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~~J. Hamacle~~
Steve West

ADVANCED ENVIRONMENTAL CONTROL SYSTEM COMPUTER PROGRAM USERS MANUAL

MCDONNELL AIRCRAFT COMPANY
MCDONNELL DOUGLAS CORPORATION
SAINT LOUIS, MISSOURI 63166

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This report is a supplement to the "IECS Computer Program Users Manual," AFFDL-TR-72-9, Volume III, and provides a Users Manual for the AECS version of the IECS Computer Program. The computer program is capable of analyzing the steady state performance, determining typical sizing data, and evaluating relative aircraft penalties for virtually any air cycle or vapor cycle aircraft ECS. The program was written in the Fortran IV language for the CDC 6600 Computer. This users manual provides supplementary information for this version of the computer program.

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FOREWORD

This Users Manual was developed by the McDonnell Aircraft Company, a component of the McDonnell Douglas Corporation, St. Louis, Missouri; under Air Force Contract F33615-74-C-3039, "Advanced Environmental Control System." This development program was conducted under the sponsorship of the Air Force Flight Dynamics Laboratory, Project No. 444A, Task No. 0001, with Mr. Eugene A. Zara, FEB, as Program Manager.

The report covers work performed from May 1974 to August 1976.

APPENDIX A

PERFORMANCE COMPONENTS

Component Name		Component	Section
APU		Auxiliary Power Unit	A1
BØILER	R	Boiler	A2
ECS CNNCT		Leg and Station Connector	A3
CØMP	R	Compressor	A4
COND		Condenser	A5
CVALVE		Control Valve	A6
DRAIN		Water Drain	A7
DSEP		Dust Separator	A8
EJECT	R	Ejector	A9
EVAP		Evaporator	A10
FAN FUNC		Fan	A11
HXA	R	Heat Exchanger	A12
~~HXB~~	D	~~Heat Exchanger~~	~~A13~~
INJECT	R	Water Injector	A14
INLET		Inlet to ECS	A15
LINE	R	Line	A16
LØØP		Fluid Loop	A17
MERGE	R	Flow Merge	A18
MISC	R	Miscellaneous Operations	A19
NØZZLE	R	Nozzle	A20
ØRIF		Orifice	A21
ØUTLET		Outlet from ECS	A22
PREG		Pressure Regulator	A23
PUMP		Pump	A24
QLØAD	R	Compartment Heat Load	A25
SENSØR		Flow, Pressure, Temperature, Humidity/ Enthalpy Sensor	A26
SHAFT	R	Shaft Initialization	A27
SPLIT		Flow Split	A28
SPØWER		Shaft Power Balance	A29
TURB	R	Turbine	A30
VALVE		Valve	A31

VCØMP	Vapor Cycle Compressor	A32
VLINE	Vapor Line	A33
WSEP	Water Separator	A34
CCS	/ Conditional Card Skip	A38
FUNC	/ Function Computation	A43

Notes: 1. Data card fields which refer to the parameter table are indicated by brackets, [ ].

2. A card column specified by a single value represents the right-hand column of a four column integer data field. Data values punched in these fields must be right justified.

Sizing

Boiler	B2
Heat Exchanger	B11

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

ABBREVIATIONS:

AECS - Advanced Environmental Control System

°F - Degrees Fahrenheit

ICS - Internal Countermeasure System

IECS - Integrated Environmental Control System

lb - Pound

PSIA - Pounds per Square Inch Absolute

PSIG - Pounds per Square Inch Gauge

SUMMARY

This report is a supplement to the "IECS Computer Program Users Manual", AFFDL-TR-72-9, Volume III, and provides a Users Manual for the AECS version of the IECS Computer Program. This version of the computer program was developed under USAF Advanced Environmental Control System Contract F33615-74-C-3039, Project 444A, sponsored by the Air Force Flight Dynamics Laboratory, with Eugene A. Zara as Air Force Program Manager.

The Advanced Environmental Control System (AECS) project computational requirements have exceeded some of the limitations in the original IECS Computer Program. These requirements include: condensation, separation, injection, and evaporation of large quantities of water in the air flow; liquid loops with large temperature changes; and new component performance specifications. The AECS Computer Program provides improved simulation of these requirements, and also provides several other changes allowing for easier set up of the model data cards.

The changes to the performance components are:

1) Components BOILER, HXA, LINE, and QLOAD: these components have been changed to use a sensible heat ratio to better account for large amounts of condensation or evaporization of water in the air flow;
2) Component INJECT: this component has been changed to better account for a large amount of water injection to the air flow;
3) Components BOILER, HXA, LINE, QLOAD, and MERGE: these components have been changed to use enthalpies for liquid flows, or specific heats evaluated at average temperatures for gas flows, to better account for a heat balance;
4) Component HXA: this component has been changed to optionally allow for input of ηhA data, reference temperatures, or average temperatures to better account for heat exchanger temperature level effects;
5) Component HXB: this component has been eliminated, and should be replaced by use of the components LOOP and HXA;
6) Component COMP: this component has been changed to provide additional map specification options, including head function;
7) Component TURB: this component has been changed to provide additional map specification options, including static

efficiency and variable nozzle area;

8) Component EJECT: this component has been changed to provide another general argument;

9) Component NOZZLE: this component has been changed to define the flow ratio general argument when the freestream velocity is undefined, and to make the discharge coefficient table optional;

10) Component MISC: this component has been changed to allow the result variable to define a one dimensional table;

11) Component LINE: this component has been changed to allow another pressure drop option.

Note that none of the vapor cycle components have been changed.

Two new performance components have been provided:

1) Component FUNC: this component has been provided to compute several flow functions in common use, such as critical flow through an area for leakage;

2) Component CCS: this component has been provided to allow component cards to be skipped during the Z phase, such as ejectors turned on or off.

Performance options have also been provided for input of ambient humidity, and for more selective printout of component performance results.

The changes to the sizing components are to the BOILER and HX components. These changes are the same that were made to the performance components for sensible heat ratio and enthalpy.

The permanent table set has been changed. Heat exchanger effectiveness tables for cross-counter-flow from one through six passes have been provided for use in either heat exchanger sizing, or heat exchanger performance when the ηhA option is used. Fluid property tables for liquids and gases have also been changed to define fluid enthalpy values.

The following changes and additions are referenced to the "IECS Computer Program Users Manual" by section and subsection numbers.

SECTION I

NOMENCLATURE CHANGES

Symbol	Definition
F_H	Compressor Adiabatic Head Function
h	Liquid or Gas Enthalpy, Btu/lb
SHR	Sensible Heat Ratio
ηhA	Heat Transfer Surface Fin Conductance, Btu/min -°R

SECTION II

CARD NAME AND PRINTOUT SYMBOL CHANGES

Word	Definition
AE	Turbine Exit Area (A)
HAM	Ambient Humidity Card Name (4.10)
HAMB	Ambient Humidity (4.3)
ICPØ	Component Performance Print Option (4.5)
IFNC	Function Option (A)
IHA1 or IHA2	Heat Transfer Fin Effective Conductance Table Relative Number (A)
ISØP	Pressure Drop Option (A)
NAR3	Argument Relative Number (4.6)
NAT3	Argument Type Code (4.6)
NCS	Number of Cards to Skip (A)
NEI3	Extrapolation/Interpolation Code (4.6)
NPT3	Number of Points of Independent Variables (4.6)
SC	Skip Condition (A)
SHR, SR1 or SR2	Sensible Heat Ratio (A&B)
TR1 or TR2	Reference Temperature (A)

SECTION III

SECTION 4 CHANGES

PROGRAM INPUT

Section 4.3.1 Performance Case Specification Cards

The performance case CASEC data card has been modified to allow the input of freestream or ambient humidity. The CASEC data card format is:

Card Column	Name	Value
1-5	CN	CASEC card name
11-20	ALT	altitude, ft.
21-30	PAMB	freestream or ambient pressure, psia (not used if IPA≠0 on CASEB card)
31-40	TAMB	freestream or ambient temperature, °R (not used if ITA≠0 on CASEB card)
41-50	HAMB	freestream or ambient humidity, $lb_{water}/lb_{dry\ air}$

Section 4.5.1 Performance Component Cards

The performance case component cards can include CMPNNT cards. This card can be used to change the component performance printout code (ICPP on the CASEA data card) for the preceding component. The data card format is:

Card Column	Name	Value
1-6	CN	CMPNNT card name
8	CC	change code
12	NC	card number
16	ICPØ	component performance print change option = 0 - print option will be the same as that on the CASEA card = 1 - print option will be reversed from that on the CASEA card

Section 4.6 Table Cards

The functional table form has been expanded to allow four dimensional tables, y = f(x, z, w). The tables can be specied by two formats: regular grid, NDIM=4; or irregular grid, NDIM=44. These forms are similar to the three dimensional table forms, NDIM=3 and 33, and the table values are entered as sets of three dimensional table values.

The new TABID data card format is:

Card Column	Name	Value
1-5	CN	TABID card name
12	NREL	relative number of required table
16	NTYP	type of required table
20	NDIM	number of dimensions
24	IST	scale type code 0 = all linear 15=all log
28	NAT1	type of first independent variable in TABR
32	NAR1	relative number of first independent variable
36	NEI1	extrapolation/interpolation code of first independent variable IEI1 — ee ii (IE IE)
40	NPT1	number of points of first independent variable 30 → INT II
44	NAT2	type of second independent variable ee=01 don't extrap
48	NAR2	relative number of second independent variable ee=00 OK to extrap
52	NEI2	extrapolation/interpolation code of second independent variable
56	NPT2	number of points of second independent variable
60	NAT3	type of third independent variable
64	NAR3	relative number of third independent variable
68	NEI3	extrapolation/interpolation code of third independent variable
72	NPT3	number of points of third independent variable

The scale type codes are:

	Scale (col 2A) Type Code	Dependent Variable	First Independent Variable	Second Independent Variable	Third Independent Variable
1D	0	Linear	Linear	Linear	Linear
	1	Log	Linear	Linear	Linear
	2	Linear	Log	Linear	Linear
2D	3	Log	Log	Linear	Linear
	4	Linear	Linear	Log	Linear
	5	Log	Linear	Log	Linear
	6	Linear	Log	Log	Linear
3D	7	Log	Log	Log	Linear
	8	Linear	Linear	Linear	Log
	9	Log	Linear	Linear	Log
	10	Linear	Log	Linear	Log
	11	Log	Log	Linear	Log
	12	Linear	Linear	Log	Log
	13	Log	Linear	Log	Log
	14	Linear	Log	Log	Log
4D	15	Log	Log	Log	Log

The table values are entered in the following order:

1) starting on the first card, all values of the third independent variable in ascending order, four values per card;
2) starting on a new card, input the tables values in the three dimensional form (3D form for a 4D regular grid, or 33D form for a 44D irregular grid) that correspond to the first value of the third independent variable;
3) repeat step 2 for each value of the third independent variable.

Examples of four dimensional tables are given on the following pages.

The general arguments set up by the program for a performance case has been expanded to include freestream humidity as general argument number 9.

DECK NO. AECS	GENERAL ECS PROGRAM	TEMPORARY TABLE INPUT 1

1		NREL 12	NTYP 16	NDIM 20	IST 24	NAT1 28	NAR1 32	NEI1 36	NPT1 40	NAT2 44	NAR2 48	NEI2 52	NPT2 56	NAT3 60	NAR3 64	NEI3 68	NPT3 72	76	80
TABID		?	?	4	?	?	?	?	5	?	?	?	2	?	?	?	3		.

5 X 2 Z 3W

1	7
TABT	SAMPLE[b] FUNCTIONAL[b] TABLE[b] 4D[b] Y = F(X, Z, W) W's 8 T's 2 H's 3

W=H's
X=FLOWS
Z=TEMPS

1		11	20 21	30 31	40 41 50
TABV		W_1	W_2	W_3	
		X_1 for W_1	X_2 for W_1	X_3 for W_1	X_4 for W_1
		X_5 for W_1			
		Z_1 for W_1	Z_2 for W_1		
		$Y(X_1, Z_1, W_1)$	$Y(X_2, Z_1, W_1)$	$Y(X_3, Z_1, W_1)$	$Y(X_4, Z_1, W_1)$
		$Y(X_5, Z_1, W_1)$	$Y(X_1, Z_2, W_1)$	$Y(X_2, Z_2, W_1)$	$Y(X_3, Z_2, W_1)$
		$Y(X_4, Z_2, W_1)$	$Y(X_5, Z_2, W_1)$		
		X_1 for W_2	X_2 for W_2	X_3 for W_2	X_4 for W_2
		X_5 for W_2			
		Z_1 for W_2	Z_2 for W_2		
		$Y(X_1, Z_1, W_2)$	$Y(X_2, Z_1, W_2)$	$Y(X_3, Z_1, W_2)$	$Y(X_4, Z_1, W_2)$
		$Y(X_5, Z_1, W_2)$	$Y(X_1, Z_2, W_2)$	$Y(X_2, Z_2, W_2)$	$Y(X_3, Z_2, W_2)$
		$Y(X_4, Z_2, W_2)$	$Y(X_5, Z_2, W_2)$		
		X_1 for W_3	X_2 for W_3	X_3 for W_3	X_4 for W_3
		X_5 for W_3			
		Z_1 for W_3	Z_2 for W_3		
		$Y(X_1, Z_1, W_3)$	$Y(X_2, Z_1, W_3)$	$Y(X_3, Z_1, W_3)$	$Y(X_4, Z_1, W_3)$
		$Y(X_5, Z_1, W_3)$	$Y(X_1, Z_2, W_3)$	$Y(X_2, Z_2, W_3)$	$Y(X_3, Z_2, W_3)$
		$Y(X_4, Z_2, W_3)$	$Y(X_5, Z_2, W_3)$		

DECK NO. AECS | GENERAL ECS PROGRAM | TEMPORARY TABLE INPUT 1

1		NREL 12	NTYP 16	NDIM 20	IST 24	NAT1 28	NAR1 32	NEI1 36	NPT1 40	NAT2 44	NAR2 48	NEI2 52	NPT2 56	NAT3 60	NAR3 64	NEI3 68	NPT3 72	76	80
TABID		?	?	44	?	?	?	?	3	?	?	?	2	?	?	?	3		
									X WCORR				Z WENG				W		

1 7

TABT SAMPLEb FUNCTIONALb TABLEb 44Db Y = F(X, Z, W)

1		11 3rd	20 21	30 31	40 41 50
TABV		W_1	W_2	W_3	
		X_1 for Z_1 and W_1	X_2 for Z_1 and W_1	X_3 for Z_1 and W_1	
		X_1 for Z_2 and W_1	X_2 for Z_2 and W_1	X_3 for Z_2 and W_1	
		Z_1 for W_1	Z_2 for W_1		
		$Y(X_1, Z_1, W_1)$	$Y(X_2, Z_1, W_1)$	$Y(X_3, Z_1, W_1)$	$Y(X_1, Z_2, W_1)$
		$Y(X_2, Z_2, W_1)$	$Y(X_3, Z_2, W_1)$		
		X_1 for Z_1 and W_2	X_2 for Z_1 and W_2	X_3 for Z_1 and W_2	
		X_1 for Z_2 and W_2	X_2 for Z_2 and W_2	X_3 for Z_2 and W_2	
		Z_1 for W_2	Z_2 for W_2		
		$Y(X_1, Z_1, W_2)$	$Y(X_2, Z_1, W_2)$	$Y(X_3, Z_1, W_2)$	$Y(X_1, Z_2, W_2)$
		$Y(X_2, Z_2, W_2)$	$Y(X_3, Z_2, W_2)$		
		X_1 for Z_1 and W_3	X_2 for Z_1 and W_3	X_3 for Z_1 and W_3	
		X_1 for Z_2 and W_3	X_2 for Z_2, and W_3	X_3 for Z_2 and W_3	
		Z_1 for W_3	Z_2 for W_3		
		$Y(X_1, Z_1, W_3)$	$Y(X_2, Z_1, W_3)$	$Y(X_3, Z_1, W_3)$	$Y(X_1, Z_2, W_3)$
		$Y(X_2, Z_2, W_3)$	$Y(X_3, Z_2, W_3)$		

Section 4.10 Change Case Cards

The performance quick change case data cards have been expanded to allow a data card to change the ambient humidity. The data card format is:

Card Column	Name	Value
1-3	CN	HAM card name
11-20	H	ambient humidity value $lb_{water}/lb_{dry\ air}$

A1

Performance Component APU

Auxiliary Power Unit

Purpose: This component will compute the performance of an APU used to supply bleed air and/or shaft power.

Options: APU performance is computed with the following options:

NL = 0 no bleed air supplied

NL ≠ 0 bleed air supplied

NST = 0 no shaft power is supplied

NST ≠ 0 shaft power is supplied

Equations:

$$P_{out} = P_{in} \cdot PR$$

$$\overline{T}_{out} = T_{in} \cdot PR^{\left(\frac{\gamma-1}{\eta_p \gamma}\right)}$$

$$H_{out} = H_{in}$$

$$T_{out} = f\,(P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

Restrictions:

1. This component can only be used for fluid type 2.
2. The APU shaft number must be previously defined (see component SHAFT).

Notes:

1. Fluid properties

   γ - evaluated at T_{in}
2. Bleed air and shaft power options may be used simultaneously.
3. The component performance printout consists of the following items:

   NL - leg number

   NSI - inlet station number

   NSØ - outlet station number

   FT - fluid type

   FN - fluid number

W - flow rate

PI - inlet pressure

PØ - outlet pressure

TI - inlet temperature

TØ - outlet temperature

HI - inlet humidity

HØ - outlet humidity

if NL $\neq$ 0

PR - pressure ratio

EFF - polytropic efficiency

if NST $\neq$ 0

SHAFT - shaft number

HP - horsepower

Performance Component APU

Data Card Format

Card Column	Symbol	Value
1-3	CN	APU component name
8	CC	change code
12	NC	card number
16	NL	leg number = 0 no bleed air ≠ 0 bleed air
20	NSI	inlet station number (if NL ≠ 0)
24	NSØ	outlet station number (if NL ≠ 0)
28	NST	shaft number = 0 no shaft power ≠ 0 shaft power
32	[PR]	pressure ratio (P_{out}/P_{in})(if NL ≠ 0)
36	[EFF]	polytropic efficiency (if NL ≠ 0)
40	[PWR]	shaft power supplied (if NST ≠ 0)

SECTION IV

A2 - REPLACEMENT

PERFORMANCE COMPONENT BØILER

Boiler

Purpose: This component will compute the heat transfer performance and flow side pressure drop for a boiler.

Options: The flow side pressure drop may be computed with the following options:

ISIG = 0 ΔP is read from a table

ISIG = 1 $\sigma\Delta P$ is read from a table

Equations:

$$SHR = (T_{in} - \bar{T}_{out})/(T_{in} - T_{out})$$

$$W' = W \cdot SHR$$

$$\varepsilon = f(W')$$

$\underline{\text{if } T_{in} > T_{boil}}$

$$\bar{T}_{out} = T_{in} - \varepsilon\,(T_{in} - T_{boil})$$

$$\bar{T}_{out} = f\,(P_{in}, T_{in}, H_{in}, P_{out}, T_{out}, H_{out})$$

$\underline{\text{if } T_{in} \le T_{boil}}$

$$\bar{T}_{out} = T_{in}$$

$$T_{out} = f\,(P_{in}, T_{in}, H_{in}, P_{out}, \bar{T}_{out}, H_{out})$$

$$\sigma\Delta P \text{ or } \Delta P = f(W)$$

$$P_{out} = P_{in} - \Delta P$$

$$H_{out} = H_{in}$$

$\underline{\text{for fluid type 1}}$

$$Q = W(h_{out} - h_{in})$$

$\underline{\text{for fluid type 2}}$

$$Q = W \cdot C_p\,(T_{out} - T_{in}) \cdot SHR$$

$$W_{boil} = Q/H_{fg}$$

Required Tables:

ΔP or $\sigma\Delta P$ - Table ID(IPD,1) - Pressure drop

ε - Table ID(IE,5) - Temperature effectiveness

Restrictions:

1. This component may only be used for fluid types 1 and 2.

Notes:

1. The following general arguments are set up in this component.
   - argument 26 - boiling temperature
   - argument 41 - modified flow in leg
   - argument 43 - inlet pressure
2. Fluid properties

   σ - evaluated at P_{in}, T_{avg}

   C_p - evaluated at T_{avg}

   where $T_{avg} = (T_{in} + \bar{T}_{out})/2$
3. The component performance printout consists of the following items:

   NL - leg number
   NSI - inlet station number
   NSØ - outlet station number
   FT - fluid type
   FN - fluid number
   W - flow rate
   PI - inlet pressure
   PØ - outlet pressure
   TI - inlet temperature
   TØ - outlet temperature
   HI - inlet humidity
   HØ - outlet humidity
   TB - boiling temperature
   EFF - temperature effectiveness
   Q - boiling heat rate
   SHR - sensible heat ratio

   if HFG $\neq$ 0.

   WB - boiling rate

Performance Component BØILER

Data Card Format

Card Column	Symbol	Value
1-6	CN	BØILER component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	ISIG	option = 0 use ΔP = 1 use $\sigma\Delta P$
32	IPD	pressure drop table relative number (type 1)
36	[TB]	boiling temperature
40	IE	temperature effectiveness table relative number (type 5)
44	[HFG]	heat of vaporization (optional)

p 255 of Vol I
Boiler w/ 2 sides

SECTION XVII

A38 - ADDITION

PERFORMANCE COMPONENT CCS

Conditional Card Skip

Purpose: This component will conditionally skip the processing of component data cards depending on the value of a parameter table value. The number of component cards to be skipped is also specified.

Options: The skipping of the component data cards is dependent on the skip condition value and the skip operation. Cards can be skipped when the skip condition is greater than, less than, or equal to zero, and any combinations of these conditions.

Restrictions:

1. The testing of the skip condition, and the skipping of component data cards is performed during the Z phase. Thus, the user must supply the value of the skip condition in the parameter table, (i.e., via a parameter table VALUE or VALUES data card). The MISC component, which can modify the parameter table values during the P phase, cannot be used to set the skip condition and the skip option cannot be altered on QCHANGE cases since the QCHANGE case is processed in the P phase.

Notes:

1. Invalid skip data will cause an error and the card will be ignored, (i.e., no cards will be skipped).
2. If the number of cards to be skipped is greater than the number of remaining component data cards, no error occurs and the remaining component data cards are skipped.

Performance Component CCS

Data Card Format

Card Column	Symbol	Value
1-3	CN	CCS component name
8	CC	change code
12	NC	card number
16	NCS	number of cards to skip
20	[SC]	skip condition
24	IØPR	skip operation
		= 0 skip when SC $\neq$ 0
		= 1 skip when SC = 0
		= 2 skip when SC $\geq$ 0
		= 3 skip when SC $\leq$ 0
		= 4 skip when SC > 0
		= 5 skip when SC < 0

parameter #

works before first pass

52KW
188

6527
6223

A3

Performance Component CNNCT

Leg and Station Connector

Purpose: This component may be used to connect legs and/or stations in a model to add or delete components in a change case.

Options: None

Equations:

$$W_{out} = W_{in}$$

$$P_{out} = P_{in}$$

$$T_{out} = T_{in}$$

$$H_{out} = H_{in}$$

Notes:

1. There is no performance printout for this component.
2. Inlet and outlet leg numbers may be equal or different. Inlet and outlet station numbers may be equal or different.

Performance Component CNNCT

Data Card Format

Card Column	Symbol	Value
1-5	CN	CNNCT component name
8	CC	Change code
12	NC	card number ✓
16	NLI	inlet leg number ✓
20	NSI	inlet station number ✓
24	NLØ	outlet leg number ✓
28	NSØ	outlet station number ✓

SECTION V

A4 - REPLACEMENT

PERFORMANCE COMPONENT CØMP

Compressor

Purpose: This component will compute compressor performance.

Options: Compressor performance is computed with the following options:

IØP = 0 - Fixed pressure ratio. No state variable or error variable is set up.

IØP = 1 - Variable pressure ratio. A type 8 state variable is set up for the pressure ratio.

IØP = 2 - Pressure ratio table is used. No state or error variables are set up.

IØP = 3 - Corrected flow table is used. A type 8 state variable for the pressure ratio and a type 1 error variable for the compressor flow balance are set up.

IØP = 4 - Adiabatic head table is used. No state or error variables are set up.

IØT = 0 - Efficiency table is used.

IØT = 1 - $\Delta T/T$ table is used $\left(\frac{T_{out} - T_{in}}{T_{in}}\right)$.

Equations: <u>if IØP=0</u>

PR = parameter value

<u>if IØP=1</u>

PR = state variable (type 8)

<u>if IØP=2</u>

PR = table lookup

<u>if IØP=3</u>

PR = state variable (type 8)

<u>if IØP=4</u>

F_H = table lookup

η_c = table lookup

$$PR = (F_H \eta_c / T_o + 1)^{\gamma/(\gamma-1)}$$

$$P_{out} = P_{in} \cdot PR$$

$\Delta T_i / T_{in} = PR^{(\gamma-1)/\gamma} - 1.0$

<u>if IØT=0</u>

η_c = table lookup

$\bar{T}_{out} = T_{in} + T_{in} \; (\Delta T_i / T_{in}) / \eta_c$

<u>if IØT=1</u>

$\Delta T/T$ = table lookup

$T_{out} = T_{in} + T_{in} \; (\Delta T/T)$

$\eta_c = (\Delta T_i / T_{in}) / (\Delta T/T)$

$H_{out} = H_{in}$

$T_{out} = f\,(P_{in}, T_{in}, H_{in}, P_{out}, \bar{T}_{out}, H_{out})$

$HP = 0.02356 \; W \cdot C_p \cdot (T_{in} - \bar{T}_{out}) / \eta_m$

<u>if IØP=3</u>

$w_{calc} = W_c \cdot P_{in} / (14.7 \sqrt{T_{in}/519})$

Wcorr from graph not W compressor

Error Variable = $W - W_{calc}$

Required Tables:

for IØT = 0 only

η_c - Table ID (ICT, 6) - Compressor efficiency

for IØT = 1 only

$\Delta T/T$ - Table ID (ICT, 24) - Compressor efficiency function

for IØP = 2 only

PR - Table ID (ICT, 4) - Compressor pressure ratio (P_{out}/P_{in}) vs corr flow vs Wcorr & $N/\sqrt{\theta}$

for IØP = 3 only

W_c - Table ID (ICT, 21) - Compressor corrected flow

$W \cdot 14.7 \cdot \sqrt{T_{in}/519/P_{in}}$

for IØP = 4 only

F_H - Table ID (ICT, 25) - Compressor adiabatic head function

$$F_H = \frac{H_{ad}/\eta_c \Theta}{R(\frac{\gamma}{\gamma-1})}$$

Restrictions:

1. This component can only be used for fluid type 2.
2. The CØMP shaft number must be previously defined (see component SHAFT).
3. The IØP = 4 and the IØT = 1 options cannot be used together.

Notes:

1. The following general arguments are set up in this component:

   for IØP = 2, 3 and 4 only

   - argument 22, corrected flow $W\sqrt{T_{in}/519}/(P_{in}/14.7)$
   - argument 25, corrected speed $N/\sqrt{T_{in}/519}$
   - argument 41, flow in leg
   - argument 24, pressure ratio P_{out}/P_{in}

   80+NST, SHAFT RPM
   90+NST, SHAFT POWER

2. Fluid properties:

   γ - evaluated at T_{in}

   C_p - evaluated at $T_{avg} = (T_{in} + \bar{T}_{out})/2$

3. A shaft power balance may be obtained by inserting a SPØWER card (see SPOWER component).

4. Option 2 requires compressor maps with PR and η_c as dependent variables in tables. The arguments frequently used for the independent variables are corrected flow and corrected speed. This option should be used for most cases.

   Option 3 inverts the pressure ratio map so that W_c is the dependent variable. The arguments which should be used for the independent variables are pressure ratio and corrected speed. This option should be used for compressors which have very steep pressure ratio lines as a function of corrected flow and corrected speed. Maps which fall in that category generally are low pressure ratio fans.

   Option 4 provides for the alternate form of adiabatic head input in place of pressure ratio. The arguments which should be used for the independent variables are corrected flow and corrected speed.

(COMP)

5. The component performance printout consists of the following items:

NL - leg number
NSI - inlet station number
NSØ - outlet station number
FT - fluid type
FN - fluid number
W - flow rate
PI - inlet pressure
PØ - outlet pressure
TI - inlet temperature
TØ - outlet temperature
HI - inlet humidity
HØ - outlet humidity
SHAFT - shaft number
PR - compressor pressure ratio
EFF - compressor efficiency
HP - compressor horsepower

6. Compressor shaft power is accumulated in general argument (90+NST).

Performance Component CØMP

Data Card Format

Card Column	Symbol	Value
1-4	CN	CØMP component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	NST	shaft number
32	IØPT	option = ijkℓ
		i - not used
		j - not used
		k - IØT efficiency option
		if IØT
		= 0 - efficiency table
		= 1 - efficiency function table
		ℓ - IØP pressure option
		if IØP
		= 0 - fixed pressure ratio - no table
		= 1 - variable pressure ratio - no table
		= 2 - variable pressure ratio - pressure ratio table
		= 3 - variable pressure ratio - corrected flow table
		= 4 - variable pressure ratio - adiabatic head table
		5 - $(\Delta P_T \times 10^8 / \sigma N^2)$ VS CFM/RPM
36	[PR]	pressure ratio P_{out}/P_{in}
		if IØP
		= 0 - fixed pressure ratio value
		= 1 - pressure ratio initial guess
		= 2,5 - not used
		= 3 - pressure ratio initial guess
		= 4 - not used
40	ICT	if IØT = 0
		efficiency table relative number (type 6)

if IØT = 1

efficiency function table

relative number (type 24)

if IØP = 2

pressure ratio table relative number (type 4)

if IØP = 3

corrected flow table relative number (type 21)

if IØP = 4

adiabatic head function table relative

number (type 25)

IF IØP = 5 FAN TOTAL PRESS RISE COEFF. TABLE RELATIVE # (TYPE 41)

44 [ME] mechanical efficiency

A5

Performance Component CØND

Condenser

Purpose: This component will compute the heat exchange and pressure drop for a refrigerant condenser.

Options: Pressure drop is computed on the sink side of the condenser for the following options:

ISIG = 0 use ΔP

ISIG = 1 use $\sigma\Delta P$

Equations:

for refrigerant

$$H_{in} = f\,(P_{in}, T_{in})$$

$$P_{out} = P_{in}$$

$$T_{cond} = f\,(P_{in})$$

$$V_g = f\,(P_{in}, T_{cond})$$

$$H_g = f\,(P_{in}, T_{cond}, V_g)$$

$$H_{fg} = f\,(T_{cond})$$

$$H_{out} = H_g - H_{fg}$$

$$Q = W\,(H_{in} - H_{out})$$

$$T_{out} = T_{cond}$$

for sink

$$P_{out} = P_{in} - \Delta P$$

$$\overline{T}_{out} = T_{in} + \varepsilon\,(T_{cond} - T_{in})$$

$$H_{out} = H_{in}$$

$$T_{out} = f\,(P_{in},\ T_{in},\ H_{in},\ P_{out},\ \overline{T}_{out},\ H_{out})$$

$$\overline{T}'_{out} = T_{in} + Q/W\ C_p$$

$$\text{Error Variable} = T_{out} - \overline{T}'_{out} \quad \text{(type 3)}$$

Requried Tables:

ΔP or $\sigma\Delta P$ - Table ID(IPD,1) - Sink side pressure drop

ϵ - Table ID (IE,5) - Sink side temperature effectiveness

Restrictions:

1. The refrigerant side fluid must be type 3. The sink side fluid must be type 1 or 2.

Notes:

1. The following general arguments are set up in this component.
   - argument 41 - sink side flow rate
   - argument 42 - refrigerant side flow rate
   - argument 43 - sink side inlet pressure
2. Fluid properties:
   C_p - evaluated at T_{in}
   σ - evaluated at P_{in}, T_{in}
3. The component performance printout consists of the following items:

NL	- leg number	for refrigerant and sink side
NSI	- inlet station number	
NSØ	- outlet station number	
FT	- fluid type	
FN	- fluid number	
W	- flow rate	
PI	- inlet pressure	
PØ	- outlet pressure	
TI	- inlet temperature	
TØ	- outlet temperature	
HI	- inlet enthalpy/humidity	
HØ	- outlet enthalpy/humidity	

EFF - sink side temperature effectiveness

Q - heat transfer

Performance Component CØND

Data Card Format

Card Column	Symbol	Value	
1-4	CN	CØND component name	
8	CC	change code	
12	NC	card number	
16	NLR	leg number	refrigerant side
20	NSIR	inlet station number	refrigerant side
24	NSØR	outlet station number	refrigerant side
28	NLS	leg number	sink side
32	NSIS	inlet station number	sink side
36	NSØS	outlet station number	sink side
40	ISIG	option = 0 use ΔP = 1 use $\sigma\Delta P$	sink side only
44	IPD	sink side pressure drop table relative number (type 1)	
48	IE	sink side temperature effectiveness table relative number (type 5)	

Performance Component CVALVE

Control Valve

Purpose: This component will compute the pressure loss across a modulating valve with a variable loss coefficient.

Options: Pressure loss is computed with the following options.

ISIG = 0 - ΔP is calculated

ISIG = 1 - $\sigma\Delta P$ is calculated

Equations:

State Variable = K (type 6) PR

$$\left.\begin{matrix}\Delta P \\ \sigma\Delta P\end{matrix}\right\} = KW^2$$

$$P_{out} = P_{in} - \Delta P$$

$$\overline{T}_{out} = T_{in}$$

$$H_{out} = H_{in}$$

$$T_{out} = f\,(P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

Notes:

1. The component performance printout consists of the following items:

NL - leg number
NSI - inlet station number
NSØ - outlet station number
FT - fluid type
FN - fluid number
W - flow rate
PI - inlet pressure
PØ - outlet pressure
TI - inlet temperature
TØ - outlet temperature
HI - inlet humidity/enthalpy
HØ - outlet humidity/enthalpy
K - loss coefficient

Performance Component CVALVE

Data Card Format

Card Column	Symbol	Value
1-6	CN	CVALVE component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	ISIG	option = 0 use ΔP = 1 use $\sigma \Delta P$
32	[KM]	minimum value of K
36	[K]	K initial guess

A7

Performance Component DRAIN

Water Drain

Purpose: This component will compute the water removed from a saturated fluid stream. No pressure drop is computed for the drain component.

Equations:

$$P_{out} = P_{in}$$

$$T_{out} = T_{in}$$

<u>if $H_{in} > H_{sat}$</u>

$$\Delta H = \eta \, (H_{in} - H_{sat})$$

$$H_{out} = H_{in} - \Delta H$$

$$\Delta W = \Delta H \cdot W_{in}/(1 + H_{in})$$

$$W_{out} = W_{in} - \Delta W$$

$$W_{drain} = \Delta W$$

<u>if $H_{in} \leq H_{sat}$</u>

$$H_{out} = H_{in}$$

$$W_{out} = W_{in}$$

$$W_{drain} = 0.0$$

Required Tables:

η - Table ID(IEF,17) - Drain efficiency

Restrictions:

1. This component may only be used for fluid type 2.

Notes:

1. The component performance printout consists of the following items:

NL	- leg number	for inlet, outlet and drain leg
NS	- station number	
FT	- fluid type	
FN	- fluid number	
W	- flow rate	
P	- pressure	
T	- temperature	
H	- humidity	
EFF	- drain efficiency	

Performance Component DRAIN

Data Card Format

Card Column	Symbol	Value
1-5	CN	DRAIN component name
8	CC	change code
12	NC	card number
16	NLI	inlet leg number
20	NSI	inlet station number
24	NLØ1	outlet leg number
28	NSØ1	outlet station number
32	NLØ2	drain leg number
36	NSØ2	drain station number
40	IEF	water removal efficiency table relative number (type 17)

Performance Component DSEP

Dust Separator

Purpose: This component will compute pressure loss across a dust separator.

Options: Pressure drops are computed by the following options:

ITE = 0 ΔP or $\sigma\Delta P$ is read from a table

ITE = 1 ΔP is calculated from equation 1

ITE = 2 ΔP is calculated from equation 2

Equations:

$$P_{out} = P_{in} - \Delta P$$

where

$$\left.\begin{matrix}\Delta P \\ \sigma\Delta P\end{matrix}\right\} = \text{table lookup}$$

or

$$\Delta P = 1.008 \times 10^{-3} K_t W^2/\rho D^4 \quad (1)$$

or

$$\left.\begin{matrix}\Delta P \\ \sigma\Delta P\end{matrix}\right\} = KW^2 \quad (2)$$

$$\overline{T}_{out} = T_{in}$$

$$H_{out} = H_{in}$$

$$T_{out} = f(P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

Required Tables:

for ITE = 0 only

ΔP or $\sigma\Delta P$ - Table ID(IPD,1) - Pressure drop

Restrictions:

1. This component can use only fluid type 2.

Notes:

1. The following general argument is set up in this component:
   - argument 41, flow in leg
2. Fluid properties:
   ρ - evaluated at P_{in}, T_{in}
   σ - evaluated at P_{in}, T_{in}

3. The component performance printout consists of the following items:

NL - leg number
NSI - inlet station number
NSØ - outlet station number
FT - fluid type
FN - fluid number
W - flow rate
PI - inlet pressure
PØ - outlet pressure
TI - inlet temperature
TØ - outlet temperature
HI - inlet humidity
HØ - outlet humdity

Performance Component DSEP

Data Card Format

Card Column	Symbol	Value
1-4	CN	DSEP component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	ISIG	option (for ITE = 0, 2) = 0 use ΔP = 1 use $\sigma \Delta P$
32	ITE	table or equation option = 0 use table = 1 use equation 1 = 2 use equation 2
if ITE = 0		
[36	IPD	pressure drop table relative number (type 1)
if ITE = 1		
[36	[KT]	K_t
40	[D]	diameter
if ITE = 2		
[36	[K]	K

SECTION VI

A9 - REPLACEMENT

PERFORMANCE COMPONENT EJECT

Ejector

Purpose: This component will compute ejector performance.

Options: Ejector performance is computed with the following options:

IØP = 0 primary to secondary flow is specified

IØP = 1 primary flow is computed

Equations:

$$PR = P_{sec}/P_{pri}$$

$$PR_{crit} = \left(\frac{2}{\gamma+1}\right)^{\left(\frac{\gamma}{\gamma-1}\right)} = .528 \text{ for } \gamma = 1.4$$

if $PR > PR_{crit}$ then $PR = PR_{crit}$

for IØP = 0

$$W_{calc} = W_{sec} \cdot WR$$

for IØP = 1

$$W_{calc} = 40.124\ C_D A \sqrt{\frac{\gamma}{\gamma-1}\,\rho\,P_{pri}\left(PR^{2/\gamma} - PR^{\gamma+1/\gamma}\right)}$$ — primary flow

— mixed flow

$$W_{out} = W_{pri} + W_{sec}$$

$$W_W = \frac{H_{pri}}{(1 + H_{pri})} W_{pri} + \frac{H_{sec}}{(1 + H_{sec})} W_{sec}$$

$$H_{out} = W_W/(W_{out} - W_W)$$

$$P_{out} = P_{sec} \cdot PR_{sec}$$

$$T_{PI} = T_{pri} \cdot PR^{(\gamma-1)/\gamma} = .8333 \text{ if sonic at throat}$$

$$\bar{T}_{out} = (W_{sec}T_{sec} + W_{pri}T_{PI})/W_{out}$$

$$T_{out} = f\,(P_{pri}, T_{pri}, H_{pri}, P_{sec}, T_{sec}, H_{sec}, P_{out}, \bar{T}_{out}, H_{out})$$

Error Variable = $W_{calc} - W_{pri}$ (type 1)

A9.1 EJECT

Required Tables:

PR_{sec} - Table ID(IPR,4) - Secondary pressure ratio (P_{out}/P_{sec}) $= f\left(\frac{[W\sqrt{T}]_{sec}}{[W\sqrt{T}]_{prim}}, \frac{P_{prim}}{P_{sec}}\right)$

if IØP = 0

WR - Table ID(IWR,19) - Primary to secondary flow ratio $\frac{W_{PRIM}}{W_{SEC}}$.

if IØP = 1 (optional) ⇒ primary flow is computed

C_D - Table ID(ICD,9) - Primary nozzle discharge coefficient

Restrictions:

1. This component can only be used for fluid type 2.

Notes:

1. The following general arguments are set up in this component:
   - argument 24, primary to secondary pressure ratio
   - argument 41, primary flow
   - argument 42, secondary flow

   for IØP = 1 only
   - argument 27, secondary to primary corrected flow ratio

   $$\left(\frac{W\sqrt{T}}{P}\right)_{sec} \Big/ \left(\frac{W\sqrt{T}}{P}\right)_{pri}$$

   - argument 34 secondary to primary corrected flow ratio

   $$(W\sqrt{T})_{sec}/(W\sqrt{T})_{pri}$$

2. Fluid properties:

   γ - evaluated at T_{pri}

   ρ - evaluated at P_{pri}, T_{pri}

3. The component performance printout consists of the following items:

NL	- leg number	For primary, secondary and outlet leg
NS	- station number	
FT	- fluid type	
FN	- fluid number	
W	- flow rate	
P	- pressure	

A9.2 EJECT

T - temperature
H - humidity } for primary, secondary and outlet leg

PPR - primary to secondary pressure ratio

SPR - secondary pressure ratio

WR - secondary to primary flow ratio

A9.3 EJECT

Performance Component EJECT

Data Card Format

Card Column	Symbol	Value
1-5	CN	EJECT component name
8	CC	change code
12	NC	card number
16	NLP	primary leg number
20	NSP	primary station number
24	NLS	secondary leg number
28	NSS	secondary station number
32	NLØ	outlet leg number
36	NSØ	outlet station number
40	IPR	secondary pressure ratio (P_{out}/P_{sec}) table relative number (type 4)
44	IØP	option = 0 flow ratio specified = 1 flow ratio calculated
if IØP = 0		
[48	IWR	primary to secondary flow ratio table relative number (type 19)
if IØP = 1		
48	ICD	discharge coefficient table relative number (type 9) (optional)
52	[D]	primary nozzle throat diameter
56	[A]	primary nozzle throat area, if [A] = 0, use $A = \pi D^2/4$

A9.4 EJECT

A10

Performance Component EVAP

Evaporator

Purpose: This component will compute the heat exchange and pressure drop for a refrigerant evaporator.

Options: Pressure drop is computed on the source side of the evaporator for the following options:

ISIG = 0 use ΔP

ISIG = 1 use $\sigma \Delta P$

Equations:

for refrigerant

$$H_{in} = f\ (P_{in}, T_{in})$$

$$P_{out} = P_{in}$$

$$T_{evap} = T_{in}$$

$$T_{out} = T_{evap} + \Delta T_{superheat}$$

$$V_g = f\ (P_{out}, T_{out})$$

$$H_{out} = f\ (P_{out}, T_{out}, V_g)$$

$$Q = W\ (H_{out} - H_{in})$$

for source

$$P_{out} = P_{in} - \Delta P$$

$$\overline{T}_{out} = T_{in} - \varepsilon\ (T_{in} - T_{evap})$$

$$H_{out} = H_{in}$$ (humidity only for evap source side)

$$T_{out} = f\ (P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

$$\overline{T}'_{out} = T_{in} - Q/W.C_p$$

$$\text{Error Variable} = \overline{T}_{out} - \overline{T}'_{out} \quad \text{(type 3)}$$

Required Tables:

ΔP or $\sigma\Delta P$ - Table ID(IPD,1) - Source side pressure drop

ε - Table ID(IE,5) - Source side temperature effectiveness

Restrictions:

1. The refrigerant side fluid must be type 3. The source side fluid must be type 1 or 2.

Notes:

1. The following general arguments are set up in this component:
   - argument 41, source side flow rate
   - argument 42, refrigerant side flow rate
   - argument 43, source side inlet pressure
2. Fluid properties:

   C_p - evaluated at T_{in}

   σ - evaluated at P_{in}, T_{in}
3. The component performance printout consists of the following items:

   NL - leg number
   NSI - inlet station number
   NSØ - outlet station number
   FT - fluid type
   FN - fluid number
   W - flow rate
   PI - inlet pressure
   PØ - outlet pressure
   TI - inlet temperature
   TØ - outlet temperature
   HI - inlet enthalpy/humidity
   HØ - outlet enthalpy/humidity

   for refrigerant and source sides

   EFF - source side temperature effectiveness
   Q - heat transfer

Performance Component EVAP

Data Card Format

Card Column	Symbol	Value	
1-4	CN	EVAP component name	
8	CC	change code	
12	NC	card number	
16	NLR	leg number	refrigerant side
20	NSIR	inlet station number	refrigerant side
24	NSØR	outlet station number	refrigerant side
28	NLS	leg number	source side
32	NSIS	inlet station number	source side
36	NSØS	outlet station number	source side
40	ISIG	option = 0 use ΔP = 1 use $\sigma \Delta P$	source side only
44	IPD	source side pressure drop table relative number (type 1)	
48	IE	source side temperature effectiveness table relative number (type 5)	
52	[DSH]	refrigerant outlet degrees of superheat	

Performance Component FAN

Fan

Purpose: This component will compute fan performance.

Equations:

$$P_{out} = P_{in} + \Delta P$$

$$\overline{T}_{out} = T_{in} + [T_{in} (PR^{\gamma-1/\gamma}-1)/\eta_f]$$

$$H_{out} = H_{in}$$

$$T_{out} = f (P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

$$HP = 0.02356 \; W \; C_p \; (T_{in} - \overline{T}_{out})/\eta_m$$

Required Tables:

ΔP - Table ID(IFT,16) - Fan pressure rise

η_f - Table ID(IFT,17) - Fan efficiency

Restrictions:

1. This component may only be used for fluid type 2.
2. The FAN shaft number must be previously defined (see component SHAFT).

Notes:

1. The following general ~~arguments are set~~ up in this subroutine:
   - argument 28 - inlet volumetric flow (cfm)
   - argument 41 - flow in leg
2. Fluid properties:

   ρ - evaluated at P_{in}, T_{in}

   γ - evaluated at T_{in}

   C_p - evaluated at T_{in}
3. A shaft power balance may be obtained by inserting a SPØWER card (see component SPØWER).
4. The component performance printout consists of the following items:

   NL - leg number

   NSI - inlet station number

NSØ - outlet station number
FT - fluid type
FN - fluid number
W - flow rate
PI - inlet pressure
PØ - outlet pressure
TI - inlet temperature
TØ - outlet temperature
HI - inlet humidity
HØ - outlet humdiity
SHAFT - shaft number
CFM - inlet volumetric flow
EFF - static efficiency
HP - fan horsepower

Performance Component FAN

Data Card Format

Card Column	Symbol	Value
1-3	CN	FAN component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	NST	shaft number
32	IFT	pressure rise table relative number (type 16)
		static efficiency table relative number (type 17)
36	[ME]	mechanical efficiency

SECTION XVIII

A43 - ADDITION

PERFORMANCE COMPONENT FUNC

Function Computation

Purpose: This component may be used to compute various functions which are commonly used in flow analyses.

Operation: This component will compute flow rate related functions. The flow rate related functions include flow functions, critical flow, and flow rate ratio. The user may specify if the computation will be performed for only the first iteration, for all iterations, or for all iterations and perturbations. The computed result can be stored as either a general argument or a parameter value.

Equations:

for IFNC = 11 (flow function)

$$FF1 = W\sqrt{\theta}/\delta$$

where: $\theta = T/T_o$, $\delta = P/P_o$

for IFNC = 12 (flow function)

$$FF2 = W\sqrt{T}/C_D AP$$

where: P and T are evaluated at either station pressure and temperature or freestream total pressure and temperature

for IFNC = 13 (critical flow rate) as in nozzle

$$W_{cr} = 40.124\, C_D A \left[\frac{\gamma}{\gamma-1}\rho P \left(PR_c^{\frac{2}{\gamma}} - PR_c^{\frac{\gamma+1}{\gamma}}\right)\right]^{\frac{1}{2}}$$

where: $PR_c = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$, and P and T are evaluated at either station pressure and temperature or freestream total pressure and temperature

for IFNC = 14
$FR1 = W/W_{cr}$ (flow rate ratio)

for IFNC = 15
$FR2 = 2.4\ W/\rho_{\infty} AV_{\infty}$ (flow rate ratio)

144/60

Restrictions:

1. This component can only be used for fluid type 2.

Notes:

1. If the result type is a general argument (IRT = 0), the relative number (IRN) must be greater than 100.
2. The component performance printout consists of the following items:

   VX - computed result

   IRT - result type

   IRN - result relative number

   IFNC - function code

   IØPT - option

Performance Component FUNC

Data Card Format

Card Column	Symbol	Value
1-4	CN	FUNC component name
8	CC	change code
12	NC	card number
16	IRT	result type
		= 0 for a general argument
		= -1 for a parameter value
20	IRN	result relative number
		= a general argument number if IRT =0
		= a parameter index if IRT = -1
24	IØPT	option
		1 perform computation only on first iteration
		0 perform computation on all iterations and perturbations
		-1 perform computation on all iterations
28	IFNC	function code $W\sqrt{\theta}/\delta$
		= 11 FF1
		= 12 FF2 $W\sqrt{T}/PAC_D$
		= 13 W_{cr}
		= 14 FR1
		= 15 FR2
if IFNC = 11		
32	NL	leg number
36	NS	station number
if IFNC = 12, 13, 14		
32	NL	leg number
36	NS	station number
		if = 0 use free stream total pressure and temperature
40	[A]	Location? cross-sectional area (optional for IFNC=13)
44	[CD]	flow coefficient (optional)

$\frac{W\sqrt{T}}{PAC_D}$

Card Column	Symbol	Value
if IFNC = 15		
32	NL	leg number
40	[A]	cross-sectional area

Result relative number

SECTION VII

A12 - REPLACEMENT

PERFORMANCE COMPONENT HXA

Heat Exchanger

Purpose: This component will compute heat transfer and pressure drops for both sides of a heat exchanger when both inlet flows have been defined.

Options: Pressure drops are computed for sides 1 and 2 with the following options:

ISIG = 0 use ΔP side 1 and 2

ISIG = 1 use $\sigma\Delta P$ side 1; ΔP side 2

ISIG = 2 use ΔP side 1; $\sigma\Delta P$ side 2

ISIG = 3 use $\sigma\Delta P$ side 1 and 2

The heat exchanger performance can be specified two ways. The first way inputs the temperature effectiveness of side 1 (ε_1), generally as a function of side 1 and side 2 flow rates (general arguments 41 and 42, respectively). The second way inputs the heat transfer function (ηhA) for side 1 and side 2, generally as a function of flow rate (general arguments 41 and 42, respectively), and the general heat transfer effectiveness (ε) for the particular heat exchanger configuration as a function of NTU (general argument 55) and CR (general argument 56).

Equations:

$$SHR = \frac{T_{in} - \bar{T}_{out}}{T_{in} - T_{out}}$$ side 1 and 2

T dry air rated

T dry bulb

$$C = WC_p$$ side 1 and 2

<u>ε option</u>

$$W' = W \cdot SHR$$ side 1 and 2

$$W'' = W$$ side 1 and 2

$$\varepsilon_1 = f(W_1', W_2')$$

$$T_{1\ out} = T_{1\ in} - \varepsilon_1(T_{1\ in} - T_{2\ in})$$

<u>for side 1 fluid type 1</u>

$$Q = W_1\ (h_{1\ out} - h_{1\ in})$$

for side 1 fluid type 2

$Q = C_1\,(T_{1\ out} - T_{1\ in}) \cdot SHR_1$

for side 2 fluid type 1

$h_{2\ out} = h_{2\ in} - Q/W_2$

$T_{2\ out} = f(h_{2\ out})$

for side 2 fluid type 2

$\varepsilon_2 = \varepsilon_1 \cdot (C_1 \cdot SHR_1)/(C_2 \cdot SHR_2)$

$T_{2\ out} = T_{2\ in} + \varepsilon_2 (T_{1\ in} - T_{2\ in})$

$\varepsilon_2 = (T_{2\ out} - T_{2\ in})/(T_{1\ in} - T_{2\ in})$

ηhA option

$W' = W \cdot \frac{\mu_{ref}}{\mu} \cdot SHR$ side 1 and 2

$W'' = W \cdot \frac{\mu_{ref}}{\mu}$ side 1 and 2

$\eta hA' = f(W')$ side 1 and 2

$$\eta hA = \eta hA' \cdot \frac{\mu}{\mu_{ref}} \cdot \left(\frac{Pr_{ref}}{Pr}\right)^{2/3} \cdot \left(\frac{C_p}{C_{p_{ref}}}\right)$$ side 1 and 2

$$NTU = \frac{1/(1/\eta hA_1 + 1/\eta hA_2)}{(C \cdot SHR)_{min}}$$

$CR = (C \cdot SHR)_{min}/(C \cdot SHR)_{max}$

$NTU = \frac{UA}{C_{min}}$

$\varepsilon = f(NTU, CR)$

if $C_1 \cdot SHR_1 < C_2 \cdot SHR_2$ if C_1 is the C_{min}

$\varepsilon_1 = \varepsilon$

$T_{1\ out} = T_{1\ in} - \varepsilon_1 (T_{1\ in} - T_{2\ in})$

for side 1 fluid type 1 (liquid)

$Q = W_1 (h_{1\ out} - h_{1\ in})$

for side 1 fluid type 2 (gas)

$Q = C_1 (T_{1\ out} - T_{1\ in}) \cdot SHR_1$

<u>for side 2 fluid type 1</u>

$h_{2\ out} = h_{2\ in} - Q/W_2$

$T_{2\ out} = f(h_{2\ out})$

<u>for side 2 fluid type 2</u>

$T_{2\ out} = T_{2\ in} + Q/(C_2 \cdot SHR_2)$

$\varepsilon_2 = (T_{2\ out} - T_{2\ in})/(T_{1\ in} - T_{2\ in})$

if $C_1 \cdot SHR_1 > C_2 \cdot SHR_2$

$\varepsilon_2 = \varepsilon$

$T_{2\ out} = T_{2\ in} + \varepsilon_2(T_{1\ in} - T_{2\ in})$

<u>for side 2 fluid type 1</u>

$Q = W_2(h_{2\ in} - h_{2\ out})$

<u>for side 2 fluid type 2</u>

$Q = C_2(T_{2\ in} - T_{2\ out}) \cdot SHR_2$

<u>for side 1 fluid type 1</u>

$h_{1\ out} = h_{1\ in} + Q/W_1$

$T_{1\ out} = f(h_{1\ out})$

<u>for side 1 fluid type 2</u>

$T_{1\ out} = T_{1\ in} + Q/(C_1 \cdot SHR_1)$

$\varepsilon_1 = (T_{1\ in} - T_{1\ out})/(T_{1\ in} - T_{2\ in})$

$\sigma\Delta P$ or $\Delta P = f(W'') \cdot (W/W'')^2$ side 1 and 2

$P_{out} = P_{in} - \Delta P$ side 1 and 2

$H_{out} = H_{in}$ side 1 and 2

$\bar{T}_{out} = f(P_{in}, T_{in}, H_{in}, P_{out}, T_{out}, H_{out})$ side 1 and 2

Required Tables:

ΔP or $\sigma\Delta P$ - Table ID (IPD1, 1) - Pressure drop side 1

ΔP or $\sigma\Delta P$ - Table ID (IPD2, 1) - Pressure drop side 2

ε - Table ID (IE, 5) - Temperature effectiveness side 1, if the ε option is used. General heat transfer effectiveness, if the ηhA option is used.

ηhA_1 - Table ID (IHA1, 22) - ηhA side 1, if the ηhA option is used

ηhA_2 - Table ID (IHA2, 22) - ηhA side 2, if the ηhA option is used

Restrictions:

1. This component can only use fluid types 1 and 2.
2. If the component performance maps are a function of flow rates, they must be input as functions of general arguments 41 and 42 for side 1 and side 2, respectively.
3. The computation of the sensible heat ratios, SHR, is an iterative process. An initial guess of 1.0 is assumed, and 20 iterations are allowed to converge to a tolerance of 0.00005. If convergence is not obtained a warning message is written.

Notes:

1. The following general arguments are set up in this component:
   - argument 41, modified flow in side 1
   - argument 42, modified flow in side 2
   - argument 43, inlet pressure side 1
   - argument 44, inlet pressure side 2
   - argument 45, average temperature side 1 (ηhA option only)
   - argument 46, average temperature side 2 (ηhA option only)

   that is, these are not generated (are = 0.0) if ηhA not used. (ε And. is)
2. Fluid properties evaluated at $T_{avg} = (T_{in} + T_{out})/2$
3. The temperature effectiveness of both side 1 and side 2 will be checked: $0 \leq \varepsilon_1 \leq 1$; $0 \leq \varepsilon_2 \leq 1$. An error message will be written if an effectiveness is invalid.
4. The temperature effect corrections used in the ηhA option are optional.
5. The component performance printout consists of the following items:

(HXA)

NL	- leg number	side 1 and 2
NSI	- inlet station number	side 1 and 2
NSØ	- outlet station number	side 1 and 2
FT	- fluid type	side 1 and 2
FN	- fluid number	side 1 and 2
W	- flow rate	side 1 and 2
PI	- inlet pressure	side 1 and 2
PØ	- outlet pressure	side 1 and 2
TI	- inlet temperature	side 1 and 2
TØ	- outlet temperature	side 1 and 2
HI	- inlet humidity	side 1 and 2
HØ	- outlet humidity	side 1 and 2
EF1	- side 1 temperature effectiveness	
EF2	- side 2 temperature effectiveness	
SR1	- side 1 sensible heat ratio	
SR2	- side 2 sensible heat ratio	
Q	- side 1 heat transfer rate	

Performance Component HXA

Data Card Format

Card Column	Symbol	Value	
1-3	CN	HXA component name	
8	CC	change code	
12	NC	card number	
16	NL1	leg number	side 1
20	NSI1	inlet station number	side 1
24	NSØ1	outlet station number	side 1
28	NL2	leg number	side 2
32	NSI2	inlet station number	side 2
36	NSØ2	outlet station number	side 2
40	ISIG	option = 0 use ΔP both sides = 1 use σΔP side 1 = 2 use σΔP side 2 = 3 use σΔP both sides	
44	IPD1	side 1 pressure drop table relative number (type 1)	
48	IPD2	side 2 pressure drop table relative number (type 1)	
52	IE -3	side 1 temperature effectiveness table relative number (type 5) if the ε option is used general heat transfer effectiveness table relative number (type 5) if the ηhA option is used	ENDS NTU + CRATIOS
56	IHA1 HOT ηhA	side 1 ηhA table relative number (type 22) if the ηhA option is used	
60	[TR1]	side 1 reference temperature if the ηhA option is used (optional)	
64	IHA2 — COLD ηhA	side 2 ηhA table relative number (type 22) if the ηhA option is used	
68	[TR2]	side 2 reference temperature if the ηhA option is used (optional)	
72	BHA1	mult Factor for ηhA1	
76	BHA2	" " " ηhA2	

SECTION VIII

A13 - REPLACEMENT

PERFORMANCE COMPONENT HXB

Heat Exchanger

THIS COMPONENT HAS BEEN ELIMINATED!

Performance analyses requiring this type of component must now use the HXA and LØØP components.

SECTION IX

A14 - REPLACEMENT

PERFORMANCE COMPONENT INJECT

Water Injector

Purpose: This component will compute the mass and energy balance for the addition of water to a gas flow.

Equations:

$$W_{out} = W_{in} + W_{water}$$

$$P_{out} = P_{in}$$

$$\bar{T}_{out} = (W_{in} \; C_{P_{in}} \; T_{in} + W_{water} \; C_{P_{water}} \; T_{water})/W_{out} \; C_{P_{in}}$$

$$H_{out} = H_{in} + W_{water} \; (1 + H_{in})/W_{in}$$

$$T_{out} = f(W_{in}, P_{in}, T_{in}, H_{in}, W_{water}, P_{water}, T_{water}, P_{out}, \bar{T}_{out}, H_{out})$$

Restrictions:

1. The inlet leg must use fluid type 2 and the water leg must be fluid type 1.

Notes:

1. A message will be printed if the pressure in the water leg is less than the pressure in the inlet leg. The mass and energy balance will be computed regardless of the message.
2. Fluid Properties:

   C_p - for gas evaluated at T_{in}

   C_p - for water = 1.0
3. The component performance printout consists of the following items:

   NL - leg number
   NS - station number
   FT - fluid type
   FN - fluid number   for inlet, water and outlet legs
   W - flow rate
   P - pressure
   T - temperature
   H - humidity

Performance Component INJECT

Data Card Format

Card Column	Symbol	Value
1-6	CN	INJECT component name
8	CC	change code
12	NC	card number
16	NLI1	inlet leg number
20	NSI1	inlet station number
24	NLI2	water leg number
28	NSI2	water station number
32	NLØ	outlet leg number
36	NSØ	outlet station number

A15

Performance Component INLET

Inlet to ECS

Purpose: This component specifies an inlet to the ECS. Values of flow, pressure, temperature and humidity for the flow leg are defined. The user may specify either constant values or assumed values which are allowed to vary to balance the system.

Options: The values may be input as constant values or assumed values as specified by the code work ijkℓ. The digit i specifies the flow rate option, the digit j the pressure option, the digit k the temperature option, and the digit ℓ the humidity option. If the digit is 0, the respective value is a known value and if the digit is 1 the value is assumed. The following state variables may be set up:

State variable type 1 - flow
State variable type 2 - pressure
State variable type 3 - temperature
State variable type 4 - humidity

Required Tables:

- - Table ID(IFN,10) - Fluid properties

Performance Component INLET

Data Card Format

Card Column	Symbol	Value
1-5	CN	INLET component name
8	CC	change code
12	NC	card number ✓
16	NL	leg number ✓
20	NS	station number
24	IØP	option = ijkℓ
		i = 0 flow rate known
		21 i = 1 flow rate unknown ✓
		j = 0 pressure known
		22 j = 1 pressure unknown
		k = 0 temperature known
		23 k = 1 temperature unknown
		ℓ = 0 humidity known
		24 ℓ = 1 humidity unknown
28 1	[W]	inlet flow rate (initial guess if i = 1) Location
32 2	[P]	inlet pressure (initial guess if j = 1)
36 3	[T]	inlet temperature (initial guess if k = 1)
40 4	[H]	inlet humidity (initial guess if ℓ = 1)
44 2	IFT	inlet fluid type 1=liq
48 1	IFN	inlet fluid property table relative number (type 10) -1 for air

6/26/40

brackets indicate reference to parameter tables

IFT = 1 liquid
= 2 gas
= 3 refrigerant

SECTION X

A16 - REPLACEMENT

PERFORMANCE COMPONENT LINE

Line

Purpose: This component will compute pressure drop and heat exchange for a circular or non-circular flow passage.

Options: Pressure drops are computed by the following options:

ITE = 0 - read from a table

ITE = 1 - calculated from Equation 1

ITE = 2 - calculated from Equation 2

Heat exchange to the fluid is optional for all pressure drop calculations.

Equations:

$$P_{out} = P_{in} - \Delta P$$

where

$$\left.\begin{array}{l}\Delta P \\ \sigma\Delta P \\ \Delta P/P\end{array}\right\} = \text{table lookup}$$

ITE = 0

W_1 / W_2

or

$$\Delta P = 6.216 \times 10^{-4} \; (4 \; f \; L/D + C \; K_t) \; W_2^2/\rho A^2 \qquad (1)$$

ITE =

$[lbm/ft^3]$

or

$$\left.\begin{array}{l}\Delta P \\ \sigma\Delta P\end{array}\right\} = KW^2 \qquad (2)$$

$A_1 \; [in^2]$ ITE =

$$\cancel{H_{out} = H_{in}}$$

$$SHR = (T_{in} - \bar{T}_{out})/(T_{in} - T_{out})$$

UA option

$$Q_t = UA \; (T_S - T_f) \cdot B1$$

where

$$T_f = (T_{in} + T_{out})/2$$

for fluid type 1 liq

$$h_{out} = h_{in} + Q_t/W$$

$$T_{out} = f(h_{out})$$

for fluid type 2 gas

$$T_{out} = T_{in} + Q_t/(W \cdot C_p \cdot SHR)$$

$\bar{T}_{out} = f\ (P_{in}, T_{in}, H_{in}, P_{out}, T_{out}, H_{out})$

<u>Q option</u>

$Q_t = Q \cdot B2$

$T_f = (T_{in} + \bar{T}_{out})/2$

<u>for fluid type 1</u>

$h_{out} = h_{in} + Q_t/W$

$\bar{T}_{out} = f(H_{out})$

<u>for fluid type 2</u>

$\bar{T}_{out} = T_{in} + Q_t/(W \cdot C_p)$

$T_{out} = f\ (P_{in}, T_{in}, H_{in}, P_{out}, \bar{T}_{out}, H_{out})$

<u>neither option</u>

$Q_t = 0$

$\bar{T}_{out} = T_{in}$

$T_{out} = F\ (P_{in}, T_{in}, H_{in}, P_{out}, \bar{T}_{out}, H_{out})$

Required Tables:

for ITE = 0 only

ΔP, $\sigma\Delta P$, or $\Delta P/P$ - Table ID (IPD, 1) - Pressure drop

for ITE = 1 only

f - Table ID (IF, 3) - Friction Factor

K_t - Table ID (IKT, 2) - Pressure loss coefficient

optional

UA - Table ID (IUA, 11) - Overall heat transfer coefficient

T_S - Table ID (ITS, 12) - Source/Sink temperature

Q - Table ID (IQ, 13) - Heat Load

Restrictions:

1. This component can use only fluid types 1 and 2.
2. Either the UA or Q option may be used. The UA option will be used if values are input for both options.

Notes:

1. The following general argument is set up in this component:

   - argument 21, Reynolds number

   - argument 41, flow in leg

2. Fluid properties:

   C_p - evaluated at an approximate T_{avg}

   μ - evaluated at T_{avg}

   ρ - evaluated at P_{in}, T_{avg}

   σ - evaluated at P_{in}, T_{avg}

   where $T_{avg} = (T_{in} + T_{out})/2$

3. The component performance printout consists of the following items:

   NL - leg number
   NSI - inlet station number
   NSØ - outlet station number
   FT - fluid type
   FN - fluid number
   W - flow rate
   PI - inlet pressure
   PØ - outlet pressure
   TI - inlet temperature
   TØ - outlet temperature
   HI - inlet humidity
   HØ - outlet humidity
   QT - heat load
   SHR - sensible heat ratio
   (if [A] $\neq$ 0)
   V - fluid velocity (fluid types 1 and 2)
   M - fluid Mach number (fluid type 2)

W P T H

Performance Component LINE

Data Card Format

Card Column	Symbol	Value
1-4	CN	LINE component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	ISØP	option $\boxed{-2 \text{ use } \Delta P/P,\ W\sqrt{\theta}/\delta \text{ calculated iteratively at NSO}}$ (GAZZ)
		= -1 use $\Delta P/P$ (for ITE = 0) GAZZ calculated at NSI
		= 0 use ΔP
		= 1 use $\sigma\Delta P$ (for ITE = 0 or 2)
32	ITE	table or equation option
		= 0 use table for pressure drop
		= 1 use equation 1 for pressure drop (ΔP eqn)
		= 2 use equation 2 for pressure drop KW^2
if ITE = 0		
36	IPD	pressure drop table relative number (type 1)
if ITE = 1 ΔP eqn		
36	IF	friction factor table relative number (type 3) vO
40	[C]	constant
44	IKT	K_t table relative number (type 2) 11
48	[L]	length
52	[D]	hydraulic diameter
56	[A]	cross-sectional area; if A = 0, use A = $\pi D^2/4$ K
if ITE = 2 $\Delta P = KW^2$		
44	[K]	loss coefficient
52	[D]	hydraulic diameter (optional)
56	[A]	cross sectional area; if A = 0, use A = $\pi D^2/4$ (optional)

Card Column	Symbol	Value	
60	IUA	overall heat transfer coefficient table relative number (type 11)	optional
64	ITS	source/sink temperature table relative number (type 12)	optional
68	[B1]	multiplier	optional
72	IQ	heat load table relative number (type 13)	optional
76	[B2]	multiplier	optional
80	[HO]	"H" OUTSIDE TUBE	

A17

Performance Component L$\emptyset\emptyset$P

Fluid Loop

Purpose: This component specifies the start and end of a fluid loop. The loop is fictitiously cut, forming a loop start and loop end. The loop is started by a L$\emptyset\emptyset$PS card and ended by a L$\emptyset\emptyset$PE card. Values of flow rate, pressure, temperature, and humidity are defined for the starting flow leg. The user may specify either known values or assumed values which are allowed to vary to balance the system.

Options: Loop start

The loop starting values may be input as known values or assumed values as specified by the code word $ijk\ell$ on the L$\emptyset\emptyset$PS data card. The digit i specifies the flow rate option, the digit j the pressure option, the digit k the temperature option, and the digit ℓ the humidity option. If the digit is 0 the respective value is known and if the digit is 1 the value is assumed. The following state variables may be set up:

State variable type 1 - flow
State variable type 2 - pressure
State variable type 3 - temperature
State variable type 4 - humidity

Loop end

The loop end values which are to be matched are specified by the code word $ijk\ell$ on the L$\emptyset\emptyset$PE data card. The digit i specifies the flow rate option, the digit j the pressure option, the digit k the temperature option, and the digit ℓ the humidity option. If the digit is 0 no matching of start and end values will occur and if the digit is 1 the values will be matched. The following error variables may be set up.

Error variable type 1 - flow
Error variable type 2 - pressure
Error variable type 3 - temperature
Error variable type 4 - humidity/enthalpy

Equations:

Error Variable = loop start value - loop end value

(A17.1)(L$\emptyset\emptyset$P)

Required Tables:

- - Table ID (IFN,10) - Fluid properties

Restrictions:

1. Conditions at the loop end which will automatically be satisfied must not be specified as error variables on the LØØPE data card. For example, a loop containing only one flow leg will automatically balance the flow rate at the loop end.
2. A refrigerant loop cannot select enthalpy as a state variable. The loop starting pressure and temperature must define a superheated or saturated vapor.

Performance Component LØØPS

Data Card Format

Card Column	Symbol	Value
1-5	CN	LØØPS component name
8	CC	change code
12	NC	card number
16	NLI	inlet leg number
20	NSI	inlet station number
24	NLØ	outlet leg number
28	NSØ	outlet station number
32	IFT	fluid type
36	IFN	fluid property table relative number (type 10)
40	IØP	option = ijkℓ
		i = 0 flow rate known
		i = 1 flow rate unknown
		j = 0 pressure known
		j = 1 pressure unknown
		k = 0 temperature known
		k = 1 temperature unknown
		ℓ = 0 humidity known
		ℓ = 1 humidity unknown
44	[W]	loop starting values and/or initial guesses
48	[P]	
52	[T]	
56	[H]	

[illegible]

1 - liquid
2 gas
3 refrigerant

1 air
2 water
3 EGW
4 JP4
5 coolanol 25
6 " 45

Performance Component LØØPE

Data Card Format

Card Column	Symbol	Value
1-5	CN	LØØPE component name
8	CC	change code
12	NC	card number
16	NLI	inlet leg number
20	NSI	inlet station number
24	NLØ	outlet leg number
28	NSØ	outlet station number
32	IØP	option = ijkℓ
		i = 0 no flow error
		i = 1 flow error
		j = 0 no pressure error
		j = 1 pressure error
		k = 0 no temperature error
		k = 1 temperature error
		ℓ = 0 no humidity/enthalpy error
		ℓ = 1 humidity/enthalpy error

SECTION XI

A18 - REPLACEMENT

PERFORMANCE COMPONENT MERGE

Flow Merge

Purpose: This component will merge two flow lines into one line.

Options: The flow merge is computed with the following options:

Option - 1 - Symmetric merge, no error variable is computed

Option 0 - Merge, no pressure balance required, no error variable computed

Option 1 - Merge, pressure balance required, type 2 error variable computed

Equations:

for IØP = -1 only

$$W_{out} = 2 \cdot W_{in_1}$$

$$P_{out} = P_{in_1}$$

$$T_{out} = T_{in_1}$$

$$H_{out} = H_{in_1}$$

for IØP = 0 or 1

$$W_{out} = W_{in_1} + W_{in_2}$$

for IØP = 0

$$P_{out} = P_{in_1}$$

for IØP = 1

$$P_{out} = (P_{in_1} \cdot W_{in_1} + P_{in_2} \cdot W_{in_2})/W_{out}$$

for fluid type 1

$$h_{out} = (W_{in_1} h_{in_1} + W_{in_2} h_{in_2})/W_{out}$$

$$\bar{T}_{out} = f(h_{out})$$

for fluid type 2

$$\bar{T}_{out} = (W_{in_1} \cdot T_{in_1} + W_{in_2} \cdot T_{in_2})/W_{out}$$

$$C1 = H_{in_1}/(1.0 + H_{in_1})$$

$$C2 = H_{in_2}/(1.0 + H_{in_2})$$

$$H_{out} = (C1 \cdot W_{in_1} + C2 \cdot W_{in_2})/(W_{out} - C1 \cdot W_{in_1} - C2 \cdot W_{in_2})$$

$$T_{out} = f\ (P_{in_1}, T_{in_1}, H_{in_1}, P_{in_2}, T_{in_2}, H_{in_2}, P_{out}, \bar{T}_{out}, H_{out})$$

<u>for fluid type 3</u>

$$H_{out} = (W_{in_1} \cdot H_{in_1} + W_{in_2} \cdot H_{in_2})/W_{out}$$

$$T_{out} = f(P_{out}, H_{out})$$

Error Variable = $P_{in_1} - P_{in_2}$ (type 2) (optional)

Performance Component MERGE

Data Card Format

Card Column	Symbol	Value
1-5	CN	MERGE component name
8	CC	change code
12	NC	card number
16	NLI1	inlet 1 leg number
20	NSI1	inlet 1 station number
24	NLI2	inlet 2 leg number (not required if IOP = -1)
28	NSI2	inlet 2 station number (not required if IØP = -1)
32	NLØ	outlet leg number
36	NSØ	outlet station number
40	IØP	option
		= -1 symmetric merge
		= 0 merge (no pressure balance)
		= 1 merge (pressure balance)

SECTION XII

A19 - REPLACEMENT

PERFORMANCE COMPONENT MISC

Miscellaneous Operations

Purpose: This component may be used to compute any value desired using basic mathematical expressions. The result of the operation may be a function of one or two variables. The result and the variables may be a general argument, a flow rate, a pressure, a temperature, a humidity/enthalpy, a parameter table value, a functional table value, a state variable or an error variable.

Options: The operations which are a function of one variable are: equality, absolute value, square root, base ten logarithm, natural logarithm, ten to a power, and e to a power. The operations which are a function of two variables are: addition, subtraction, multiplication, division, the minimum of two variables, the maximum of two variables, variable one to the variable two power, average value, and a code which indicates that variable one is either less than, equal to, or greater than variable two. The last option also allows for skipping data cards. The user may specify if the operation will be done for only the first iteration; for all iterations; or for all iterations and perturbations. The user may set up state and error variables or change state and error variables. The latter options are done for all perturbations and iterations.

Equations:

if IØPR $\leq$ 0

VX = f (V1)

if IØPR > 0

VX = f (V1, V2)

Notes:

1. The component performance printout consists of the following items:

   VX - result variable value

   IVXT - result variable type

   IVXN - result variable relative number

   IØPR - operation code

   IØPT - option code

V1	- variable value	variable one
IV1T	- variable type	
IV1N	- variable relative number	
V2	- variable value	variable two (printed if IØPR > 0)
IV2T	- variable type	
IV2N	- variable relative number	

The printout will not be given for results which are performed only on the first iteration, or for results which generate state variables.

Performance Component MISC

Data Card Format

Card Column	Symbol	Value
1-4	CN	MISC component name
8	CC	change code
12	NC	card number
16	IVXT	result type
		= 0 for a general argument
		= 1 for a flow rate
		= 2 for a pressure
		= 3 for a temperature
		= 4 for a humidity/enthalpy
		=-1 for a parameter value
		=-2 for a table (type 99, 1D)
		=-3 for a state variable
		=-4 for an error variable
20	NVX	result relative number
		= a general argument number — if IVXT is 0
		= a leg number — 1
		= a station number — 2
		= a station number — 3
		= a station number — 4
		= a parameter index — -1
		= a table relative number (type 99) — -2
		= a state variable code — first iter only — if IVXT is -3
		if IØPT is 1 not used
		if IØPT is -1 — on all iterations
		-N for the Nth next (preceding) state variable
		0 for the last state variable
		+N for the Nth state variable
		= an error variable code — if IVXT is -4
		if IØPT is 1 not used
		if IØPT is -1
		-N for the Nth last error variable
		0 for the last error variable
		+N for the Nth error variable

col 44

must put -1 or +1 for IOPT in col 44 to use SV as result (Ø will not work)

if +1 in col 44, put blank in col 20

W=1

1000

1

W=1

1001/2 = 500.5

Card Column	Symbol	Value	
24	IV1T	Variable one type	
		= 0 for a general argument	
		= 1 for a flow rate	
		= 2 for a pressure	
		= 3 for a temperature	
		= 4 for a humidity/enthalpy	
		=-1 for a parameter value	
		=-2 for a table (type 99)	
		=-3 for a state variable	
		=-4 for an error variable	
28	NV1	variable one relative number	
		= a general argument number	if IV1T is 0
		= a leg number	1
		= a station number	2
		= a station number	3
		= a station number	4
		= a parameter table index	-1
		= a table relative number (type 99)	-2
		= a state variable number	-3
		= an error variable number	-4
32	IØPR	operation	
		if IØPR > 0 VX = f(V1, V2)	
		= 1 - V1 + V2	
		= 2 - V1 - V2	
		= 3 - V1 x V2	
		= 4 - V1 ÷ V2	
		= 5 - minimum value (V1, V2)	
		= 6 - maximum value (V1, V2)	
		= 7 - $V1^{V2}$	
		= 8 - (V1 + V2)/2	
		= 9 - 0 if V1 = V2; 1 if V1 > V2; -1 if V1 < V2 } and skip (see ISP, ISZ, and ISM)	
		if IØPR = 0	
		VX = V1	

see preceding page (col. 20) "O" for last preceding SV or EV

skip.

Card Column	Symbol	Value
		if IØPR < 0 VX = f(V1)
		= −1 $\lvert V1 \rvert$
		= −2 $\sqrt{V1}$
		= −3 log V1
		= −4 ln V1
		= −5 10^{V1}
		= −6 e^{V1}
36	IV2T	variable two type (same as IV1T)
40	NV2	variable two relative number (same as NV1)
44	IØPT	option col 16 (result type)
		if IVXT −1, 0, 1, 2, 3, 4
		1 perform operation only on first iteration
		0 perform operation on all iterations and perturbations
		−1 perform operation on all iterations
		if IVXT = −3 – SV result
		1 generate and initialize new state variable (first iteration only)
		−1 change old state variable (iteration only - automatically perturbed to obtain next iteration)
		if IVXT = −4 – EV result
		1 generate and compute new error variable (all iterations and perturbations)
		−1 change old error variable (all iterations and perturbations)

column 32

if IØPR = 9

Card Column	Symbol	Value	
48	ISP	number of cards to skip if V1 > V2	+ values skip forward
52	ISZ	number of cards to skip if V1 = V2	− values skip backward
56	ISM	number of cards to skip if V1 < V2	

column 16

if IVXT = 1 and leg is undefined

Card Column	Symbol	Value
60	IFT	fluid type
64	IFN	fluid property table relative number (type 10)

flow rate result

SECTION XIII

A20 - REPLACEMENT

PERFORMANCE COMPONENT NOZZLE

Nozzle

Purpose: This component will compute nozzle performance for choked and unchoked nozzles and ram air exits.

Options: Nozzle performance is calculated using the following options:

IØP = 0 pressure ratio across the nozzle is specified in a table. A type 2 error variable is computed.

IØP = 1 pressure ratio across the nozzle is calculated. A type 1 error variable is computed.

Equations:

$$PR = P_{discharge}/P_{in}$$

$$PR_{critical} = [2/(\gamma+1)]^{\gamma/(\gamma-1)} = .528 @ k=1.4$$

if $PR < PR_{critical}$, then $PR = PR_{critical}$

if IØP = 0

$$P_{out} = P_{in} \cdot PR$$

$$\text{Error Variable} = P_{out} - P_{discharge}$$

if IØP = 1

$$P_{out} = P_{discharge}$$

lbm/ft³ psia

$$W_{calc} = 40.124 \cdot \overset{1.0}{C_D} \cdot \overset{in^2}{A} \frac{\sqrt{[\gamma/(\gamma-1)]\, \rho \cdot P_{in}\, \overbrace{[PR^{2/\gamma} - PR^{(\gamma+1)/\gamma}]}^{.0670 @ \gamma=1.4, PR=.528}}}{\sqrt{1 - DR^4\, PR^{2/\gamma}}}$$

$$\text{Error Variable} = W_{in} - W_{calc} \quad \text{(type 1)}$$

Dthroat/Dline

$$\dot{W} = 31.92\, P A * C_D \frac{1}{\sqrt{T}}$$

$$\bar{T}_{out} = T_{in} [1 - \eta_n (1 - PR^{(\gamma-1)/\gamma})]$$

$$H_{out} = H_{in}$$

$$T_{out} = f(P_{in}, T_{in}, H_{in}, P_{out}, \bar{T}_{out}, H_{out})$$

Required Tables:

if IØP = 0

PR - Table ID(IPR,4) - Nozzle pressure ratio ($P_{discharge}/P_{in}$)

if IØP = 1

C_D - Table ID(ICD,9) - Nozzle discharge coefficient (optional)

η_n - Table ID(IE,17) - Nozzle efficiency

Restrictions:

1. This component can only be used for fluid type 2.

Notes:

1. The following general arguments are set in this component:
   - argument 27, flow ratio (W/W_∞) where $W_\infty = \rho_\infty A V_\infty$ (set to -1.0 if V_∞ is zero or undefined)
   - argument 41, flow in leg
2. Fluid properties:

   γ - evaluated at T_{in}

   ρ - evaluated at P_{in}, T_{in}
3. The component performance printout consists of the following items:

   NL - leg number
   NSI - inlet station number
   NSØ - outlet station number
   FT - fluid type
   FN - fluid number
   W - flow rate
   PI - inlet pressure
   PØ - outlet pressure
   TI - inlet temperature
   TØ - outlet temperature
   HI - inlet humidity
   HØ - outlet humidity
   PR - nozzle pressure ratio
   EFF - nozzle adiabatic efficiency

Performance Component NØZZLE

Data Card Format

Card Column	Symbol	Value
1-6	CN	NØZZLE component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	[PD] 54	discharge pressure
32	IØP	option
		= 0 pressure ratio specified
		= 1 pressure ratio calculated
if IØP = 0		
36	IPR	nozzle pressure ratio table relative number (type 4)
40	IE	adiabatic efficiency table relative number (type 17)
if IØP = 1		
36	ICD	discharge coefficient table relative number (type 9) (optional)
40	IE	adiabatic efficiency table relative number (type 17)
44	[DR] 55	diameter ratio D_{throat}/D_{line}
48	[D] 56	throat diameter
52	[A] 57	throat area; if [A] = 0, use $A = \pi D^2/4$

Performance Component ØRIF

Orifice

Purpose: This component will compute the pressure loss across an orifice.

$Q = K_f A \sqrt{2g \frac{\Delta P}{W}}$

Options: Orifice pressure loss is computed with the following options:

$\Delta P = \frac{Q^2}{K_f^2 A^2} \frac{W}{2g} = \frac{(\dot m \frac{lbm}{sec} / \rho \frac{lbm}{ft^3})^2}{K_f^2 (\frac{\pi}{4} D^2)^2} \frac{\rho}{2g}$

ITE = 0 - Liquid pressure loss (ΔP) is read from a table.

- Gas pressure ratio (P_{out}/P_{in}) is read from a table.

ITE = 1 - Liquid pressure loss is computed from equation 1.

- Gas pressure ratio is computed from equation 1.

$\Delta P = \frac{\dot m^2}{\rho 2g K^2 (\frac{\pi}{4})^2 D^4}$

A state variable type 9 for pressure ratio is set up and an error variable type 1 for flow rate is computed.

Equations:

$\Delta P = \frac{1}{39.72} \frac{\dot m^2}{\rho K^2 D^4}$

for fluid type 1 - Liquid

$\Delta P \times 144 = \frac{1}{39.72} \frac{\dot m^2/3600}{\rho K^2 D^4/1728}$

$P_{out} = P_{in} - \Delta P$

$\boxed{\Delta P = 1/993\, \dot m^2 / \rho C_D^2 D^4}$

where

DR = D_{throat}/D_{line}

ΔP = table lookup

or

D_{throat}

$\Delta P = W^2 \sqrt{1 - DR^4} / [\rho \cdot (31.513 \cdot C_D \cdot D_t^2)]^2$

discharge coeff

$\Delta P = W^2 / [\rho \times (31.513 \times C_D \times D_t^2)^2]$

for fluid type 2 - Gas

State Variable = PR (type 9) (optional)

$PR = P_{out}/P_{in}$ = table lookup

$P_{out} = P_{in} \cdot PR$

S/B $[\gamma+1]$

S/B $[\gamma/(\gamma-1)]$ ✓

$PR_{critical} = [2/(\gamma+1)]^{\gamma/(\gamma-1)}$

(1) $W_{calc} = \frac{31.513 \cdot C_D \cdot D_t^2 \sqrt{[(\gamma-1)/\gamma] \cdot \rho \cdot P_{in} \, [PR^{2/\gamma} - PR^{(\gamma+1)/\gamma}]}}{\sqrt{1 - DR^4\, PR^{2/\gamma}}}$

3.5 .06698

$= \cdots \sqrt{.2344\, \rho P}$

Error Variable = $W_{calc} - W_{in}$

$D_t = \sqrt{\frac{W_{calc}\sqrt{1 - DR^4 PR^{2/\gamma}}}{31.513 \cdot C_D \sqrt{(\gamma/\gamma-1) \cdot \rho \cdot P_{IN} [\cdots]}}}$

$\overline{T}_{out} = T_{in}$

$= \cdots \sqrt{.2344\; 2.701 \frac{P}{T} P}$

$= \cdots \sqrt{.63319\, P^2/T}$

$H_{out} = H_{in}$

$= 25.08\, C_D D_t^2 P/\sqrt{T}$

$T_{out} = f(P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$

$= 31.93\, C_D A P/\sqrt{T}$

S/B 31.86 ✓ for air

A21

Performance Component ØRIF

Orifice

Purpose: This component will compute the pressure loss across an orifice.

Options: Orifice pressure loss is computed with the following options:

IOP ~~ITE~~ = 0 – Liquid pressure loss (ΔP) is read from a table.
– Gas pressure ratio (P_{out}/P_{in}) is read from a table.

IOP ~~ITE~~ = 1 – Liquid pressure loss is computed from equation 1.
– Gas pressure ratio is computed from equation 1.
A state variable type 9 for pressure ratio is set up and an error variable type 1 for flow rate is computed.

Equations:

IOP=2

$$\Delta P = \frac{\left(W / (C_D \cdot B2 \cdot D_t^2 \times 31.513)\right)^2}{\rho}$$

for fluid type 1 – Liquid

$$P_{out} = P_{in} - \Delta P$$

where

$$\Delta P = \text{table lookup}$$

or

$$\cancel{\Delta P = W\sqrt{1 - DR^4} / \rho \cdot (31.513 \cdot C_D \cdot D_t^2)^2}$$

DR = Dthroat / Dline

Dthroat

discharge coeff.

IOP=1

$$\Delta P = \frac{W^2}{\rho \times (31.513 \times C_D \times D_t^2)^2} = \frac{.01316\ W^2}{\sigma\ D^4 C_D^2}$$

for fluid type 2 – Gas

State Variable = PR (type 9) (optional)

$$PR = P_{out}/P_{in} = \text{table lookup}$$

$$P_{out} = P_{in} \cdot PR$$

S/B [γ+1]

$$PR_{critical} = [2/(\gamma+1)]^{\gamma/(\gamma-1)}$$

S/B [γ/γ-1]

P_{out}/P_{IN}

(1)

$$W_{calc} = \frac{31.513 \cdot C_D \cdot D_t^2 \sqrt{[2\gamma/(\gamma-1)] \cdot \rho \cdot P_{in}\left[PR^{2/\gamma} - PR^{(\gamma+1)/\gamma}\right]}}{\sqrt{1 - DR^4\ PR^{2/\gamma}}}$$

$$\text{Error Variable} = W_{calc} - W_{in}$$

$$\overline{T}_{out} = T_{in}$$

$$H_{out} = H_{in}$$

$$T_{out} = f(P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

Required Tables:

for ITE = 0, fluid type 1

ΔP - Table ID (IPD,1) - Pressure loss

for ITE = 0, fluid type 2

PR - Table ID(IPD,4) - Pressure ratio

for ITE = 1, fluid types 1 & 2

C_D - Table ID (ICD,9) - Orifice coefficient

Restrictions:

1. This component may only be used for fluid types 1 and 2.

Notes:

1. The following general arguments are set up in this component.
   - argument 20, diameter ratio D_t/D_{line}
   - argument 21, Reynolds number $0.2565\ W\ D_{line}/\mu$
   - argument 33, flow function $W\sqrt{T_{in}}/(0.78539 \cdot P_{in} \cdot D_t^2)$
   - argument 41, flow in leg
2. Fluid properties

   ρ - evaluated at T_{in}, P_{in}

   γ - evaluated at T_{in}

   μ - evaluated at T_{in}
3. The component performance printout consists of the following items:

   NL - leg number

   NSL - inlet station number

   NSØ - outlet station number

   FT - fluid type

   FN - fluid number

   W - flow rate

   PI - inlet pressure

   PØ - outlet pressure

   TI - inlet temperature

   TØ - outlet temperature

   HI - inlet humidity

   HØ - outlet humidity

   for fluid type 1

   PD - Pressure drop

for fluid type 2

PR - Pressure ratio

Performance Component ØRIF

Data Card Format

Card Column	Symbol	Value
1-4	CN	ØRIF component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	~~ITE~~ IOP	table or equation option = 0 use table = 1 use equation
if ITE = 0		
[32	IPD	pressure drop table relative number - fluid type 1 (table type 1) <- see p 154 top or pressure ratio table relative number - fluid type 2 (table type 4)
if ITE = 1		
[32	ICD	orifice coefficient table relative number (type 9)
36	[DT]	throat diameter
40	[DR]	diameter ratio D_{throat}/D_{line}
44		SV index
48		EV index
52	[BZ]	FLOW COEFF MULT
56	[PR]	PRESS RATIO INITIAL GUESS

ΔP - fluid

P_{in}/P_{out} - gas

C_D VS Diam

A22

Performance Component ØUTLET

Outlet from ECS

Purpose: This component specifies an outlet from the ECS. The user may specify values of flow rate, pressure, temperature, and humidity which are to be matched.

Options: The values which are to be matched are specified by the code word ijkℓ. The digit i specifies the flow rate option, j the pressure option, k the temperature option, and ℓ the humidity/enthalpy option. If the digit is 0 no matching of the values will occur, and if the digit is 1 the program will balance the model to match the value specified. The following error variables may be set up:

Error variable type 1 - flow
Error variable type 2 - pressure
Error variable type 3 - temperature
Error variable type 4 - humidity/enthalpy

Equations:

Error Variable = computed value - outlet value

Notes:

1. This component is optional and is not required to terminate a leg if no values are to be matched.

Performance Component ØUTLET

Data Card Format

Card Column	Symbol	Value
1-6	CN	ØUTLET component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NS	station number
24	IØP	option = ijkℓ
		i = 0 no flow rate error
		i = 1 flow rate error
		j = 0 no pressure error
		j = 1 pressure error
		k = 0 no temperature error
		k = 1 temperature error
		ℓ = 0 no humidity/enthalpy error
		ℓ = 1 humidity/enthalpy error
28	[W]	outlet flow rate (if i = 1)
32	[P]	outlet pressure (if j = 1) (5 8]
36	[T]	outlet temperature (if k = 1)
40	[H]	outlet humidity/enthalpy (if ℓ = 1)

Performance Component PREG
Pressure Regulator

Purpose: This component will compute the performance of a pressure regulator. A minimum pressure loss is computed across the regulator. If the outlet pressure exceeds the regulator set value, the outlet pressure is reduced to the set value.

Options: Pressure losses are calculated with the following options:

ITE = 0 ΔP or $\sigma\Delta P$ is read from a table

ITE = 1 ΔP is calculated from equation 1

ITE = 2 ΔP or $\sigma\Delta P$ is calculated from equation 2

Equations:

$$P_{out} = P_{in} - \Delta P$$

where

$$\left.\begin{matrix}\Delta P \\ \sigma\Delta P\end{matrix}\right\} = \text{table lookup}$$

or

$$\Delta P = 1.008 \times 10^{-3} K_t W^2/D^4 \tag{1}$$

ITE = 1

or

$$\left.\begin{matrix}\Delta P \\ \sigma\Delta P\end{matrix}\right\} = KW^2 \tag{2}$$

ITE = 2

if $P_{out} > P_{reg}$, then $P_{out} = P_{reg}$

$$\overline{T}_{out} = T_{in}$$

$$H_{out} = H_{in}$$

$$T_{out} = f\,(P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

Required Tables:

for ITE = 0 only

ΔP or $\sigma\Delta P$ - Table ID (IPD,1) - Pressure drop

Restrictions:

1. This component can only be used for fluid types 1 and 2.

Notes:

1. The following general argument is set up in this component:
   - argument 41, flow in leg
2. Fluid properties:
   σ - evaluated at P_{in}, T_{in}
   ρ - evaluated at P_{in}, T_{in}
3. The component performance printout consists of the following items:
   NL - leg number
   NSI - inlet station number
   NSØ - outlet station number
   FT - fluid type
   FN - fluid number
   W - flow rate
   PI - inlet pressure
   PØ - outlet pressure
   TI - inlet temperature
   TØ - outlet temperature
   HI - inlet humidity
   HØ - outlet humidity

Performance Component PREG

Data Card Format

Card Column	Symbol	Value
1-5	CN	PREG component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	ISIG	option (for ITE = 0, 2) = 0 use ΔP = 1 use σΔP
32	ITE	table or equation option = 0 use table = 1 use equation 1 $= 1.008 \times 10^{-3} \frac{K_t W^2}{D^4}$ = 2 use equation 2 ΔP or $\sigma \Delta P = K W^2$
if ITE = 0		
36	IPD	pressure drop table relative number (type 1)
if ITE = 1		
36	[KT]	K_t
40	[D]	diameter
if ITE = 2		
36	[K]	K
44	[PREG]	regulator pressure setting
48	EFF	ACTUATOR EFFICIENCY (LIQUID ONLY) 0. = ALL ΔP → HEAT 1.0 = NO ΔP APPEARS AS HEAT

Performance Component PUMP

Pump

Purpose: This component will compute pump performance.

Equations:

$$P_{out} = P_{in} + \Delta P$$

$$FPWR = 4.3636 \times 10^{-3}\ \Delta P\ W/\rho \text{ (fluid power)}$$

$$SPWR = FPWR/\eta_p \text{ (shaft power)}$$

$$HP = SPWR/\eta_m$$

$$Q_t = 42.416\ (SPWR-FPWR)$$

$$T_{out} = T_{in} + Q_t/W \cdot C_p$$

Required Tables:

ΔP - Table ID(IPT,16) - Pump pressure rise

η_s - Table ID(IPT,17) - Pump static efficiency

Restrictions:

1. This component may only be used for fluid type 1.
2. The PUMP shaft number must be previously defined (see component SHAFT).

Notes:

1. The following general arguments are set up in this component:
   - argument 29 - inlet volumetric flow (gpm)
   - argument 31 - pressure rise (ΔP)
   - argument 41 - flow in leg
2. Fluid properties:
   ρ - evaluated at P_{in}, T_{in}
   C_p - evaluated at T_{in}
3. A shaft power balance may be obtained by inserting an SPØWER card (see subroutine SPØWER).

4. The component performance printout consists of the following items:

NL	- leg number	
NSI	- inlet station number	
NSØ	- outlet station number	
FT	- fluid type	
FN	- fluid number	
W	- flow rate	
PI	- inlet pressure	
PØ	- outlet pressure	
TI	- inlet temperature	
TØ	- outlet temperature	
HI	- inlet humidity	not applicable
HØ	- outlet humidity	
SHAFT	- shaft number	
GPM	- volumetric flow rate	
EFF	- static efficiency	
HP	- pump horsepower	

Performance Component PUMP

Data Card Format

Card Column	Symbol	Value
1-4	CN	PUMP component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	NST	shaft number
32	IPT	pressure rise table relative number (type 16)
		static efficiency table relative number (type 17)
36	[ME]	mechanical efficiency

SECTION XIV

A25 - REPLACEMENT

PERFORMANCE COMPONENT QLOAD

Compartment Heat Load

Purpose: This component may be used to simulate an equipment compartment or cabin. It allows for both heat transfer and pressure drop.

Options: Pressure drops are computed with the following options:

ISIG = 0 use ΔP

ISIG = 1 use $\sigma\Delta P$

Equations:

$P_{out} = P_{in} - \Delta P$

$H_{out} = H_{in}$

$SHR = (T_{in} - \bar{T}_{out})/(T_{in} - T_{out})$

UA option

$Q_t = UA\ (T_S - T_f) \cdot B1$

$T_f = (T_{in} + T_{out})/2$

for fluid type 1 (liquid)

$h_{out} = h_{in} + Q_t/W$

$T_{out} = f(h_{out})$

for fluid type 2 (gas)

$T_{out} = T_{in} + Q_t/(W \cdot C_p \cdot SHR)$

$\bar{T}_{out} = f\ (P_{in}, T_{in}, H_{in}, P_{out}, T_{out}, H_{out})$

Q option

$Q_t = Q \cdot B2$

$T_f = (T_{in} + \bar{T}_{out})/2$

for fluid type 1 (liquid)

$h_{out} = h_{in} + Q_t/W$ ← s/b $W \cdot C_p$?

$\bar{T}_{out} = f(h_{out})$

for fluid type 2 (gas)

$\bar{T}_{out} = T_{in} + Q_t/(W \cdot C_p)$

$T_{out} = f\ (P_{in}, T_{in}, H_{in}, P_{out}, \bar{T}_{out}, H_{out})$

<u>neither option</u>

$Q_t = 0$

$\bar{T}_{out} = T_{in}$

$T_{out} = f\ (P_{in}, T_{in}, H_{in}, P_{out}, \bar{T}_{out}, H_{out})$

Required Tables:

ΔP or $\sigma\Delta P$ - Table ID (IPD, 1) - Pressure drop

optional:

UA - Table ID (IUA, 11) - Overall heat transfer coefficient

T_s - Table ID (ITS, 12) - Source/Sink temperature

Q - Table ID (IQ, 13) - Heat load

Restrictions:

1. This component can use only fluid types 1 and 2.
2. Either the UA or Q option may be used. The UA option will be used if values are input for both options.

Notes:

1. The following general argument is set up in this component:
   - argument 41, flow in leg G.n 41 = W
2. Fluid properties:

   C_p - evaluated at an approximate T_{avg}

   σ - evaluated at T_{avg}

   where $T_{avg} = (T_{in} + T_{out})/2$
3. The component performance printout consists of the following items:

   NL - leg number

   NSI - inlet station number

   NSØ - outlet station number

   FT - fluid type

   FN - fluid number

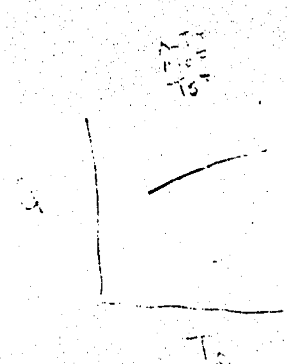
   W - flow rate

   PI - inlet pressure

   PØ - outlet pressure

   TI - inlet temperature

   TØ - outlet temperature



HI - inlet humidity

HØ - outlet humidity

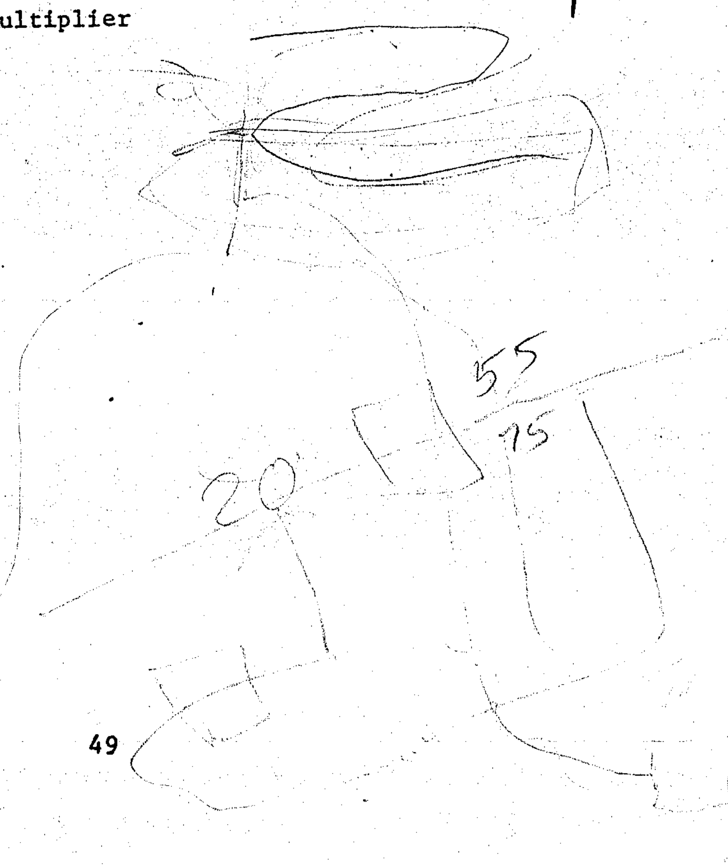
QT - heat load

SHR - sensible heat ratio

Performance Component QLOAD

Data Card Format

Card Column	Symbol	Value	
1-5	CN	QLOAD component name	
8	CC	change code	
12	NC	card number	
16	NL	leg number	
20	NSI	inlet station number	
24	NSØ	outlet station number	
28	ISIG	option = 0 use ΔP = 1 use σΔP	
32	IPD	pressure drop table relative number (type 1)	
36	IUA	overall heat transfer coefficient table relative number (type 11)	optional
40	B1 ITS	source/sink temperature table relative number (type 12)	optional
44	[B1]	multiplier	optional
48	IQ	heat load table relative number (type 13)	optional
52	[B2]	multiplier	optional



Performance Component SENSØR

Flow rate, Pressure, Temperature, Humidity/Enthalpy Sensor

Purpose: This component represents a flow rate, pressure, temperature, or humidity/enthalpy sensor and will require the system to balance to the desired value.

Options: Error variables are computed with the following options:

ICT = 1 - flow rate sensor error computed (type 1)

ICT = 2 - pressure sensor error computed (type 2)

ICT = 3 - temperature sensor error computed (type 3)

ICT = 4 - humidity/enthalpy sensor error computed (type 4)

Equations:

Error Variable = computed value - control value

OLD

Performance Component SENSØR

Data Card Format

SENPP
SENPZ

Card Column	Symbol	Value
1-6	CN	SENSØR component name
8	CC	change code
12	NC	card number
16	ICT	control type = 1 flow rate = 2 pressure = 3 temperature = 4 humidity/enthalpy
20	NCS	number of control sensor if ICT = 1 leg number = 2, = 3, = 4 station number
24	[CV]	control value

SECTION XV

A27 - REPLACEMENT

PERFORMANCE COMPONENT SHAFT

Shaft Initialization

Purpose: This component will initialize a shaft number for reference by other subroutines, i. e., COMP, TURB, VCOMP, FAN, PUMP, APU.

Options: This subroutine has the following options:

ISRS = 0 fixed speed or no speed

ISRS = 1 variable speed. A type 7 state variable is set up.

Equations:

State Variable = N (type 7) (optional)

Restrictions:

1. A SHAFT data card defining a shaft must appear before that shaft number is referenced by any other component data cards.
2. Shaft numbers must be limited to values of 1 through 10.

Notes:

1. The component performance printout consists of the following items:

   SHAFT - shaft number

   N - shaft speed
2. Shaft speed is set up in general argument (80+NST).

Performance Component SHAFT

Data Card Format

Card Column	Symbol	Value
1-5	CN	SHAFT component name
8	CC	change code
12	NC	card number
16	NST	shaft number
20	ISRS	speed option = 0 fixed speed or no speed = 1 variable speed
24	[N]	speed value if ISRS = 0 fixed speed or no speed = 1 speed initial guess

A28

Performance Component SPLIT

Flow Split

Purpose: This component will split a flow line into two outlet flow lines.

Options: The flow split is computed with the following options:

Option -1 - Symmetric split. No state variable is set up.

Option 0 - Fixed split ratio. No state variable is set up.

Option 1 - Variable split ratio. A state variable type 6 is set up for the split ratio.

Equations:

State Variable = SR = W_{out1}/W_{in} (type 6) (optional)

for IØP = -1

$W_{out1} = W_{in}/2$

option

for IØP = 0, 1

$W_{out1} = SR\ W_{in}$

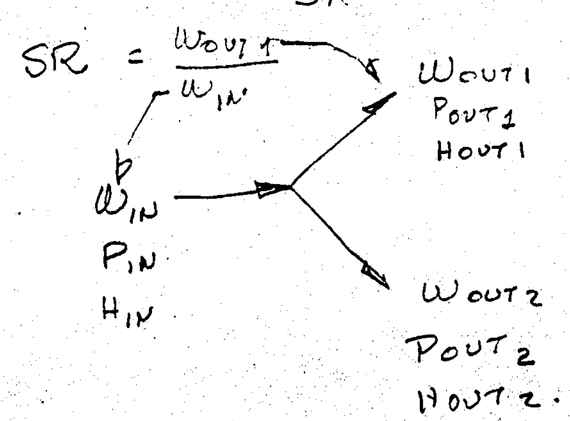
$W_{out2} = W_{in} - W_{out1}$

$P_{out1} = P_{out2} = P_{in}$

$T_{out1} = T_{out2} = T_{in}$

$H_{out1} = H_{out2} = H_{in}$

SR = SPLIT RATIO



WOUT1/WIN

Performance Component SPLIT

Data Card Format

Card Column	Symbol	Value
1-5	CN	SPLIT component name
8	CC	change code
12	NC	card number
16	NLI	inlet leg number
20	NSI	inlet station number
24	NLØ1	outlet 1 leg number
28	NSØ1	outlet 1 station number
32	NLØ2	outlet 2 leg number (not required if IØP = -1)
36	NSØ2	outlet 2 station number (not required if IØP = -1)
40	IØP	option = -1 symmetric split — .5 = 0 specified split ratio = ~~1 unknown split ratio~~ — (1)
44	[SR]	split ratio (not required if IØP = -1, initial guess if IØP = 1) option

Performance Component SPØWER

Shaft Power Balance

Purpoee: This component is used to compute a power balance for a shaft and to specify the power balance desired.

Equations:

Error Variable = Σ(HP) - power balance desired (type 5)

Restrictions:

1. The SPØWER data card for a shaft must follow the last component card which references the shaft number on the SPØWER card.
2. Shaft numbers may only have values of 1 through 10 and must agree with the shaft number referenced on a SHAFT card.

Notes:

1. A power balance on a shaft is optional and may be omitted if the error variable is not required regardless of the shaft speed being specified as state variable.
2. Power required from a shaft (e.g. compressor power) is summed as a negative value and power supplied to a shaft (e.g., turbine) is summed as a positive value.

Performance Component SPØWER

Data Card Format

Card Column	Symbol	Value
1-6	CN	SPØWER component name
8	CC	change code
12	NC	card number
16	NST	shaft number
20	[PØW]	power balance desired ⇒ equals Ø if $HP_{in} = HP_{out}$

SECTION XVI

A30 - REPLACEMENT

PERFORMANCE COMPONENT TURB

Turbine

Purpose: This component will compute turbine performance.

Options: Turbine performance is computed with the following options:

IØP = 0 - Fixed pressure ratio. No state variable or error variable is set up.

IØP = 1 - Variable pressure ratio. A type 8 state variable is set up for the pressure ratio.

IØP = 2 - Variable pressure ratio, flow factor table is used. A type 8 state variable for the pressure ratio and a type 1 error variable for the nozzle flow balance are set up.

IØT = 0 - Turbine total efficiency table is used.

IØT = 1 - Turbine static efficiency table is used.

Equations:

State Variable = PR (type 8) (optional)

if IØT = 0

$$P_{out} = P_{in}/PR$$

if IØT = 1

$$P_{out} = (P_{in}/PR)(P_{out}/P_{out\ static})$$

where $P_{out}/P_{out\ static} = f\ (W,\ P_{out},\ \bar{T}_{out},\ AE)$

$$\Delta T_i = T_{in}\ [1 - (1/PR)^{(\gamma-1)/\gamma}]$$

$$\bar{T}_{out} = T_{in} - \eta_t \cdot \Delta T_i$$

$$H_{out} = H_{in}$$

$$T_{out} = f\ (P_{in},\ T_{in},\ H_{in},\ P_{out},\ \bar{T}_{out},\ H_{out})$$

$$HP = 0.02356 \cdot W \cdot C_p\ (T_{in} - \bar{T}_{out}) \cdot \eta_m$$

if IØP = 2

$$W_{calc} = F_f \cdot B \cdot P_{in}/\sqrt{T_{in}}$$

NOZZLE AREA

$$\text{Error Variable} = W - W_{calc}$$

Required Tables:

η_t = Table ID(ITT,7) - Turbine efficiency (total if IØT = 0, static if IØT = 1) for IØP = 2 only

F_f - Table ID(ITT,8) - Turbine flow factor

Restrictions:

1. This component can only be used for fluid type 2.

Notes:

1. The following general arguments are set up in this component:
   - argument 24, pressure ratio: P_{in}/P_{out} if IØT = 0, P_{in}/P_{out} static if IØT = 1
   - argument 23, velocity factor $N/\sqrt{\Delta T_i}$ ~~corrected speed~~
   - argument 25, corrected speed $N/\sqrt{T_{in}/519}$
   - argument 41, flow in leg

   90+NST, SHAFT POWER
2. Fluid properties:

   γ - evaluated at T_{in}

   C_p - evaluated at $T_{avg} = (T_{in} + \bar{T}_{out})/2$
3. A shaft power balance may be obtained by inserting a SPØWER card (see component SPOWER).
4. The component performance printout consists of the following items:

   NL - leg number
   NSI - inlet station number
   NSØ - outlet station number
   FT - fluid type
   FN - fluid number
   W - flow rate
   PI - inlet pressure
   PØ - outlet pressure
   TI - inlet temperature
   TØ - outlet temperature
   HI - inlet humidity
   HØ - outlet humidity
   SHAFT - shaft number

PR - pressure ratio

EFF - turbine efficiency

HP - turbine power

5. Turbine shaft power is accumulated in general argument (90+NST).
6. One use of the B factor is the separation of the nozzle area from the flow factor. The nozzle area, represented by B, could then be either fixed or variable (e. g., via the MISC component).

Performance Component TURB

Data Card Format

Card Column	Symbol	Value
1-4	CN	TURB component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	NST	shaft number
32	IØPT	option = ijkℓ
		i - not used
		j - not used
		k - IØT ARACM
		= 0 - total efficiency specified
		= 1 - static efficiency specified
		ℓ - IØP
		= 0 - fixed pressure ratio
		= 1 - variable pressure ratio (no map)
		= 2 - variable pressure ratio (map)
36	[PR]	pressure ratio: P_{in}/P_{out} if IØT = 0, AR ACM
		P_{in}/P_{out} static if IØT = 1
		if IØP
		= 0 fixed pressure ratio
		= 1 } pressure ratio assumed value
		= 2 }
40	ITT	efficiency table relative number (type 7)
		(total if IØT = 0, static if IØT = 1)
		also if IØP = 2
		flow factor table relative number (type 8)
44	[ME]	mechanical efficiency
48	[B]	~~flow factor multiplier~~ (optional) NOZZLE AREA
52	[AE]	exit area (IØT = 1 only)

$\frac{\dot{m}^2}{A^2} = V^2$

$V = \frac{\dot{m}}{\rho A} \Rightarrow V^2 = \frac{\dot{m}^2}{A^2}\frac{1}{\rho^2}$

A31

Performance Component VALVE

Valve

Purpose: This component will compute the pressure drop in a fixed valve.

Options: Pressure drops are computed by the following options.

ITE = 0 ΔP or $\sigma\Delta P$ is read from a table

ITE = 1 ΔP is calculated from equation 1

ITE = 2 ΔP or $\sigma\Delta P$ is calculated from equation 2 .

Equations:

$$P_{out} = P_{in} - \Delta P$$

$\Delta P = K_t q = K_t \left(\tfrac{1}{2}\rho V^2\right) = \frac{G^2}{2\rho g_c} K_t$

$= \frac{W^2}{\rho A^2 g_c} K_t$

where

$$\left.\begin{matrix}\Delta P \\ \sigma\Delta P\end{matrix}\right\} = \text{table lookup} \quad (1)$$

or

$$\Delta P = 1.008 \times 10^{-3} K_t \; W^2/\rho D^4 = K_t q \quad (2)$$

$\Delta P = K_t \frac{W^2}{\pi^2 \frac{D^4}{16} \times 144 \; \rho \times 32.2}$ (1)

$\Rightarrow \Delta P = 1.007 K_t \frac{W^2}{\rho D^4}$ (2)

or

$$\left.\begin{matrix}\Delta P \\ \sigma\Delta P\end{matrix}\right\} = KW^2 \quad (3)$$

W ... lbm/min

D ... inches

ρ ... lbm/ft³

$$\overline{T}_{out} = T_{in}$$

$$H_{out} = H_{in}$$

$$T_{out} = f(P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

Required Tables:

for ITE = 0 only

ΔP or $\sigma\Delta P$ - Table ID (IPD,1) - Pressure drop

Restrictions:

1. This component can use only fluid types 1 and 2.

Notes:

1. The following general argument is set up in this component :
   - argument 41, flow in leg
2. Fluid properties:

   σ - evaluated at P_{in}, T_{in}

   ρ - evaluated at P_{in}, T_{in}

3. The component performance printout consists of the following items:

NL - leg number
NSI - inlet station number
NSØ - outlet station number
FT - fluid type
FN - fluid number
W - flow rate
PI - inlet pressure
PØ - outlet pressure
TI - inlet temperature
TØ - outlet temperature
HI - inlet humidity
HØ - outlet humidity

Performance Component VALVE

Data Card Format

Card Column	Symbol	Value
1-5	CN	VALVE component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	ISIG	option (for ITE = 0, 2)
		= 0 use ΔP
		= 1 use $\sigma \Delta P$
32	ITE	table or equation option
		= 0 use table
		= 1 use equation 1
		= 2 use equation 2
if ITE = 0		
[36	IPD	pressure drop table relative number (type 1)
if ITE = 1		
[36	[KT]	K_t
[40	[D]	diameter
if ITE = 2		
[36	[K]	K

$\Delta P = 1.008 \times 10^{-3} K_t W^2 / \rho D^4$

$\Delta P = K W^2$

ΔP

$\sigma \Delta P$

Performance Component VCØMP
Vapor Cycle Compressor

Purpose: This component will compute vapor cycle compressor performance.

Options: Vapor cycle compressor performance is computed with the following options:

IØP = 0 - Fixed pressure ratio with efficiency read from a table. No state variable or error variable is set up.

IØP = 1 - Variable pressure ratio with efficiency read from a table. A type 8 state variable is set up for the pressure ratio.

IØP = 2 - Pressure ratio and efficiency maps are used. No state variable or error variable is set up.

Equations:

State Variable = PR (type 8) (optional)

$$P_{out} = P_{in} \cdot PR$$

$$V_{in} = f\,(P_{in}, T_{in})$$

$$H_{in} = f\,(P_{in}, T_{in}, V_{in})$$

$$S_{in} = f\,(T_{in}, V_{in})$$

$$S'_{out} = S_{in}$$

$$T'_{out}, V'_{out} = f\,(P_{out}, S'_{out})$$

$$H'_{out} = f\,(P_{out}, T'_{out}, V'_{out})$$

$$H_{out} = H_{in} + (H'_{out} - H_{in})/\eta_c$$

$$T_{out} = f\,(P_{out}, H_{out})$$

$$HP = 0.02356 \cdot W\,(H_{in} - H_{out})$$

Required Tables:

η_c - Table ID(ICT,6) - Compressor efficiency

for IØP = 2 only

PR - Table ID(ICT,4) - Compressor pressure ratio

Restrictions:

1. This component can only be used for fluid type 3.
2. The VCØMP shaft number must be previously defined (see component SHAFT).
3. The inlet state of the compressor must be a saturated or superheated vapor.

Notes:

1. The following general arguments are set up in this component:
   - argument 28, inlet volumetric flow (cfm)
   - argument 41, flow in leg
2. A shaft power balance may be obtained by inserting a SPØWER data card (see SPØWER component).
3. The component performance printout consists of the following items:

   NL - leg number
   NSI - inlet station number
   NSØ - outlet station number
   FT - fluid type
   FN - fluid number
   W - flow rate
   PI - inlet pressure
   PØ - outlet pressure
   TI - inlet temperature
   TØ - outlet temperature
   HI - inlet enthalpy
   HØ - outlet enthalpy
   SHAFT - shaft number
   PR - compressor pressure ratio
   EFF - compressor efficiency
   HP - compressor horsepower

Performance Component VCØMP

Data Card Format

Card Column	Symbol	Value
1-5	CN	VCØMP component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	NST	shaft number
32	IØP	option
		= 0 fixed pressure ratio
		= 1 variable pressure ratio (no map)
		= 2 variable pressure ratio (map)
36	[PR]	pressure ratio
		if IØP
		= 0 fixed pressure ratio
		= 1 pressure ratio initial guess
		= 2 not used
40	ICT	efficiency table relative number (type 6)
		also if IØP = 2
		pressure ratio table relative number (type 4)
44	[ME]	mechanical efficiency

Performance Component VLINE

Vapor Line

Purpose: This component will compute a pressure loss in a refrigerant line.

Equations:

$$P_{out} = P_{in} - \Delta P$$

$$H_{out} = H_{in}$$

$$T_{out}, V_{out} = f\ (H_{out}, P_{out})$$

Required Tables:

ΔP - Table ID (IPD,1) - Pressure drop

Restrictions:

1. This component can only be used for fluid type 3
2. The state of the refrigerant must be a saturated or superheated vapor.

Notes:

1. The following general argument is set up in this component
   - argument 41 - flow in leg

Performance Component VLINE

Data Card Format

Card Column	Symbol	Value
1-5	CN	VLINE component name
8	CC	change code
12	NC	card number
16	NL	leg number
20	NSI	inlet station number
24	NSØ	outlet station number
28	-	
32	IPD	pressure drop table relative number (type 1)

Performance Component WSEP

Water Separator

Purpose: This component will compute water separator moisture removal and pressure drop.

Options: The water separator pressure drop may be computed with the following options:

ISIG = 0 ΔP is read from a table

ISIG = 1 $\sigma \Delta P$ is read from a table

Equations:

$$P_{out} = P_{in} - \Delta P$$

$$\overline{T}_{out} = T_{in}$$

$$H_{sat} = f\,(P_{out}, \overline{T}_{out})$$

<u>if $H_{in} \leq H_{sat}$</u>

$$H_{out} = H_{in}$$

$$W_{out} = W_{in}$$

$$W_{drain} = 0.0$$

<u>if $H_{in} > H_{sat}$</u>

$$\Delta H = \eta\,(H_{in} - H_{sat})$$

$$\Delta\, H_{\cancel{o}ut} = H_{in} - H_{out}$$?

$$\Delta W = \Delta H \cdot W/(1 + H_{in})$$

$$W_{out} = W_{in} - \Delta W$$

$$W_{drain} = \Delta W$$

$$T_{out} = f\,(P_{in}, T_{in}, H_{in}, P_{out}, \overline{T}_{out}, H_{out})$$

Required Tables:

ΔP or $\sigma\Delta P$ - Table ID(IPD,1) - Pressure drop

η - Table ID(IEF,17) - Water separator efficiency

Restrictions:

1. This component may only be used for fluid type 2.

Notes:

1. The following general arguments are set up in this component :
   - argument 30, wet/dry entrained moisture code
     $= 0.0$ if $H_{in} < H_{sat}$
     $= 1.0$ if $H_{in} \geq H_{sat}$
   - argument 41, flow in leg
2. Fluid properties:
   σ - evaluated at P_{in}, T_{in}
3. The component performance printout consists of the following items:

   NL - leg number
   NS - station number
   FT - fluid type
   FN - fluid number
   W - flow rate
   P - pressure
   T - temperature
   H - humidity

   for inlet, outlet, and drain leg

   EFF - water separator efficiency

Performance Component WSEP

Data Card Format

Card Column	Symbol	Value
1-4	CN	WSEP component name
8	CC	change code
12	NC	card number
16	NLI	inlet leg number
20	NSI	inlet station number
24	NLØ1	outlet leg number
28	NSØ2	outlet station number
32	NLØ2	water drain leg number
36	NSØ2	water drain station number
40	ISIG	option = 0 use ΔP = 1 use $\sigma\Delta P$
44	IPD	pressure drop table relative number (type 1)
48	IEF	water collection efficiency table relative number (type 17)

1	SOLUTION ITERATION NUM
2	ALT
3	MACH (FREE STREAM)
4	VELOCITY (FREE STREAM)
5	PRESSURE (FREE STREAM)
6	TEMPERATURE (FREE STREAM)
7	TOTAL PRESSURE (FREE STREAM)
8	TOTAL TEMPERATURE (FREE STREAM)
20	DIAMETER RATIO (DTHROAT/DLINE) -ORIF
21	REYNOLDS NUMBER (LINE)
22	CORRECTED FLOW (W*SQROOT(THETA)/DELTA) -COMP, LINE(ADDED)
23	VELOCITY FACTOR N/(ROOT(DELTATISENTROPIC)) -TURB
24	PRIMARY TO SECONDARY PRESSURE RATIO -EJECT, COMP
25	CORRECTED SPEED (N/SQROOT(THETA))
26	BOILING TEMPERATURE (BOILER)
27	FLOW RATIO (W/WINFINITY) WHERE WINF=RHOINF*A*VINF- NOZZLE
	OR FLOW RATIO ((W*ROOTT/P)SEC/(W(ROOTT/P)PRI) -EJECT
28	INLET VOLUMETRIC FLOW (CFM) -FAN, COMP(ADDED)
29	INLET VOLUMETRIC FLOW (GPM) -PUMP
30	WET/DRY ENTRAINED MOISTURE CODE; =0.0 IF HIN<HSAT =1. IF HIN>HSAT -WSEP
31	PRESSURE RISE -PUMP
33	FLOW FUNCTION W*ROOTT/(.78539*PIN*DTHROAT^2) -ORIF
34	FLOW RATIO ((W*ROOTT)SEC/(W(ROOTT)PRI) -EJECT
35	CORRECTED FLOW (W*SQROOT(T)/P) -LINE (ADDED)
36	INLET TEMP -LINE (ADDED FOR UA)
38	"H" OUTSIDE DUCT -LINE (ADDED FOR UA)
41	FLOW IN LEG
42	FLOW IN LEG 2
43	INLET PRESSURE (SIDE 1)
44	INLET PRESSURE (SIDE 2)
45	AVERAGE TEMPERATURE SIDE 1 (ETAHA OPTION ONLY)- HX
46	AVERAGE TEMPERATURE SIDE 2 (ETAHA OPTION ONLY)- HX
55	NTU -HX SIZE
56	WCPMIN/WCPMAX OR WCPMIXED/WCPUNMIXED -HX SIZE
62	ENGINE THRUST
63	BLEED AIR FLOW RATE
64	SHAFT HORSEPOWER
71	LHOT -HX
72	LCOLD -HX
73	LNOFLOW -HX
74	VTOTAL -HX
75	VLIQUIDHOT -HX
76	VLIQUIDCOLD -HX
8X	SHAFT SPEED OF SHAFT #1 WILL BE GEN ARG 81
	SHAFT SPEED OF SHAFT #2 WILL BE GEN ARG 82, ETC.
9X	SHAFT POWER OF SHAFT #1 WILL BE GEN ARG 91
	SHAFT POWER OF SHAFT #2 WILL BE GEN ARG 92, ETC.
101-110	USER-DEFINED IN MODELS
111-120	RESERVED FOR BAECS PROGRAM GROWTH
111	FAN TOTAL PRESS RISE COEFF =DPTOTAL*1.E8/(SIGMA*RPM^2) [IN-H2O/RPM^2] -COMP (ADDED)
112	VOLUMETRIC AIR FLOW COEFFICIENT (CFM/RPM) -COMP (ADDED)
113	FAN POWER COEFF = SHP*1.E12/(SIGMA*RPM^3) [SHP/RPM^3] -COMP (ADDED)