HRE1=HRE
00       50 CONTINUE
00          WRITE(6,660)I,HDIF
00      660 FORMAT(' CASE 3 TUBE DOES NOT CONVERGE, I,HDIF=',I4,1PE14.4)
00       52 Q=Q1+Q2
00          XRAV=0.5*(1.+XRE)
00          TAE=TAI+Q/(CPA*AMS)
00      810 FORMAT(' XSUP=',F8.2)
00    CVXCDE      PRINT 810,XSUP
00    C
00    C**** CALCULATE FRICTIONAL PRESSURE DROP IN A TUBE
00          IF(XRAV.GT..99)THEN        @SUPERHEATED VAPOR IN A TUBE ONLY
00             AL1=WWIDTH+20.*DDI
00             DP1=SPHDP1(RMS,AL1,DDI,VW,AMR)
00             DP2=0.
00          ELSE                       @SUPERHEATED VAPOR & 2-PHASE IN A TUBE
00             AL1=XSUP*WWIDTH
00             DP1=SPHDP1(RMS,AL1,DDI,VW,AMR)
00             XL=0.5*(XLD+XL)
00             XLW=XL/(W1/W2*(1.-XL)+XL)
00             WML=W1*(1.-XL)+W2*XL
00             TKRAV=(TRAV+459.67)/1.8
00    CVV      PRINT 814,TKRAV,PARAV
00      814 FORMAT(' TKRAV,PARAV=',2F10.3)
00             CALL VOLIT1(NO,TKRAV,PARAV,XL,VL)
00             VLW=VL*16.01846/WML
00             AMR=VISCON(N1,TRAV,XLW)
00    CVV      PRINT 819,AMR
00      819 FORMAT(' AMR=',1PE15.5)
00             AL2=(1.-XSUP)*WWIDTH+20.*DDI
00             RMSX=(1.-XRAV)*RMS
00             DP2=SPHDP1(RMSX,AL2,DDI,VLW,AMR)
00             XV=0.5*(XM+XV)
00             VV=0.5*(VVD+VV)
00    CVV      PRINT 818,XRAV,TRAV,XL,XV,VL,VV
00      818 FORMAT(' XRAV,TRAV,XL,XV,VL,VV=',F4.2,F7.2,2F5.2,2F10.4)
00             FEE2=FEELIQ(XRAV,TRAV,XL,XV,VL,VV,XTT(IIO,I))
00             DP2=DP2*FEE2
00          END IF
00    CVV      PRINT 815,DP1,DP2
00      815 FORMAT(' DP1,DP2=',2F10.3)
00          PRE=PRI-DP1-DP2
00          GOTO 78
00    C
00    C**** CASE 4 & 5
00    C**** 2-PHASE FLOW AT TUBE I INLET
00       58 IXRE=0
00          X2PH=1.
00          TKRE=(TRE+459.67)/1.8
00          DO 63 ITPH=1,6
00          CPR=CPRS(I)
00          TRAV=0.5*(TRI+TRE)
00          XRAV=0.5*(XRI+XRE)
00          HI=HTCCON(TRAV,PRAV,RMS,DDI)
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00        UAO=OVLHTC(AO,API,APM,APO,AF,HI,HD,HP,HCO(ICT),FFEE(ICT))
00        QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
00        Q1=CPR*RMS*(TRI-TAI)*(1.-EXP(-QQ/(CPR*RMS)))
00        HRE=HRI-Q1/RMS
00  CCC      IF(I.EQ.72)PRINT 821,HRE
00  CCC  821 FORMAT(' ::HRE=',F9.3)
00        CALL HPIN(N1,HRE,PARAV,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
00        TRE=TKRE*1.8-459.67
00        IF(XRE.EQ.0.)THEN
00           IF(IXRE.EQ.1)GOTO 65
00           TKB=TKRI
00           CALL BUBTEM(N1,PARAV,XM,TKB,XVB)
00           CALL VOLIT1(N0,TKB,PARAV,XM,VLB)
00           CALL HCVCP(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(I)=(HRI-HGL)/(TRI-TB)
00           IXRE=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(I)=2.*CPR
00           GOTO 62
00        END IF
00        CPRS(I)=(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     62 HRE1=HRE
00     63 CONTINUE
00        WRITE(6,670)I,HDIF
00    670 FORMAT(' CASE 4 TUBE DOES NOT CONVERGE, I,HDIF=',I4,1PE14.4)
00        GOTO 68
00     65 CONTINUE
00  C
00  C**** CASE 5
00  C**** SUBCOOLED LIQUID AT OUTLET OF TUBE WITH 2-PHASE FLOW AT INLET
00  C**** COMPUTE HEAT TRANSFERED 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           X2PH=1.
00           GOTO 68
00        END IF
00  C**** COMPUTE HEAT TRANSFERED BY A SINGLE-PHASE PART OF A TUBE
00        DO 67 ITPH=1,6
00        IF(TRE.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 HCVCP(N5,TKRAV,VL,XM,H,CV,CPR)
00        AMR=VISCON(1,TRAV,XW)
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00          AKR=VISCON(2,TRAV,XW)
00          HI=SPHTC(CPR,AMR,AKR,RMS,DDI)
00          UAO=OVLHTC(AO,API,APM,APO,AF,HI,HD,HP,HCO(ICT),FFEE(ICT))
00          QQ=CPA*AMS*(1.-EXP(-AO*UAO/(CPA*AMS)))
00          Q2=CPR*RMS*(TD-TAI)*(1.-EXP(-QQ/(CPR*RMS)))*(1.-X2PH)
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       66 HRE1=HRE
00       67 CONTINUE
00       68 CONTINUE
00    CCC       IF(I.EQ.72)PRINT 820,HRE
00    CCC   820 FORMAT(' HRE=',F8.2)
00          Q=Q1+Q2
00          TAE=TAI+Q/(CPA*AMS)
00          TAIRI(2,I)=TAE
00    C**** COMPUTE FRICTIONAL PRESSURE DROP
00          XTUBE(IIO,I)=X2PH
00          IF(X2PH.LT.1.)THEN
00             XML=0.5*(XLS(1,I)+XM)
00             XMV=0.5*(XVS(1,I)+XVB)
00             XWL=XML/(W1/W2*(1.-XML)+XML)
00             TRT=0.5*(TRI+TB)
00             AMR=VISCON(1,TRT,XWL)
00             VLW=0.5*(VLM(IIO,1,I)+VLB*16.01846/WM)
00             AL1=WWIDTH*X2PH
00             RMSX=(1.-XRAV)*RMS
00             DP1=SPHDP1(RMSX,AL1,DDI,VLW,AMR)
00             WML=W1*(1.-XML)+W2*XML
00             VML=0.5*(VLB+VLS(1,I))
00             VMV=0.5*(VVS(1,I)+VVB)
00             FEE2=FEELIQ(XRAV,TRT,XML,XMV,VML,VMV,XTT(IIO,I))
00             DP1=DP1*FEE2
00             AL2=(1.-X2PH)*WWIDTH+20.*DDI
00             VLW=VL*16.01846/WM
00             DP2=SPHDP1(RMS,AL2,DDI,VLW,AMR)
00          ELSE             @2-PHASE FLOW IN TUBE ONLY
00             WML=W1*(1.-XL)+W2*XL
00             VLW=0.5*(VLM(IIO,1,I)+16.01846*VL/WML)
00             XL=0.5*(XLS(1,I)+XL)
00             XWL=XL/(W1/W2*(1.-XL)+XL)
00             AMR=VISCON(1,TRAV,XWL)
00             AL1=WWIDTH+20.*DDI
00             RMSX=(1.-XRAV)*RMS
00             DP1=SPHDP1(RMSX,AL1,DDI,VLW,AMR)
00             VL=0.5*(VL+VLS(1,I))
00             VV=0.5*(VV+VVS(1,I))
00             FEE2=FEELIQ(XRAV,TRAV,XL,XV,VL,VV,XTT(IIO,I))
00             DP1=DP1*FEE2
00             DP2=0.
00          END IF
00          PRE=PRI-DP1-DP2
00       73 CONTINUE
00    CC***FOLLOWING STATEMETS FOR CALC. OF DYNAMIC PRESSURE DROP ARE
00    CC   SKIPPED. THEY PROVIDE LITTLE CORRECTION FOR PRESSURE DROP
00    CC   AT EXPENSE OF A LOT OF COMPUTING.
00    CC    IF(XRI.LT.1..AND.XPE.GT.0.1)THEN
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00   CC       DIX=DYNDP2(PRI,TRI,PRE,TRE,RMS,DDI)
00   CC     ELSE
00   CC       DIX=DYNDP1(PRI,HRI,PRE,HRE,RMS,DDI)
00   CC     END IF
00   CC     PRE=PRE-DIX
00   C
00   C**** ENTHALPY & PRESSURE AT TUBE I OUTLET ARE KNOWN
00   C**** FIND TEMP.,QUALITY & SPEC. VOLUME
00         TKRE=(TRE+459.67)/1.8
00         PARE=PRE/14.6959
00         CALL HPIN(N1,HRE,PARE,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
00         TRM(IIO,2,I)=TKRE*1.8-459.67
00         PRM(IIO,2,I)=PRE
00         HR(2,I)=HRE
00         XRM(IIO,2,I)=XRE
00         DTR(I)=TRI-TRM(IIO,2,I)
00         DPR(I)=PRI-PRE
00         DXR(I)=XRI-XRE
00         IF(XRE.EQ.0.)THEN
00            VLM(IIO,2,I)=16.01846*VL/WM
00         ELSE
00            IF(XRE.LT.1.)THEN
00               WMV=W1*(1.-XV)+W2*XV
00               VGM(IIO,2,I)=16.01846*VV/WMV
00               WML=W1*(1.-XL)+W2*XL
00               VLM(IIO,2,I)=16.01846*VL/WML
00               XLS(2,I)=XL
00               XVS(2,I)=XV
00               VLS(2,I)=VL
00               VVS(2,I)=VV
00            ELSE
00               VGM(IIO,2,I)=16.01846*VV/WM
00            END IF
00         END IF
00         JJ=I
00         TAIR(2,ICT+1)=(TAE+AIRN(ICT)*TAIR(2,ICT+1))/
00        &(AIRN(ICT)+1.)
00         AIRN(ICT)=AIRN(ICT)+1.
00         GOTO 18
00      85 IEN=IEN+1
00         IEND(IEN)=JJ
00      86 CONTINUE
00   C**** ALL TUBES OF COIL COMPUTED. CHECK IF CONVERGENCE OBTAINED
00         H2=0.
00         DO 90 I=1,IEN
00         IE=IEND(I)
00         H2=H2+HR(2,IE)*FLOW(IIO,IE)
00      90 CONTINUE
00         H2=H2*NSECT(IIO)
00         IF(IAIR.EQ.1)GOTO 92
00         H2PH2=H2P-H2
00         PRINT 850,H2,H2PH2
00     850 FORMAT(' H2,H2PH2=',2F8.2)
00         IF(IAIR.LT.3)GOTO 91
00         IF(ABS(H2PH2).LT.0.02.AND.ABS(H2PH2P).LT..1)GOTO 202
00      91 H2PH2P=H2PH2
00      92 H2P=H2
00   C
```

```
C**** CONVERGENCE NOT OBTAINED
C**** PREPARE AIR SIDE DATA FOR NEW LOOP
      DO 94 I=1,NNDEP
      J=I+1
      TAIR(1,J)=TAIR(2,J)
   94 TAIR(2,J)=0.
      NTOT=0
      NDEEP=NDEP(IIO)-1
      DO 149 ICT=1,NDEEP
      NTOT=NTOT+NTUB(IIO,ICT)
      NDIF=NTUB(IIO,ICT)-NTUB(IIO,ICT+1)
C
      IF(NDIF.EQ.0)THEN
         IA=NTOT+1
         IB=NTOT+NTUB(IIO,ICT+1)
         DO 142 I=IA,IB
         J=JFROM(IIO,I)
  142    TAIRI(1,I)=TAIRI(2,J)
      END IF
C
      IF(NDIF.LT.0)THEN
      IA=NTOT+1
      IB=NTOT+NTUB(IIO,ICT)-1
      DO 143 I=IA,IB
      J=JFROM(IIO,I)
  143 TAIRI(1,I)=0.5*(TAIRI(1,I)+TAIRI(2,J))
      IA=NTOT-NTUB(IIO,ICT)+1
      IB=NTOT-1
      T=0.
      DO 144 I=IA,IB
  144 T=T+TAIRI(2,I)
      T=T*(AMSI(ICT)-AMSI(ICT+1))+TAIRI(2,NTOT)*AMSI(ICT)
      SEG=(NTUB(IIO,ICT+1)-NTUB(IIO,ICT)+1)*AMSI(ICT+1)
      T=T/SEG
      IA=NTOT+NTUB(IIO,ICT)
      IB=NTOT+NTUB(IIO,ICT+1)
      DO 145 I=IA,IB
  145 TAIRI(1,I)=0.5*(TAIRI(1,I)+T)
      END IF
C
      IF(NDIF.GT.0)THEN
      IA=NTOT-NDIF+1
      TCOR=0.
      DO 146 I=IA,NTOT
  146 TCOR=TCOR+TAIRI(2,I)
      TCOR=TCOR/NTUB(IIO,ICT+1)
      IA=NTOT+1
      IB=NTOT+NTUB(IIO,ICT+1)
      DO 147 I=IA,IB
      J=JFROM(IIO,I)
  147 TAIRI(1,I)=.5*(TAIRI(1,I)+(TAIRI(2,J)+TCOR)*AMSI(ICT)/AMSI(ICT+1))
      END IF
  149 CONTINUE
  100 CONTINUE
C***************************************************************************
C**** END OF MAIN LOOP
C***************************************************************************
      WRITE(6,505)H2PH2
```

```
00        202 CONTINUE
00            P2=0.
00            DO 206 I=1,IEN
00            IE=IEND(I)
00            P2=P2+PRM(IIO,2,IE)*FLOW(IIO,IE)
00        206 CONTINUE
00            P2=P2*NSECT(IIO)
00            PA2=P2/14.6959
00            CALL HPIN(NO,H2,PA2,XH,ACC,TK2,X2,XL,XV,VL,VV)
00            T2=TK2*1.8-459.67
00        500 FORMAT(/2X,'INPUT DATA TO CONDHX:'//2X,
00           &'T',10X,'P',10X,'TAIR',7X,'RH',9X,'RMASS',/5(1PE11.3))
00            WRITE(6,501)T1,P1,H1,X1,T2,P2,H2,X2
00        501 FORMAT(/2X,'CONDENSER ITERATION:',//
00           &2X,'T',10X,'P',10X,'H',10X,'X'/4(1PE11.3)/4(1PE11.3))
00        505 FORMAT(' CONDHX DOES NOT CONVERGE, MAX. ERROR=',1PE11.3,
00           1'  (BTU/LB)')
00            RETURN
00            END

END ELT.  ERRORS: NONE. TIME:  0.835 SEC. IMAGE COUNT: 713

@HDG,P  ******  DBUBTE  ****** .L,0
```

```
@ELT,L DD.DBUBTE
ELT 8R1 S74Q1C 07/21/84 15:55:00 (0)
      SUBROUTINE DBUBTE(IG,P,X,T,XV)
C
      REAL*8 P,T,XV
C
C**** PURPOSE:
C       TO CALCULATE IN DOUBLE PRECISION A BUBBLE POINT
C       TEMPERATURE OF A NON-AZEOTROPIC BINARY MIXTURE FROM GIVEN
C       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
C**** OUTPUT:
C       T  - BINARY MIXTURE TEMPERATURE AT BUBBLE POINT   (K)
C       XV - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
C             IN SAT. VAPOR IN EQUILIBRIUM WITH LIQUID   (-)
C
C**** SUBPROGRAMS CALLED BY DBUBTE:
C       EBUBTE,DQLITY
C
      REAL*8 SLOPE,TLAST,PLAST,XVLAST,XL,T1,T2,
     *       XDIF1,XDIF2,DT,XQ
      DATA SLOPE/0.D0/,PLAST/0.D0/
C
      IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
      IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
      T=TLAST
      XV=XVLAST
      RETURN
C
   10 PS=P
      IF(IG.NE.1)T=EBUBTE(PS,X)
      DO 50 I=1,20
      CALL DQLITY(T,P,X,XQ,XV,XL)
      T2=T
      XDIF2=X-XL
      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.GT.0.)T=T2-5.
         GOTO 50
C
   20 IF(XDIF1.EQ.XDIF2)GOTO 15
      SLOPE=(T2-T1)/(XDIF2-XDIF1)
      IF(DABS(XDIF1).LT.DABS(XDIF2))GOTO 30
```

```
00              T1=T2
00              XDIF1=XDIF2
00          30 DT=XDIF1*SLOPE
00             IF(DABS(DT).LT.0.000001)GOTO 100
00             IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
00             T=T1-DT
00          50 CONTINUE
00             WRITE(6,600)XD'F2
00         600 FORMAT(' ERROR 600 IN DBUBTE, XDIF2=',1PE12.4)
00         100 PLAST=P
00             XLAST=X
00             TLAST=T
00             XVLAST=XV
00             RETURN
00             END

END ELT.  ERRORS: NONE. TIME:  0.131 SEC. IMAGE COUNT: 71

@HDG,P  ******  DDENFA  ****** .L,0
```

```
@ELT,L DD.DDENFA
ELT 8R1 S74Q1C 07/21/84 15:55:00 (0)
00              DOUBLE PRECISION FUNCTION DDENFA(XM,P,HO,GG)
00      C
00      C**** PURPOSE:
00      C          TO CALCULATE IN DOUBLE PRECISION
00      C          DENSITY OF NON-AZEOTROPIC TWO-PHASE MIXTURE
00      C          IN THE FANNO FLOW FOR A GIVEN PRESSURE
00      C
00      C**** INPUT DATA:
00      C            HO         - REFRIG. TOTAL ENTHALPY   (BTU/LM)
00      C            GG         = G*G/(64.4*778.104)    (BTU*LM/FT**6)
00      C                         WHERE G - REFRIG. MASS FLUX    (LM/(SEC*FT**2))
00      C            P          - REFRIG. PRESSURE AT WHICH DENSITY IS DESIRED    (PSIA)
00      C            XM         - MOLAR COMPOSITION    (FRACTION OF LESS VOLATILE COMPONENT)
00      C**** OUTPUT DATA:
00      C            DDENFA     - DENSITY   (BTU/LM R)
00      C
00      C**** SUBPROGRAMS CALLED BY DDENFA:
00      C          DBUBTE,DH,DQLITY,DVOL1,FBUBTE,VISCON
00      C
00              REAL*8 DH,DVOL1
00              REAL*8 SLOPE,TKB,XVB,PA,TK2,XQ,XV,XL,VMV,HV,VML,HL,HFG,
00             *VMV,WML,VV,VL,VFG,R,S,C,XQO,DIFXQ2,DIFXQ1,TK1
00              COMMON/RDATA2/W1,W2,TC1,TC2
00              DATA SLOPE/0.D0/NO,N1/0,1/
00      C
00              IF(P.GT.0.)GOTO 10
00              WRITE(6,600)P
00          600 FORMAT(' ERROR IN CALLING DDENFA, P=',1PE15.5,'  PSIA')
00              RETURN
00      C
00           10 PA=P/14.6959
00              CALL DBUBTE(NO,PA,XM,TKB,XVB)
00              TKD=TKB+9.5-20.*(.55-XM)
00              TK2=0.9*TKB+0.1*TKD
00              DO 100 I=1,20
00              IF(TK2.LT.TKB)THEN
00                 TK2=TKB
00                 XL=XM
00                 XV=XVB
00                 XQ=0.D0
00              ELSE
00                 CALL DQLITY(TK2,PA,XM,XQ,XV,XL)
00              END IF
00              VMV=DVOL1(N1,TK2,PA,XV)
00              HV=DH(TK2,VMV,XV)
00              VML=DVOL1(NO,TK2,PA,XL)
00              HL=DH(TK2,VML,XL)
00              HFG=HV-HL
00              WMV=W1*(1.-XV)+W2*XV
00              WML=W1*(1.-XL)+W2*XL
00              VV=VMV*16.01846/WMV
00              VL=VML*16.01846/WML
00              VFG=VV-VL
00              R=GG*VFG*VFG
00              S=2.*GG*VL*VFG+HFG
00              C=GG*VL*VL+HL-HO
```

```
00            XQQ=(-S+DSQRT(S*S-4.*R*C))/(2.*R)
00            DIFXQ2=XQQ-XQ
00            IF(ABS(XQ).LT.1.E-5.AND.ABS(XQQ).LT.1.E-5)GOTO 105
00            IF(XQ.EQ.0.D0.AND.XQQ.LT.0.)GOTO 110
00            IF(DABS(DIFXQ2).LT.5.E-8)GOTO 105
00      C
00            IF(I.GT.1)GOTO 70
00            TK1=TK2
00            DIFXQ1=DIFXQ2
00            IF(SLOPE.NE.0.D0)THEN
00               TDEL=DIFXQ2*SLOPE
00               TD=ABS(TDEL)
00               TD=AMIN1(2.,TD)
00               TK2=TK1-SIGN(TD,TDEL)
00            ELSE
00               TK2=TK1+SIGN(1.,DIFXQ2)
00            END IF
00            GOTO 100
00      C
00         70 SLOPE=(TK2-TK1)/(DIFXQ2-DIFXQ1)
00            IF(ABS(XQ).LT.1.E-3)GOTO 75
00            IF(DABS(DIFXQ1).LT.DABS(DIFXQ2))GOTO 80
00        75     TK1=TK2
00               DIFXQ1=DIFXQ2
00         80 TK2=TK1-DIFXQ1*SLOPE
00        100 CONTINUE
00            PRINT 602,DIFXQ2,XQ
00        602 FORMAT(' DDENFA DOES NOT CONVERGE, DIFXQ2=',1PE13.4,
00           1'  XQ=',1PE13.4)
00        105 XQ=0.5*(XQ+XQQ)
00        110 CONTINUE
00            DDENFA=1./(VL+XQQ*VFG)
00            RETURN
00            END

END ELT.  ERRORS: NONE. TIME:  0.155 SEC. IMAGE COUNT: 90

@HDG,P  ******  DDEWTE  ****** .L,0
```

```
@ELT,L DD.DDEWTE
ELT 8R1 S74Q1C 07/21/84 15:55:00 (0)
   00          SUBROUTINE DDEWTE(IG,P,X,T,XL)
   00    C
   00             REAL*8 P,T,XL
   00    C
   00    C**** PURPOSE:
   00    C        TO CALC. IN DOUBLE PRECISION A DEW POINT TEMPERATURE
   00    C        OF A NON-AZEOTROPIC MIXTURE FROM GIVEN PRESSURE
   00    C        AND COMPOSITION
   00    C
   00    C**** INPUT:
   00    C        IG = 0,   IF GUESS OF TEMPERATURE IS NOT GIVEN
   00    C           = 1,   IF GUESS OF TEMPERATURE IS GIVEN
   00    C        P  - PRESSURE    (STD ATM)
   00    C        T  - GUESS OF TEMPERATURE, OPTIONAL   (K)
   00    C        X  - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
   00    C
   00    C**** OUTPUT:
   00    C        T  - BINARY MIXTURE TEMPERATURE AT DEW POINT    (K)
   00    C        XL - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
   00    C             IN SAT. LIQUID IN EQUILIBRIUM WITH VAPOR    (-)
   00    C
   00    C**** SUBPROGRAMS CALLED BY DDEWTE:
   00    C        EBUBTE,DQLITY
   00    C
   00          REAL*8 SLOPE,TLAST,PLAST,XLLAST,XV,T1,T2,
   00         *       XDIF1,XDIF2,DT,XQ
   00    C
   00          DATA SLOPE/0.D0/,PLAST/0.D0/
   00    C
   00          IF(DABS(P-PLAST).GT.1.E-4)GOTO 10
   00          IF(DABS(X-XLAST).GT.1.E-3)GOTO 10
   00          T=TLAST
   00          XL=XLLAST
   00          RETURN
   00    C
   00       10 IF(IG.NE.1)THEN
   00             PS=P
   00             TS=EBUBTE(PS,X)+9.5-20.*(.55-X)
   00             T=TS
   00          END IF
   00          DO 50 I=1,20
   00          CALL DQLITY(T,P,X,XQ,XV,XL)
   00          T2=T
   00          XDIF2=X-XV
   00          IF(I.NE.1)GOTO 20
   00       15    T1=T2
   00             XDIF1=XDIF2
   00             IF(SLOPE.NE.0.)THEN
   00                DT=XDIF2*SLOPE
   00                IF(DABS(DT).GT.10.)DT=SIGN(10.,DT)
   00                T=T2-DT
   00                GOTO 50
   00             END IF
   00             T=T2+5.
   00             IF(XDIF2.LT.0.)T=T2-5.
   00             GOTO 50
```

```
00     C
00        20 IF(XDIF1.EQ.XDIF2)GOTO 15
00           SLOPE=(T2-T1)/(XDIF2-XDIF1)
00           IF(DABS(XDIF1).LT.DABS(XDIF2))GOTO 30
00              T1=T2
00              XDIF1=XDIF2
00        30 DT=XDIF1*SLOPE
00           IF(DABS(DT).LT.0.000001)GOTO 100
00           IF(DABS(DT).GT.10.)DT=SIGN(10.,DT)
00           T=T1-DT
00        50 CONTINUE
00           WRITE(6,600)IG,P,X,XDIF2
00       600 FORMAT(' DDEWTE DID NOT CONVERGE',/' IG,P,X,XDIF2=',I4,4F8.3)
00       100 PLAST=P
00           XLAST=X
00           TLAST=T
00           XLLAST=XL
00           RETURN
00           END

END ELT.  ERRORS: NONE. TIME:  0.141 SEC. IMAGE COUNT: 75

@HDG,P  ******  DENTRO  ****** .L,0
```

```
@ELT,L DD.DENTRO
ELT 8R1 S74Q1C 07/21/84 15:55:01 (0)
        00              DOUBLE PRECISION FUNCTION DENTRO(T,V,X)
        00      C
        00      C
        00              REAL*8 T,V,X
        00      C
        00      C****   PURPOSE:
        00      C         TO CALCULATE IN DOUBLE PRECISION REFRIGERANT ENTROPY
        00      C
        00      C****   INPUT:
        00      C         T  - REFRIG. TEMPERATURE    (K)
        00      C         V  - REFRIG. SPEC VOLUME    (L/MOL)
        00      C         W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT    (G)
        00      C         W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT    (G)
        00      C         X  - MOLAR CONCENTRATION OF A LESS VOLATILE REFRIG.    (-)
        00      C         *  - CONSTANTS A,B,C1,D1, AS PER COMMON STATEMENT /PARAM/
        00      C
        00      C****   OUTPUT:
        00      C         DENTRO - ENTROPY    (BTU/(LB*F))
        00      C
        00      C****   SUBPROGRAMS CALLED BY DENTRO:
        00      C         HPAR
        00      C
        00              REAL*8 WM,CONV,S
        00              COMMON/PARAM/A,B,C1,C2,D1,D2
        00              COMMON/RDATA2/W1,W2
        00              DATA R/0.08206/
        00      C
        00              WM=(1.-X)*W1+X*W2
        00              CONV=453.5924/(1.055056*WM)
        00              IQ=1
        00              TK=T
        00              XM=X
        00              CALL HPAR(IQ,TK,XM)
        00              S=(C1*B-A*D1)/B**2*DLOG((V+B)/V)+A*D1/B/(V+B)
        00              S=S-R*B/4./(V-B/4.)**2*(4.*V-3*B/4.)
        00              S=S-R*T*D1*V/2./(V-B/4.)**3*(2.*V-B/4.)
        00              S=S+(1.-X)*0.3209879329924+X*0.401655769501
        00              S=S+R*(X*DLOG(V/0.0632978)+(1.-X)*DLOG(V/0.0776799))
        00              S=0.101325*S
        00              S=S+(0.0116393*(1.-X)+0.013966*X)*DLOG(T/233.15)
        00              S=S+(2.163944E-4*(1.-X)+1.540093E-4*X)*(T-233.15)
        00              S=S-(3.512035E-8*(1.-X)+1.533352E-9*X)*(T**2-233.15**2)
        00              IF(X.EQ.1.D0.OR.X.EQ.0.D0)GOTO 1000
        00              S=S-0.101325*R*(X*DLOG(X)+(1.-X)*DLOG(1.-X))
        00        1000  DENTRO=S*CONV/1.8
        00              RETURN
        00              END

END ELT.  ERRORS: NONE. TIME:  0.098 SEC.  IMAGE COUNT: 47

@HDG,P  ******  DEWPRE  ****** .L,0
```

```
@ELT,L DD.DEWPRE
ELT 8R1 S74Q1C 07/21/84 15:55:01 (0)
      SUBROUTINE DEWPRE(IG,T,X,P,XL)
C
C
C**** PURPOSE:
C       TO CALC. DEW POINT PRESSURE OF BINARY MIXTURE
C       FROM GIVEN TEMPERATURE AND COMPOSITION
C
C**** INPUT:
C       IG = 0,  IF GUESS OF PRESSURE IS NOT GIVEN
C          = 1,  IF GUESS OF PRESSURE IS GIVEN
C       P  - GUESS OF PRESSURE, OPTIONAL   (STD ATM)
C       T  - TEMPERATURE   (K)
C       X  - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
C
C**** OUTPUT:
C       P  - BINARY MIXTURE PRESSURE AT BUBBLE POINT   (STD ATM)
C       XL - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
C            IN SAT. LIQUID IN EQUILIBRIUM WITH VAPOR   (-)
C
C**** SUBPROGRAMS CALLED BY DEWPRE:
C       EBUBPR,QLITY
C
      DATA SLOPE/0./,TLAST/0./
C
      IF(ABS(T-TLAST).GT.1.E-3)GOTO 10
      IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
      P=PLAST
      XL=XLLAST
      RETURN
C
   10 IF(IG.NE.1)THEN
         P=EBUBPR(T,X)
         P=P-(T-255.)*0.16*X*(1.-X)
      END IF
      DO 50 I=1,20
      CALL QLITY(T,P,X,XQ,XV,XL)
      P2=P
      XDIF2=X-XV
      IF(ABS(XDIF2).LT.0.00001)GOTO 100
      IF(I.NE.1)GOTO 20
   15    P1=P2
         XDIF1=XDIF2
         IF(SLOPE.NE.0.)THEN
            DP=XDIF2*SLOPE
            IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)
            P=P2-DP
            GOTO 50
         END IF
         P=P2+0.5
         IF(XDIF2.GT.0.)P=P2-0.5
         GOTO 50
C
   20 IF(XDIF1.EQ.XDIF2)GOTO 15
      SLOPE=(P2-P1)/(XDIF2-XDIF1)
      IF(ABS(XDIF1).LT.ABS(XDIF2))GOTO 30
         P1=P2
```

```
          00            XDIF1=XDIF2
          00         30 DP=XDIF1*SLOPE
          00            IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)
          00            P=P1-DP
          00         50 CONTINUE
          00            WRITE(6,600)XDIF2
          00        600 FORMAT(' ERROR 600 IN DEWPRE, XDIF2=',1PE12.4)
          00        100 TLAST=T
          00            XLAST=X
          00            PLAST=P
          00            XLLAST=XL
          00            RETURN
          00            END

END ELT.  ERRORS: NONE. TIME:  0.130 SEC. IMAGE COUNT: 69

@HDG,P  ******  DEWTEM  ****** .L,0
```

```
@ELT,L DD.DEWTEM
ELT 8R1 S74Q1C 07/21/84 15:55:01 (0)
    00              SUBROUTINE DEWTEM(IG,P,X,T,XL)
    00        C
    00        C
    00        C**** PURPOSE:
    00        C        TO CALC. DEW POINT TEMPERATURE OF BINARY MIXTURE
    00        C        FROM GIVEN PRESSURE AND COMPOSITION
    00        C
    00        C**** INPUT:
    00        C        IG = 0,  IF GUESS OF TEMPERATURE IS NOT GIVEN
    00        C           = 1,  IF GUESS OF TEMPERATURE IS GIVEN
    00        C        P  - PRESSURE    (STD ATM)
    00        C        T  - GUESS OF TEMPERATURE, OPTIONAL   (K)
    00        C        X  - MOLAR CONCENTRATION (FRACTION OF LESS VOLATILE COMPONENT)
    00        C
    00        C**** OUTPUT:
    00        C        T  - BINARY MIXTURE TEMPERATURE AT DEW POINT    (K)
    00        C        XL - MOLAR CONCENTRATION OF LESS VOLATILE COMPONENT
    00        C             IN SAT. LIQUID IN EQUILIBRIUM WITH VAPOR    (-)
    00        C
    00        C**** SUBPROGRAMS CALLED BY DEWTEM:
    00        C        EBUBTE,QLITY
    00        C
    00              DATA SLOPE/0./,PLAST/0./
    00        C
    00              IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
    00              IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
    00              T=TLAST
    00              XL=XLLAST
    00              RETURN
    00        C
    00           10 IF(IG.NE.1)T=EBUBTE(P,X)+9.5-20.*(.55-X)
    00              DO 50 I=1,20
    00              CALL QLITY(T,P,X,XQ,XV,XL)
    00              T2=T
    00              XDIF2=X-XV
    00              IF(I.NE.1)GOTO 20
    00           15    T1=T2
    00                 XDIF1=XDIF2
    00                 IF(SLOPE.NE.0.)THEN
    00                    DT=XDIF2*SLOPE
    00                    IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
    00                    T=T2-DT
    00                    GOTO 50
    00                 END IF
    00                 T=T2+5.
    00                 IF(XDIF2.LT.0.)T=T2-5.
    00                 GOTO 50
    00        C
    00           20 IF(XDIF1.EQ.XDIF2)GOTO 15
    00              SLOPE=(T2-T1)/(XDIF2-XDIF1)
    00              IF(ABS(XDIF1).LT.ABS(XDIF2))GOTO 30
    00                 T1=T2
    00                 XDIF1=XDIF2
    00           30 DT=XDIF1*SLOPE
    00              IF(ABS(DT).LT.0.003)GOTO 100
    00              IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
```

```
          00             T=T1-DT
          00          50 CONTINUE
          00             WRITE(6,600)IG,P,X,XDIF2
          00         600 FORMAT(' DEWTEM DID NOT CONVERGE',/' IG,P,X,XDIF2=',I4,4F8.3)
          00         100 PLAST=P
          00             XLAST=X
          00             TLAST=T
          00             XLLAST=XL
          00             RETURN
          00             END

END ELT.  ERRORS: NONE. TIME:  0.127 SEC. IMAGE COUNT: 66

@HDG,P  ******  DFANNO  ****** .L,0
```

```
@ELT,L DD.DFANNO
ELT 8RI S74Q1C 07/21/84 15:55:02 (0)
 00        DOUBLE PRECISION FUNCTION DFANNO(XM,P,HO,GG)
 00  C
 00  C**** PURPOSE:
 00  C       TO CALCULATE IN DOUBLE PRECISION
 00  C       ENTROPY OF NON-AZEOTROPIC TWO-PHASE MIXTURE
 00  C       IN THE FANNO FLOW FOR A GIVEN PRESSURE
 00  C
 00  C**** INPUT DATA:
 00  C         HO        - REFRIG. TOTAL ENTHALPY  (BTU/LM)
 00  C         GG        = G*G/(64.4*778.104)   (BTU*LM/FT**6)
 00  C                     WHERE G - REFRIG. MASS FLUX   (LM/(SEC*FT**2))
 00  C         P         - REFRIG. PRESSURE AT WHICH ENTROPY IS DESIRED   (PSIA)
 00  C         XM        - MOLAR COMPOSITION   (FRACTION OF LESS VOLATILE COMPONENT)
 00  C**** OUTPUT DATA:
 00  C         DFANNO    - ENTROPY  (BTU/LM R)
 00  C
 00  C**** SUBPROGRAMS CALLED BY DFANNO:
 00  C       DBUBTE,DENTRO,DH,DQLITY,DVOL1,EBUBTE
 00  C
 00        REAL*8 DENTRO,DH,DVOL1
 00        REAL*8 SLOPE,TKB,XVB,PA,TK2,XQ,XV,XL,VMV,HV,VML,HL,HFG,
 00       *WMV,WML,VV,VL,VFG,R,S,C,XQQ,DIFXQ2,DIFXQ1,TK1,SL,SV
 00        COMMON/RDATA2/W1,W2,TC1,TC2
 00        DATA SLOPE/0.D0/NO,N1/0,1/
 00  C
 00        IF(P.GT.0.)GOTO 10
 00        WRITE(6,600)P
 00    600 FORMAT(' ERROR IN CALLING DFANNO, P=',1PE15.5,'  PSIA')
 00        RETURN
 00  C
 00     10 PA=P/14.6959
 00        CALL DBUBTE(NO,PA,XM,TKB,XVB)
 00        TKD=TKB+9.5-20.*(.55-XM)
 00        TK2=0.9*TKB+0.1*TKD
 00        DO 100 I=1,20
 00        IF(TK2.LT.TKB)THEN
 00           TK2=TKB
 00           XL=XM
 00           XV=XVB
 00           XQ=0.D0
 00        ELSE
 00           CALL DQLITY(TK2,PA,XM,XQ,XV,XL)
 00        END IF
 00        VMV=DVOL1(N1,TK2,PA,XV)
 00        HV=DH(TK2,VMV,XV)
 00        VML=DVOL1(NO,TK2,PA,XL)
 00        HL=DH(TK2,VML,XL)
 00        HFG=HV-HL
 00        WMV=W1*(1.-XV)+W2*XV
 00        WML=W1*(1.-XL)+W2*XL
 00        VV=VMV*16.01846/WMV
 00        VL=VML*16.01846/WML
 00        VFG=VV-VL
 00        R=GG*VFG*VFG
 00        S=2.*GG*VL*VFG+HFG
 00        C=GG*VL*VL+HL-HO
```

```
00              XQQ=(-S+DSQRT(S*S-4.*R*C))/(2.*R)
00              DIFXQ2=XQQ-XQ
00              IF(ABS(XQ).LT.1.E-5.AND.ABS(XQQ).LT.1.E-5)GOTO 105
00              IF(XQ.EQ.0.D0.AND.XQQ.LT.0.)GOTO 110
00              IF(DABS(DIFXQ2).LT.5.E-8)GOTO 105
00      C
00              IF(I.GT.1)GOTO 70
00              TK1=TK2
00              DIFXQ1=DIFXQ2
00              IF(SLOPE.NE.0.D0)THEN
00                 TDEL=DIFXQ2*SLOPE
00                 TD=ABS(TDEL)
00                 TD=AMIN1(2.,TD)
00                 TK2=TK1-SIGN(TD,TDEL)
00              ELSE
00                 TK2=TK1+SIGN(1 ,DIFXQ2)
00              END IF
00              GOTO 100
00      C
00           70 SLOPE=(TK2-TK1)/(DIFXQ2-DIFXQ1)
00              IF(ABS(XQ).LT.1.E-3)GOTO 75
00              IF(DABS(DIFXQ1).LT.DABS(DIFXQ2))GOTO 80
00         75      TK1=TK2
00                 DIFXQ1=DIFXQ2
00           80 TK2=TK1-DIFXQ1*SLOPE
00          100 CONTINUE
00              PRINT 602,DIFXQ2
00          602 FORMAT(' DFANNO DOES NOT CONVERGE,  DIFXQ2=',1PE15.5)
00          105 XQ=0.5*(XQ+XQQ)
00          110 CONTINUE
00              SL=DENTRO(TK2,VML,XL)
00              SV=DENTRO(TK2,VMV,XV)
00              DFANNO=(1.-XQ)*SL+XQ*SV
00              RETURN
00              END

END ELT.  ERRORS: NONE. TIME:  0.140 SEC. IMAGE COUNT: 91

@HDG,P  ******  DH  ****** .L,0
```

```
******  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)
          00      C
          00            REAL*8 T,V,X
          00      C
          00      C**** PURPOSE:
          00      C       TO CALCULATE REFRIGERANT ENTHALPY
          00      C       IN DOUBLE PRECISION
          00      C
          00      C**** INPUT:
          00      C       T  - REFRIG. TEMPERATURE    (K)
          00      C       V  - REFRIG. SPEC VOLUME    (L/MOL)
          00      C       X  - MOLAR CONCENTRATION    (FRACTION OF LESS VOLATILE REFRIG.)
          00      C       W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT    (G/MOL)
          00      C       W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT    (G/MOL)
          00      C       *  - CONSTANTS AS PER COMMON STATEMENT /PARAM/
          00      C            A,B,C1,D1     FOR CALC. OF ENTHALPY
          00      C
          00      C**** OUTPUT:
          00      C       DH - ENTHALPY    (BTU/LB)
          00      C
          00      C
          00            COMMON/PARAM/A,B,C1,C2,D1,D2
          00            COMMON/RDATA2/W1,W2
          00            REAL*8 WMOL,CONV,T2,T3
          00            DATA R/0.08206/
          00      C
          00      C**** SUBPROGRAMS CALLED BY HCVCP:
          00      C       HPAR
          00      C
          00            TS=T
          00            XS=X
          00            CALL HPAR(1,TS,XS)
          00            WMOL=(1.-X)*W1+X*W2
          00            CONV=453.5924/(1.055056*WMOL)
          00            T2=T*T
          00            T3=T2*T
          00            DH=(C1*B*T-A*D1*T-A*B)/B**2*DLOG((V+B)/V)
          00            DH=DH+(A*D1*T-A*B)/(B*(V+B))
          00            DH=DH+2.*R*T*V*(2.*V-B/4.)/(V-B/4.)**3*(B/4.-D1*T/4.)
          00            DH=0.101325*DH
          00            DH=DH+(1.-X)*(0.0199537*(T-233.15)+1.081972E-04*(T2-233.15**2))
          00            DH=DH-(1.-X)*(5.67469E-08*(T3-233.15**3))
          00            DH=DH+(1.-X)*16.8976630893
          00            DH=DH+X*(0.0222804*(T-233.15)+7.700465E-05*(T2-233.15**2))
          00            DH=DH+X*(1.0222346E-09*(233.15**3-T3)+21.9460206504)
          00            DH=DH*CONV
          00            RETURN
          00            END

END ELT.  ERRORS: NONE. TIME:  0.098 SEC. IMAGE COUNT: 48

@HDG,P  ******  DPDYN1  ****** .L,0
```

```
@ELT,L DD.DPDYN1
ELT 8R1 S74Q1C 07/21/84 15:55:02 (0)
      00                FUNCTION DPDYN1(P1,H1,P2,H2,RMS,D)
      00          C
      00          C**** PURPOSE:
      00          C       TO CALCULATE DYNAMIC PRESSURE DROP IN A TUBE
      00          C       FOR A NON-AZEOTROPIC MIXTURE SINGLE-PHASE FLOW
      00          C
      00          C**** INPUT DATA:
      00          C       D      - TUBE DIAMETER    (FT)
      00          C       H1     - REFRIG. ENTHALPY AT TUBE INLET    (BTU/LBM)
      00          C       H2     - REFRIG. ENTHALPY AT TUBE OUTLET    (BTU/LBM)
      00          C       P1     - REFRIG. PRESSURE AT TUBE INLET    (PSIA)
      00          C       P2     - REFRIG. PRESSURE AT TUBE OUTLET    (PSIA)
      00          C       RMS    - REFRIG. MASS FLOW RATE    (LBM/H)
      00          C       WM     - MOLECULAR WEIGHT     (G/MOL)
      00          C       XM     - MOLAR COMPOSITION    (FRACTION  OF LESS VOLATILE COMPONENT)
      00          C
      00          C**** OUTPUT DATA:
      00          C       DPDYN1 - DYNAMIC SINGLE-PHASE PRESSURE DROP    (PSI)
      00          C
      00          C**** SUBPROGRAMS CALLED BY DPDYN1:
      00          C       HPIN
      00          C
      00                COMMON/RDATA3/XW,XM,WM
      00                DIMENSION VL(2),VV(2)
      00          C
      00                PA=P1/14.6959
      00                H=H1
      00                IG=0
      00                DO 10 I=1,2
      00                IF(I.EQ.2)THEN
      00                   IG=1
      00                   PA=P2/14.6959
      00                   H=H2
      00                END IF
      00             10 CALL HPIN(IG,H,PA,XM,0.005,T,XQ,XL,XV,VL(I),VV(I))
      00          C
      00                IF(XQ.GT.0.)THEN
      00                   DV=(VV(2)-VV(1))*16.01846/WM
      00                ELSE
      00                   DV=(VL(2)-VL(1))*16.01846/WM
      00                END IF
      00                G=RMS/(0.7853982*D*D)
      00                G=G*G/(32.2*144.*3600.*3600.)
      00                DPDYN1=G*DV
      00                RETURN
      00                END

END ELT.  ERRORS: NONE. TIME:  0.097 SEC. IMAGE COUNT: 46

@HDG,P  ******  DPDYN2  ****** .L,0
```

```
@ELT,L DD.DPDYN2
ELT 8R1 S74Q1C 07/21/84 15:55:03 (0)
     00             FUNCTION DPDYN2(P1,T1,P2,T2,RMS,DI)
     00       C
     00       C**** PURPOSE:
     00       C        TO CALCULATE DYNAMIC PRESSURE DROP IN A TUBE
     00       C        FOR A TWO-PHASE FLOW OF NON-AZEOTROPIC MIXTURE
     00       C
     00       C**** INPUT DATA:
     00       C        DI      - TUBE INNER DIAMETER    (FT)
     00       C        P1      - REFRIG. PRESSURE AT TUBE INLET    (PSIA)
     00       C        P2      - REFRIG. PRESSURE AT TUBE OUTLET    (PSIA)
     00       C        T1      - REFRIG. TEMPERATURE AT TUBE INLET    (F)
     00       C        T2      - REFRIG. TEMPERATURE AT TUBE OUTLET    (F)
     00       C        RMS     - REFRIG. MASS FLOW RATE    (LBM/H)
     00       C
     00       C**** OUTPUT DATA:
     00       C        DPDYN2 - DYNAMIC TWO-PHASE PRESSURE DROP    (PSIA)
     00       C
     00       C**** SUBPROGRAMS CALLED BY DPDYN2:
     00       C        QLITY,VISCON,VOLIT1
     00       C
     00             COMMON/RDATA2/W1,W2,TC1,TC2
     00             COMMON/RDATA3/XW,XM,WM
     00             DIMENSION END(2)
     00       C
     00             AREA=3.145927*DI*DI/4.
     00             G=RMS/AREA/3600.
     00             PA=P1/14.6959
     00             TK=(T1+459.67)/1.8
     00             T=T1
     00             DO 100 I=1,2
     00             IF(I.EQ.2)THEN
     00                PA=P2/14.6959
     00                TK=(T2+459.67)/1.8
     00                T=T2
     00             END IF
     00             CALL QLITY(TK,PA,XM,XQ,XV,XL)
     00             CALL VOLIT1(0,TK,PA,XL,VM)                  @LIQUID
     00             WMOL=W1*(1.-XL)+W2*XL
     00             VL=16.01846*VM/WMOL
     00             XWL=XL/(W1/W2*(1.-XL)+XL)
     00             VISL=VISCON(1,T,XWL)
     00             CALL VOLIT1(1,TK,PA,XV,VM)                  @VAPOR
     00             WMOL=W1*(1.-XV)+W2*XV
     00             VV=16.01846*VM/WMOL
     00             XWV=XV/(W1/W2*(1.-XV)+XV)
     00             VISV=VISCON(3,T,XWV)
     00             XTT=((1.-XQ)/XQ)**0.9*(VISL/VISV)**0.1
     00             XTT=XTT*(VL/VV)**0.5
     00             VOID=(1.+XTT**0.8)**(-.378)
     00             IF(XTT.GT.10.)VOID=0.823-0.157*ALOG(XTT)
     00             END(I)=VV*XQ*XQ/VOID+VL*(1.-XQ)**2/(1.-VOID)
     00         100 CONTINUE
     00             DPDYN2=G*G*(END(2)-END(1))/144./32.2
     00             RETURN
     00             END
```

```
@ELT,L DD DQLITY
ELT 8R1 S74Q1C 07/21/84 15:55:03 (0)
      SUBROUTINE DQLITY(T,P,X,XQ,XV,XL)
C
C
      REAL*8 T,P,XQ,XV,XL
C
C**** PURPOSE:
C       TO CALCULATE QUALITY OF A BINARY FLUID
C       IN DOUBLE PRECISION
C**** INPUT:
C       P  - PRESSURE    (STD ATM)
C       T  - TEMPERATURE    (K)
C       X  - MOLAR CONCENTRATION OF A LESS VOLATILE
C              COMPONENT    (-)
C
C**** OUTPUT:
C       XL - MOLAR CONCENTRATION AT BUBBLE POINT    (-)
C       XQ - FLUID QUALITY    (-)
C       XV - MOLAR CONCENTRATION AT DEW POINT    (-)
C
C
      REAL*8 T2,P1,P2,RP,SEG0,SEG8,SEG9,SEG,Z0,Z1,Z2,Z
C
         T2=T*T
         P1=10.0522804-2204.5632/T+9636.5313/T2
         P1=DEXP(P1)
         P2=10.6410518-2642.8994/T+450.87565/T2
         P2=DEXP(P2)
      IF(P.GE.P1)THEN      @FLUID IS LIQUID AT ALL CONCENTRATIONS
         XQ=0.D0
         XL=0.D0
         XV=0.D0
         GOTO 1000
      END IF
      IF(P.LE.P2)THEN      @FLUID IS VAPOR AT ALL CONCENTRATIONS
         XL=1.D0
         XQ=1.D0
         XV=1.D0
         GOTO 1000
      END IF
      RP=(P1-P)/(P1-P2)
      SEG0=12.58741-0.06465226*T+9.53391E-5*T2
      SEG8=-43.9799+0.289414*T-4.504945E-4*T2
      SEG9=47.7509-0.273993*T+4.14487E-4*T2
      SEG=SEG0+SEG8*RP+SEG9*RP**2
      Z0=-0.34065415-3.337532E-3*T+9.66115E-6*T2
      Z1=-10.3139754+0.0653356*T-9.9899162E-5*T2
      Z2=10.035917-0.05527259*T+7.6821554E-5*T2
      Z=1.+Z0*(RP-1.)+Z1*(RP**2-1.)+Z2*(RP**3-1.)
      XL=(1.+SEG)*RP/(1.+SEG*RP)     @SAT. LIQUID COMPOSITION
      XV=XL*Z                        @SAT. VAPOR COMPOSITION
      XQ=(XL-X)/(XL-XV)
      IF(XQ.GE.1.D0)XQ=1.D0
      IF(XQ.LT.0.D0)XQ=0.D0
 1000 RETURN
      END
```

```
****** DVOL1 ******                                                  DATE 072184

@ELT,L DD.DVOL1
ELT 8R1 S74Q1C 07/21/84 15:55:03 (0)
00          DOUBLE PRECISION FUNCTION DVOL1(N,T,P5,X)
00    C
00          REAL*8 T,P5,X
00    C
00    C**** PURPOSE:
00    C       TO ITERATE REFRIG. MIXTURE R-13B1/R-152A SPEC. VOL.
00    C       FROM EQUATION OF STATE IN DOUBLE PRECISION
00    C
00    C**** INPUT:
00    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    C       T  - REFRIG. TEMPERATURE   (K)
00    C       P5 - REFRIG. SAT. PRESSURE   (STD ATM)
00    C       X  - MOLAR COMPOSITION   (FRACTION OF LESS VOLATILE COMPONENT)
00    C       *  - REFRIG. CONSTANTS A & B  (SEE COMMON STATEMENT /PARAM/)
00    C**** OUTPUT:
00    C       DVOL1 - REFRIG. SPEC. VOLUME   (L/MOL)
00    C
00    C**** SUBPROGRAMS CALLED BY DVOL1:
00    C       ESVOL,EQPAR
00    C
00    C
00          REAL*8 Y,Y2,Y3,Y4,P,P0,P6,V6,V7,V
00          COMMON/PARAM/A,B,C1,C2,D1,D2
00          DATA R/0.08206/
00    C
00          IF(P5.GT.0.)GOTO 10
00          PRINT 601,P5
00      601 FORMAT(' DVOL1 CALLED WITH NEG. PRESSURE, P5=',1PD13.3)
00          DVOL1=1.D0
00          GOTO 1000
00    C
00    C  10 IF(T.LT.220.)PRINT 602,T
00    C 602 FORMAT(' WARNING, DVOL1 CALLED WITH TEMP.=',1PD13.3)
00    C
00       10 TS=T
00          P5S=P5
00          XS=X
00          V=ESVOL(N,TS,P5S,XS)
00          CALL EQPAR(TS,XS)
00          DO 100 I=1,15
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          IF(DABS(P6).LT.1.D-7)GOTO 200
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-P5)/P0
00          V7=V-V6
00          IF(V7.GT.(B/4.))GOTO 50
00          V=V-(V-B/4.)/10.
00          GOTO 100
```

```
00          50 V=V7
00         100 CONTINUE
00             WRITE(6,600)P6
00         600 FORMAT(' ERROR 600 IN DVOL1, P6 =',1PD16.8)
00         200 DVOL1=V
00        1000 RETURN
00             END
```

END ELT. ERRORS: NONE. TIME: 0.119 SEC. IMAGE COUNT: 63

@HDG,P ****** EBUBPR ****** .L,0

```
******  EBUBPR  ******                                                                    DATE 072184

@ELT,L DD.EBUBPR
ELT 8R1 S74Q1C 07/21/84 15:55:04 (0)
          00              FUNCTION EBUBPR(TK,XM)
          00        C
          00        C
          00        C****PURPOSE:
          00        C       ESTIMATE BUBBLE POINT PRESSURE OF MIXTURE
          00        C       FROM GIVEN TEMPERATURE AND COMPOSITION
          00        C
          00        C**** INPUT:
          00        C         TK - TEMPERATURE    (K)
          00        C         XM - COMPOSITION    (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
          00        C
          00        C**** OUTPUT:
          00        C         EBUBPR - ESTIMATE OF BUBBLE POINT PRESSURE    (STD ATM)
          00        C
          00              COMMON/RDATA2/W1,W2,TC1,TC2
          00              COMMON/ESDATA/A(2,3),B(2,3),C(2.3)
          00              DIMENSION P(2)
          00        C
          00        C
          00              TK2=TK*TK
          00              DO 10 I=1,2
          00           10 P(I)=EXP(A(I,1)+A(I,2)/TK+A(I,3)/TK2)
          00        C**** WEIGHT COMPOSITION
          00              XW=XM/(W1/W2*(1.-XM)+XM)
          00        C**** INTERPOLATE
          00              EBUBPR=P(1)*(1.-XW)+P(2)*XW
          00              RETURN
          00              END

END ELT.  ERRORS: NONE. TIME:  0.080 SEC. IMAGE COUNT: 28

@HDG,P  ******  EBUBTE  ****** .L,0
```

```
@ELT,L DD.EBUBTE
ELT 8R1 S74Q1C 07/21/84 15:55:04 (0)
    00          FUNCTION EBUBTE(P,X)
    00    C
    00    C
    00    C**** PURPOSE:
    00    C        TO ESTIMATE BUBBLE POINT TEMP. OF A MIXTURE
    00    C        FROM GIVEN PRESSURE AND COMPOSITION
    00    C
    00    C**** INPUT:
    00    C        P  - PRESSURE    (STD. ATM)
    00    C        X  - MOLAR COMPOSITION (FRACTION OF LESS VOLATILE COMPONENT)
    00    C
    00    C**** OUTPUT:
    00    C        EBUBTE - ESTIMATE OF BUBBLE POINT TEMPERATURE    (K)
    00    C
    00          DIMENSION PS(2),XW(2)
    00          COMMON/RDATA2/W1,W2,TC1,TC2
    00          COMMON/ESDATA/A(2,3),B(2,3),C(2,3)
    00    C
    00          XW(2)=W1/W2*(1.-X)+X
    00          XW(2)=X/XW(2)
    00          XW(1)=1.-XW(2)
    00          T=280.
    00          DO 50 N=1,10
    00          T2=T*T
    00          DO 10 I=1,2
    00       10 PS(I)=XW(I)*EXP(A(I,1)+A(I,2)/T+A(I,3)/T2)
    00          PDELTA=PS(1)+PS(2)-P
    00          IF(ABS(PDELTA).LT.0.1)GOTO 100
    00          T3=T2*T
    00          DP=0.
    00          DO 20 I=1,2
    00       20 DP=DP+PS(I)*(-A(I,2)/T2-2.*A(I,3)/T3)
    00          T=T-PDELTA/DP
    00       50 CONTINUE
    00          WRITE(6,600)PDELTA
    00      600 FORMAT(' ERROR 600 IN EBUBTE, PDELTA=',1PE12.4)
    00      100 EBUBTE=T
    00          RETURN
    00          END

END ELT.  ERRORS: NONE. TIME:  0.086 SEC. IMAGE COUNT: 39

@HDG,P  ******  ENTROP  ****** .L,0
```

```
@ELT,L DD.ENTROP
ELT 8R1 S74Q1C 07/21/84 15:55:04 (0)
      00             FUNCTION ENTROP(T,V,X)
      00       C
      00       C
      00       C**** PURPOSE:
      00       C        TO CALCULATE REFRIG. ENTROPY
      00       C
      00       C**** INPUT:
      00       C        T  - REFRIG. TEMPERATURE    (K)
      00       C        V  - REFRIG. SPEC VOLUME    (L/MOL)
      00       C        W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT    (G)
      00       C        W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT    (G)
      00       C        X  - MOLAR CONCENTRATION OF A LESS VOLATILE REFRIG.    (-)
      00       C        *  - CONSTANTS A,B,C1,D1, AS PER COMMON STATEMENT /PARAM/
      00       C
      00       C**** OUTPUT:
      00       C        S  - ENTROPY    (BTU/(LB*F))
      00       C
      00       C**** SUBPROGRAMS CALLED BY ENTROP:
      00       C        HPAR
      00       C
      00             COMMON/PARAM/A,B,C1,C2,D1,D2
      00             COMMON/RDATA2/W1,W2,TC1,TC2
      00             DATA R/0.08206/
      00       C
      00             WM=(1.-X)*W1+X*W2
      00             CONV=453.5924/(1.055056*WM)
      00             IQ=1
      00             CALL HPAR(IQ,T,X)
      00             S=(C1*B A*D1)/B**2*ALOG((V+B)/V)+A*D1/B/(V+B)
      00             S=S-R*B/4./(V-B/4.)**2*(4.*V-3*B/4.)
      00             S=S-R*T*D1*V/2./(V-B/4.)**3*(2.*V-B/4.)
      00             S=S+(1.-X)*0.3209879339241+X*0.4916557619501
      00             S=S+R*(X*ALOG(V/0.0632978)+(1.-X)*ALOG(V/0.0776799))
      00             S=0.101325*S
      00             S=S+(0.0116393*(1.-X)+0.013966*X)*ALOG(T/233.15)
      00             S=S+(2.163944E-4*(1.-X)+1.540093E-4*X)*(T-233.15)
      00             S=S-(8.512035E-8*(1.-X)+1.533352E-9*X)*(T**2-233.15**2)
      00             IF(X.EQ.1.OR.X.EQ.0.)GOTO 1000
      00             S=S-0.101325*R*(X*ALOG(X)+(1.-X)*ALOG(1.-X))
      00        1000 ENTROP=S*CONV/1.8
      00             RETURN
      00             END

END ELT.  ERRORS: NONE. TIME:  0.086 SEC. IMAGE COUNT: 42

@HDG,P  ******  ENTRO2  ****** .L,0
```

```
@ELT,L DD.ENTRO2
ELT 8R1 S74Q1C 07/21/84 15:55:05 (0)
      00              SUBROUTINE ENTRO2(XW,TF,P,S,XQ)
      00        C
      00        C
      00        C**** PURPOSE:
      00        C       TO CALC. ENTROPY OF NON-AZEOTROPIC REFRIGERANT
      00        C
      00        C**** INPUT:
      00        C       P  - REFRIG. PRESSURE     (PSIA)
      00        C       TF - REFRIG. TEMPERATURE    (F)
      00        C       XW - WEIGHT CONCENTRATION OF A LESS VOLATILE REFRIG.    (-)
      00        C
      00        C**** OUTPUT:
      00        C       S  - ENTROPY    (BTU/(LB*F))
      00        C       XQ - QUALITY    (-)
      00        C
      00        C**** SUBPROGRAMS CALLED BY ENTRO2:
      00        C       ENTROP,QLITY,VOLIT1
      00        C
      00              COMMON/RDATA2/W1,W2,TC1,TC2
      00        C
      00              XM=XW/(W2/W1*(1.-XW)+XW)
      00              TK=(TF+459.67)/1.8
      00              PA=P/14.6959
      00              CALL QLITY(TK,PA,XM,XQ,XV,XL)
      00              IF(XQ.LT..0001.OR.XQ.GT..9999)THEN
      00                 N=1.1*XQ
      00                 CALL VOLIT1(N,TK,PA,XM,V)
      00                 S=ENTROP(TK,V,XM)
      00              ELSE
      00                 CALL VOLIT1(0,TK,PA,XL,V)
      00                 S=(1.-XQ)*ENTROP(TK,V,XL)
      00                 CALL VOLIT1(1,TK,PA,XV,V)
      00                 S=S+XQ*ENTROP(TK,V,XV)
      00              END IF
      00              RETURN
      00              END

END ELT.  ERRORS: NONE. TIME:  0.084 SEC. IMAGE COUNT: 36

@HDG,P  ******  EQPAR  ****** .L,0
```

```
@ELT,L DD.EQPAR
ELT 8R1 S74Q1C 07/21/84 15:55:05 (0)
      00          SUBROUTINE EQPAR(T,X)
      00    C
      00    C
      00    C**** PURPOSE:
      00    C       TO CALC. REFRIG. PARAMETERS FOR EQUATION OF STATE
      00    C
      00    C**** INPUT:
      00    C       REFRIG. CONSTANTS AS LISTED IN THE COMMON STATEMENT /RDATA1/
      00    C       T   - REFRIG. TEMPERATURE  (K)
      00    C       X   - MOLAR CONCENTRATION OF A LESS VOLATILE REFRIG.    (-)
      00    C
      00    C**** OUTPUT:
      00    C       *   - CONSTANTS A & B FOR EQUATION OF STATE
      00    C
      00    C
      00          COMMON/RDATA1/A3,A4,A5,A6,A7,A8,B3,B4,B5,B6,B7,B8,F0,F1
      00          COMMON/PARAM/A,B,C1,C2,D1,D2
      00          COMMON/STORE1/A1,A2,B1,B2,SEG31
      00          DATA TLAST,XLAST/2*0./
      00    C
      00          IF(ABS(T-TLAST).GT.0.0001)GOTO 10
      00          IF(ABS(X-XLAST).GT.0.0001)GOTO 10
      00          RETURN
      00    C
      00       10 TLAST=T
      00          XLAST=X
      00          X2=X**2
      00          XX=1.-X
      00          XX2=XX**2
      00          XXX=X*XX
      00          T2=T**2
      00          B1=B3+B4*T+B5*T2
      00          B2=B6+B7*T+B8*T2
      00          B=XX2*B1+X2*B2
      00          SEG31=(B1**(1./3.)+B2**(1./3.))/2.
      00          SEG32=SEG31**2
      00          B=B+2.*XXX*SEG31*SEG32
      00          A1=A3+A4*T+A5*T2
      00          A2=A6+A7*T+A8*T2
      00          A1A2S=SQRT(A1*A2)
      00          SEG1=XXX*A1A2S
      00          F=F0+F1*T
      00          SEG2=XXX*(1.-F)*A1A2S
      00          A=A1*XX2+A2*X2+2.*SEG2
      00          RETURN
      00          END

END ELT.  ERRORS: NONE. TIME:  0.089 SEC. IMAGE COUNT: 46

@HDG,P  ******  ESVOL  ****** .L,0
```

```
@ELT,L DD.ESVOL
ELT 8R1 S74Q1C 07/21/84 15:55:05 (0)
      00            FUNCTION ESVOL(N,T,P,X)
      00      C
      00      C
      00      C**** PURPOSE:
      00      C       TO ESTIMATE SPEC. VOLUME OF LIQUID OR VAPOR
      00      C       OF A NON-AZEOTROPIC, BINARY MIXTURE
      00      C
      00      C**** INPUT:
      00      C       N - OUTPUT QUALIFIER
      00      C         = 0    FOR LIQUID
      00      C         = 1    FOR VAPOR
      00      C       P - PRESSURE (REQUIRED FOR N=1 ONLY)   (STD ATM)
      00      C       T - TEMPERATURE   (K)
      00      C       X - MOLAR COMPOSITION   (FRACTION OF LESS VOLATILE COMPONENT)
      00      C
      00      C**** OUTPUT:
      00      C       ESVOL - SPECIFIC VOLUME   (L/MOL)
      00      C
      00      C
      00            COMMON/ESDATA/A(2,3),B(2,3),C(2,3)
      00            DIMENSION V(2)
      00      C
      00            T2=T*T
      00            IF(N.NE.0)GOTO 10
      00      C**** SPEC. VOL. OF SAT. LIQUID
      00            DO 5 I=1,2
      00          5 V(I)=C(I,1)+C(I,2)*T+C(I,3)*T2
      00            VV=(1.-X)*V(1)+X*V(2)
      00            GOTO 1000
      00      C**** SPEC. VOL. OF SAT. VAPOR
      00         10 DO 15 I=1,2
      00         15 V(I)=B(I,1)+B(I,2)*T+B(I,3)*T2
      00            VV=((1.-X)*V(1)+X*V(2))*T/P
      00      C
      00       1000 ESVOL=VV
      00            RETURN
      00            END

END ELT.  ERRORS: NONE. TIME:  0.100 SEC. IMAGE COUNT: 37

@HDG,P  ******  EVAPHX  ****** .L,0
```

```
@ELT,L DD.EVAPHX
ELT 8R1 S74Q1C 07/21/84 15:55:05 (0)
00                SUBROUTINE EVAPHX(IIO,RMASS,TI,PI,ATIN,APIN,ARHIN,
00           &                       X1,T2,P2,H2,X2)
00        C
00        C       FEBRUARY 1984
00        C
00        C
00        C**** EVAPORATOR SIMULATION
00        C
00        C**** PERFORMANCE OF CROSS-FLOW AIR HEATED EVAPORATOR
00        C**** WITH UP TO 130 PLATE FINNED TUBES
00        C**** PLACED IN UP TO 5 DEPTH ROWS.
00        C
00        C       FORWARD SCHEME, TUBE-BY-TUBE LOGIC.   INLET TEMPERATURES
00        C       OF AIR & REFRIGERANT CALCULATED FOR EACH TUBE INDIVIDUALLY.
00        C
00        C
00        C**** INPUT DATA:
00        C          AMAS(IIO)       - AIR MASS FLOW RATE THROUGH COIL    (LBM/H)
00        C          ANGLE(IIO)      - ANGLE BETWEEN COIL FACE & AIR STREAMLINES    (RAD)
00        C          APIN            - AIR INLET PRESSURE    (PSIA)
00        C          ARHIN           - AIR INLET RELATIVE HUMIDITY    (-)
00        C          ATIN            - AIR INLET TEMPERATURE    (F)
00        C          CONST(IIO)      - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION    (-)
00        C          CFOW(IIO)       - CONSTANT FOR AIR SIDE HEAT TRANSFER CORRELATION    (-)
00        C          DI(IIO)         - INNER DIAMETER OF TUBES    (FT)
00        C          DO(IIO)         - OUTER DIAMETER OF TUBES    (FT)
00        C          DPCH(IIO)       - TUBE DEPTH PITCH    (FT)
00        C          DT(IIO)         - FIN TIP DIAMETER    (FT)
00        C          FLOW(IIO,M)     - FRACTION OF COIL TOTAL REFRIG. MASS FLOW PASSING
00        C                            THROUGH TUBE M    (-)
00        C          FMK(IIO)        - FIN MATERIAL THERMAL CONDUCTIVITY    (BTU/FT*H*F)
00        C          FPCH(IIO)       - FIN PITCH    (FT)
00        C          FTK(IIO)        - FIN THICKNESS    (FT)
00        C          IDEPTH(IIO,M)   - DEPTH ROW OF A TUBE M
00        C          IFROM(IIO,M)    - NUMBER OF TUBE TUBE M RECEIVES REFRIG. FROM
00        C                            WHEN COIL WORKS AS EVAPORATOR    (-)
00        C          IIO             = 1    FOR INDOOR COIL    (-)
00        C                          = 2    FOR OUTDOOR COIL    (-)
00        C          IMER(IIO)       - NUMBER OF MERGING TUBES    (-)
00        C          IST(IIO)        - NUMBER OF TUBES REFRIG. FLOWS INTO COIL
00        C                            WORKING AS CONDENSER    (-)
00        C          ISTART(IIO,L)   - NUMBER OF TUBE REFRIG. FLOWS INTO COIL
00        C                            WORKING AS CONDENSER, FOUND AS L SUCH TUBE    (-)
00        C          JFROM(IIO,J)    - NUMBER OF TUBE POSITIONED AIR UPSTREAM
00        C          KFEED(IIO,J,N)  - NUMBER OF TUBE RECEIVING REFRIGERANT FROM
00        C                            TUBE J WHEN COIL WORKS AS EVAPORATOR.
00        C                            NOTE THAT TUBE J CAN FEED UP TO 3 TUBES
00        C                            (N CAN BE 1,2 AND 3)    (-)
00        C          KSTART(IIO,N)   - NUMBER OF TUBE REFRIGERANT FLOWS INTO COIL
00        C                            WORKING AS EVAPORATOR    (-)
00        C          KST(IIO)        - NUMBER OF TUBES REFRIGERANT FLOWS INTO COIL
00        C                            WORKING AS EVAPORATOR
00        C          NDEP(IIO)       - NUMBER OF TUBE ROW DEPTHS    (-)
00        C          NROW(IIO)       - NUMBER OF TUBES PER ROW    (-)
00        C          NSECT(IIO)      - NUMBER OF REPEATING SECTIONS OF COIL    (-)
00        C          NTPS(IIO)       - NUMBER OF TUBES PER SECTION    (-)
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```
00   C        NTUB(IIO,I)     - NUMBER OF TUBES IN ROW I OF EACH COIL SECTION   (-)
00   C        P1              - REFRIGERANT PRESSURE AT EVAPORATOR OUTLET   (PSIA)
00   C        RMASS           - TOTAL REFRIG. MASS FLOW RATE THROUGH COIL   (LBM/H)
00   C        RPCH(IIO)       - TUBE ROW PITCH   (FT)
00   C        TMK(IIO)        - TUBE MATERIAL THERMAL CONDUCTIVITY   (BTU/FT*H*F)
00   C        T1              - REFRIGERANT TEMPERATURE AT EVAPORATOR OUTLET   (F)
00   C        WIDTH(IIO)      - COIL WIDTH   (FT)
00   C
00   C        XM              - MOLAR COMPOSITION
00   C                          (FRACTION OF LESS VOLATILE COMPONENT)
00   C        XW              - WEIGHT COMPOSITION
00   C                          (FRACTION OF LESS VOLATILE COMPONENT)
00   C        WM              - MIXTURE MOLECULAR WEIGHT   (G/MOL)
00   C        W1              - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT   (G/MOL)
00   C        W2             - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT   (G/MOL)
00   C**** OUTPUT DATA:
00   C        H2              - REFRIGERANT ENTHALPY AT EVAPORATOR INLET   (BTU/LBM)
00   C        PRM(2,1,I)      - REFRIG. PRESSURE AT I TUBE OUTLET   (PSIA)
00   C        PRM(2,2,I)      - REFRIG. PRESSURE AT I TUBE INLET   (PSIA)
00   C        P2              - REFRIGERANT PRESSURE AT EVAPORATOR INLET   (PSIA)
00   C        TRM(2,1,I)      - REFRIG. TEMP. AT I TUBE OUTLET   (F)
00   C        TRM(2,2,I)      - REFRIG. TEMP. AT I TUBE INLET   (F)
00   C        T2              - REFRIGERANT TEMPERATURE AT EVAPORATOR INLET   (F)
00   C        XRM(2,1,I)      - REFRIG. QUALITY AT I TUBE OUTLET   (-)
00   C        XRM(2,2,I)      - REFRIG. QUALITY AT I TUBE INLET   (-)
00   C        XTUBE(2,J)      - FRACTION OF TUBE J WITH SUPERHEATED VAPOR
00   C                          (WHEN 2-PHASE MIXTURE IS IN REST OF TUBE)   (-)
00   C                          OR
00   C                        - FRACTION OF TUBE J WITH 2-PHASE MIXTURE
00   C                          (WHEN SUBCOOLED LIQUID IS IN REST OF TUBE)   (-)
00   C        X1              - REFRIGERANT QUALITY AT EVAPORATOR INLET   (-)
00   C        X2              - REFRIGERANT QUALITY AT EVAPORATOR OUTLET   (-)
00   C        VGM(2,1,I)      - SPEC. VOLUME OF SATURATED REFRIG. VAPOR AT
00   C                          SAT. TEMP. OF I TUBE OUTLET   (FT**3/LBM)
00   C        VGM(2,2,I)      - SPEC. VOLUME OF SATURATED REFRIG. VAPOR AT
00   C                          SAT. TEMP. OF I TUBE INLET   (FT**3/LBM)
00   C        VLM(2,1,I)      - REFRIG. SPEC VOLUME AT I TUBE OUTLET   (FT**3/LBM)
00   C        VLM(2,2,I)      - REFRIG. SPEC. VOLUME AT I TUBE INLET   (FT**3/LBM)
00   C
00   C**** SUBPROGRAMS CALLED BY EVAPHX:
00   C        AIRHT,AIRFR,BUBTEM,DEVTEM,DYNDP1,DPDYN2,EBUBTE,ESVOL,FEELIQ,
00   C        FINEFF,HCVCP,HPIN,HTCEV,OVLWET,PXQIN2,QLITY,SPHDP1,SPHTC,
00   C        VISCON,VOLIT1
00   C
00          COMMON/ACCURA/NEAT,ICOMP
00          COMMON/RDATA2/W1,W2,TC1,TC2
00          COMMON/RDATA3/XW,XM,WM
00          COMMON/HPHX/NDEP(2),NROW(2),DI(2),DO(2),DT(2),RPCH(2),DPCH(2),
00         &WIDTH(2),FPCH(2),FTK(2),FMK(2),TMK(2),AMAS(2),ANGLE(2),
00         &CONST(2),CPOW(2),NTUB(2,5),IFROM(2,130),NSECT(2),NTPS(2)
00          COMMON/MERG/MERGE(2,20,2),IMER(2),ISTARI(2,20),IST(2),
00         &IDEPTH(2,130),FLOW(2,130),JFROM(2,130),KFEED(2,130,3),
00         &KSTART(2,20),KST(2)
00          COMMON/MASS/TRM(2,2,130),PRM(2,2,130),XRM(2,2,130),
00         &   VLM(2,2,130),VGM(2,2,130),XTUBE(2,130),XTT(2,130)
00          DIMENSION TAIR(2,6),AIRN(5),HR(2,130),HBACK(10,2),
00         & OMEGA(2,6),DTHFG(130),MY(130),FFEE(5),
00         @ DFR(130),CPRS(130),HCO(5),HCOD(5),ILOOK(15)
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```
00          DIMENSION TPIP(5),TWAT(5),UD1(5),HICE(5),HFCWT(5),TKICE(5),CPAS(5)
00          DIMENSION TAIRI(2,130),WAIRI(2,130),AMSI(5),XLWS(130)
00          DATA N0,N1,N3,N4,N5/0,1,3,4,5/
00    C
00    C**** DATA PREPARATION
00          AANGLE=ANGLE(IIO)
00          NNDEP=NDEP(IIO)
00          DDI=DI(IIO)
00          DDO=DO(IIO)
00          DDT=DT(IIO)
00          RRPCH=RPCH(IIO)
00          DDPCH=DPCH(IIO)
00          WWIDTH=WIDTH(IIO)
00          FFPCH=FPCH(IIO)
00          FFTK=FTK(IIO)
00          FFMK=FMK(IIO)
00          TTMK=TMK(IIO)
00          AIRMAS=AMAS(IIO)
00          CCONST=CONST(IIO)
00          CCPOW=CPOW'IIO)
00          API=3.1415927*DDI*WWIDTH
00          APO=3.1415927*DDO*WWIDTH
00          APM=0.5*(API+APO)
00          APO=APO*(FFPCH-FFTK)/FFPCH
00          AF=1.570796*(DDT+DDO)*(DDT-DDO)
00          AF=AF*WWIDTH/FFPCH
00          AO=APO+AF
00          AFLOW=WWIDTH*RRPCH*NROW(IIO)
00          AFLOW=AFLOW*(RRPCH-DDO)/RRPCH
00          AFLOW=AFLOW/FFPCH
00          AFLOW=39.75*AFLOW
00          WFLW=AO/RRPCH
00          HDEP=5000.
00          HP=2.*TTMK/(DDO-DDI)
00          AIRMS=AIRMAS/NROW(IIO)
00    C**** FIND INLET STATE FROM PRESSURE AND TEMPERATURE
00          PA1=P1/14.6959
00          TK1=(T1+459.67)/1.8
00          CALL QLITY(TK1,PA1,XM,X1,XV,XL)
00          IF(X1.GT.0.)THEN
00             CALL VOLIT1(N0,TK1,PA1,XL,VL)
00             CALL HCVCP(N1,TK1,VL,XL,HL,CV,CP)
00             CALL VOLIT1(N1,TK1,PA`,XV,VV)
00             CALL HCVCP(N1,TK1,VV,XV,HV,CV,CP)
00             H1=(1.-X1)*HL X1*HV
00             WML=W1*(1.-XL)+W2*XL
00             WMV=W1*(1.-XV)+W2*XV
00             VLW=16.01846*VL/WML
00             VVW=16.01846*VV/WMV
00          XLW1=XL/(W1/W2*(1.-XL)+XL)
00          ELSE
00             CALL VOLIT1(N0,TK1,PA1,XM,VL)
00             CALL HCVCP(N1,TK1,VL,XM,H1,CV,CP)
00             VLW=16.01846*VL/WM
00             VVW=0.
00             XLW1=XW
00          END IF
00    C
```

```
00          WRITE(6,900)T1,P1,X1,ATIN,ARHIN,RMASS
00     C
00          DO 4 IS=1,KST(IIO)
00          I=KSTART(IIO,IS)
00          TRM(IIO,1,I)=T1
00          PRM(IIO,1,I)=P1
00          XRM(IIO,1,I)=X1
00          HR(1,I)=H1
00          VGM(IIO,1,I)=VVW
00          VLM(IIO,1,I)=VLW
00        4 CONTINUE
00     C**** ESTIMATE CHANGE OF AIR TEMPERATURE
00          CALL AIRPR(1,ATIN,APIN,ARHIN,WAIR,CPAIR,RAIR,
00         &AMAIR,AKAIR)
00          CALL DEWTEM(NO,PA1,XM,TKD,XL)
00          TD2=TKD*1.8-460.
00          DTAIR=0.85*(ATIN-TD2)/(NNDEP-1)
00          DTAIR=AMAX1(0 ,DTAIR)
00             DO 6 I=1,NTUB(IIO,1)
00             TAIRI(1,I)=ATIN
00             TAIRI(2,I)=TAIRI(1,I)-DTAIR
00             WAIRI(1,I)=WAIR
00        6    WAIRI(2,I)=WAIR
00             IA=NTUB(IIO,1)+1
00             DO 7 I=IA,NTPS(IIO)
00             J=JFROM(IIO,I)
00             TAIRI(1,I)=TAIRI(2,J)
00             TAIRI(2,I)=TAIRI(1,I)-DTAIR
00             WAIRI(1,I)=WAIRI(2,J)
00        7    WAIRI(2,I)=WAIRI(2,J)
00     CC     END IF
00          OMEGA(1,1)=WAIR
00          OMEGA(2,1)=WAIR
00          TAIR(1,1)=ATIN
00          DO 8 I=1,NNDEP
00          J=I+1
00          TAIR(1,J)=TAIR(1,I)-DTAIR
00          OMEGA(1,J)=OMEGA(1,I)
00          HICE(I)=1.E+30
00          HFGWT(I)=0.
00          TKICE(I)=0.
00          TWAT(I)=0.
00        8 TFIP(I)=0.
00          HBACK(1,2)=999.
00     C**** EVALUATE 'TWO-PHASE SPEC. HEAT'
00          TK2=TKD
00          PA2=PA1
00          VV=ESVOL(N1,TK2,PA2,XM)
00          CALL HCVCP(N1,TK2,VV,XM,H2,CV,CP)
00          CPR=(H2-H1)/(1.8*(TK2-TK1))
00          DO 12 I=1,NTPS(IIO)
00          VLM(IIO,2,I)=0.0
00          VGM(IIO,2,I)=0.0
00          DPR(I)=0.
00          CPRS(I)=CPR
00          DTHFG(I)=0.
00       12 MY(I)=0
00          DO 13 I=1,IMER(IIO)
```

```
00          J=MERGE(IIO,I,1)
00       13 MY(J)=1
00          ACC=0.003
00          HBACK(1,2)=999.
00          AFIN=3.14159*(DDT-DDO)*(DDT+DDO)/4.
00          SEGFIN=DDT**3/24.-DDT*DDT*DDO/16.+DDO**3/48.
00          SEGFIN=SEGFIN*2./(AFIN*(DDT-DDO))
00          HTOL=0.003
00          H2P=0.
00    C
00    C*************************************************************
00    C**** START MAIN LOOP
00    C*************************************************************
00    C
00          IAIRN=10
00          DO 150 IAIR=1,IAIRN
00    C**** CALC. CHANGE OF AIR MASS FLOW RATE DUE TO WATER/FROST ACCUM.
00          AFEE=0.
00          DO 16 I=1,NNDEP
00       16 AFEE=AFEE+(FFPCH-FFTK-2.*TKICE(I))
00          AFEE=AFEE/(NNDEP*(FFPCH-FFTK))
00          AAMAS=AIRMAS*AFEE**0.56*(530./(460.+ATIN))**0.64
00    C**** CALC. AIR DATA FOR EACH TUBE
00          DO 18 I=1,NNDEP
00          NT=NSECT(IIO)*NTUB(IIO,I)
00          AMS=AAMAS/NT
00          AMSI(I)=AMS
00          TAAV=0.5*(TAIR(1,I)+TAIR(1,I+1))
00          WAIR=0.5*(OMEGA(1,I)+OMEGA(1,I+1))
00          CALL AIRPR(2,TAAV,APIN,RHA,WAIR,CPA,RA,AMA,AKA)
00          FFFTK=FFTK+2.*TKICE(I)
00          HCOD(I)=AIRHT(AAMAS,CPA,AMA,AKA,DDO,DDT,NT,WWIDTH,
00         &                RRPCH,FFPCH,FFFTK,CCONST,CCPOW,AANGLE)
00          HCO(I)=HCOD(I)*(1.+HFGWT(I))
00          FFEE(I)=FINEFF(IIO,DDT,DDO,FFTK,FFMK,HCO(I))
00          UD1(I)=HCO(I)*(1.-AF*(1.-FFEE(I))/AO)
00          CPAS(I)=CPA
00       18 AIRN(I)=0.
00    C**** FIND TUBE REFRIG. FLOWS INTO EVAPORATOR
00          ILN=0
00          ILNEXT=0
00          DO 110 NUMB=1,KST(IIO)
00          I=KSTART(IIO,NUMB)
00          TRI=T1
00          PRI=P1
00          HRI=H1
00          XRI=X1
00          XLWI=XLW1
00          GOTO 30
00    C**** ASSIGN INLET PARAMETERS FOR NEXT TUBE
00       22 CONTINUE
00          TRI=TRM(IIO,2,JJ)
00          PRI=PRM(IIO,2,JJ)
00          HRI=HR(2,JJ)
00          XRI=XRM(IIO,2,JJ)
00          VLM(IIO,1,I)=VLM(IIO,2,JJ)
00          VGM(IIO,1,I)=VGM(IIO,2,JJ)
00          XLWI=XLWS(JJ)
```

```
00    C
00    C
00    C**** TUBE SELECTION FOR CALCULATION DONE
00    C**** COMPUTE HEAT TRANSFER & REFRIG. PRESSURE DROP FOR TUBE I
00    C**** FIND REFRIG. STATE AT OUTLET
00    C
00       30 TRM(IIO,1,I)=TRI
00          PRM(IIO,1,I)=PRI
00          HR(1,I)=HRI
00          XRM(IIO,1,I)=XRI
00          TRII=TRI
00          TRIX=TRI
00          HRII=HRI
00          HRIX=HRI
00          XRII=XRI
00          XRIX=XRI
00          RMS=RMASS*FLOW(IIO,I)
00          XLIQ=.0
00          XSLUG=.0
00          XANNUL=.0
00          XMIST=.0
00          TKRI=(TRI+459.67)/1.8
00          PRE=PRI+DPR(I)
00          PRAV=0.5*(PRI+PRE)
00          PARAV=PRAV/14.6959
00          DP1=0.
00          DP2=0.
00          DP3=0.
00          VIX=(1.-XRI)*VLM(IIO,1,I)+XRI*VGM(IIO,1,I)
00          ICT=IDEPTH(IIO,I)
00          TAI=TAIRI(1,I)
00          IF(TAI.LT.(TRI+0.1))TAI=TRI+0.1
00          CPA=CPAS(ICT)
00          AMS=AMSI(ICT)
00          OMEGI=WAIRI(1,I)
00          OMEGE=WAIRI(2,I)
00    CDE      IF(IAIR.EQ.1)PRINT 444,IAIR,I,XRI,PRI,TRI,HRI,TAI
00      444 FORMAT(' I,XRI,PRI,TRI,HRI,TAI=',2I5,F5.2,4F8.2)
00    C
00          IF(XRI.GT.0.)GOTO 45
00    C
00    C**** CASE 1 ****************************************************
00    C
00    C**** INLET QUALITY 0
00    C
00    C
00          CALL BUBTEM(NC,PARAV,XM,TKB,XV)
00          CALL VOLIT1(NO,TKB,PARAV,XM,VLB)
00          CALL HCVCP(N1,TKB,VLB,XM,HB,CV,CP)
00          TRE=TKB*1.8-459.67
00    C
00          DO 36 IT=1,5
00          TRAV=0.5*(TRI+TRE)
00          TKRAV=(TRAV+459.67)/1.8
00          AMR=VISCON(1,TRAV,XW)
00          AKR=VISCON(2,TRAV,XW)
00          CALL VOLIT1(NO,TKRAV,PARAV,XM,VL)
00          CALL HCVCP(N5,TKRAV,VL,XM,H,CV,CPR)
```

```
00          HI=SPHTC(CPR,AMR,AKR,RMS,DDI)
00          CALL OVLWET(AO,AFI,AFM,HI,HDEP,HP,HICE(ICT),UD1(ICT),UAO,UPO,UWO)
00          QQ=CPA*AMS*(1.-EXP(-UAO/(CPA*AMS)))/(CPR*RMS)
00          Q=1.-EXP(-QQ)
00          Q=CPR*RMS*(TAI-TRI)*Q
00          HRE=HRI+Q/RMS
00          TRE=TRI+(HRE-HRI)/CPR
00          IF(IT.EQ.1)GOTO 34
00          IF(HRE.GT.HB)THEN
00             XLIQ=-ALOG(1.-(HB-HRI)/(CPR*(TAI-TRI)))/QQ
00             AL1=XLIQ*WWIDTH
00             TRII=TKB*1.8-459.67
00             HRII=HB
00             XRII=0.
00             TRIX=TRII
00             HRIX=HRII
00             XRIX=0.
00             VIX=VLB*16.01846/WM
00             GOTO 40
00          END IF
00          HDIF=HRE1-HRE
00          XRE=0.
00          XLIQ=0.
00          IF(ABS(HDIF).LT.HTOL)GOTO 38
00       34 HRE1=HRE
00       36 CONTINUE
00          WRITE(6,650)IAIR,I,ICT,XRI,HDIF
00      650 FORMAT(' CASE 1 TUBE DOES NOT CONVERGE',/' IAIR,I,ICT,XRI,HDIF=',
00         @3I4,F5.2,F10.5)
00       38 CONTINUE
00    C
00          XLVS(I)=XW
00          AL1=WWIDTH*20.*DDI
00       40 VL=VL*16.01846/WM
00          DP1=SFHDP1(RMS,AL1,DDI,VL,AMR)
00          IF(XLIQ.EQ.0.)GOTO 100
00       45 IF(XRI.GT.0.1)GOTO 58
00    C
00    C**** CASE 2 *********************************************
00    C
00    C**** INLET QUALITY 0.0 - 0.1
00    C
00          CALL BUBTEM(NO,PARAV,XM,TKB,XV)
00          TB=TKB*1.8-459.67
00          CALL VOLIT1(NO,TKB,PARAV,XM,VLB)
00          CALL HCVCP(N5,TKB,VLB,XM,H,CV,CPR)
00          VISL=VISCON(N1,TB,XW)
00          CONL=VISCON(N2,TB,XW)
00          HI00=SPHTC(CPR,VISL,CONL,RMS,DDI)
00          X10=.1
00          CALL PXQIN2(XM,PARAV,X10,TK10,XL,XV,VL,VV,H10)
00          TF10=TK10*1.8-459.67
00          HI10=HTCEV(TF10,PRAV,RMS,DDI,XTT(I10,I ))
00          TRE=TF10
00          TKRE=TK10
00          XRE=0.1
00    C
00          ITE=0
```

```
      DO 55 IT=1,6
      CPR=CPRS(I)
      TRAV=0.5*(TRII+TRE)
      XRAV=0.5*(XRII+XRE)
      HI=HI10-10.*(.1-XRAV)*(HI10-HI00)
      CALL OVLWET(AO,API,APM,HI,HDEP,HP,HICE(ICT),UD1(ICT),UAO,UPO,UWO)
      QQ=CPA*AMS*(1.-EXP(-UAO/(CPA*AMS)))/(CPR*RMS)
      Q=CPR*RMS*(TAI-TRII)*(1.-EXP(-QQ*(1.-XLIQ)))
      HRE=HRII+Q/RMS
      CALL HPIN(N1,HRE,PARAV,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
      TRE=TKRE*1.8-459.67
      IF(TRE.NE.TRII)GOTO 52
      IF(ITE.EQ.0)THEN
         ITE=1
         CPRS(I)=3.*CPR
         GOTO 54
      ELSE
         GOTO 77
      END IF
   52 CPRS(I)=(HRE-HRII)/(TRE-TRII)
      IF(IT.EQ.1)GOTO 54
      IF(HRE.GT.H10)THEN
         XSLUG=-ALOG(1.-(H10-HRII)/(CPR*(TAI-TRII)))/QQ
         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=',
     @3I4,F5.2,F10.5)
      GOTO 77
C
   58 IF(XRI.GT..9)GOTO 68
C
C**** CASE 3 *******************************************************
C
C**** INLET QUALITY 0.1 - 0.9
C
   60 TRE=TRII
      TKRE=(TRE+459.67)/1.8
      XRE=XRII
      ITE=0
      DO 65 IT=1,6
      CPR=CPRS(I)
      TRAV=0.5*(TRII+TRE)
      XRAV=0.5*(XRII+XRE)
      HI=HTCEV(TRAV,PRAV,RMS,DDI,XTT(I10,I))
      CALL OVLWET(AO,API,APM,HI,HDEP,HP,HICE(ICT),UD1(ICT),UAO,UPO,UWO)
      QQ=CPA*AMS*(1.-EXP(-UAO/(CPA*AMS)))/(CPR*RMS)
      Q=CPR*RMS*(TAI-TRII)*(1.-EXP(-QQ*(1.-XLIO-XSLUG)))
      HRE=HRII+Q/RMS
```

```
00          CALL HPIN(N1,HRE,PARAV,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
00          TRE=TKRE*1.8-459.67
00          IF(TRE.NE.TRI1)GOTO 62
00          IF(ITE.EQ.0)THEN
00             ITE=1
00             CPRS(I)=3.*CPR
00             GOTO 64
00          ELSE
00             GOTO 77
00          END IF
00       62 CPRS(I)=(HRE-HRI1)/(TRE-TRI1)
00          IF(IT.EQ.1)GOTO 64
00          IF(XRE.GT..9)THEN
00             X90=.9
00             CALL PXQIN2(XM,PARAV,X90,TK90,XL,XV,VL,VV,H90)
00             XANNUL=-ALOG(1.-(H90-HRI1)/(CPR*(TAI-TRI1)))/OO
00             HRI1=H90
00             TRI1=TK90*1.8-459.67
00             XRI1=.9
00             GOTO 70
00          END IF
00          IF(ABS(HRE-HRE1).LT.HTOL)GOTO 77
00       64 IF(XRE.GT.0.9)THEN
00             X90=0.9
00             CALL PXQIN2(XM,PARAV,X90,TK90,XL,XV,VL,VV,H90)
00             TRE=TK90*1.8-459.67
00          END IF
00          HRE1=HRE
00       65 CONTINUE
00    C
00          WRITE(6,652)IAIR,I,ICT,XRI,HDIF
00      652 FORMAT(' CASE 3 TUBE DOES NOT CONVERGE',/' IAIR,I,ICT,XRI,HDIF=',
00         @3I4,F5.2,F10.5)
00          GOTO 77
00    C
00       68 IF(XRI.GT..999)GOTO 82
00    C**** CASE 4 ******************************************
00    C
00    C**** INLET QUALITY 0.9 - 1.0
00    C
00       70 X90=.9
00          CALL PXQIN(XM,PARAV,X90,TK90,XL,XV)
00          TF90=TK90*1.8-459.67
00          HI90=HTCEV(TF90,PRAV,RMS,DDI,XTT(110,I ))
00          CALL DEWTEM(NO,PARAV,XM,TKD,XLD)
00          TD=TKD*1.8-459.67
00          CALL VOLIT1(N1,TKD,PARAV,XM,VVD)
00          CALL HCVCP(N3,TKD,VVD,XM,HD,CV,CPR)
00    CXC      PRINT 708,TD,HD
00      708 FORMAT(' TD,HD=',2F14.5)
00          VISV=VISCON(N3,TD,XW)
00          CONV=VISCON(N4,TD,XW)
00          HI1=SPHTC(CPR,VISV,CONV,RMS,DDI)
00          TRE=TD
00          TKRE=TKD
00          XRE=1.
00    C
00          ITE=0
```

```
00          DO 75 IT=1,6
00    CXC        IF(I.EQ.14)PRINT 710,XRE
00      710 FORMAT(' XRE=',F12.6)
00          CPR=CPRS(I)
00          TRAV=0.5*(TRII+TRE)
00          XRAV=0.5*(XRII+XRE)
00          HI=HI1-10.*(1.-XRAV)*(HI1-HI90)
00    CXC        IF(I.EQ.14)PRINT 707,HI
00      707 FORMAT(' HI=',F12.5)
00          CALL OVLWET(AO,API,APM,HI,HDEP,HP,HICE(ICT),UD1(ICT),UAO,UPO,UWO)
00          QQ=CPA*AMS*(1.-EXP(-UAO/(CPA*AMS)))/(CPR*RMS)
00          Q=CPR*RMS*(TAI-TRII)*(1.-EXP(-QQ*(1.-XLIQ-XSLUG-XANNUL)))
00          HRE=HRII+Q/RMS
00    CXC        IF(I.EQ.14)PRINT 709,HRE,PARAV,TKRE
00      709 FORMAT(' HRE,PARAV,TKRE=',4F14.6)
00          CALL HPIN(N1,HRE,PARAV,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
00          TRE=TKRE*1.8-459.67
00    CXC        IF(I.EQ.14)PRINT 711,HRE,HD,TRII,TRE
00      711 FORMAT(' HRE,HD,TRII,TRE**=',4F10.5)
00          IF(TRE.NE.TRII)GOTO 72
00          IF(ITE.EQ.0)THEN
00             ITE=1
00             CPRS(I)=3.*CPR
00             GOTO 74
00          ELSE
00             GOTO 77
00          END IF
00       72 CPRS(I)=(HRE-HRII)/(TRE-TRII)
00          IF(IT.EQ.1)GOTO 74
00          IF(HRE.GT.HD)THEN
00    CXC        IF(I.EQ.14)PRINT 765,HD,HRII,TAI,TRII
00      765 FORMAT(' HG,HRII,TAI,TRII=',4F12.4)
00             XRE=1.
00             XMIST=-ALOG(1.-(HD-HRII)/(CPR*(TAI-TRII)))/QQ
00             HRII=HD
00             TRII=TD
00             XRII=1.
00             XV=XM
00             VV=VVD
00             XL=XLD
00             CALL VOLIT1(NO,TKD,PARAV,XLD,VL)
00             XTUBE(IIO,I)=XSLUG+XANNUL+XMIST
00             AL1=XTUBE(IIO,I)*WWIDTH
00             TRAV=0.5*(TRIX+TRII)
00             XREX=1.
00             HREX=HRII
00             GOTO 80
00          END IF
00          HDIF=HRE1-HRE
00          IF(ABS(HDIF).LT.HTOL)GOTO 77
00       74 HRE1=HRE
00       75 CONTINUE
00    C
00          WRITE(6,653)IAIR,I,ICT,XRI,HDIF
00      653 FORMAT(' CASE 4 TUBE DOES NOT CONVERGE',/' IAIR,I,ICT,XRI,HDIF=',
00         @3I4,F5.2,F10.5)
00    C
00    C**** COMPUTE FRICTIONAL, 2-PHASE PRESSURE DROP
```

```
00      C
00         77 AL1=(1.-XLIQ)*WWIDTH+20.*DDI
00            TRAV=0.5*(TRIX+TRE)
00            XREX=XRE
00            HREX=HRE
00         80 XRAV=0.5*(XRIX+XREX)
00      CXC         IF(I.EQ.14)PRINT 720,XRI,XRII,XRE
00        720 FORMAT(' XRI,XRII,XRE=',4F6.2)
00            WML=W1*(1.-XL)+W2*XL
00            VLW=VL*16.01846/WML
00            WMV=W1*(1.-XV)+W2*XV
00            VVW=VV*16.01846/WMV
00            VMIX=(1.-XREX)*VLW+XREX*VVW
00            VMIX=0.5*(VMIX+VIX)
00            XLWS(I)=XL/(W1/W2*(1.-XL)+XL)
00            XWL=.5*(XLWI+XLWS(I))
00            VISL=VISCON(1,TRAV,XWL)
00      CXC         IF(I.EQ.14)PRINT 843,HRI,HREX
00        843 FORMAT(' HRI,HREX=',2F15.6)
00            IF(HRI.NE.HREX)THEN
00               DP2=1.4*EVDP(RMS,HRI,HREX,VMIX,VISL,AL1,DDI)
00            ELSE
00               F=FEELIQ(XRAV,TRAV,XL,XV,VL,VV,XT)
00               RMSX=(1.-XRAV)*RMS
00               DP2=F*SPHDP1(RMSX,AL1,DDI,VLW,VISL)
00            END IF
00      C
00            IF(XRII.NE.1.)GOTO 100
00      C
00      C**** CASE 5 ******************************************
00      C
00      C**** INLET QUALITY 1
00      C
00         82 DO 86 IS=1,5
00            TRAV=0.5*(TRII+TRE)
00            TKRAV=(TRAV+459.67)/1.8
00            AMR=VISCON(3,TRAV,XW)
00            AKR=VISCON(4,TRAV,XW)
00            CALL VOLIT1(N1,TKRAV,PARAV,XM,VV)
00            CALL HCVCP(N5,TKRAV,VV,XM,H,CV,CPR)
00            HI=SPHTC(CPR,AMR,AKR,RMS,DDI)
00            CALL CVLWET(AO,API,APM,HI,HDEP,HP,HICE(ICT),UDI(ICT),UAO,UPO,UWO)
00            QQ=CPA*AMS*(1.-EXP(-UAO/(CPA*AMS)))/(CPR*RMS)
00            Q=1.-EXP(-QQ*(1.-XLIQ-XSLUG-XANNUL-X1ST))
00            Q=CPR*RMS*(TAI-TRII)*Q
00            HRE=HRII+Q/RMS
00      CXC         IF(I.EQ.14)PRINT 740
00        740 FORMAT(' HRE=',F10.4)
00            TRE=TRII+(HRE-HRII)/CPR
00            IF(IS.EQ.1)GOTO 84
00            HDIF=HRE1-HRE
00            IF(ABS(HDIF).LT.HTOL)GOTO 88
00         84 HRE1=HRE
00         86 CONTINUE
00      C
00            WRITE(6,654)IAIR,I,ICT,XRI,HDIF
00        654 FORMAT(' CASE 5 TUBE DOES NOT CONVERGE',/' IAIR,I,ICT,XRI,HDIF=',
00           @3I4,F5.2,F10.5)
```

```
00       88 CONTINUE
00     C
00           XTUBE(IIO,I)=1.-XLIQ-XSLUG-XANNUL-XMIST
00           AL1=XTUBE(IIO,I)*WWIDTH+20.*DDI
00           VV=VV*16.01846/WM
00           AL1=WWIDTH+20.*DDI
00           DP3=SPHDP1(RMS,AL1,DDI,VV,AMR)
00      750 FORMAT(' PRE=',F10.5)
00      100 PRE=PRI-DP1-DP2-DP3
00           PRE=AMAX1(3.,PRE)
00     CXC       IF(I.EQ.14)PRINT 750,PRE
00           Q=(HRE-HRI)*RMS
00           TAE=TAIRI(1,I)-Q/(CPA*AMS)
00           TAEE=TAE+DTHFG(I)
00     CC*** FOLLOWING STATEMETS FOR CALC. OF DYNAMIC PRESSURE DROP ARE
00     CC    SKIPPED. THEY PROVIDE LITTLE CORRECTION FOR PRESSURE DROP
00     CC    AT EXPENSE OF A LOT OF COMPUTING.
00     CC    IF(XRI.LT.1..AND.XRE.GT.0.1)THEN
00     CC      DIX=DYNDP2(PRI,TRI,PRE,TRE,RMS,DDI)
00     CC    ELSE
00     CC      DIX=DYNDP1(PRI,HRI,PRE,HRE,RMS,DDI)
00     CC    END IF
00     CC    PRE=PRE+DIX
00     C
00     C****************************************************************
00     C**** END OF HEAT TRANSFER AND PRESSURE DROP CALCULATIONS*************
00     C**** ENTHALPY & PRESSURE AT TUBE I OUTLET ARE KNOWN
00     C**** FIND TEMP.,QUALITY & SPEC. VOLUME
00           TKRE=(TRE+459.67)/1.8
00           PARE=PRE/14.6959
00           CALL HPIN(N1,HRE,PARE,XM,ACC,TKRE,XRE,XL,XV,VL,VV)
00           TRM(IIO,2,I)=TKRE*1.8-459.67
00           PRM(IIO,2,I)=PRE
00           HR(2,I)=HRE
00           XRM(IIO,2,I)=XRE
00           DPR(I)=PRI-PRE
00           IF(XRE.EQ.0.)THEN
00              VLM(IIO,2,I)=16.01846*VL/WM
00           ELSE
00              IF(XRE.LT.1.)THEN
00                 WMV=W1*(1.-XV)+W2*XV
00                 VGM(IIO,2,I)=16.01846*VV/WMV
00                 WML=W1*(1.-XL)+W2*XL
00                 VLM(IIO,2,I)=16.01846*VL/WML
00              ELSE
00                 VGM(IIO,2,I)=16.01846*VV/WM
00              END IF
00           END IF
00     C
00     C**** REFRIGERANT SIDE CALCULATIONS FOR TUBE I COMPLETED.
00     C**** FIND AIR STATE PAST TUBE
00           OMEGE=OMEGI
00           WATHFG=0.
00           IF(Q.LE.0.)THEN
00              TWATA=TRI
00              TPIPE=TRI
00              GOTO 104
00           END IF
```

```
00     C
00              OMECHF=0.
00              TWATAI=TRI+Q/UWO
00              TWATAE=TRE+Q/UWO
00              TWATA=.5*(TWATAI+TWATAE)
00              TPIPA=0.5*(TRI+TRE)+Q/UPO
00     CXC           IF(I.EQ.14)PRINT 755,TWATA
00         755  FORMAT(' TWATA=',F12.5)
00              CALL AIRPR(1,TWATAI,APIN,1.,OMEGWI,CPW,RW,AMW,AKW)
00              CALL AIRPR(1,TWATAE,APIN,1.,OMEGWE,CPW,RW,AMW,AKW)
00              IF(OMEGI.LE.OMEGWI)GOTO 104
00              XCOND=(OMEGI-OMEGWI)/(OMEGWE-OMEGWI)
00              XCOND=AMIN1(1.,XCOND)
00              TWATA=TWATAI+0.5*XCOND*(TWATAE-TWATAI)
00              CALL AIRPR(1,TWATA,APIN,1.,OMEGW,CPW,RW,AMW,AKW)
00              OMECHP=(OMEGI-OMEGW)*(1.-EXP(-HCOD(ICT)*APO/(CPA*AMS)))
00              TTTAIR=TAEE+0.5*XCOND*(TAI-TAEE)
00                 TEM=TTTAIR-FFEE(ICT)*(TTTAIR-TWATA)
00                 TEND=TWATA+(TEM-TWATA)/SEGFIN
00                 IF(TEND.GT.TAEE)TEND=TAEE
00                 CALL AIRPR(1,TEND,APIN,1.,OMEGIS,CPW,RW,AMW,AKW)
00              IF(OMEGIS.LE.OMEGW)THEN
00              OMEGFM=OMEGW
00              GOTO 101
00              END IF
00                 DDTS=DDO+(DDT-DDO)*(OMEGI-OMEGW)/(OMEGIS-OMEGW)
00                 DDTS=AMIN1(DDTS,DDT)
00              IF(DDTS.EQ.DDO)GOTO 103
00                 AFIN=3.14159*(DDTS-DDO)*(DDTS+DDO)/4.
00                 AFS=AFIN*2.*WWIDTH/FFPCH
00                 SEG=DDTS**3/24.-DDTS*DDTS*DDO/16.+DDO**3/48.
00                 SEG=SEG*2./(AFIN*(DDTS-DDO))
00                 OMEGIS=AMIN1(OMEGIS,OMEGI)
00                 OMEGFM=OMEGW+(OMEGIS-OMEGW)*SEG
00         101     OMECHF=(OMEGI-OMEGFM)*(1.-EXP(-HCOD(ICT)*AFS/(CPA*AMS)))
00         103  OMECH=XCOND*(OMECHP+OMECHF)
00     C
00              OMEGE=OMEGI-OMECH
00     CXC           IF(I.EQ.14)PRINT 760,OMEGE
00         760  FORMAT(' OMEGE=',F14.6)
00              TWATA=.5*(TWATAI+TWATAE)
00              TPIPA=.5*(TRI+TRE)+Q/UPO
00         104  TTAIR=0.5*(TAI+TAEE)
00              VELA=AAMAS*(460.+TTAIR)/(AFLOW*(FFPCH-FFTK-2.*TKICE(ICT)))
00              CALL WATPR(TWATA,TPIPA,VELA,OMEGI,WATRO,WATK,
00             &WATM,WATHFG,WATCP)
00              DTHFG(I)=WATHFG*(OMEGI-OMEGE)/CPA
00              TAE=TAE+DTHFG(I)
00              TAIRI(2,I)=TAE
00              WAIRI(2,I)=OMEGE
00              AA1=1./(AIRN(ICT)+1.)
00              AA2=AA1*AIRN(ICT)
00              TAIR(2,ICT+1)=AA1*TAE+AA2*TAIR(2,ICT+1)
00              OMEGA(2,ICT+1)=AA1*OMEGE+AA2*OMEGA(2,ICT+1)
00              TWAT(ICT)=AA1*TWATA+AA2*TWAT(ICT)
00              TPIP(ICT)=AA1*TPIPA+AA2*TPIP(ICT)
00              AIRN(ICT)=AIRN(ICT)+1.
00     C
```

```
00      C**** SELECT NEXT TUBE FOR CALCULATIONS
00        106 IF(MY(I).EQ.1)THEN
00                DO 108 N=2,3
00                NN=KFEED(II0,I,N)
00                IF(NN.EQ.0)GOTO 109
00                ILN=ILN+1
00                ILOOK(ILN)=NN
00        108     CONTINUE
00            END IF
00        109 JJ=I
00            I=KFEED(II0,JJ,1)
00            IF(I.NE.-1)GOTO 22
00            IF(ILN.EQ.ILNEXT)GOTO 110
00                ILNEXT=ILNEXT+1
00                I=ILOOK(ILNEXT)
00                JJ=IFROM(II0,I)
00                GOTO 22
00        110 CONTINUE
00      C
00      C**** ALL TUBES OF COIL COMPUTED. CHECK IF CONVERGENCE OBTAINED
00      C
00            H2=0.
00            DO 111 IT=1,IST(II0)
00            I=ISTART(II0,IT)
00        111 H2=H2+HR(2,I)*FLOW(II0,I)
00            H2=H2*NSECT(II0)
00            H2PH2=H2P-H2
00            IF(IAIR.LT.3)GOTO 114
00        112 IF(ABS(H2PH2).LT.0.06)GOTO 160
00        114 H2P=H2
00            HBACK(IAIR,1)=H2
00            HBACK(IAIR,2)=H2PH2
00      C**** CONVERGENCE NOT OBTAINED
00      C**** PREPARE AIR SIDE DATA FOR NEW LOOP
00            DO 124 I=1,NNDEP
00            J=I+1
00            TAIR(1,J)=0.5*(TAIR(1,J)+TAIR(2,J))
00            OMEGA(1,J)=OMEGA(2,J)
00        124 OMEGA(2,J)=0.
00            DO 140I=1,NNDEP
00            TWATA=TWAT(I)
00            TTAIR=0.5*(TAIR(1,I+1)+TAIR(2,I+1))
00            TAIR(2,I+1)=0.
00            WWAIR=OMEGA(1,I)
00            CALL AIRPR(1,TWATA,APIN,1.,WWATER,CCPA,RRA,
00           &AAMA,AAKA)
00            TPIPE=TPIP(I)
00            VELA=AAMAS*(460.+TTAIR)/AFLOW
00            VELA=VELA/(FFPCH-FFTK-2.*TKICE(I))
00            CALL WATPR(TWATA,TPIPE,VELA,WWAIR,WATRO,WATK,
00           &WATM,WATHFG,WATCP)
00            IF(OMEGA(1,I).GT.WWATER)GOTO 125
00            HICE(I)=1.E+30
00            HFGWT(I)=0.
00            TKICE(I)=0.
00            GOTO 140
00        125 IF(OMEGA(1,I+1).LT.OMEGA(1,I))GOTO 126
00            OMEGA(1,I+1)=OMEGA(1,I)
```

```
00          HICE(I)=1.E+30
00          HFGWT(I)=0.
00          TKICE(I)=0.
00          GOTO 140
00      126 WMAS=AAMAS*(OMEGA(1,I)-OMEGA(1,I+1))
00          HFGWT(I)=WATHFG*(OMEGA(1,I)-WWATER)
00          CALL AIRPR(2,TTAIR,APIN,PRRH,WWAIR,CPA,RRA,AAMA,AAKA)
00          HFGWT(I)=HFGWT(I)/(CPA*(TAIR(1,I)-TWATA))
00          IF(TWATA.GT.32.)GOTO 128
00          TKICE(I)=0.125*WMAS/(AO*NROW(IIO)*WATRO)
00          TKMAX=0.5*(FFPCH-FFTK)
00          IF(TKICE(I).GE.TKMAX)TKICE(I)=0.9*TKMAX
00          GOTO 132
00      128 WWW=WMAS/WFLW
00          WWW=WATM*WWW/(WATRO*WATRO)
00          TKICE(I)=1.449E-03*WWW**0.333
00      132 HICE(I)=WATK/TKICE(I)
00          IF(HICE(I).LT.0.)HICE(I)=0.
00          IF(TKICE(I).LT.0.)TKICE(I)=0.
00          IF(HFGWT(I).LT.0.)HFGWT(I)=0.
00      140 CONTINUE
00          NTOT=0
00          NDEEP=NDEP(IIO)-1
00          DO 149 ICT=1,NDEEP
00          NTOT=NTOT+NTUB(IIO,ICT)
00          NDIF=NTUB(IIO,ICT)-NTUB(IIO,ICT+1)
00    C
00          IF(NDIF.EQ.0)THEN
00          IA=NTOT+1
00          IB=NTOT+NTUB(IIO,ICT+1)
00          DO 142 I=IA,IB
00          J=JFROM(IIO,I)
00          TAIRI(1,I)=TAIRI(2,J)
00      142 WAIRI(1,I)=WAIRI(2,J)
00          END IF
00    C
00          IF(NDIF.LT.0)THEN
00          IA=NTOT+1
00          IB=NTOT+NTUB(IIO,ICT)-1
00          DO 143 I=IA,IB
00          J=JFROM(IIO,I)
00          TAIRI(1,I)=0.5*(TAIRI(1,I)+TAIRI(2,J))
00      143 WAIRI(1,I)=0.5*(WAIRI(1,I)+WAIRI(2,J))
00          IA=NTOT-NTUB(IIO,ICT)+1
00          IB=NTOT-1
00          T=0.
00          WW=0.
00          DO 144 I=IA,IB
00          T=T+TAIRI(2,I)
00      144 WW=WW+WAIRI(2,I)
00          T=T*(AMSI(ICT)-AMSI(ICT+1))+TAIRI(2,NTOT)*AMSI(ICT)
00          WW=WW*(AMSI(ICT)-AMSI(ICT+1))+WAIRI(2,NTOT)*AMSI(ICT)
00          SEG=(NTUB(IIO,ICT+1)-NTUB(IIO,ICT)+1)*AMSI(ICT+1)
00          T=T/SEG
00          WW=WW/SEG
00          IA=NTOT+NTUB(IIO,ICT)
00          IB=NTOT+NTUB(IIO,ICT+1)
00          DO 145 I=IA,IB
```

```
00          TAIRI(1,I)=0.5*(TAIRI(1,I)+T)
00      145 WAIRI(1,I)=0.5*(WAIRI(1,I)+WW)
00          END IF
00    C
00          IF(NDIF.GT.0)THEN
00          IA=NTOT-NDIF+1
00          TCOR=0.
00          WCOR=0.
00          DO 146 I=IA,NTOT
00          TCOR=TCOR+TAIRI(2,I)
00      146 WCOR=WCOR+WAIRI(2,I)
00          TCOR=TCOR/NTUB(IIO,ICT+1)
00          WCOR=WCOR/NTUB(IIO,ICT+1)
00          IA=NTOT+1
00          IB=NTOT+NTUB(IIO,ICT+1)
00          DO 147 I=IA,IB
00          J=JFROM(IIO,I)
00          TAIRI(1,I)=.5*(TAIRI(1,I)+(TAIRI(2,J)+TCOR)*AMSI(ICT)/AMSI(ICT+1))
00      147 WAIRI(1,I)=.5*(WAIRI(1,I)+(WAIRI(2,J)+WCOR)*AMSI(ICT)/AMSI(ICT+1))
00          END IF
00      149 CONTINUE
00          PRINT 858,H2
00      858 FORMAT(' H2=',F8.4)
00      150 CONTINUE
00    C
00    C***************************************************************
00    C**** END OF MAIN LOOP
00    C***************************************************************
00    C
00          I=5
00          DO 151 IEV=6,IAIRN
00      151 IF(ABS(HBACK(I,2)).GT.ABS(HBACK(IEV,2)))I=IEV
00          H2PH2=HBACK(I,2)
00          H2=HBACK(I,1)+H2PH2
00          Q=ABS(H2PH2*RMASS)
00          WRITE(6,1021)H2PH2,Q
00      160 CONTINUE
00          DO 162 I=1,NTPS(IIO)
00          T=TRM(IIO,1,I)
00          TRM(IIO,1,I)=TRM(IIO,2,I)
00          TRM(IIO,2,I)=T
00          T=PRM(IIO,1,I)
00          PRM(IIO,1,I)=PRM(IIO,2,I)
00          PRM(IIO,2,I)=T
00          T=XRM(IIO,1,I)
00          XRM(IIO,1,I)=XRM(IIO,2,I)
00          XRM(IIO,2,I)=T
00          T=VLM(IIO,1,I)
00          VLM(IIO,1,I)=VLM(IIO,2,I)
00          VLM(IIO,2,I)=T
00          T=VGM(IIO,1,I)
00          VGM(IIO,1,I)=VGM(IIO,2,I)
00      162 VGM(IIO,2,I)=T
00          P2=0.
00          DO 164 I=1,IST(IIO)
00          IE=ISTART(IIO,I)
00          P2=P2+PRM(IIO,2,IE)*FLOW(IIO,IE)
00      164 CONTINUE
```

```
00          P2=P2*NSECT(IIO)
00          PA2=P2/14.6959
00          CALL HFIN(NO,H2,PA2,XM,ACC,TK2,X2,XL,XV,VL,VV)
00          T2=TK2*1.8-459.67
00          IF(X2.LT..9999)THEN
00             TSUP2=0.
00          ELSE
00             CALL DEWTEM(N1,PA2,XM,TKD,XL)
00             TD=TKD*1.8-459.67
00             TSUP2=T2-TD
00          END IF
00          QT=RMASS*(H2-H1)
00          QL=WATHFG*AAMAS*(OMEGA(1,1)-OMEGA(1,NNDEP+1))
00          QS=QT-QL
00          PRINT 880,QT,QS
00      880 FORMAT(' QT,QS=',3(1PE11.3))
00          WRITE(6,1012)T1,P1,H1,X1,T2,P2,H2,X2,TSUP2
00      900 FORMAT(/2X,'INPUT DATA TO EVAPHX:'//2X,'T',
00         &10X,'P',10X,'X',10X,'TAIR',7X,'RH',9X,'RMASS'/6(1PE11.3))
00     1021 FORMAT(' EVAPHX DOES NOT CONVERGE',/
00         & ' CONVERGENCE OBTAINED = ',F6.2,' BTU/LB ',F11.1,' BTU/H')
00     1012 FORMAT(/2X,'EVAPORATOR ITERATION:'//2X,
00         &'T',10X,'P',10X,'H',10X,'X',10X,'TSUP',/4(1PE11.3)/5(1PE11.3))
00          RETURN
00          END
```

END ELT. ERRORS: NONE. TIME: 1.071 SEC. IMAGE COUNT: 951

@HDG,P ****** EVDP ****** .L,0

```
******  EVDP  ******                                                    DATE 072184

@ELT,L DD.EVDP
ELT 8R1 S74Q1C 07/21/84 15:55:06 (0)
    00          FUNCTION EVDP(RMS,H1,H2,VMIX,VISL,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       VISL   - 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/(0.78539816*D*D)
    00          RE=G*D/VISL
    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
```

```
@ELT,L DD.FANNO
ELT 8R1 S74Q1C 07/21/84 15:55:07 (0)
00            FUNCTION FANNO(XM,P,HO,GG)
00      C
00      C**** PURPOSE:
00      C       TO CALCULATE ENTROPY OF NON-AZEOTROPIC
00      C       TWO-PHASE MIXTURE IN THE FANNO FLOW
00      C       FOR A GIVEN PRESSURE
00      C
00      C**** INPUT DATA:
00      C         HO       - REFRIG. TOTAL ENTHALPY   (BTU/LM)
00      C         GG       = G*G/(64.4*778.104)    (BTU*LM/FT**6)
00      C                    WHERE G - REFRIG. MASS FLUX    (LM/(SEC*FT**2))
00      C         P        - REFRIG. PRESSURE AT WHICH ENTROPY IS DESIRED    (PSIA)
00      C       XM         - MOLAR COMPOSITION    (FRACTION OF LESS VOLATILE COMPONENT)
00      C**** OUTPUT DATA:
00      C         FANNO    - ENTROPY   (BTU/LM R)
00      C
00      C**** SUBPROGRAMS CALLED BY FANNO:
00      C       EBUTE,ENTROP,HCVCP,QLITY,VOLIT1
00      C
00            COMMON/RDATA2/W1,W2,TC1,TC2
00            DATA SLOPE/0./NO,N1/0,1/
00      C
00            IF(P.GT.0.)GOTO 10
00            WRITE(6,600)P
00        600 FORMAT(' ERROR IN CALLING FANNO, P=',1PE15.5,'  PSIA')
00            RETURN
00      C
00         10 PA=P/14.6959
00            TKB=EBUBTE(PA,XM)
00            TKD=TKB+9.5-20.*(.55-XM)
00            TB=TKB*1.8-459.67
00            TD=TKD*1.8-459.67
00            TK2=0.5*(TKB+TKD)
00            DO 100 I=1,20
00            CALL QLITY(TK2,PA,XM,XQ,XV,XL)
00            CALL VOLIT1(N1,TK2,PA,XV,VMV)
00            CALL HCVCP(N1,TK2,VMV,XV,HV,CV,CP)
00            CALL VOLIT1(NO,TK2,PA,XL,VML)
00            CALL HCVCP(N1,TK2,VML,XL,HL,CV,CP)
00            HFG=HV-HL
00            WMV=W1*(1.-XV)+W2*XV
00            WML=W1*(1.-XL)+W2*XL
00            VV=VMV*16.01846/WMV
00            VL=VML*16.01846/WML
00            VFG=VV-VL
00            R=GG*VFG*VFG
00            S=2.*GG*VV*VFG+HFG
00            C=GG*VL*VL+HL-HO
00            XQQ=(-S+SQRT(S*S-4.*R*C))/(2.*R)
00            DIFXQ2=XQQ-XQ
00            TF=TK2*1.8-460.
00            PRINT 800,P,TF,XQQ,DIFXQ2
00        800 FORMAT(' P,TF,XQQ,XDIF=',4(1PE15.6))
00            IF(ABS(DIFXQ2).LT.0.000001)GOTO 110
00      C
00            IF(I.GT.1)GOTO 70
```

```
00          TK1=TK2
00          DIFXQ1=DIFXQ2
00          IF(SLOPE.NE.0.)THEN
00             TDEL=DIFXQ2*SLOPE
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
00       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 CONTINUE
00          PRINT 602,DIFXQ2
00      602 FORMAT(' FANNO DOES NOT CONVERGE, DIFXQ2=',1PE15.5)
00      110 CONTINUE
00          SL=ENTROP(TK2,VML,XL)
00          SV=ENTROP(TK2,VMV,XV)
00          FANNO=(1.-XQQ)*SL+XQQ*SV
00          RETURN
00          END

END ELT.  ERRORS: NONE. TIME:  0.135 SEC. IMAGE COUNT: 82

@HDG,P  ******  FEELIQ  ****** .L,0
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```
******  FEELIQ  ******                                                                  DATE 072184

@ELT,L DD.FEELIQ
ELT 8R1 S74Q1C 07/21/84 15:55:07 (0)
          00             FUNCTION FEELIQ(X,T,XML,XMV,VML,VMV,XTT)
          00       C
          00       C**** PURPOSE:
          00       C        COMPUTE FOR A NON-AZEOTROPIC MIXTURE TWO-PHASE FLOW
          00       C        LOCKHARD-MARTINELLI CORRECTION PRESSURE DROP FACTOR
          00       C
          00       C**** INPUT DATA:
          00       C        T       - REFRIG. AVERAGE TEMPERATURE   (F)
          00       C        VML     - LIQUID SPECIFIC VOLUME    (L/MOL)
          00       C        VMV     - VAPOR SPECIFIC VOLUME    (L/MOL)
          00       C        X       - REFRIG. AVERAGE QUALITY    (-)
          00       C        XL      - LIQUID MOLAR COMPOSITION
          00       C                  (FRACTION OF LESS VOLATILE COMPONENT)
          00       C        XV      - VAPOR MOLAR COMPOSITION
          00       C                  (FRACTION OF LESS VOLATILE COMPONENT)
          00       C        W1      - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT    (G/MOL)
          00       C        W2      - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT    (G/MOL)
          00       C
          00       C**** OUTPUT DATA:
          00       C        FEELIQ  - PRESSURE DROP CORRECTION FACTOR    (-)
          00       C        XTT     - LOCKHART-MARTINELLI PARAMETER    (-)
          00       C
          00       C**** SUBPROGRAMS CALLED BY FEELIQ:
          00       C        VISCON
          00       C
          00             COMMON/RDATA2/W1,W2,TC1,TC2
          00       C
          00             A0=-.418956
          00             A1=1.47330
          00             A2=.668583
          00             A3=-.321168
          00             A4=0.0408167
          00             XWL=XML/(W1/W2*(1.-XML)+XML)
          00             VISL=VISCON(1,T,XWL)
          00             XWV=XMV/(W1/W2*(1.-XMV)+XMV)
          00             VISV=VISCON(3,T,XWV)
          00             WML=W1*(1.-XML)+W2*XML
          00             VL=16.01846*VML/WML
          00             WMV=W1*(1.-XMV)+W2*XMV
          00             VV=16.01846*VMV/WMV
          00             XTT=((1.-X)/X)**.9*(VL/VV)**.5*(VISL/VISV)**.1
          00             H4=1./XTT
          00             H1=H4**0.25
          00             H2=H1*H1
          00             H3=H2*H1
          00             FEELIQ=EXP(A0+A1*H1+A2*H2+A3*H3+A4*H4)
          00             FEELIQ=FEELIQ**2
          00             END

END ELT.  ERRORS: NONE.  TIME:  0.098 SEC.  IMAGE COUNT: 48

@HDG,P  ******  FGIBBS  ****** .L,0
```

```
@ELT,L DD.FGIBBS
ELT 8R1 S74Q1C 07/21/84 15:55:07 (0)
00            FUNCTION FGIBBS(T,P,X,V)
00      C
00      C
00      C**** PURPOSE:
00      C        TO EVALUATE GIBBS FREE ENERGY
00      C
00      C**** INPUT:
00      C        P  - REFRIG. PRESSURE   (ATM)
00      C        T  - REFRIG. TEMPERATURE   (K)
00      C        V  - REFRIG. SPEC. VOLUME   (L/MOL)
00      C        X  - MOLAR CONCENTRATION OF A LESS VOLATILE REFRIG.   (-)
00      C        *  - CONSTANTS A @ B AS PER COMMON STATEMENT PARAM
00      C
00      C**** OUTPUT:
00      C        G  - GIBBS FREE ENERGY   (KJ)
00      C
00      C
00            COMMON/PARAM/A,B,C1,C2,D1,D2
00            DATA R/0.08206/
00      C
00      C
00            G=R*T*ALOG(R*T/(P*V))
00            G=G-2.*R*T/(V-B/4.)*(V-B/2.)
00            G=G+A/B*(ALOG(V/(V+B))-B/(V+B))
00            G=G+R*T/(V-B/4.)**2*(2.*V**3/(V-B/4.)+B**2/16.)
00            IF(X.EQ.0.OR.X.EQ.1.)GOTO 10
00            G=G+R*T*(X*ALOG(X)+(1.-X)*ALOG(1.-X))
00         10 FGIBBS=G
00            RETURN
00            END

END ELT.  ERRORS: NONE. TIME:  0.081 SEC. IMAGE COUNT: 30

@HDG,P  ******  HCVCP  ****** .L,0
```

```
@ELT,L DD.HCVCP
ELT 8R1 S74Q1C 07/21/84 15:55:07 (0)
00            SUBROUTINE HCVCP(IQ,T,V,X,H,CV,CP)
00      C
00      C
00      C**** PURPOSE:
00      C        TO CALCULATE REFRIG. THERMODYNAMIC PROPERTIES
00      C
00      C**** INPUT:
00      C        IQ - OUTPUT QUALIFIER
00      C            = 1 FOR ENTHALPY ONLY
00      C            = 2 FOR ENTHALPY AND SPEC. HEAT AT CONST. VOL.
00      C            = 3 FOR ENTHALPY, SPEC. HEAT AT CONST. VOL. @
00      C                SPEC. HEAT AT CONST. PRESSURE
00      C            = 4 FOR SPEC. HEAT AT CONST. VOL. ONLY
00      C            = 5 FOR SPEC HEAT AT CONST. VOL. @ SPEC. HEAT
00      C                AT CONST. PRESSURE
00      C        T  - REFRIG. TEMPERATURE    (K)
00      C        V  - REFRIG. SPEC VOLUME    (L/MOL)
00      C        X  - MOLAR CONCENTRATION    (FRACTION OF LESS VOLATILE REFRIG.)
00      C        W1 - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT    (G/MOL)
00      C        W2 - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT    (G/MOL)
00      C        *  - CONSTANTS AS PER COMMON STATEMENT /PARAM/
00      C             A,B,C1,D1      FOR CALC. OF ENTHALPY
00      C             A,B,C1,C2,D1,D2  FOR CALC. OF EITHER OF SPEC. HEAT
00      C
00      C**** OUTPUT:
00      C        CP - SPEC. HEAT AT CONST. PRESSURE    (BTU/(LB*F))
00      C        CV - SPEC. HEAT AT CONST. VOLUME    (BTU/(LB*F))
00      C        H  - ENTHALPY    (BTU/LB)
00      C
00      C
00            COMMON/PARAM/A,B,C1,C2,D1,D2
00            COMMON/RDATA2/W1,W2
00            DATA R/0.08206/
00      C
00      C**** SUBPROGRAMS CALLED BY HCVCP:
00      C        HPAR
00      C
00            CALL HPAR(IQ,T,X)
00            WMOL=(1.-X)*W1+X*W2
00            CONV=453.5924/(1.055056*WMOL)
00            T2=T*T
00            T3=T2*T
00            IF(IQ.GT.3)GOTO 10
00      C**** CALC. OF ENTHALPY
00            H=(C1*B*T-A*D1*T-A*B)/B**2*ALOG((V+B)/V)
00            H=H+(A*D1*T-A*B)/(B*(V+B))
00            H=H+2.*R*T*V*(2.*V-B/4.)/(V-B/4.)**3*(B/4.-D1*T/4.)
00            H=0.101325*H
00            H=H+(1.-X)*(0.0199537*(T-233.15)+1.0819725E-04*(T2-233.15**2))
00            H=H-(1.-X)*(5.67469E-08*(T3-233.15**3))
00            H=H+(1.-X)*16.8976630893
00            H=H+X*(0.0222804*(T-233.15)+7.700465E-05*(T2-233.15**2))
00            H=H+X*(1.0222346E-09*(233.15**3-T3)+21.9460206504)
00            H=H*CONV
00      C
00            IF(IQ.EQ.1)GOTO 1000
```

```
00      10 D12=D1*D1
00         CV=(C2*B**2*T-2.*C1*D1*B*T+2.*A*D12*T-A*D2*B*T)/B**3
00         CV=CV*ALOG((V+B)/V)
00         CV=CV+T/B/(V+B)*((A*D2*B+2.*C1*D1*B-2.*A*D12)/B)
00         CV=CV-T/B/(V+B)*A*D12/(V+B)
00         CV=CV+2.*R*T*V/(V-B/4.)**3*((D2/4.*T+D1/2.)*(B/4.-2.*V)+D12/16.*T)
00         CV=CV+6.*R*T2*V*D12/16.*(B/4.-2.*V)/(V-B/4.)**4
00         CV=0.101325*CV
00         CV=CV+(1.-X)*(0.0116293+2.163944E-04*T-1.792407E-7*T2)
00         CVM=CV+X*(0.013966+1.540093E-04*T-3.0667049E-9*T2)
00         CV=CVM*CONV/1.8
00         IF(IQ.EQ.2.OR.IQ.EQ.4)GOTO 1000
00         Y=B/V/4.
00         Y2=Y*Y
00         Y3=Y2*Y
00         Y4=Y3*Y
00         PO=-R/(1.-Y)**4*(1+4.*Y+4.*Y2-4.*Y3+Y4)+A*(2.*V+B)/T/(V+B)**2
00         TO=R/(1.-Y)**3*(1+Y+Y2-Y3+D1*T*(4.+4.*Y-2.*Y2)/V/4./(1.-Y))
00         TO=TO-C1/(V+B)+A*D1/(V+B)**2
00         CP=-0.101325*TO**2/PO
00         CP=CONV*(CP+CVM)/1.8
00    1000 RETURN
00         END
```

END ELT. ERRORS: NONE. TIME: 0.134 SEC. IMAGE COUNT: 79

@HDG,P ****** HPAR ****** .L,0

```
@ELT,L DD.HPAR
ELT 8R1 S74Q1C 07/21/84 15:55:08 (0)
00          SUBROUTINE HPAR(IQ,T,X)
00    C
00    C
00    C**** PURPOSE:
00    C       TO CALC. PARAMETERS FOR CALCULATIONS OF REFRIG.
00    C       ENTHALPY ,SPEC. HEAT AND ENTROPY
00    C       (CONSTANTS A @ B FOR EQ. OF STATE ARE INCLUDED)
00    C
00    C**** INPUT:
00    C       REFRIG. CONSTANTS AS LISTED IN THE COMMON STATEMENT /RDATA1/
00    C       IQ - OUTPUT QUALIFIER
00    C          = 1,  IF CONSTANTS FOR CALC. OF ENTHALPY OR ENTROPY REQUIRED
00    C          > 1,  IF ALSO CONSTANTS FOR SPEC. HEAT REQUIRED
00    C       T  - REFRIG. TEMPERATURE  (K)
00    C       X  - MOLAR CONCENTRATION OF A LESS VOLATILE REFRIG.   (-)
00    C
00    C**** OUTPUT:
00    C       *  - CONSTANTS FOR EVALUATION OF REFRIG.
00    C            ENTHALPY, A,B,C1,D1
00    C            ENTROPY, A,B,C1,D1
00    C            SPEC. HEAT, A,B,C1,C2,D1,D2
00    C
00    C**** PROGRAMS CALLED BY HPAR:
00    C       EQPAR
00    C
00          COMMON/RDATA1/A3,A4,A5,A6,A7,A8,B3,B4,B5,B6,B7,B8,F0,F1
00          COMMON/PARAM/A,B,C1,C2,D1,D2
00          COMMON/STORE1/A1,A2,B1,B2,SEG31
00          DATA TLAST,XLAST/2*0./
00    C
00    C
00          CALL EQPAR(T,X)
00          IF(ABS(T-TLAST).GT.0.0001)GOTO 10
00          IF(ABS(X-XLAST).GT.0.0001)GOTO 10
00          IF(IQ.NE.1)GOTO 10
00          RETURN
00    C
00       10 TLAST=T
00          XLAST=X
00          X2=X**2
00          XX=1.-X
00          XX2=XX**2
00          XXX=X*XX
00          T2=T**2
00          A1A2S=SQRT(A1*A2)
00          SEG1=XXX*A1A2S
00          F=F0+F1*T
00          SEG2=XXX*(1.-F)*A1A2S
00          SEG32=SEG31**2
00          SEG5=B4+2.*B5*T
00          SEG6=B7+2.*B8*T
00          SEG7=A4+2.*A5*T
00          SEG8=A7+2.*A8*T
00          SEG9=B1**(2./3.)
00          SEG10=B2**(2./3.)
00          D1=XX2*SEG5+X2*SEG6
```

```
00      D4=SEG5/SEG9+SEG6/SEG10
00      D4=D4*XXX*SEG32
00      D1=D1+D4
00      C1=XX2*SEG7+X2*SEG8
00      C1=C1+SEG1*((1.-F)*SEG7/A1)
00      C1=C1+SEG1*((1.-F)*SEG8/A2)
00      C1=C1-2.*XXX*F1*A1A2S
00      IF(IQ.EQ.1)RETURN
00   C
00      D2=SEG5**2/B1**(5./3.)+SEG6**2/B2**(5./3.)
00      D2=-2./3.*D2+2.*(B5/SEG9+B8/SEG10)
00      D2=D2*XXX*SEG32
00      D3=SEG5/SEG9+SEG6/SEG10
00      D3=D3**2*XXX*SEG31/3.
00      D2=D2+D3+2.*(XX2*B5+X2*B8)
00      C2=2.*(XX2*A5+X2*A8)
00      C2=C2-2.*SEG1*F1*(SEG7/A1+SEG8/A2)
00      C2=C2+SEG2*(2.*A5/A1+2.*A8/A2)
00      C2=C2+SEG2*(SEG7*SEG8/A1/A2)
00      C3=(SEG7/A1)**2+(SEG8/A2)**2
00      C2=C2-XXX*(1.-F)*(A1*A)**0.5*C3/2.
00      RETURN
00      END
```

END ELT. ERRORS: NONE. TIME: 0.125 SEC. IMAGE COUNT: 79

@HDG,P ****** HPIN ****** .L,0

```
@ELT,L DD.HPIN
ELT 0R1 S74Q1C 07/21/84 15:55:08 (0)
00          SUBROUTINE HPIN(IG,H,P,X,ACCUR,T,XQ,XL,XV,VL,VV)
00    C
00    C
00    C**** PURPOSE:
00    C       TO CALC. TEMPERATURE OF BINARY MIXTURE FROM GIVEN
00    C       ENTHALPY AND PRESSURE
00    C
00    C**** INPUT:
00    C       ACCUR   - REQUIRED ACCURACY OF CONVERGANCE   (BTU/LB)
00    C       IG      = 0,  IF GUESS OF TEMPERATURE IS NOT GIVEN
00    C               = 1,  IF GUESS OF TEMPERATURE IS GIVEN
00    C       H       - ENTHALPY   (BTU/LB)
00    C       P       - PRESSURE   (STD ATM)
00    C       T       - GUESS OF TEMPERATURE, OPTIONAL  (K)
00    C       X       - MOLAR CONCENTRATION   (FRACTION OF LESS VOLATILE COMPONENT)
00    C
00    C**** OUTPUT:
00    C       T       - BINARY MIXTURE TEMPERATURE    (K)
00    C       VL      - SPEC. VOLUME OF SUBCOOLED OR SAT. LIQUID AT T TEMP.
00    C                 AND P PRESSURE, IF MIXTURE IS SUBCOOLED
00    C                 OR IN TWO-PHASE, RESPECTIVELY.   (L/MOL)
00    C       VV      - SPEC. VOLUME OF SUPERHEATED OR SAT. VAPOR AT T TEMP.
00    C                 AND P PRESSURE, IF MIXTURE IS SUPERHEATED
00    C                 OR IN TWO-PHASE, RESPECTIVELY.   (L/MOL)
00    C       XL      - MOLAR COMPOSITION OF SAT. LIQUID
00    C                 (FRACTION OF LESS VOLATILE COMPONENT)
00    C       XV      - MOLAR COMPOSITION OF SAT. VAPOR  (FRACTION OF LESS VOLATILE COMPONENT)
00    C       XQ      - QUALITY   (-)
00    C
00    C**** SUBPROGRAMS CALLED BY HPIN:
00    C       DBUBTE,DDEWTE,DQLITY,EBUBTE,HCVCP,QLITY,VOLIT1
00    C
00          REAL*8 TDD,PDD,XQDD,XVDD,XLDD
00    C
00          COMMON/RDATA2/W1,W2,TC1,TC2
00          DATA SLOPE/0./,PLAST/0./
00    C
00          IF(P.LE.0.)THEN
00             PRINT 590,P
00      590 FORMAT(' HPIN CALLED WITH NON-POSSITIVE PRESSURE, PATM=',1PE15.6)
00             RETURN
00          END IF
00    C
00          TT=T
00          IF(ABS(P-PLAST).GT.1.E-4)GOTO 2
00          IF(ABS(H-HLAST).GT.ACCUR)GOTO 2
00          IF(ABS(X-XLAST).GT.1.E-4)GOTO 2
00          T=TLAST
00          XQ=XQLAST
00          XL=XLLAST
00          XV=XVLAST
00          VL=VLLAST
00          VV=VVLAST
00          RETURN
00    C
00        2 IF(IG.NE.1)T=EBUBTE(P,X)-3.
```

```
00         XQX=.5
00         IDD=1.0029-ACCUR
00         DO 50 I=1,20
00         IF(I.EQ.1)GOTO 8
00         IF(XQ.EQ.0..AND.HDIF2.LT.0.)GOTO 11
00         IF(XQ.EQ.1..AND.HDIF2.GT.0.)GOTO 12
00       8 IF(T.GT.TC1)THEN
00            XQ=1.
00            GOTO 12
00         END IF
00         IF(IDD.EQ.0)THEN
00            CALL QLITY(T,P,X,XQ,XV,XL)
00         ELSE
00            TDD=T
00            PDD=P
00            CALL DQLITY(TDD,PDD,X,XQDD,XVDD,XLDD)
00            XQ=XQDD
00            XV=XVDD
00            XL=XLDD
00         END IF
00         IF(XQ.EQ.1.)GOTO 12
00      11 XX=X
00         IF(XQ.NE.0.)XX=XL
00         CALL VOLIT1(0,T,P,XX,VL)
00         CALL HCVCP(1,T,VL,XX,HL,CV,CP)
00         IF(XQ.EQ.0.)GOTO 14
00      12 XX=X
00         IF(XQ.NE.1.)XX=XV
00         CALL VOLIT1(1,T,P,XX,VV)
00         CALL HCVCP(1,T,VV,XX,HV,CV,CP)
00      14 HH=(1.-XQ)*HL+XQ*HV
00         T2=T
00         HDIF2=H-HH
00         IF(ABS(HDIF2).LT.ACCUR)GOTO 100
00         IF(I.NE.1)GOTO 20
00      15    T1=T2
00            HDIF1=HDIF2
00            IF(SLOPE.NE.0.)THEN
00               DT=HDIF2*SLOPE
00               IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
00               T=T2-DT
00               GOTO 48
00            END IF
00            T=T2+8.
00            IF(HDIF2.LT.0.)T=T2-8.
00            GOTO 48
00   C
00      20 IF(XQ.EQ.0..AND.HDIF2.GT.0.)THEN
00            IF(XQX.EQ.0.)GOTO 22
00            IDD=1
00            TDD=T2
00            PDD=P
00            CALL DBUBTE(1,PDD,X,TDD,XVDD)
00            TB=TDD
00            CALL VOLIT1(0,TB,P,X,VL)
00            CALL HCVCP(1,TB,VL,X,HB,CV,CP)
00            IF(H.GT.HB)THEN
00               HDIF2=H-HB
```

```
00                T2=TB
00             ELSE
00                HDIF1=H-HB
00                T1=TB
00             END IF
00             GOTO 22
00          END IF
00          IF(XQ.EQ.1..AND.HDIF2.LT.0.)THEN
00             IF(XQX.EQ.1.)GOTO 22
00             IDD=1
00             TDD=T2
00             PDD=P
00             CALL DDEWTE(1,PDD,X,TDD,XLDD)
00             TD=TDD
00             CALL VOLIT1(1,TD,P,X,VV)
00             CALL HCVCP(1,TD,VV,X,HV,CV,CP)
00             IF(H.LT.HV)THEN
00                T2=TD
00                HDIF2=H-HV
00             ELSE
00                T1=TD
00                HDIF1=H-HV
00             END IF
00          END IF
00       22 IF(HDIF1.EQ.HDIF2)THEN
00             WRITE(6,601)XQ,DT,HDIF2
00             GOTO 60
00          END IF
00          SLOPE=(T2-T1)/(HDIF2-HDIF1)
00          IF(ABS(HDIF1).LT.ABS(HDIF2))GOTO 30
00             T1=T2
00             HDIF1=HDIF2
00       30 DT=HDIF1*SLOPE
00          IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
00          T=T1-DT
00       48 XQX=XQ
00       50 CONTINUE
00       60 WRITE(6,600)IG,HDIF2,H,P,X,ACCUR,TT,XQ,XQX
00      600 FORMAT(' ERROR 600 IN HPIN, IG,HDIF2=',I3,1PE12.4,
00         & /,' H,P,X,ACCUR,TT,XQ,XQX=',7(1PE12.4))
00      601 FORMAT(' HPIN DOES NOT CONVERGE ANY FURTHER, XQ,DT,HDIF2=',3F8.4)
00      100 PLAST=P
00          HLAST=H
00          XLAST=X
00          TLAST=T
00          XQLAST=XQ
00          XLLAST=XL
00          XVLAST=XV
00          VLLAST=VL
00          VVLAST=VV
00          RETURN
00          END
```

END ELT. ERRORS: NONE. TIME: 0.221 SEC. IMAGE COUNT: 166

@HDG,P ****** HPPROP ****** .L,0

```
@ELT,L DD.HPPROP
ELT 8R1 S74Q1C 07/21/84 15:55:08 (0)
      SUBROUTINE HPPROP(IG,H,PA,XM,ACC,TK,XQ,XML,XMV,VLM,VVM,
     @ VM,V,CP,CV,AM,AK)
C
C**** PURPOSE:
C       TO CALC. THERMODYNAMIC AND TRANSPORT AND PROPERTIES
C       OF BINARY MIXTURE FROM GIVEN PRESSURE AND ENTHALPY
C
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  - MOLAR COMPOSITION   (FRACTION OF LESS VOLATILE COMPONENT)
C
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*F))
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       XML - COMPOSITON OF SAT. LIQUID AT TK TEMP. AND PA PRESSURE
C             (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
C       XMV - COMPOSITION OF SAT. VAPOR AT TK TEMP. AND PA PRESSURE
C             (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
C       XQ  - QUALITY   (-)
C
C**** SUBPROGRAMS CALLED BY HPPROP:
C       HCVCP,HPIN,VISCON
C
      COMMON/RDATA2/W1,W2,TC1,TC2
      DATA N1,N2,N3,N4,N5/1,2,3,4,5/
C
C
      WM=(1.-XM)*W1+XM*W2
      XW=XM/(W1/W2*(1.-XM)+XM)
      CALL HPIN(IG,H,PA,XM,ACC,TK,XQ,XML,XMV,VLM,VVM)
      T=TK*1.8-459.67
      IF(XQ.EQ.0.)THEN                    @SUBCOOLED LIQUID
         VM=VLM
         V=VM*16.01846/WM
         AM=VISCON(N1,T,XW)
         AK=VISCON(N2,T,XW)
         CALL HCVCP(N5,TK,VLM,XM,DUM,CV,CP)
         GOTO 1000
      END IF
C
      IF(XQ.NE.1.)THEN                    @TWO-PHASE
         XL=XML/(W1/W2*(1.-XML)+XML)
```

```
  570.        00              XV=XMV/(W1/W2*(1.-XMV)+XMV)
  580.        00              AM=(1.-XQ)*VISCON(N1,T,XL)
  590.        00              AM=AM+XQ*VISCON(N3,T,XV)
  600.        00              AK=(1.-XQ)*VISCON(N2,T,XL)
  610.        00              AK=AK+XQ*VISCON(N4,T,XV)
  620.        00              WML=(1.-XML)*W1+XML*W2
  630.        00              WMV=(1.-XMV)*W1+XMV*W2
  640.        00              V=16.01845*((1.-XQ)*VLM/WML+XQ*VVM/WMV)
  650.        00              VM=V*WM/16.01846
  660.        00              CALL HCVCP(N5,T,VLM,XML,DUM,CVL,CPL)
  670.        00              CALL HCVCP(N5,T,VVM,XMV,DUM,CVV,CPV)
  680.        00              CP=(1.-XQ)*CPL+XQ*CPV
  681.        00              CV=(1.-XQ)*CVL+XQ*CVV
  690.        00           ELSE                          @SUPERHEATED VAPOR
  700.        00              VM=VVM
  710.        00              V=VM*13.01846/WM
  720.        00              AM=VISCON(N3,T,XW)
  730.        00              AK=VISCON(N4,T,XW)
  740.        00              CALL HCVCP(N5,TK,VVM,XM,DUM,CV,CP)
  750.        00           END IF
  760.        00      1000 RETURN
  770.        00           END

END ELT.  ERRORS: NONE.  TIME:  0.161 SEC.  IMAGE COUNT: 78

@HDG,P  ******  HTCCON  ***-** .L,0
```

```
@ELT,L DD.HTCCON
ELT 8R1 S74Q1C 07/21/84 15:55:09 (0)
          00                FUNCTION HTCCON(T,P,RMAS,D)
          00          C
          00          C**** PURPOSE:
          00          C       TO COMPUTE CONDENSATION HEAT TRANSFER COEFFICIENT
          00          C       FOR NON-AZEOTROPIC MIXTURE FLOW INSIDE A TUBE
          00          C
          00          C**** INPUT DATA:
          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                 (FRACTION OF LESS VOLATILE COMPONENT)
          00          C       XM      - MIXTURE MOLAR COMPOSITION
          00          C                 (FRACTION OF LESS VOLATILE COMPONENT)
          00          C       W1      - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT   (G/MOL)
          00          C       W2      - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT   (G/MOL)
          00          C
          00          C**** SUBPROGRAMS CALLED BY HTCCON:
          00          C       BUBTEM,DEWTEM,HCVCP,QLITY,SPHTC,VISCON,VOLIT1
          00          C
          00                COMMON/RDATA2/W1,W2,TC1,TC2
          00                COMMON/RDATA3/XW,XM,WM
          00          C
          00                TK=(T+459.67)/1.8
          00                PA=P/14.6959
          00                CALL QLITY(TK,PA,XM,X,XV,XL)
          00                X1=X
          00                IF(X.LT.0.1)X1=0.1
          00                IF(X.GT.0.95)X1=0.95
          00                G=0.7853981*D*D
          00                G=RMAS/G
          00          C
          00                CALL VOLIT1(0,TK,PA,XL,VL)
          00                CALL HCVCP(5,TK,VL,XL,H,CV,CPL)
          00                WMOL=W1*(1.-XL)+W2*XL
          00                VL=16.01846*VL/WMOL
          00                XL=XL/(W1/W2*(1.-XL)+XL)
          00                VISL=VISCON(1,T,XL)
          00                CONL=VISCON(2,T,XL)
          00                CALL VOLIT1(1,TK,PA,XV,VV)
          00                WMOL=W1*(1.-XV)+W2*XV
          00                VV=16.01846*VV/WMOL
          00                XV=XV/(W1/W2*(1.-XV)+XV)
          00                VISV=VISCON(3,T,XV)
          00                PRF=VISL*CPL/CONL
          00                RETP=G*(1.-X1)*D/VISL
          00                XTT=((1.-X1)/X1)**0.9*SQRT(VL/VV)*(VISL/VISV)**0.1
          00                F1=0.15*(1.+2.85*XTT**0.524)/XTT
          00                F2=0.707*PRF*SQRT(RETP)
          00                IF(RETP.GT.50..AND.RETP.LT.1125.)F2=5.*PRF+5.*ALOG(1.+PRF*(
          00               &0.09636*RETP**0.585-1.))
          00                IF(RETP.GE.1125.)F2=5.*PRF+5.*ALOG(1.+5.*PRF)+2.5*ALOG(0.0031*RETP
          00               &**0.812)
          00                ALF=1.
          00                IF(F1.GT.1.)ALF=1.15
```

```
******  HTCCON  ******                                                  DATE 072184

          00          HTCCON=CONL*PRF*F1**ALF*RETP**0.9/(D*F2)
          00          IF(X.GE.0.1)GOTO10
          00          CALL BUBTEM(1,PA,XM,TK,XV)
          00          CALL VOLIT1(0,TK,PA,XM,VL)
          00          CALL HCVCP(5,TK,VL,XM,H,CV,CPL)
          00          TFB=TK*1.8-459.67
          00          VISL=VISCON(1,TFB,XW)
          00          CONL=VISCON(2,TFB,XW)
          00          HL=SPHTC(CPL,VISL,CONL,RMAS,D)
          00          HTCCON=HL+10.*X*(HTCCON-HL)
          00          GOTO20
          00       10 CONTINUE
          00          IF(X.LE.0.95)GOTO20
          00          CALL DEWTEM(1,PA,XM,TK,XL)
          00          CALL VOLIT1(1,TK,PA,XM,VV)
          00          CALL HCVCP(5,TK,VV,XM,H,CV,CPV)
          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
```

```
@ELT,L DD.HTCEV
ELT 8R1 S74Q1C 07/21/84 15:55:09 (0)
00             FUNCTION HTCEV(TF,PSIA,RMS,DDI,XTT)
00       C
00       C**** PURPOSE:
00       C        TO COMPUTE EVAPORATION HEAT TRANSFER COEFFICIENT
00       C        FOR NON-AZEOTROPIC MIXTURE FLOW INSIDE A TUBE
00       C
00       C**** INPUT DATA:
00       C        DDI    - TUBE DIAMETER   (FT)
00       C        PSIA   - REFRIG. AVERAGE PRESSURE   (PSIA)
00       C        RMS    - REFRIG. MASS FLOW RATE   (LBM/H)
00       C        TF     - REFRIG. AVERAGE TEMPERATURE   (F)
00       C        XM     - MIXTURE MOLAR COMPOSITION
00       C                 (FRACTION OF LESS VOLATILE COMPONENT)
00       C        W1     - MOLECULAR WEIGHT OF MORE VOLATILE COMPONENT   (G/MOL)
00       C        W2     - MOLECULAR WEIGHT OF LESS VOLATILE COMPONENT   (G/MOL)
00       C
00       C**** OUTPUT DATA:
00       C        HTCEV - EVAPORATIVE HEAT TRANSFER COEFF.   (BTU/(H*F*FT**2))
00       C        XTT   - LOCKHART-MARTINELLI PRESSURE DROP PARAMETER
00       C
00       C**** SUBPROGRAMS CALLED BY HTCEV:
00       C        HCVCP,QLITY,SPHTC,VISCON,VOLIT1
00       C
00             COMMON/RDATA2/W1,W2,TC1,TC2
00             COMMON/RDATA3/XW,XM,WM
00       C
00             PA=PSIA/14.6959
00             TK=(TF+459.67)/1.8
00             CALL QLITY(TK,PA,XM,XQ,XV,XL)
00       C
00             IF(XQ.EQ.0..OR.XQ.EQ.1.)THEN
00             PRINT 10,XQ
00          10 FORMAT('  ERROR IN CALLING HTCEV, XQ=',F4.1)
00             HTCEV=200.
00             RETURN
00             END IF
00       C
00             XLW=XL/(W1/W2*(1.-XL)+XL)
00             XVW=XV/(W1/W2*(1.-XV)+XV)
00             VISL=VISCON(1,TF,XLW)
00             CONL=VISCON(2,TF,XLW)
00             VISV=VISCON(3,TF,XVW)
00             CALL VOLIT1(0,TK,PA,XL,VL)
00             CALL HCVCP(5,TK,VL,XL,HL,CV,CPL)
00             CALL VOLIT1(1,TK,PA,XV,VV)
00             WML=W1*(1.-XL)+W2*XL
00             WMV=W1*(1.-XV)+W2*XV
00             VLW=VL*16.01846/WML
00             VVW=VV*16.01846/WMV
00             XTT=((1.-XQ)/XQ)**.9*(VLW/VVW)**.5*(VISL/VISV)**.1
00             HL=SPHTC(CPL,VISL,CONL,RMS,DDI)
00             HTCEV=2.12*HL*(1./XTT)**0.866
00             HTCEV=3.23*HL*XTT**(-0.3)
00             RETURN
00             END
```

```
@ELT,L DD.HXCODE
ELT 8R1 S74Q1C 07/21/84 15:55:09 (0)
      SUBROUTINE HXCODE(IIO)
C
C
C**** THIS PROGRAM DETERMINES REFRIGERANT & AIR FLOW
C**** DISTRIBUTION FOR HEAT EXCHANGER TUBES
C
C**** INPUT DATA:
C        IFROM(IIO,J)   - NUMBER OF TUBE TUBE J RECEIVES REFRIG. FROM
C                         WHEN COIL WORKS AS EVAPORATOR   (-)
C        IIO            = 1  FOR INDOOR COIL   (-)
C                       = 2  FOR OUTDOOR COIL   (-)
C        NDEP(IIO)      - NUMBER OF COIL TUBE ROW DEPTHS   (-)
C        NSECT(IIO)     - NUMBER OF REPEATING SECTIONS   (-)
C        NTUB(IIO,N)    - NUMBER OF TUBES IN ROW N FOR EACH SECTION
C                         OF TUBE J   (-)
C
C**** OUTPUT DATA:
C        FLOW(IIO,J)    - FRACTION OF COIL TOTAL REFRIG. MASS FLOW
C                         PASSING THROUGH TUBE J   (-)
C        IDEPTH(IIO,J)  - DEPTH ROW OF A TUBE J   (-)
C        IMER(IIO)      - NUMBER OF MERGING TUBES   (-)
C        IST(IIO)       - NUMBER OF TUBES REFRIG. FLOWS INTO COIL
C                         WORKING AS CONDENSER   (-)
C        ISTART(IIO,L)  - NUMBER OF TUBE REFRIG. FLOWS INTO COIL
C                         WORKING AS CONDENSER, FOUND AS L SUCH TUBE   (-)
C        JFROM(IIO,J)   - NUMBER OF TUBE POSITIONED AIR UPSTREAM
C        KFEED(IIO,J,N) - NUMBER OF TUBE RECEIVING REFRIGERANT FROM
C                         TUBE J WHEN COIL WORKS AS EVAPORATOR.
C                         NOTE THAT TUBE J CAN FEED UP TO 3 TUBES
C                         (N CAN BE 1,2 AND 3)   (-)
C        KSTART(IIO,N)  - NUMBER OF TUBE REFRIGERANT FLOWS INTO COIL
C                         WORKING AS EVAPORATOR   (-)
C        KST(IIO)       - NUMBER OF TUBES REFRIGERANT FLOWS INTO COIL
C                         WORKING AS EVAPORATOR
C        MERGE(IIO,K,1) - NUMBER OF TUBE FOUND AS K MERGING TUBE   (-)
C        MERGE(IIO,K,2) - NUMBER OF TUBES MERGING INTO TUBE K   (-)
C        NTPS(IIO)      - NUMBER OF TUBES PER SECTION   (-)
C
      COMMON/HPHX/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),IFROM(2,130),NSECT(2),NTPS(2)
      COMMON/MERG/MERGE(2,20,2),IMER(2),ISTART(2,20),IST(2),
     &IDEPTH(2,130),FLOW(2,130),JFROM(2,130),KFEED(2,130,3),
     &KSTART(2,20),KST(2)
      DIMENSION IMC(20),IDID(130)
C
C**** FIND NUMBER TUBES PER SECTION
      NTPS(IIO)=0
      DO 1 I=1,5
    1 NTPS(IIO)=NTPS(IIO)+NTUB(IIO,I)
C
      DO 2 I=1,NTPS(IIO)
    2 FLOW(IIO,I)=0.
      DO 4 I=1,20
    4 MERGE(IIO,I,1)=0
C
```

```
00      C**** FIND TUBES REFRIGERANT ENTERS CONDENSER
00      C**** FIND TUBES REFRIGERANT MERGES
00            IS=0
00            IM=0
00            DO 10 J=1,NTPS(IIO)
00            NM=0
00            DO 6 I=1,NTPS(IIO)
00            IF(IFROM(IIO,I).NE.J)GOTO 6
00            NM=NM+1
00          6 CONTINUE
00            IF(NM.EQ.0)GOTO 8
00            IF(NM.EQ.1)GOTO 10
00            IM=IM+1
00            MERGE(IIO,IM,1)=J
00            MERGE(IIO,IM,2)=NM
00            GOTO 10
00          8 IS=IS+1
00            ISTART(IIO,IS)=J
00         10 CONTINUE
00            IST(IIO)=IS
00            IMER(IIO)=IM
00      C
00      C**** FIND REFRIGERANT FLOW DISTRIBUTION
00            DO 12 L=1,IM
00            IMC(L)=MERGE(IIO,L,2)
00         12 CONTINUE
00            SECFLW=1./FLOAT(NSECT(IIO))
00            STFLOW=SECFLW/FLOAT(IS)
00            DO 20 IB=1,IS
00            I=ISTART(IIO,IB)
00            FLOW(IIO,I)=STFLOW
00         14 J=IFROM(IIO,I)
00            IF(J.EQ.0)GOTO 20
00            DO 16 IC=1,IM
00            IF(MERGE(IIO,IC,1).EQ.J)GOTO 18
00         16 CONTINUE
00            FLOW(IIO,J)=FLOW(IIO,I)
00            I=J
00            GOTO 14
00         18 FLOW(IIO,J)=FLOW(IIO,J)+FLOW(IIO,I)
00            IMC(IC)=IMC(IC)-1
00            IF(IMC(IC).NE.0)GOTO 20
00            I=J
00            GOTO 14
00         20 CONTINUE
00      C
00      C**** FIND DEPTH ROW FOR EACH TUBE
00            NNDEP=NDEP(IIO)
00            ILAST=0
00            DO 22 J=1,NNDEP
00            IFIRST=ILAST+1
00            ILAST=ILAST+NTUB(IIO,J)
00            DO 22 I=IFIRST,ILAST
00            IDEPTH(IIO,I)=J
00         22 CONTINUE
00      C
00      C**** FIND AIR FLOW DISTRIBUTION
00            DO 40 I=1,NTUB(IIO,1)
```

```
00       40 JFROM(IIO,I)=999
00          N=1+NTUB(IIO,1)
00          DO 44 I=N,NTPS(IIO)
00          ICT=IDEPTH(IIO,I)
00          J=I-NTUB(IIO,ICT-1)
00          ICTJ=IDEPTH(IIO,J)
00          IF(ICTJ.EQ.ICT)THEN
00             IB=ICT-1
00             J=0
00             DO 42 K=1,IB
00       42    J=J+NTUB(IIO,K)
00          END IF
00          JFROM(IIO,I)=J
00       44 CONTINUE
00    C
00    C**** FIND REFRIG. FLOW PATH IN EVAPORATOR COIL
00          DO 50 I=1,NTPS(IIO)
00          DO 48 IK=1,IMER(IIO)
00          IF(I.NE.MERGE(IIO,IK,1))GOTO 48
00          IDID(I)=MERGE(IIO,IK,2)
00          GOTO 50
00       48 CONTINUE
00          IDID(I)=1
00       50 CONTINUE
00    C
00          KS=0
00          DO 60 IS=1,IST(IIO)
00          I=ISTART(IIO,IS)
00          KFEED(IIO,I,1)=-1
00       54 J=I
00          I=IFROM(IIO,J)
00          IF(I.EQ.0)THEN
00             KS=KS+1
00             KSTART(IIO,KS)=J
00             KST(IIO)=KS
00             GOTO 60
00          END IF
00          IF(IDID(I).EQ.0)GOTO 60
00          N=IDID(I)
00          KFEED(IIO,I,N)=J
00          IDID(I)=IDID(I)-1
00          GOTO 54
00       60 CONTINUE
00          RETURN
00          END
```

END ELT. ERRORS: NONE. TIME: 0.225 SEC. IMAGE COUNT: 159

@HDG,P ****** MVAL4 ****** .L,0

```
@ELT,L DD.MVAL4
ELT 8R1 S74Q1C 07/21/84 15:55:10 (0)
       00             SUBROUTINE MVAL4(XW,RMASS,V2,AM2,AK2,CP2,
       00            @  V7,AM7,AK7,CP7,V11,AM11,AK11,CP11,V71,AM71,AK71,CP71)
       00       C
       00       C**** PURPOSE:
       00       C       TO SIMULATE PERFORMANCE OF 4-WAY VALVE
       00       C       (BINARY MIXTURE REFRIGERANT)
       00       C
       00       C**** INPUT DATA:
       00       C       RMASS      - REFRIG. MASS FLOW RATE   (LB/H)
       00       C       XW         - COMPOSITION   (WEIGHT FRACTION OF LESS VOLATILE COMPONENT)
       00       C     * REFRIG. PARAMETERS & PROPERTIES:
       00       C       AK2,AK7    - THERMAL CONDUCTIVITY    (BTU/H*F*FT)
       00       C       AM2,AM7    - DYNAMIC VISCOSITY    (LB/H*FT)
       00       C       CP2,CP7    - SPECIFIC HEAT AT CONST. PRESSURE   (BTU/LB*F)
       00       C       H2,H7      - ENTHALPY   (BTU/LB)
       00       C       P2,P7      - PRESSURE   (PSIA)
       00       C       T2,T7      - TEMPERATURE   (F)
       00       C       V2,V7      - SPEC. VOLUME   (FT**3/LB)
       00       C       WHERE IN ABOVE SYMBOLS NUMBERS DENOTE LOCATION:
       00       C                  2      4-WAY VALVE LOW PRESSURE OUTLET
       00       C                  7      4-WAY VALVE HIGH PRESSURE INLET
       00       C     * 4-WAY VALVE PARAMETERS:
       00       C       CPDR       - PARAMETER FOR PRESSURE DROP   (LBF*H**2/LB*IN**2*FT**3)
       00       C       CQ         - PARAMETER FOR HEAT TRANSFER   (FT**.2)
       00       C
       00       C**** OUTPUT DATA:
       00       C     * REFRIG. PARAMETERS & PROPERTIES:
       00       C       AK11,AK71  - THERMAL CONDUCTIVITY   (BTU/H*F*FT)
       00       C       AM11,AM71  - DYNAMIC VISCOSITY   (LB/H*FT)
       00       C       CP11,CP71  - SPECIFIC HEAT AT CONST. PRESSURE   (BTU/LB*F)
       00       C       H11,H71    - ENTHALPY   (BTU/LB)
       00       C       P11,P71    - PRESSURE   (PSIA)
       00       C       T11,T71    - TEMPERATURE   (F)
       00       C       X11        - QUALITY   (-)
       00       C       V11,V71    - SPECIFIC VOLUME   (LB/FT**3)
       00       C       WHERE IN ABOVE SYMBOLS NUMBERS DENOTE LOCATION:
       00       C                  11    4-WAY VALVE LOW PRESSURE INLET
       00       C                  71    4-WAY VALVE HIGH PRESSURE OUTLET
       00       C
       00       C**** SUBPROGRAMS CALLED BY MVAL4:
       00       C       HPPROP
       00       C
       00             COMMON/RDATA2/W1,W2,TC1,TC2
       00             COMMON/COND2/P11,T11,H11,X11,S11
       00             COMMON/COND3/P2,T2,H2,S2
       00             COMMON/COND8/P7,T7,H7,S7
       00             COMMON/COND9/P71,T71,H71,S71
       00             COMMON/WAY4/CQ,CPDR
       00       C
       00             NO=0
       00             N1=1
       00             ACCUR=0.0003
       00       C
       00             PDRF=CPDR*RMASS*RMASS
       00       C
       00             XM=XW/(W2/W1*(1.-XW)+XW)
```

```
00          WM=(1-XM)*W1+XM*W2
00          TK2=(T2+459.67)/1.8
00          PA2=P2/14.6959
00          TK7=(T7+459.67)/1.8
00          PA7=P7/14.6959
00          RMASS8=RMASS**0.8
00          T11=T2
00          V11=V2
00          AM11=AM2
00          AK11=AK2
00          CP11=CP2
00          T71=T7
00          V71=V7
00          AM71=AM7
00          AK71=AK7
00          CP71=CP7
00    C
00          DO 100 I=1,10
00          VS=(V11+V2)/2.
00          AMS=(AM11+AM2)/2.
00          AKS=(AK11+AK2)/2.
00          CPS=(CP11+CP2)/2.
00          VH=(V7+V71)/2.
00          AMH=(AM7+AM71)/2.
00          AKH=(AK71+AK7)/2.
00          CPH=(CP7+CP71)/2.
00          P11=P2+PDRF*VS
00          PA11=P11/14.6959
00          P71=P7-PDRF*VH
00          PA71=P71/14.6959
00          HCS=RMASS8*AKS**0.667*CPS**0.333/AMS**0.467
00          HCH=RMASS8*AKH**0.667*CPH**0.333/AMH**0.467
00          DTA=T71-T11
00          DTB=T7-T2
00          IF(ABS(DTA-DTB).LT.0.01)GOTO20
00          TF=(DTA-DTB)/(ALOG(DTA/DTB))
00          GOTO 21
00       20 TF=T7-T2
00       21 Q=CO*TF/(1./HCS+1./HCH)
00          H71=H7-Q/RMASS                   @HIGH PRESSURE OUTLET
00          T71=T7-Q/(RMASS*CPH)
00          TK71=(T71+459.67)/1.8
00          CALL HPPROP(N1,H71,PA71,XM,ACCUR,TK71,XQ,XL,XV,VL71,VV71,
00         @ VM71,V71,CP71,CV,AM71,AK71)
00          T71=TK71*1.8-459.67
00    C
00          H11=H2-Q/RMASS                   @LOW PRESSURE OUTLET
00          T11=T2-Q/(RMASS*CPS)
00          TK11=(T11+459.67)/1.8
00          CALL HPPROP(N1,H11,PA11,XM,ACCUR,TK11,X11,XL,XV,VL11,VM11,
00         @ VM11,V11,CP11,CV,AM11,AK11)
00          T11=TK11*1.8-459.67
00          IF(I.EQ.1)GOTO51
00          IF(ABS(H71-H71A).LT.0.001)GOTO101
00          H71B=H71A
00       51 H71A=H71
00      100 CONTINUE
00          WRITE(6,600)H71A,H71B
```

```
          00     600 FORMAT(' MVAL4 DOES NOT CONVERGE, H71A,H71B=',2(1PE16.6))
          00     101 CONTINUE
          00         RETURN
          00         END

END ELT.  ERRORS: NONE. TIME:  0.161 SEC. IMAGE COUNT: 118

@HDG,P  ******  ØVLWET  ****** .L,0
```

```
****** OVLWET ******                                                DATE 072184

@ELT,L DD.OVLWET
ELT 8R1 S74Q1C 07/21/84 15:55:10 (0)
   00          SUBROUTINE OVLWET(AO,API,APM,HI,HD,HP,HL,HO,UAO,UPO,UWO)
   00    C
   00    C**** PURPOSE:
   00    C        TO COMPUTE OVERALL HEAT TRANSFER COEFFICIENT
   00    C        FOR A WET FINNED TUBE
   00    C
   00    C**** INPUT DATA:
   00    C        AO    - TOTAL OUTSIDE SURFACE AREA   (FT**2)
   00    C        API   - TUBE INSIDE SURFACE AREA   (FT**2)
   00    C        APM   - SURFACE AREA BASED ON TUBE MEAN DIAMETER   (FT**2)
   00    C        HD    - TUBE INSIDE SURFACE DEPOSIT HEAT TRANSFER COEFF.   (BTU/H*F*FT**2)
   00    C        HI    - TUBE INSIDE SURFACE HEAT TRANSFER COEFF.   (BTU/H*F*FT**2)
   00    C        HL    - HEAT TRANSFER COEFF. FOR WATER (FROST) LAYER   (BTU/H*F*FT**2)
   00    C        HP    - TUBE WALL HEAT TRANSFER COEFFICIENT   (BTU/H*F*FT**2)
   00    C        HO    - AIR-SIDE HEAT TRANSFER COEFF. FOR WET FINNED TUBE   (BTU/H*F*FT**2)
   00    C
   00    C**** OUTPUT DATA:
   00    C        UAO   - OVERALL HEAT TRANSFER COEFF. FOR WET FINNED TUBE   (BTU/H*F*FT**2)
   00    C        UPO   - HEAT CONDUCTANCE FROM REFRIGERANT TO TUBE SURFACE   (BTU/H*F)
   00    C        UWO   - HEAT CONDUCTANCE FROM REFRIGERANT TO WATER (FROST) SURFACE   (BTU/H*F)
   00    C
   00          U=AO/(API*HI)+AO/(API*HD)+AO/(APM*HP)
   00          UPO=AO/U
   00          U=U+1./HL
   00          UWO=AO/U
   00          U=U+1./HO
   00          UAO=AO/U
   00          RETURN
   00          END

END ELT.  ERRORS: NONE. TIME:  0.073 SEC. IMAGE COUNT: 29

@HDG,P  ******  PFLASH  ****** .L,0
```

```
@ELT,L DD.PFLASH
ELT 8R1 S74Q1C 07/21/84 15:55:10 (0)
      00               SUBROUTINE PFLASH(XM,H1,GN,TIN,TFLASH,PFLA,VL)
      00         C
      00         C**** PURPOSE:
      00         C        TO CALCULATE FLASHING PRESSURE  & TEMPERATURE
      00         C        FOR GIVEN CONSTANT ENERGY FLOW OF NON-AZEOTROPIC MIXTURE
      00         C
      00         C**** INPUT DATA:
      00         C        GN      = G*G/(64.4*778.104)    (BTU*LB/FT**6)
      00         C                  WHERE G - REFRIG. MASS FLUX   (LB/(SEC*FT**2))
      00         C        H1      - REFRIG TOTAL ENTHALPY    (BTU/LB)
      00         C        TIN     - PFLASHING TEMPERATURE ( GUESS)    (F)
      00         C
      00         C**** OUTPUT DATA:
      00         C        PFLASH - FLASHING PRESSURE    (PSIA)
      00         C        TFLASH - FLASHING TEMPERATURE    (F)
      00         C        VL     - SPEC. VOLUME OF LIQ. REFRIG.  (FT**3/LB)
      00         C        XM     - MOLAR COMPOSITION    (FRACTION OF LESS VOLATILE COMPONENT)
      00         C
      00         C**** SUBPROGRAMS CALLED BY PFLASH:
      00         C        BUBPRE,HCVCP,VOLIT1
      00         C
      00               COMMON/RDATA2/W1,W2,TC1,TC2
      00               DATA NO,N1/0,1/
      00               WM=W1*(1.-XM)+W2*XM
      00               TKIN=(TIN+459.67)/1.8
      00               DO 3 I=1,10
      00               TFIN=TKIN*1.8-459.67
      00               CALL BUBPRE(NO,TKIN,XM,PAFL,XV)
      00               CALL VOLIT1(NO,TKIN,PAFL,XM,VML)
      00               VL=VML*16.01846/WM
      00               PAFL3=PAFL+3.
      00               CALL VOLIT1(NO,TKIN,PAFL3,XM,VML3)
      00               VL3=VML3*16.01846/WM
      00               PFL=PAFL*14.6959
      00               PFL3=PAFL3*14.6959
      00               HIN=H1-GN*VL*VL
      00               CALL HCVCP(N1,TKIN,VML,XM,HF,CV,CP)
      00               HDIF=HIN-HF
      00               IF(ABS(HDIF).LT..0003)GOTO 5
      00               IF(I.EQ.1)GOTO 1
      00               TK=TKIN-HDIF*(TKINP-TKIN)/(HDIFP-HDIF)
      00               GOTO 2
      00             1 TK=TKIN+SIGN(1.,HDIF)
      00             2 IF(TK.GT.TC1)TK=TC1-2.
      00               TKINP=TKIN
      00               TKIN=TK
      00               HDIFP=HDIF
      00             3 CONTINUE
      00               PRINT 4,HDIF
      00             4 FORMAT(' PFLASH DOES NOT CONVERGE, HDIF=',1PE15.5)
      00             5 CONTINUE
      00               PFLA=PAFL*14.6959
      00               TFLASH=TKIN*1.8-459.67
      00               RETURN
      00               END
```

```
@ELT,L DD.PIPE
ELT 8R1 S74Q1C 07/21/84 15:55:11 (0)
00            SUBROUTINE PIPE(IBACK,XW,TAIR,RMASS,T1,P1,V1,H1,AM1,AK1,CP1,
00           & T2,P2,H2,XQ2,PL,PD1,PK1,PD2,PK2,PD3,PK3,PD4)
00      C
00      C**** PURPOSE:
00      C       TO COMPUTE PARAMETERS OF SUPERHEATED OR WET REFRIG. VAPOR
00      C       (BINARY MIXTURE) FLOWING THROUGH A PIPE FOR OUTLET
00      C       OR INLET CONDITIONS KNOWN
00      C
00      C**** ASSUPTIONS:
00      C       SINGLE PHASE HEAT TRANSFER INSIDE PIPE
00      C       FREE CONVECTION OUTSIDE PIPE
00      C
00      C**** INPUT DATA:
00      C       AK1    - REFRIG. THERMAL CONDUCTIVITY AT PIPE INLET (OUTLET)
00      C                (BTU/H*F*FT)
00      C       AM1    - REFRIG. DYNAMIC VISCOSITY AT PIPE INLET (OUTLET)   (LBM/H*FT)
00      C       CP1    - REFRIG. SPEC. HEAT AT PIPE INLET (OUTLET)    (BTU/LBM*F)
00      C       H1     - REFRIG. ENTHALPY AT PIPE INLET (OUTLET)    (BTU/LBM)
00      C       IBACK = 0   IF INLET REFRIG. STATE KNOWN, OUTLET IS CALCULATED
00      C             = 1   IF OUTLET REFRIG. STATE KNOWN, INLET IS CALCULATED
00      C       PD1    - PIPE INSIDE DIAMETER    (FT)
00      C       PD2    - PIPE OUTSIDE DIAMETER    (FT)
00      C       PD3    - OUTER DIAMETER OF INSIDE INSULATION    (FT)
00      C       PD4    - OUTER DIAMETER OF OUTSIDE INSULATION    (FT)
00      C       PK1    - THERMAL CONDUCTIVITY OF PIPE MATERIAL    (BTU/H*F*FT)
00      C       PK2    - THERMAL CONDUCTIVITY OF INSIDE INSULATION MATERIAL
00      C                (BTU/H*F*FT)
00      C       PK3    - THERMAL CONDUCTIVITY OF OUTSIDE INSULATION MATERIAL
00      C                (BTU/H*F*FT)
00      C       PL     - PIPE LENGTH    (FT)
00      C       P1     - REFRIG. PRESSURE AT PIPE INLET (OUTLET)    (PSIA)
00      C       RMASS  - REFRIG. MASS FLOW RATE    (LBM/H)
00      C       TAIR   - AMBIENT AIR TEMPERATURE    (F)
00      C       T1     - REFRIG. TEMPERATURE AT PIPE INLET (OUTLET)    (F)
00      C       V1     - REFRIG. SPEC. VOLUME AT PIPE INLET (OUTLET)    (FT**3/LBM)
00      C       XW     - MIXTURE COMPOSITION
00      C                (WEIGHT FRACTION OF LESS VOLATILE COMPONENT)
00      C
00      C**** OUTPUT DATA:
00      C       H2     - REFRIG. ENTHALPY AT PIPE OUTLET (INLET)    (BTU/LBM)
00      C       P2     - REFRIG. PRESSURE AT PIPE OUTLET (INLET)    (PSIA)
00      C       T2     - REFRIG. TEMPERATURE AT PIPE OUTLET (INLET)    (F)
00      C       XQ2    - REFRIG. QUALITY AT PIPE OUTLET (INLET)    (-)
00      C
00      C**** SUBPROGRAMS CALLED BY PIPE:
00      C       ESVOL,HCVCP,HPIN,QLITY,SPHDP1,SPHTC,VISCON
00      C
00            COMMON/RDATA2/W1,W2,TC1,TC2
00            DATA N0,N1,N2,N3,N4,N5/0,1,2,3,4,5/
00      C
00            ACCUR=0.0005
00            XM=XW/(W2/W1*(1.-XW)+XW)
00            WM=(1.-XM)*W1+XM*W2
00            AREA=3.1415927*PD1*PL
00            RUP=PD1*ALOG(PD2/PD1)/(2.*PK1)
00            PDO=PD2
```

```
00         IF(PK2.LT.1.E-08)GOTO 5
00         RUP=RUP+PD1*ALOG(PD3/PD2)/(2.*PK2)
00         PDO=PD3
00         IF(PK3.LT.1.E-08)GOTO 5
00         RUP=RUP+PD1*ALOG(PD4/PD3)/(2.*PK3)
00         PDO=PD4
00       5 CONTINUE
00         TK1=(T1+459.67)/1.8
00         PA1=P1/14.6959
00         CALL QLITY(TK1,PA1,XM,XQ1,XV1,XL1)
00         T2=T1
00         TK2=TK1
00         PA2=PA1
00         CP2=CP1
00         AM2=AM1
00         AK2=AK1
00         V2=V1
00         TP=T1
00         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)
00    C**** CALC. PRESSURE DROP
00         IF(XQ1.NE.1..AND.XQ2.NE.1.)THEN
00            XL=0.5*(XL1+XL2)                        @TWO PHASE PRESSURE DROP
00            XV=0.5*(XV1+XV2)
00            AML=VISCON(N1,T,XL)
00            AMV=VISCON(N3,T,XV)
00            WL=(1.-XL)*W1+XL*W2
00            PA=0.5*(PA1+PA2)
00            TK=0.5*(TK1+TK2)
00            VL=ESVOL(NO,TK,PA,XL)
00            VL=VL*16.01846/WL
00            WV=(1.-XV)*W1+XV*W2
00            VV=FSVOL(N1,TK,PA,XV)
00            VV=VV*16.01846/WV
00            XQ=0.5*(XQ1+XQ2)
00            XTT=(AML/AMV)**.1*(VL/VV)**.5*((1.-XQ)/XQ)**.9
00            FI=1.+2.85*XTT**.523
00            RMS=XQ*RMASS
00            PDROP=FI*SPHDP1(RMS,PL,PD1,VV,AMV)
00         ELSE
00            PDROP=SPHDP1(RMASS,PL,PD1,V,AM)         @SINGLE-PHASE PRESSURE DROP
00         END IF
00         P2=P1-PDROP
00         IF(IBACK.EQ.1)P2=P1+PDROP
00    C**** CALC. HEAT TRANSFER, SINGLE PHASE FLOW ASSUMED
00         UI=SPHTC(CP,AM,AK,RMASS,PD1)
00         UO=0.27*(ABS(TAIR-TP)/PDO)**0.25
00         RUI=1./UI
00         RUO=PD1/(PDO*UO)
00         UOA=1./(RUI+RUP+RUO)
00         UOI=1./(RUI+RUP)
00         Q=UOA*AREA*(TAIR-T)
00         TP=T+Q/(UOI*AREA)
00         H2=H1+Q/RMASS
```

```
      PA2=P2/14.6959
      CALL HPIN(N1,H2,PA2,XM,ACCUR,TK2,XQ2,XL2,XV2,VL2,VV2)
         T2=TK2*1.8-459.67
      IF(XQ2.NE.1.)THEN
         WL=(1.-XL2)*W1+XL2*W2
         WV=(1.-XV2)*W1+XV2*W2
         VL2=VL2*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.ABS(P2-P2A).LT.0.005)GOTO 60
   40 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,0
```

```
@ELT,L DD.PXQIN
ELT 8R1 S74Q1C 07/21/84 15:55:11 (0)
 00              SUBROUTINE PXQIN(X,P,XQ,T,XL,XV)
 00        C
 00        C
 00        C
 00        C**** PURPOSE:
 00        C        TO CALC. TEMPERATURE OF NON-AZEOTROPIC MIXTURE
 00        C        FORM GIVEN PRESSURE,COMPOSITION AND QUALITY
 00        C
 00        C**** INPUT:
 00        C        P   - PRESSURE    (STD ATM)
 00        C        X   - COMPOSITION (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
 00        C        XQ  - QUALITY    (-)
 00        C
 00        C**** OUTPUT:
 00        C        T   - TEMPEPATURE OF MIXTURE    (K)
 00        C        XL  - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
 00        C                (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
 00        C        XV  - COMPOSITION OF SAT. VAPOR AT TEMP. TK AND PRESSURE PA
 00        C                (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
 00        C
 00        C**** SUBPROGRAMS CALLED BY PXQIN:
 00        C        DBUBTE,DDEWTE,DQLITY,EPUBTE,QLITY
 00        C
 00              REAL*8 TDD,PDD,XQDD,XLDD,XVDD
 00        C
 00              DATA SLOPE/0./,PLAST/0./
 00        C
 00              IF(XQ.LE.0..OR.XQ.GE.1.)THEN
 00              PRINT 666,XQ
 00          666 FORMAT(' ERROR IN CALLING PXQIN, XQ=',1PE16.6)
 00              RETURN
 00              END IF
 00        C
 00              IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
 00              IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
 00              IF(ABS(XQ-XQLAST).GT.1.E-4)GOTO 10
 00              T=TLAST
 00              XL=XLLAST
 00              XV=XVLAST
 00              RETURN
 00        C
 00           10 XQDIF1=0.
 00              DT=1.
 00              T=EBUBTE(P,X)-XQ*SLOPE
 00              DO 50 I=1,20
 00              IF(XQ.LT..01.OR.XQ.GT..99)THEN
 00                 TDD=T
 00                 PDD=P
 00                 CALL DQLITY(TDD,PDD,X,XQDD,XVDD,XLDD)
 00                 XQN=XQDD
 00                 XV=XVDD
 00                 XL=XLDD
 00              ELSE
 00                 CALL QLITY(T,P,X,XQN,XV,XL)
 00              END IF
 00              IF(XQN.EQ.0..AND.XQDIF1.LT.0.)THEN
```

```
00          PDD=P
00          TDD=T
00          CALL DBUBTE(1,PDD,X,TDD,XVDD)
00          T=TDD
00          XV=XVDD
00       END IF
00       IF(XQN.EQ.1..AND.XQDIF1.GT.0.)THEN
00          PDD=P
00          TDD=T
00          CALL DDEWTE(1,PDD,X,TDD,XLDD)
00          T=TDD
00          XL=XLDD
00       END IF
00       T2=T
00       XQDIF2=XQ-XQN
00       IF(ABS(DT).LT.0.005.AND.ABS(XQDIF2).LT..0001)GOTO 100
00       IF(I.NE.1)GOTO 20
00          T1=T2
00          XQDIF1=XQDIF2
00          IF(SLOPE.NE.0.)THEN
00             IF(XQN.EQ.1..OR.XQN.EQ.0.)GOTO 15
00             DT=XQDIF2*SLOPE
00             IF(ABS(DT).GT.5.)DT=SIGN(5.,DT)
00             T=T2-DT
00             GOTO 50
00          END IF
00    15 T=T2+5.
00       IF(XQDIF2.LT.0.)T=T2-5.
00       GOTO 50
00  C
00    20 IF(XQDIF1.EQ.XQDIF2)GOTO 15
00       SLOPE=(T2-T1)/(XQDIF2-XQDIF1)
00       T1=T2
00       XQDIF1=XQDIF2
00       DT=XQDIF1*SLOPE
00       IF(ABS(DT).GT.10.)DT=SIGN(10.,DT)
00       T=T1-DT
00    50 CONTINUE
00       WRITE(6,600)X,P,XQ,DT,XQDIF2
00   600 FORMAT(' PXQIN DID NOT CONVERGE; X,P,XQ,DT,XQDIF2=',5(1PE12.4))
00   100 PLAST=P
00       XLAST=X
00       XQLAST=XQ
00       TLAST=T
00       XLLAST=XL
00       XVLAST=XV
00       RETURN
00       END
```

END ELT. ERRORS: NONE. TIME: 0.154 SEC. IMAGE COUNT: 104

@HDG,P ****** PXQIN2 ****** .L,0

```
@ELT,L DD.PXQIN2
ELT 8R1 S74Q1C 07/21/84 15:55:11 (0)
      SUBROUTINE PXQIN2(X,P,XQ,T,XL,XV,VL,VV,H)
C
C
C**** PURPOSE:
C       TO CALC. TEMPERATURE & ENTHALPY OF 2-PHASE NON-AZEOTROPIC MIXTURE
C       FORM GIVEN PRESSURE,COMPOSITION AND QUALITY
C
C**** INPUT:
C       P   - PRESSURE    (STD ATM)
C       X   - COMPOSITION (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
C       XQ  - GUALITY    (-)
C
C**** OUTPUT:
C       H   - MIXTURE ENTHALPY    (BTU/LB)
C       T   - TEMPERATURE OF MIXTURE    (K)
C       XL  - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
C             (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
C       XV  - 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       VV  - SPECIFIC. VOLUME OF SAT. VAPOR OF XV COMPOSITION
C             AT TEMPERATURE TK    (L/MOL)
C
C**** SUBPROGRAMS CALLED BY PXQIN2:
C       HCVCP,PXQIN,VOLIT1
C
      IF(XQ.LE.0..OR.XQ.GE.1.)THEN
      PRINT 666,XQ
  666 FORMAT(' ERROR IN CALLING PXQIN2, XQ=',1PE16.6)
      RETURN
      END IF
C
      IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
      IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
      IF(ABS(XQ-XQLAST).GT.1.E-4)GOTO 10
      T=TLAST
      XL=XLLAST
      XV=XVLAST
      VL=VLLAST
      VV=VVLAST
      H=HLAST
      RETURN
C
   10 CALL PXQIN(X,P,XQ,T,XL,XV)
      CALL VOLIT1(0,T,P,XL,VL)
      CALL HCVCP(1,T,VL,XL,HL,CV,CP)
      CALL VOLIT1(1,T,P,XV,VV)
      CALL HCVCP(1,T,VV,XV,HV,CV,CP)
      H=(1.-XQ)*HL+XQ*HV
  100 PLAST=P
      XLAST=X
      XQLAST=XQ
      TLAST=T
      XLLAST=XL
      XVLAST=XV
```

```
  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
```

```
@ELT,L DD.QLITY
ELT 8R1 S74Q1C 07/21/84 15:55:12 (0)
00            SUBROUTINE QLITY(T,P,X,XQ,XV,XL)
00      C
00      C
00      C**** PURPOSE:
00      C        TO CALCULATE QUALITY OF A BINARY FLUID
00      C
00      C**** INPUT:
00      C        IA - QUALIFIER OF PRECISION OF CALCULATIONS    (-)
00      C           = 0,  SIMPLIFIED CORRELATIONS TO BE USED
00      C           = POSSITIVE INTEGER, COMPLETE SET EOATIONS TO BE USED
00      C        P  - PRESSURE    (STD ATM)
00      C        T  - TEMPERATURE    (K)
00      C        X  - MOLAR CONCENTRATION OF A LESS VOLATILE
00      C             COMPONENT    (-)
00      C
00      C**** OUTPUT:
00      C        XL - MOLAR CONCENTRATION AT BUBBLE POINT    (-)
00      C        XQ - FLUID QUALITY    (-)
00      C        XV - MOLAR CONCENTRATION AT DEW POINT    (-)
00      C
00      C**** SUBPROGRAMS CALLED BY QLITY:
00      C        SATCOM
00      C
00      C
00            COMMON/ACCURA/IA
00      C
00            IF(IA.EQ.0)THEN
00               T2=T*T
00               P1=10.0522804-2204.5632/T+9636.5313/T2
00               P1=EXP(P1)
00               P2=10.6410518-2642.8994/T+460.87585/T2
00               P2=EXP(P2)
00               GOTO 10
00            END IF
00            CALL SATCOM(T,P1,V1,VL1,P2,V2,VL2)
00         10 IF(P.GE.P1)THEN      @FLUID IS LIQUID AT ALL CONCENTRATIONS
00               XQ=0.
00               XL=0.
00               XV=0.
00               GOTO 1000
00            END IF
00            IF(P.LE.P2)THEN      @FLUID IS VAPOR AT ALL CONCENTRATIONS
00               XL=1.
00               XQ=1.
00               XV=1.
00               GOTO 1000
00            END IF
00            T2=T*T
00            RP=(P1-P)/(P1-P2)
00            SEG0=12.58741-0.06465226*T+9.56391E-5*T2
00            SEG8=-48.9799+0.289414*T-4.504915E-4*T2
00            SEG9=47.7509-0.273993*T+4.14487E-4*T2
00            SEG=SEG0+SEG8*RP+SEG9*RP**2
00            Z0=-0.34065415-3.337532E-3*T+9.66115E-6*T2
00            Z1=-10.3139754+0.0653856*T-9.9899162E-5*T2
00            Z2=10.035917-0.05527259*T+7.6821554E-5*T2
```

```
****** QLITY ******                                                          DATE 072184

      00            Z=1.+Z0*(RP-1.)+Z1*(RP**2-1.)+Z2*(RP**3-1.)
      00            XL=(1.+SEG)*RP/(1.+SEG*RP)    @SAT. LIQUID COMPOSITION
      00            XV=XL*Z                       @SAT. VAPOR COMPOSITION
      00            XQ=(XL-X)/(XL-XV)
      00            IF(XQ.GE.1.)XQ=1.
      00            IF(XQ.LT.0.)XQ=0.
      00       1000 RETURN
      00            END

END ELT.  ERRORS: NONE. TIME:  0.125 SEC. IMAGE COUNT: 64

@HDG,P  ******  ROFANN  ****** .L,0
```

```
@ELT,L DD.ROFANN
ELT 8R1 S74Q1C 07/21/84 15:55:12 (0)
 00          FUNCTION ROFANN(XM,P,HO,GG)
 00    C
 00    C**** PURPOSE:
 00    C        TO CALCULATE DENSITY OF NON-AZEOTROPIC TWO-PHASE MIXTURE
 00    C        FOR ANY PRESSURE ON A FANNO FLOW PATH
 00    C
 00    C**** INPUT DATA:
 00    C          HO       - REFRIG. TOTAL ENTHALPY  (BTU/LB)
 00    C          GG       = G*G/(64.4*778.104)   (BTU*LB/FT**6)
 00    C                     WHERE G - REFRIG. MASS FLUX   (LB/(SEC*FT**2))
 00    C          P        - REFRIG. PRESSURE AT WHICH ENTROPY IS DESIRED   (PSIA)
 00    C          XM       - MOLAR COMPOSITION   (FRACTION OF LESS VOLATILE COMPONENT)
 00    C**** OUTPUT DATA:
 00    C          ROFANN   - ENTROPY  (BTU/LB R)
 00    C
 00    C**** SUBPROGRAMS CALLED BY ROFANN:
 00    C        EBUBTE,ENTROP,HCVCP,QLITY,VOLIT1
 00    C
 00          COMMON/RDATA2/W1,W2,TC1,TC2
 00          DATA SLOPE/0./NO,N1/0,1/
 00    C
 00          IF(P.GT.0.)GOTO 10
 00          WRITE(6,600)P
 00      600 FORMAT(' ERROR IN CALLING ROFANN, P=',1PE15.5,'  PSIA')
 00          RETURN
 00    C
 00       10 PA=P/14.6959
 00          TKB=EBUBTE(PA,XM)
 00          TKD=TKB+9.5-20.*(.55-XM)
 00          TB=TKB*1.8-459.67
 00          TD=TKD*1.8-459.67
 00          TK2=0.5*(TKB+TKD)
 00          DO 100 I=1,20
 00          CALL QLITY(TK2,PA,XM,XQ,XV,XL)
 00          CALL VOLIT1(N1,TK2,PA,XV,VMV)
 00          CALL HCVCP(N1,TK2,VMV,XV,HV,CV,CP)
 00          CALL VOLIT1(NO,TK2,PA,XL,VML)
 00          CALL HCVCP(N1,TK2,VML,XL,HL,CV,CP)
 00          HFG=HV-HL
 00          WMV=W1*(1.-XV)+W2*XV
 00          WML=W1*(1.-XL)+W2*XL
 00          VV=VMV*16.01846/WMV
 00          VL=VML*16.01846/WML
 00          VFG=VV-VL
 00          R=GG*VFG*VFG
 00          S=2.*GG*VV*VFG+HFG
 00          C=GG*VL*VL+HL-HO
 00          XQQ=(-S+SQRT(S*S-4.*R*C))/(2.*R)
 00          DIFXQ2=XQQ-XQ
 00          IF(ABS(DIFXQ2).LT.0.000001)GOTO 110
 00    C
 00          IF(I.GT.1)GOTO 70
 00          TK1=TK2
 00          DIFXQ1=DIFXQ2
 00          IF(SLOPE.NE.0.)THEN
 00             TK2=TK1-DIFXQ2*SLOPE
```

```
00            ELSE
00               TK2=TK1+SIGN(1.,DIFXQ2)
00            END IF
00            GOTO 100
00      C
00         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 CONTINUE
00            PRINT 602,DIFXQ2
00        602 FORMAT(' ROFANN DOES NOT CONVERGE, DIFXQ2=',1PE15.5)
00        110 CONTINUE
00            ROFANN=1./(VL+XQQ*VFG)
00            RETURN
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)
00                SUBROUTINE SATCOM(T,P1,V1,VL1,P2,V2,VL2)
00          C
00          C
00          C**** PURPOSE:
00          C        TO CALC. FOR PURE MIXTURE COMPONETS AT SATURATION:
00          C        PRESSURE, SPEC. VOLUME OF LIQUID, SPEC. VOLUME OF VAPOR
00          C
00          C**** INPUT:
00          C        T      - TEMPERATURE    (K)
00          C
00          C**** OUTPUT:
00          C        P(1)   - SAT. PRESSURE OF MORE VOLATILE REFRIGERANT    (ATM)
00          C        P(2)   - SAT. PRESSURE OF LESS VOLATILE REFRIGERANT    (ATM)
00          C        V(1)   - SPEC. VOLUME OF VAPOR OF MORE VOLATILE REFRIG. AT SATURATION
00          C                 (L/MOL)
00          C        V(2)   - SPEC. VOLUME OF VAPOR OF LESS VOLATILE REFRIG. AT SATURATION
00          C                 (L/MOL)
00          C        VL(1)  - SPEC. VOLUME OF LIQUID OF MORE VOLATILE REFRIG. AT SATURATION
00          C                 (L/MOL)
00          C        VL(2)  - SPEC. VOLUME OF LIQUID OF LESS VOLATILE REFRIG. AT SATURATION
00          C
00          C**** SUBPROGRAMS CALLED BY SATCOM:
00          C        FGIBBS,SATLIB,VOLIT
00          C
00          C
00                COMMON/RDATA2/W1,W2,TC1,TC2
00                DIMENSION P(2),X(2),V(2),VL(2)
00                DATA X(1),X(2)/0.,1./
00          C
00                CALL SATLIB(T,P(1),V(1),VL(1),P(2),V(2),VL(2))
00                IF(T.GT.(TC1-10.))GOTO 100
00          C
00                DO 100 I=1,2
00                DO 90 J=1,20
00                CALL VOLIT(T,P(I),X(I),V(I))
00                GV=FGIBBS(T,P(I),X(I),V(I))
00                CALL VOLIT(T,P(I),X(I),VL(I))
00                GL=FGIBBS(T,P(I),X(I),VL(I))
00                P7=(GL-GV)/(VL(I)-V(I))
00                P(I)=P(I)-P7/3.
00                P7=P7/P(I)
00                IF(ABS(P7).LT.1E-04)GOTO 100
00             90 CONTINUE
00                PRINT 600,I,P(I),P7
00            600 FORMAT(' ERROR 600 IN SATCOM, I,P,P7=',I3,2(1PE14.6))
00            100 CONTINUE
00                P1=P(1)
00                V1=V(1)
00                VL1=VL(1)
00                P2=P(2)
00                V2=V(2)
00                VL2=VL(2)
00                RETURN
00                END

END ELT.  ERRORS: NONE.  TIME:  0.113 SEC.  IMAGE COUNT: 54
```

```
@ELT,L DD.SATLIB
ELT 8R1 S74Q1C 07/21/84 15:55:13 (0)
      00             SUBROUTINE SATLIB(T,P1,V1,VL1,P2,V2,VL2)
      00       C
      00       C
      00       C**** PURPOSE:
      00       C        FOR GIVEN T, ESTIMATE SAT. PRESSURE, SPEC. VOLUME OF VAPOR,
      00       C        AND SPEC. VOLUME OF LIQUID. OF MIXTURE PURE COMPONENTS
      00       C
      00       C**** INPUT:
      00       C        T    - TEMPERATURE    (K)
      00       C
      00       C**** OUTPUT:
      00       C        P1   - SAT. PRESSURE OF MORE VOLATILE COMPONENT    (ATM)
      00       C        P2   - SAT. PRESSURE OF LESS VOLATILE COMPONENT    (ATM)
      00       C        V1   - SPEC. VOLUME OF MORE VOLATILE COMPONENT SAT. VAPOR
      00       C               (L/MOL)
      00       C        V2   - SPEC. VOLUME OF LESS VOLATILE COMPONENT SAT. VAPOR
      00       C               (L/MOL)
      00       C        VL1 - SPEC. VOLUME OF MORE VOLATILE COMPONENT SAT. LIQUID
      00       C               (L/MOL)
      00       C        VL2 - SPEC. VOLUME OF LESS VOLATILE COMPONENT SAT. LIQUID
      00       C               (L/MOL)
      00       C
      00             COMMON/ESDATA/A(2,3),B(2,3),C(2,3)
      00       C
      00             T2=T*T
      00       C**** MORE VOLATILE COMPONENT
      00             P1=EXP(A(1,1)+A(1,2)/T+A(1,3)/T2)
      00             V1=(B(1,1)+B(1,2)*T+B(1,3)*T2)*T/P1
      00             VL1=C(1,1)+C(1,2)*T+C(1,3)*T2
      00       C**** LESS VOLATILE COMPONENT
      00             P2=EXP(A(2,1)+A(2,2)/T+A(2,3)/T2)
      00             V2=(B(2,1)+B(2,2)*T+B(2,3)*T2)*T/P2
      00             VL2=C(2,1)+C(2,2)*T+C(2,3)*T2
      00             RETURN
      00             END

END ELT.  ERRORS: NONE. TIME:  0.064 SEC. IMAGE COUNT: 35

@HDG,P  ******  SPHDP1  ****** .L,0
```

```
******  SPHDP1  ******                                                    DATE 072184

@ELT,L DD.SPHDP1
ELT 8R1 S74Q1C 07/21/84 15:55:13 (0)
           00             FUNCTION SPHDP1(AM,AL,D,VSP,AMU)
           00      C
           00      C****  PURPOSE:
           00      C        TO COMPUTE FRICTIONAL PRESSURE DROP
           00      C        FOR SINGLE PHASE FLOW IN A TUBE
           00      C
           00      C****  INPUT DATA:
           00      C        AL      - TUBE LENGTH    (FT)
           00      C        AM      - FLUID MASS FLOW RATE    (LBM/H)
           00      C        AMU     - FLUID DYNAMIC VISCOSITY    (LBM/H*FT)
           00      C        D       - TUBE DIAMETER    (FT)
           00      C        VSP     - FLUID SPECIFIC VOLUME    (FT**3/LBM)
           00      C
           00             ACC=3.3309E-11
           00             G=0.78539816*D*D
           00             G=AM/G
           00             RE=G*D/AMU
           00             F=0.046/RE**0.2
           00             SPHDP1=ACC*F*VSP*AL*G*G/D
           00             RETURN
           00             END

END ELT.  ERRORS: NONE. TIME:  0.069 SEC. IMAGE COUNT: 21

@HDG,P  ******  SPHTC  ****** .L,0
```

```
******  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
      00    C**** PURPOSE:
      00    C        TO COMPUTE SINGLE PHASE HEAT TRANSFER COEFFICIENT
      00    C        FOR FLOW INSIDE TUBE
      00    C
      00    C**** INPUT DATA:
      00    C        AM    - FLUID DYNAMIC VISCOSITY   (LBM/FT*H)
      00    C        AK    - FLUID THERMAL CONDUCTIVITY   (BTU/H*F*FT)
      00    C        CP    - FLUID SPECIFIC HEAT AT CONST. PRESSURE   (BTU/LBM*F)
      00    C        D     - TUBE DIAMETER   (FT)
      00    C        RMASS - FLUID MASS FLOW RATE   (LBM/H)
      00    C
      00    C**** OUTPUT DATA:
      00    C        SPHTC - SINGLE PHASE HEAT TRANSFER COEFF.   (BTU/H*F*FT**2)
      00    C
      00          G=RMASS/(0.7853982*D*D)
      00          RE=D*G/AM
      00          IF(RE.GE.2000.)GOTO10
      00          SPHTC=4.36*AK/D
      00          GOTO20
      00       10 PR=(AM*CP/AK)**0.4
      00          RE=RE**0.8
      00          SPHTC=0.023*AK*PR*RE/D
      00       20 RETURN
      00          END

END ELT.  ERRORS: NONE. TIME:  0.071 SEC. IMAGE COUNT: 26

@HDG,P  ******  SPIN  ****** .L,0
```

```
@ELT,L DD.SPIN
ELT 8R1 S74Q1C 07/21/84 15:55:13 (0)
00             SUBROUTINE SPIN(IG,S,P,X,ACCUR,T,V)
00       C
00       C
00       C**** PURPOSE:
00       C        TO CALC. TEMPERATURE OF BINARY MIXTURE VAPOR
00       C        FROM GIVEN ENTROPY AND PRESSURE
00       C
00       C**** INPUT:
00       C        ACCUR   - ACCURACY OF CONVERGANCE    (BTU/LB)
00       C        IG      = 0,  IF GUESS OF TEMPERATURE IS NOT GIVEN
00       C                = POSITIVE INTEGER,  IF GUESS OF TEMPERATURE IS GIVEN
00       C        P       - PRESSURE    (STD ATM)
00       C        S       - ENTROPY    (BTU/LB*F)
00       C        T       - GUESS OF TEMPERATURE, OPTIONAL  (K)
00       C        X       - MOLAR CONCENTRATION    (FRACTION OF LESS VOLATILE COMPONENT)
00       C
00       C**** OUTPUT:
00       C        T       - BINARY MIXTURE TEMPERATURE     (K)
00       C        V       - SPEC. VOLUME    (L/MOL)
00       C
00       C**** SUBPROGRAMS CALLED BY SPIN:
00       C        DEWTEM,ENTROP,ESVOL,VOLIT
00       C
00             DATA SLOPE/0./,PLAST/0./
00       C
00             IF(ABS(P-PLAST).GT.1.E-4)GOTO 10
00             IF(ABS(S-SLAST).GT.ACCUR)GOTO 10
00             IF(ABS(X-XLAST).GT.1.E-4)GOTO 10
00             T=TLAST
00             V=VLAST
00             RETURN
00       C
00          10 N1=1
00             CALL DEWTEM(0,P,X,TD,XL)
00             IF(IG.EQ.0)T=TD+20.
00             DO 50 I=1,15
00             T=AMAX1(TD,T)
00             V=ESVOL(N1,T,P,X)
00             CALL VOLIT(T,P,X,V)
00             SS=ENTROP(T,V,X)
00             T2=T
00             SDIF2=S-SS
00             IF(ABS(SDIF2).LT.ACCUR)GOTO 100
00             IF(SDIF1.EQ.SDIF2)THEN
00                WRITE(6,601)
00                GOTO 60
00             END IF
00             IF(I.NE.1)GOTO 20
00          15    T1=T2
00                SDIF1=SDIF2
00                IF(SLOPE.NE.0.)THEN
00                   DT=SDIF2*SLOPE
00                   IF(ABS(DT).GT.15.)DT=SIGN(15.,DT)
00                   T=T2-DT
00                   GOTO 50
00                END IF
```

```
      00                T=T2+10.
      00                IF(SDIF2.LT.0.)T=T2-10.
      00                GOTO 50
      00        C
      00           20 SLOPE=(T2-T1)/(SDIF2-SDIF1)
      00              IF(ABS(SDIF1).LT.ABS(SDIF2))GOTO 30
      00                 T1=T2
      00                 SDIF1=SDIF2
      00           30 DT=SDIF1*SLOPE
      00              IF(ABS(DT).GT.15.)DT=SIGN(15.,DT)
      00              T=T1-DT
      00           50 CONTINUE
      00           90 WRITE(6,600)SDIF2
      00          600 FORMAT(' ERROR 600 IN SPIN, SDIF2=',1PE12.4)
      00          601 FORMAT(' SPIN DOES NOT CONVERGE ANY FURTHER=')
      00          100 PLAST=P
      00              SLAST=S
      00              XLAST=X
      00              TLAST=T
      00              VLAST=V
      00              RETURN
      00              END

END ELT.  ERRORS: NONE. TIME:  0.142 SEC. IMAGE COUNT: 78

@HDG,P  ******  TPPROP  ****** .L,0
```

```
@ELT,L DD.TPPROP
ELT 8R1 S74Q1C 07/21/84 15:55:14 (0)
    00           SUBROUTINE TPPROP(TF,PSIA,XW,XQ,H,V)
    00     C
    00     C**** PURPOSE:
    00     C       TO CALCULATE NON-AZEOTROPIC MIXTURE THERMODNAMIC PROPERTIES
    00     C       FROM GIVEN TEMPERATURE, PRESSURE AND COMPOSITION
    00     C
    00     C**** INPUT:
    00     C       TF   - TEMPERATURE   (F)
    00     C       PSIA - PRESSURE (PSIA)
    00     C       XW   - WEIGHT COMPOSITION   (FRACTION OF LESS VOLATILE COMPONENT)
    00     C
    00     C**** OUTPUT:
    00     C       H    - ENTHALPY   (BTU/LB)
    00     C       V    - SPEC. VOLUME   (FT**3/LB)
    00     C       XQ   - QUALITY   (-)
    00     C
    00           COMMON/RDATA2/W1,W2,TC1,TC2
    00     C
    00           TK=(TF+459.67)/1.8
    00           PA=PSIA/14.6959
    00           XM=XW/(W2/W1*(1.-XW)+XW)
    00           WM=(1.-XM)*W1+XM*W2
    00           CALL QLITY(TK,PA,XM,XQ,XV,XL)
    00              IF(XQ.NE.0..AND.XQ.NE.1.)GOTO 10
    00              N=1.0001*XQ
    00              CALL VOLIT1(N,TK,PA,XM,V)
    00              CALL HCVCP(1,TK,V,XM,H,CV,CP)
    00              V=V*16.01846/WM
    00              GOTO 1000
    00     C
    00        10 CALL VOLIT1(0,TK,PA,XL,VI )
    00           CALL HCVCP(1,TK,VL,XL,HL,CV,CP)
    00           CALL VOLIT1(1,TK,PA,XV,VV)
    00           CALL HCVCP(1,TK,VV,XV,HV,CV,CP)
    00           H=(1.-XQ)*HL+XQ*HV
    00           WML=(1.-XL)*W1+XL*W2
    00           WMV=(1.-XV)*W1+XV*W2
    00           VLW=VL*16.01846/WML
    00           VVW=VV*16.01846/WMV
    00           V=(1.-XQ)*VLW+XQ*VVW
    00      1000 RETURN
    00           END

END ELT.  ERRORS: NONE. TIME:  0.095 SEC. IMAGE COUNT: 42

@HDG,P  ******  TPPRO2  ****** .L,0
```

```
******  TPPRO2  ******                                                                    DATE 072184

@ELT,L DD.TPPRO2
ELT 8R1 S74Q1C 07/21/84 15:55:14 (0)
          00           SUBROUTINE TPPRO2(TF,PSIA,XW,XQ,H,V,XL,XV,VL,VV)
          00      C
          00      C**** PURPOSE:
          00      C        TO CALCULATE NON-AZEOTROPIC MIXTURE THERMODNAMIC PROPERTIES
          00      C        FROM GIVEN TEMPERATURE, PRESSURE AND COMPOSITION
          00      C
          00      C**** INPUT:
          00      C        TF   - TEMPERATURE   (F)
          00      C        PSIA - PRESSURE (PSIA)
          00      C        XW   - WEIGHT COMPOSITION   (FRACTION OF LESS VOLATILE COMPONENT)
          00      C
          00      C**** OUTPUT:
          00      C        H    - ENTHALPY   (BTU/LB)
          00      C        V    - SPEC. VOLUME   (FT**3/LB)
          00      C        XQ   - QUALITY   (-)
          00      C
          00           COMMON/RDATA2/W1,W2,TC1,TC2
          00      C
          00           TK=(TF+459.67)/1.8
          00           PA=PSIA/14.6959
          00           XM=XW/(W2/W1*(1.-XW)+XW)
          00           WM=(1.-XM)*W1+XM*W2
          00           CALL QLITY(TK,PA,XM,XQ,XV,XL)
          00               IF(XQ.NE.0..AND.XQ.NE.1.)GOTO 10
          00               N=1.0001*XQ
          00               CALL VOLIT1(N,TK,PA,XM,V)
          00               CALL HCVCP(1,TK,V,XM,H,CV,CP)
          00               V=V*16.01846/W1
          00               GOTO 1000
          00      C
          00        10 CALL VOLIT1(0,TK,PA,XL,VL)
          00           CALL HCVCP(1,TK,VL,XL,HL,CV,CP)
          00           CALL VOLIT1(1,TK,PA,XV,VV)
          00           CALL HCVCP(1,TK,VV,XV,HV,CV,CP)
          00           H=(1.-XQ)*HL+XQ*HV
          00           WML=(1.-XL)*W1+XL*W2
          00           WMV=(1.-XV)*W1+XV*W2
          00           VLW=VL*16.01846/WML
          00           VVW=VV*16.01846/WMV
          00           V=(1.-XQ)*VLW+XQ*VVW
          00      1000 RETURN
          00           END

END ELT.  ERRORS: NONE. TIME:  0.087 SEC. IMAGE COUNT: 42

@HDG,P  ******  TXQIN  ****** .L,O
```

```
@ELT,L DD.TXQIN
ELT 8R1 S74QIC 07/21/84 15:55:14 (0)
00          SUBROUTINE TXQIN(X,T,XQ,P,XL,XV)
00    C
00    C
00    C**** PURPOSE:
00    C       TO CALC. PRESSURE OF NON-AZEOTROPIC MIXTURE
00    C       FORM GIVEN COMPOSITION, TEMPERATURE AND QUALITY
00    C
00    C**** INPUT:
00    C       T    - TEMPERATURE    (F')
00    C       X    - COMPOSITION (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
00    C       XQ   - QUALITY    (-)
00    C
00    C**** OUTPUT:
00    C       P    - PRESSURE OF MIXTURE    (STD ATM)
00    C       XL   - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
00    C              (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
00    C       XV   - COMPOSITION OF SAT. VAPOR AT TEMP. TK AND PRESSURE PA
00    C              (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
00    C
00    C**** SUBPROGRAMS CALLED BY TXQIN:
00    C       EBUBPR,QLITY
00    C
00          DATA SLOPE/0./,TLAST/0./
00    C
00          IF(XQ.LE.0..OR.XQ.GE.1.)THEN
00          PRINT 677,XQ
00      677 FORMAT(' ERROR IN CALLING TXQIN, XQ=',1PE16.6)
00          RETURN
00          END IF
00    C
00          IF(ABS(T-TLAST).GT.1.E-3)GOTO 10
00          IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
00          IF(ABS(XQ-XQLAST).GT.1.E-4)GOTO 10
00          P=PLAST
00          XL=XLLAST
00          XV=XVLAST
00          RETURN
00    C
00       10 P=EBUBPR(T,X)-XQ*SLOPE
00          DO 50 I=1,20
00          CALL QLITY(T,P,X,XQN,XV,XL)
00          P2=P
00          IF(XQN.EQ.0.)CALL BUBPRE(0,T,X,P2,XV)
00          IF(XQN.EQ.1.)CALL DEWPRE(0,T,X,P2,XL)
00          XQDIF2=XQ-XQN
00          IF(I.NE.1)GOTO 20
00             P1=P2
00             XQDIF1=XQDIF2
00             IF(SLOPE.NE.0.)THEN
00                DP=XQDIF2*SLOPE
00                IF(ABS(DP).GT.1.)DP=SIGN(1.,DP)
00                P=P2-DP
00                GOTO 50
00             END IF
00       15    P=P2-.5
00             IF(XQDIF2.LT.0.)P=P2+.5
```

```
00            GOTO 50
00    C
00       20 IF(XQDIF1.NE.XQDIF2)GOTO 25
00          WRITE(6,610)XQDIF1
00      610 FORMAT(' TXQIN DOES NOT CONVERGE ANY FURTHER, XQDIF1=',1PE14.5)
00          GOTO 110
00    C
00       25 SLOPE=(P2-P1)/(XQDIF2-XQDIF1)
00          IF(ABS(XQDIF1).LT.ABS(XQDIF2))GOTO 30
00            P1=P2
00            XQDIF1=XQDIF2
00       30 DP=XQDIF1*SLOPE
00          IF(ABS(DP).LT.0.002.AND.ABS(XQDIF2).LT.0.0001)GOTO 100
00          IF(ABS(DP).GT.2.)DP=SIGN(2.,DP)
00          P=P1-DP
00       50 CONTINUE
00          WRITE(6,600)XQDIF2
00      600 FORMAT(' ERROR 600 IN TXQIN, XQDIF2=',1PE12.4)
00      100 PLAST=P
00          XLAST=X
00          XQLAST=XQ
00          TLAST=T
00          XLLAST=XL
00          XVLAST=XV
00      110 RETURN
00          END

END ELT.  ERRORS: NONE. TIME:  0.135 SEC. IMAGE COUNT: 82

@HDG,P  ******  TXQIN2  ****** .L,0
```

```
@ELT,L DD.TXQIN2
ELT 8R1 S74Q1C 07/21/84 15:55:14 (0)
00            SUBROUTINE TXQIN2(X,T,XQ,P,XL,XV,VL,VV,H)
00      C
00      C
00      C**** PURPOSE:
00      C        TO CALC. PRESSURE & ENTHALPY OF 2-PHASE NON-AZEOTROPIC MIXTURE
00      C        FORM GIVEN COMPOSITION, TEMPERATURE AND QUALITY
00      C
00      C**** INPUT:
00      C        T    - TEMPERATURE    (K)
00      C        X    - COMPOSITION (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
00      C        XQ   - QUALITY    (-)
00      C
00      C**** OUTPUT:
00      C        H    - MIXTURE ENTHALPY    (BTU/LB)
00      C        P    - PRESSURE    (STD ATM)
00      C        XL   - COMPOSITION OF SAT. LIQUID AT TEMP. TK AND PRESSURE PA
00      C                (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
00      C        XV   - COMPOSITION OF SAT. VAPOR AT TEMP. TK AND PRESSURE PA
00      C                (MOLAR FRACTION OF LESS VOLATILE COMPONENT)
00      C        VL   - SPECIFIC VOLUME OF SAT. LIQUID OF XL COMPOSITION
00      C               AT TEMPERATURE TK    (L/MOL)
00      C        VV   - SPECIFIC. VOLUME OF SAT. VAPOR OF XV COMPOSITION
00      C               AT TEMPERATURE TK    (L/MOL)
00      C
00      C**** SUBPROGRAMS CALLED BY TXQIN2:
00      C        HCVCP,TXQIN,VOLIT1
00      C
00            IF(XQ.LE.0..OR.XQ.GE.1.)THEN
00            PRINT 666,XQ
00        666 FORMAT(' ERROR IN CALLING TXQIN2, XQ=',1PE16.6)
00            RETURN
00            END IF
00      C
00            IF(ABS(T-TLAST).GT.1.E-4)GOTO 10
00            IF(ABS(X-XLAST).GT.1.E-3)GOTO 10
00            IF(ABS(XQ-XQLAST).GT.1.E-4)GOTO 10
00            P=PLAST
00            XL=XLLAST
00            XV=XVLAST
00            VL=VLLAST
00            VV=VVLAST
00            H=HLAST
00            RETURN
00      C
00         10 CALL TXQIN(X,T,XQ,P,XL,XV)
00            CALL VOLIT1(0,T,P,XL,VL)
00            CALL HCVCP(1,T,VL,XL,HL,CV,CP)
00            CALL VOLIT1(1,T,P,XV,VV)
00            CALL HCVCP(1,T,VV,XV,HV,CV,CP)
00            H=(1.-XQ)*HL+XQ*HV
00        100 PLAST=P
00            XLAST=X
00            XQLAST=XQ
00            TLAST=T
00            XLLAST=XL
00            XVLAST=XV
```

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******  TXQIN2  ******                                              DATE 072184

  570.          00          VLLAST=VL
  580.          00          VVLAST=VV
  590.          00          HLAST=H
  600.          00          RETURN
  610.          00          END

END ELT.  ERRORS: NONE. TIME:  0.115 SEC. IMAGE COUNT: 61

@HDG,P  ******  VALVPA  ****** .L,0
```

```
@ELT,L DD.VALVPA
ELT 8R1 S74Q1C 07/21/84 15:55:15 (0)
00          SUBROUTINE VALVPA
00    C
00    C
00    C**** PURPOSE:
00    C        TO EVALUATE 4-WAY VALVE PERFORMANCE PARAMETERS
00    C        FROM TEST UNDER ONE OPERATION CONDITION
00    C        (BINARY MIXTURE REFRIGERANT)
00    C
00    C**** INPUT DATA:
00    C [1] REFRIGERANT CONSTANTS
00    C     LISTED IN COMMON STATEMENTS RDATA1 & RDATA2
00    C [2] TEST DATA AS EXPLAINED BELOW:
00    C        P2,T2 - REFRIG. PRESSURE & TEMP. AT VALVE LOW PRESSURE INLET
00    C                  (PSIA),(F)
00    C        P3,T3   - REFRIG. PRESSURE & TEMP. AT VALVE LOW PRESSURE OUTLET
00    C                  (PSIA),(F)
00    C        P8,T8   - REFRIG. PRESSURE & TEMP. AT VALVE HIGH PRESSURE INLET
00    C                  (PSIA),(F)
00    C        P9,T9 - REFRIG. PRESSURE & TEMP. AT VALVE HIGH PRESSURE OUTLET
00    C                  (PSIA),(F)
00    C        RMASS   - REFRIG. MASS FLOW RATE   (LBM/H)
00    C        XW      - MIXTURE COMPOSITION
00    C                  (WEIGHT FRACTION OF MORE VOLATILE COMPONENET)
00    C
00    C**** OUTPUT DATA:
00    C        CPD     - PARAMETER FOR 4-WAY VALVE PRESSURE DROP
00    C                  (LBF*H**2/LBM*IN**2*FT**3)
00    C        CPDH    - PARAMETER FOR PRESSURE DROP ON HIGH PRESSURE SIDE
00    C                  (LBF*H**2/LBM*IN**2*FT**3)
00    C        CPDS    - PARAMETER FOR PRESSURE DROP ON LOW PRESSURE SIDE
00    C                  (LBF*H**2/LBM*IN**2*FT**3)
00    C        CQ      - PARAMETER FOR 4-WAY VALVE HEAT TRANSFER   (FT**.2)
00    C        Q       - HEAT TRANSFER RATE BETWEEN HIGH & LOW PRESSURE REFRIG.
00    C                  (BTU/H)
00    C        QS      - LOW PRESSURE REFRIG. VAPOR HEAT GAIN   (BTU/H)
00    C        QH      - HIGH PRESSURE REFRIG. VAPOR HEAT LOSS   (BTU/H)
00    C
00    C**** SUBPROGRAMS CALLED BY VALVPA:
00    C        ESVOL,HCVCP,VISCON,VOLIT
00    C
00    C
00          COMMON/RDATA1/A3,A4,A5,A6,A7,A8,B3,B4,B5,B6,B7,B8,F0,F1
00          COMMON/RDATA2/W1,W2,TC1,TC2
00          DIMENSION TK(4),PA(4),VM(4),H(4),CP(4),AK(4),AM(4)
00    C
00    C
00          WRITE(6,19)
00       15 WRITE(6,20)
00          READ(5,777)T11,P11,T2,P2
00          WRITE(6,21)
00          READ(5,777)T7,P7,T71,P71
00          WRITE(6,22)
00          READ(5,777)RMASS,XW
00          XW=1.-XW
00    C
00          XM=W2/W1*(1.-XW)+XW
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00            XM=XW/XM                                    @MOLAR COMPOSITION
00            WM=(1.-XM)*W1+XM*W2                         @MOLECULAR WEIGHT
00            PA(1)=P11/14.6959                           @PRESSURE IN STD. ATM
00            PA(2)=P2/14.6959
00            PA(3)=P7/14.6959
00            PA(4)=P71/14.6959
00            TK(1)=(T11+459.67)/1.8                      @TEMPERATURE IN K
00            TK(2)=(T2+459.67)/1.8
00            TK(3)=(T7+459.67)/1.8
00            TK(4)=(T71+459.67)/1.8
00      C
00      C**** FIND TRANSPORT AND THERMODYNAMIC PROPERTIES AT EACH POINT
00            DO 18 I=1,4
00            VM(I)=ESVOL(1,TK(I),PA(I),XM)
00            CALL VOLIT(TK(I),PA(I),XM,VM(I))
00            CALL HCVCP(N3,TK(I),VM(I),XM,H(I),CV,CP(I))
00            AM(I)=VISCON(3,TK(I),XW)
00            AK(I)=VISCON(4,TK(I),XW)
00         18 CONTINUE
00      C
00            AMS=(AM(1)+AM(2))/2.
00            AKS=(AK(1)+AK(2))/2.
00            CPS=(CP(1)+CP(2))/2.
00            AMH=(AM(4)+AM(3))/2.
00            AKH=(AK(4)+AK(3))/2.
00            CPH=(CP(4)+CP(3))/2.
00            VS=0.5*(VM(1)+VM(2))*16.01846/WM
00            VH=0.5*(VM(4)+VM(3))*16.01846/WM
00            RMASS8=RMASS**0.8
00            HCS=RMASS8*AKS**0.667*CPS**0.333/AMS**0.467
00            HCH=RMASS8*AKH**0.667*CPH**0.333/AMH**0.467
00            RHT=1./HCS+1./HCH
00            QS=RMASS*(H(2)-H(1))
00            QH=RMASS*(H(3)-H(4))
00            Q=(QS+QH)/2.
00            DTA=T7-T2
00            DTB=T71-T11
00            TF=(DTA-DTB)/(ALOG(DTA/DTB))
00            CQ=Q*RHT/TF
00            CPDS=(P11-P2)/(RMASS*RMASS*VS)
00            CPDH=(P7-P71)/(RMASS*RMASS*VH)
00            CPD=(CPDS+CPDH)/2.
00            WRITE(6,31)Q,QS,QH
00            WRITE(6,32)CPDS,CPDH
00            WRITE(6,34)CQ,CPD
00      C
00            WRITE(6,36)
00            READ(5,777)I
00            IF(I.NE.999)GOTO 15
00         19 FORMAT(' EVALUATION OF FOUR-WAY VALVE PARAMETERS')
00         20 FORMAT(' ENTER: T2,P2,T3,P3=')
00         21 FORMAT(' ENTER: T8,P8,T9,P9=')
00         22 FORMAT(' ENTER: RMASS,XW=')
00         31 FORMAT(' Q,QS,QH=',3(1PE10.3))
00         32 FORMAT(' CPDS,CPDH=',2(1PE10.3))
00         34 FORMAT(' CQ,CPD',2(1PE10.3))
00         36 FORMAT(' I=999 TO STOP, I=?')
00        777 FORMAT( )
```

```
 1150.          00          RETURN
 1160.          00          END

END ELT.  ERRORS: NONE. TIME:  0.188 SEC. IMAGE COUNT: 116

@HDG,P  ******  VISCON  ****** .L,0
```

```
@ELT,L DD.VISCON
ELT 8R1 S74Q1C 07/21/84 15:55:15 (0)
      00           FUNCTION VISCON(IQ,T,XW)
      00      C
      00      C
      00      C**** PURPOSE:
      00      C       TO CALCULATE ABS. VISCOSITY OR THERMAL CONDUCTIVITY
      00      C       OF LIQUID OR VAPOR, OR SPEC. HEAT OF SAT. LIQUID
      00      C       OF R-13B1/R-152A MIXTURE
      00      C
      00      C**** INPUT:
      00      C       IQ      - OUTPUT QUALIFIER
      00      C               = 1,  IF LIQUID ABS. VISCOSITY REQUIRED
      00      C               = 2,  IF LIQUID THERMAL CONDUCTIVITY REQUIRED
      00      C               = 3,  IF VAPOR ABS. VISCOSITY REQUIRED
      00      C               = 4,  IF VAPOR THERMAL CONDUCTIVITY REQUIRED
      00      C               = 5,  IF SPEC. HEAT OF SAT. LIQUID REQUIRED
      00      C       T       - TEMPERATURE   (F)
      00      C       XW      - WEIGHT COMPOSITION   (FRACTION OF R-152A)
      00      C
      00      C**** OUTPUT:
      00      C       VISCON - LIQ. ABS. VISCOSITY (IQ=1)   (LB/(H*FT))
      00      C              - LIQ. THERMAL CONDUCTIVITY (IQ=2)   (BTU/(H*FT*F))
      00      C              - VAP. ABS. VISCOSITY (IQ=3)   (LB/(H*FT))
      00      C              - VAP. THERMAL CONDUCTIVITY (IQ=4)   (BTU/(H*FT*F))
      00      C              - SAT. LIQUID SPEC. HEAT (IQ=5)   (BTU/(LB*F))
      00      C
      00           DATA W1,W2/148.93,66.05/,TB1,TB2/215.4,248.15/
      00           DATA R/0.125885/
      00      C
      00           GOTO (10,20,30,30,50)IQ
      00      C
      00      C**** LIQ. ABS. VISCOSITY
      00        10 TK=(T+459.68)/1.8
      00           TK2=TK*TK
      00           VL1=0.2749422-0.001702569*TK+3.71008313E-6*TK2
      00           VL1=VL1*16.01846/W1
      00           VL2=0.1023688715-4.0752759E-4*TK
      00           VL2=VL2+1.0409447E-6*TK2
      00           VL2=VL2*16.01846/W2
      00           VLM=(1.-XW)*VL1+XW*VL2
      00           VI1=2419.09*EXP(-4.22529+710.843/TK)*1.E-3
      00           VI1=VI1*VL1
      00           VI2=2419.09*EXP(-4.28224-753.013/TK)*1.E-3
      00           VI2=VI2*VL2
      00           FIA=(1.-XW)*VL1/VLM
      00           FIB=1.-FIA
      00           SEG=ALOG(VL2/VL1)
      00           ALFAA=-1.7*SEG
      00           ALFAB=0.27*SEG+SQRT(1.3*SEG)
      00           VISCON=FIA*VI1*EXP(FIB*ALFAB)+FIB*VI2*EXP(FIA*ALFAA)
      00           VISCON=VISCON/VLM
      00           GOTO 1000
      00      C
      00      C**** LIQ. THERMAL CONDUCTIVITY
      00        20 C1=0.035-1.5E-4*T
      00           C2=0.577778*(0.1165-4.97E-4*(T-32.)/1.8)
      00           VISCON=C1+(C2-C1)*XW*(0.72*XW+0.28)
```

```
00            GOTO 1000
00       C
00       C**** VAP. ABS. VISCOSITY
00          30 TK=(T+459.67)/1.8
00            TK2=TK*TK
00            X=W2/W1*(1.-XW)+XW
00            X=XW/X
00            VI1=-0.67329+7.60593E-3*TK-2.81108E-5*TK2
00            VI1=2.41909*(VI1+3.4741E-8*TK*TK2)
00            C2=0.1*(-0.08357+6.32E-4*TK+4.257E-7*TK2)
00            CP=-7.33704+0.093438*TK-3.61094E-4*TK2+4.80149E-7*TK2*TK
00            FE=0.115+0.354*CP/R
00            VI2=2.41909*0.03205*C2*W2/FE
00            IF(IQ.NE.3)GOTO 40
00            F12=(1.+SQRT(VI1/VI2)*(W2/W1)**0.25)**2
00            F12=F12/SQRT(8+8*W1/W2)
00            F21=F12*VI2*W1/(VI1*W2)
00            VISCON=(1.-X)*VI1/(1.-X+X*F12)
00            VISCON=VISCON+X*VI2/(X+(1.-X)*F21)
00            GOTO 1000
00       C**** VAP. THERMAL CONDUCTIVITY
00          40 C1=8.2982E-3-5.1971E-5*TK+1.8413E-7*TK2
00            S1=1.5*TB1
00            S2=1.5*TB2
00            S12=0.73*SQRT(S1*S2)
00            SEG=SQRT(VI1*(TK+S1)*(W2/W1)**0.75/(VI2*(TK+S2)))
00            A12=.25*(1.+SEG)**2*(TK+S12)/(TK+S1)
00            A21=.25*(1.+1./SEG)**2*(TK+S12)/(TK+S2)
00            VISCON=(1.-X)*C1/(1.-X+X*A12)
00            VISCON=0.577789*(VISCON+X*C2/((1.-X)*A21+X))
00            GOTO 1000
00       C**** SPEC. HEAT OF SAT. LIQUID
00          50 TK=(T+459.67)/1.8
00            TK2=TK*TK
00            C1=-1.49637+0.0278024*TK-1.23753E-4*TK2+1.92012E-7*TK*TK2
00            C2=-1.78539+0.0252241*TK-8.71975E-5*TK2+1.39262E-7*TK*TK2
00            VISCON=0.23902*((1.-XW)*C1+XW*C2)
00        1000 RETURN
00            END
```

END ELT. ERRORS: NONE. TIME: 0.171 SEC. IMAGE COUNT: 95

@HDG,P ****** VOLIT1 ****** .L,0

****** VOLIT1 ******

DATE 072184

```
@ELT,L DD.VOLIT1
ELT 8R1 S74Q1C 07/21/84 15:55:15 (0)
            SUBROUTINE VOLIT1(N,T,P5,X,V)
      C
      C**** PURPOSE:
      C        TO ITERATE REFRIG. MIXTURE R-13B1/R-152A SPEC. VOL.
      C        FROM EQUATION OF STATE
      C
      C**** INPUT:
      C        N  - OUTPUT QUALIFIER
      C             = 0, IF SPEC. VOL. OF LIQUID IS REQUIRED
      C             = 1, IF SPEC. VOL. OF VAPOR IS REQUIRED
      C        T  - REFRIG. TEMPERATURE    (K)
      C        P5 - REFRIG. SAT. PRESSURE    (STD ATM)
      C        X  - MOLAR COMPOSITION    (FRACTION OF LESS VOLATILE COMPONENT)
      C        *  - REFRIG. CONSTANTS A & B  (SEE COMMON STATEMENT /PARAM/)
      C**** OUTPUT:
      C        V  - REFRIG. SPEC. VOLUME    (L/MOL)
      C
      C**** SUBPROGRAMS CALLED BY VOLIT1:
      C        ESVCL,EQPAR
      C
      C
            COMMON/PARAM/A,B,C1,C2,D1,D2
            DATA R/0.08206/
      C
            IF(P5.GT.0.)GOTO 10
            PRINT 601,P5
        601 FORMAT(' VOLIT1 CALLED WITH NEG. PRESSURE, P5=',1PE13.3)
            RETURN
      C
         10 IF(T.LT.150.)PRINT 602,T
        602 FORMAT(' WARNING, VOLIT1 CALLED WITH TEMP.=',1PE11.3)
      C
            V=ESVCL(N,T,P5,X)
            CALL EQPAR(T,X)
            DO 100 I=1,25
            Y=B/(4.*V)
            Y2=Y*Y
            Y3=Y2*Y
            Y4=Y3*Y
            P=(R*T*(1.+Y+Y2-Y3)/(1.-Y)**3-A/(V+B))/V
            P6=(P5-P)/P5
            IF(ABS(P6).LT.1.E-04)GOTO 1000
            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
         50 V=V7
        100 CONTINUE
            WRITE(6,600)P6
        600 FORMAT(' ERROR 600 IN VOLIT1, P6 =',1PE12.4)
       1000 RETURN
            END
```

```
******  VOLIT1  ******                                      DATE 072184
END ELT.  ERRORS: NONE. TIME:  0.121 SEC. IMAGE COUNT: 55
@HDG,P  ******  WACCUM  ****** .L,0
```

```
@ELT,L DD.WACCUM
ELT 8R1 S74Q1C 07/21/84 15:55:16 (0)
      SUBROUTINE WACCUM(T,P.RMASS,WACC,XWA)
C
C**** PURPOSE:
C        TO CALCULATE MASS OF NON-AZEOTROPIC REFRIGERANT
C        IN AN ACCUMULATOR
C        3/13/84
C
C**** INPUT DATA:
C        AHGT      - ACCUMULATOR HEIGHT    (FT)
C        DACC      - INNER DIAMETER OF ACCUMULATOR    (FT)
C        DHOLE(1)  - INNER DIA. OF THE OIL RETURN HOLE  (FT)
C        DHOLE(2)  - INNER DIA. OF THE UPPER HOLE    (FT)
C        DTUBE     - INNER DIA. OF ACCUMULATOR TUBE    (FT)
C        HDIS      - VERTICAL DISTANCE BETWEEN HOLES    (FT)
C        P         - REFRIG. PRESSURE    (PSIA)
C        RMASS     - REFRIG. MASS FLOW RATE    (LB/H)
C        T         - REFRIG. TEMPERATURE    (F)
C
C**** OUTPUT DATA:
C        XWA       - WEIGHT COMPOSITION OF MIXTURE IN ACCUMULATOR
C                    (FRACTION OF LESS VOLATILE COMPONENT)
C        WACC      - MASS OF REFRIG. IN THE ACCUMULATOR    (LB)
C
C**** SUBPROGRAMS CALLED BY WACCUM:
C     QLITY,VOLIT1
C
      COMMON/RDATA2/W1,W2,TC1,TC2
      COMMON/RDATA3/XW,XM,WM
      COMMON/ACCDIM/AHGT,DACC,DHOLE(2),DTUBE,HDIS
C      DIMENSION AHCLE(2)
      REAL*8 WL,AHOL,PD,HL(2),HLL,HLDIFA,HLDIFB,HLLA,ZZ,Y1,Y2,
     &        HLLB,Z1,Z2,DP,RM,RMT,DIFF1,DIFF2,SLOPE,ALFA,AT
      REAL*8 RO,PDYN,AHOLE(2),RMSL
      DATA PI/3.1415927/
C
      AACC=PI*DACC*DACC/4.
      PA=P/14.6959
      TK=(T+459.67)/1.8
      CALL QLITY(TK,PA,XM,X,XV,XL)
      XLW=XL/(W1/W2*(1.-XL)+XL)
      XVW=XV/(W1/W2*(1.-XV)+XV)
C
      IF(X.GT..999)THEN            @VAPOR ONLY IN ACCUMULATOR
         CALL VOLIT1(1,TK,PA,XM,V)
         V=V*16.01846/WM
         WACC=AACC*AHGT/V
         XWA=XW
         GOTO 100
      END IF
C
      CALL VOLIT1(0,TK,PA,XL,V)    @LIQUID PRESENT IN ACCUMULATOR
      WML=W1*(1.-XL)+W2*XL
      RO=WML/(V*16.01846)
      CALL VOLIT1(1,TK,PA,XV,V)
      WMV=W1*(1.-XV)+W2*XV
      V=V*16.01646/WMV
```

```
00          RMS=RMASS/3600.
00          RMSL=(1.-X)*RMS
00          AHOLE(1)=PI*DHOLE(1)*DHOLE(1)/4.
00          ATUBE=PI*DTUBE*DTUBE/4.
00          AHOL=AHOLE(1)
00          HLL=DHOLE(1)
00          PDYN=0.5*(X*RMS/ATUBE)**2*V
00    C
00          DO 10 I=1,20
00          WL=RMSL/AHOL
00          PD=WL*WL/(.585*.585*2.*RO)
00          HL(1)=(PD-PDYN)/(RO*32.2)
00          IF(I.EQ.1.AND.HL(1).GT.DHOLE(1))GOTO 12
00          IF(ABS((HL(1)-HLL)/DHOLE(1)).LT.0.01)GOTO 12
00          IF(I.EQ.1)THEN
00             HLL=DHOLE(1)/2.
00             HLLA=DHOLE(1)
00             HLDIFA=HL(1)-DHOLE(1)
00          ELSE
00             HLDIFB=HL(1)-HLL
00             HLLB=HLL
00             HLL=HLLA-HLDIFA*(HLLA-HLLB)/(HLDIFA-HLDIFB)
00             HLLA=HLLB
00             HLDIFA=HLDIFB
00             IF(HLL.LT.0.)HLL=.9*HLLA
00          END IF
00          R=0.5*DHOLE(1)
00          Z1=HLL-R
00          Z2=DSQRT(R*R-Z1*Z1)
00          AT=Z1*Z2
00          ALFA=2.*ARCOS(ABS(Z1/R))
00          IF(HLL.GT.R)ALFA=2.*PI-ALFA
00          AHOL=AHOLE(1)*ALFA/(2.*PI)+AT
00       10 CONTINUE
00          WRITE(6,90)
00       90 FORMAT(' WACCUM LOOP 10 DID NOT CONVERGE')
00          GOTO 40
00    C
00       12 VHGT=AHGT-HL(1)
00          VHGT=AMAX1(0.,VHGT)
00          AMASS2=AACC*(HL(1)*RO+VHGT/V)
00          IF(HL(1).LE.HDIS.OR.HDIS.EQ.0.)GOTO 40
00          AHOLE(2)=PI*DHOLE(2)*DHOLE(2)/4.
00          Z1=HL(1)
00          HL(2)=HL(1)-HDIS
00          DP=HL(2)*RO*32.2+PDYN
00          RM=0.585*AHOLE(2)*DSQRT(2.*RO*DP)
00          DIFF1=RM
00          VHGT=AHGT-HL(1)
00          VHGT=AMAX1(0.,VHGT)
00          AMASS1=AACC*(Z2*RO+VHGT/V)
00          Z2=HDIS
00          DO 30 J=1,20
00          HL(1)=Z2
00          HL(2)=Z2-HDIS
00          RMT=0.D0
00          DO 16 I=1,2
00          DP=HL(I)*RO*32.2D0+PDYN
```

```
00          IF(HL(I).EQ.0.D0)DP=0.D0
00          AHOL=1.
00          IF(I.EQ.2)THEN
00             IF(HL(2).GT.DHOLE(2))GOTO 15
00             IF(HL(2).EQ.0.D0)GOTO 15
00             R=.5*DHOLE(2)
00             Y1=HL(2)-R
00             Y2=DSQRT(R*R-Y1*Y1)
00             AT=Y1*Y2
00             ALFA=2.*ARCOS(DABS(Y1/R))
00             IF(HL(2).GT.R)ALFA=2.*PI-ALFA
00             AHOL=AHOLE(2)*ALFA/(2.*PI)+AT
00             AHOL=AHOLE(2)/AHOL
00          END IF
00       15 RM=0.585*AHOLE(I)*DSQRT(2.*RO*DP)/AHOL
00       16 RMT=RMT+RM
00          DIFF2=RMT-RMSL
00          VHGT=AHGT-HL(1)
00          VHGT=AMAX1(0.,VHGT)
00          AMASS2=AACC*(HL(1)*RO+VHGT/V)
00          IF(ABS(AMASS1-AMASS2).LT.0.01)GOTO 40
00          SLOPE=(Z1-Z2)/(DIFF1-DIFF2)
00          ZZ=Z2-DIFF2*SLOPE
00          IF(ABS(DIFF1).LT.ABS(DIFF2))GOTO 20
00          AMASS1=AMASS2
00          DIFF1=DIFF2
00          Z1=Z2
00       20 Z2=ZZ
00          Z2=DMAX1(Z2,HDIS)
00       30 CONTINUE
00          ERROR=AACC*ABS(Z2-Z1)*RO
00          WRITE(6,602)ERROR
00       40 CONTINUE
00          IF(VHGT.EQ.0.)WRITE(6,600)
00          WACC=AMASS2
00          W152A=AACC*(HL(1)*RO*XLW+VHGT/V*XVW)
00          XWA=W152A/WACC
00      100 XWB=1.-XWA
00          WRITE(6,604)XWB,WACC
00      600 FORMAT(' ACCUMULATOR OVERFILLED')
00      602 FORMAT(' WACCUM DOES NOT CONVERGE, MAX.ERROR =',1PE10.3,'  (LB)')
00      604 FORMAT('  COMPOSITION OF REFRIG. IN ACCUMULATOR =' ,F6.3,/
00         @ '  (WEIGHT FRACTION OF MORE VOLATILE COMPONENT)' ,//
00         @ '  REFRIG. IN ACCUMULATOR =',F8.3, ' LB')
00          RETURN
00          END

END ELT.  ERRORS: NONE. TIME:  0.217 SEC. IMAGE COUNT: 160

@HDG,N

@OFFSEND,S
```

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Piotr Domanski

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10\. SUPPLEMENTARY NOTES

[ ] Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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)

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 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.

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 heat pump. User's Manual and listing of the program is included in the report.

12\. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

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

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