ESL-TR-01/02-02

AIR-SIDE ACCURACY TESTS FOR FOUR HVAC SYSTEMS: DUAL DUCT CONSTANT VOLUME (DDCAV), DUAL DUCT VARIABLE VOLUME (DDVAV), CONSTANT VOLUME WITH REHEAT (CAVRH), VARIABLE VOLUME WITH REHEAT (VAVRH), FOUR PIPE FAN COIL UNIT (FC), FOUR PIPE INDUCTION UNIT (FI), AND SINGLE ZONE (SZ) SYSTEMS

Prepared by

Jeff S. Haberl, Ph.D., P.E.
Namir Saman, Ph.D., P.E.
Tarek Bou-Saada

March 2001
Revised June 2002

ENERGY SYSTEMS LABORATORY

Texas Engineering Experiment Station
Texas A&M University System

ABSTRACT

This report contains engineering calculations for seven (7) air-side, heating, ventilating and air-conditioning systems (HVAC) systems, including: dual duct constant volume (DDCAV), dual duct variable volume (DDVAV), constant volume with reheat (CAVRH), and variable volume with reheat (VAVRH), four pipe fan coil unit (FC), four pipe induction unit (FI), and a single zone air conditioning system (SZ).

These calculations are presented in spreadsheets that include a running commentary so that the reader can trace through the calculations to see what is being performed. Each system also contains a one-line diagram that shows the system being simulated and the location of the variables used in the calculation.

These calculations were developed as part of the ASHRAE 865-RP project, and include tables that list the results for the 865-RP accuracy tests, as well as the test conditions. These spreadsheets are also useful for developing educational materials, and can be used to check the values obtained from a computer simulation program that contain the exact same schematic as is shown for each system. With only a few exceptions, the formulas for the calculations have come from the ASHRAE Handbook, as indicated in the spreadsheet narrative.

These spreadsheets were developed in the most basic Lotus *.wk1 format and can be run in any spreadsheet that accepts Lotus *.wk1 format. To use the spreadsheets the user loads the spreadsheet, updates only the values needed and recalculates the spreadsheet manually (i.e., press the F9 button). Calculations are repeated column-wise in the spreadsheet to reach convergence. Each calculation represents one set of conditions. To obtain answers for multiple conditions the user will need to enter the new conditions and recalculate for each set of conditions.

ACKNOWLEDGEMENTS

This work was sponsored by ASHRAE under research project 865-RP. The original spreadsheets were developed by Drs. Saman and Haberl and refined by Haberl. The DOE-2 input files were developed by Tarek Bou-Saada.

TABLE OF CONTENTS

LISTING OF TABLES

LISTING OF FIGURES

1.0 GENERAL INSTRUCTIONS FOR USING THE SPREADSHEETS

The spreadsheets that are used to perform the air-side calculations are formatted as shown in Figure 1.1. Input values are entered into the cells in the upper left comer of the spreadsheet. The output from the spreadsheet is posted directly to the right of the input section. The calculations are performed in the columns below the input-output section. Since the air-side calculations often require an iterative solution, the calculations are repeated in columns across the spreadsheet from left to right using the values from the columns that were previously calculated. The “answer” is posted from the rightmost set of columns in the output section. These spreadsheets are provided in an unprotected mode. Hence the user should only enter values into the "input” section shown. Changing values in other parts of the spreadsheet can cause incorrect answers.

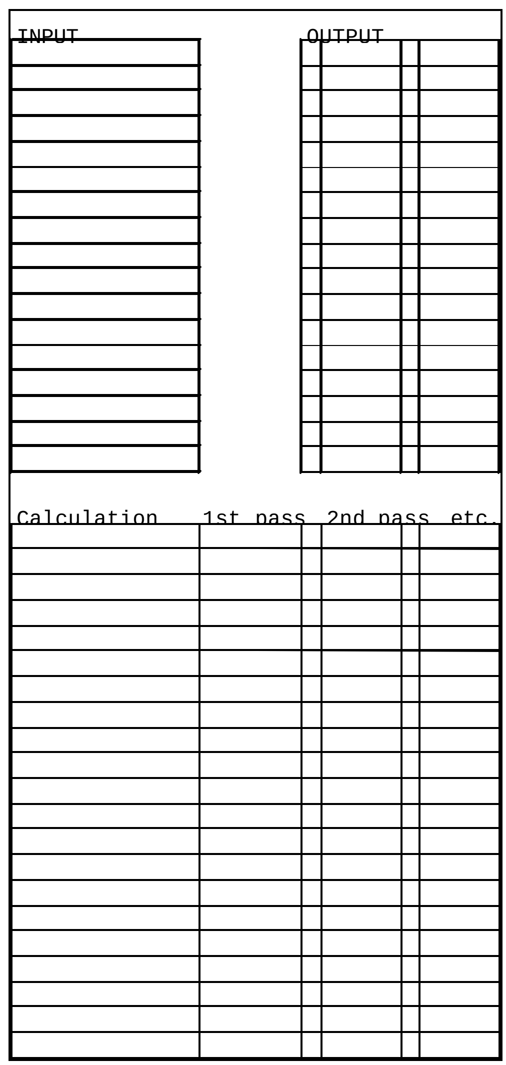

Figure 1: General layout of the spreadsheets used for the air-side calculations.

*** spreadsheet for calculating CVDDUCT.WK1 03/05/00

TEST # (1..8)=	8.00	
ECON(0,1=T,2=E	2.00	
CCLASP(F) =	55.00	
CCLABP(psia)=	14.70	
EXHAUST(0=sys,	1.00	
CFMZD1 (CFM) =	600.00	
CFMZD2 (CFM) =	700.00	
CFMZMIN1=	200.00	
CFMZMIN2=	300.00	
CPAIR(Btu/lbF)=	0.2402	@ 80 F
CPh20(Btu/lbF)=	1.0019	@ 55 F
FTP(in-H20) =	2.00	
FRACT(0,1)=	0.00	
FRACTR(0,1)=	0.00	
FAN EFFICIENCY	0.70	
HCLASP (F) =	110.00	
HCLABP(psia)=	14.696	
MOTEFF=	0.90	
MOTEFFR=	0.90	
OADB(F)=	74.00	
OAWB(F)=	70.00	
PHLABP (PSIA) =	14.70	
PHLASP(F)=	45.00	
QZL1(Btuh)=	2000	
QZL2(Btuh)=	3000	
QZS1(Btuh)=	5000	
QZS2 =	8000	
RFAN EFFICIEN(	0.70	
R =	1545.32	
Ra =	53.35	
RABPNF=	14.696	
RABP=	14.696	
RFTP(in-H20)=	1.00	
ZDB1(F)=	74.00	
QRA1(F)=	0.00	
ZDB2(F)=	76.00	
QRA2(F)=	0.00	
ZSABP1(Psia)=	14.696	
ZSABP2(Psia)=	14.696	
ZBP1(Psia)	14.696	
ZBP2(Psia)	14.696	

Case 6 -RAEE

SAMPLE W calc...

Tdew(F	55.000		
Tdew(R	514.670		
Tdry(F)	75.000		
Tdry(R)	534.670		
P(psia)=	14.696		
pws,dev	0.242		
pws,dev	0.214		
pws,dry	0.540		
pws,dry	0.430		
w(sat,de	0.009		
w(sat,dr	0.019		
mu=	0.490		
RH%=	0.498		
		Coefficients for pw, p6.14, ASHRAE HOF, 1997	
C1=	-10214	C14=	100.45
c2=	-4.893	C15=	33.1930
c3=	-0.005	C16=	2.3190
c4=	0.000	C17=	0.1707
c5=	0.000	C18=	1.1907
c6=	0.000		
c7=	4.164		
c8=	-10440		
c9=	-11.295		
c10=	-0.027		
c11=	0.000		
c12=	0.000		
c13=	6.546		

NOTE:This assumes 1"H20 = 0.0361 psi

RESULTS:			
	"u col."	"v col."	average"
QCL=	14645.05	14645.40	14645.22
QCS=	23570.06	23570.28	23570.17
QCT=	38215.11	38215.67	38215.39
QPH=	0.00	0.00	0.00
QHC=	9187.08	9186.90	9186.99
QHT=	9187.08	9186.90	9186.99
FAN(HP)=	0.649	0.649	0.649
RFAN(HP)=	0.199	0.199	0.199
CONV(H)=	0.000	0.000	0.000
CONV(C)=	0.000	0.000	0.000

	o!	ma	pco	s	cd
T(F)	OADB	MADB	PHLADB	SADB	CCLADB
W(lb/lb)	OAW	MA	PHLAW	SAW	CCLAW
v(ft3/lb)			Vtot	Vs	Vcc
i(Btu/lbda)					
M(lb/min)	Moa	Mma	Mma	Ms	Mcc
"v col"	oa	ma	pco	s	cd
T(F)	74.0000	74.9403	74.9403	76.0126	55.0000
W(lb/lb)	0.01483	0.01222	0.01222	0.01222	0.00920
v(ft3/lb)			13.7425		13.1668
i(Btu/lbda)	33.9947			31.6379	23.1918
M(lb/min)	36.4594	94.5971	94.5971	94.5971	76.2556
	z2s	Z1	Z2	mr	rfi
T(F)	ZSADB2	ZDB1	ZDB2	RADBNF	RADBNF
W(lb/lb)	ZSAW2	ZW1	ZW2	RAW	RAW
v(ft3/lb)	Vz2			Vradbnf	Vradbnf
i(Btu/lbda)					
M(lb/min)	Mz2	M1	M2	Mradbnf	Mradbnf
"v col"	z2s	Z1	Z2	mr	rfi
T(F)	65.2954	74.0000	76.0000	75.0009	75.0009
W(lb/lb)	0.00976	0.01051	0.01066	0.01059	0.01059
v(ft3/lb)	13.4422			13.7086	13.7086
i(Btu/lbda)					
M(lb/min)	50.9369	29.0416	29.0961	58.1377	58.1377

Figure 2: Example spreadsheet for the dual duct constant air volume system (DDCAV). NOTE: the ma, pca,s, cd, z2s, Z1, Z2, mr, rfi, z2s values indicate those listed in the results tables.

2.0 FILES INCLUDED WITH THIS REPORT

This report includes a CDROM with four spreadsheets that contain the air-side accuracy tests for four HVAC systems, including: dual duct constant volume (DDCAV), dual duct variable volume (DDVAV), constant volume with reheat (CAVRH), and variable volume with reheat (VAVRH).

The file names and contents of the four files on the CDROM are included in the table below. The spreadsheets were written with Lotus 123 and can be executed with any spreadsheet that can read .wk1 format files. No external calls or macros are used in the files.

ITEM NO:	FILENAME:	DESCRIPTION:
1.	CVDDUCT.WK1	Spreadsheet containing accuracy tests for the dual duct constant volume system (listed as DDCAV in 865-RP final report).
2.	VVDDUCT.WK1	Spreadsheet containing accuracy tests for the dual duct variable volume system (DDVAV).
3.	CVREHEAT.WK1	Spreadsheet containing accuracy tests for the constant volume with reheat system (CAVRH).
4.	VVREHEAT.WK1	Spreadsheet containing accuracy tests for the variable volume with reheat system (VAVRH).
5.	FOURPIPE.WK1	Spreadsheet containing accuracy tests for the four pipe fan coil system (FC).
6.	FPINDUCT.WK1	Spreadsheet containing accuracy tests for the four pipe induction system (FI).
7.	SINGLEZ.WK1	Spreadsheet containing accuracy tests for the single zone system (SZ).
8.	DDCAV.INP	DOE-2 input file used for the dual duct constant volume system .
9.	DDVAV.INP	DOE-2 input file used for the dual duct variable volume system .
10.	CAVRH.INP	DOE-2 input file used for the constant volume reheat system .
11.	VAVRH.INP	DOE-2 input file used for the variable volume reheat system .

3.0 DESCRIPTION OF 865-RP TEST CASES

In ASHRAE Research Project 865-RP each of the seven mechanical systems was tested over a range of four conditions using all possible economizer cycles. The four conditions are summarized in the first four cases shown in Table 1. Those systems capable of enthalpy economizer operation were tested, using only the enthalpy economizer, under two additional conditions. These two conditions are summarized in the final two cases of Table 1. Negative cooling loads shown in Table 1 are equivalent to positive heating loads. Other fixed conditions and their applicability to the various systems are shown in Table 2.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Ambient						
Dry bulb (F)	-20	30	60	80	77	74
Wet bulb (F)	-20	20	45	75	55	70
Zone 1						
Dry bulb set point temperature (F)	70	71	74	75	74	74
Sensible cooling load (Btu/hr)	-10,000	-2,000	5,000	10,000	5,000	5,000
Latent cooling load (Btu/hr)	2,000	2,000	2,000	2,000	2,000	2,000
Zone 2						
Dry bulb set point temperature (F)	72	73	76	77	76	76
Sensible cooling load (Btu/hr)	-8,000	1,000	8,000	12,000	8,000	8,000
Latent cooling load (Btu/hr)	3,000	3,000	3,000	3,000	3,000	3,000

Table 1: Test cases (I-P units)

	CV	VAV	DDCV	DDVAV	SZ	FC	IU
2” design supply fan pressure	X	X	X	X	X	X	X
1” design return fan pressure	X	X	X	X	X		
55°F supply air set point	X	X					
55°F cold deck set point			X	X			
110°F hot deck set point			X	X			
1°F return duct heat gain	X	X	X	X	X		
600 CFM zone 1 supply	X		X		X	X	X
200 CFM zone 1 exhaust	X	X	X	X	X	X	X
700 CFM zone 2 supply	X		X		X	X	X
300 CFM zone 2 exhaust	X	X	X	X	X	X	X
Return air temperature economy cycle	X	X	X	X	X		
Return air enthalpy economy cycle	X	X	X	X	X		
45°F preheat coil set point	X	X	X	X			X

Table 2: Test case parameters (I-P) Units

4.0 SYSTEM DESCRIPTIONS

4.1 DUAL DUCT CONSTANT VOLUME (DDCAV).

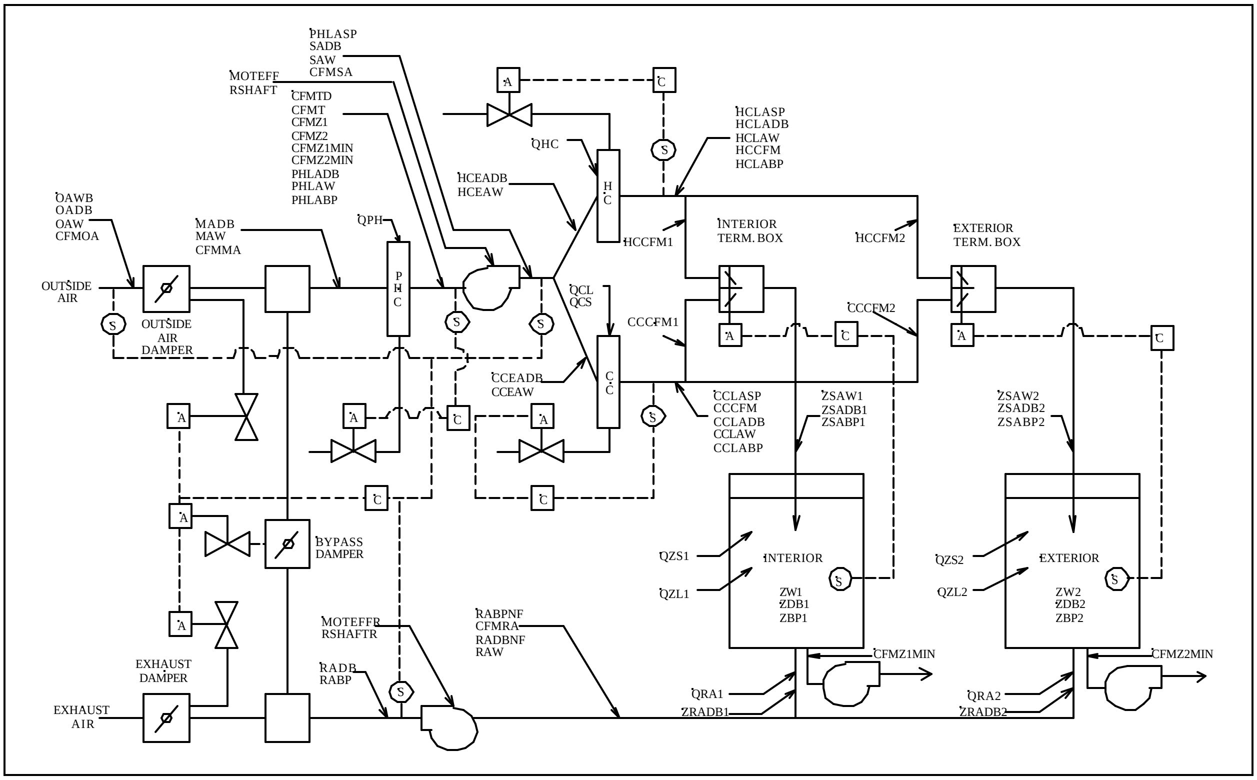

Figure 3: Constant Volume Dual Duct System Schematic (DDCAV)

The input values for the DDCAV spreadsheet are as follows:

TEST # (1..8)=	8.00	This switch is used for cosmetic purposes only. It is used to change the label that appears directly to the right of the input cell and creates a set of “canned” labels used for one of the tests that the spreadsheet was developed for.
ECON(0,1=T,2=E)	2.00	This switch turns the economizer “on” or “off”. It is also used to select whether the temperature (T) or enthalpy (E) economizer is used.
CCLASP(F) =	55.00	This variable is the cooling coil leaving air setpoint temperature (F).
CCLABP(psia)=	14.70	This variable is the cooling coil leaving air barometric pressure (PSIA).
EXHAUST(0=sys,1=zone)	1.00	This switch is used to calculate ‘zone air exhaust’ or ‘system air exhaust’. This will cause a difference in the mass flow rates returning from the zone, and heat gain from the return fan.
CFMZD1 (CFM) =	600.00	This is the design air flow for zone 1 (CFM).
CFMZD2 (CFM) =	700.00	This is the design air flow for zone 2 (CFM).
CFMZMIN1=	200.00	This is the exhaust air for zone 1 (CFM)
CFMZMIN2=	300.00	This is the exhaust air for zone 2 (CFM)
CPAIR(Btu/lbF)=	0.2402	This is the constant that is used for the specific heat of air (80F).
CPh20(Btu/lbF)=	1.0019	This is the constant that is used for the specific heat of water (55F).
FTP(in-H20) =	2.00	This is the total fan pressure across the supply fan (in-H20).
FRACT(0,1)=	0.00	This is the switch that is used to place the supply fan in the air stream (1) or outside of the air stream (0).
FRACTR(0,1)=	0.00	This is the switch that is used to place the return fan in the air stream (1) or outside of the air stream (0).
FAN EFFICIENCY=	0.70	This is the constant fan efficiency (%).
HCLASP (F) =	110.00	This is the heating coil leaving air setpoint temperature (F).

HCLABP(psia)=	14.696	This variable is the heating coil leaving air barometric pressure (PSIA).
MOTEFF=	0.90	This variable is the constant motor efficiency of the supply fan (%).
MOTEFFR=	0.90	This variable is the constant motor efficiency of the return fan (%).
OADB(F)=	74.00	This variable is the outside air dry bulb temperature (F).
OAWB(F)=	70.00	This variable is the outside air wet bulb temperature (F).
PHLABP (PSIA) =	14.70	This variable is the preheat coil leaving air barometric pressure (PSIA).
PHLASP(F)=	45.00	This variable is the setpoint temperature of the preheat coil (F).
QZL1(Btuh)=	2000	This variable is the latent load of zone 1 (BTUH).
QZL2(Btuh)=	3000	This variable is the latent load of zone 2 (BTUH).
QZS1(Btuh)=	5000	This variable is the sensible load of zone 1 (BTUH).
QZS2 =	8000	This variable is the sensible load of zone 2 (BTUH).
RFAN EFFICIENCY=	0.70	This variable is the constant fan efficiency of the return fan (%).
R =	1545.32	This variable is the gas constant for dry air (currently not used).
Ra =	53.35	This variable is the gas constant for dry air (ft-lbf/R-lb).
RABPNF=	14.696	This variable is the barometric pressure at a point in front of the return fan (PSIA).
RABP=	14.696	This variable is the barometric pressures at point in back of the return fan (PSIA).
RFTP(in-H20)=	1.00	This is the total fan pressure across the supply fan (in-H20).
ZDB1(F)=	74.00	This variable is the zone temperature for zone 1 (F).
QRA1(F)=	0.00	This variable is the heat gain of the ducts returning from zone 1 (F).
ZDB2(F)=	76.00	This variable is the zone temperature for zone 2 (F).
QRA2(F)=	0.00	This variable is the heat gain of the ducts returning from zone 2 (F).

ZSABP1(Psia)=	14.696	This variable is the barometric pressure of the supply air for zone 1 (PSIA).
ZSABP2(Psia)=	14.696	This variable is the barometric pressure of the supply air for zone 2 (PSIA).
ZBP1(Psia)	14.696	This variable is the barometric pressure of the air in zone 1 (PSIA).
ZBP2(Psia)	14.696	This variable is the barometric pressure of the air in zone 2 (PSIA).

The output from the DDCAV is listed in two tables to the left of the input table. In the upper table that is shown below, the coil loads and fan loads are shown. The QCL, QCS and QCT rows indicate the

RESULTS:			
	"u col."	"v col."	average
QCL=	0.00	0.00	0.00
QCS=	-0.22	0.00	-0.11
QCT=	-0.22	0.00	-0.11
QPH=	10032.82	10032.96	10032.89
QHC=	54929.10	54928.80	54928.95
QHT=	64961.92	64961.76	64961.84
FAN(HP)=	0.649	0.649	0.649
RFAN(HP)=	0.217	0.217	0.217
CONV(H)=	0.000	0.000	0.000
CONV(C)=	0.000	0.000	0.000

Figure 4: Results section of the spreadsheet showing coil loads.

main latent (QCL) and sensible (QCS) cooling coil loads. The “u col” and “v col” show the values for the last two iterations of the spreadsheet and the “average” shows the average of the last two columns of calculations.

The QPH, QHC and QHT are the totals of the preheating coil load (QPH), the main heating coil load (QHC) and the total of the preheat and main coil loads (QHT).

The power required by the supply (FAN) and return fans (RFAN) is indicated in horsepower (HP).

The CONV(H) and CONV(C) values indicate the difference between the calculations in the last two columns (i.e., a convergence indicator.

The second table indicates the psychrometric properties at various points around the simulation. The location of these points is shown in the DDCAV one-line schematic.

In the second table the values are listed in two rows. The units are listed in the vertical leftmost column. The variable names are listed across the rows. In the first row the OADB, MADB, PHLADB, SADB, CCLADB, HCLADB and ZSADB1 are shown. Where the OADB are the outside air conditions, the MADB are the mixed air conditions just before the preheating coil, the PHLADB are the conditions after the preheating coil. The SADB are the conditions after the main supply fan, the CCLADB are the conditions after the cooling coil, the HCLADB are the conditions after the heating coil, and the ZSADB1 are the conditions of the air entering zone 1.

	o!	ma	pco	s	cd	hd	z1s
T(F)	OADB	MADB	PHLADB	SADB	CCLADB	HCLADB	ZSADB1
W(lb/lb)	OAW	MA_	PHLAW	SAW	CCLAW	HCLAW	ZSAW1
v(ft3/lb)			Vtot	Vs	Vcc	Vhc	Vz1
i(Btu/lbda)							
M(lb/min)	Moa	Mma	Mma	Ms	Mcc	Mhc	Mz1
"v col"	oa	ma	pco	s	cd	hd	z1s
T(F)	-20.0000	38.1894	45.0000	46.0093	46.0093	110.0000	84.7077
W(lb/lb)	0.00026	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157
v(ft3/lb)			12.7550		12.7805	14.3978	13.7586
i(Btu/lbda)	-4.5284			12.7483	12.7523		
M(lb/min)	37.2204	101.9206	101.9206	101.9206	42.5330	59.3879	47.0403
	z2s	Z1	Z2	mr	rfi	rfo	
T(F)	ZSADB2	ZDB1	ZDB2	RADBNF	RADBNF	RADB	
W(lb/lb)	ZSAW2	ZW1	ZW2	RAW	RAW	RAW	
v(ft3/lb)	Vz2			Vradbnf	Vradbnf	Vradb	
i(Btu/lbda)							
M(lb/min)	Mz2	M1	M2	Mradbnf	Mradbnf	Mradb	
"v col"	z2s	Z1	Z2	mr	rfi	rfo	
T(F)	82.0853	70.0000	72.0000	71.0072	71.0072	71.5378	
W(lb/lb)	0.00157	0.00222	0.00241	0.00232	0.00232	0.00232	
v(ft3/lb)	13.6923			13.4284	13.4284		
i(Btu/lbda)						19.7198	
M(lb/min)	54.8803	32.1158	32.5844	64.7002	64.7002	64.7002	

Figure 5: Results section of the spreadsheet showing conditions.

In the second row, the ZSADB2, ZDB1, ZDB2, RADBNF, and RADB conditions are indicated. The ZSADB2 are the conditions entering zone 2, the ZDB1 are the conditions in the zone (i.e., the set point temperature), the ZDB2 are the setpoint conditions of zone 2, the RADBNF are the conditions just prior to the return fan (if used), and the RADB are the conditions immediately after the return fan (if used).

DDCV system	OA	MA	PCLA	SFLA	CCLA	HCLA	ZSA1	ZSA2	Z1	Z2	MRA	RFEA	RFLA
Case 1 - all AMS													
DB (F)	-20.0000	38.1894	45.0000	46.0093	46.0093	110.0000	84.7077	82.0853	70.0000	72.0000	71.0072	71.0072	71.5378
W (lb/lbda)	0.00026	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00222	0.00241	0.00232	0.00232	0.00232
V (ft3/lbda)			12.7550		12.7805	14.3978	13.7586	13.6923			13.4284	13.4284	
i (BTU/lbda)	-4.5284			12.7483	12.7523								19.7198
δ_m/δ_t (lbda/min)	37.2204	101.9206	101.9206	101.9206	42.5330	59.3879	47.0403	54.8803	32.1158	32.5844	64.7002	64.7002	64.7002
Case 2 - NE													
DB (F)	30.0000	56.7100	56.7100	57.7428	55.0000	110.0000	74.0100	71.7100	71.0000	73.0000	72.0049	72.0049	72.5365
W (lb/lbda)	0.00000	0.00129	0.00129	0.00129	0.00129	0.00129	0.00129	0.00129	0.00196	0.00214	0.00206	0.00206	0.00206
V (ft3/lbda)			13.0451		13.0019	14.3913	13.4822	13.4240			13.4480	13.4480	
i (BTU/lbda)	7.2061			15.2714	14.6132								19.6719
δ_m/δ_t (lbda/min)	37.1661	99.6542	99.6542	99.6542	67.4535	32.2006	45.9943	53.6600	31.0915	31.3966	62.4881	62.4881	62.4881
Case 2 - RAEE, RATE													
DB (F)	30.0000	53.9726	53.9726	55.0000	55.0000	110.0000	73.9942	71.7168	71.0000	73.0000	72.0055	72.0055	72.5371
W (lb/lbda)	0.00000	0.00103	0.00103	0.00103	0.00103	0.00103	0.00103	0.00103	0.00169	0.00187	0.00179	0.00179	0.00179
V (ft3/lbda)			12.9704		12.9964	14.3852	13.4760	13.4185			13.4422	13.4422	
i (BTU/lbda)	7.2061			14.3248	14.3255								19.3774
δ_m/δ_t (lbda/min)	41.1938	100.2279	100.2279	100.2279	67.8485	32.3792	46.2590	53.9689	31.3499	31.6959	63.0458	63.0458	63.0458
Case 3 - NE													
DB (F)	60.0000	69.6447	69.6447	70.7026	55.0000	110.0000	66.2919	65.4288	74.0000	76.0000	75.0026	75.0026	75.5369
W (lb/lbda)	0.00292	0.00420	0.00420	0.00420	0.00420	0.00420	0.00420	0.00420	0.00488	0.00508	0.00499	0.00499	0.00499
V (ft3/lbda)			13.4342		13.0626	14.4585	13.3491	13.3272			13.5873	13.5873	
i (BTU/lbda)	17.5840			21.5697	17.7684								23.6009
δ_m/δ_t (lbda/min)	36.7850	96.7677	96.7677	96.7677	77.7175	19.0498	44.6620	52.1057	29.9122	30.0705	59.9827	59.9827	59.9827
Case 3 - RAEE, RATE													
DB (F)	60.0000	60.0000	60.0000	61.0390	55.0000	110.0000	66.4300	65.6183	74.0000	76.0000	75.0048	75.0048	75.5392
W (lb/lbda)	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00358	0.00378	0.00369	0.00369	0.00369
V (ft3/lbda)			13.1624		13.0358	14.4289	13.3253	13.3047			13.5592	13.5592	
i (BTU/lbda)	17.5840			17.8349	16.3765								22.1805
δ_m/δ_t (lbda/min)	98.7659	98.7659	98.7659	98.7659	79.0246	19.7409	45.5842	53.1816	30.8039	31.1006	61.9045	61.9045	61.9045
Case 4 - all AMS													
DB (F)	80.0000	77.8884	77.8884	78.9682	55.0000	110.0000	59.2725	60.8264	75.0000	77.0000	76.0003	76.0003	76.5349
W (lb/lbda)	0.01757	0.01316	0.01316	0.01316	0.00920	0.01316	0.00950	0.00961	0.01020	0.01052	0.01037	0.01037	0.01037
V (ft3/lbda)			13.8388		13.1668	14.6654	13.2825	13.3246			13.7296	13.7296	
i (BTU/lbda)	38.4833			33.3942	23.1918								29.7404
δ_m/δ_t (lbda/min)	36.4032	93.9391	93.9391	93.9391	85.2682	8.6703	43.3565	50.5826	28.7583	28.7776	57.5359	57.5359	57.5359
Case 5 - RAEE													
DB (F)	77.0000	77.0000	77.0000	78.0726	55.0000	110.0000	66.1847	65.2819	74.0000	76.0000	75.0010	75.0010	75.5352
W (lb/lbda)	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00487	0.00507	0.00498	0.00498	0.00498
V (ft3/lbda)			13.6206		13.0622	14.4581	13.3461	13.3232			13.5871	13.5871	
i (BTU/lbda)	23.0766			23.3362	17.7513								23.5952
δ_m/δ_t (lbda/min)	95.4438	95.4438	95.4438	95.4438	76.8773	18.5661	44.0510	51.3928	29.3011	29.3575	58.6586	58.6586	58.6586
Case 6 - RAEE													
DB (F)	74.0000	74.9403	74.9403	76.0126	55.0000	110.0000	66.1953	65.2954	74.0000	76.0000	75.0009	75.0009	75.5345
W (lb/lbda)	0.01483	0.01222	0.01222	0.01222	0.00920	0.01222	0.00981	0.00976	0.01051	0.01066	0.01059	0.01059	0.01059
V (ft3/lbda)			13.7425		13.1668	14.6437	13.4663	13.4422			13.7086	13.7086	
i (BTU/lbda)	33.9947			31.6379	23.1918								29.7312
δ_m/δ_t (lbda/min)	36.4594	94.5971	94.5971	94.5971	76.2556	18.3411	43.6602	50.9369	29.0416	29.0961	58.1377	58.1377	58.1377

Table 3: Constant Volume Dual Duct System Conditions for 865-RP Accuracy Tests (DDCAV)

DDCV system	Preheat Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)	Heating Coil	Total Heat
Case 1 - all AMS						
PSU1	9,934.00	0.00	0.00	0.00	54,891.00	64,825.00
PSU2	24,528.00	0.00	0.00	0.00	40,404.00	64,932.00
TAMU	10,032.89	0.00	0.00	0.00	54,928.95	64,961.84
BLAST	24,578.00	0.00	0.00	0.00	40,461.00	65,039.00
DOE II	16,446.00	0.00	0.00	0.00	54,989.00	71,435.00
Case 2 - NE						
PSU1	0.00	2,708.00	0.00	2,708.00	24,269.00	24,269.00
PSU2	0.00	2,116.00	0.00	2,116.00	23,785.00	23,785.00
TAMU	0.00	2,672.45	0.00	2,672.45	24,309.33	24,309.33
BLAST	0.00	2,123.00	16.00	2,139.00	23,846.00	23,846.00
DOE II	0.00	0.00	0.00	3,028.00	26,560.00	26,560.00
Case 2 - RAEE, RATE						
PSU1	0.00	0.00	0.00	0.00	25,693.00	25,693.00
PSU2	0.00	0.00	0.00	0.00	24,797.00	24,797.00
TAMU	0.00	-0.07	0.00	-0.07	25,714.51	25,714.51
BLAST	0.00	0.00	0.00	0.00	24,862.00	24,862.00
DOE II	0.00	0.00	0.00	0.00	28,688.00	28,688.00
Case 3 - NE						
PSU1	0.00	17,732.00	0.00	17,732.00	10,850.00	10,850.00
PSU2	0.00	17,524.00	0.00	17,524.00	10,722.00	10,722.00
TAMU	0.00	17,724.34	0.00	17,724.34	10,872.78	10,872.78
BLAST	0.00	17,549.00	225.00	17,774.00	10,786.00	10,786.00
DOE II	0.00	0.00	0.00	17,453.00	11,542.00	11,542.00
Case 3 - RAEE, RATE						
PSU1	0.00	6,914.00	0.00	6,914.00	13,982.00	13,982.00
PSU2	0.00	6,805.00	0.00	6,805.00	13,325.00	13,325.00
TAMU	0.00	6,914.83	0.00	6,914.83	14,004.90	14,004.90
BLAST	0.00	6,811.00	71.00	6,883.00	13,406.00	13,406.00
DOE II	0.00	0.00	0.00	8,220.00	15,082.00	15,082.00
Case 4 - all AMS						
PSU1	0.00	30,410.00	20,874.00	51,285.00	3,960.00	3,960.00
PSU2	0.00	30,149.00	22,270.00	52,870.00	4,163.00	4,163.00
TAMU	0.00	30,087.57	21,439.12	51,526.69	3,972.08	3,972.08
BLAST	0.00	30,108.00	24,176.00	54,356.00	4,221.00	4,221.00
DOE II	0.00	0.00	0.00	49,848.00	3,179.00	3,179.00
Case 5 - RAEE						
PSU1	0.00	25,748.00	0.00	25,748.00	8,594.00	8,594.00
PSU2	0.00	25,866.00	0.00	25,866.00	8,695.00	8,695.00
TAMU	0.00	25,760.97	0.00	25,760.97	8,609.11	8,609.11
BLAST	0.00	24,889.00	380.00	25,269.00	8,994.00	8,994.00
DOE II	0.00	0.00	0.00	24,147.00	8,885.00	8,885.00
Case 6 - RAEE						
PSU1	0.00	23,466.00	14,823.00	38,289.00	9,173.00	9,173.00
PSU2	0.00	23,561.00	7,138.00	30,699.00	9,255.00	9,255.00
TAMU	0.00	23,570.17	14,645.22	38,215.39	9,186.99	9,186.99
BLAST	0.00	23,593.00	7,942.00	31,535.00	9,311.00	9,311.00
DOE II	0.00	0.00	0.00	27,957.00	9,767.00	9,767.00

Table 4: Constant Volume Dual Duct System Results for 865-RP Accuracy Tests (DDCAV). NOTE: the PSU1 and PSU2 values are those that represent accuracy calculations by Penn State University. The TAMU values are the current spreadsheets. The BLAST values are the simulations performed by Penn State using BLAST, and the DOE-2 values represent the simulations run by the authors using the DOE-2 input files contained in this report.

Listing of example DDCAV spreadsheet.

The spreadsheet for the dual duct constant air volume system is listed in the following pages. These calculations begin directly below the input-output section and continue down the spreadsheet for the first iteration. The second iteration then uses the calculations from the first column, and so forth across the columns until the last column is reached. The number of columns was determined by a convergence of less than 1% for this type of system.

The spreadsheets were written in a narrative format to allow them to be easily traced. The actual calculations take place in the "First pass", "second pass" … etc… columns.

NOTE: In certain systems, oscillation has been observed. In such a case it is recommended to use the average value of the last two columns.

Calculations begin here...		First	Second
	Pass	Pass	

[STEP 1a:]---

Calculate the supply air temperature for Zone#1 necessary

for meeting the sensible loads on the zone.

(First pass) Assume a supply air temperature = 55 F.
and assume a RH = 100% to start the simulation.

ZSADB1 = 55	55.0	66.5
ZSADB1(R) =	514.7	526.2

Calculate (w= ZSAW1) with assumed ZSADB1.
assume that Tdew = Tdry = ZSADB1.

First, calculate Pws<32, Pws>32.

Pws,dew(<32)=	0.2
Pws,dew(>32)=	0.2

Now, calculate the (W = ZSAW1) with assumed ZSADB1

and Tdew = Tdry = ZSADB1.

ZSAW1 =	0.0092

NOTE: in the 2nd and following passes...one can calculate the ZSAW1

using a moisture balance from the first pass

First, calculate the mass flow rate of the cold air entering

the terminal box.

Mcold#1 = Mmix#1 - Mhot#1

Now, solve a moisture balance around terminal box #1 using values from the first pass.

Wmix#1 = Mhot#1 x HCLAW + Mcold#1 x CCLAW / Mmix#1

ZSAW1= 0.0087

Calculate (v) the specific volume w/ T = 55F.

NOTE: 7/99 OLD METHOD USES (v) at SADB1... First, convert the ZSABP1 from psia to inHg.

using 1 psia = 2.036 in Hg

v = Ra x T (1 + 1.6078 x W)/(70.7262 x Pzsabp1) 13.2 13.5

NOTE: This is the 7/99 change to move mass calc. to the supply fan.

Copy the specific volume from the previously calculated fan...

using the conditions at PHLADB which are in front of the fan...

Use this "v" instead of the "v" calc'd at the diffuser on 2,3,4 calcs.

Vphladb = Ra x Tphladb (1 + 1.6078 x Wphlaw) / (70.7262 x Pfan,enter)

Vphladb= 13.73

Next, calculate the air mass flow rate for Zone #1 using

NOTE: This uses Vsabp1 for #1 calc, and Vphladb for #2,#3,#4...etc.

m = CFMZ1 x 60 x 1/v m1 = 2734.2 2621.1

NOTE: 7/99 Changed to include sensible heat of moisture in the air .444xW

This next equation assumes that Wzdb1 = Wzsadb1...i.e. moisture at room conditions.

Calculate the ZSADB1 = ZDB1 - QZS1/(m x (cp + .444 W))

ZSADB1 = 66.5 66.18

[Step 1b:]---

Now, repeat the calculations for the Zone #2

(First pass) Assume a supply air temperature = 55 F.
and assume a RH = 100% to start the simulation.

(2nd pass) Use the calculated ZSADB1 temperature from the end

of this step.

ZSADB2 = 55	55.0	65.7
ZSADB2(R) =	514.7	525.4

Calculate (w= ZSAW2) with assumed ZSADB2.
assume that Tdew = Tdry = ZSADB2.

First, calculate Pws<32, Pws>32.

Pws,dew(<32)=	0.2
Pws,dew(>32)=	0.2

Now, calculate the (W = ZSAW2) with assumed ZSADB2

and Tdew = Tdry = ZSADB2.

ZSAW2 = 0.0092

NOTE: in the 2nd and following passes...one can calculate the ZSAW2

using a moisture balance from the first pass

First, calculate the mass flow rate of the cold air entering

the terminal box.

Mcold#2 = Mmix#2 - Mhot#2

Now, solve a moisture balance around terminal box #2 using values from

the first pass.

Wmix#2 = (Mhot#2 x HCLAW + Mcold#2 x CCLAW) / Mmix#2

ZSAW2= 0.009

Calculate (v) the specific volume w/ T = 55F.

First, convert the ZSABP2 from psia to inHg.
using 1 psia = 2.036 in Hg

v = Ra x T (1 + 1.6078 x W)/(70.7262 x Pzsabp2) 13.2 13.4

Next, calculate the air mass flow rate for Zone #2 using

NOTE: This is the 7/99 change to move mass calc. to the supply fan.

Copy the specific volume from the previously calculated fan...

using the conditions at PHLADB which are in front of the fan...

Use this "v" instead of the "v" calc'd at the diffuser on 2,3,4 calcs.

Vphladb = Ra x Tphladb (1 + 1.6078 x Wphlaw) / (70.7262 x Pfan,enter)

Vphladb= 13.73

Next, calculate the air mass flow rate for Zone #1 using
NOTE: This uses Vsabp1 for #1 calc, and Vphladb for #2,#3,#4...etc.

m = CFMZ2 x 60 x 1/v m2 = 3189.8 3058.0

NOTE: 7/99 Changed to include sensible heat of moisture in the air .444xW

Now, calculate the ZSADB1 = ZDB1 - QZS1/(m x cp + .444 W)

NOTE: 7/99 Changed to include sensible heat of moistu2e in the air .444xW

This next equation assumes that Wzdb2 = Wzsadb2...i.e. moisture at room conditions.

Calculate the ZSADB2 = ZDB2 - QZS2/(m x (cp + .444 W))

ZSADB2 = 65.7 65.28

[Step 2a:]

Calculate the return air temperature for zone#1 (ZRADB1) including any

return air heat gain (QRA1).

NOTE: This next calculation assumes QRA1 is entered in degrees F.

ZRADB1 = ZDB1 + QRA1 74.0 74.0

Now, calculate the humidity ratio leaving the zone

ZW1 = ZSAW1 + QZL1 / [(1061 + .444 (ZDB1)) m1]

ZW1 = 0.0099 0.0094

[Step 2b:]--

Calculate the return air temperature for zone#2 (ZRADB2) including any

return air heat gain (QRA2).

NOTE: This next calculation assumes QRA2 is in degrees F.

ZRADB2 = ZDB2 + QRA2/(m2 x cp2)
ZRADB2= 76.0 76.0

Now, calculate the humidity ratio leaving the zone

ZW2 = ZSAW2 + QZL2 / [(1061 + .444 (ZDB2)) m2]

ZW2 =	0.0101	0.0095

[Step 3]:--

NOTE: 7/99 This next calc. has been modified to include air leaving

the zone...at the zone exhaust...this is controlled by the "EXHAUST"

variable that is set = 0 for system exhaust (no zone exhaust) or

set =1 for zone exhaust = minimum air for each zone.

First, calculate the exhaust air = minimum ventilation air for each zone.

using the conditions at each zone for (v) calc.

Calc. the (v) for zone#1

v = Ra x ZDB1 (1 + 1.6078 x ZW1)/(70.7262 x Pzone#1)

v =	13.7	13.7

Calc. the (v) for zone#2

v = Ra x ZDB2 (1 + 1.6078 x ZW2)/(70.7262 x Pzone#2)

v =	13.7	13.7
m1,min = CFMZMIN1 x 60 x 1/v	878.0	878.7
m2,min = CFMZMIN2 x 60 x 1/v	1311.7	1312.8

Now, depending upon value of EXHAUST = 0,1 calc. m1 + m2 = mra

EXHAUST (0=sys, 1=zone) =	1.00	1.00
From previously, m1 =	2734.15	2621.13
From previously, m2 =	3189.84	3057.99
Mma =	5924.00	5679.12
m1,w/exh =	1856.15	1742.48
m2,w/exh =	1878.15	1745.17

Calculate the average return air dry bulb temperature before the return fan RADBNF

RADBNF = (ZRADB1 x m1 x cp1 + ZRADB2 x m2 x cp2)/(mradb x cpradb)

Where it is assumed cp1 = cp2 = cpradb...(CP+.444W) has small effect.

mradb = m1 + m2

RADBNF = (ZRADB1 x m1 + ZRADB2 x m2)/(m1 + m2)

RADBNF= 75.0 75.0

Now, calculate the humidity ratio in the return air duct from both

zones by calculating a humidity balance.

NOTE: 9/18/99 the equation below uses the M1 & M2 air flow into the zone...versus M1 & M2 (EXHAUST) above...?

RAW = (ZW1 x m1 + ZW2 x m2) / (m1 + m2)

RAW = 0.0100 0.0095

Now calculate the return air temperature after the fan (RADB)

First, calculate the specific volume (v)

Vra = Ra x Tra (1 + 1.6078 x Wra) / (70.7262 x Pfan,enter)

P = RABPNF = see above in variables...

Vra= 13.7 13.7

Next, calculate the total CFM across the return fan (CFMT)

CFMTr = Mradb x 1/60 x vra

Mradbnf = M1 + M2 Mradbnf = 3734.3 3487.6

CFMTr = 852.4 795.4

NOTE: 7/99 This now includes the sensible heating of the dry air (CP)

and moisture contained in the moist air (.444W)

Now, calculate the temperature rise across the fan
using DTRAF = QFAN/Mra x (cp+.444W)

NOTE: 2/12...new FAN equations from Knebel, checked against p. 207 Kreider,Rabl

First, assume constant volume, design conditions...calculate FanHP, Motor HP, DTFAN

then calculate conditions for variable speed fan using Brandemuehl's equations.

for VSD, Inlet vane, discharge dampers, etc.

Fan HP(design) = 0.0001573 x CFM x TP / EFFfan

where Fan HP is calculated on CFMTD = total design CFM

where TP = FTP = total pressure across fan inH2O
EFFfan = fan efficiency

CFMdesign = value from above

Fan HP(design) =	0.19	0.18

Next, calculate the Motor HP for the constant volume system

Motor HP = Fan HP(design)/EFFmotor

where Motor HP = HP of constant volume design conditions

EFFmotor = electric motor efficiency

Motor HP(design) =	0.21	0.20

Next calculate DTFAN(design) using FRACT = 0,1
where FRACT = 1 (motor in air), 0 (motor not in air)

DTFAN = FanHP x 2544.85 / [Mdesign x (CP + .444xRAW)]

for the motor NOT in the air stream...

DTFAN = FanHP x 2544.85 / [Mdesign x (CP + .444xRAW)] x EFFm

for the motor in the air stream...use FRACT = 0,1 as choice...

where

Mdesign = (CFMdesign)*60/Vradb=			3734.3	3487.6
DTFAN(design,motor out) =		0.53	0.53	
DTFAN(design,motor in) =		0.59	0.59	
FRACT=		0		
DTRAF(F) =	0.53	0.53		

Now, calculate the return air dry bulb temperature after the fan

RADB = RADBNF + DTRAF

RADB = 75.5 75.5

[Step 4]:--

These next set of equations are for temperature-base economizer.

Next, precalculate all possible MADB temperatures
depending upon economizer mode...then select economizer type

[Cold range]---

First, we need to calculate the minimum mass flow rate of the

ventilation air for zone #1 and zone#2. This requires
recalculating (v1) at ZW1 and ZDB1 for zone #1 and etc. for zone#2.

NOTE: 7/99 This calculation was left alone...since it appears that PSU

is calculating the conditions at the zone conditions for min air.

This therefore assumes ZDB1, ZDB2, etc...for calc. (v).
Vphladb is not used here...

Zone#1

v = Ra x T (1 + 1.6078 x W)/(70.7262 x P)

where

v = Ra x ZDB1 (1 + 1.6078 x ZW1)/(70.7262 x Pzone#1)

v= 13.7 13.7

Vphladb = Ra x Tphladb (1 + 1.6078 x Wphlaw) / (70.7262 x Pfan,enter)

Vphladb= 13.73

Next, calculate the ventilation air mass flow rate for Zone #1 using

m1,min = CFMZMIN1 x 60 x 1/v

m1,min= 878.0 878.7

Zone#2

v = Ra x T (1 + 1.6078 x W)/(70.7262 x P) where

v = Ra x ZDB2 (1 + 1.6078 x ZW2)/(70.7262 x Pzone#2)

NOTE: 7/99 this assumes zone conditions for min air..as Zone #2.

v=	13.7	13.7

Next, calculate the ventilation air mass flow rate for Zone #2 using

m2,min = CFMZMIN2 x 60 x 1/v	m2,min =	1311.7	1312.8	
moa,(zone#1+#2)=(m1,min + m2,min)	moa,1+2=		2189.7	2191.5

Next, calculate the mass of the return air = mra = (m1+m2)

NOTE: 7/99 this copies down the prev. calc. mradbnf

mra =	3734.3	3487.6

NOTE: 7/99 This had to be changed to account for zone exhaust.

The next equation only works when EXHAUST = 0.
This is because it assumes Mma = Mra since there is no zone exhaust.

Now, calculate the mixed air dry bulb temperature (cold range, w/sys exhaust)

MADB = (moa x OADB + (mra - moa)xRADB)/mra

(w/system exhaust)	MADB,cold range =	74.6	74.6

NOTE: 8/99...NEW...Now, calculate the mixed air dry bulb for zone exhaust...

Knowing that Mra = Mma - (Moa#1 + Moa#2)
Where Moa#1 and Moa#2 was exhausted at the zone.
MADB=[Moa(cp+.444Woa)OADB+Mra(cp+.444Wra)RADB]/[Mma(cp+.444Wma)]

(w/zone exhaust)	MADB,cold range =	75.0	74.9

Now, choose which one based on EXHAUST(0=sys,1=zone)

	EXHAUST =	1.00	1.00
(either system)	MADB,cold range =	75.02	74.91

SADB = MADB + DTSAF

Assume DTSAF = 1 F for first iteration, calc. for 2,3,4th.

	SADB,cold range	76.0	76.0

Next, calculate the humidity ratio of the mixed air

First, calculate the saturation vapor pressure at (Pws(OAWB))

	OAWB(F)=	70.0	70.0
	OAWB(R)=	529.7	529.7
<32	Pws,dew(<32)=	0.4	0.4
>32	Pws,dew(>32)=	0.4	0.4

Now, calculate the (Wwb = at T = OAWB).

Wwb =	0.0	0.0

Next, calculate the Woa using

Woa = [(1093 - 0.556 * OAWB)*Wwb - (0.24(OADB-OAWB))]/(1093+0.444*OADB-OAWB)

Woa =	0.0148	0.0148

This next calculation fixes the ASHRAE Handbook when OAW < 0 at cold, dry temps

by replacing the ASHRAE value with a slightly positive value = 0.0000001

Woa = OAW	OAW=	0.0148	0.0148

Now, calculate the humidity ratio of the mixed air using:

NOTE: 7/99 This also needs two equations with EXHAUST as a 0,1 variable.

This equation works for EXHAUST =0

Wma = (moa x Woa +mbp x wbp)/mma = MAW

MAW = [moa x OAW + (mra-moa) x RAW]/mra

(w/sys. exhaust)	MAW,cold range =	0.0128	0.0128

This new equation works with EXHAUST = 1 = zone exhaust

MAW = (Moa x OAW + (Mra)RAW)/Mma

(w/zone exhaust)	MAW,cold range =	0.0118	0.0115

	EXHAUST =	1.0	1.0
(either system)	MAW,cold range =	0.0118	0.0115

NOTE: 7/99 Enthalpy calculation added here for cold range

Calc. the enthalpy at OADB,OAW using p. 6.13 of HOF

where h = 0.24T + W(1061+.444T)

h(OADB,OAW)=	33.99	33.99

Calc. the enthalpy at RADB,RAW

h(RADB,RAW)=	29.05	28.50

Calc. the enthalpy at SADB,MAW, where SADB = MADB + DTSAF

h(SADB,MAW)=	31.14	30.88

Calc. the enthalpy at PHLASP,MAW

h(PHLASP,MAW)=	23.53	23.27

[Free cooling range]: ---

Free cooling range MADB = SADB - DTSAF
until SADB reaches CCLASP (i.e. 55 F)...then the system enters Economizer range.

This calculation therefore assumes SADB = CCLASP = 55.

For the first calc. use 1 F then DTSAF for 2,3,4...

MADB,free cool =	54.0	53.9

NOTE: 7/99 this was changed to switch between EXHAUST = 0,1

When there is EXHAUST =0 (system) then use the following;

NOTE: this eq. only considers sensible energy (i.e., CP only ... no CP+.444)

Moa = [Mra *(SADB - RADB) - Qfan/(cp)] / (OADB - RADB)

where

SADB = PHLASP = (input variable) =	45.0	45.0

Qfan/cp is assumed = 2000/.2402 lbm-F/hr for first iteration

The second iteration uses the actual Qfan from the first iteration...

where SADB is fixed at CCLADB

(EXHAUST=system) Moa,free,system= 55231 #VALUE!

MAW = [moa x OAW + (mra-moa) x RAW]/mra

(EXHAUST=system) MAW,free cooling = 0.0819 #VALUE!

When there is a zone exhaust (EXHAUST=1) use the following

Calculate the mass flow of the outside air using
an energy balance at the economizer = MADB...and assume Moa & Mbp & iteratively solve...

Assume Moa = M1,min + M2,min from above

Assume Mbp = Mma - (M1,min + M2,min) from above

Calc. the difference in energy balance to determine difference in Moa,est and Moa,act.

and plug into next iteration...assume CPAIR = same...so it cancels.

Mma x MADB = 319896 306173

Moa x OADB + Mbp x RADB= 444125 440576
(2nd,3rd...) Moa,adjust x OADB + Mbp,adjust x RADB=

Adj.to Moa & Mbp = diff./MADB = -2300.53 ########
This is now used in the 2,3,4 calcs...etc.

Moa,adjust = Moa - Moa,adjust for 1st...then look at previous calc.

Mbp,adjust = Mbp + Moa,adjust for 1st...then look at previous calc.

(EXHAUST=zone) Moa,adjust = 4490 6983

Mbp,adjust= 1434 -1059

Finally, calc. the MADB using the above Moa and Mbp

MADB = ((Moa x OADB) + (Mbp x RADB))/Mma

MADB,adjust= 74.37 76.90

MADB,target= 54.00 53.91

MAW = (Moa x OAW + (Mbp)RAW)/Mma

(w/zone exhaust) MAW,cold range = 0.0137 0.0165

Now, choose the Moa depending upon EXHAUST = 1,0

	EXHAUST =	1.00	1.00
(EXHAUST=either)	Moa,free cool =	4490.24	6983.23
	MAW,free cooling =	0.0137	0.0165

NOTE: 7/99 Enthalpy calculation added here for free cooling range

This assumes that h(OADB, OAW) and h(RADB,RAW) are the same as cold range.

Therefore, only h(MADB, MAW) needs to be calculated with values from free cooling.

where h = 0.24T + W(1061+.444T)

Calc. the enthalpy at SADB,MAW note this is the same as PHLASP,MAW

h(PHLASP,MAW) & h(SADB,MAW)=		25.57	28.61

Calc. the enthalpy at OADB+DTSAF,OAW

h(OADB+DTSAF,OAW)=	34.24	34.26

Calc. the enthalpy at CCLASP/MAW

h(CCLASP,MAW)=	28.03	31.09

[Economizer Range]: ---

In the economizer range the O.A. damper us full open, R.A. damper is closed.

therefore MADB = OADB whenever OADB > SADB and OADB < RADB.

where DTSAF = 1 F assumed for first iteration...and calculated 2nd,3rd,& 4th.

MADB=economizer =		74.0	74.0

In the economizer range MADB = OADB

and Moa = Mma, Mbp = 0, and MAW = OAW.

MAW,economizer =	0.015	0.015
Moa,economizer=	5924.0	5679.1

NOTE: 7/99 Enthalpy calculation added here for economizer range

This assumes that h(OADB, OAW) and h(RADB,RAW) are the same as cold range.

Therefore, only h(MADB, MAW) needs to be calculated with values from economizer.

where h = 0.24T + W(1061+.444T)

Calc. the enthalpy at MADB/MAW

h(MADB,MAW)=	33.99	33.99

Calc. the enthalpy at PHLASP,MAW

h(PHLASP,MAW)=	26.84	26.84

Calc. the enthalpy at CCLASP/MAW

h(CCLASP,MAW)=	29.31	29.31

[Maximum Cooling Range]:---

In the maximum cooling range the o.a. dampers are at minimum

air and the calculation is the same as the cold range.

and OADB > RADB

Therefore, this copies down the equations from the cold range...

MADB,max cooling =	75.0	74.9

and, the humidity ratio is calculated in a similar fashion as the

and therefore the number is copied down from above.

MAW,max cooling =	0.0118	0.0115

NOTE: 7/99 Enthalpy calculation added here for max cooling range

This assumes that h(OADB, OAW) and h(RADB,RAW) are the same as max cooling.

Therefore, only h(MADB, MAW) needs to be calculated with values from economizer.

where h = 0.24T + W(1061+.444T)

Calc. the enthalpy at MADB/MAW

h(MADB,MAW)=	30.89	30.61

[Temperature based economizer selection]-----------------------------------

NOTE: 7/99 These temperature equations were modified during the edit.

Now, select which range the economizer is in based on the following

test (assume 1 F for DTSAF for 1st iter):

Cold Range = SADB < 45 (=PHLASP) where SADB = MADB + DTSAF

Free Cooling = SADB > 45 (=PHLASP) and OADB+DTSAF < 55 (=CCLASP)

Economizer = OADB+DTSAF >= CCLASP (55) and OADB < RADB

Max Cool = OADB > RADB.

Now, select the range by showing (=1):

Cold Range=1	0.0	0.0
Free Cooling=2	0.0	0.0
Economizer=3	3.0	3.0
Max Cooling=4	0.0	0.0
	------	------
Total	3.0	3.0

[Enthalpy based economizer selection]-------------------------------------

NOTE: 7/99 Here is the addition of the enthalpy economizer equations.

Now, select which range the economizer is in based on the following

test (assume 1 F for DTSAF for 1st iter):

Now, test the enthalpy at each of the conditions:

Cold Range = h(SADB,MAW) < h(PHLASP,MAW) where SADB = MADB + DTSAF

Free Cooling = h(SADB,MAW) > h(PHLASP,MAW)
and h(OADB+DTSAF,OAW) < h(CCLASP,MAW)

and h(OADB,OAW) < h(RADB,RAW)
Economizer = h(OADB+DTSAF,OAW) >= h(CCLASP,MAW)

and h(OADB,OAW) < h(RADB,RAW)
Max Cool = h(OADB,OAW) > h(RADB,RAW).

Now, select the range by showing (=1,2,3..):

Cold Range=1	0.0	0.0
Free Cooling=2	0.0	0.0
Economizer=3	0.0	0.0
Max Cooling=4	4.0	4.0

	------	------			
Total		4.0	4.0		

Now, check to see if the economizer is activated by looking at b3

Finally, select the MADB and MAW according to the economizer schedule

using an @choose(1,2,3,4) statement

ECONOMIZER=				2.00	2.00
ECONOMIZER SWITCH=			4.00	4.00	
MADB=		75.0	74.9		
MAW=		0.0118		0.0115	
Moa=	2189.7	2191.5			

[Step 5]:--

NOTE: The DTSAF was removed from the following equations 7/99.

Calculate the preheat coil load (QPHC) and leaving air conditions

depe.ding upon the m)xed air dry bul" temp (MADB) & 0reheat coil sep/int.

IF MADB >= PHLASP=45F then QPHC=0 and PHLADB=MADB

IF MADB < PHLASP = 45 then

NOTE: 7/99 The (CP) changed to (CP+.444W) to ac#ount for sensib,e heating

of the moisture contained in the moist air.

QPHC= mma x (CP+.444w)(PHLASP - MADB) and PHLADB = PHLASP

Mma =	5924.00		5679.12
QPHC=	0.0	0.0	
PHLADB=	75.0	74.9	

[Step 6]:--

Calculate the cooling coil (CCEADB) and heating coil (HCEADB)

entering air dry bulb temperature, including the temperature rise across the fan.

First, calculate the specific volume (v)

Vphladb = Ra x Tphladb (1 + 1.6078 x Wphlaw) / (70.7262 x Pfan,enter)

Assuming P=atmospheric pressure

Vphladb=	13.7	13.7

Next, calculate the total CFM across the fan (CFMT)

CFMT = Mphladb x 1/60 x v

Mphladb =	5924.0	5679.1

where Mphladb = Mma

CFMT=	1356.1	1299.3

NOTE: 7/99 The (CP) changed to (CP+.444W) to account for sensible heating

of the moisture in the moist air.

Now, calculate the temperature rise across the fan
using DTSAF = QFAN/Mphladb x (cp+.444w)

NOTE: 2/12...new FAN equations from Knebel, checked against p. 207 Kreider,Rabl

First, assume constant volume, design conditions...calculate FanHP, Motor HP, DTFAN

then calculate conditions for variable speed fan using Brandemuehl's equations.

for VSD, Inlet vane, discharge dampers, etc.

Fan HP(design) = 0.0001573 x CFM x TP / EFFfan

where Fan HP is calculated on CFMTD = total design CFM

where TP = FTP = total pressure across fan inH2O
EFFfan = fan efficiency
CFM = CFMT

Fan HP(design) =	0.61	0.58

Next, calculate the Motor HP for the constant volume system

Motor HP = Fan HP(design)/EFFmotor

where Motor HP = HP of constant volume design conditions

EFFmotor = electric motor efficiency

Motor HP(design) =	0.68	0.65

Next calculate DTFAN(design) using FRACT = 0,1
where FRACT = 1 (motor in air), 0 (motor not in air)

DTFAN = FanHP x 2544.85 / [Mdesign x (CP + .444xCCLAW)]

for the motor NOT in the air stream...

DTFAN = FanHP x 2544.85 / [Mdesign x (CP + .444xCCLAW)] x EFFm

for the motor in the air stream...use FRACT = 0,1 as choice...

where

Mdesign = (CFMT)*60/Vphladb= 5924.0 5679.1

DTFAN(design,motor out) = 1.09 1.07

DTFAN(design,motor in) = 1.21 1.19

FRACT= 0

DTSAF(F) = 1.09 1.07

Now, calculate the cooling coil & heating coil entering air dry bulb

CCEADB = HCEADB = SADB = PHLADB + DTSAF

CCEADB= 76.1 76.0

HCEADB= 76.1 76.0

[Step 7a,7b]:--

NOTE: 7/99 DTSAF added to thermostat of CCLADB and HCLADB test.

Now, calculate the heating coil and cooling coil leaving air

temperature = HCLASP and CCLASP respectively
Test to see if PHLADB+DTSAF < CCLADB
or if PHLADB+DTSAF > HCLADB

CCLADB= 55.0 55.0

HCLADB= 110.0 110.0

and HCLAW = MAW

HCLAW= 0.0118 0.0115

[Step 8]:--

Calculate the air flow in the hot ducts HCCFM1 & HCCFM2, and

in the cold ducts CCCFM1 & CCCFM2.
First, set Mmix#1 = m1

Mmix#1=	2734.2	2621.1

NOTE: 7/99 In the next equations (CP) replaced with (CP+.444W)

in the terminal box equation to determine air flows for #1 and #2

Mh(cp+.444Wh)Th + Mc(cp+.444Wc)Tc = Mm(cp+.444Wm)Tm

Solve for Mh = [Mm(cp+.444Wm)Tm - Mc(cp+.444Wc)Tc]/[(cp+.444Wh)Th]

or

Mhot#1 = [Mm1(cp+.444xZSAW1)ZSADB1-
Mc1(cp+.444xCCLAW)CCLADB]/[(cp+.444xHCLAW)HCLADB]

First, calculat Vcold

Vcold = Ra x Tccladb (1 + 1.6078 x CCLAW) / (70.7262 x CCLABP)

Vcold=	13.0	13.2

Now, calculate Mcold#1 = CCCFM1 x 60 / Vcold
use CCCFM1 = 1/2 CFMZD1 for first pass...then interate using CCCFM1 below

NOTE: 7/19/99...change this to be Mcold#1 = Mmix#1 - Mhot#1 for 2nd,3rd,4th...

1st iteration uses CFMZD1/2

Mcold#1=	1385.06	1682.10

Now calculate Mhot#1 using 0.001 for CCLAW first pass..then interate

Now calculate	Mhot#1=	939.04	731.49

Next, calculate Vhot using

Vhot = Ra x Thcladb (1 + 1.6078 x HCLAW) / (70.7262 x Phclabp)

Vhot=	14.6	14.6

Assuming P=atmospheric pressure

Now, calculate HCCFM1 = Mhot#1 x Vhot/60

HCCFM1= 229.0 178.3

NOTE: 7/99 CCCFM1=Mcold#1 x Vcold/60

CCFM1= 300.0 369.1

Now, repeat for zone#2

First, set Mmix#2 = m2

Mmix#2= 3189.8 3058.0

First, set Mmix#2 = m2

Mhot#2 = [Mm2(cp+.444xZSAW)ZSADB2-
Mc2(cp+.444xCCLAW)CCLADB]/[(cp+.444xHCLAW)HCLADB]

First, calculate Mcold#2 = CCCFM2 x 60 / Vcold
use CCCFM2 = 1/2 CFMZD2 for first pass...then interate using CCCFM2 below

NOTE: 7/19/99...change this Mcold#2=Mmix#2 - Mhot#2 for 2nd,3,4...

1st iteration uses CFMZD2/2

Mcold#2= 1615.90 1984.60

Now calculate Mhot#2 using CCLAW=0.01 for first and iterate

Mhot#2= 1073.39 817.08

and therefore the Mhot for the heating coil is

Mhot = Mhot#1 + Mhot#2

Mhot= 2012.43 1548.57

And finally calculate the total mass flow...
this just copies down from calculations at zonal level

Mmix(total) = Mmix1 + Mmix2

Mmix= 5924.0 5679.1

Now, calculate HCCFM2 = Mhot#2 x Vhot/60

HCCFM2= 261.8 199.2

NOTE: CCFM1(new#2) uses CCCFM1=Mcold#1 x Vcold/60

CCCFM2= 350.0 435.5

[Step 9]:--

Now, calculate the HCCFM and CCCFM

HCCFM = HCCFM1 + HCCFM2

HCCFM= 490.8 377.5

CCCFM = CCCFM1 + CCCFM2

CCCFM= 650.0 804.6

[Step 10]:---

Calculate the cooling coil sensible cooling load (Qcs)

First, calculate the Mcooling coil = Mmix - Mheating coil

NOTE: 7/99 Mcool = Mcool#1 + Mcool#2

Mcool(#1+#2)= 3001.0 3666.7

Now, calculate the cooling coil load = QCS
using p.21.15 of ASHRAE S&E, 1996.,
Qsensible = Qs+Qw=mair[(hin-hout)-(Win-Wout)(hfg,Tdew,in+hw,Tdew,in)]

First, calculate (pw) using P x W/(.62198 + W)
where P = total pressure of moist air
W = humidity ratio = MAW

pw = 0.2728 0.2675

ln(pw)= -1.30 -1.32

Then, calculate Tdew,in = CCEADB,dewpoint
using p.6.14,HOF,1997, Tdew(>32F)=C14+C15a+C16a^2+C17a^3+C18(pw)^.1984

Tdew(<32F)=90.12+26.412a+0.8927a^2

Then choose Tdew based of 32<T=SADB<32.

Tdew(>32)= 61.79 61.24

Tdew(<32)= 57.32 56.84

Now choose Tdew based on 32<Tdew<32

Tdew = 61.79 61.24

Next, calculate (hfg,Tdew,in) using 1075.15-(T-32)*.56506

NOTE: This expression is only valid for T>32 F...which is o.k. since no

cooling loads are expected at MADB=32.

hfg=	1058.32	1058.63

Now, calculate (hw,Tdew,in) using hw=.02 + 1.000845*(T-32)

hw=	29.83	29.28

Now, calculate the enthalpy using p. 6.13, 1997 HOF
where h = 0.24T + W(1061+.444T)

h(CCEADB)=	31.16	30.87
h(CCLADB)=	23.19	23.19

Finally, calculate the sensible load on the coil using
an estimate for the CCLAW=ZSAW for the first calculation...then use

CCLAW list further down for 2nd calculation....

Now, test to see if PHLADB<(CCLADB-DTSAF If so then QCS=0.

QCS =	15522.1	18849.0

[Step 11a]:---

Now, calculate the latent loads..

QZL=	5000.0	5000.0

Qlatent(#1+#2) = QZL1 + QZL2

The latent heat of vapor hfg is calculated from

hfg = 1061 + (.444 x RADB)

hfg=	1094.5	1094.5

First, calculate the saturation vapor pressure at (Pws(CCLASP))

CCLASP(F)=	55.0	55.0
CCLASP(R)=	514.7	514.7

Pws,dew(<32)=	0.2	0.2
Pws,dew(>32)=	0.2	0.2

Now, calculate the (CCLAW = Ws = at T = CCLASP).

For wet coil...	CCLAW = Ws =	0.0092	0.0092

Now, test to see whether or not the coil is dry or wet

If coil is wet (CCLAW<MAW) then "coil wet" = 0 and CCLAW=CCLAW

if coil is dry (CCLAW>MAW) and "coil wet"=1, then CCLAW=MAW.

Coil wet?	0.0	0.0
CCLAW =	0.0092	0.0092

[Step 12]:---

Calculate the cooling coil latent load QCL depending upon whether or

not the coil is wet or dry. Use the switch "coil wet?" for this.

Wet coil:

QCL = Mcooling x (CCEAW - CCLAW) * Hfg,Tdew,CCEADB

QCLwet=	8156.7	9065.3

Dry coil:

QCLdry=	0.0	0.0

Now, select the wet or dry answer according to "coil wet" above.

QCL=	8156.7	9065.3

[Step 13]:---

Now, calculate the total cooling load = QCT = QCL + QCS

QCS=	15522.1	18849.0
QCT=	23678.7	27914.3

[Step 14]:--

NOTE: 7/99 The (CP) changed to (CP+.444T) to account for sensible heating

of the moisture in the moist air.

Calc. total heating load = QHC = Mheating coil x (CP+.444W) x (HCLADB - HCEADB)

QHC =	16741.1	12930.1

[Step 15]:--

Calculate the total heating load = QHT = QHC + QPHC

QPHC=	0.0	0.0
QHT =	16741.1	12930.1

[Step 16]:--

Calculate the convergence...

Heating	-29.474%
Cooling	15.173%

DOE-2 LISTING FOR DDVAV ACCURACY TEST (DDCAV)

This input file for the DOE-2 simulation program is the file that was used to produce the "DOE-2" results that are shown in the results tables for the DDCAV system. It is intended to represent a reasonable effort to simulate the equivalent 865-RP system using the DOE-2 program. As indicated, no attempt was made to create special DOE-2 function commands to manipulate the program to perform tasks that would not be available to the average user.

```
INPUT LOADS ..

TITLE     LINE-1 *2 ZONE PARAMETRIC RUN, START WITH RUN 1*
          LINE-2 *RP865 CV, DD, WITH ECONOMIZER *
          LINE-3 *TEXAS A&M UNIVERSITY *  ..

                          $ -----HEADING----- $

          ABORT                 ERRORS ..
          DIAGNOSTIC            CAUTIONS
                                NARROW   ..
          BUILDING-LOCATION     LATITUDE=42
                                LONGITUDE=88
                                ALTITUDE=0
                                GROSS-AREA=200
                                HOLIDAY=NO
                                DAYLIGHT-SAVINGS=NO
                                TIME-ZONE=6
                                AZIMUTH=0  ..

$LOADS-REPORT  SUMMARY= (ALL-SUMMARY)  ..

RUN-PERIOD
              JAN 5 1991 THRU JAN 5 1991  ..


                        $ ---- INPUT FOR PARAMETRIC RUN ---- $

            $ PARAMETERS FOR: DRYBULB-HI AND DRYBULB-LO  =  OADB
            $                 DEWPT-HI AND DEWPT-LO      =  OADP
            $                 ROOF-1 U-VALUE             =  ROOF-U1
            $                 ROOF-2 U-VALUE             =  ROOF-U2
            $                 ZONE-1 EQUIPMENT-W/SQFT    =  EQ-LOAD1
            $                 ZONE-1 EQUIP-SENSIBLE      =  EQ-SEN1
            $                 ZONE-1 EQUIP-LATENT        =  EQ-LAT1
            $                 ZONE-1 TEMPERATURE         =  TEMP1
            $                 ZONE-2 EQUIPMENT-W/SQFT    =  EQ-LOAD2
            $                 ZONE-2 EQUIP-SENSIBLE      =  EQ-SEN2
            $                 ZONE-2 EQUIP-LATENT        =  EQ-LAT2
            $                 ZONE-2 TEMPERATURE         =  TEMP2

                              PARAMETER OADB = -20
                                        OADP = -20
                                        ROOF-U1 = 1.35
                                        ROOF-U2 = 1.01
```

```
                                             EQ-LOAD1 = 5.86
                                             EQ-SEN1 = 0
                                             EQ-LAT1 = 1
                                             TEMP1 = 70
                                             EQ-LOAD2 = 8.79
                                             EQ-SEN2 = 0
                                             EQ-LAT2 = 1
                                             TEMP2 = 72  ..

HEATING-DESIGN=DESIGN-DAY     DRYBULB-HI=OADB   DRYBULB-LO=OADB
                              HOUR-HI=16        HOUR-LO=2
                              DEWPT-HI=OADP     DEWPT-LO=OADP
                              DHOUR-HI=16       DHOUR-LO=2
                              WIND-SPEED=30     WIND-DIR=14
                              CLOUD-AMOUNT=10 CLOUD-TYPE=1
                              CLEARNESS=1     GROUND-T=-20  ..

                        $ -----CONSTRUCTIONS----- $

ROOF-1     = CONSTRUCTION  U=ROOF-U1  ..
ROOF-2     = CONSTRUCTION  U=ROOF-U2  ..
SLAB-1     = CONSTRUCTION  U=.0001  ..
ADIABWALL  = CONSTRUCTION  U=.0001  ..

                          $ -----SCHEDULE----- $

SCH-1      =SCHEDULE          THRU DEC 31 (ALL) (1,24) (1)  ..

INT-LDS-1  =SCHEDULE          THRU DEC 31 (ALL) (1,24) (1)  ..

              $ -----ZONE-1 SPACE DESCRIPTION----- $

COND-1    =SPACE-CONDITIONS   EQUIP-SCHEDULE=INT-LDS-1
                              EQUIPMENT-W/SQFT=EQ-LOAD1
                              EQUIP-SENSIBLE=EQ-SEN1
                              EQUIP-LATENT=EQ-LAT1
                              FLOOR-WEIGHT = 70
                              TEMPERATURE = (TEMP1)  ..

ZONE-1   =SPACE               A=100
                              V=1000
                              S-C=COND-1 ..

FRONT-WL-1=E-W                H=10  W=10
                              AZ=180
                              X=0   Y=0
                              CONS=ADIABWALL ..

INT-WL-1-2=E-W                H=10  W=10
                              AZ=90
                              X=10  Y=0
                              CONS=ADIABWALL ..

LEFT-WL-1 =E-W                H=10  W=10
                              AZ=270
                              X=0  Y=10
                              CONS=ADIABWALL  ..
```

```
ROOF-ZN1=ROOF                 X=0  Y=0  Z=10
                              H=10  W=10
                              AZ=180  TILT=0
                              CONS=ROOF-1 ..

FLOOR-1 =U-F                  AREA=100
                              CONS=SLAB-1
                              U-EFFECTIVE=.0001
                              TILT=180  ..

              $ -----ZONE-2 SPACE DESCRIPTION----- $

COND-2    =SPACE-CONDITIONS   EQUIPMENT-W/SQFT=EQ-LOAD2
                              EQUIP-SENSIBLE=EQ-SEN2
                              EQUIP-LATENT=EQ-LAT2
                              EQUIP-SCHEDULE=INT-LDS-1
                              FLOOR-WEIGHT = 70
                              TEMPERATURE = (TEMP2)  ..

ZONE-2   =SPACE               A=100
                              V=1000
                              S-C=COND-2 ..

FRONT-WL-2=E-W                H=10  W=10
                              AZ=180
                              X=10   Y=0
                              CONS=ADIABWALL ..

RIGHT-WL-2=E-W                H=10  W=10
                              AZ=90
                              X=20  Y=0
                              CONS=ADIABWALL ..

ROOF-ZN2=ROOF                 X=10  Y=0  Z=10
                              H=10  W=10
                              AZ=180  TILT=0
                              CONS=ROOF-2  ..

FLOOR-2 =U-F                  AREA=100
                              CONS=SLAB-1
                              U-EFFECTIVE=.0001
                              TILT=180  ..

END ..

COMPUTE LOADS ..

INPUT SYSTEMS ..

$          SYSTEMS-REPORT      VERIFICATION=(ALL-VERIFICATION)  ..
$                              SUMMARY=(SS-A,SS-B,SS-C,SS-F,SS-H)  ..


                        $ ---- INPUT FOR PARAMETRIC RUN ---- $

            $ PARAMETERS FOR: ZONE-1 TEMPERATURE   =  ZDB1
```

```
$                   ZONE-2 TEMPERATURE   =  ZDB2
$                   ZONE-1 DESIGN-HEAT-T =  DHT1
$                   ZONE-1 DESIGN-COOL-T =  DCT1
$                   ZONE-2 DESIGN-HEAT-T =  DHT2
$                   ZONE-2 DESIGN-COOL-T =  DCT2
$                   COOLING-CAPACITY     =  CCAP
$                   HEATING-CAPACITY     =  HCAP

                    PARAMETER ZDB1 = 70
                              ZDB2 = 72
                              DHT1 = 70
                              DCT1 = 70
                              DHT2 = 72
                              DCT2 = 72
                              CCAP = 95000
                              HCAP = -95000  ..

        $ -----ZONE-1 SCHEDULES----- $

HEAT-1A    =SCHEDULE        THRU DEC 31 (ALL) (1,24) (ZDB1)  ..
COOL-1A    =SCHEDULE        THRU DEC 31 (ALL) (1,24) (ZDB1)  ..

        $ -----ZONE-2 SCHEDULES----- $

HEAT-2A    =SCHEDULE        THRU DEC 31 (ALL) (1,24) (ZDB2)  ..
COOL-2A    =SCHEDULE        THRU DEC 31 (ALL) (1,24) (ZDB2)  ..

        $ -----ZONE DESCRIPTIONS ----$

ZN-CONT-1 = ZONE-CONTROL      DESIGN-HEAT-T=DHT1
                              HEAT-TEMP-SCH=HEAT-1A
                              DESIGN-COOL-T=DCT1
                              COOL-TEMP-SCH=COOL-1A
                              THERMOSTAT-TYPE=TWO-POSITION
                              THROTTLING-RANGE=.1  ..

ZN-AIR-1 = ZONE-AIR           ASSIGNED-CFM=600
                              EXHAUST-CFM=200
                              EXHAUST-EFF=.7
                              EXHAUST-STATIC=0  ..

ZONE-1   = ZONE               ZONE-CONTROL=ZN-CONT-1
                              ZONE-AIR=ZN-AIR-1
                              ZONE-TYPE=CONDITIONED
                              MIN-CFM-RATIO=1  ..

ZN-CONT-2 = ZONE-CONTROL      DESIGN-HEAT-T=DHT2
                              HEAT-TEMP-SCH=HEAT-2A
                              DESIGN-COOL-T=DCT2
                              COOL-TEMP-SCH=COOL-2A
                              THERMOSTAT-TYPE=TWO-POSITION
                              THROTTLING-RANGE=.1  ..

ZN-AIR-2 = ZONE-AIR           ASSIGNED-CFM=700
                              EXHAUST-CFM=300
                              EXHAUST-EFF=.7
                              EXHAUST-STATIC=0  ..
```

```
ZONE-2   =ZONE                  ZONE-CONTROL=ZN-CONT-2
                                ZONE-AIR=ZN-AIR-2
                                ZONE-TYPE=CONDITIONED
                                MIN-CFM-RATIO=1  ..

            $ -----COOLING AND HEATING PARAMETERS----- $

COOL-1 = SCHEDULE               THRU DEC 31 (ALL) (1,24) (1)  ..
HEAT-1 = SCHEDULE               THRU DEC 31 (ALL) (1,24) (1)  ..

                   $ -----SYSTEM CHARACTERISTICS------- $

S-CONT=SYSTEM-CONTROL           MAX-SUPPLY-T=110
                                HEAT-CONTROL=CONSTANT
                                HEAT-SET-T=110
                                HEATING-SCHEDULE=HEAT-1
                                MIN-SUPPLY-T=55
                                COOL-CONTROL=CONSTANT
                                COOL-SET-T=55
                                COOLING-SCHEDULE=COOL-1
                                PREHEAT-T=45  ..

S-AIR=SYSTEM-AIR                SUPPLY-CFM=1300
                                RETURN-CFM=1300
                                MIN-OUTSIDE-AIR=.385
                                OA-CONTROL=TEMP
                                DUCT-DELTA-T=0  ..

SYSFAN=SYSTEM-FANS              SUPPLY-STATIC=2
                                SUPPLY-EFF=.7
                                SUPPLY-MECH-EFF=.7
                                RETURN-STATIC=0
                                RETURN-EFF=.7
                                RETURN-DELTA-T=0
                                FAN-CONTROL=CONSTANT-VOLUME
$                                FAN-PLACEMENT=DRAW-THROUGH
                                MOTOR-PLACEMENT=OUTSIDE-AIRFLOW  ..

SYSEQ = SYSTEM-EQUIPMENT        COOLING-CAPACITY=CCAP
                                HEATING-CAPACITY=HCAP
                                COIL-BF=.001  ..

SYS =SYSTEM                     SYSTEM-CONTROL=S-CONT
                                SYSTEM-AIR=S-AIR
                                SYSTEM-FANS=SYSFAN
                                SYSTEM-EQUIPMENT=SYSEQ
                                SYSTEM-TYPE=DDS
                                ZONE-NAMES=(ZONE-1,ZONE-2)
                                PREHEAT-SOURCE=ELECTRIC
                                HEAT-SOURCE=ELECTRIC
                                RETURN-AIR-PATH=DUCT  ..

      $ -----------------HOURLY REPORT------------------------$

 RP-2 = SCHEDULE THRU JAN 5 (ALL) (1,24) (1)  ..
```

```
 BLOCK-2-1 = REPORT-BLOCK
                   VARIABLE-TYPE = SYS
                   VARIABLE-LIST = (1,2,3,4,5,6,10,20,21)  ..

 BLOCK-2-2 = REPORT-BLOCK
                   VARIABLE-TYPE = ZONE-1

                   VARIABLE-LIST = (1,2,11,31)  ..

 BLOCK-2-3 = REPORT-BLOCK
                   VARIABLE-TYPE = ZONE-2
                   VARIABLE-LIST = (1,2,11,31)  ..

HR-2      = HOURLY-REPORT
                   REPORT-SCHEDULE = RP-2
            REPORT-BLOCK=(BLOCK-2-1,BLOCK-2-2,BLOCK-2-3)  ..

HVAC=PLANT-ASSIGNMENT         SYSTEM-NAMES=(SYS) ..

END ..

COMPUTE SYSTEMS ..

INPUT PLANT ..

      $----- PLANT INPUT WITH ONE PIECE OF EQUIPMENT -----$
          $----- IS REQUIRED TO GET BEPS REPORT -----$

$          PLANT-REPORT        SUMMARY=(BEPS,PS-A,PS-G) ..

HVAC=PLANT-ASSIGNMENT ..
     FURN-1 =PLANT-EQUIPMENT
             TYPE=FURNACE
             SIZE=.6  ..

     A-C-1  =PLANT-EQUIPMENT
             TYPE=HERM-CENT-CHLR
             SIZE=.6  ..

     P-H-1  =PLANT-EQUIPMENT
             TYPE=FURNACE
             SIZE=.6  ..

END ..
COMPUTE PLANT ..

$ RUN 2
PARAMETRIC-INPUT LOADS  ..
PARAMETER OADB = 30
          OADP = -20
          ROOF-U1 = 0.505
          ROOF-U2 = 0.0001
          EQ-LOAD1 = 5.86
          EQ-SEN1 = 0
          EQ-LAT1 = 1
          TEMP1 = 71
          EQ-LOAD2 = 11.72
```

```
          EQ-SEN2 = 0.25
          EQ-LAT2 = 0.75
          TEMP2 = 73  ..
END  ..
COMPUTE LOADS  ..

PARAMETRIC-INPUT SYSTEMS  ..
PARAMETER ZDB1 = 71
          ZDB2 = 73
          DHT1 = 110
          DCT1 = 71
          DHT2 = 110
          DCT2 = 73
          CCAP = 80000
          HCAP = -80000  ..

END  ..
COMPUTE SYSTEMS  ..
COMPUTE PLANT  ..

$ RUN 3
PARAMETRIC-INPUT LOADS  ..
PARAMETER OADB = 60
          OADP = 26.2
          ROOF-U1 = 0.0001
          ROOF-U2 = 0.0001
          EQ-LOAD1 = 20.52
          EQ-SEN1 = 0.714
          EQ-LAT1 = 0.286
          TEMP1 = 74
          EQ-LOAD2 = 32.24
          EQ-SEN2 = 0.727
          EQ-LAT2 = 0.273
          TEMP2 = 76  ..
END  ..
COMPUTE LOADS  ..

PARAMETRIC-INPUT SYSTEMS  ..
PARAMETER ZDB1 = 74
          ZDB2 = 76
          DHT1 = 74
          DCT1 = 74
          DHT2 = 110
          DCT2 = 76
          CCAP = 80000
          HCAP = -80000  ..

END  ..
COMPUTE SYSTEMS  ..
COMPUTE PLANT  ..

$ RUN 4
PARAMETRIC-INPUT LOADS  ..
PARAMETER OADB = 80
          OADP = 73.1
          ROOF-U1 = 0.0001
          ROOF-U2 = 0.0001
```

```
          EQ-LOAD1 = 35.17
          EQ-SEN1 = 0.833
          EQ-LAT1 = 0.167
          TEMP1 = 75
          EQ-LOAD2 = 43.96
          EQ-SEN2 = 0.8
          EQ-LAT2 = 0.2
          TEMP2 = 77  ..
END  ..
COMPUTE LOADS  ..

PARAMETRIC-INPUT SYSTEMS  ..
PARAMETER ZDB1 = 75
          ZDB2 = 77
          DHT1 = 110
          DCT1 = 75
          DHT2 = 110
          DCT2 = 77
          CCAP = 95000
          HCAP = -95000  ..

END  ..
COMPUTE SYSTEMS  ..
COMPUTE PLANT  ..

$ RUN 5
PARAMETRIC-INPUT LOADS  ..
PARAMETER OADB = 77
          OADP = 34.7
          ROOF-U1 = 0.0001
          ROOF-U2 = 0.0001
          EQ-LOAD1 = 20.52
          EQ-SEN1 = 0.714
          EQ-LAT1 = 0.286
          TEMP1 = 74
          EQ-LOAD2 = 32.24
          EQ-SEN2 = 0.727
          EQ-LAT2 = 0.273
          TEMP2 = 76  ..
END  ..
COMPUTE LOADS  ..

PARAMETRIC-INPUT SYSTEMS  ..
PARAMETER ZDB1 = 74
          ZDB2 = 76
          DHT1 = 74
          DCT1 = 74
          DHT2 = 76
          DCT2 = 76
          CCAP = 95000
          HCAP = -95000  ..

END  ..
COMPUTE SYSTEMS  ..
COMPUTE PLANT  ..

$ RUN 6
```

```
PARAMETRIC-INPUT LOADS  ..
PARAMETER OADB = 74
          OADP = 60.2
          ROOF-U1 = 0.0001
          ROOF-U2 = 0.0001
          EQ-LOAD1 = 20.52
          EQ-SEN1 = 0.714
          EQ-LAT1 = 0.286
          TEMP1 = 74
          EQ-LOAD2 = 32.24
          EQ-SEN2 = 0.727
          EQ-LAT2 = 0.273
          TEMP2 = 76  ..

END  ..
COMPUTE LOADS  ..

PARAMETRIC-INPUT SYSTEMS  ..
PARAMETER ZDB1 = 74
          ZDB2 = 76
          DHT1 = 74
          DCT1 = 74
          DHT2 = 76
          DCT2 = 76
          CCAP = 95000
          HCAP = -95000  ..

END  ..
COMPUTE SYSTEMS  ..
COMPUTE PLANT  ..

STOP ..
```

4.2 DUAL DUCT VARIABLE VOLUME (DDVAV).

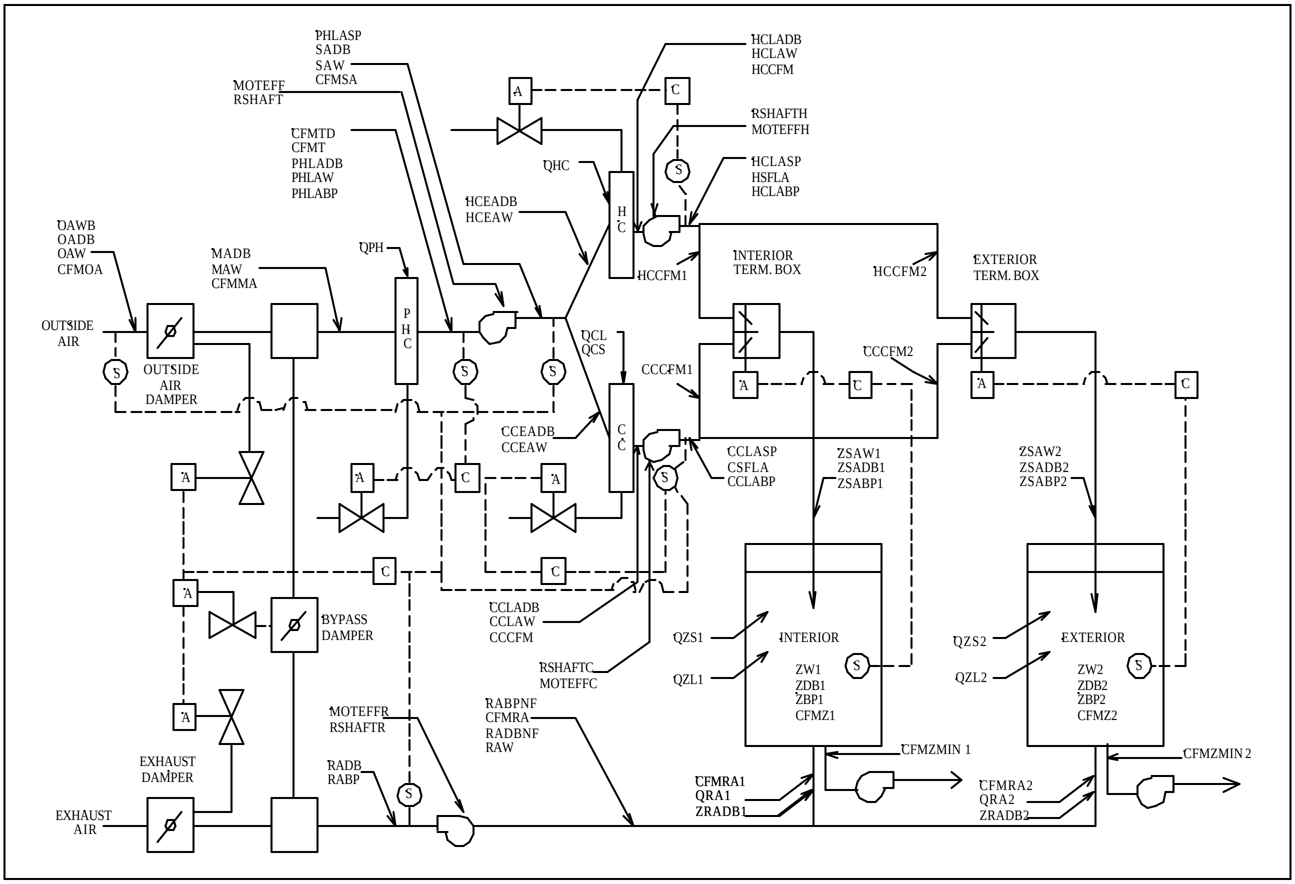

Figure 6: Dual Duct Variable Air Volume System Schematic (DDVAV)

The input values for the DDVAV spreadsheet are as follows:

TEST # (1..7)=	7	This switch is used for cosmetic purposes only. It is used to change the label that appears directly to the right of the input cell and creates a set of "canned" labels used for one of the tests that the spreadsheet was developed for.
ECON(0,1=T,2=E)	2	This switch turns the economizer "on" or "off". It is also used to select whether the temperature (T) or enthalpy (E) economizer is used.
AIR CRLR(1,2,3,4)=	3	This switch is used to control the type of variable flow fan that is being used: 1=Inlet Vanes, 2=Discharge Dampers, 3=Var.Speed Drive, 4=Constant
CCLASP(F) =	55.00	This variable is the cooling coil leaving air setpoint temperature (F).
CCLABP(psia)=	14.696	This variable is the cooling coil leaving air barometric pressure (PSIA).
EXHAUST(0=sys,1=zone)	1	This switch is used to calculate 'zone air exhaust' or 'system air exhaust'. This will cause a difference in the mass flow rates returning from the zone, and heat gain from the return fan.
CFMZD1 (CFM) =	600.00	This is the design air flow for zone 1 (CFM).
CFMZD2 (CFM) =	700.00	This is the design air flow for zone 2 (CFM).
CFMFANH (%) =	100%	This variable is used in the fan calculations when the fan is a draw-through fan placed downstream of the heating coil.
CFMFANC (%) =	100%	This variable is used in the fan calculations when the fan is a draw-through fan placed downstream of the cooling coil.
CFMZMIN1=	200.00	This is the exhaust air for zone 1 (CFM)
CFMZMIN2=	300.00	This is the exhaust air for zone 2 (CFM)
CPAIR(Btu/lbF)=	0.2402	This is the constant that is used for the specific heat of air (80F).
CPh20(Btu/lbF)=	1.0019	This is the constant that is used for the specific heat of water (55F).
FTP(in-H20) =	0.00	This is the total fan pressure across the supply fan (in-H20). NOTE: this is set = 0 when a two draw-through fans are being used.
RFTP(in-H20)=	1.00	This is the total fan pressure across the return fan (in-H20).
CFTP(in-H20)=	2.00	This is the total fan pressure across the cold deck supply fan (in-H20). NOTE: this is set = 0 when one blow-through fan is being used.
HFTP(in-H20)=	2.00	This is the total fan pressure across the hot deck supply fan (in-H20). NOTE: this is set = 0 when one blow-through fan is being used.
FRACT(0,1)=	0	This is the switch that is used to place the supply fan in the air stream (1) or outside of the air stream (0).
FRACTr(0,1)=	0	This is the switch that is used to place the return fan in the air stream (1) or outside of the air stream (0).
FRACTc(0,1)=	0	This is the switch that is used to place the cold deck supply fan in the air stream (1) or outside of the air stream (0).
FRACTh(0,1)=	0	This is the switch that is used to place the hot deck supply fan in the air stream (1) or outside of the air stream (0).
FAN EFFICIENCY=	0.70	This is the constant fan efficiency for the single supply

		fan (%).
RFAN EFFICIENCY=	0.70	This is the constant fan efficiency for the return fan (%).
CFAN EFFICIENCY=	0.70	This is the constant fan efficiency for the cold deck fan (%).
HFAN EFFICIENCY=	0.70	This is the constant fan efficiency for the hot deck fan (%).
HCLASP (F) =	110.00	This is the heating coil leaving air setpoint temperature (F).
HCLABP(psia)=	14.696	This variable is the heating coil leaving air barometric pressure (PSIA).
MOTEFF=	0.90	This variable is the constant motor efficiency of the supply fan (%).
MOTEFFR=	0.90	This variable is the constant motor efficiency of the return fan (%).
MOTEFFC=	0.90	This variable is the constant motor efficiency of the cold deck fan (%).
MOTEFFH=	0.90	This variable is the constant motor efficiency of the hot deck fan (%).
OADB(F) =	74.00	This variable is the outside air dry bulb temperature (F).
OAWB(F)=	70.00	This variable is the outside air wet bulb temperature (F).
PHLABP (PSIA) =	14.70	This variable is the preheat coil leaving air barometric pressure (PSIA).
PHLASP(F)=	45.00	This variable is the setpoint temperature of the preheat coil (F).
QZL1(Btuh)=	2000	This variable is the latent load of zone 1 (BTUH).
QZL2(Btuh)=	3000	This variable is the latent load of zone 2 (BTUH).
QZS1(Btuh)=	5000	This variable is the sensible load of zone 1 (BTUH).
QZS2 =	8000	This variable is the sensible load of zone 2 (BTUH).
R =	1545	This variable is the gas constant for dry air (currently not used).
Ra =	53.35	This variable is the gas constant for dry air (ft-lbf/R-lb).
RABPNF=	14.70	This variable is the barometric pressure at a point in front of the return fan (PSIA).
RABP=	14.70	This variable is the barometric pressures at point in back of the return fan (PSIA).
ZDB1(F)=	74.00	This variable is the zone temperature for zone 1 (F).
QRA1(F)=	0.00	This variable is the heat gain of the ducts returning from zone 1 (F).
ZDB2(F)=	76.00	This variable is the zone temperature for zone 2 (F).
QRA2(F)=	0.00	This variable is the heat gain of the ducts returning from zone 2 (F).
ZSABP1(Psia)=	14.696	This variable is the barometric pressure of the supply air for zone 1 (PSIA).
ZSABP2(Psia)=	14.696	This variable is the barometric pressure of the supply air for zone 2 (PSIA).
ZBP1(Psia)	14.696	This variable is the barometric pressure of the air in zone 1 (PSIA).
ZBP2(Psia)	14.696	This variable is the barometric pressure of the air in zone 2 (PSIA).

The output from the DDVAV is listed in two tables to the left of the input table in a similar fashion as the DDCAV system.

DDVAV system	OA	MA	PCLA	CCLA	CSFLA	HCLA	HSFLA	ZSA1	ZSA2	Z1	Z2	MRA	RFEA	RFLA
Case 1 - all AMS														
DB (F)	-20.0000	-14.5132	45.0000	45.0000	45.0039	109.8134	110.0000	110.0000	96.8802	70.0000	72.0000	70.0000	70.0000	70.0019
W (lb/lbda)	0.00026	0.00038	0.00038	0.00038	0.00038	0.00038	0.00038	0.00038	0.00038	0.00214	0.00243	0.00214	0.00214	0.00214
V (ft3/lbda)			12.7305			14.3702		14.3615	14.0392			13.3990	13.3990	
i (BTU/lbda)	-4.5284			11.2153										19.1478
δm/δt (lbda/min)	37.2216	39.6297	39.6297	4.5004	4.5004	35.1294	35.1294	17.3346	22.2951	2.4081	0.0000	2.4081	2.4081	2.4081
Case 2 - all AMS														
DB (F)	30.0000	30.0000	45.0000	45.0000	45.0470	109.9555	110.0000	80.3133	69.8838	71.0000	73.0000	72.1975	72.1975	72.1983
W (lb/lbda)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00205	0.00205	0.00205	0.00205	0.00205
V (ft3/lbda)			12.7229			14.3615		13.6131	13.3502			13.4527	13.4527	
i (BTU/lbda)	7.2061			10.8091										19.5843
δm/δt (lbda/min)	37.1671	37.1671	37.1671	20.5625	20.5625	16.6046	16.6046	14.9005	22.2666	0.0000	0.0000	0.0000	0.0000	0.0000
Case 3 - NE														
DB (F)	60.0000	62.6080	62.6080	54.7803	55.0000	109.9983	110.0000	55.0000	55.0000	74.0000	76.0000	75.1093	75.1093	75.1203
W (lb/lbda)	0.00292	0.00327	0.00327	0.00327	0.00327	0.00327	0.00327	0.00327	0.00327	0.00495	0.00501	0.00498	0.00498	0.00498
V (ft3/lbda)			13.2360			14.4371		12.9750	13.0432			13.5899	13.5899	
i (BTU/lbda)	17.5840			16.7093										23.4979
δm/δt (lbda/min)	36.7856	44.4240	44.4240	44.4240	44.4240	0.0000	0.0000	18.1499	26.2741	3.4017	4.2366	7.6383	7.6383	7.6383
Case 3 - RAEE, RATE														
DB (F)	60.0000	60.0000	60.0000	54.7803	55.0000	109.9983	110.0000	55.0000	55.0000	74.0000	76.0000	75.1093	75.1093	75.1204
W (lb/lbda)	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00459	0.00465	0.00463	0.00463	0.00463
V (ft3/lbda)			13.1624			14.4289		12.9750	13.0358			13.5822	13.5822	
i (BTU/lbda)	17.5840			16.3234										23.1077
δm/δt (lbda/min)	44.4530	44.4530	44.4530	44.4530	44.4530	0.0000	0.0000	18.1617	26.2913	3.4052	4.2412	7.6464	7.6464	7.6464
Case 4 - all AMS														
DB (F)	80.0000	78.0964	78.0964	54.4468	55.0000	109.9982	110.0000	55.0000	55.0000	75.0000	77.0000	75.8824	75.8824	76.0846
W (lb/lbda)	0.01757	0.01389	0.01389	0.00901	0.00901	0.01389	0.01389	0.00901	0.00901	0.00990	0.01024	0.01005	0.01005	0.01005
V (ft3/lbda)			13.8600			14.6822		12.9750	13.1629			13.7196	13.7196	
i (BTU/lbda)	38.4833			22.8546										29.2770
δm/δt (lbda/min)	36.4198	71.3523	71.3523	71.3523	71.3523	0.0000	0.0000	34.1250	37.2273	19.5198	15.4127	34.9325	34.9325	34.9325
Case 5 - RAEE														
DB (F)	77.0000	77.0000	77.0000	54.7805	55.0000	109.9983	110.0000	55.0000	55.0000	74.0000	76.0000	75.1092	75.1092	75.1202
W (lb/lbda)	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00586	0.00592	0.00590	0.00590	0.00590
V (ft3/lbda)			13.6206			14.4581		12.9750	13.0622			13.6098	13.6098	
i (BTU/lbda)	23.0766			17.6981										24.4981
δm/δt (lbda/min)	44.3497	44.3497	44.3497	44.3497	44.3497	0.0000	0.0000	18.1195	26.2302	3.3929	4.2248	7.6176	7.6176	7.6176
Case 6 - RAEE														
DB (F)	74.0000	74.1901	74.1901	54.7812	55.0000	109.9982	110.0000	55.0000	55.0000	74.0000	76.0000	75.1087	75.1087	75.1196
W (lb/lbda)	0.01483	0.01415	0.01415	0.00912	0.00912	0.01415	0.01415	0.00912	0.00912	0.01082	0.01088	0.01085	0.01085	0.01085
V (ft3/lbda)			13.7649			14.6882		12.9750	13.1652			13.7171	13.7171	
i (BTU/lbda)	33.9947			23.0580										29.9192
δm/δt (lbda/min)	36.4445	43.9516	43.9516	43.9516	43.9516	0.0000	0.0000	17.9569	25.9947	3.3455	4.1616	7.5071	7.5071	7.5071

Table 5: Variable Volume Dual Duct System Conditions for 865-RP Accuracy Tests (DDVAV)

DDVAV system	Preheat Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)	Heating Coil	Total Heat
Case 1 - all AMS						
PSU1	33,980.00				32,837.00	66,817.00
PSU2	39,561.00				27,217.00	66,778.00
TAMU	34,014.23				32,836.80	66,851.03
BLAST	39,629.00				27,229.00	66,858.00
DOE II						68,449.00
Case 2 - all AMS						
PSU1	8,028.00				15,535.00	3,563.00
PSU2	13,315.00				10,219.00	23,533.00
TAMU	8,034.79				15,544.20	23,578.99
BLAST	13,336.00				10,244.00	23,580.00
DOE II						24,670.00
Case 3 - NE						
PSU1		5,039.00		5,039.00		
PSU2		5,001.00		5,001.00		
TAMU		5,041.89		5,041.89		
BLAST		5,026.00		5,082.00		
DOE II				4,404.00		54.00
Case 3 - RAEE, RATE						
PSU1		3,353.00		3,353.00		
PSU2		3,368.00		3,368.00		
TAMU		3,362.09		3,362.09		
BLAST		3,371.00		3,406.00		
DOE II				4,230.00		
Case 4 - all AMS						
PSU1		25,195.00	21,808.00	47,003.00		
PSU2		24,762.00	22,990.00	47,753.00		
TAMU		24,839.34	22,052.87	46,892.21		
BLAST		24,921.00	24,335.00	49,255.00		
DOE II				38,908.00		
Case 5 - RAEE						
PSU1		14,303.00		14,303.00		
PSU2		14,318.00		14,318.00		
TAMU		14,311.84		14,311.84		
BLAST		14,157.00	192.00	14,349.00		
DOE II				14,289.00		
Case 6 - RAEE						
PSU1		12,593.00	5,389.00	17,983.00		
PSU2		12,750.00	13,938.00	26,688.00		
TAMU		12,548.33	13,992.96	26,541.29		
BLAST		12,373.00	6,171.00	18,544.00		
DOE II				13,697.00		

Table 6: Variable Volume Dual Duct System Results for 865-RP Accuracy Tests (DDVAV)

4.3 CONSTANT VOLUME WITH REHEAT (CAVRH).

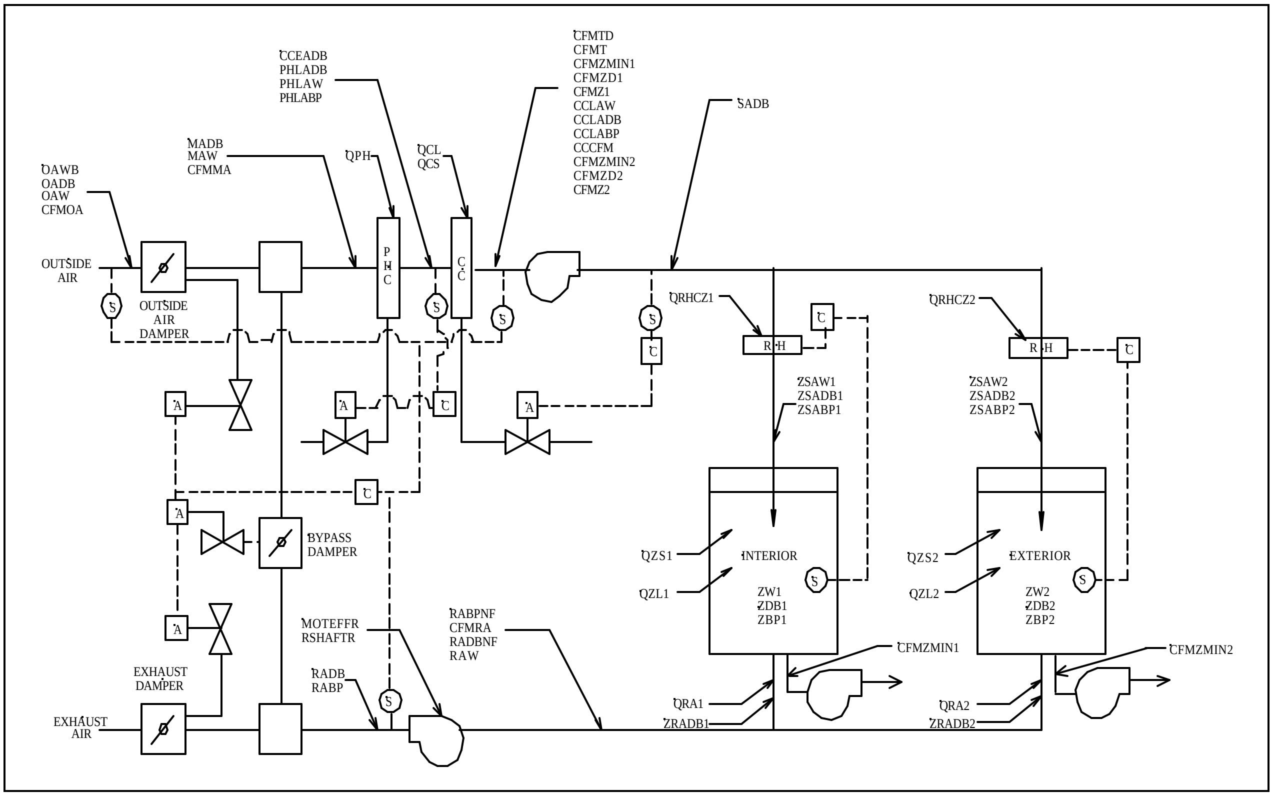

Figure 7: Constant Air Volume with Reheat System Schematic (CAVRH)

<u>The input values for the CAVRH spreadsheet are as follows:</u>

TEST # (1..8)=	1	This switch is used for cosmetic purposes only. It is used to change the label that appears directly to the right of the input cell and creates a set of “canned” labels used for one of the tests that the spreadsheet was developed for.
ECON(0=n,1=T,2=E)=	0	This switch turns the economizer “on” or “off”. It is also used to select whether the temperature (T) or enthalpy (E) economizer is used.
CCLASP(F) =	55.00	This variable is the cooling coil leaving air setpoint temperature (F).
CCLABP(psia)=	14.696	This variable is the cooling coil leaving air barometric pressure (PSIA).
EXHAUST(0=sys,1=zone)=	1	This switch is used to calculate ‘zone air exhaust’ or ‘system air exhaust’. This will cause a difference in the mass flow rates returning from the zone, and heat gain from the return fan.
CFMZD1 (CFM) =	600.00	This is the design air flow for zone 1 (CFM).
CFMZD2 (CFM) =	700.00	This is the design air flow for zone 2 (CFM).
CFMZMIN1=	200.00	This is the exhaust air for zone 1 (CFM)
CFMZMIN2=	300.00	This is the exhaust air for zone 2 (CFM)
CPAIR(Btu/lbF)=	0.2402	This is the constant that is used for the specific heat of air (80F).
CPh20(Btu/lbF)=	1.0019	This is the constant that is used for the specific heat of water (55F).
FTP(in-H20) =	2.00	This is the total fan pressure across the supply fan (in-H20).
FRACT(0,1)=	0.00	This is the switch that is used to place the supply fan in the air stream (1) or outside of the air stream (0).
FRACTR(0,1)=	0.00	This is the switch that is used to place the return fan in the air stream (1) or outside of the air stream (0).
FAN EFFICIENCY=	0.70	This is the constant fan efficiency (%).
HCLASP (F) =	110.00	This is the heating coil leaving air setpoint temperature (F).
HCLABP(psia)=	14.696	This variable is the heating coil leaving air barometric pressure (PSIA).

MOTEFF=	0.90	This variable is the constant motor efficiency of the supply fan (%).
MOTEFFR=	0.90	This variable is the constant motor efficiency of the return fan (%).
OADB(F) =	-20.00	This variable is the outside air dry bulb temperature (F).
OAWB(F)=	-20.00	This variable is the outside air wet bulb temperature (F).
PHLABP (PSIA) =	14.696	This variable is the preheat coil leaving air barometric pressure (PSIA).
PHLASP(F)=	45.00	This variable is the setpoint temperature of the preheat coil (F).
QZL1(Btuh)=	2000	This variable is the latent load of zone 1 (BTUH).
QZL2(Btuh)=	3000	This variable is the latent load of zone 2 (BTUH).
QZS1(Btuh)=	-10000	This variable is the sensible load of zone 1 (BTUH).
QZS2 =	-8000	This variable is the sensible load of zone 2 (BTUH).
RFAN EFFICIENCY=	0.70	This variable is the constant fan efficiency of the return fan (%).
R =	1545.32	This variable is the gas constant for dry air (currently not used).
Ra =	53.35	This variable is the gas constant for dry air (ft-lbf/R-lb).
RABPNF=	14.696	This variable is the barometric pressure at a point in front of the return fan (PSIA).
RABP=	14.696	This variable is the barometric pressures at point in back of the return fan (PSIA).
RFTP(in-H20)=	1.00	This is the total fan pressure across the supply fan (in-H20).
ZDB1(F)=	70.00	This variable is the zone temperature for zone 1 (F).
QRA1(F)=	0.00	This variable is the heat gain of the ducts returning from zone 1 (F).
ZDB2(F)=	72.00	This variable is the zone temperature for zone 2 (F).
QRA2(F)=	0.00	This variable is the heat gain of the ducts returning from zone 2 (F).
ZSABP1(Psia)=	14.696	This variable is the barometric pressure of the supply air for zone 1 (PSIA).
ZSABP2(Psia)=	14.696	This variable is the barometric pressure of the supply air for zone 2 (PSIA).
ZBP1(Psia)	14.696	This variable is the barometric pressure of the air in zone 1 (PSIA).
ZBP2(Psia)	14.696	This variable is the barometric pressure of the air in zone 2 (PSIA).

The output from the CAVRH is listed in two tables to the left of the input table in a similar fashion as the DDCAV system.

DDCV system	OA	MA	PCLA	CCLA	SFLA	ZSA1	ZSA2	Z1	Z2	MRA	RFEA	RFLA
Case 1 - all AMS												
DB (F)	-20.0000	38.1894	45.0000	45.0000	46.0093	84.7077	82.0853	70.0000	72.0000	71.0072	71.0072	71.5378
W (lb/lbda)	0.00026	0.00157	0.00157	0.00157	0.00157	0.00158	0.00158	0.00222	0.00241	0.00232	0.00232	0.00232
V (ft3/lbda)				12.7551		13.7587	13.6924			13.4285	13.4285	
i (BTU/lbda)	-4.5284		12.5074	12.5126								19.7233
δ_m/δ_t (lbda/min)	37.2202	101.9201	101.9201	101.9201	101.9201	47.0400	54.8800	47.0400	54.8800	64.6999	64.6999	64.6999
Case 2 - NE												
DB (F)	30.0000	56.7941	56.7941	53.9727	55.0000	73.9940	71.7168	71.0000	73.0000	72.0055	72.0055	72.5371
W (lb/lbda)	0.00000	0.00130	0.00130	0.00130	0.00130	0.00130	0.00130	0.00196	0.00215	0.00206	0.00206	0.00206
V (ft3/lbda)				12.9762		13.4820	13.4245			13.4481	13.4481	
i (BTU/lbda)	7.2060		15.0519	14.3774								19.6792
δ_m/δ_t (lbda/min)	37.1657	100.1836	100.1836	100.1836	100.1836	46.2386	53.9450	46.2386	53.9450	63.0179	63.0179	63.0179
Case 2 - RAEE, RATE												
DB (F)	30.0000	53.9233	53.9233	53.9233	54.9505	73.9939	71.7169	71.0000	73.0000	72.0055	72.0055	72.5371
W (lb/lbda)	0.00000	0.00102	0.00102	0.00102	0.00102	0.00102	0.00102	0.00168	0.00187	0.00178	0.00178	0.00178
V (ft3/lbda)				12.9691		13.4760	13.4185			13.4421	13.4421	
i (BTU/lbda)	7.2060		14.0619	14.0635								19.3745
δ_m/δ_t (lbda/min)	41.2973	100.2380	100.2380	100.2380	100.2380	46.2637	53.9743	46.2637	53.9743	63.0557	63.0557	63.0557
Case 3 - NE												
DB (F)	60.0000	69.8210	69.8210	53.9734	55.0000	66.5201	65.7419	74.0000	76.0000	75.0061	75.0061	75.5403
W (lb/lbda)	0.00292	0.00423	0.00423	0.00423	0.00423	0.00423	0.00423	0.00489	0.00508	0.00499	0.00499	0.00499
V (ft3/lbda)				13.0372		13.3556	13.3359			13.5876	13.5876	
i (BTU/lbda)	17.5840		21.3878	17.5547								23.6114
δ_m/δ_t (lbda/min)	36.7845	99.7149	99.7149	99.7149	99.7149	46.0223	53.6927	46.0223	53.6927	62.9305	62.9305	62.9305
Case 3 - RAEE, RATE												
DB (F)	60.0000	60.0000	60.0000	53.9731	55.0000	66.5178	65.7387	74.0000	76.0000	75.0061	75.0061	75.5405
W (lb/lbda)	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00358	0.00377	0.00368	0.00368	0.00368
V (ft3/lbda)				13.0098		13.3275	13.3078			13.5590	13.5590	
i (BTU/lbda)	17.5840		17.5840	16.1285								22.1710
δ_m/δ_t (lbda/min)	99.9248	99.9248	99.9248	99.9248	99.9248	46.1191	53.8056	46.1191	53.8056	63.0629	63.0629	63.0629
Case 4 - all AMS												
DB (F)	80.0000	77.8262	77.8262	53.9745	55.0000	60.0565	61.6295	75.0000	77.0000	76.0063	76.0063	76.5410
W (lb/lbda)	0.01757	0.01255	0.01255	0.00885	0.00885	0.00885	0.00885	0.00952	0.00971	0.00962	0.00962	0.00962
V (ft3/lbda)				13.1334		13.2889	13.3292			13.7134	13.7134	
i (BTU/lbda)	38.4833		32.4418	22.5697								28.9208
δ_m/δ_t (lbda/min)	36.4468	98.9841	98.9841	98.9841	98.9841	45.6850	53.2991	45.6850	53.2991	62.5373	62.5373	62.5373
Case 5 - RAEE												
DB (F)	77.0000	77.0000	77.0000	53.9734	55.0000	66.5200	65.7418	74.0000	76.0000	75.0061	75.0061	75.5403
W (lb/lbda)	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00485	0.00503	0.00495	0.00495	0.00495
V (ft3/lbda)				13.0362		13.3546	13.3348			13.5865	13.5865	
i (BTU/lbda)	23.0766		23.0766	17.5028							62.9353	23.5590
δ_m/δ_t (lbda/min)	99.7226	99.7226	99.7226	99.7226	99.7226	46.0258	53.6968	46.0258	53.6968	62.9353	62.9353	62.9353
Case 6 - RAEE												
DB (F)	74.0000	74.9684	74.9684	53.9745	55.0000	66.5282	65.7530	74.0000	76.0000	75.0061	75.0061	75.5398
W (lb/lbda)	0.01483	0.01154	0.01154	0.00885	0.00885	0.00885	0.00885	0.00952	0.00971	0.00962	0.00962	0.00962
V (ft3/lbda)				13.1334		13.4544	13.4346			13.6878	13.6878	
i (BTU/lbda)	33.9947		30.6383	22.5697								28.6764
δ_m/δ_t (lbda/min)	36.5150	98.9841	98.9841	98.9841	98.9841	45.6850	53.2991	45.6850	53.2991	62.4692	62.4692	62.4692

Table 7: Constant Volume Reheat System Conditions for 865-RP Accuracy Tests (CAVRH)

DDCV system	Preheat Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)	Zone 1 reheat	Zone 2 reheat	Total Heat
Case 1 - all AMS							
PSU1	9,934.00				26,295.00	28,596.00	64,825.00
PSU2	24,528.00				19,648.00	20,756.00	64,932.00
TAMU	10,032.94				26,311.65	28,616.73	64,961.32
BLAST	24,578.00				19,671.00	20,790.00	65,039.00
DOE II							60,995.00
Case 2 - NE							
PSU1		4,146.00		4,146.00	12,679.00	13,016.00	25,693.00
PSU2		3,129.00		3,129.00	12,291.00	12,507.00	24,797.00
TAMU		4,083.14		4,083.14	12,687.91	13,027.88	25,715.79
BLAST		3,139.00	23.00	3,162.00	12,319.00	12,543.00	24,862.00
DOE II				3,676.00			28,047.00
Case 2 - RAEE, RATE							
PSU1					12,678.00	13,015.00	25,693.00
PSU2					12,291.00	12,507.00	24,797.00
TAMU					12,721.26	13,066.83	25,788.09
BLAST					12,319.00	12,543.00	24,862.00
DOE II							28,633.00
Case 3 - NE							
PSU1		23,010.00		23,010.00	7,690.00	8,363.00	16,053.00
PSU2		21,780.00		21,780.00	7,220.00	7,758.00	14,978.00
TAMU		22,952.37		22,952.37	7,700.74	8,377.27	16,078.01
BLAST		21,832.00	280.00	22,112.00	7,256.00	7,813.00	15,069.00
DOE II				21,344.00			15,569.00
Case 3 - RAEE, RATE							
PSU1		8,724.00		8,724.00	7,686.00	8,353.00	16,044.00
PSU2		8,458.00		8,458.00	7,220.00	7,758.00	14,978.00
TAMU		8,726.24		8,726.24	7,696.78	8,372.17	16,068.95
BLAST		8,474.00	88.00	8,562.00	7,256.00	7,813.00	15,069.00
DOE II				10,162.00			15,569.00
Case 4 - all AMS							
PSU1		35,158.00	22,612.00	57,770.00	3,372.00	5,161.00	8,534.00
PSU2		33,357.00	24,535.00	57,893.00	2,863.00	4,508.00	7,371.00
TAMU		34,727.80	23,208.77	57,936.56	3,383.72	5,175.78	8,559.50
BLAST		33,434.00	26,113.00	59,547.00	2,906.00	4,570.00	7,476.00
DOE II				57,090.00			6,611.00
Case 5 - RAEE							
PSU1		33,327.00		33,327.00	7,690.00	8,363.00	16,053.00
PSU2		32,148.00		32,148.00	7,220.00	7,758.00	14,978.00
TAMU		33,349.76		33,349.76	7,700.60	8,377.09	16,077.69
BLAST		30,963.00	474.00	31,437.00	7,256.00	7,813.00	15,069.00
DOE II				30,648.00			15,115.00
Case 6 - RAEE							
PSU1		30,490.00	17,108.00	47,597.00	7,704.00	8,381.00	16,085.00
PSU2		29,284.00	8,675.00	37,959.00	7,220.00	7,758.00	14,978.00
TAMU		30,540.61	16,911.09	47,451.70	7,714.54	8,395.06	16,109.60
BLAST		29,352.00	9,645.00	38,997.00	7,256.00	7,813.00	15,069.00
DOE II							15,075.00

Table 8: Constant Volume Reheat System Results for 865-RP Accuracy Tests (CAVRH)

VARIABLE VOLUME WITH REHEAT (VAVRH).

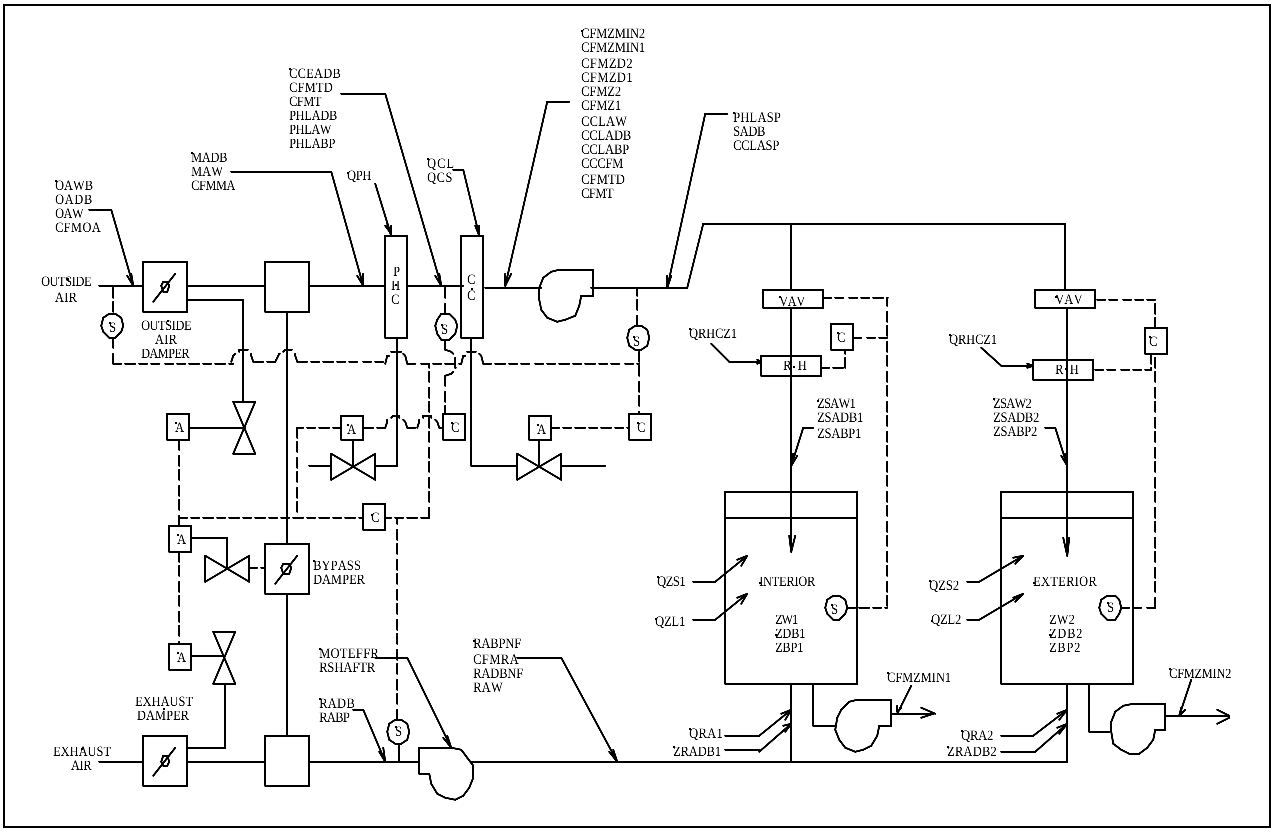

Figure 8: Variable Air Volume Reheat System Schematic (VAVRH)

The input values for the VAVRH spreadsheet are:

TEST # (1..7)=	7	This switch is used for cosmetic purposes only. It is used to change the label that appears directly to the right of the input cell and creates a set of “canned” labels used for one of the tests that the spreadsheet was developed for.
ECON(no=0,T=1,E=2)	2	This switch turns the economizer “on” or “off”. It is also used to select whether the temp erature (T) or enthalpy (E) economizer is used.
AIR CRLR(1,2,3,4)=	3	This switch is used to control the type of variable flow fan that is being used: 1=Inlet Vanes, 2=Discharge Dampers, 3=Var.Speed Drive, 4=Constant
CCLASP(F) =	55.00	This variable is the cooling coil leaving air barometric pressure (PSIA).
CCLABP(psia)=	14.696	This variable is the cooling coil leaving air barometric pressure (PSIA).
EXHAUST(0=sys,1=zone)=	1	This switch is used to calculate ‘zone air exhaust’ or ‘system air exhaust’. This will cause a difference in the mass flow rates returning from the zone, and heat gain from the return fan.
CFMZD1 (CFM) =	600.00	This is the design air flow for zone 1 (CFM).
CFMZD2 (CFM) =	700.00	This is the design air flow for zone 2 (CFM).
CFMZMIN1=	200.00	This is the exhaust air for zone 1 (CFM)
CFMZMIN2=	300.00	This is the exhaust air for zone 2 (CFM)
CPAIR(Btu/lbF)=	0.2402	This is the constant that is used for the specific heat of air (80F).
CPh20(Btu/lbF)=	1.0019	This is the constant that is used for the specific heat of water (55F).
FTP(in-H20) =	2.00	This is the total fan pressure across the supply fan (in-H20).
FRACT(0,1)=	0	This is the switch that is used to place the supply fan in the air stream (1) or outside of the air stream (0).
FRACTR(0,1)=	0	This is the switch that is used to place the return fan in the air stream (1) or outside of the air stream (0).
FAN EFFICIENCY=	0.70	This is the constant fan efficiency (%).
MOTEFF=	0.90	This variable is the constant motor efficiency of the supply fan (%).
MOTEFFR=	0.90	This variable is the constant motor efficiency of the return fan (%).

OADB(F) =	74.00	This variable is the outside air dry bulb temperature (F).
OAWB(F)=	70.00	This variable is the outside air wet bulb temperature (F).
PHLABP (PSIA) =	14.70	This variable is the preheat coil leaving air barometric pressure (PSIA).
PHLASP(F)=	45.00	This variable is the setpoint temperature of the preheat coil (F).
QZL1(Btuh)=	2000	This variable is the latent load of zone 1 (BTUH).
QZL2(Btuh)=	3000	This variable is the latent load of zone 2 (BTUH).
QZS1(Btuh)=	5000	This variable is the sensible load of zone 1 (BTUH).
QZS2 =	8000	This variable is the sensible load of zone 2 (BTUH).
RFAN EFFICIENCY=	0.70	This variable is the constant fan efficiency of the return fan (%).
RHCZ1SP=	120.00	This is the maximum temperature of the reheat coil leaving air for zone 1 (F).
RHCZ2SP=	120.00	This is the maximum temperature of the reheat coil leaving air for zone 2 (F).
R =	1545.32	This variable is the gas constant for dry air (currently not used).
Ra =	53.35	This variable is the gas constant for dry air (ft-lbf/R-lb).
RABPNF=	14.696	This variable is the barometric pressure at a point in front of the return fan (PSIA).
RABP=	14.696	This variable is the barometric pressures at point in back of the return fan (PSIA).
RFTP(in-H20)=	1.00	This is the total fan pressure across the supply fan (in-H20).
ZDB1(F)=	74.00	This variable is the zone temperature for zone 1 (F).
QRA1(F)=	0.00	This variable is the heat gain of the ducts returning from zone 1 (F).
ZDB2(F)=	76.00	This variable is the zone temperature for zone 2 (F).
QRA2(F)=	0.00	This variable is the heat gain of the ducts returning from zone 2 (F).
ZSABP1(Psia)=	14.696	This variable is the barometric pressure of the supply air for zone 1 (PSIA).
ZSABP2(Psia)=	14.696	This variable is the barometric pressure of the supply air for zone 2 (PSIA).
ZBP1(Psia)	14.696	This variable is the barometric pressure of the air in zone 1 (PSIA).
ZBP2(Psia)	14.696	This variable is the barometric pressure of the air in zone 2 (PSIA).

VAV reheat system	OA	MA	PCLA	CCLA	SFLA	ZSA1	ZSA2	Z1	Z2	MRA	RFEA	RFLA
Case 1 - all AMS												
DB (F)	-20.0000	-20.0000	45.0000	45.0000	45.1464	116.4757	96.8809	70.0000	72.0000	71.0667	71.0667	71.0675
W (lb/lbda)	0.00026	0.00026	0.00026	0.00026	0.00026	0.00026	0.00026	0.00231	0.00231	0.00231	0.00231	0.00231
V (ft3/lbda)										13.4297	13.4297	
i (BTU/lbda)	-4.5284		11.0921	11.0921								19.5949
δ_m/δ_t (lbda/min)	37.2216	37.2216	37.2216	37.2216	37.2216	14.9224	22.2992	14.9224	22.2992	0.0000	0.0000	0.0000
Case 2 - all AMS												
DB (F)	30.0000	30.0000	45.0000	45.0000	45.1459	80.3133	69.8838	71.0000	73.0000	72.6471	72.6471	72.6479
W (lb/lbda)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00205	0.00205	0.00205	0.00205	0.00205
V (ft3/lbda)										13.4641	13.4641	
i (BTU/lbda)	7.2061		10.8091	10.8091								19.6942
δ_m/δ_t (lbda/min)	37.1671	37.1671	37.1671	37.1671	37.1671	14.9005	22.2666	14.9005	22.2666	0.0000	0.0000	0.0000
Case 3 - NE												
DB (F)	60.0000	62.6080	62.6080	54.7803	55.0000	55.0000	55.0000	74.0000	76.0000	75.1093	75.1093	75.1203
W (lb/lbda)	0.00292	0.00327	0.00327	0.00327	0.00327	0.00327	0.00327	0.00495	0.00501	0.00498	0.00498	0.00498
V (ft3/lbda)										13.5899	13.5899	
i (BTU/lbda)	17.5840		18.6008	16.7093								23.4979
δ_m/δ_t (lbda/min)	36.7856	44.4240	44.4240	44.4240	44.4240	18.1499	26.4721	18.1499	26.2741	7.6383	7.6383	7.6383
Case 3 - RAEE, RATE												
DB (F)	60.0000	60.0000	60.0000	54.7803	55.0000	55.0000	55.0000	74.0000	76.0000	75.1093	75.1093	75.1204
W (lb/lbda)	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00292	0.00459	0.00465	0.00463	0.00463	0.00463
V (ft3/lbda)										13.5822	13.5822	
i (BTU/lbda)	17.5840		17.5840	16.3234								23.1077
δ_m/δ_t (lbda/min)	44.4530	44.4530	44.4530	44.4530	44.4530	18.1617	26.2913	18.1617	26.2913	7.6464	7.6464	7.6464
Case 4 - all AMS												
DB (F)	80.0000	78.0964	78.0964	54.4468	55.0000	55.0000	55.0000	75.0000	77.0000	75.8824	75.8824	76.0846
W (lb/lbda)	0.01757	0.01389	0.01389	0.00901	0.00901	0.00901	0.00901	0.00990	0.01024	0.01005	0.01005	0.01005
V (ft3/lbda)										13.7196	13.7196	
i (BTU/lbda)	38.4833		33.9761	22.8546								29.2770
δ_m/δ_t (lbda/min)	36.4198	71.3523	71.3523	71.3523	71.3523	34.1250	37.2273	34.1250	37.2273	34.9325	34.9325	34.9325
Case 5 - RAEE												
DB (F)	77.0000	77.0000	77.0000	54.7805	55.0000	55.0000	55.0000	74.0000	76.0000	75.1092	75.1092	75.1202
W (lb/lbda)	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00418	0.00586	0.00592	0.00590	0.00590	0.00590
V (ft3/lbda)										13.6098	13.6098	
i (BTU/lbda)	23.0766		23.0766	17.6981								24.4981
δ_m/δ_t (lbda/min)	44.3497	44.3497	44.3497	44.3497	44.3497	18.1195	26.2302	18.1195	26.2302	7.6176	7.6176	7.6176
Case 6 - RAEE												
DB (F)	74.0000	74.1901	74.1901	54.7812	55.0000	55.0000	55.0000	74.0000	76.0000	75.1087	75.1087	75.1196
W (lb/lbda)	0.01483	0.01415	0.01415	0.00912	0.00912	0.00912	0.00912	0.01082	0.01088	0.01085	0.01085	0.01085
V (ft3/lbda)			13.7000							13.7171	13.7171	
i (BTU/lbda)	33.9947		33.2986	23.0580								29.9192
δ_m/δ_t (lbda/min)	36.4445	43.9516	43.9516	43.9516	43.9516	17.9569	25.9947	17.9569	25.9947	7.5071	7.5071	7.5071

Table 9: Variable Volume Reheat System Conditions for 865-RP Accuracy Tests (VAVRH)

VAVreheat system	Preheat Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)	Zone 1 Reheat	Zone 2 Reheat	Total Heat
Case 1 - all AMS							
PSU1							
PSU2							
TAMU	34,885.36				15,347.65	16,634.28	66,867.29
BLAST							
DOE II	36,806				13,744	14,406	64,956
Case 2 - all AMS							
PSU1							
PSU2							
TAMU	8,034.79				7,552.06	7,938.56	23,525.41
BLAST							
DOE II	8,494				6,043	5,785	20,322
Case 3 - NE							
PSU1							
PSU2							
TAMU		5,041.89		5,041.89			
BLAST							
DOE II				4,731			
Case 3 - RAEE, RATE							
PSU1							
PSU2							
TAMU		3,362.09		3,362.09			
BLAST							
DOE II				4,562			
Case 4 - all AMS							
PSU1							
PSU2							
TAMU		24,839.34	22,052.87	46,892.21			
BLAST							
DOE II				44,344			
Case 5 - RAEE							
PSU1							
PSU2							
TAMU		14,311.84		14,311.84			
BLAST							
DOE II				14,648			
Case 6 - RAEE							
PSU1							
PSU2							
TAMU		12,548.33	13,992.96	26,541.29			
BLAST							
DOE II				16,053			

Table 10: Variable Volume Reheat System Results for 865-RP Accuracy Tests (VAVRH)

4.4 FOUR PIPE FAN COIL UNIT (FC)

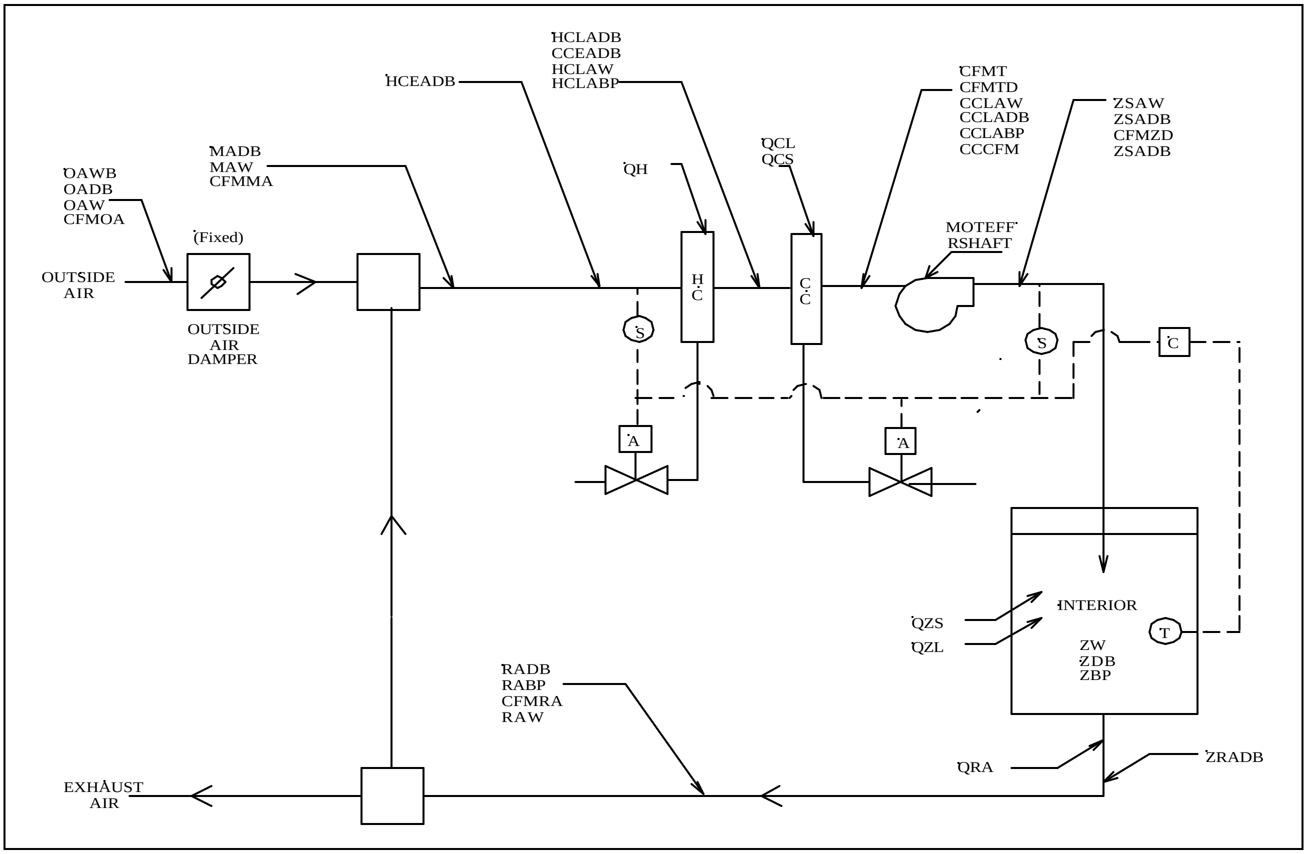

Figure 9: Four Pipe Fan Coil System Schematic (FC)

The input values for the FC spreadsheet are:

CCLAMIN(F) =	55.00	This variable is the cooling coil leaving air minimum temperature (F).
CCLABP(psia)=	14.696	This variable is the cooling coil leaving air barometric pressure (PSIA).
CFMZD(CFM) =	600.00	This is the design air flow for the zone (CFM).
CFMZMIN(CFM)=	200.00	This is the exhaust air for the zone (CFM).
CPAIR(Btu/lbF)=	0.2402	This is the constant that is used for the specific heat of air (80F).
CPh20(Btu/lbF)=	1.002	This is the constant that is used for the specific heat of water (55F).
FTP(in-H20) =	2.00	This is the total fan pressure across the supply fan (in-H20). NOTE: this is set = 0 when a two draw-through fans are being used.
FRACT(0,1)=	0	This is the switch that is used to place the supply fan in the air stream (1) or outside of the air stream (0).
FAN EFFICIENCY=	0.70	This is the constant fan efficiency for the single supply fan (%).
HCLAMAX (F) =	110.00	This is the heating coil leaving air maximum temperature (F).
HCLABP(psia)=	14.696	This variable is the heating coil leaving air barometric pressure (PSIA).
MOTEFF=	0.90	This variable is the constant motor efficiency of the supply fan (%).
OADB(F) =	80.00	This variable is the outside air dry bulb temperature (F).
OAWB(F)=	75.00	This variable is the outside air wet bulb temperature (F).
QZL(Btuh)=	2000	This variable is the latent load of the zone (BTUH).
QZS(Btuh)=	10000	This variable is the sensible load of zone 1 (BTUH).
R =	1545.32	This variable is the gas constant for dry air (currently not used).
Ra =	53.35	This variable is the gas constant for dry air (ft-lbf/R-lb).
RABPNF=	14.696	This variable is the barometric pressure at a point in front of the return fan (PSIA).
RABP=	14.696	This variable is the barometric pressures at point in back of the return fan (PSIA).
ZDB(F)=	75.00	This variable is the zone temperature for the (F).
QRA(F)=	0.00	This variable is the heat gain of the ducts returning from the zone (F).
ZSABP(Psia)=	14.696	This variable is the barometric pressure of the supply air for the zone (PSIA).
ZBP(Psia)=	14.696	This variable is the barometric pressure of the air in the zone (PSIA).

FC system	ZONE 1						ZONE 2					
	OA	MA	HCLA	CCLA	ZSA1	Z1	OA	MA	HCLA	CCLA	ZSA2	Z2
Case 1												
DB (F)	-20.0000	39.2754	84.7570	84.7570	85.8457	70.0000	-20.0000	31.9938	81.7189	81.7189	82.8017	72.0000
W (lb/lbda)	0.00026	0.00161	0.00161	0.00161	0.00162	0.00231	0.00026	0.00142	0.00142	0.00142	0.00142	0.00231
V (ft3/lbda)				13.7607	13.7882					13.6797	13.7071	
i (BTU/lbda)	-4.5284		22.1113	22.1132			-4.5284		27.1702	21.1704		
δm/δt (lbda/min)	14.9223	43.6024	43.6024	43.6024	43.6024	43.6024	22.2992	51.1707	51.1707	51.1707	51.1707	51.1707
Case 2												
DB (F)	30.0000	57.3306	73.0357	73.0357	74.1011	71.0000	30.0000	54.7194	70.6168	70.6168	71.6774	73.0000
W (lb/lbda)	0.00010	0.00147	0.00147	0.00147	0.00147	0.00215	0.00010	0.00128	0.00128	0.00128	0.00128	0.00215
V (ft3/lbda)				13.4613	13.4883					13.3962	13.4230	
i (BTU/lbda)	7.3134		19.1336	19.1360			7.3134		18.3453	18.3455		
δm/δt (lbda/min)	14.8979	44.5719	44.5719	44.5719	44.5719	44.5719	22.2630	52.2538	52.2538	52.2538	52.2538	52.2538
Case 3												
DB (F)	60.0000	69.4260	69.4260	65.3154	66.3646	74.0000	60.0000	69.3142	69.3142	64.5004	65.5480	76.0000
W (lb/lbda)	0.00292	0.00431	0.00431	0.00431	0.00432	0.00499	0.00292	0.00412	0.00412	0.00412	0.00412	0.00499
V (ft3/lbda)				13.3268	13.3535					13.3021	13.3287	
i (BTU/lbda)	17.5870		21.3719	20.3801			17.5870		21.1379	19.9740		
δm/δt (lbda/min)	14.7471	45.0219	45.0219	45.0219	45.0219	45.0219	22.0381	52.6233	52.6233	52.6233	52.6233	52.6233
Case 4												
DB (F)	80.0000	76.6272	76.6272	58.9028	59.9377	75.0000	80.0000	78.2515	78.2515	60.4315	61.4693	77.0000
W (lb/lbda)	0.01757	0.01332	0.01332	0.01061	0.01061	0.01129	0.01757	0.01436	0.01436	0.01122	0.01122	0.01209
V (ft3/lbda)				13.2964	13.3229					13.3483	13.3750	
i (BTU/lbda)	38.4843		32.9716	25.6718			38.4843		34.5172	26.7046		
δm/δt (lbda/min)	14.5733	45.1251	45.1251	45.1251	45.1251	45.1251	21.7510	52.4410	52.4410	52.4410	52.4410	52.4410

Table 11: Four pipe Fan Coil Unit Conditions for 865-RP Accuracy Tests (FC)

FC system	ZONE 1				ZONE 2			
	Heating Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)	Heating Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)
Case 1								
PSU1	28,660				36,753			
PSU2	28,607				36,783			
TAMU	28,666	0	0	0	36,767	0	0	0
BLAST	28,648				36,849			
DOE II	32,720	0	0	0	38,325	0	0	0
Case 2								
PSU1	10,109				11,984			
PSU2	10,102				12,025			
TAMU	10,116	0	0	0	12,000	0	0	0
BLAST	10,123				12,058			
DOE II	11,782	0	0	0	12,492	0	0	0
Case 3								
PSU1		2,699		2,699		3,698		3,698
PSU2		2,687		2,687		3,657		3,657
TAMU	0	2,686	0	2,686	0	3,676	0	3,676
BLAST		2,675		2,675		3,698		3,698
DOE II	0	n/a	n/a	2,163	0	n/a	n/a	3,569
Case 4								
PSU1		12,016	8,035			14,112	10,872	24,984
PSU2		11,760	8,377			13,767	11,392	25,160
TAMU	0	11,783	7,738	19,520	0	13,787	10,445	24,232
BLAST		11,752	5,714			13,747	6,092	19,839
DOE II	0	n/a	n/a	14,814	0	n/a	n/a	17,549

Table 12: Four pipe Fan Coil Unit Results for 865-RP Accuracy Tests (FC)

4.5 FOUR PIPE INDUCTION UNIT (FI)

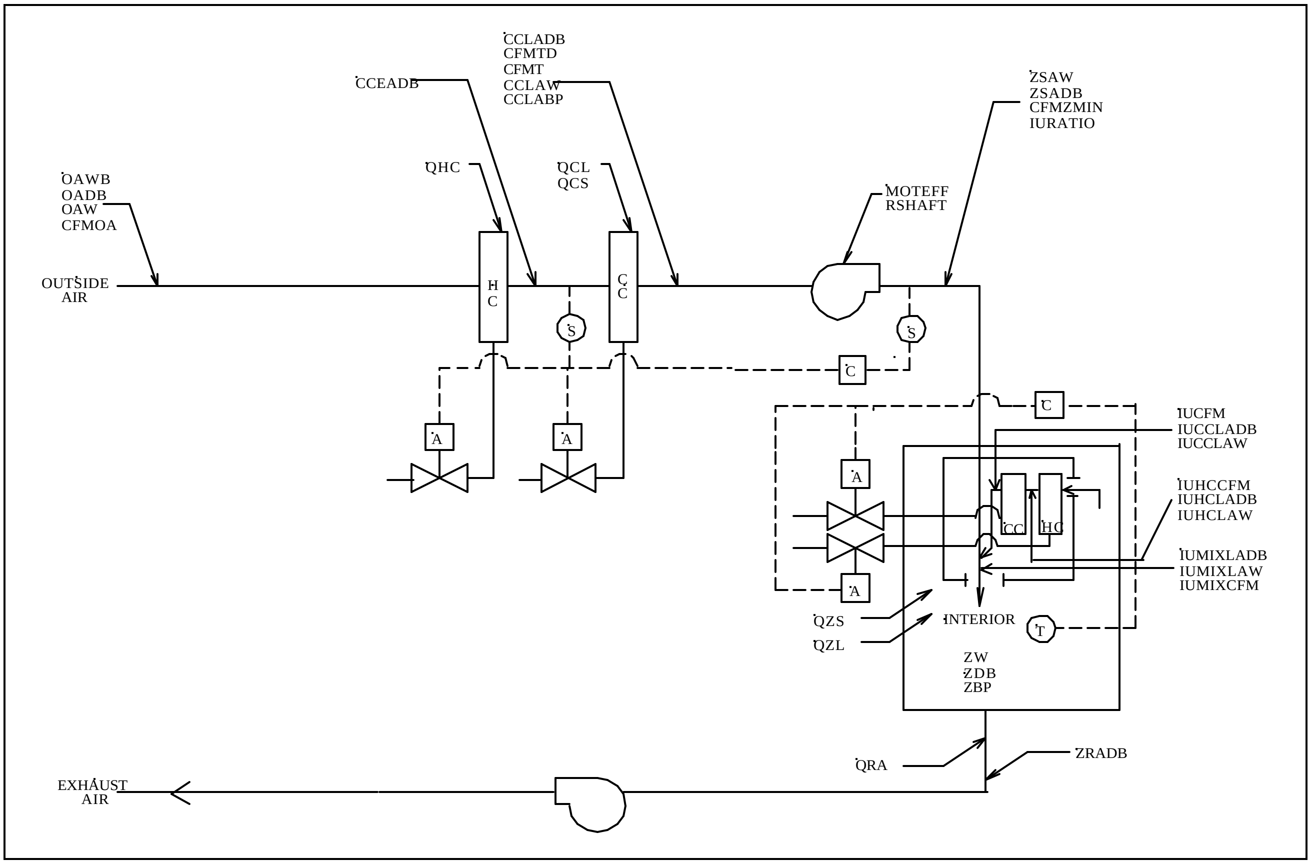

Figure 10: Four Pipe Induction System Schematic (FI)

<u>The input values for the FI spreadsheet are:</u>

TEST# (1..4)=	2	This switch is used for cosmetic purposes only. It is used to change the label that appears directly to the right of the input cell and creates a set of "canned" labels used for one of the tests that the spreadsheet was developed for.
CCLASP(F) =	55.00	This variable is the cooling coil leaving air minimum temperature (F).
IULAMIN(F)=	55.00	This variable is the induction box leaving air minimum temperature (F).
CCLABP(psia)=	14.696	This variable is the cooling coil leaving air barometric pressure (PSIA).
CFMZD(CFM) =	700.00	This is the design air flow for the zone (CFM).
IURATIO(%)=	**calc'd**	This calculated variable describes the ratio of induction air to main air (%).
CFMZMIN(CFM)=	300.00	This is the exhaust air for the zone (CFM).
CPAIR(Btu/lbF)=	0.2402	This is the constant that is used for the specific heat of air (80F).
CPh20(Btu/lbF)=	1.0019	This is the constant that is used for the specific heat of water (55F).
FTP(in-H20) =	2.00	This is the total fan pressure across the supply fan (in-H20). NOTE: this is set = 0 when a two draw-through fans are being used.
FRACT(0,1)=	0	This is the switch that is used to place the supply fan in the air stream (1) or outside of the air stream (0).
FAN EFFICIENCY=	0.70	This is the constant fan efficiency for the single supply fan (%).
HCLASP (F) =	45.00	This is the heating coil leaving air setpoint temperature (F).
IULAMAX(F)=	120.00	This is the leaving air maximum temperature for the induction unit (F).
HCLABP(psia)=	14.696	This variable is the heating coil leaving air barometric pressure (PSIA).
MOTEFF=	0.90	This variable is the constant motor efficiency of the supply fan (%).
OADB(F) =	80.00	This variable is the outside air dry bulb temperature (F).
OAWB(F)=	75.00	This variable is the outside air wet bulb temperature (F).
OABP(Psia)=	14.70	This variable is the outside air dry bulb temperature (F).
QZL(Btuh)=	3000	This variable is the latent load of the zone (BTUH).
QZS(Btuh)=	12000	This variable is the sensible load of zone 1 (BTUH).
R =	1545	This variable is the gas constant for dry air (currently not used).
Ra =	53.35	This variable is the gas constant for dry air (ft-lbf/R-

		lb).
ZDB(F)=	77.00	This variable is the zone temperature for the zone (F).
QRA(F)=	0.00	This variable is the heat gain of the ducts returning from t he zone (F).
ZSABP(Psia)=	14.696	This variable is the barometric pressure of the supply air entering the zone (PSIA).
ZBP(Psia)=	14.696	This variable is the barometric pressure of the air in the zone (PSIA).
PHLASP(F)=	45.00	This variable is the setpoint temperature of the preheat coil (F).

FC system	PRIMARY				ZONE 1				ZONE 2			
	Heating Coil	Cooling Coil (sens)	Cooling Coil (lat)	Cooling Coil (total)	Heating Coil	Cooling Coil (sens)	Cooling Coil (lat)	Cooling Coil (total)	Heating Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)
Case 1												
PSU1	34,855	0	0	0	15,179	0	0	0	16,382	0	0	0
PSU2	39,625	0	0	0	13,216	0	0	0	13,467	0	0	0
TAMU	34,885	0	0	0	15,162	0	0	0	16,357	0	0	0
BLAST	39,712	0	0	0	13,194	0	0	0	13,469	0	0	0
DOE II												
Case 2												
PSU1	8,028	0	0	0	7,384	0	0	0	7,687	0	0	0
PSU2	12,826	0	0	0	5,430	0	0	0	4,789	0	0	0
TAMU	8,035	0	0	0	7,367	0	0	0	7,662	0	0	0
BLAST	12,855	0	0	0	5,437	0	0	0	4,804	0	0	0
DOE II												
Case 3												
PSU1	0	3,166	0	3,166	0	943	0	943	0	1,300	0	1,300
PSU2	0	3,253	0	3,253	0	927	0	927	0	1,247	0	1,247
TAMU	0	3,207	0	3,207	0	939	0	939	0	1,293	0	1,293
BLAST	0	3,259	34	3,293	0	913	0	913	0	1,215	0	1,215
DOE II												
Case 4												
PSU1	0	13,808	20,796	34,604	0	5,732	0	5,732	0	4,984	0	4,984
PSU2	0	13,973	21,504	35,477	0	5,712	0	5,712	0	4,925	0	4,925
TAMU	0	13,912	19,222	33,134	0	5,723	0	5,723	0	4,973	0	4,973
BLAST	0	14,002	22,529	36,531	0	5,692	0	5,692	0	4,887	0	4,887
DOE II												

Table 13: Four pipe Induction Unit Conditions for 865-RP Accuracy Tests (FI)

FC system	PRIMARY				ZONE 1					ZONE 2				
	OA	PCLA	CCLA	SFLA	PA	ZSA1	Z1	HCLA	CCLA	PA	ZSA1	Z1	HCLA	CCLA
Case 1														
DB (F)	-20.0000	45.0000	45.0000	46.0092	46.0092	86.1681	70.0000	107.5915	107.5915	46.0092	83.0941	72.0000	112.9363	112.9363
W (lb/lbda)	0.00026	0.00026	0.00026	0.00026	0.00026	0.00160	0.00231	0.00231	0.00231	0.00026	0.00140	0.00231	0.00231	0.00231
V (ft3/lbda)														
i (BTU/lbda)		11.0831	11.0831											
δ_m/δ_t (lbda/min)	37.2215	37.2215	37.2215	37.2215	14.9252	42.7892		27.8669	27.8669	22.2992	49.9059		27.6067	27.6067
Case 2														
DB (F)	30.0000	45.0000	45.0000	46.0095	46.0095	74.1646	71.0000	88.6554	88.6554	46.0095	71.6414	73.0000	91.4561	91.4561
W (lb/lbda)	0.00010	0.00010	0.00010	0.00010	0.00010	0.00145	0.00215	0.00215	0.00215	0.00010	0.00126	0.00215	0.00215	0.00215
V (ft3/lbda)														
i (BTU/lbda)		10.9081	10.9081											
δ_m/δ_t (lbda/min)	37.1610	37.1610	37.1610	37.1610	14.8980	43.7345		29.8366	29.8366	22.2630	50.9530		28.6900	28.6900
Case 3														
DB (F)	60.0000	60.0000	53.9779	55.0000	55.0000	66.2413	74.0000	74.0000	71.8178	55.0000	65.3210	76.0000	76.0000	72.9891
W (lb/lbda)	0.00292	0.00292	0.00292	0.00292	0.00292	0.00430	0.00499	0.00499	0.00499	0.00292	0.00411	0.00499	0.00499	0.00499
V (ft3/lbda)														
i (BTU/lbda)		17.5750	16.1219											
δ_m/δ_t (lbda/min)	36.7853	36.7853	36.7853	36.7853	14.7472	44.3627		29.6155	29.6155	22.0381	51.5884		29.5503	29.5503
Case 4														
DB (F)	80.0000	80.0000	53.9895	55.0000	55.0000	59.6884	75.0000	75.0000	63.6275	55.0000	61.1208	77.0000	77.0000	65.5967
W (lb/lbda)	0.01757	0.01757	0.00920	0.00920	0.00920	0.01035	0.01104	0.01104	0.01092	0.00920	0.01040	0.01129	0.01129	0.01129
V (ft3/lbda)														
i (BTU/lbda)		38.4683	22.9342											
δ_m/δ_t (lbda/min)	36.3572	36.3572	36.3572	36.3572	14.5790	44.4654		29.8864	29.8864	21.7782	51.4463		29.6681	29.6681

Table 14: Four pipe Induction Unit Results for 865-RP Accuracy Tests (FI)

4.6 SINGLE ZONE (SZ)

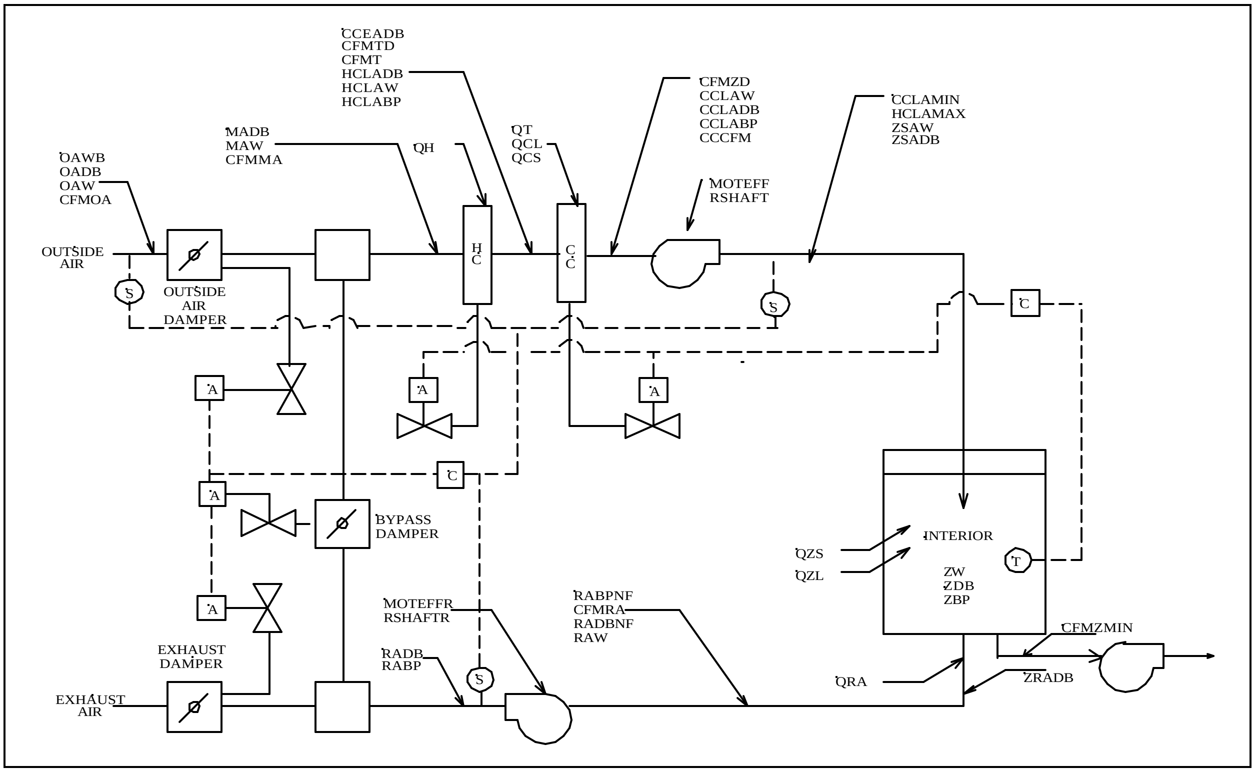

Figure 11: Single Zone System Schematic (SZ)

The input values for the SZ spreadsheet are:

TEST # (1..7)=	7	This switch is used for cosmetic purposes only. It is used to change the label that appears directly to the right of the input cell and creates a set of "canned" labels used for one of the tests that the spreadsheet was developed for.
ECON(0=n,1=T,2=E)=	2	This switch turns the economizer "on" or "off". It is also used to select whether the temperature (T) or enthalpy (E) economizer is used.
CCLAMIN(F) =	55.00	This variable is the cooling coil leaving air minimum temperature (F).
CCLABP(psia)=	14.696	This variable is the cooling coil leaving air barometric pressure (PSIA).
EXHAUST(0=sys,1=zone) =	1	This switch is used to calculate 'zone air exhaust' or 'system air exhaust'. This will cause a difference in the mass flow rates returning from the zone, and heat gain from the return fan.
CFMZD(CFM) =	700.00	This is the design air flow for zone 1 (CFM).
CFMZMIN(CFM)=	300.00	This is the exhaust air for zone 1 (CFM)
CPAIR(Btu/lbF)=	0.2402	This is the constant that is used for the specific heat of air (80F).
CPh20(Btu/lbF)=	1.002	This is the constant that is used for the specific heat of water (55F).
FTP(in-H20) =	2.00	This is the total fan pressure across the supply fan (in-H20).
FRACT(0,1)=	0	This is the switch that is used to place the supply fan in the air stream (1) or outside of the air stream (0).
FRACTR(0,1)=	0	This is the switch that is used to place the return fan in the air stream (1) or outside of the air stream (0).
FAN EFFICIENCY=	0.70	This is the constant fan efficiency (%).
HCLAMAX (F) =	110.00	This is the heating coil leaving air maximum temperature (F).
HCLAMIN (F)=	45.00	This is the heating coil leaving air minimum temperature (F).
HCLABP(psia)=	14.696	This variable is the heating coil leaving air barometric pressure (PSIA).
MOTEFF=	0.90	This variable is the constant motor efficiency of the supply fan (%).
MOTEFFR=	0.90	This variable is the constant motor efficiency of the return fan (%).
OADB(F) =	74.00	This variable is the outside air dry bulb temperature (F).
OAWB(F)=	70.00	This variable is the outside air wet bulb temperature (F).
QZL(Btuh)=	3000	This variable is the latent load of zone 1 (BTUH).
QZS(Btuh)=	8000	This variable is the sensible load of zone 1 (BTUH).
RFAN EFFICIENCY=	0.70	This variable is the constant fan efficiency of the return fan (%).
R =	1545.32	This variable is the gas constant for dry air (currently not used).
Ra =	53.35	This variable is the gas constant for dry air (ft-lbf/R-lb).
RABPNF=	14.696	This variable is the barometric pressure at a point in front of the return fan (PSIA).

RABP=	14.696	This variable is the barometric pressures at point in back of the return fan (PSIA).
RFTP(in-H20)=	1.00	This is the return fan pressure across the supply fan (in-H20). NOTE: this is set = 0 when a two draw-through fans are being used.
ZDB(F)=	76.00	This variable is the zone temperature for the (F).
QRA(F)=	0.00	This variable is the heat gain of the ducts returning from the zone (F).
ZSABP(Psia)=	14.696	This variable is the barometric pressure of the supply air for the zone (PSIA).
ZBP(Psia)	14.696	This variable is the barometric pressure of the air in the zone (PSIA).

SZ system	ZONE 1								ZONE 2							
	OA	MA	HCLA	CCLA	ZSA1	Z1	RFEA	RFLA	OA	MA	HCLA	CCLA	ZSA2	Z2	RFEA	RFLA
Case 1 - all AMS																
DB (F)	-20.0000	39.7090	84.7166	84.7166	85.8025	70.0000	70.0000	70.5296	-20.0000	32.3880	81.6963	81.6963	82.7765	72.0000	72.0000	72.5316
W (lb/lbda)	0.00026	0.00163	0.00163	0.00163	0.00163	0.00234	0.00234	0.00234	0.00026	0.00142	0.00142	0.00142	0.00142	0.00232	0.00232	0.00232
V (ft3/lbda)	11.0889	12.6224		13.7241			13.4033		11.0889	12.4333		13.6480			13.4535	
i (BTU/lbda)	-4.5284	-4.5284	22.1207	22.1314				19.4929	-4.5284	-4.5284	21.1689	21.1704				19.9546
δm/δt (lbda/min)	14.9217	43.7187	43.7187	43.7187	43.7187	28.7970	28.7970	28.7970	22.2991	51.2897	51.2897	51.2897	51.2897	28.9906	28.9906	28.9906
Case 2 - all AMS																
DB (F)	30.0000	57.7184	73.0307	73.0307	74.0935	71.0000	71.0000	71.5306	30.0000	55.0637	70.6217	70.6217	71.6801	73.0000	73.0000	73.5326
W (lb/lbda)	0.00010	0.00149	0.00149	0.00149	0.00149	0.00218	0.00218	0.00218	0.00010	0.00128	0.00128	0.00128	0.00128	0.00216	0.00216	0.00216
V (ft3/lbda)	12.3432	13.0747		13.4295			13.4253		12.3432	13.0033		13.3688			13.4753	
i (BTU/lbda)	7.3134	7.3134	19.1552	19.1681				19.5676	7.3134	7.3134	18.3508	18.3528				20.0229
δm/δt (lbda/min)	14.8973	44.6777	44.6777	44.6777	46.6777	29.7805	29.7805	29.7805	22.2629	52.3608	52.3608	52.3608	52.3608	30.0979	30.0979	30.0979
Case 3 - NE																
DB (F)	60.0000	69.8177	69.8177	65.3750	66.4170	74.0000	74.0000	74.5332	60.0000	69.6704	69.6704	64.5747	65.6156	76.0000	76.0000	76.5352
W (lb/lbda)	0.00292	0.00434	0.00434	0.00434	0.00434	0.00502	0.00502	0.00502	0.00292	0.00413	0.00413	0.00413	0.00413	0.00500	0.00500	0.00500
V (ft3/lbda)	13.1625	13.4417		13.2365			13.5626		13.1625	13.4335		13.2163			13.6129	
i (BTU/lbda)	17.5870	17.5870	21.4951	30.4340				23.4001	17.5870	17.5870	21.2330	20.0029				23.8549
δm/δt (lbda/min)	14.7464	45.3291	45.3291	45.3291	45.3291	30.5827	30.5827	30.5827	22.0380	52.9647	52.9647	52.9647	52.9647	30.9267	30.9267	30.9267
Case 3 - RAEE, RATE																
DB (F)	60.0000	65.3619	65.3619	65.3619	66.4055	74.0000	74.0000	74.5333	60.0000	64.5600	64.5600	64.5600	65.6022	76.0000	76.0000	76.5353
W (lb/lbda)	0.00292	0.00352	0.00352	0.00352	0.00352	0.00420	0.00420	0.00420	0.00292	0.00342	0.00342	0.00342	0.00342	0.00428	0.00428	0.00428
V (ft3/lbda)	13.1625	13.3111		13.2362			13.5447		13.1625	13.2886		13.2160			13.5974	
i (BTU/lbda)	17.5870	17.5870	19.5250	19.5275				22.4934	17.5870	17.5870	19.2206	19.2210				23.0728
δm/δt (lbda/min)	17.3948	45.3303	45.3303	45.3303	45.3303	30.5644	30.5644	30.5644	25.0394	52.9662	52.9662	52.9662	52.9662	30.9031	30.9031	30.9031
Case 4 - all AMS																
DB (F)	80.0000	76.9614	76.9614	59.1787	60.1958	75.0000	75.0000	75.5334	80.0000	78.5445	78.5445	60.7313	61.7503	77.0000	77.0000	77.5353
W (lb/lbda)	0.01757	0.01362	0.01362	0.01112	0.01112	0.01178	0.01178	0.01178	0.01757	0.01464	0.01464	0.01176	0.01176	0.01262	0.01262	0.01262
V (ft3/lbda)	13.9896	13.8249		13.0803			13.7346		13.9896	13.8878		13.1194			13.8041	
i (BTU/lbda)	38.4843	38.4843	33.3891	26.2940				31.0418	38.4843	38.4843	34.8902	27.3732				32.4467
δm/δt (lbda/min)	14.5618	45.8705	45.8705	45.8705	45.8705	31.3087	31.3087	31.3087	21.7327	53.3559	53.3559	53.3559	53.3559	31.6232	31.6232	31.6232
Case 5 - RAEE																
DB (F)	77.0000	77.0000	77.0000	65.3722	66.4145	74.0000	74.0000	74.5332	77.0000	77.0000	77.0000	64.5757	65.6165	76.0000	76.0000	76.5352
W (lb/lbda)	0.00419	0.00419	0.00419	0.00419	0.00419	0.00486	0.00486	0.00486	0.00419	0.00419	0.00419	0.00419	0.00419	0.00505	0.00505	0.00505
V (ft3/lbda)	13.6207	13.6207		13.2364			13.5591		13.6207	13.6207		13.2164			13.6140	
i (BTU/lbda)	23.0810	23.0810	23.0656	20.2533				23.2195	23.0810	23.0810	23.0656	20.0607				23.9128
δm/δt (lbda/min)	45.3294	45.3294	45.3294	45.3294	45.3294	30.5791	30.5791	30.5791	52.9646	52.9646	52.9646	52.9646	52.9646	30.9285	30.9285	30.9285
Case 6 - RAEE																
DB (F)	74.0000	74.3615	74.3615	65.5215	66.5458	74.0000	74.0000	74.5320	74.0000	74.0000	74.0000	64.7651	65.7889	76.0000	76.0000	76.5340
W (lb/lbda)	0.01483	0.01470	0.01470	0.01396	0.01396	0.01463	0.01463	0.01463	0.01483	0.01483	0.01483	0.01359	0.01359	0.01445	0.01445	0.01445
V (ft3/lbda)	13.7747	13.7812		13.2402			13.7705		13.7747	13.7747		13.2211			13.8182	
i (BTU/lbda)	33.9956	33.9956	33.9239	30.9430				33.9120	33.9956	33.9956	33.9808	30.3538				34.2092
δm/δt (lbda/min)	14.5238	45.3165	45.3165	45.3165	45.3165	30.7927	30.7927	30.7927	52.9455	52.9455	52.9455	52.9455	52.9455	31.2350	31.2350	31.2350

Table 15: Single Zone System Conditions for 865-RP Accuracy Tests (SZ)

SZ system	ZONE 1				ZONE 2			
	Heating Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)	Heating Coil	Cooling Coil (sens)	Cooling Coil (latent)	Cooling Coil (total)
Case 1 - all AMS								
PSU1								
PSU2								
TAMU	28,443.66	0	0	0	36,543.89	0	0	0
BLAST								
DOE II	26,140	0	0	0	28,479	0	0	0
Case 2 - all AMS								
PSU1								
PSU2								
TAMU	9,886.69	0	0	0	11,768.25	0	0	0
BLAST								
DOE II	11,806	0	0	0	12,523	0	0	0
Case 3 - NE								
PSU1								
PSU2								
TAMU	0	2,922.65	0	2,922.65	0	3,916.10	0	3,916.10
BLAST								
DOE II	0	0	0	2,156	0	0	0	3,559
Case 3 - RAEE, RATE								
PSU1								
PSU2								
TAMU	0	0	0	0	0	0	0	0
BLAST								
DOE II	0	0	0	0	0	0	0	0
Case 4 - all AMS								
PSU1								
PSU2								
TAMU	0	7,269.88	12,023.77	19,293.65	0	14,030.61	9,703.28	23,733.89
BLAST								
DOE II	0	0	0	16,590	0	0	0	20,218
Case 5 - RAEE								
PSU1								
PSU2								
TAMU	0	7,648.78	0	7,648.78	0	9,549.31	0	9,549.31
BLAST								
DOE II	0	0	0	6,369	0	0	0	9,034
Case 6 - RAEE								
PSU1								
PSU2								
TAMU	0	5,923.83	2,109.05	8,032.89	0	7,229.18	4,149.78	11,378.96
BLAST								
DOE II	0	0	0	6,185	0	0	0	8,105

Table 16: Single Zone System Results for 865-RP Accuracy Tests (SZ)