Load Calculations for Commercial Buildings – Trinidad and Tobago

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Figure 1 - Building Front Entrance

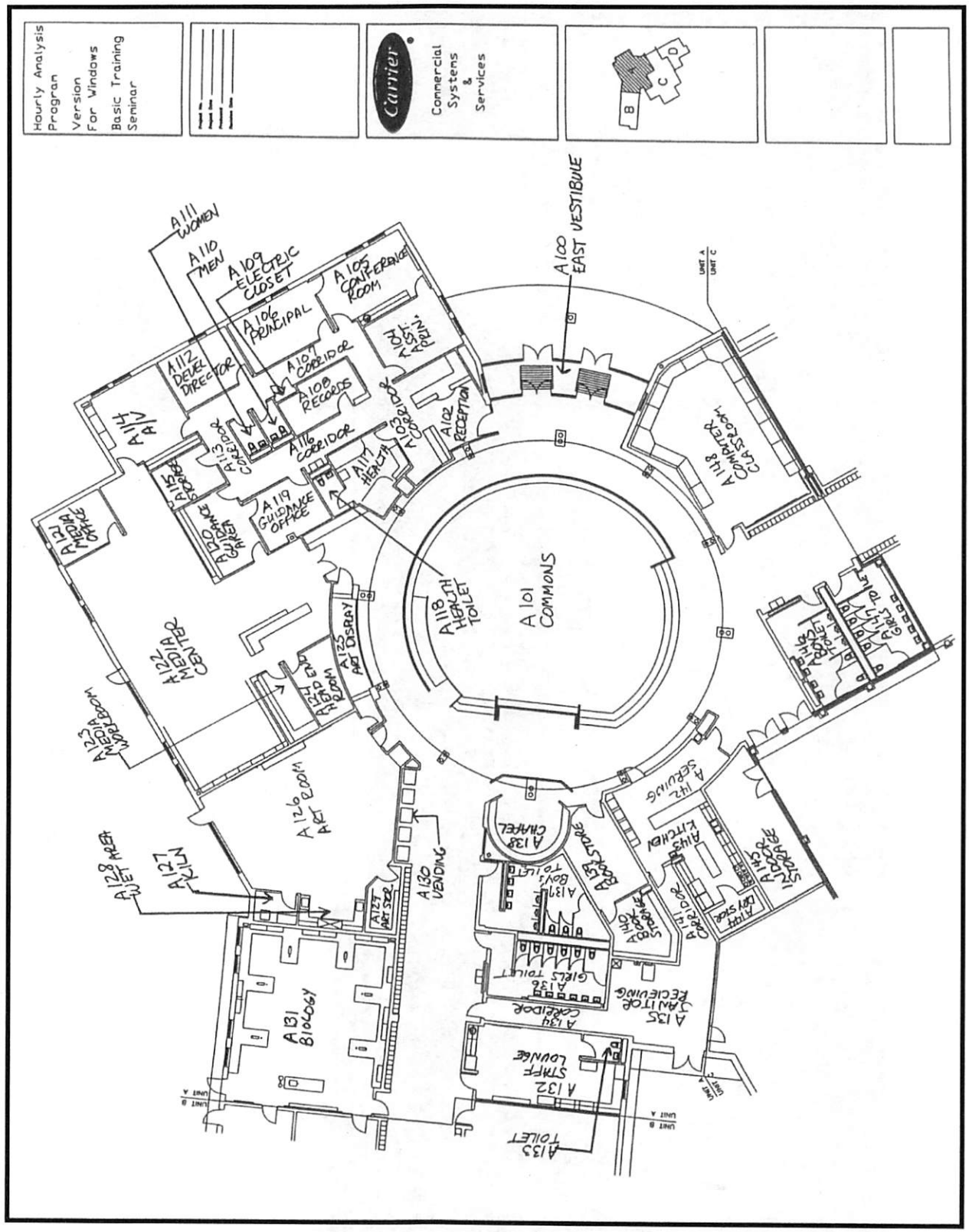

Figure 2 - Section "A" Floor Plan

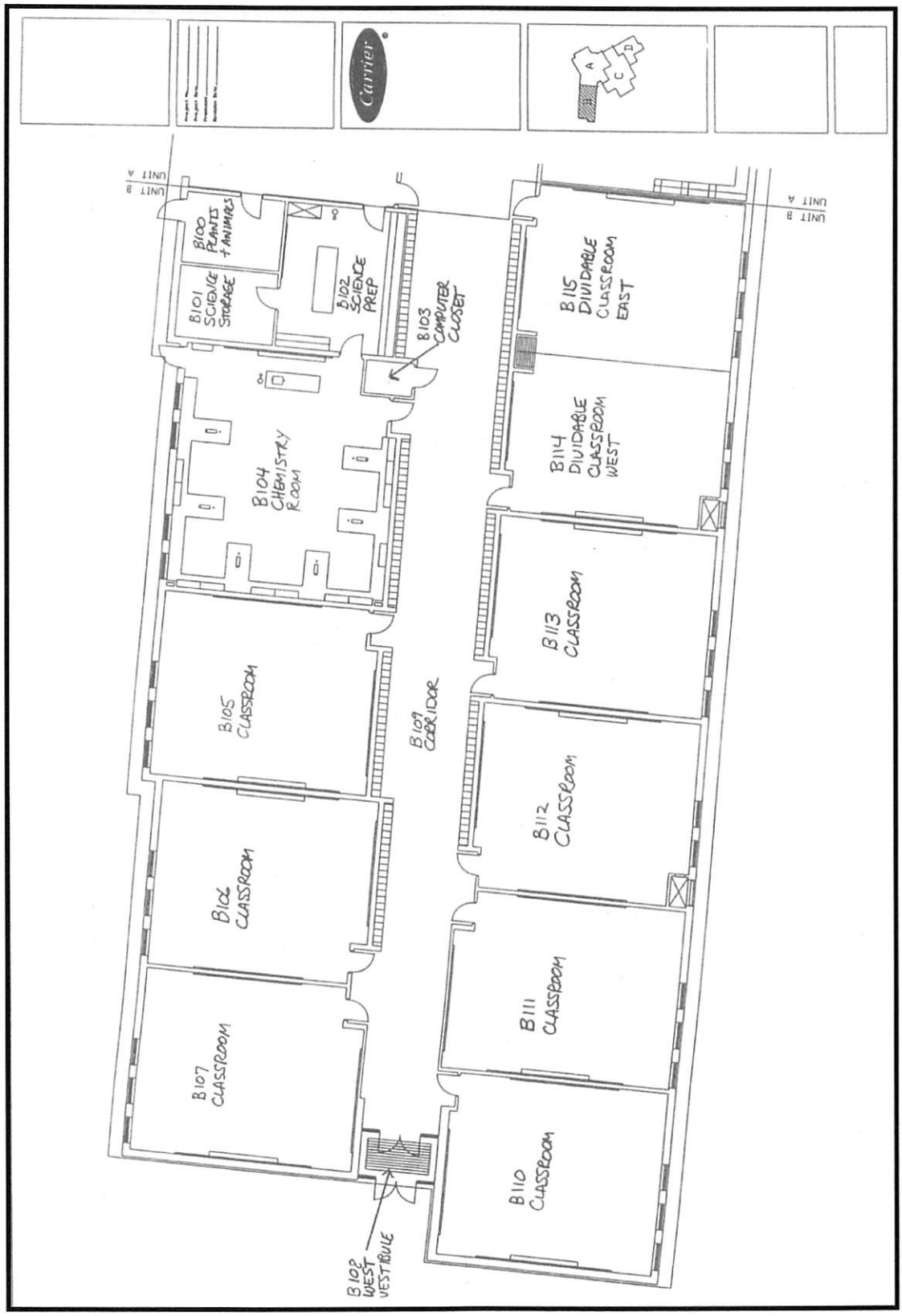

Figure 3 - Section "B" Floor Plan

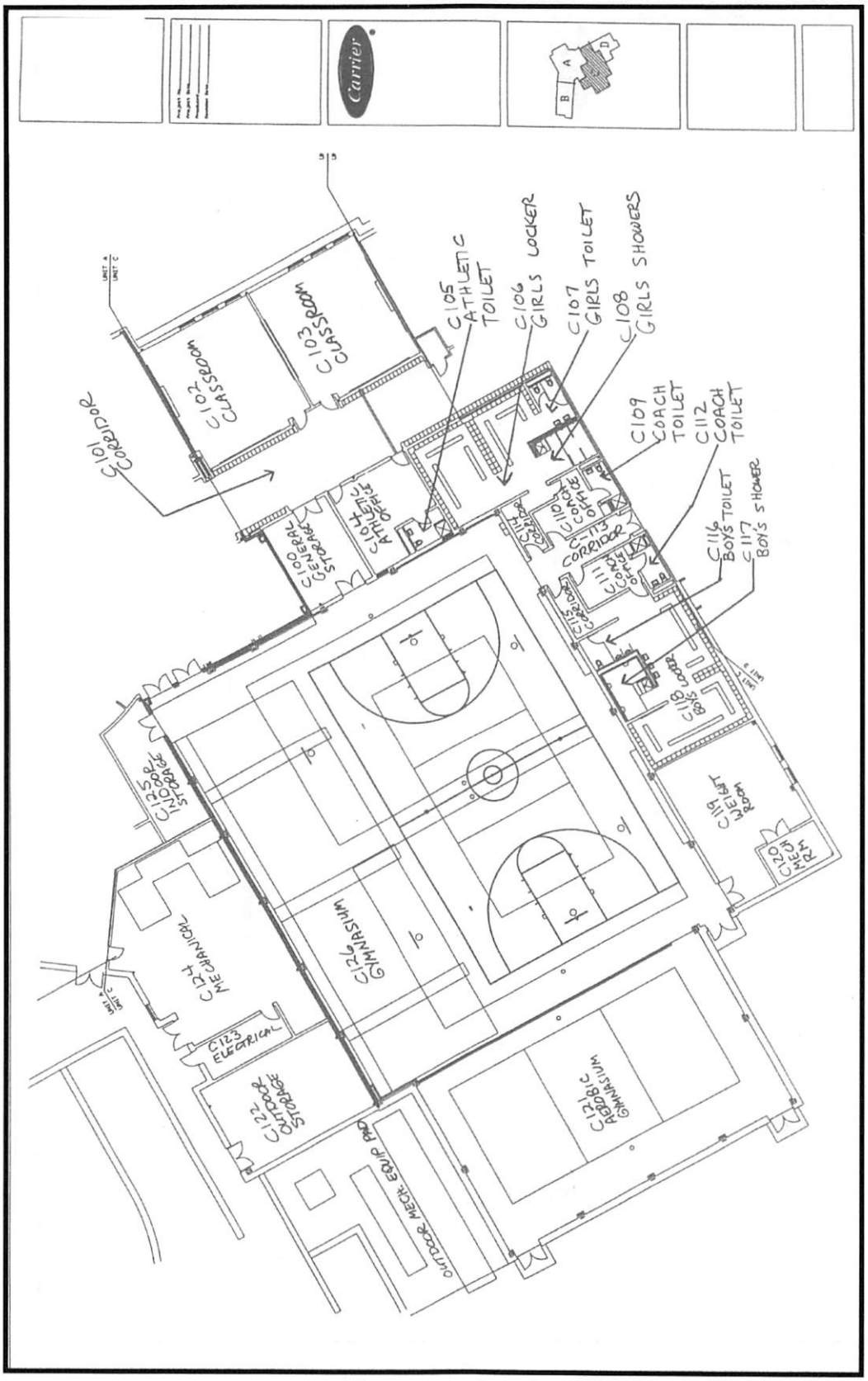

Figure 4 - Section "C" Floor Plan

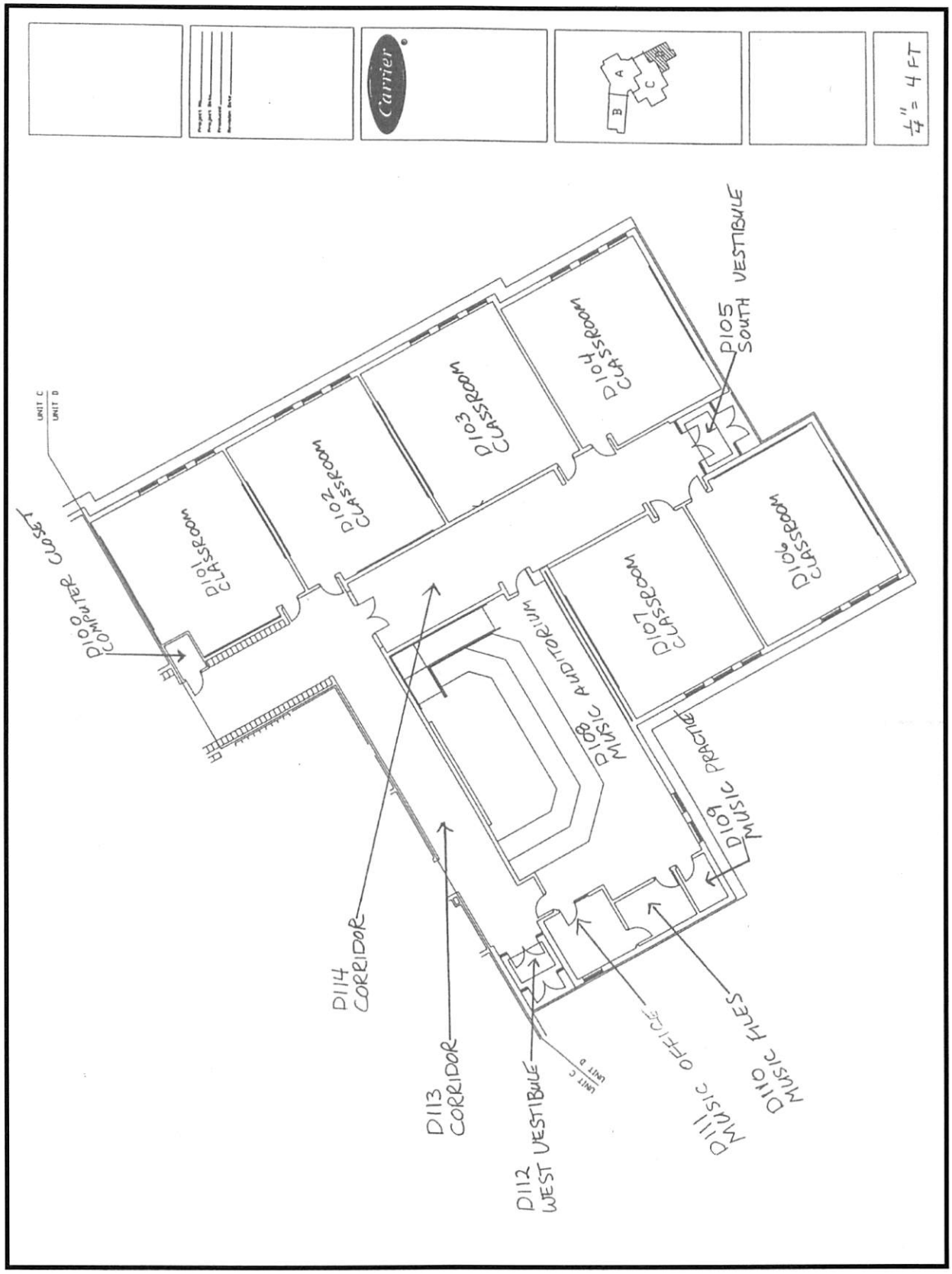

Figure 5 - Section "D" Floor Plan

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Workshop #1

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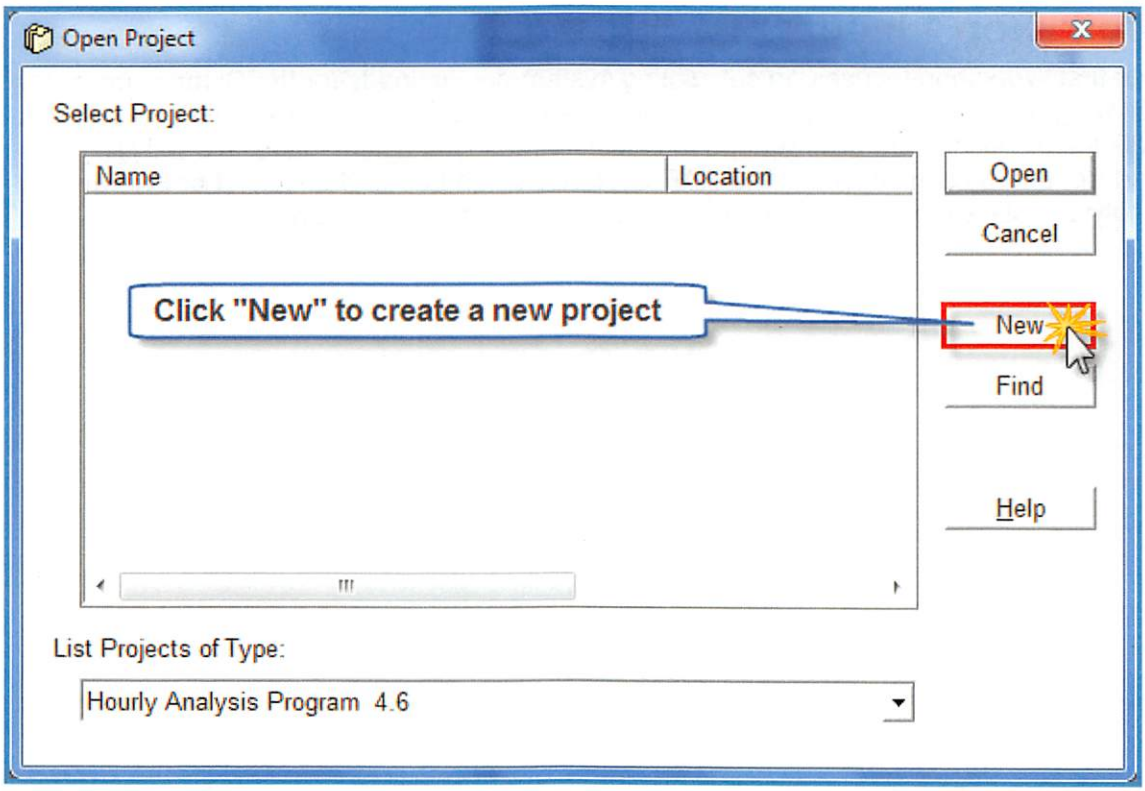
Workshop 1 Inputs

Our first Workshop focuses on calculating system design loads for the Gymnasium in the "C" wing, which the school and community use most of the year. This workshop includes defining all building details required to calculate the Gymnasium loads. We will NOT perform energy simulations in the HAP System Design Loads Seminar. (For Energy Analysis details please refer to our HAP for Energy Simulation training seminar.



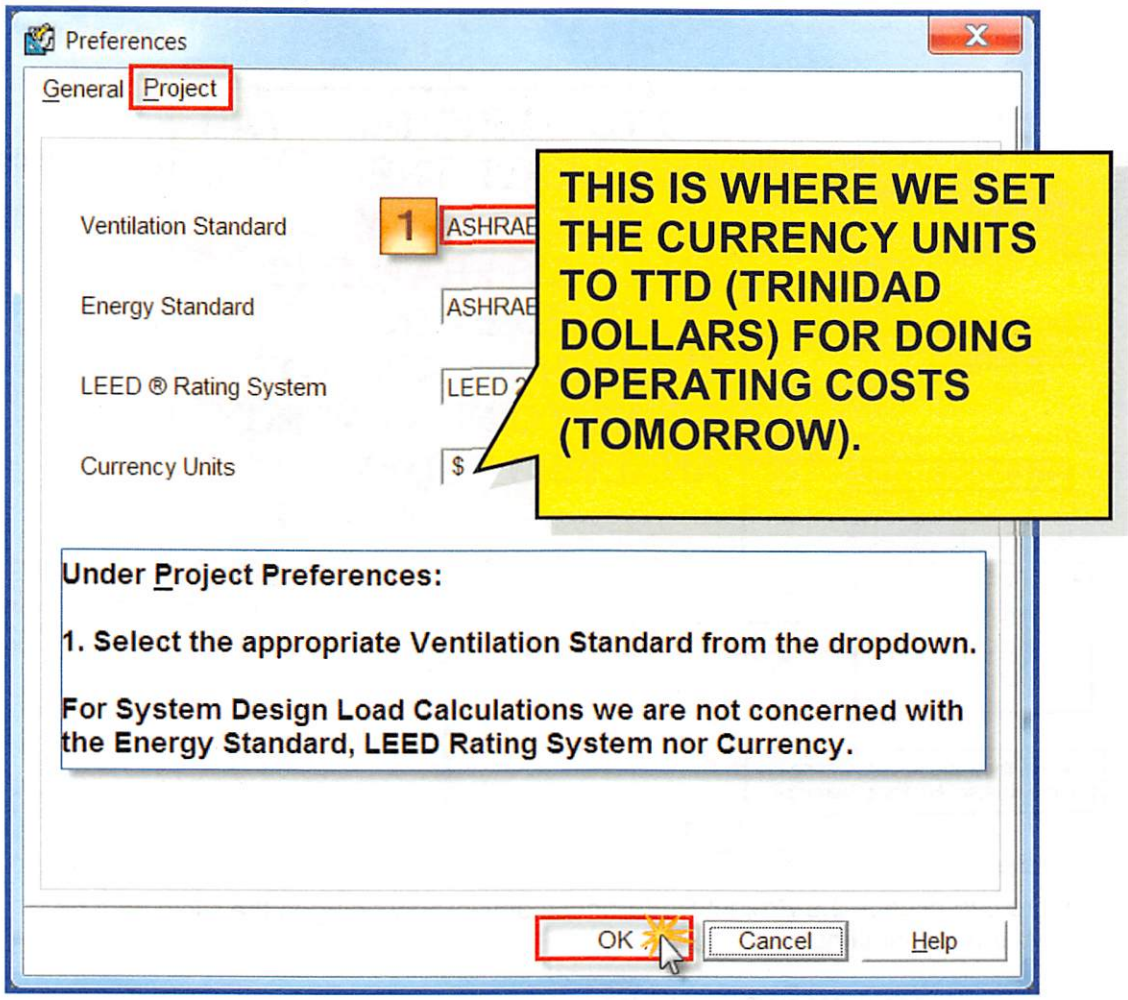
Setting Project Preferences

Once we create the New Project, HAP prompts us to choose the applicable ventilation standard for the project. This first step in our design process links our project to the appropriate database in determining the ventilation requirements for the spaces and air systems in our project. The choices include:

- User Defined
- ASHRAE 90.1-2004
- ASHRAE 90.1-2007
- ASHRAE 90.1-2010

OUR ARCHIVE HAS SET THE PREFERENCES TO ASHRAE VENTILATION STANDARD 62.1 2013 ....WE WILL USE THAT!

Figure 1.3 - Setting Project Preferences

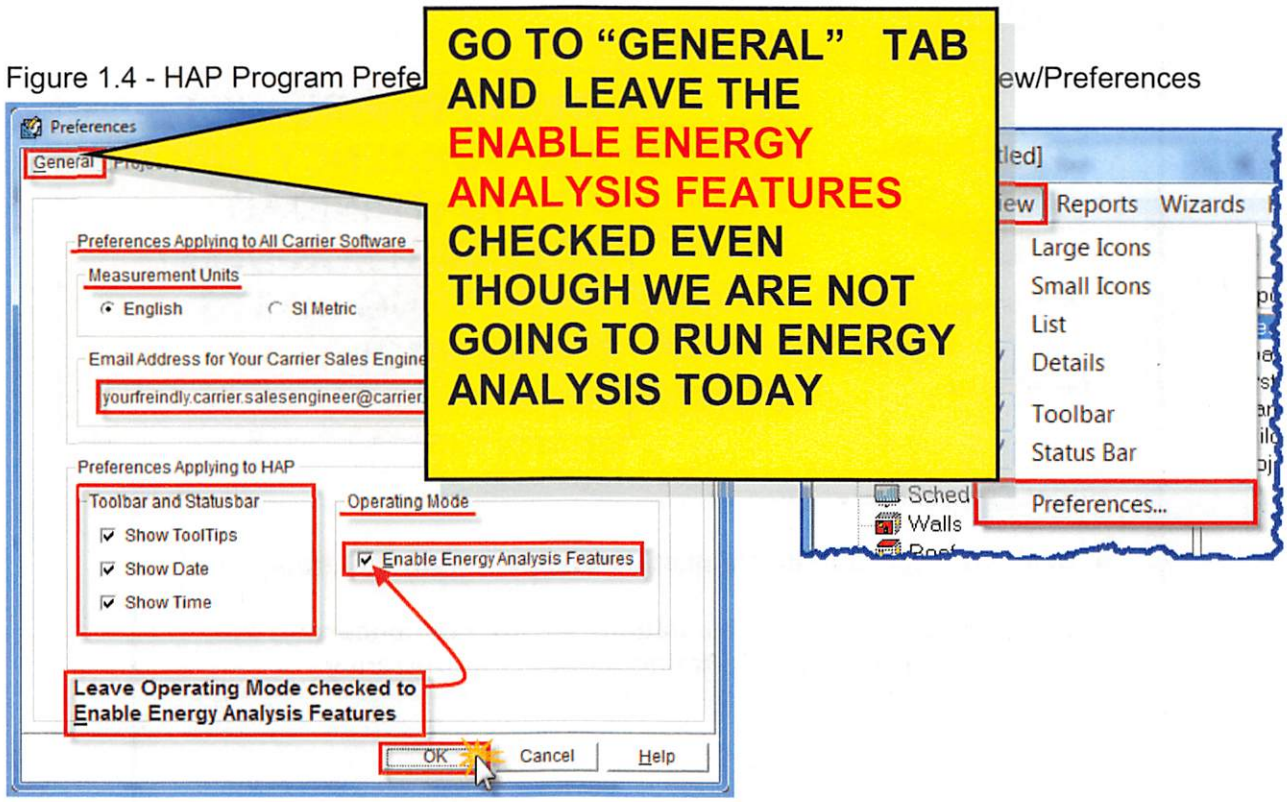


Select the ASHRAE 62.1-2007 Ventilation Standard for our workshop and class project.

Users can also set HAP program preferences under the General Tab. Please refer to Figures 1.4 and 1.5 below for additional details of the General HAP program preferences.

Change the currency units to TTD (TRINIDAD DOLLARS)
This is only used for running operating costs however.

Figure 1.4 - HAP Program Prefe ew/Preferences



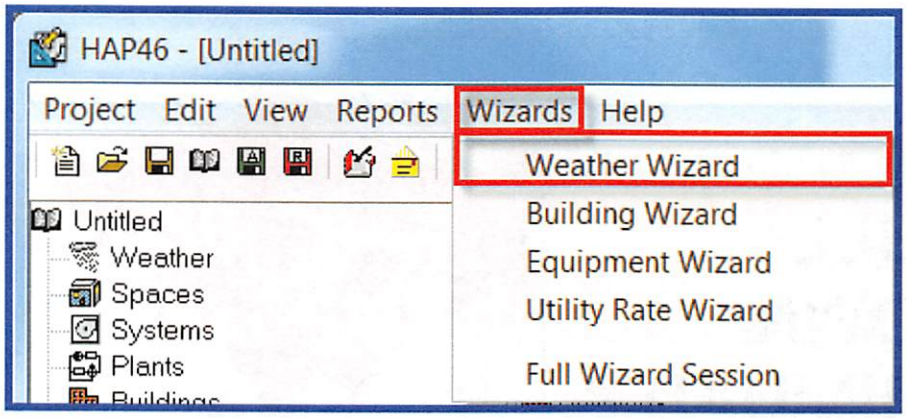
Note: Users can access the Project Preferences anytime by going to the View item on the menu bar and selecting .

Enter Design Weather Properties

Next, we define the project design weather properties using one of the following methods. We can assign the defaulted ASHRAE design weather properties by using the "Weather Wizard" or using the Weather Properties input forms. Let's first look at the Weather Wizard.

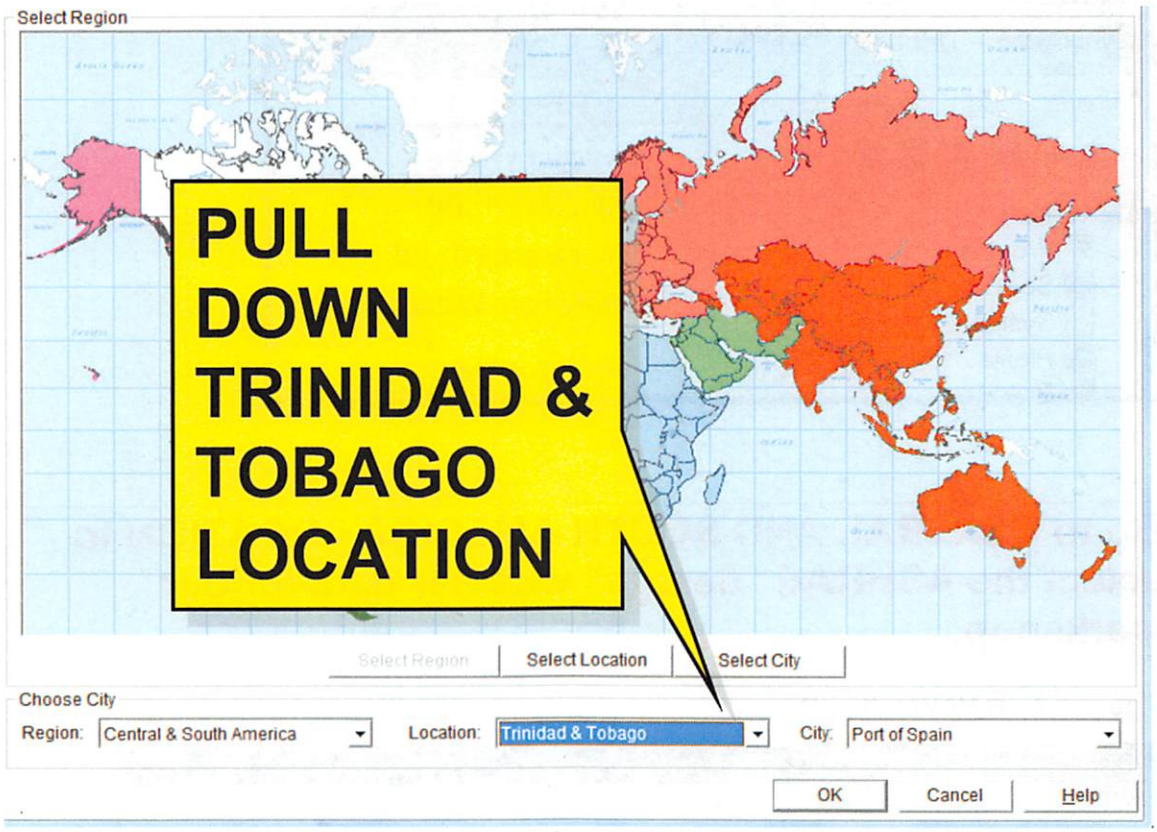
Go to the "Wizards" item on the menu bar and select "Weather Wizard." When selecting the weather wizard, HAP presents the following graphical interface where the user selects the region, location and city either from the drop down or by clicking on the map. Refer to Fig 1.6 and 1.7 below for details.

Figure 1.6 - Selecting Weather Wizard



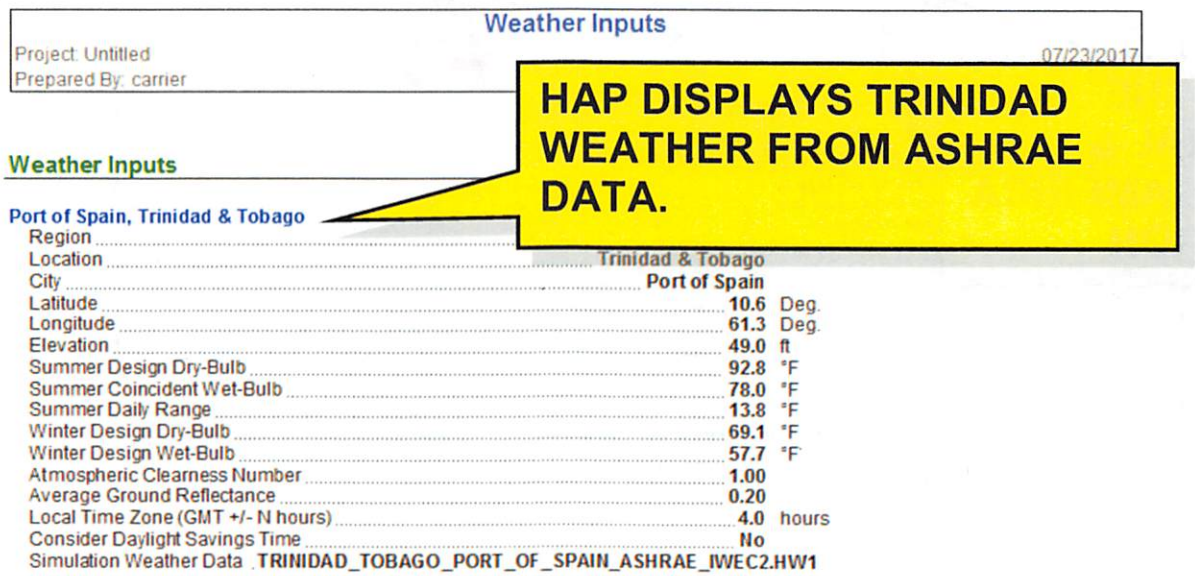
Go to CENTRAL AND SOUTH AMERICA LOCATION to select the ASHRAE "design" weather data for our workshop.

Figure 1.7 - HAP Weather Wizard



Once the user selects the Region, the next selection is Location. This defaults to the ASHRAE 0.4% summer design conditions and 99.6% winter design conditions. After selecting the weather properties HAP generates the following Weather Wizard Input Summary shown in Fig.1.8.

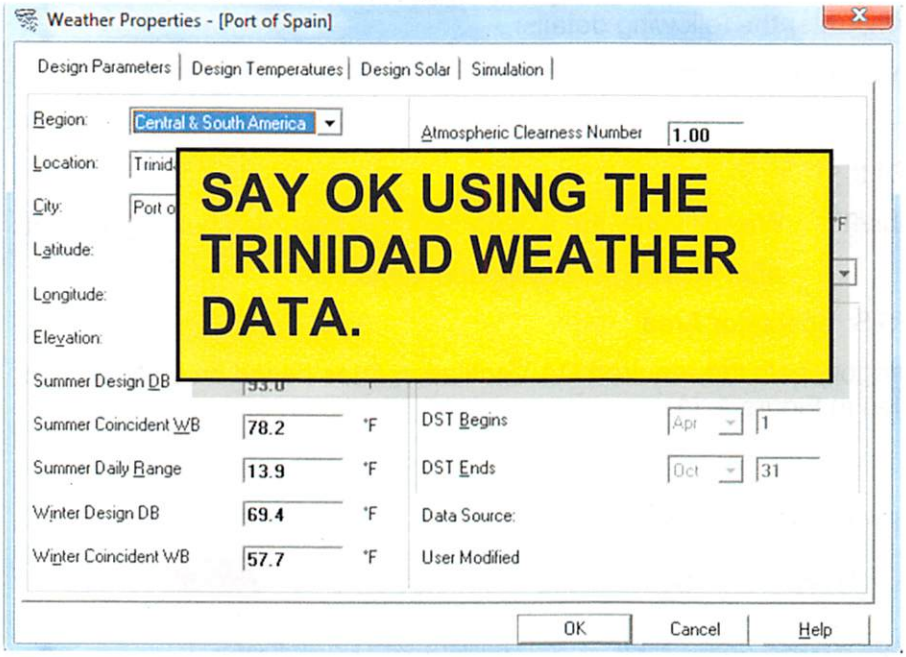
Figure 1.8 - Weather Wizard Properties



After accepting the wizard inputs HAP converts the Wizard Data to the HAP interface as shown in Fig 1.9.

Once HAP converts the Wizard Data to HAP data, the user can return to HAP and edit any of the wizard created data by accessing the weather properties input forms as shown in Figure 1.10.

1.10 - HAP Design Weather Properties Form.



SAY OK USING THE TRINIDAD WEATHER DATA.

THAT EXERCISE SHOWED US HOW TO USE THE WEATHER WIZARD. FOR OUR WORKSHOP WE WILL NOW IMPORT A HAP ARCHIVE WITH THE TRINIDAD WEATHER DATA ALREADY CONFIGURED:

1. **OPEN A "NEW" PROJECT. SAY "OK" TO PREFERENCES**
2. **GO TO 'PROJECT", "RETRIEVE HAP 5.0 DATA"**
3. **BROWSE TO THE DESKTOP AND YOUR FOLDER "2. CLASS FLASH DRIVE TRINIDAD 2017.**

4. **DOUBLE CLICK ON THE FOLDER CALLED "1. HAP ARCHIVES LOADS AND ENERGY"**
5. **HIGHLIGHT AND OPEN "UNSOLVED LOADS AND ENERGY"**
6. **HIGHLIGHT "TRINIDAD LOADS UNSOLVED 2017 POS"**
7. **OPEN THEN RETRIEVE IT INTO HAP**
8. **CLICK "PROJECT" "SAVE AS" AND KEEP THE SAME TITLE**

Enter Space Data FOR GYM SPECTATOR AREA FIRST

The next step in our workshop is entering the space data for the gymnasium. We can also create the library items from the space input form or from the individual library item icons. To expedite our hands-on workshop we choose to enter the library items data from the space input forms. The next series of exercises include defining the space configuration and creating fractional schedules, walls, roofs and doors.

Enter the Gymnasium Space data into the Space input form. Under the General tab in the space input form, enter the following details:

Space Name: C126A Gym Spectators

Floor Area: 5668 ft²

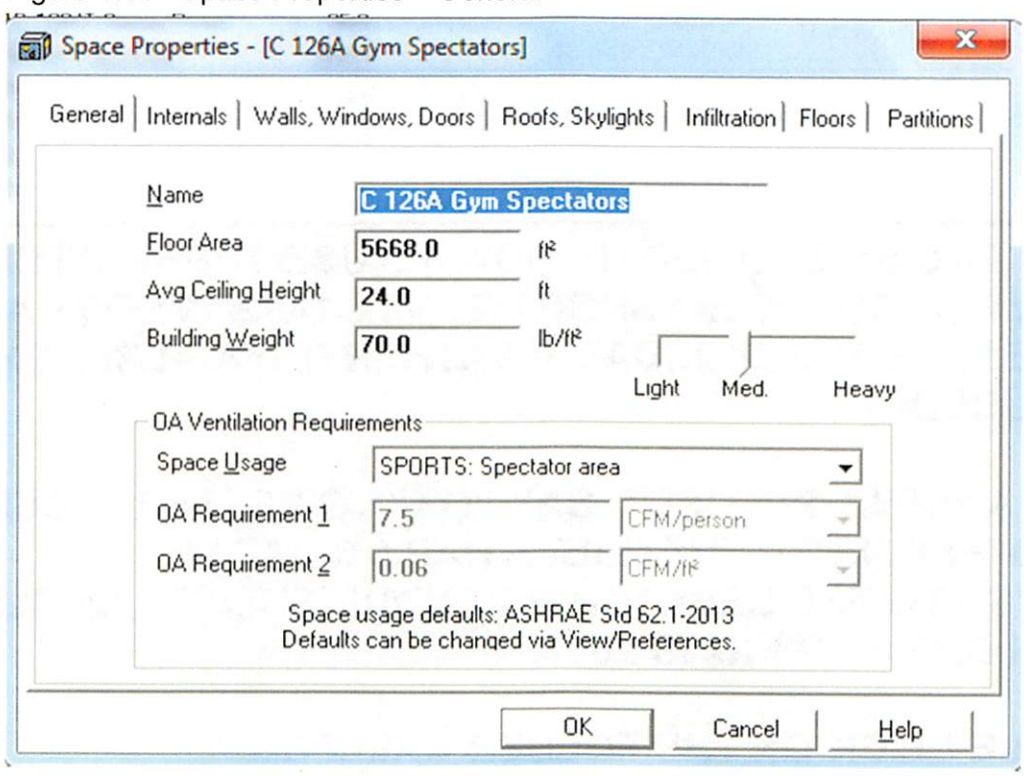
Ave Ceiling Height: 24 ft.

Building Weight: 70 lbs/ft². We will verify the accuracy of this assumed building weight after creating the envelope items.

Space Usage: SPORTS: Spectator Area

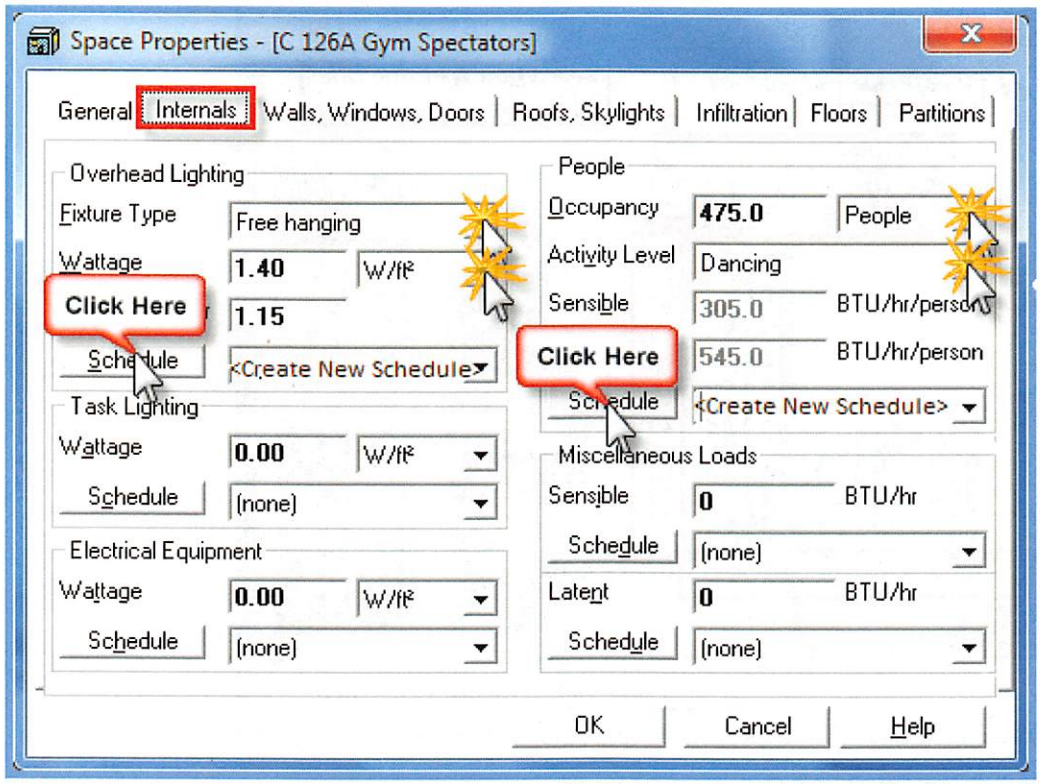
This space usage category sets the required OA Ventilation rates based on CFM/person and CFM/ft² as detailed in Figure 1.11.

Figure 1.11 - Space Properties – General



Click on the Internals tab and enter the following information detailed in Figure 1.12

Figure 1.12 - Space Properties – Internals



To create and link the fractional schedules to the internal loads, simply click on the Schedule button and create the profiles as defined in Figure 1.13 through Figure 1.15.

Figure 1.13 - Fractional Schedule – **Lights Gym**

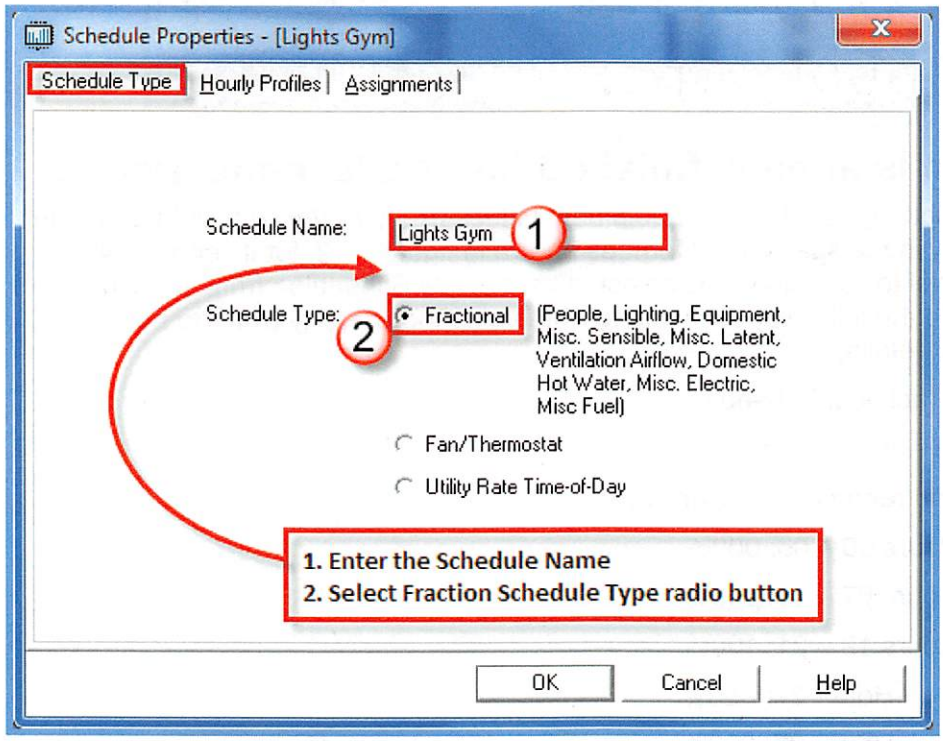


Figure 1.14 – Lights Gym – Configure Hourly Profile 1

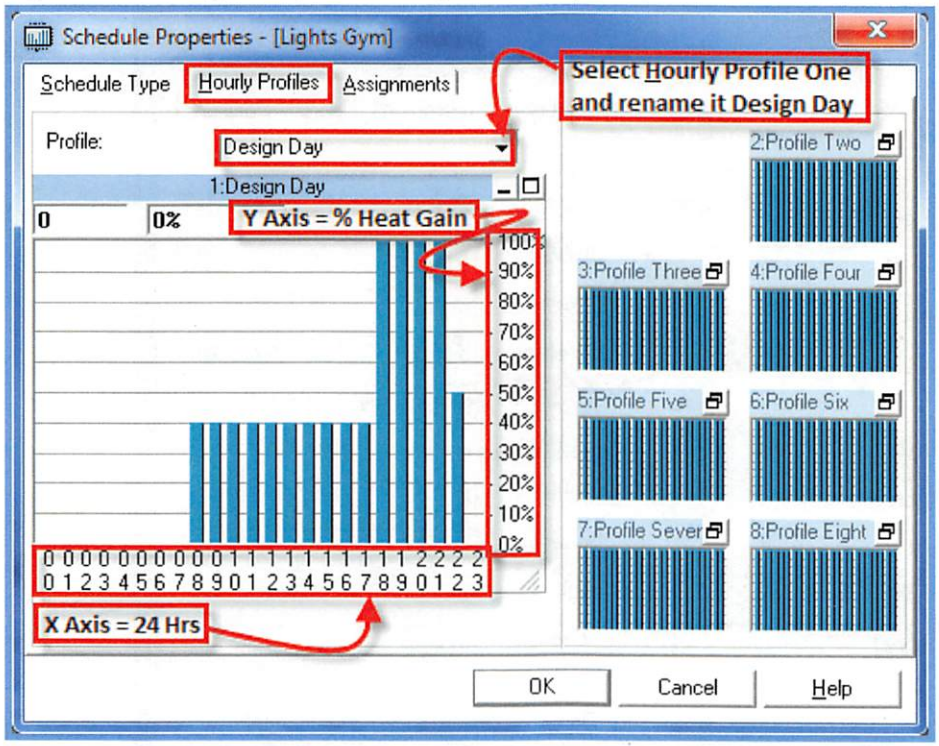


Figure 1.15 – Lights Gym - Assign Hourly Profile 1 to Design Day

People Gym is already finished for Loads in the archive.

Leave the Task Lighting and Electric Equipment values at 0.00 W/ft². Highlight and enter the people density in the space input form as shown in figure 1.12, total people = 475. Set the activity level to "Dancing" and select <Create New Schedule> from the schedule drop-down. Create the following schedule for the occupancy density (refer to Figures 1.16a, b and c for details).

Schedule Type: Fractional Schedule

Schedule Name: People – Gym

Select Profile 1 and rename it "Design Day"

Hourly Profiles: Hours 00 – 06: 000%

Hours 07 – 18: 005%

Hours 19 – 21: 100%

Hour - 22: 050%

Hour - 23: 000%

Assignments: Assign Profile 1 to Design Day for all Months

Figure 1.16a - **People Schedule for Gymnasium**

Figure 1.16b - People Gym Hourly Profiles

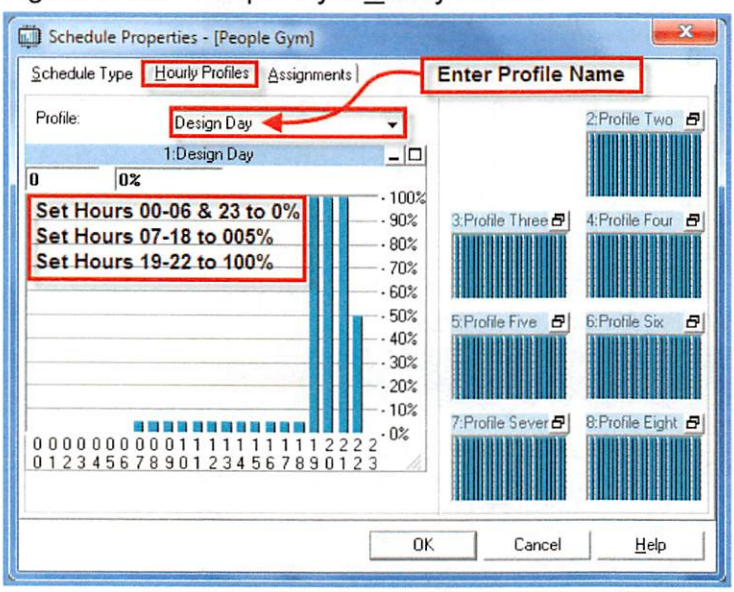
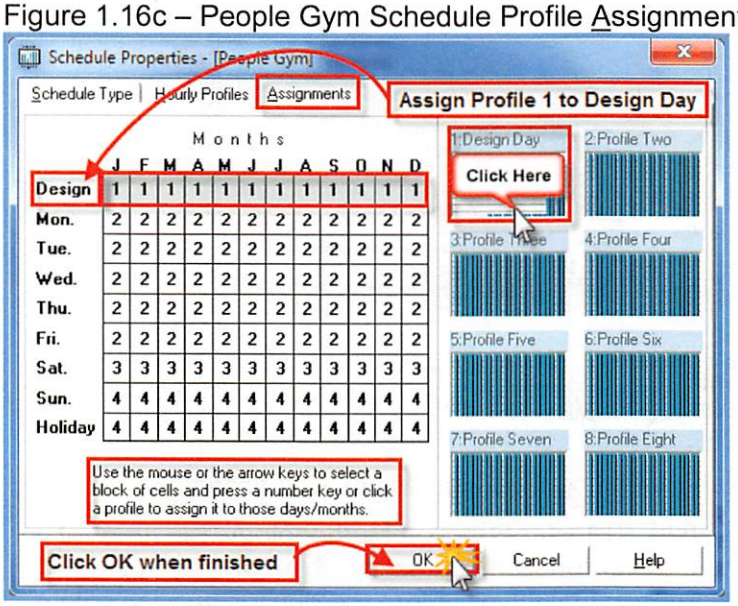


Figure 1.16c – People Gym Schedule Profile Assignments



There are no miscellaneous sensible and/or miscellaneous latent loads in this space input.

Create Gymnasium Wall, Window, Door and Roof Assemblies

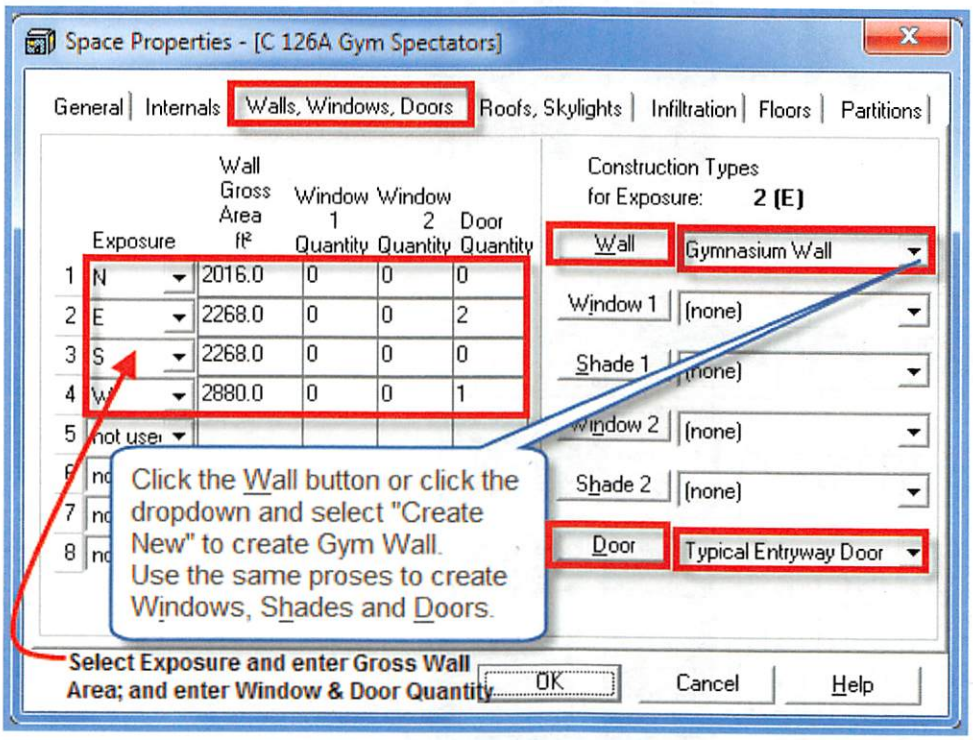
Click on the "Walls, Windows, Doors" tab to move to the next input form. In this input form, we create the envelope items for the Gymnasium beginning with the wall assembly. Please enter the details found in Table 1.1 and Figure 1.17 for the gymnasium Walls. We simplified the actual Gymnasium footprint to focus on the inputs as opposed to the building geometry. Please refer to Figures 1.17 – 1.19 for wall assembly details, Figure 1.20 for Door input details and Figure 1.21 for Roof Assembly details.

The "gross wall areas" and "door quantity" for the four (4) exposures are:

Table 1.1 - Walls, Windows, Doors Exposures, Area and Quantity

Exp.	Wall Gross Area (ft²)	Window 1 Qty.	Window 2 Qty.	Door 1 Qty.
N	2016.0	0	0	0
E	2268.0	0	0	2
S	2268.0	0	0	0
W	2880.0	0	0	1

Figure 1.17 - Space Properties – Walls, Windows & Doors



Please refer to the following details for creating the Gymnasium Wall assembly.

NOTE: Because HAP uses the ASHRAE Transfer Function Methodology, the order of the wall property layers impacts the transfer function coefficient of the layer and thus the speed at which the heat gain transfers to the next wall layer. The outside surface color impacts the assembly's ability to reflect the solar heat back out to the atmosphere.

HAP's defaults outside surface colors are Light, Medium and Dark, with default absorptivity values of 0.45, 0.675 and 0.90 respectively. The user can also enter a known absorptivity value.

To enter an equivalent to the reflectance or reflectivity value, simply take 1.0 – reflectivity value = absorptivity value. So, if the outside surface color has a reflectivity value of 0.30 the resulting Absorptivity is 1.0 – 0.30 reflectivity = 0.70 absorptivity. Please refer to Figures 1.16 through 1.18 for additional details.

Figure 1.18 - Wall Properties Form

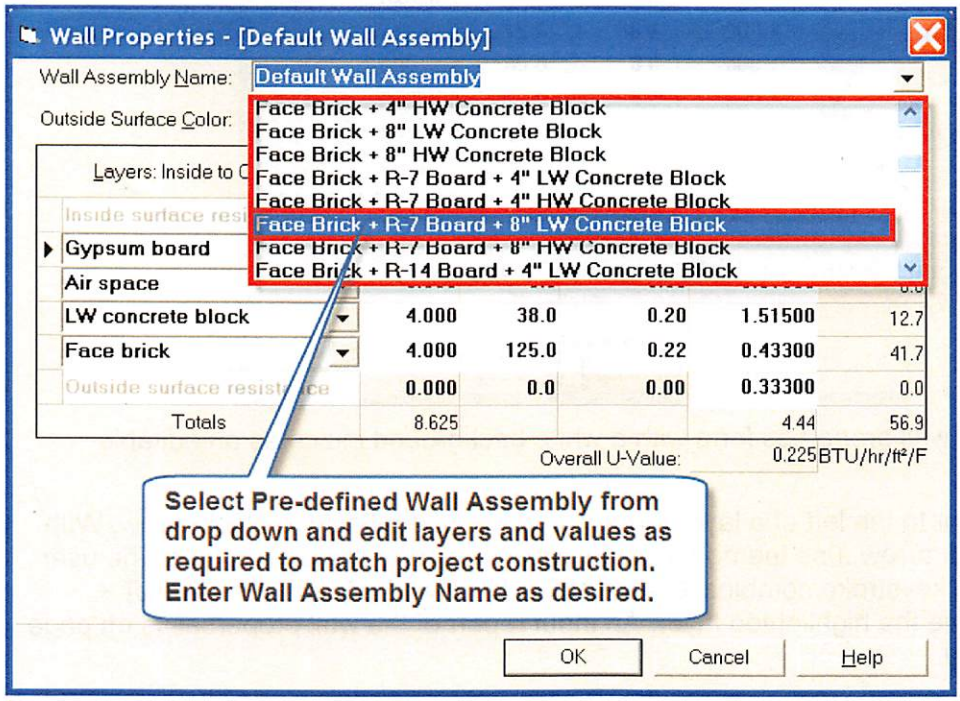


Figure 1.19 - Add/Remove/Edit Layers in Wall Properties Form

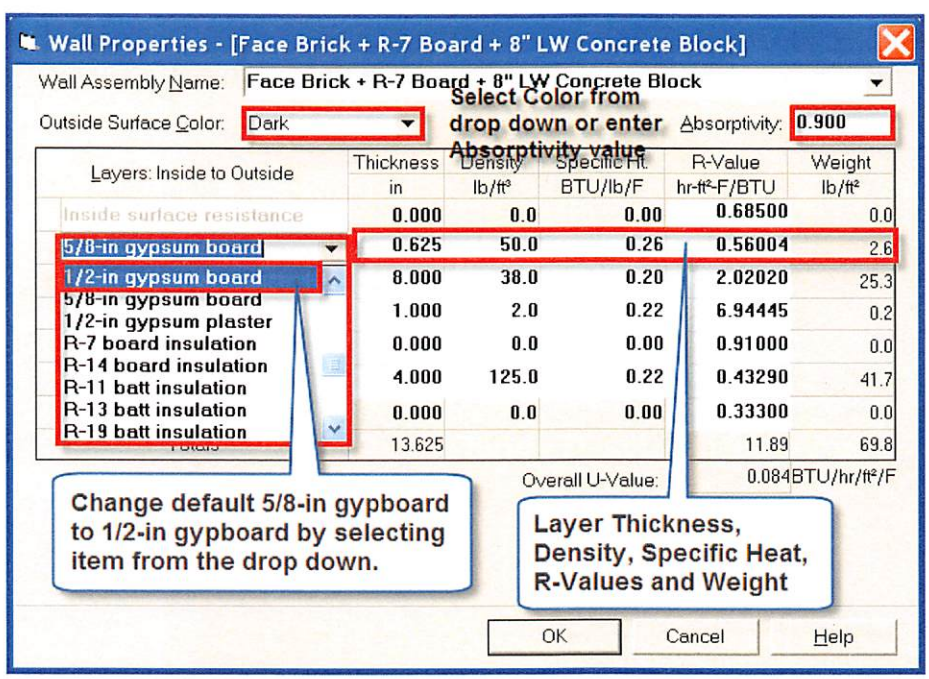
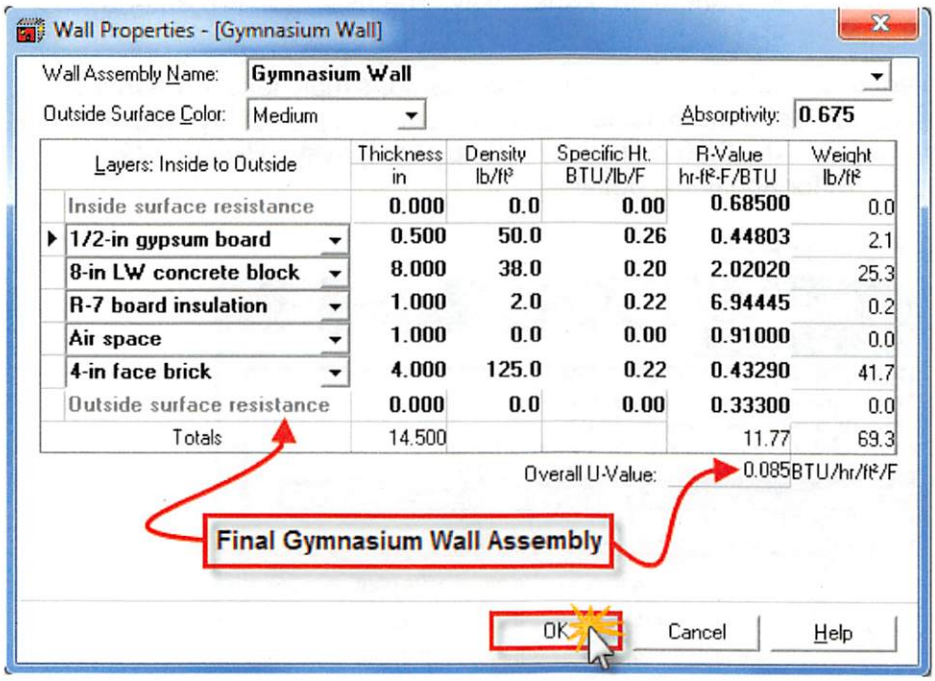


Figure 1.20 – **FINAL Gymnasium Wall Properties**



Layers: Inside to Outside	Thickness in	Density lb/ft³	Specific Ht. BTU/lb/F	R-Value hr-ft²-F/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
1/2-in gypsum board	0.500	50.0	0.26	0.44803	2.1
8-in LW concrete block	8.000	38.0	0.20	2.02020	25.3
R-7 board insulation	1.000	2.0	0.22	6.94445	0.2
Air space	1.000	0.0	0.00	0.91000	0.0
4-in face brick	4.000	125.0	0.22	0.43290	41.7
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	14.500			11.77	69.3

Each field in the wall properties form with a white background indicates an editable value.

Moving the cursor to the left of a layer turns the cursor into a flashing black arrow. With the flashing black arrow, use the right mouse click to insert or remove a layer. The user can also use the keystroke combination of <ALT + Insert> to add a layer or <ALT + Delete> to remove the highlighted layer. An input report of the wall properties is on page 53 of this manual.

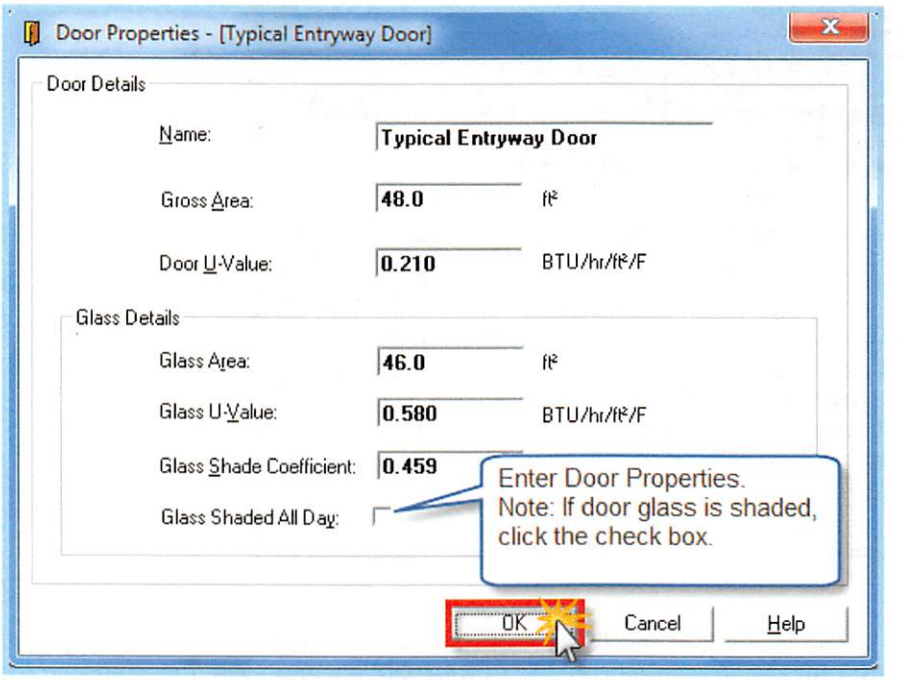
DOORS (ALREADY IN THE ARCHIVE)

While in the Walls, Windows, Doors tab and at the exposure with doors, perform the following steps to add the door assembly to the library items and assign it to the wall exposure as detailed in Figure 1.17. Please enter the following door properties:

Door Name: Typical Entry Doors

Gross Area:	48 ft²
Door U-Value:	0.210
Glass Area:	46 ft²
Glass U-Value:	0.580
Shade Coefficient:	0.459
Shaded all day:	No

Figure 1.21 - Door Properties Form

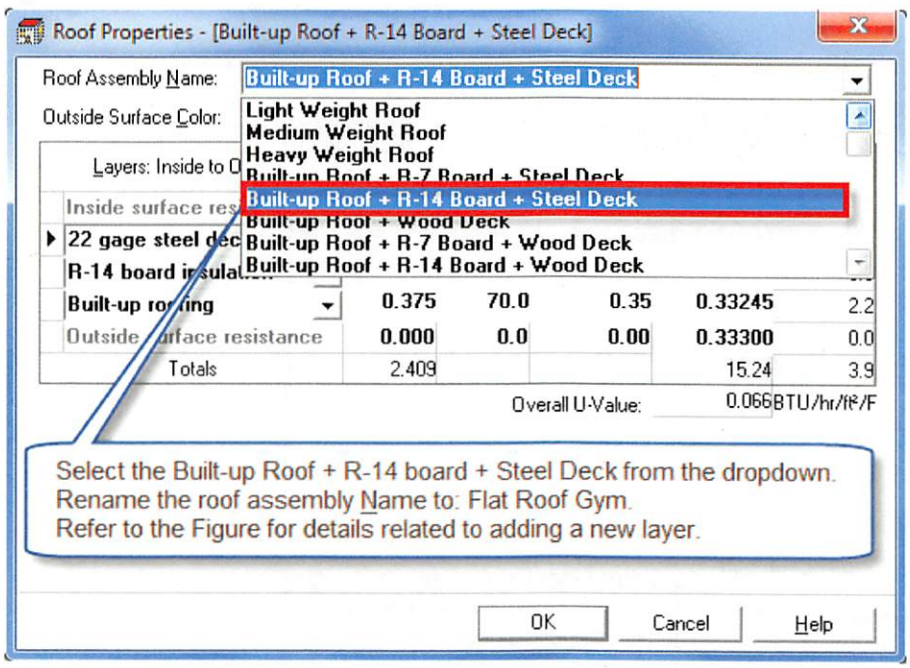


Please assign two (2) doors to the East and one (1) door to the West exposure.

Next, we move to the **Roofs, Skylights** tab to model our roof construction. The building roof is a flat (horizontal) roof so our exposure is H for horizontal. If we had a pitched roof, we would select the exposure from the drop down and then set the pitch. HAP uses a degree of slope from horizontal in setting the pitch. For equivalent pitch values, press the F1 <Function 1> key when cursor is in the Roof Slope field. This takes us to the context sensitive help for that field, which includes the pitch equivalents. Please refer to Figure 1.22a & b for details.

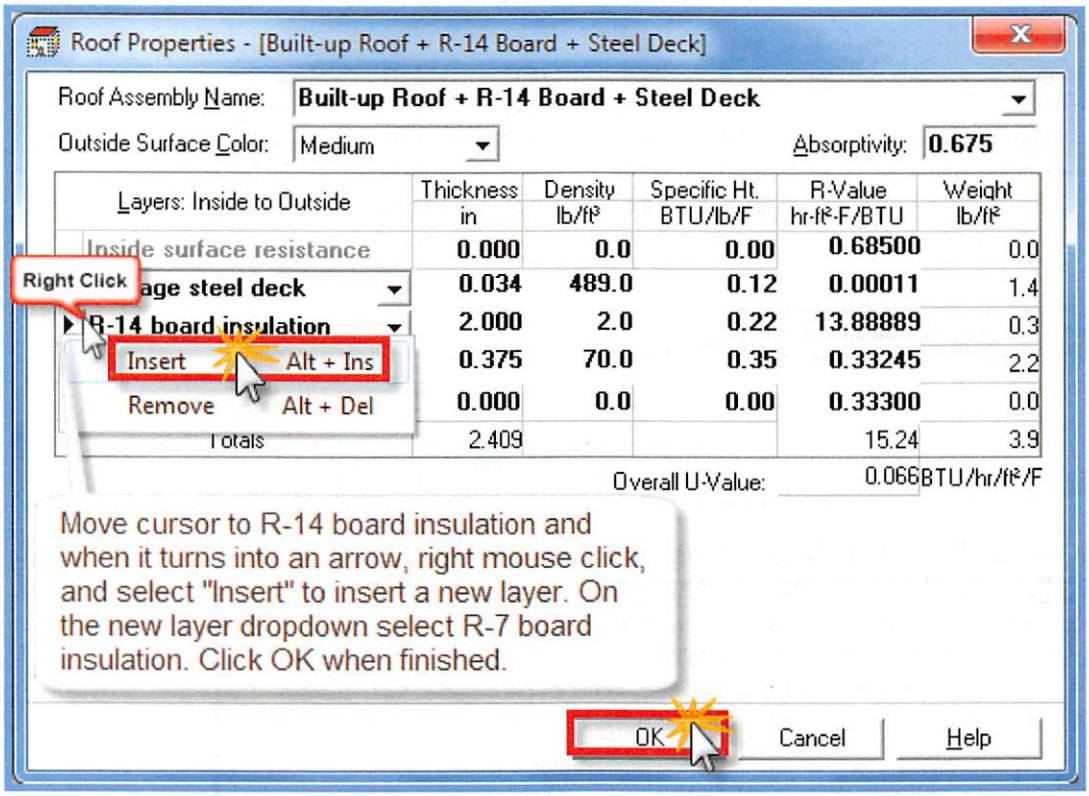
To create our roof select <Create New> from the Roof Construction Type drop down for our horizontal exposure. Select a predefined assembly that either represents or is similar to our roof construction. The Gymnasium roof construction is a "built-up roof + R-14 board insulation + steel deck." Please refer to Figures 1.22a and 1.22b for roof details.

Figure 1.22a - Roof Construction Details



Next move the cursor to the box left of the R-14 board insulation and right mouse click after the cursor turns into an arrow. Select "Insert" to add a layer and select R-7 board insulation from the drop down as detailed in figure 1.22b below.

Figure 1.22b – Roof Construction Details-**Insert a New Layer OF R-7 BOARD ABOVE THE R-14 BOARD**



Left clicking the OK button creates the Transfer Function Coefficients, returns us to the space input form and assigns the new roof to our space.

Press F1 to access the revised context-sensitive, on-line HELP system.

Figure 1.23a – **Final Gymnasium Roof Assembly**

(BELOW)

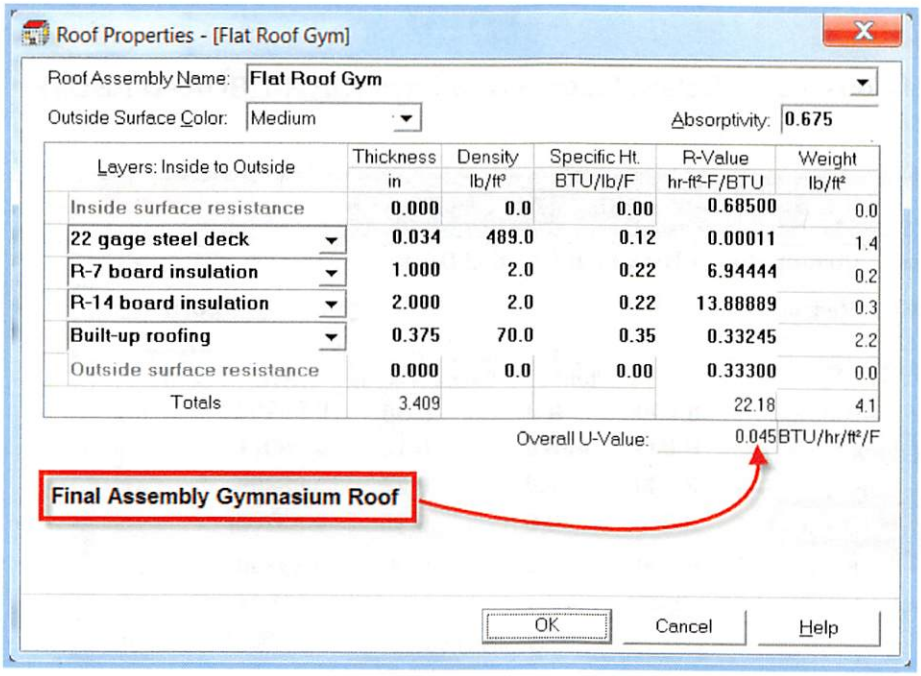


Figure 1.23b - Degree of Slope conversion to Roof Pitch

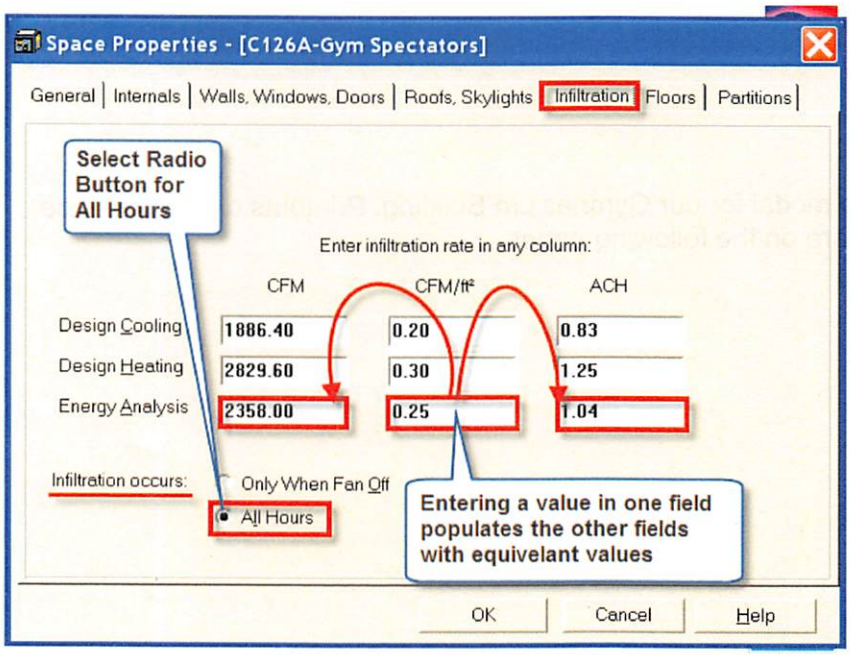
- **Roof Slope.** When a roof exposure other than horizontal is specified, the user is asked to define the slope of the roof in degrees. Roof slope is measured from horizontal. Thus a 60 degree roof slope is steeper than a 30 degree roof slope.

In some cases building plans specify roof slope in terms of pitch rather than degrees. The following table is provided to assist you in converting common pitch specifications to degrees.

Pitch (rise:run)	Slope in degrees from Horiz	Pitch (rise:run)	Slope in degrees from Horiz
1:12	5°	1:10	6°
2:12	9°	1:9	6°
3:12	14°	1:8	7°
4:12	18°	1:7	8°
5:12	23°	1:6	9°
6:12	27°	1:5	11°
7:12	30°	1:4	14°
8:12	34°	1:3	18°
9:12	37°	1:2.5	22°
10:12	40°	1:2	27°
11:12	43°	1:1.5	34°
12:12	45°	1:1	45°

Next, click on the Infiltration tab of the space properties. According to ASHRAE the "Typical air leakage values per unit wall area at 0.30" of water are 0.10, 0.30 and 0.60 cfm/ft² for tight, average and leaky walls respectively (Tamura and Shaw 1976a). With that said, we assume our building has average wall construction and model infiltration as 0.20 cfm/ft² for cooling and 0.30 cfm/ft² for heating. Entering these cfm/ft² values automatically populates the other input categories of CFM and ACH. We also assume infiltration for all hours. Please refer to Figure 1.24 for details.

Figure 1.24 - **Infiltration input**



The next tab in the space input form is the Floor tab where we enter the floor details. The floor area populates based on the value entered under the general tab "Floor Area" input. We must select the appropriate radio button for our floor location. Our project is an unheated slab-on-grade construction and therefore only requires the following inputs. Please enter these values into the Floor Properties screen.

Floor Area:	5668.0 ft²
Total Floor U-Value:	0.087 BTU/Hr/ft²/°F
Exposed Perimeter:	24.0 ft.
Edge Ins. R-Value:	0.00

Be sure to check with the local code officials having jurisdiction for the minimum construction requirements for your municipality.

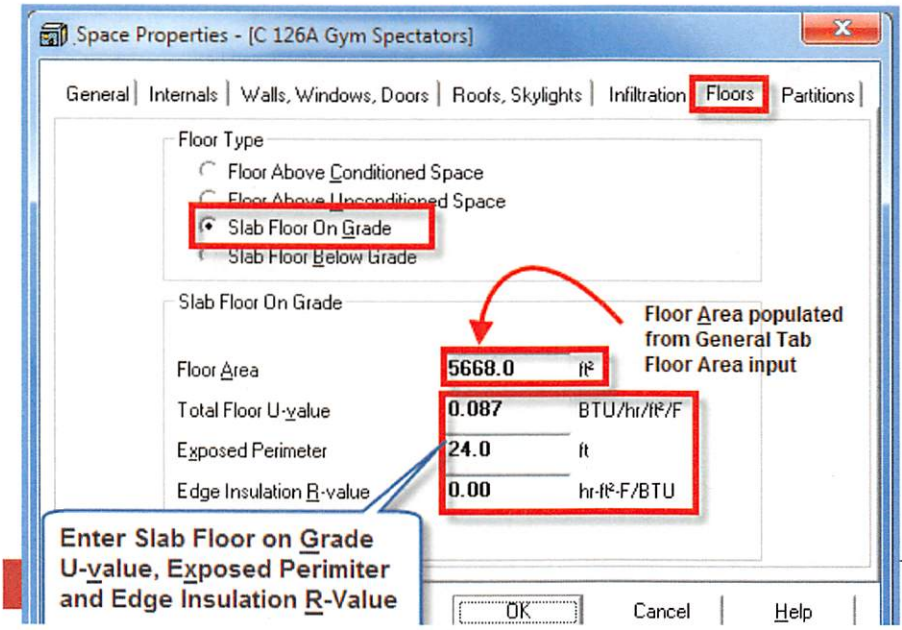


Figure 1.25 - Floor Input Form

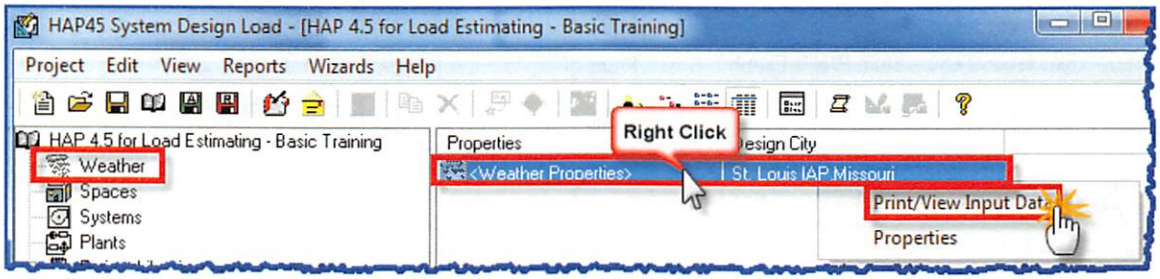
There are no partitions to model for our Gymnasium Building. Printouts of all the Space inputs and Library items are on the following pages.

The Second Space, C126B Gym Play Area is already built in your archive. Let's review it…..

Space details are on pages 54-57.

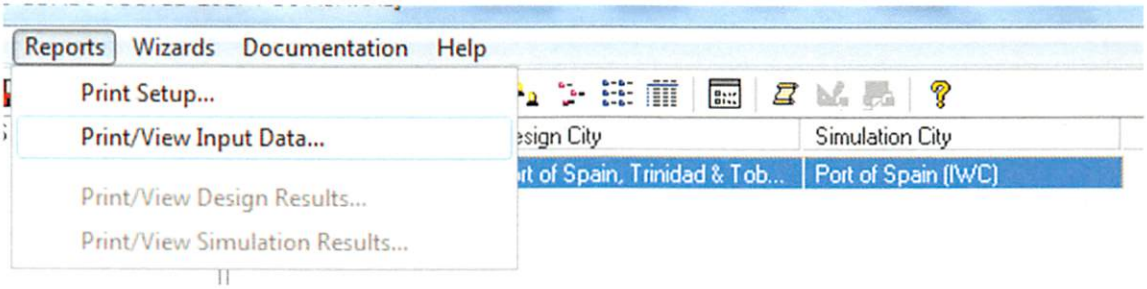
To generate the input reports highlight and right mouse click the item in the main program screen, and select view input data as detailed in Figure 1.26a below.

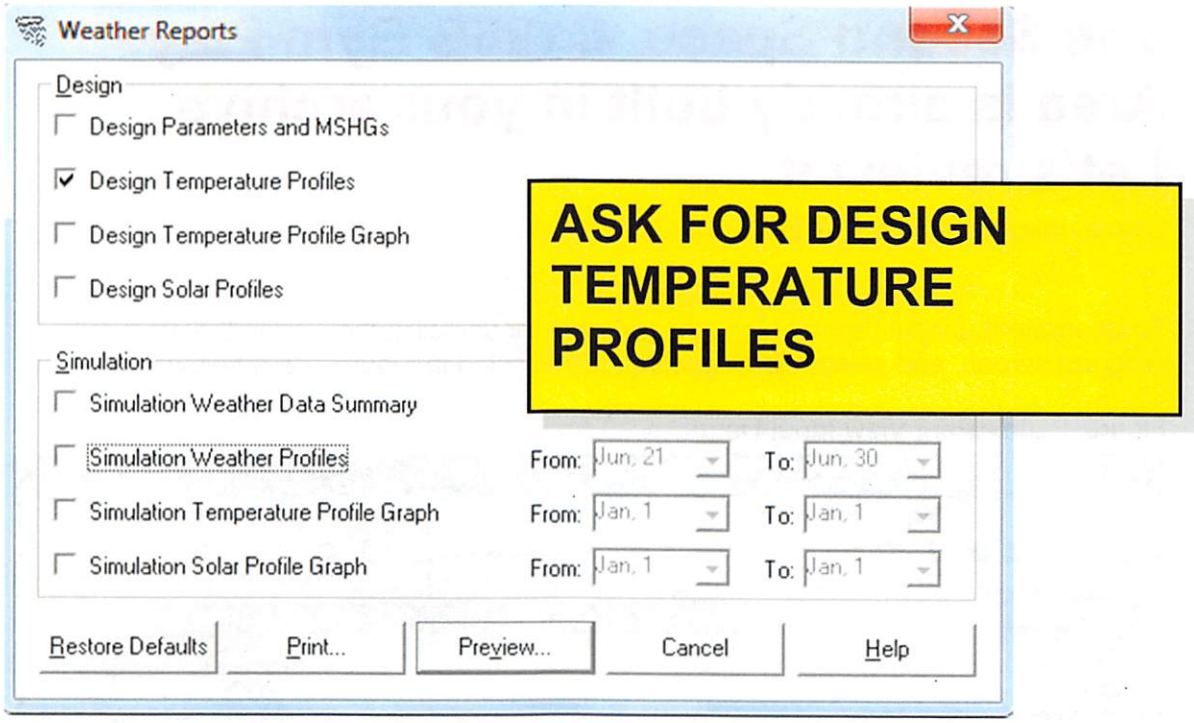
Figure 1.26a - Print View Input Data



Select any report you want and click on the Preview button as shown in Figure 1.26b.

Figure 1.26b Preview Weather Reports




Weather Reports
Design
Design Parameters and MSHGs
Design Temperature Profiles
Design Temperature Profile Graph
Design Solar Profiles
Simulation
Simulation Weather Data Summary
Simulation Weather Profiles
From: Jun, 21
To: Jun, 30
Simulation Temperature Profile Graph
From: Jan, 1
To: Jan, 1
Simulation Solar Profile Graph
From: Jan, 1
To: Jan, 1
Restore Defaults
Print...
Preview...
Cancel
Help
ASK FOR DESIGN TEMPERATURE PROFILES

Location: Port of Spain, Trinidad & Tobago

(Dry and Wet Bulb temperatures are expressed in °F)

Hr	January		February		March		April		May		June	
	DB	WB	DB	WB	DB	WB	DB	WB	DB	WB	DB	WB
0000	71.6	68.8	73.6	69.9	76.6	72.1	77.6	73.1	78.6	74.2	80.6	75.3
0100	70.9	68.6	72.9	69.7	75.9	71.9	76.9	72.9	77.9	74.0	79.9	75.1
0200	70.2	68.4	72.2	69.5	75.2	71.7	76.2	72.7	77.2	73.8	79.2	74.9
0300	69.7	68.3	71.7	69.3	74.7	71.5	75.7	72.6	76.7	73.7	78.7	74.7
0400	69.2	68.1	71.2	69.2	74.2	71.4	75.2	72.5	76.2	73.6	78.2	74.6
0500	69.1	68.1	71.1	69.2	74.1	71.3	75.1	72.4	76.1	73.5	78.1	74.6
0600	69.4	68.2	71.4	69.3	74.4	71.4	75.4	72.5	76.4	73.6	78.4	74.7
0700	70.1	68.4	72.1	69.5	75.1	71.6	76.1	72.7	77.1	73.8	79.1	74.9
0800	71.3	68.8	73.3	69.8	76.3	72.0	77.3	73.1	78.3	74.1	80.3	75.2
0900	73.1	69.3	75.1	70.4	78.1	72.5	79.1	73.6	80.1	74.6	82.1	75.7
1000	75.2	69.9	77.2	71.0	80.2	73.1	81.2	74.1	82.2	75.2	84.2	76.2
1100	77.6	70.7	79.6	71.7	82.6	73.7	83.6	74.8	84.6	75.8	86.6	76.8
1200	79.8	71.3	81.8	72.3	84.8	74.3	85.8	75.4	86.8	76.4	88.8	77.4
1300	81.5	71.8	83.5	72.8	86.5	74.8	87.5	75.8	88.5	76.8	90.5	77.8
1400	82.6	72.1	84.6	73.1	87.6	75.1	88.6	76.1	89.6	77.1	91.6	78.1
1500	83.0	72.2	85.0	73.2	88.0	75.2	89.0	76.2	90.0	77.2	92.0	78.2
1600	82.6	72.1	84.6	73.1	87.6	75.1	88.6	76.1	89.6	77.1	91.6	78.1
1700	81.6	71.8	83.6	72.8	86.6	74.8	87.6	75.8	88.6	76.8	90.6	77.9
1800	80.1	71.4	82.1	72.4	85.1	74.4	86.1	75.4	87.1	76.5	89.1	77.5
1900	78.3	70.8	80.3	71.9	83.3	73.9	84.3	75.0	85.3	76.0	87.3	77.0
2000	76.5	70.3	78.5	71.4	81.5	73.4	82.5	74.5	83.5	75.5	85.5	76.5
2100	74.9	69.9	76.9	70.9	79.9	73.0	80.9	74.1	81.9	75.1	83.9	76.1
2200	73.5	69.4	75.5	70.5	78.5	72.6	79.5	73.7	80.5	74.7	82.5	75.8
2300	72.4	69.1	74.4	70.2	77.4	72.3	78.4	73.4	79.4	74.4	81.4	75.5

Hr	July		August		September		October		November		December	
	DB	WB	DB	WB	DB	WB	DB	WB	DB	WB	DB	WB
0000	81.6	75.3	81.6	75.3	79.6	74.2	77.6	73.1	74.6	72.1	72.6	69.9
0100	80.9	75.1	80.9	75.1	78.9	74.0	76.9	72.9	73.9	71.9	71.9	69.7
0200	80.2	74.9	80.2	74.9	78.2	73.8	76.2	72.7	73.2	71.7	71.2	69.5
0300	79.7	74.7	79.7	74.7	77.7	73.7	75.7	72.6	72.7	71.5	70.7	69.3
0400	79.2	74.6	79.2	74.6	77.2	73.6	75.2	72.5	72.2	71.4	70.2	69.2
0500	79.1	74.6	79.1	74.6	77.1	73.5	75.1	72.4	72.1	71.4	70.1	69.2
0600	79.4	74.7	79.4	74.7	77.4	73.6	75.4	72.5	72.4	71.4	70.4	69.3
0700	80.1	74.9	80.1	74.9	78.1	73.8	76.1	72.7	73.1	71.6	71.1	69.5
0800	81.3	75.2	81.3	75.2	79.3	74.1	77.3	73.1	74.3	72.0	72.3	69.8
0900	83.1	75.7	83.1	75.7	81.1	74.6	79.1	73.6	76.1	72.5	74.1	70.4
1000	85.2	76.2	85.2	76.2	83.2	75.2	81.2	74.1	78.2	73.1	76.2	71.0
1100	87.6	76.8	87.6	76.8	85.6	75.8	83.6	74.8	80.6	73.8	78.6	71.7
1200	89.8	77.4	89.8	77.4	87.8	76.4	85.8	75.4	82.8	74.3	80.8	72.3
1300	91.5	77.8	91.5	77.8	89.5	76.8	87.5	75.8	84.5	74.8	82.5	72.8
1400	92.6	78.1	92.6	78.1	90.6	77.1	88.6	76.1	85.6	75.1	83.6	73.1
1500	93.0	78.2	93.0	78.2	91.0	77.2	89.0	76.2	86.0	75.2	84.0	73.2
1600	92.6	78.1	92.6	78.1	90.6	77.1	88.6	76.1	85.6	75.1	83.6	73.1
1700	91.6	77.9	91.6	77.9	89.6	76.8	87.6	75.8	84.6	74.8	82.6	72.8
1800	90.1	77.5	90.1	77.5	88.1	76.5	86.1	75.4	83.1	74.4	81.1	72.4
1900	88.3	77.0	88.3	77.0	86.3	76.0	84.3	75.0	81.3	73.9	79.3	71.9
2000	86.5	76.5	86.5	76.5	84.5	75.5	82.5	74.5	79.5	73.4	77.5	71.4
2100	84.9	76.1	84.9	76.1	82.9	75.1	80.9	74.1	77.9	73.0	75.9	70.9
2200	83.5	75.8	83.5	75.8	81.5	74.7	79.5	73.7	76.5	72.6	74.5	70.5
2300	82.4	75.5	82.4	75.5	80.4	74.4	78.4	73.4	75.4	72.3	73.4	70.2

Space Input Summary Report

C 126A Gym Spectators

1. General Details:
Floor Area ..... **5668.0** ft²
Avg. Ceiling Height ..... **24.0** ft
Building Weight ..... **70.0** lb/ft²

1.1. OA Ventilation Requirements:
Space Usage ..... **SPORTS: Spectator area**
OA Requirement 1 ..... **7.5** CFI
OA Requirement 2 ..... **0.06** CFI
Space Usage Defaults ..... **ASHRAE Std 62.1-2007**

WE USED ASHRAE 62.1 2013

2. Internals:

2.1. Overhead Lighting:
Fixture Type ..... **Free Hanging**
Wattage .....**1.40** W/f
Ballast Multiplier **1.15**
Schedule ..... **Lights Gym**

..... BTU/hr/person
Latent **545.0**
..... BTU/hr/person
Schedule ..... **People Gym**

2.2. Task Lighting:
Wattage ..... **0.00** W/ft²
Schedule ..... **None**

2.5. Miscellaneous Loads:
Sensible ..... **0** BTU/hr
Schedule ..... **None**
Latent ..... **0** BTU/hr
Schedule ..... **None**

2.3. Electrical Equipment:
Wattage ..... **0.00** W/ft²
Schedule ..... **None**

3. Walls, Windows, Doors:

Exp.	Wall Gross Area (ft²)	Window 1 Qty.	Window 2 Qty.	Door 1 Qty.
N	2016.0	0	0	0
E	2268.0	0	0	2
S	2268.0	0	0	0
W	2880.0	0	0	1

3.1. Construction Types for Exposure N
Wall Type ..... **Gymnasium Wall**

3.2. Construction Types for Exposure E
Wall Type ..... **Gymnasium Wall**
Door Type ..... **Typical Entryway Doors**

3.3. Construction Types for Exposure S
Wall Type ..... **Gymnasium Wall**

3.4. Construction Types for Exposure W
Wall Type ..... **Gymnasium Wall**
Door Type ..... **Typical Entryway Doors**

4. Roofs, Skylights:

Exp.	Roof Gross Area (ft²)	Roof Slope (deg.)	Skylight Qty.
H	5668.0	0	0

4.1. Construction Types for Exposure H
Roof Type ..... **Flat Roof - Gym**

5. Infiltration:
Design Cooling ..... **0.20** CFM/ft²
Design Heating ..... **0.30** CFM/ft²
Energy Analysis ..... **0.25** CFM/ft²
Infiltration occurs at all hours.

6. Floors:

Type	**Slab Floor on Grade**	
Floor Area	**5668.0**	ft^2
Total Floor U-Value	**0.087**	BTU/(hr-ft^2-°F)
Exposed Perimeter	**24.0**	ft
Edge Insulation R-Value	**0.00**	(hr-ft^2-°F)/BTU

7. Partitions:

(No partition data).

C 126B Gym Play Area

1. General Details:
Floor Area ..... **4700.0** ft²
Avg. Ceiling Height ..... **24.0** ft
Building Weight ..... **70.0** lb/ft²

1.1. OA Ventilation Requirements:
Space Usage ..... **SPORTS: Sports arena (play area)**
OA Requirement 1 ..... **0.0** CFM/person
OA Requirement 2 ..... **0.30** CFM/ft²
Space Usage Defaults ..... **ASHRAE Std 62.1-2007**

WE USED ASHRAE 62.1 2013

2. Internals:

2.1. Overhead Lighting:
Fixture Type ..... **Free Hanging**
Wattage ..... **1.40** W/ft²
Ballast Multiplier **1.15**
Schedule ..... **Lights Gym**

2.2. Task Lighting:
Wattage ..... **0.00** W/ft²
Schedule ..... **None**

2.3. Electrical Equipment:
Wattage ..... **0.00** W/ft²
Schedule ..... **None**

2.5. Miscellaneous Loads:
Sensible ..... **0** BTU/hr
Schedule ..... **None**
Latent ..... **0** BTU/hr
Schedule ..... **None**

3. Walls, Windows, Doors:
(No Wall, Window, Door data).

4. Roofs, Skylights:

Exp.	Roof Gross Area (ft²)	Roof Slope (deg.)	Skylight Qty.
H	4700.0	0	0

4.1. Construction Types for Exposure H
Roof Type ..... **Flat Roof - Gym**

5. Infiltration:
Design Cooling ..... **0.50** ACH
Design Heating ..... **0.50** ACH
Energy Analysis ..... **0.50** ACH
Infiltration occurs at all hours.

6. Floors:
Type ..... **Slab Floor On Grade**
Floor Area ..... **4700.0** ft²
Total Floor U-Value ..... **0.087** BTU/(hr-ft²-°F)
Exposed Perimeter ..... **0.0** ft
Edge Insulation R-Value ..... **0.00** (hr-ft²-°F)/BTU

7. Partitions:
(No partition data).

Lights Gym (Fractional)

Hourly Profiles:
1:Design Day

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40	100	100	100	100	50	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1

People Gym (Fractional)

Hourly Profiles:
1:Design Day

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5	5	5	100	100	100	50	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1

Gymnasium Wall

Wall Details

Outside Surface Color ..... **Medium**
Absorptivity **0.675**
Overall U-Value ..... **0.085** BTU/(hr-ft²-°F)

Wall Layers Details (Inside to Outside)

Layers	Thickness in	Density lb/ft³	Specific Ht. BTU / (lb - °F)	R-Value (hr-ft²-°F)/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
1/2-in gypsum board	0.500	50.0	0.26	0.44803	2.1
8-in LW concrete block	8.000	38.0	0.20	2.02020	25.3
R-7 board insulation	1.000	2.0	0.22	6.94445	0.2
Air space	1.000	0.0	0.00	0.91000	0.0
4-in face brick	4.000	125.0	0.22	0.43290	41.7
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	**14.500**	**-**		**11.77358**	**69.3**

Typical Entryway Doors

Door Details:

Gross Area ..... **48.0** ft²
Door U-Value ..... **0.210** BTU/(hr-ft²-°F)

Glass Details:

Glass Area ..... **46.0** ft²
Glass U-Value ..... **0.580** BTU/(hr-ft²-°F)
Glass Shade Coefficient **0.459**
Glass Shaded All Day? ..... **No**

Flat Roof - Gym

Roof Details

Outside Surface Color ..... **Medium**
Absorptivity **0.675**
Overall U-Value ..... **0.045** BTU/(hr-ft²-°F)

Roof Layers Details (Inside to Outside)

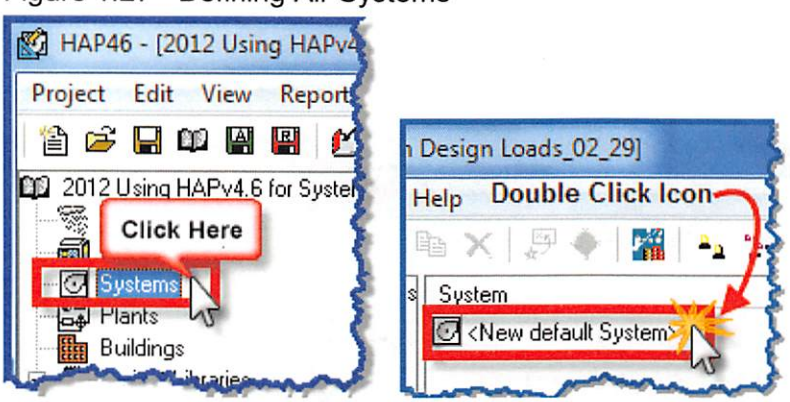
Layers	Thickness in	Density lb/ft³	Specific Ht. BTU / (lb - °F)	R-Value (hr-ft²-°F)/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
22 gage steel deck	0.034	489.0	0.12	0.00011	1.4
R-7 board insulation	1.000	2.0	0.22	6.94445	0.2
R-14 board insulation	2.000	2.0	0.22	13.88889	0.3
Built-up roofing	0.375	70.0	0.35	0.33245	2.2
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	**3.409**	**-**		**22.18389**	**4.1**

DEFINE Air System For Gymnasium

The next step in the calculation process is defining our HVAC air system. **For our example we choose chilled water providing the cooling. Heating is not required for this location SO WE WILL UNCHECK THE PREHEAT AND CENTRAL HEATING COIL.** For the Gymnasium, we chose a single zone constant volume air handler for maintaining comfort.

Left click the Air Systems icon on the HAP Main Program window in the tree structure. The details screen shows an item titled <New Default System>. Double left click this icon to open the air system properties form. .

Figure 1.27 - Defining Air Systems

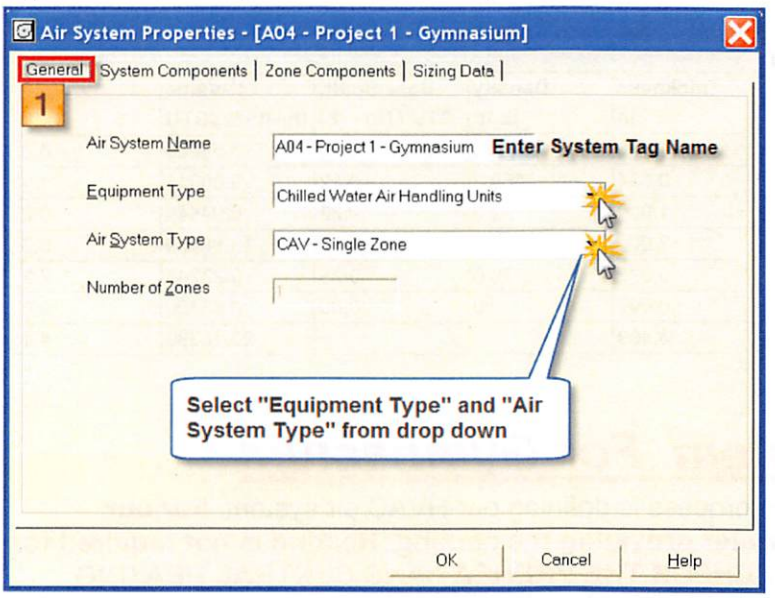


This brings up the Air System Properties input form. Please enter the following data into the air system properties form.

1. General Properties:

Air System Name	A04 - Project 1 - Gymnasium
Equipment Type	Chilled Water AHU
Air System Type	Single Zone CAV
Number of zones	1

Figure 1.28 - Air System General Properties

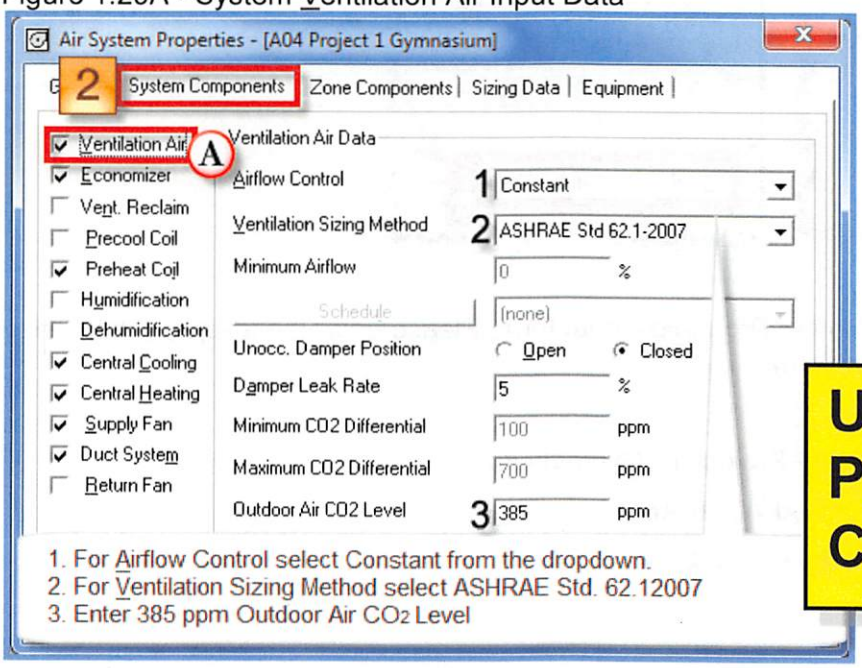


2 A - System Components

A. Ventilation Air Data (SEE NEXT PAGE)

Airflow Control:	Constant
Sizing Method:	**ASHRAE 62.1-2013**
Unoccupied Damper Position:	Closed
Damper Leakage Rate:	5%
Outdoor Air CO_2 Level:	385 ppm

Figure 1.29A - System Ventilation Air Input Data

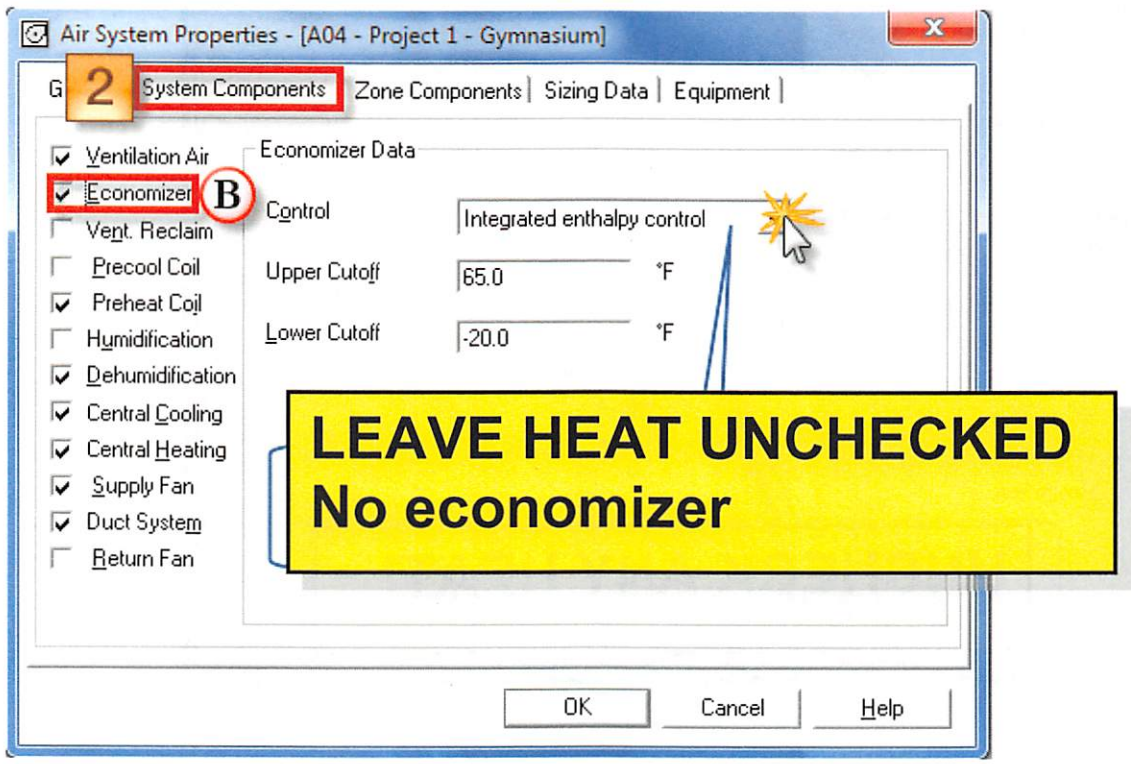


UNCHECK PREHEAT AND CENTRAL HEAT

2B – System Components

B. Economizer Data

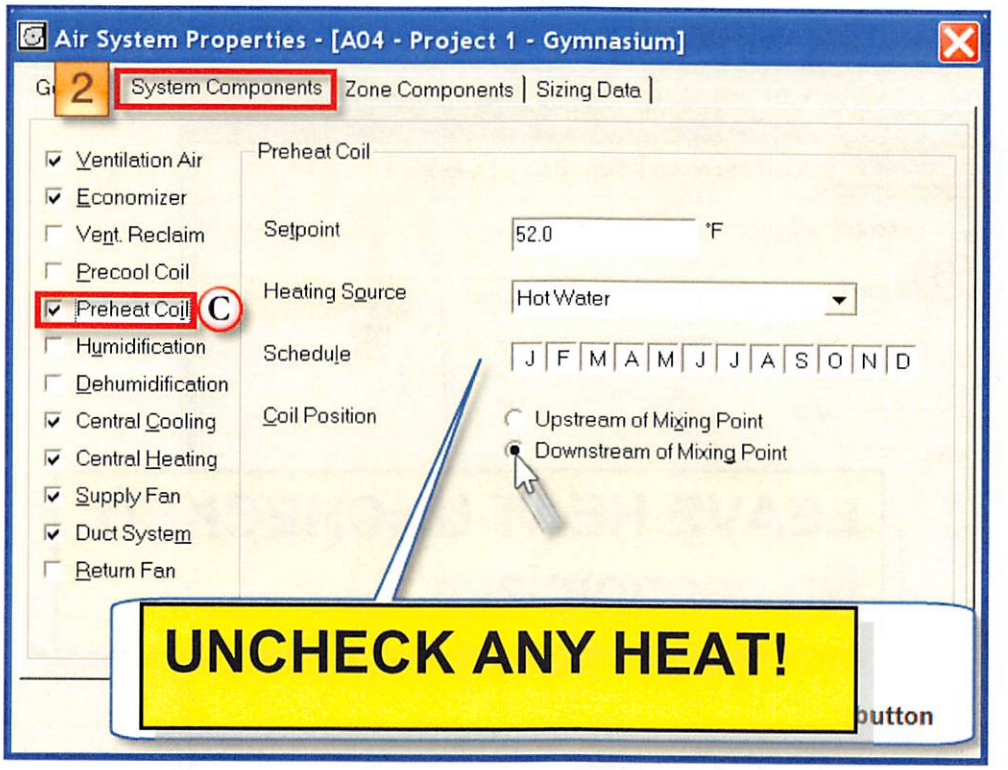
Control:	Integrated Enthalpy Control
Upper Cutoff:	+65° F
Lower Cutoff:	-20° F



2C. System Components

Preheat Coil Data NONE!!!

Figure 1.29C - Preheat Coil Data



2D. System Components

Central Cooling Coil Data

Select Supply Temp: 55°F

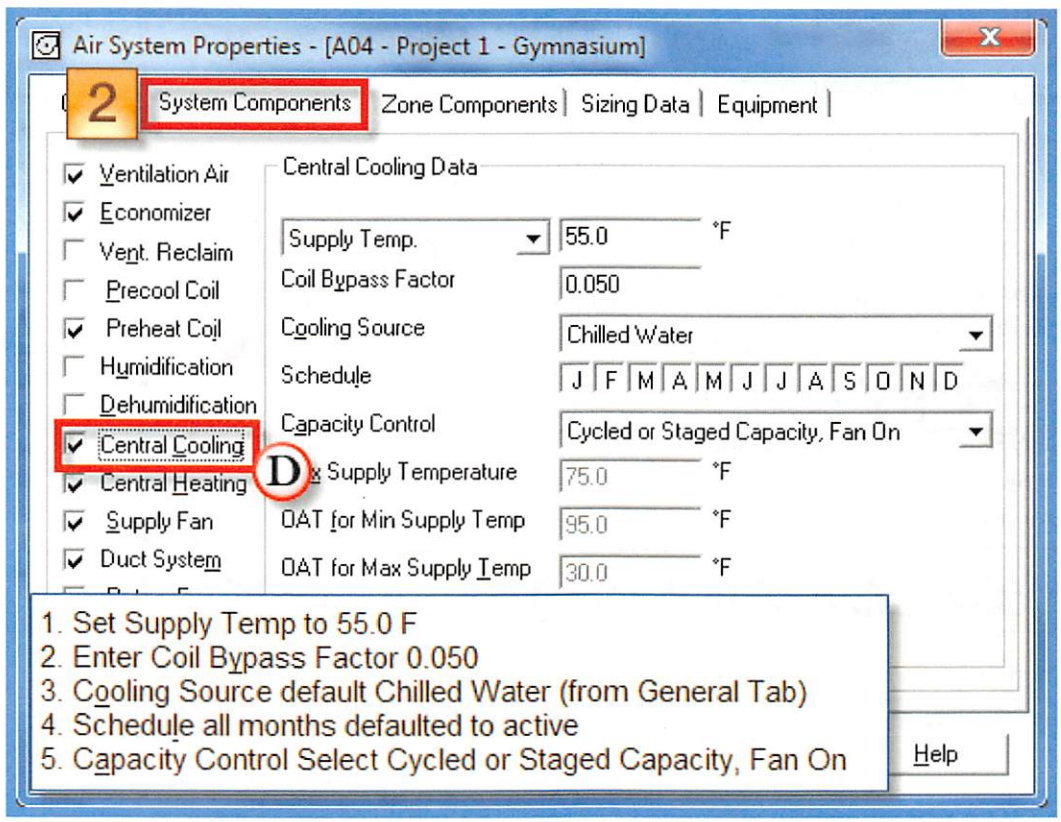
Set Coil Bypass Factor: 0.05

Cooling Source: Default Chilled Water

Schedule: Available all months

Capacity Control: Cycled or Staged Capacity, Fan On

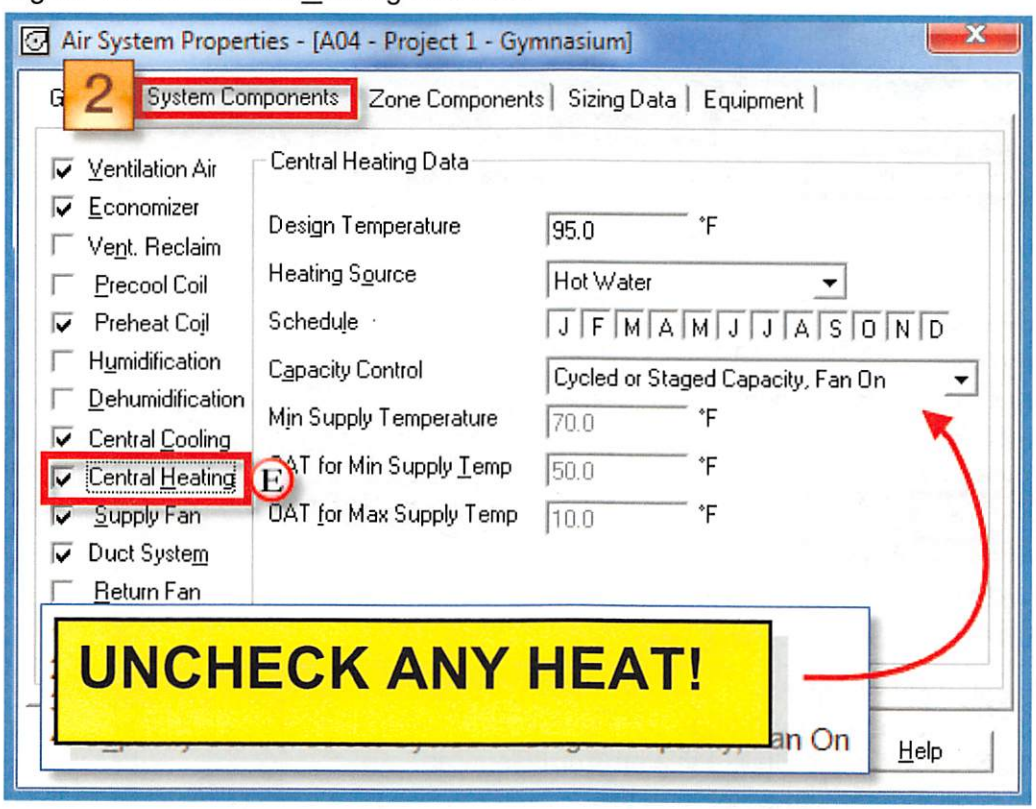
Figure 1.29D - Central Cooling Coil Data



2E. System Components

Central Heating Coil Data **NONE!!!**

Figure 1.29E - Central Heating Coil Data

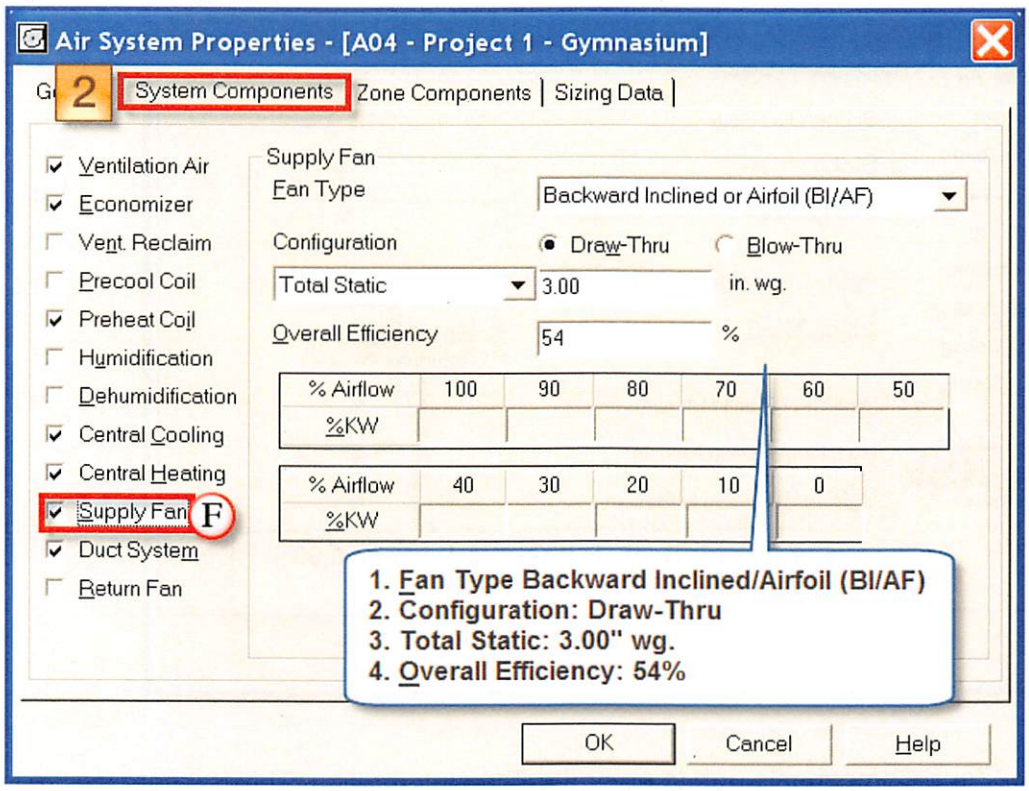


2F. System Components

Supply Fan Data

Supply Fan:	BI/AF
Configuration:	Draw – Through
Total Static:	3.00" wg.
Overall Efficiency:	54%

Figure 1.29F - Supply Fan Data



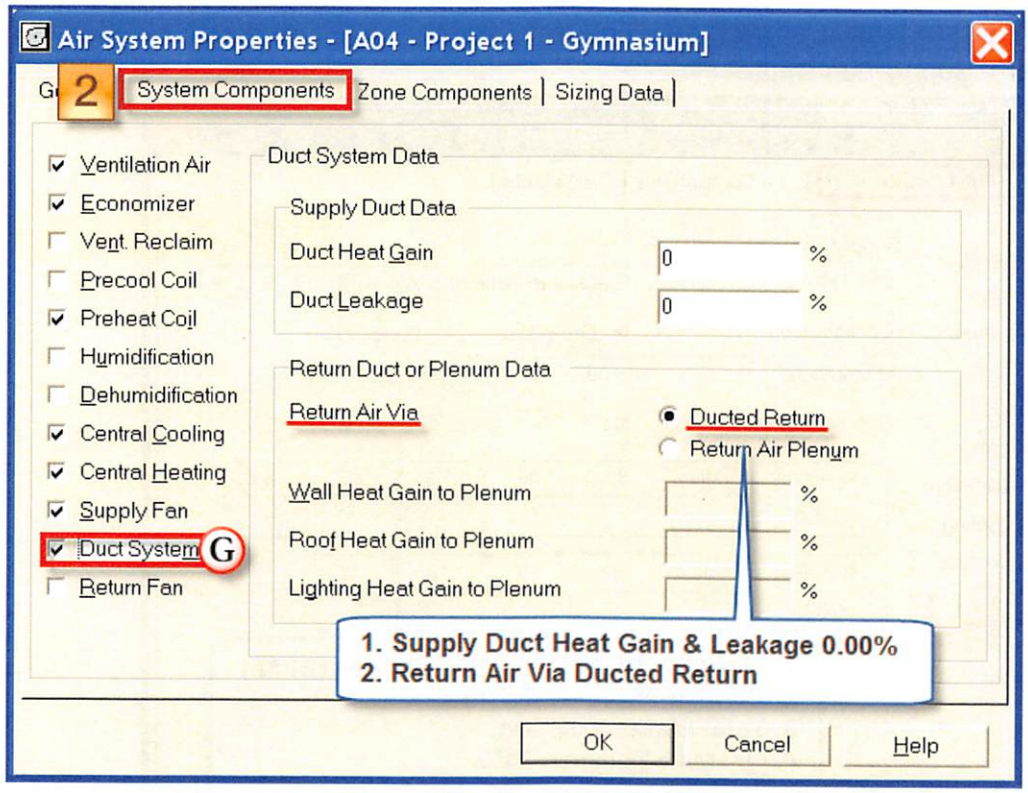
2G. System Components

Duct System Data

Supply Duct Data: 0% Duct Heat Gain, 0% Duct Leakage

Return Duct Data: Ducted Return

Figure 1.29G - Duct System Data



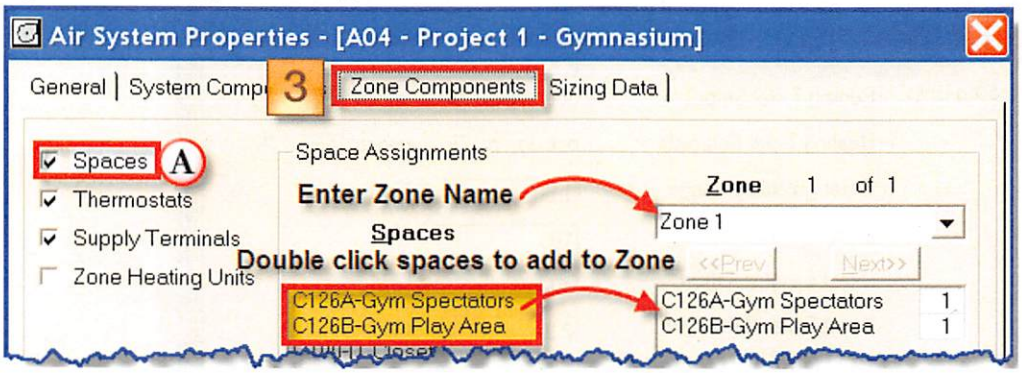
Click on the "Zone Components" tab to enter the Zone information. This is where we link the spaces to the zones, define the thermostat settings and link a t-stat schedule.

3A. Zone Components

Space Assignments

Assign **BOTH SPACES TO THE ZONE** C126A and C1126B to Zone 1 of 1

Figure 1.30A - Space Assignments



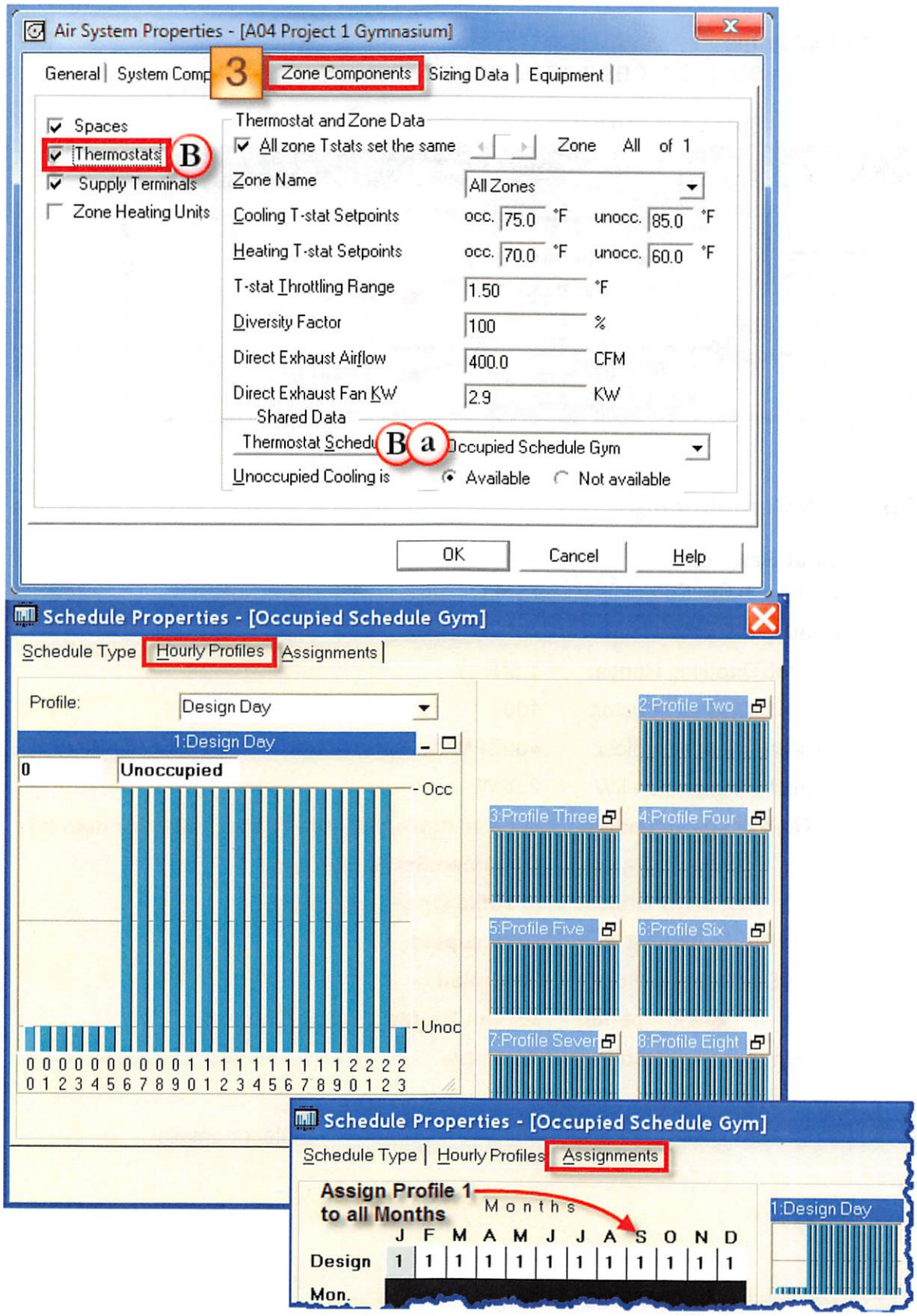
3B. Zone Components

Thermostat Settings

Cooling T-stat Setpoint:	75°F Occupied, 85°F Unoccupied
Heating T-stat Setpoint:	70°F Occupied, 60°F Unoccupied
T-stat Throttling Range:	1.5°F
Diversity Factor:	100
Direct Exhaust Airflow:	400CFM
Direct Exhaust Fan kW:	2.9kW
Thermostat Schedule:	**<create new> (Refer to Figure 1.30B for details)**
Schedule Name:	**Occupied Schedule Gym**
Hourly Profiles:	**<Profile One> Design Day**
Hours 00-05 & 23:	**Unoccupied**
All remaining Hours:	**Occupied**
Assignments:	**Assign Profile one to all months**
Unoccupied Cooling:	**Available**

Refer to Figures 1.30B Thermostat Settings and T-stat Schedule for details

Figure 1.30B - Thermostat settings AND SCHEDULE



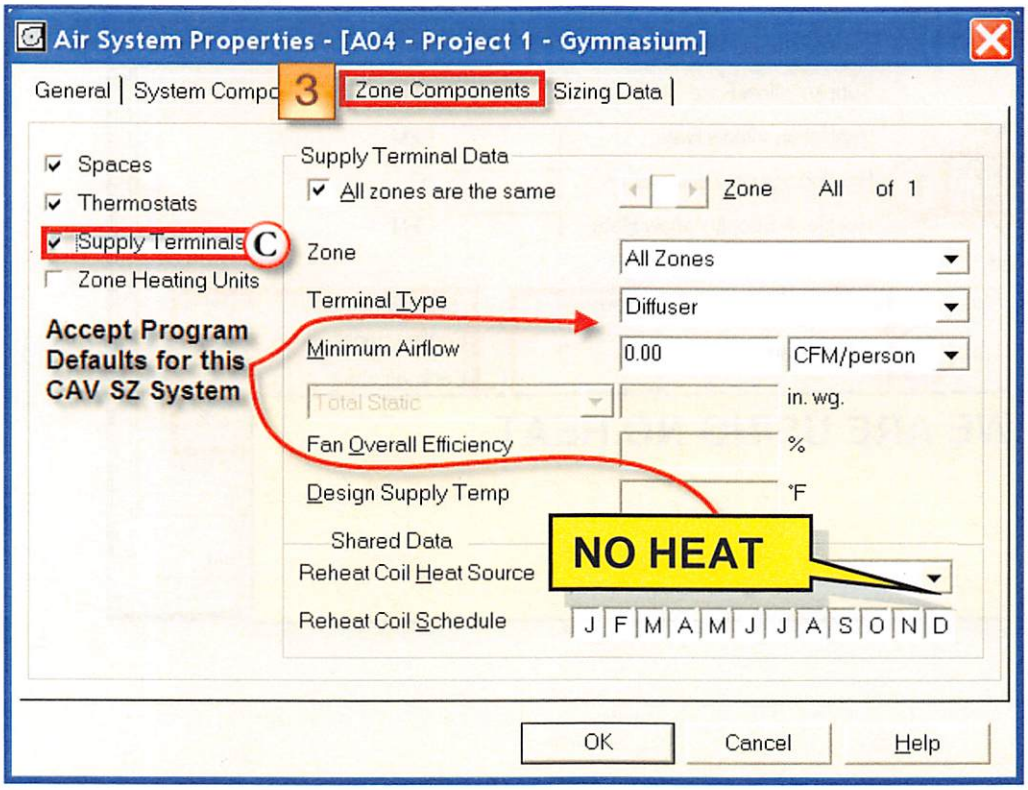
3C. Zone Components

Supply Terminal Data

Terminal Type: Diffuser

Minimum Airflow: 0.00 CFM

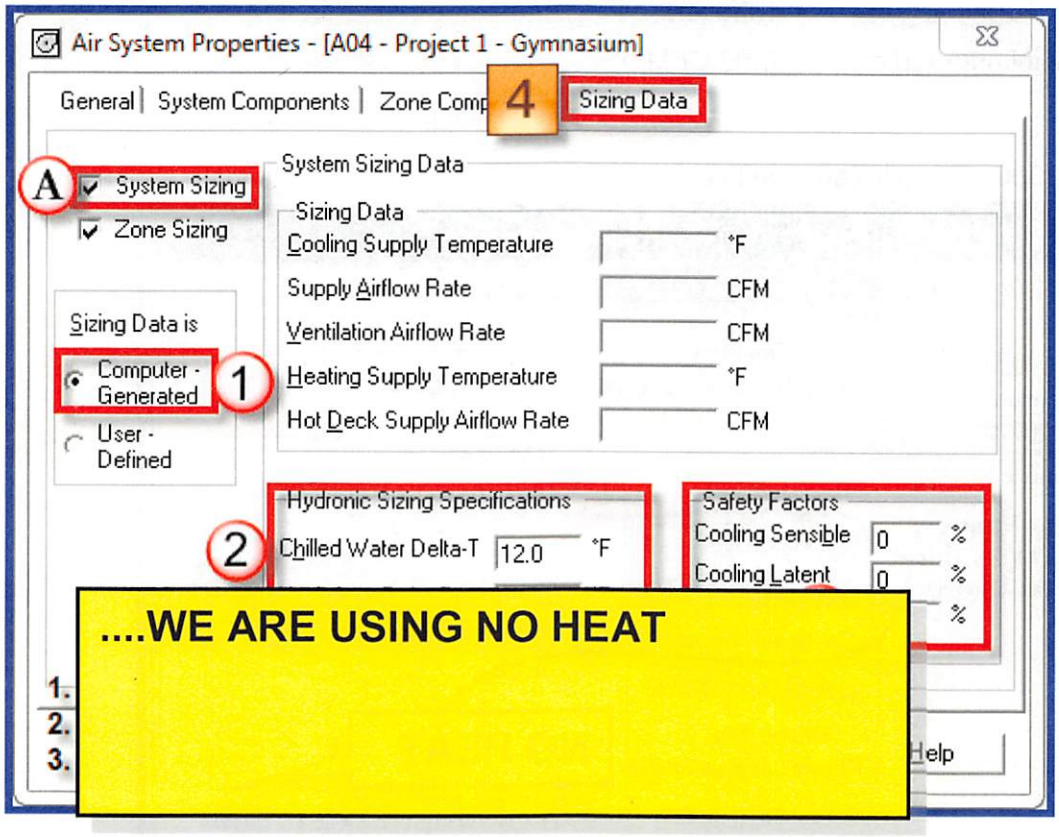
Figure 1.30C - Supply Terminal Data



There are no "Zone Heating Units" in the Gymnasium.

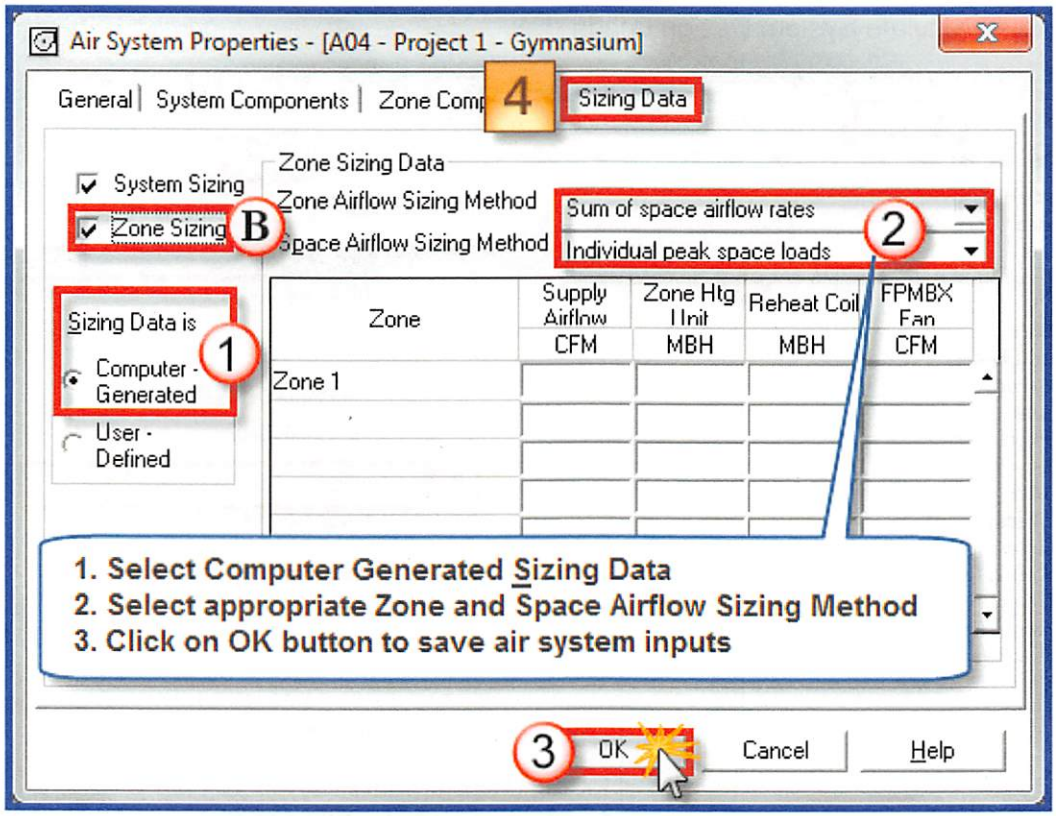
4A. Sizing Data – System Sizing

Figure 1.31A - Sizing Data Tab – System Sizing Parameters



4B. Sizing Data – Zone Sizing

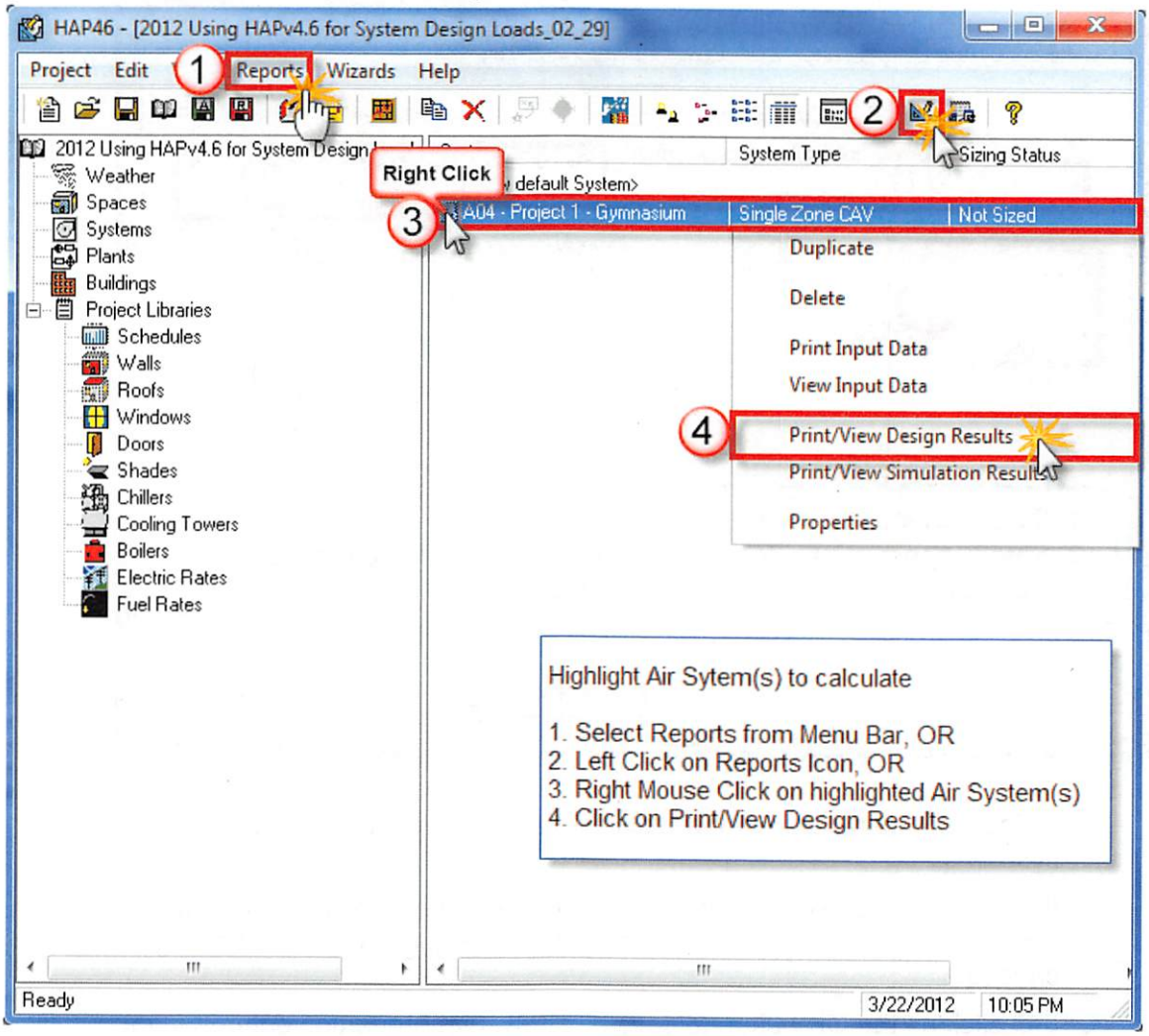
Figure 1.31B - Sizing Data Tab – Zone Sizing Parameters



1. Default Computer Generated Sizing Data. Let computer calculate the required system sizing
2. From the drop downs, select the required Zone and Space airflow sizing procedure. Refer to Appendix for a detailed discussion on which sizing method to choose.
3. Left click on the OK button to save all air system properties entered in this workshop.

At this point we are ready to calculate the design load reports for this CAV Single Zone air system. At the Main program window with the Gymnasium air system highlighted in the detailed screen, "Print/View design results"

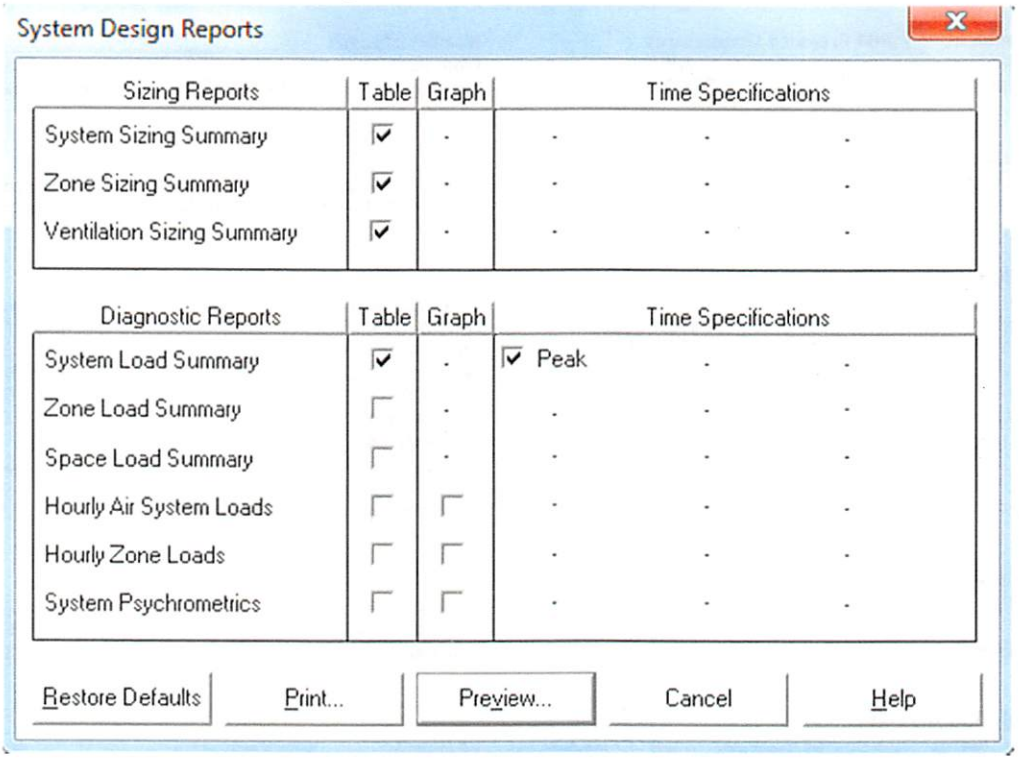
Figure 1.32 - Calculate System Design Loads



1. Click on Reports in the Menu bar.
2. Click the Calculate icon on the tool bar
3. Right Click on the highlighted air system(s)
4. Select Print/View Design Results from the options list.

This brings up the following reports selection list. Choose the reports you want to view. The default for the detailed reports is the Peak Load time. If you remove the check from the peak box you can specify the hour and month for the detailed report.

Figure 1.33 - **Select System Design Reports to Preview**



Clicking the Preview button starts the system calculations and upon completion displays the following reports. Note that each report selected generates a separate report. Refer to the following pages for the calculated System Design Loads.

Air System Sizing Summary

Air System Sizing Summary for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE — 07/21/2017
Prepared by: carrier — 02:14PM

Air System Information

Air System Name	A04 Project 1 Gymnasium		Number of zones	1	
Equipment Class	CW AHU		Floor Area	10368.0	ft²
Air System Type	SZCAV		Location	Port of Spain, Trinidad & Tobago	

Sizing Calculation Information

Calculation Months	Jan to Dec	Zone CFM Sizing	Sum of space airflow rates
Sizing Data	Calculated	Space CFM Sizing	Individual peak space loads

Central Cooling Coil Sizing Data

Total coil load	51.7	Tons	Load occurs at	Jul 1900	
Total coil load	620.4	MBH	OA DB / WB	88.3 / 77.0	°F
Sensible coil load	282.3	MBH	Entering DB / WB	82.8 / 74.7	°F
Coil CFM at Jul 1900	9083	CFM	Leaving DB / WB	54.0 / 53.8	°F
Max block CFM	9083	CFM	Coil ADP	52.4	°F
Sum of peak zone CFM	9083	CFM	Bypass Factor	0.050	
Sensible heat ratio	0.455		Resulting RH	81	%
ft²/Ton	200.5		Design supply temp.	55.0	°F
BTU/(hr·ft²)	59.8		Zone T-stat Check	1 of 1	OK
Water flow @ 12.0 °F rise	103.45	gpm	Max zone temperature deviation	0.0	°F

Supply Fan Sizing Data

Actual max CFM	9083	CFM	Fan motor BHP	7.46	BHP
Standard CFM	9070	CFM	Fan motor kW	5.92	kW
Actual max CFM/ft²	0.88	CFM/ft²	Fan static	3.00	in wg

Outdoor Ventilation Air Data

Design airflow CFM	4968	CFM	CFM/person	10.20	CFM/person
CFM/ft²	0.48	CFM/ft²			

Zone Sizing Summary Report

Zone Sizing Summary for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE 07/21/2017
Prepared by: carrier 02:14PM

Air System Information

Air System Name ..... **A04 Project 1 Gymnasium**
Equipment Class ..... **CW AHU**
Air System Type ..... **SZCAV**

Number of zones **1**
Floor Area ..... **10368.0** ft²
Location ..... **Port of Spain, Trinidad & Tobago**

Sizing Calculation Information

Calculation Months ..... **Jan to Dec**
Sizing Data ..... **Calculated**

Zone CFM Sizing ..... **Sum of space airflow rates**
Space CFM Sizing ..... **Individual peak space loads**

Zone Terminal Sizing Data

Zone Name	Design Supply Airflow (CFM)	Minimum Supply Airflow (CFM)	Zone CFM/ft²	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 30.0 °F	Zone Htg Unit Coil Load (MBH)	Zone Htg Unit Water gpm @ 30.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	9083	9083	0.88	0.0	0.00	0.0	0.00	0

Zone Peak Sensible Loads

Zone Name	Zone Cooling Sensible (MBH)	Time of Peak Sensible Cooling Load	Zone Heating Load (MBH)	Zone Floor Area (ft²)
Zone 1	193.3	Jul 1900	3.3	10368.0

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Peak Sensible Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Zone 1							
C 126A Gym Spectators	1	152.6	Jul 2100	7076	2.5	5668.0	1.25
C 126B Gym Play Area	1	43.3	Jul 1900	2007	0.7	4700.0	0.43

Ventilation Sizing Summary

Ventilation Sizing Summary for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE
Prepared by: carrier

1. Summary

Ventilation Sizing Method	ASHRAE Std 62.1-2013	
Design Condition	Cooling operation	
Occupant Diversity (D)	1.000	
Uncorrected Outdoor Air Intake (Vou)	4919	CFM
System Ventilation Efficiency (Ev)	0.990	
Outdoor Air Intake (Vot)	4968	CFM

2. Space Ventilation Analysis

Zone Name / Space Name	Mult.	Supply Air (CFM) (Vpz)	Space Floor Area (ft²) (Az)	Area Outdoor Air Rate (CFM/ft²) (Ra)	Time Averaged Occupancy (Occupants) (Pz)	People Outdoor Air Rate (CFM/person) (Rp)	Air Distribution Effectiveness (Ez)	Space Outdoor Air (CFM) (Voz)	Breathing Zone Outdoor Air (CFM) (Vbz)	Space Ventilation Efficiency (Evz)
Zone 1										
C 126A Gym Spectators	1	7076	5668.0	0.06	475.0	7.50	1.00	3903	3903	0.990
C 126B Gym Play Area	1	2007	4700.0	0.18	8.5	20.00	1.00	1016	1016	1.035
Totals (incl. Space Multipliers)		9083							4919	0.990

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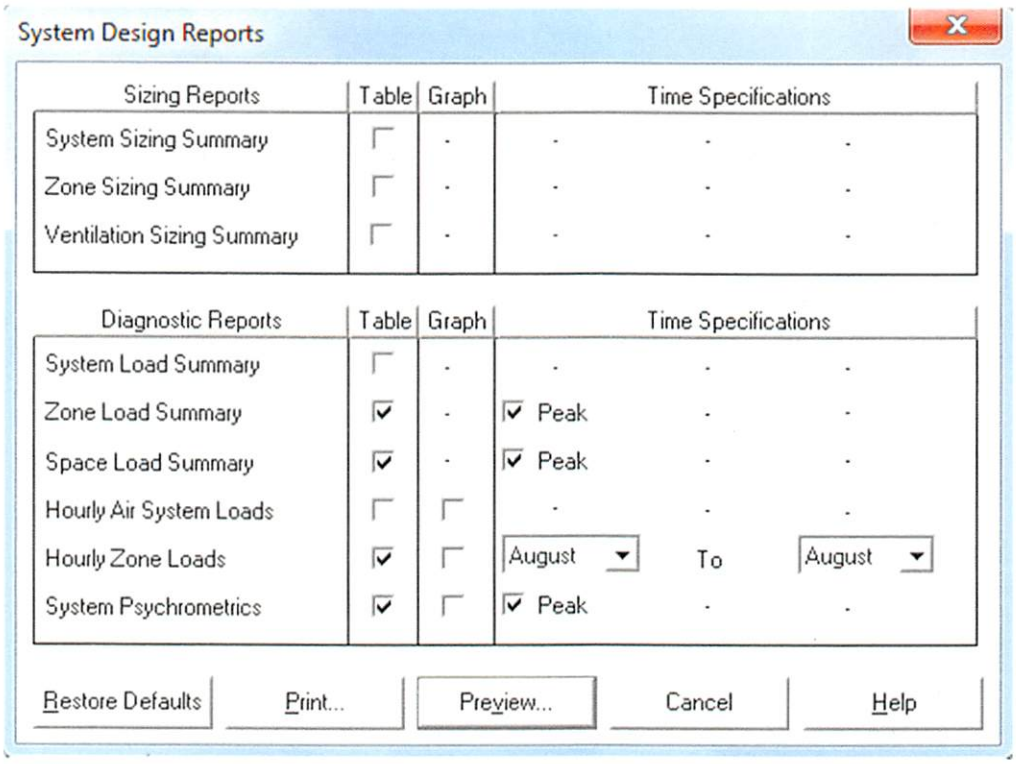
Air System Design Load Summary Report

Air System Design Load Summary for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE — 07/21/2017
Prepared by: carrier — 02:14PM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1900 COOLING OA DB / WB 88.3 °F / 77.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 69.4 °F / 57.7 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	0 ft²	0	-	0 ft²	-	-
Wall Transmission	9288 ft²	16777	-	9288 ft²	473	-
Roof Transmission	10368 ft²	8443	-	10368 ft²	280	-
Window Transmission	0 ft²	0	-	0 ft²	0	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	144 ft²	3686	-	144 ft²	49	-
Floor Transmission	10368 ft²	0	-	10368 ft²	16	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	16692 W	48075	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	487	75809	271955	0	0	0
Infiltration	-	40461	23978	-	2439	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	193252	295933	-	3257	0
Zone Conditioning	-	197062	295933	-	2112	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	8683 CFM	0	-	8683 CFM	0	-
Ventilation Load	4968 CFM	65030	42151	4968 CFM	2059	0
Supply Fan Load	9083 CFM	20200	-	9083 CFM	-20200	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	-	282292	338084	-	-16028	0
Central Cooling Coil	-	282292	338083	-	-16028	0
>> Total Conditioning	-	282292	338083	-	-16028	0
Key:	Positive values are clg loads Negative values are htg loads			Positive values are htg loads Negative values are clg loads		



Zone Design Load Summary Report

Zone Design Load Summary for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE — 07/21/2017
Prepared by: carrier — 02:40PM

Zone 1	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1900 COOLING OA DB / WB 88.3 °F / 77.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 69.4 °F / 57.7 °F		
	OCCUPIED T-STAT 75.0 °F			OCCUPIED T-STAT 70.0 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	0 ft²	0	-	0 ft²	-	-
Wall Transmission	9288 ft²	16777	-	9288 ft²	473	-
Roof Transmission	10368 ft²	8443	-	10368 ft²	280	-
Window Transmission	0 ft²	0	-	0 ft²	0	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	144 ft²	3686	-	144 ft²	49	-
Floor Transmission	10368 ft²	0	-	10368 ft²	16	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	16692 W	48075	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	487	75809	271955	0	0	0
Infiltration	-	40461	23978	-	2439	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	193252	295933	-	3257	0

Space Design Load Summary Report

Space Design Load Summary for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE — 07/21/2017
Prepared by: carrier — 02:40PM

TABLE 1.1.A. Component Loads For Space "C 126A Gym Spectators" In Zone "Zone 1"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 2100 COOLING OA DB / WB 84.9 °F / 76.1 °F OCCUPIED T-STAT 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 69.4 °F / 57.7 °F OCCUPIED T-STAT 70.0 °F		
SPACE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	0 ft²	0	-	0 ft²	-	-
Wall Transmission	9288 ft²	18003	-	9288 ft²	473	-
Roof Transmission	5668 ft²	3422	-	5668 ft²	153	-
Window Transmission	0 ft²	0	-	0 ft²	0	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	144 ft²	3167	-	144 ft²	49	-
Floor Transmission	5668 ft²	0	-	5668 ft²	16	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	9125 W	26899	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	475	80913	258875	0	0	0
Infiltration	-	20218	14758	-	1831	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	152622	273633	-	2522	0

TABLE 1.1.B. Envelope Loads For Space "C 126A Gym Spectators" In Zone "Zone 1"						
	Area (ft²)	U-Value (BTU/(hr·ft²·°F))	Shade Coeff.	COOLING TRANS (BTU/hr)	COOLING SOLAR (BTU/hr)	HEATING TRANS (BTU/hr)
N EXPOSURE						
WALL	2016	0.085	-	4119	-	103
E EXPOSURE						
WALL	2172	0.085	-	4662	-	111
DOOR	4	0.210	-	9	-	1
DOOR GLASS	92	0.580	0.459	562	1370	32
S EXPOSURE						
WALL	2268	0.085	-	3042	-	116
W EXPOSURE						
WALL	2832	0.085	-	6181	-	144
DOOR	2	0.210	-	4	-	0
DOOR GLASS	46	0.580	0.459	281	940	16
H EXPOSURE						
ROOF	5668	0.045	-	3422	-	153

Space Design Load Summary for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE — 07/21/2017
Prepared by: carrier — 02:40PM

TABLE 1.2.A. Component Loads For Space "C 126B Gym Play Area" In Zone "Zone 1"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1900 COOLING OA DB / WB 88.3 °F / 77.0 °F OCCUPIED T-STAT 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 69.4 °F / 57.7 °F OCCUPIED T-STAT 70.0 °F		
SPACE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	0 ft²	0	-	0 ft²	-	-
Wall Transmission	0 ft²	0	-	0 ft²	0	-
Roof Transmission	4700 ft²	3828	-	4700 ft²	127	-
Window Transmission	0 ft²	0	-	0 ft²	0	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	4700 ft²	0	-	4700 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	7567 W	21793	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	12	4211	13080	0	0	0
Infiltration	-	13456	7975	-	608	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	43288	21055	-	735	0

TABLE 1.2.B. Envelope Loads For Space "C 126B Gym Play Area" In Zone "Zone 1"						
	Area (ft²)	U-Value (BTU/(hr·ft²·°F))	Shade Coeff.	COOLING TRANS (BTU/hr)	COOLING SOLAR (BTU/hr)	HEATING TRANS (BTU/hr)
H EXPOSURE						
ROOF	4700	0.045	-	3828	-	127

Hourly Zone Loads

Hourly Zone Loads for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE — 07/21/2017
Prepared by: carrier — 02:40PM

ZONE: Zone 1
DESIGN MONTH: AUGUST

Hour	OA TEMP (°F)	ZONE TEMP (°F)	RH (%)	ZONE AIRFLOW (CFM)	ZONE SENSIBLE LOAD (BTU/hr)	ZONE COND (BTU/hr)	TERMINAL COOLING COIL (BTU/hr)	TERMINAL HEATING COIL (BTU/hr)	ZONE HEATING UNIT (BTU/hr)
0000	81.6	79.7	-	0.0	73605.7	0.0	0.0	0.0	0.0
0100	80.9	79.6	-	0.0	68581.8	0.0	0.0	0.0	0.0
0200	80.2	79.6	-	0.0	63624.6	0.0	0.0	0.0	0.0
0300	79.7	79.5	-	0.0	59162.0	0.0	0.0	0.0	0.0
0400	79.2	79.4	-	0.0	55231.8	0.0	0.0	0.0	0.0
0500	79.1	79.4	-	0.0	52293.1	0.0	0.0	0.0	0.0
0600	79.4	75.6	73	9083.0	51824.8	90914.4	0.0	0.0	0.0
0700	80.1	75.5	73	9083.0	58787.5	94704.9	0.0	0.0	0.0
0800	81.3	76.0	71	9083.0	84154.1	105994.1	0.0	0.0	0.0
0900	83.1	75.7	69	9083.0	94794.0	121621.6	0.0	0.0	0.0
1000	85.2	75.9	68	9083.0	105603.9	125232.5	0.0	0.0	0.0
1100	87.6	76.1	67	9083.0	116240.6	128669.7	0.0	0.0	0.0
1200	89.8	76.0	65	9083.0	125588.1	141002.3	0.0	0.0	0.0
1300	91.5	76.2	65	9083.0	132116.8	139732.3	0.0	0.0	0.0
1400	92.6	76.2	64	9083.0	135328.7	143197.3	0.0	0.0	0.0
1500	93.0	76.2	65	9083.0	134670.8	142342.1	0.0	0.0	0.0
1600	92.6	76.1	65	9083.0	129757.8	137276.5	0.0	0.0	0.0
1700	91.6	76.1	67	9083.0	121484.5	128978.5	0.0	0.0	0.0
1800	90.1	75.8	64	9083.0	136746.7	150130.9	0.0	0.0	0.0
1900	88.3	76.3	81	9083.0	192600.0	192063.6	0.0	0.0	0.0
2000	86.5	76.2	81	9083.0	191954.4	194379.9	0.0	0.0	0.0
2100	84.9	76.3	81	9083.0	191979.1	190637.7	0.0	0.0	0.0
2200	83.5	76.0	76	9083.0	137014.1	142884.5	0.0	0.0	0.0
2300	82.4	79.6	-	0.0	79144.4	0.0	0.0	0.0	0.0

System Psychrometric Report – Cooling

August DESIGN COOLING DAY, 1900

TABLE 1: SYSTEM DATA

System Psychrometrics for A04 Project 1 Gymnasium

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE — 07/21/2017
Prepared by: carrier — 02:40PM

July DESIGN COOLING DAY, 1900

TABLE 1: SYSTEM DATA

Component	Location	Dry-Bulb Temp (°F)	Specific Humidity (lb/lb)	Airflow (CFM)	CO2 Level (ppm)	Sensible Heat (BTU/hr)	Latent Heat (BTU/hr)
Ventilation Air	Inlet	88.3	0.01745	4968	385	65030	42151
Vent - Return Mixing	Outlet	82.8	0.01663	9083	1040	-	-
Central Cooling Coil	Outlet	54.0	0.00878	9083	1040	282292	338083
Supply Fan	Outlet	56.0	0.00878	9083	1040	20200	-
Cold Supply Duct	Outlet	56.0	0.00878	9083	1040	-	-
Zone Air	-	76.1	0.01566	9083	1831	197062	295933
Zone Direct Exhaust	Outlet	76.1	0.01566	400	1831	-	-
Return Plenum	Outlet	76.1	0.01566	8683	1831	0	-

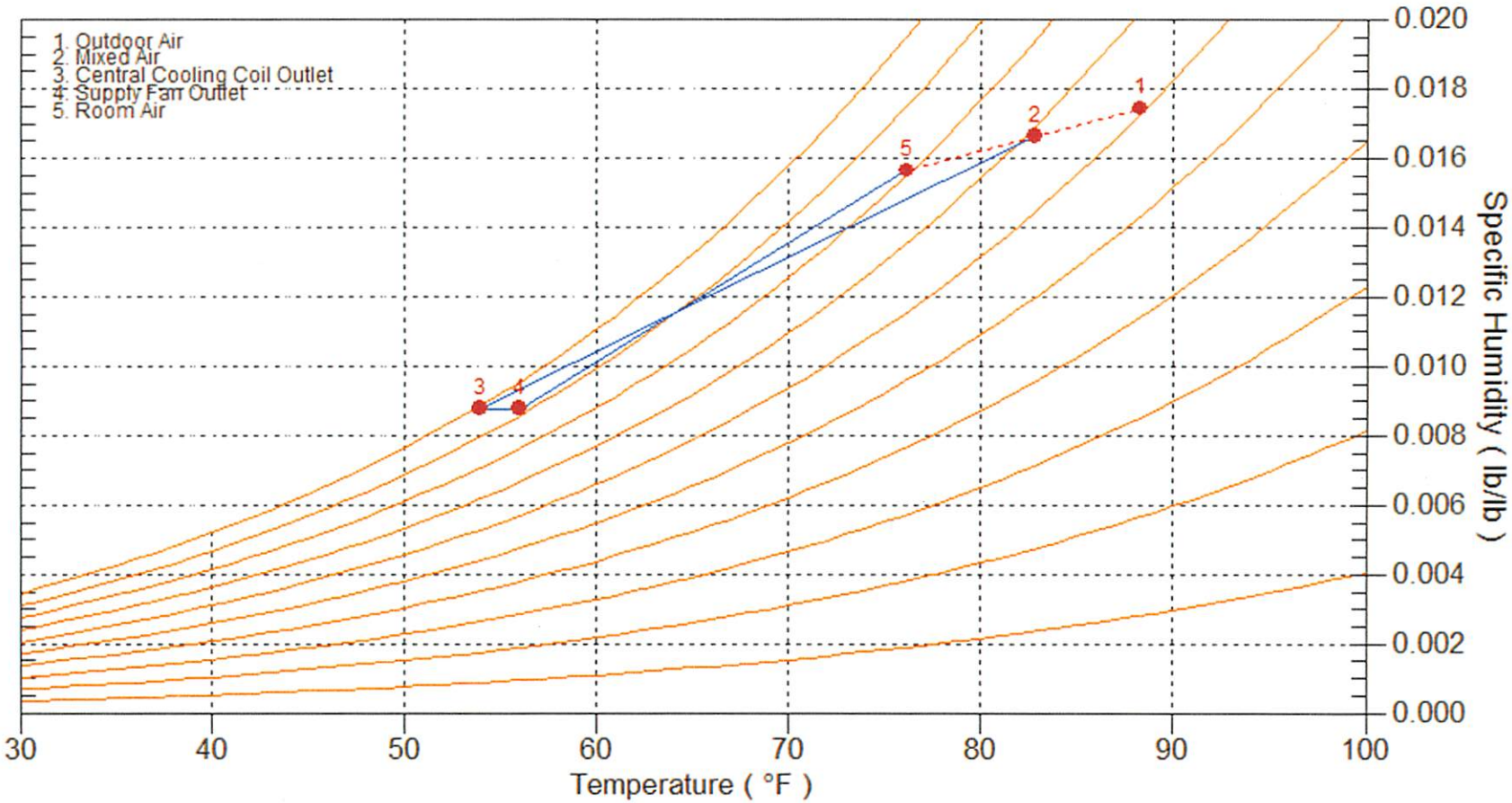
Air Density x Heat Capacity x Conversion Factor: At sea level = 1.080; At site altitude = 1.078 BTU/(hr-CFM-F)
Air Density x Heat of Vaporization x Conversion Factor: At sea level = 4746.6; At site altitude = 4730.7 BTU/(hr-CFM)
Site Altitude = 40.0 ft

TABLE 2: ZONE DATA

Zone Name	Zone Sensible Load (BTU/hr)	T-stat Mode	Zone Cond (BTU/hr)	Zone Temp (°F)	Zone Airflow (CFM)	CO2 Level (ppm)	Terminal Heating Coil (BTU/hr)	Zone Heating Unit (BTU/hr)
Zone 1	193252	Cooling	197062	76.1	9083	1831	0	0

Air Density x Heat Capacity x Conversion Factor: At sea level = 1.080; At site altitude = 1.058 BTU/(hr-CFM-F)
Air Density x Heat of Vaporization x Conversion Factor: At sea level = 4746.6; At site altitude = 4650.7 BTU/(hr-CFM)
Site Altitude = 564.0 ft

Location: Port of Spain, Trinidad & Tobago
Altitude: 40.0 ft.
Data for: July DESIGN COOLING DAY, 1900



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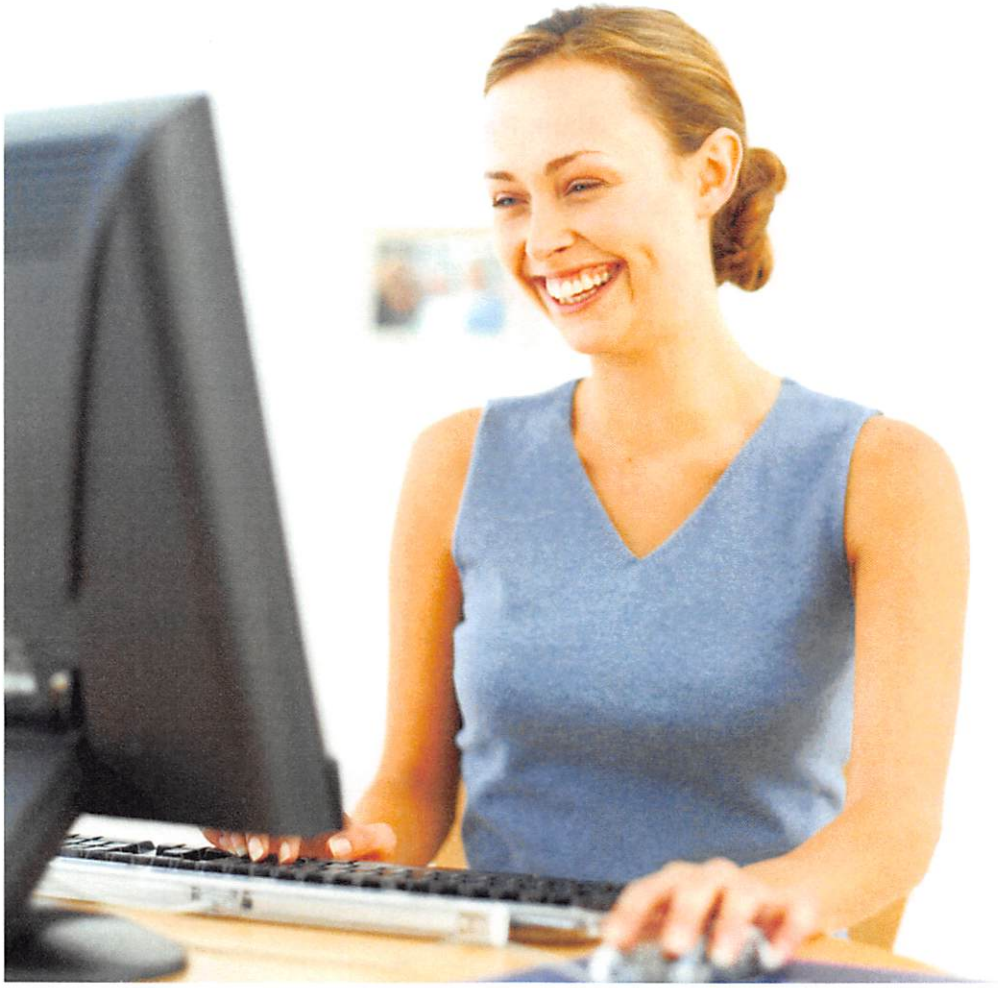
Workshop # 2



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Workshop 2 Inputs

The second workshop consists of entering the details for Wing "D" and modeling a VAV air system as our base design. School is in session 10 months of the year at full capacity with classes held from 08:00 to 16:00. The regular school year is from August through May with summer school held during June where we take advantage of a reduced occupancy schedule from 08:00 through 12:00. The school is shut down for summer during July where occupancy schedules are set to minimums.

The following are details for the Spaces, Library Items and Air System Properties. For this workshop, we enter details for one of the classrooms in wing "D".

Wing "D" Space, Schedules and Envelope Items for Classroom D104

D104 -Classroom

1. General Details:

Floor Area	**840.0**	ft²
Avg. Ceiling Height	**9.0**	ft
Building Weight	**70.0**	lb/ft²

1.1. OA Ventilation Requirements:

Space Usage	**EDUCATION: Classroom (age 9+)**	
OA Requirement 1	**10.0**	CFM/person
OA Requirement 2	**0.12**	CFM/ft²

2. In

2.1.

2.2.

2.3.

3. W

3.1.

3.2.

4. R

THE 7 SPACES REQUIRED FOR WORKSHOP #2, 3, & 4, WILL BE IMPORTED VIA "IMPORT HAP PROJECT DATA" FROM THE "TRINIDAD LOADS SOLVED 2017" PROJECT ARCHIVE WE RETRIEVED AND SAVED.

Exp.	Roof Gross Area (ft²)	Roof Slope (deg.)	Skylight Qty.
H	840.0	0	0

4.1. Construction Types for Exposure H
Roof Type ..... **Flat Roof - Classrooms**

5. Infiltration:
Design Cooling ..... **0.20** CFM/ft²
Design Heating ..... **0.30** CFM/ft²
Energy Analysis ..... **0.25** CFM/ft²
Infiltration occurs at all hours.

6. Floors:
Type ..... **Slab Floor On Grade**
Floor Area ..... **840.0** ft²
Total Floor U-Value ..... **0.087** BTU/(hr-ft²-°F)
Exposed Perimeter ..... **58.0** ft
Edge Insulation R-Value ..... **0.00** (hr-ft²-°F)/BTU

7. Partitions:
(No partition data).

Lights - Classrooms (Fractional)

Hourly Profiles:
1:Design Day

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	10	10	10																	10	10	10	10	10

2:Summer School

Hour	00	01	02																	19	20	21	22	23
Value	5	5	5																	5	5	5	5	5

3:Summer Shutdown

Hour	00	01	02																	19	20	21	22	23
Value	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

NEW CLASSROOM SPACE SCHEDULES AS SHOWN HERE WILL BE IMPORTED VIA "IMPORT HAP PROJECT DATA" AS PART OF THE IMPORTED SPACES

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	2	3	1	1	1	1	1

People - Classrooms (Fractional)

Hourly Profiles:
1:Design Day

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	5	100	100	100	100	100	100	100	100	40	10	0	0	0	0	0	0

2:Summer School

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	40	40	40	40	40	10	0	0	0	0	0	0	0	0	0	0

3:Summer Shutdown

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	2	3	1	1	1	1	1

Wing "D" Space, Schedules and Envelope Items for Classroom D104 (Cont.)

Classroom Wall

Wall Details

Outside Surface Color ..... **Medium**
Absorptivity **0.675**
Overall U-Value ..... **0.046** BTU/(hr-ft²-°F)

Wall Layers Details (Inside to Outside)

Layers	Thickness in	Density lb/ft³	Specific Ht. BTU / (lb - °F)	R-Value (hr-ft²-°F)/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
1/2-in gypsum board	0.500	50.0	0.26	0.44803	2.1
R-19 batt insulation	6.000	0.5	0.20	19.23077	0.3
1/2-in gypsum board	0.500	50.0	0.26	0.44803	2.1
4-in face brick	4.000	125.0	0.22	0.43290	41.7
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	**11.000**	**-**		**21.57773**	**46.1**

Casement Window

Window Details:

Detailed Input ..... **Yes**
Height ..... **8.00** ft.
Width ..... **4.00** ft.
Frame Type ..... **Vinyl**
Internal Shade Type ..... **None**
Overall U-Value ..... **0.346** BTU/(hr-ft²-°F)
Overall Shade Coefficient **0.459**

Glass Details:

Gap Type ..... **1/4" Air Space**

Glazing	Glass Type	Transmissivity	Reflectivity	Absorptivity
Outer Glazing	1/4" bronze reflective	0.312	0.305	0.383
Glazing #2	1/4" gra			
Glazing #3	1/4" clea			

Note: The glazing Tra ... sed on the glazing type.

NEW CLASSROOM WALLS AND WINDOW ASSEMBLIES AS SHOWN HERE WILL BE IMPORTED VIA "IMPORT HAP PROJECT DATA" FROM THE PREVIOUSLY SAVED "SOLVED" HAP PROJECT. WHEN WE BRING IN SPACES VIA IMPORT, ALL THE ASSOCIATED WALLS, ROOFS, GLASS, AND SCHEDULES WILL COME ONBOARD.

Casement Reveal

Reveal Depth..... ... in
... in
... in
... in

Left Fin:

Projection from surface..... 0.0 in
Height above window ..... **0.0** in
Dist. from edge of window ..... **0.0** in

Projection from surface ..... 0.0 in
Height above window..... **0.0** in
Dist. from edge of window..... **0.0** in

Typical Entry Door

Door Details:

Gross Area ..... **48.0** ft²
Door U-Value ..... **0.210** BTU/(hr-ft²-°F)

Glass Details:

Glass Area ..... **46.0** ft²
Glass U-Value ..... **0.580** BTU/(hr-ft²-°F)
Glass Shade Coefficient **0.459**
Glass Shaded All Day? ..... **No**

HINT: For the roof assembly, start with selecting the medium weight roof from the drop down and edit the values as shown in the roof details below. To add a layer, right mouse click on the table and select insert, then define the new layer properties.

Flat Roof - Classrooms

Roof Details

Outside Surface Color ..... **Medium**
Absorptivity **0.675**
Overall U-Value ..... **0.040** BTU/(hr-ft²-°F)

Roof Layers Details (Inside to Outside)

Layers	Thickness in	Density lb/ft³	Specific Ht. BTU / (lb - °F)	R-Value (hr-ft²-°F)/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
Acoustic tile	0.750	30.0	0.20	1.79000	1.9
Ceiling air space	0.000	0.0	0.00	1.00000	0.0
22 gage steel deck	0.034	489.0	0.12	0.00011	1.4
R-20.0 board insulation	3.000	2.0	0.22	20.83333	0.5
Built-up roofing	0.375	70.0	0.35	0.33245	2.2
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	**4.159**	**-**		**24.97389**	**5.9**

NOTE: The database does not include an R-20 board insulation layer. Start with an R-14 board insulation and edit the name. To increase the "R" value for this layer, adjust (by trial-and-error) the layer thickness until achieving the appropriate "R" value. Using this procedure creates an accurate Transfer Function Coefficient resulting in an accurate heat transfer analysis.

Save our Trinidad Loads project. Next, using the "Import HAP Project Data" feature under the Project item on the HAP Menu Bar and highlight the Project "Trinidad Loads Solved 2017" and click OK. Select the remaining 7 designated spaces and click on Import. See Figures next page for details.

Figure 1.34a – Import HAP Data

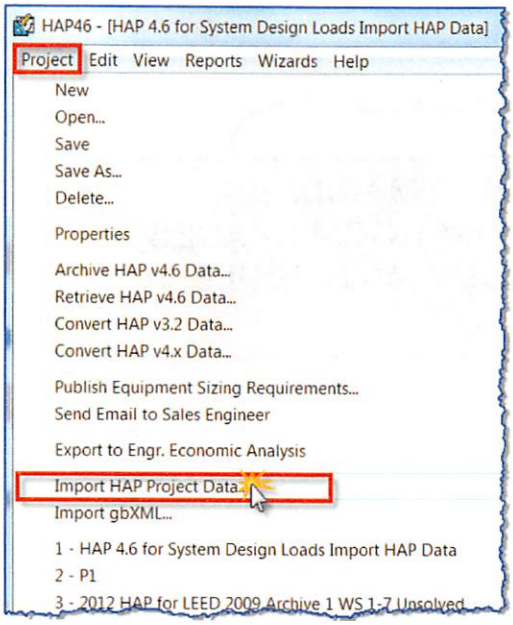


Figure 1.34b – Import HAP Data

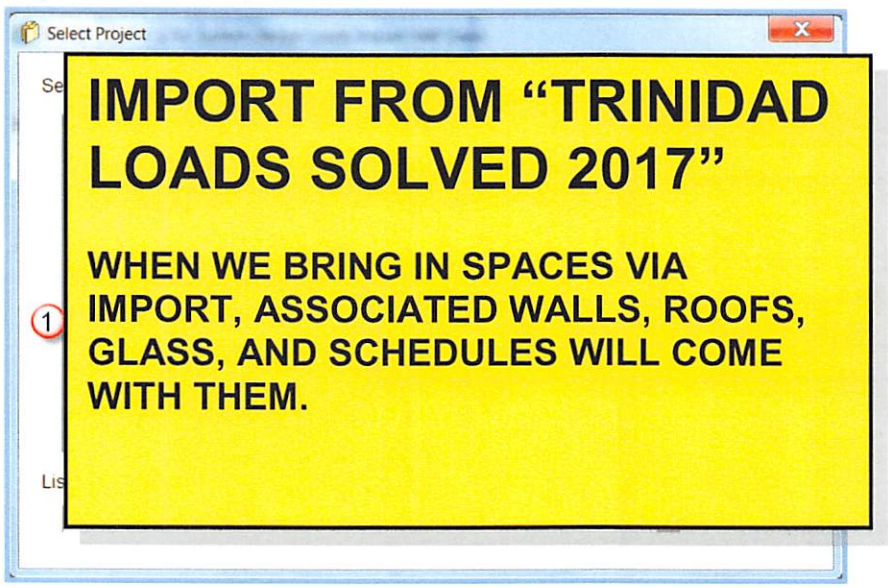


Figure 1.34c – Import HAP Data

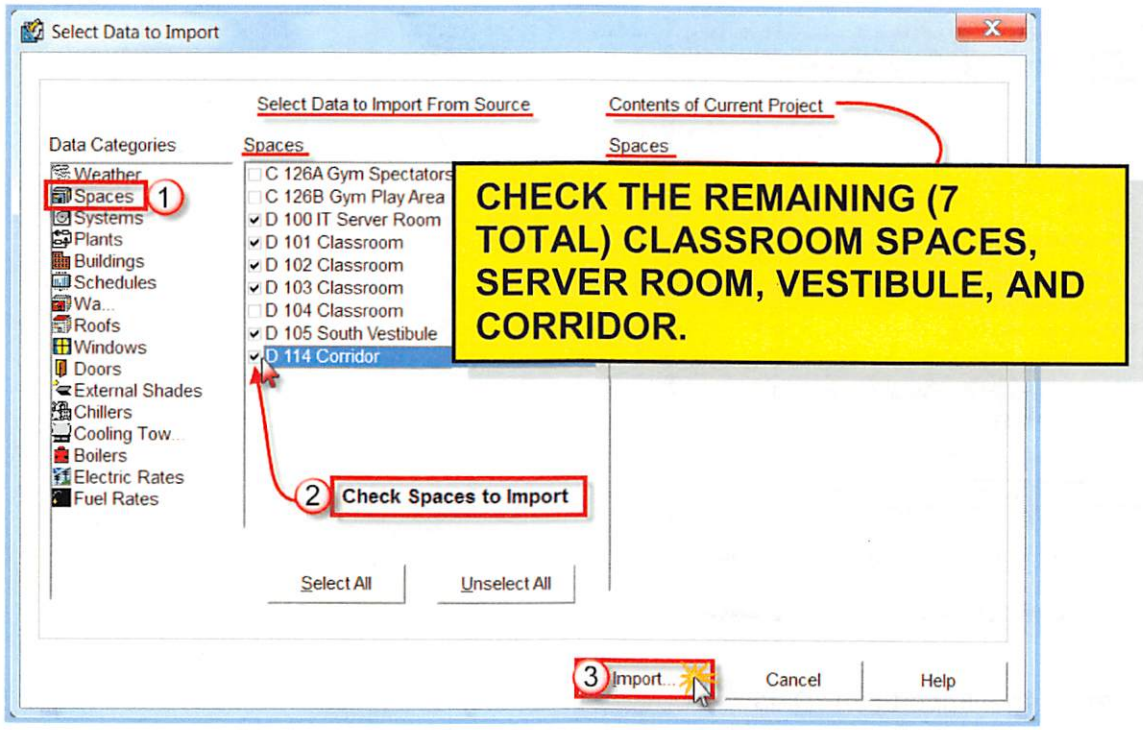


Figure 1.34d – Import HAP Data

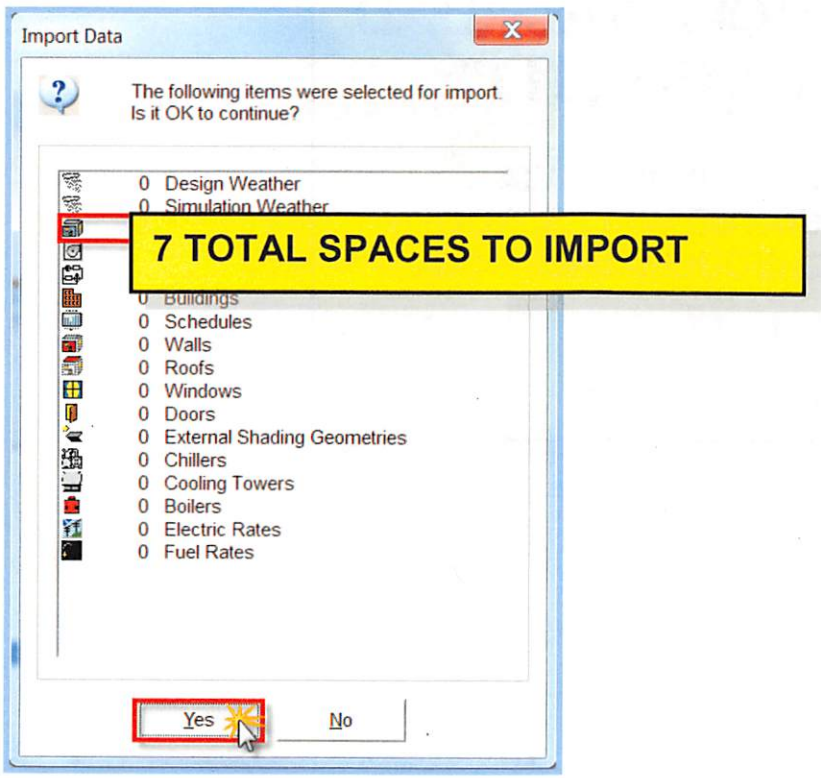


Figure 1.34e – Import HAP Data

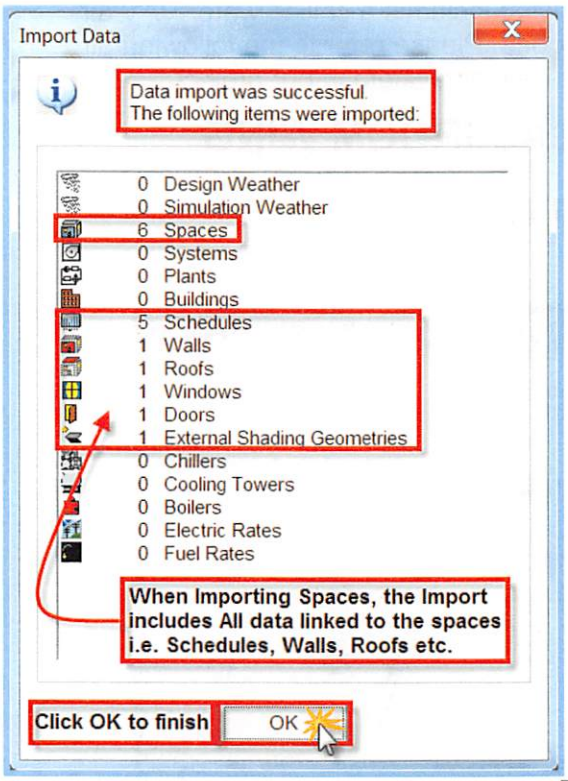
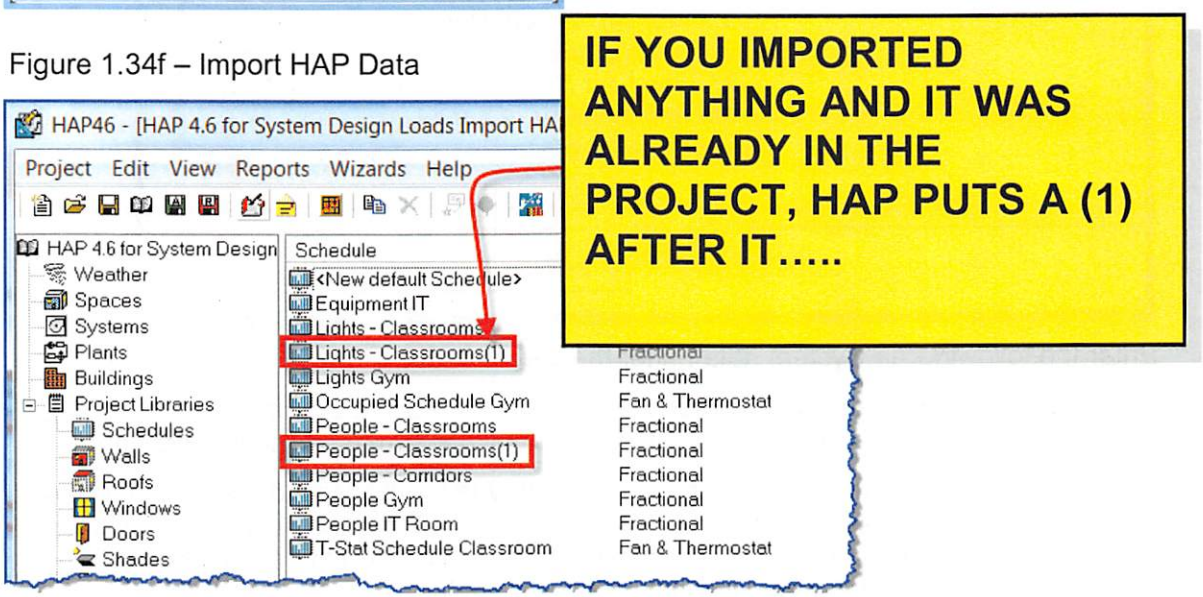


Figure 1.34f – Import HAP Data



In our next step for workshop # 2 we will create a new VAV air system to handle the (7) Wing "D" spaces that we imported in the previous step.

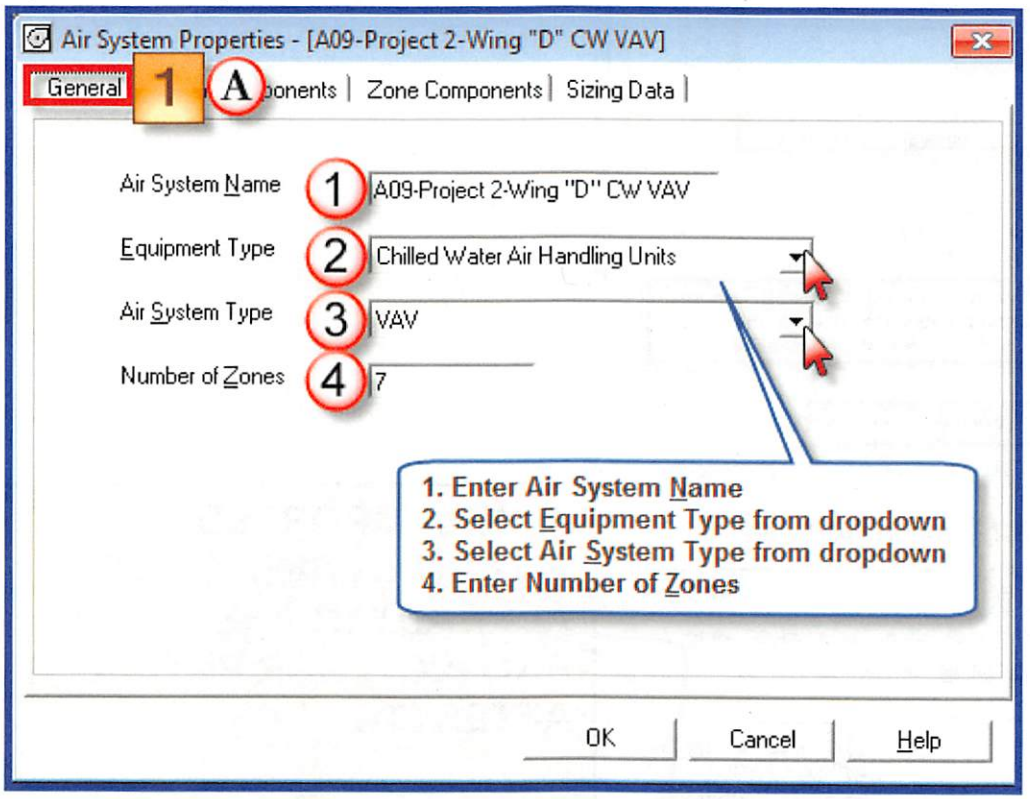
Wing "D" Air System Properties

Our base air system design for the classroom wing includes a chilled water VAV air handling unit and VAV boxes **with no reheat coils**. Please refer to the following air system properties and enter these items into a new air system in our project.

DEFINE AIR SYSTEM FOR CLASSROOM WING

1A – Air System Properties - General Tab

Figure 2.1 - Air System General Tab

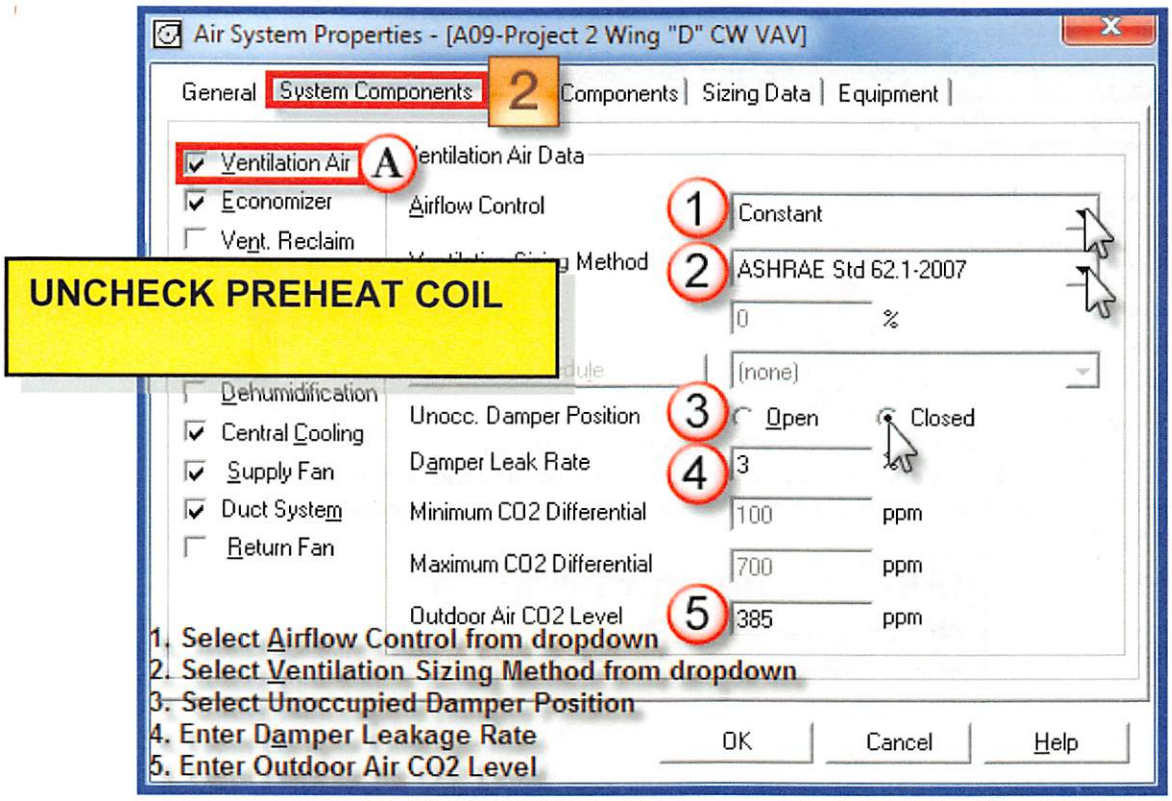


Enter the following Air System data under the General tab:

1. Enter Air Handling Unit Name you want for this project. We named our system A09-Project 2 Wing "D" CW VAV to distinguish it from other design scenarios.
2. From the dropdown, select the Equipment type for the base design case. For our project we chose a Chilled Water Air Handling Unit per the owner's request for a chilled water central plant. The owner chose not to go with packaged RTUs to minimize sound and maximize flexibility for zoning.
3. Select the Air System Type from the dropdown. The owner decided to investigate VAV central station air handling units for Wings "B", "C" and "D".
4. Enter the number of zones for this air system. In our case we have seven (7) total zones. A zone represents one thermostat control for a zone terminal unit. A zone contains one or more spaces.

2A – System Components – Ventilation Air Data

Figure 2.2 - System Components – Ventilation Air Data



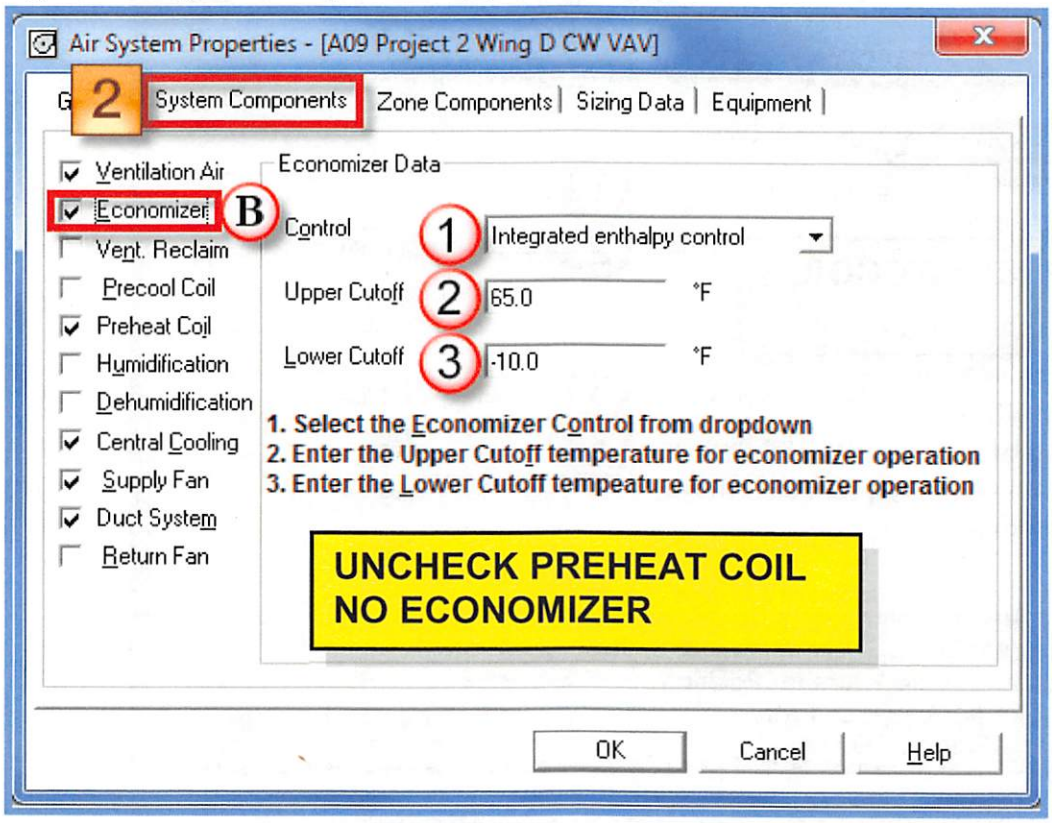
Enter the following System Components Ventilation Air Data:

1. Select Airflow Control from dropdown. For this system we use the constant airflow control for sizing the system ventilation air quantity
2. Select Ventilation Sizing Method from dropdown. We apply the ASHRAE Std. 62.1-2013 procedures in determining the system ventilation air quantity.
3. Select "Unoccupied" damper position radio button. To conserve energy we chose to close the outdoor air damper when the building is unoccupied.
4. Enter Damper Leakage Rate. We assumed a tight seal damper with 3% leakage rate.
5. Enter the Outdoor Air CO_2 Level in parts per million. The 385ppm value derived from the WMO* was the average for 2009. The past decade shows an alarming average annual increase of 0.5% and the major contributor to greenhouse gases and global warming.

*WMO = World Meteorological Organization

2B – System Components - Economizer Data

Figure 2.3 - System Components – Economizer Data

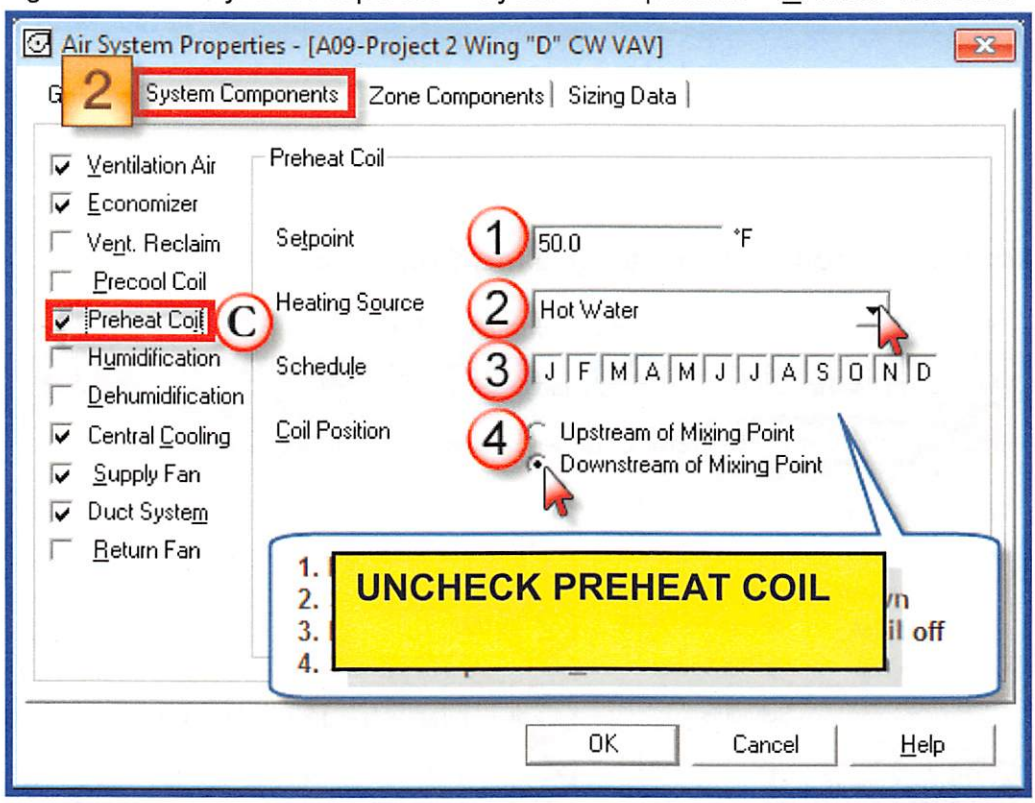


Enter the following System Components Economizer Data:

1. Select the appropriate economizer control from the dropdown. We chose an integrated enthalpy controller that compares return air enthalpy to outdoor air enthalpy and determines the best source of air to satisfy the current system load. Economizer dampers modulate to introduce sufficient outdoor air to eliminate the need for mechanical cooling, or 100% outdoor air if mechanical cooling cannot be completely eliminated.
2. Enter the upper limit cutoff. This setting determines the maximum outdoor air temperature used for economizer operation. When outdoor temperatures exceed this input, the outside air damper goes to minimum position.
3. Enter the lower limit cutoff for economizer operation. This setting determines the minimum outdoor air temperature used for the economizer operation. When outdoor temperatures fall below this setting, the outdoor air damper moves to minimum position.

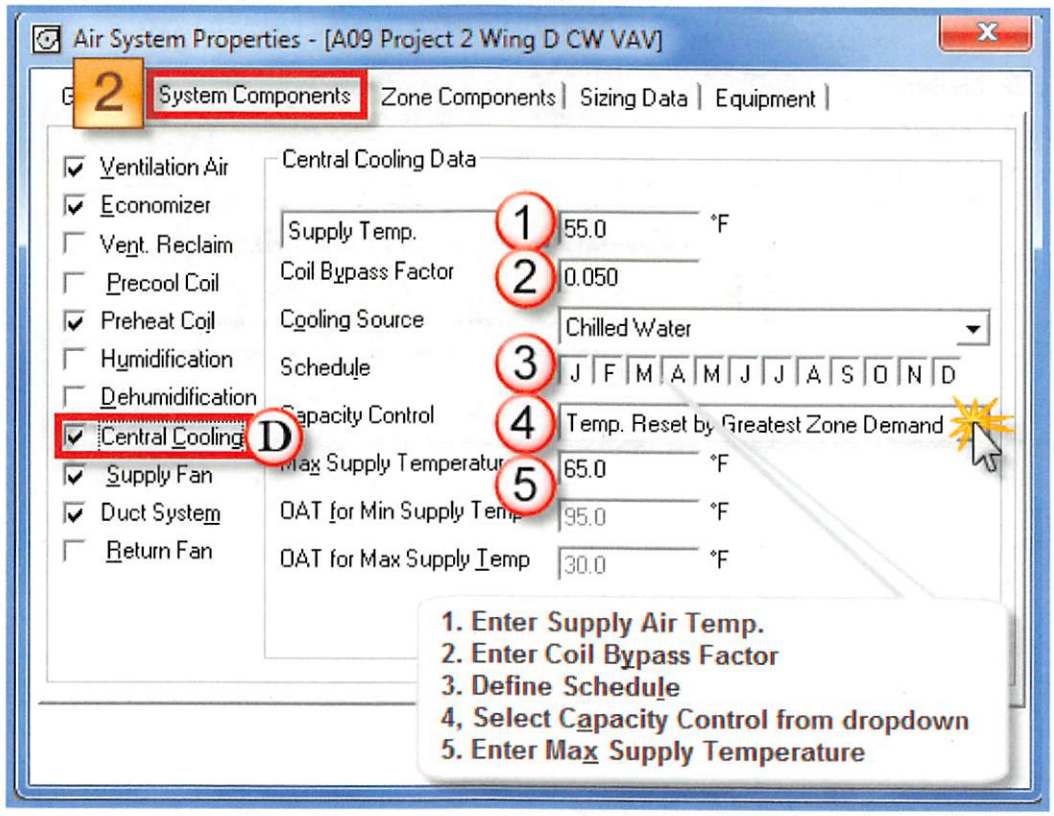
2C – System Components – Preheat Coil Data

Figure 2.4 - Air System Properties – System Components – Preheat Coil Data



2D-System Components - Central Cooling Coil Data

Figure 2.5 - System Components - Central Cooling Coil Data



Enter the following data into the Central Cooling Coil data:

1. The only option used as an anchor for calculating coil loads in a VAV air system is SAT Supply Air Temperature. This temperature represents the air temperature in the primary supply air duct entering the VAV terminal device.

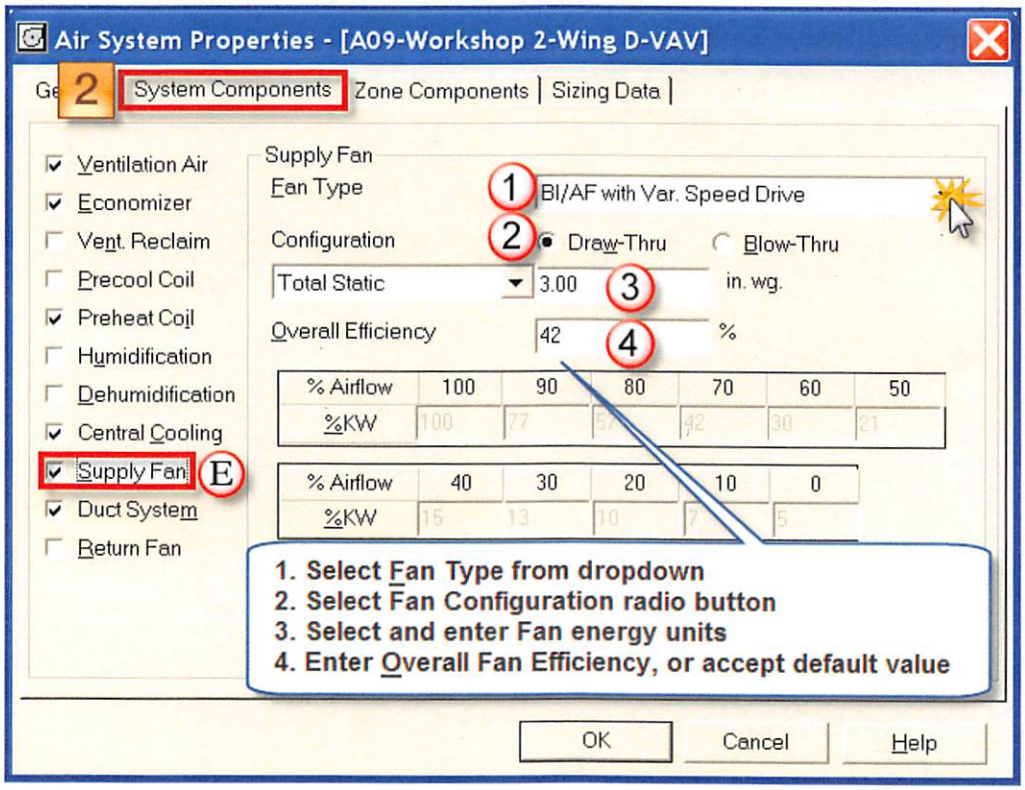
   Enter Supply Temp: 55°F

2. The Coil Bypass Factor represents the percentage of supply air passing through the cooling coil without making direct contact with the coil. Considered as the airside inefficiency of the cooling coil. These values depend on the coil configuration, coil area, air volume and velocity. Enter the Coil Bypass Factor of 0.05. The cooling source defaulted to Chilled Water from our equipment type selection under the general tab.

3. The schedule represents cooling availability and defaults to all months activated. Click on a month to deselect it. For our project we have cooling and heating available all 12 months.
4. Capacity Control: Temp. Reset by Greatest Zone Demand
5. Max. Supply Temp: 65°F

2E-System Components - Supply Fan Data

Figure 2.6 - System Components – Supply Fan Data



Enter the following data into the Supply Fan Data form:

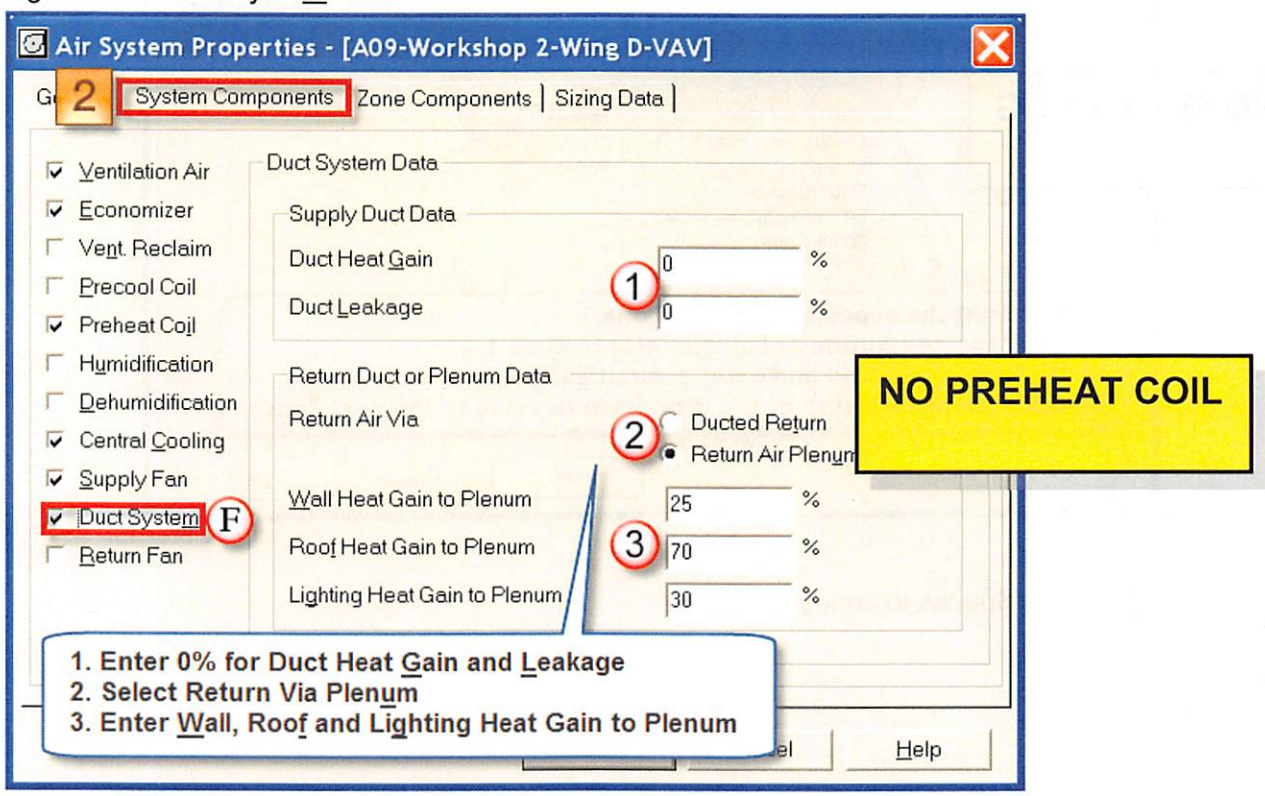
Fan Type:	BI/AF w/ Variable Speed Drive
Configuration:	Draw Through
Select fan energy:	Total Static Pressure
Enter Static:	3.00 in.wg.
Overall Fan Efficiency:	42%

HAP creates the part-load fan curve for a "generic" selected fan type, based on the above inputs.

2F. Enter Duct System Data

Enter Supply Duct Heat Gain:	00%
Enter Supply Duct Leakage:	00%
Return Air Via:	Return Plenum
Wall Heat Gain to Plenum:	25%
Roof Heat Gain to Plenum:	70%
Lighting Heat Gain to Plenum:	30%

Figure 2.7 - Duct System Data

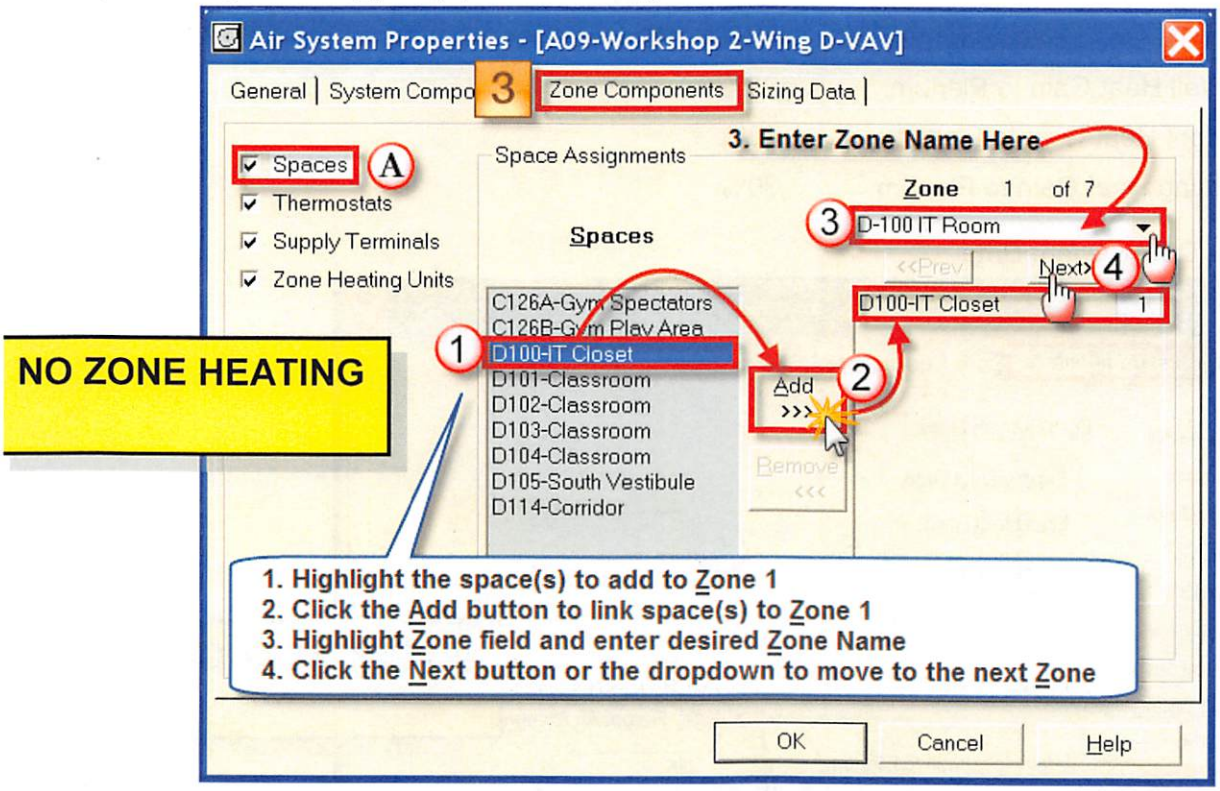


The following exercises walk us through the steps in defining the Zone Components. Click on the "Zone Components" Tab to enter the zone information. In the Zone Components input form we link the spaces to the zones, define the thermostat details and link the fan/t-stat schedule to our air system. We also enter the details about the zone terminal equipment by selecting the terminal unit type and defining the component details. If any of the zones include heating from fin-tube radiation or cabinet unit heater, we model that in the zone heating input under the zone components tab. The following exercise takes us through this input form.

Assign the following spaces to zones. Note: you can edit the default assigned zone name by clicking on the zone name field and typing in the terminal unit ID tag. Refer to Figure 2.8 below.

3A-Zone Components – Space to Zone Assignments

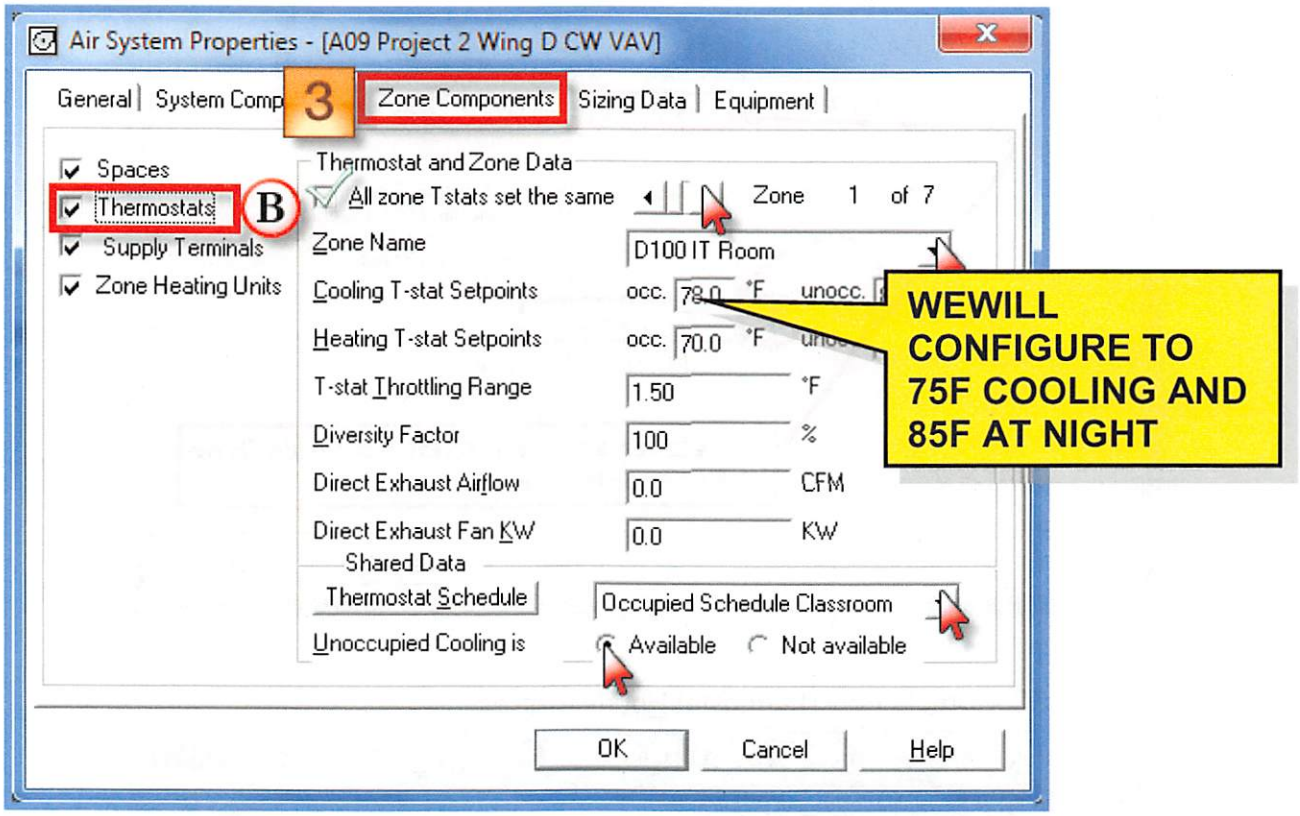
Figure 2.8 - Space(s) to Zone Assignments



3A. Assign Spaces to zones

3B-Zone Components - Thermostat and Zone Data

Figure 2.9 - Zone Components –Thermostat and Zone Data Settings



Leave check in box all zones set the same for now and enter the details for the Classrooms. .

For Typical Classroom Zones, enter the following data:

Cooling T-stat Setpoint:	75°F occupied
	85°F unoccupied
Heating T-stat Setpoint:	70°F occupied
	60°F unoccupied
T-stat Throttle Range:	1.5°F
Diversity Factor:	100% (No diversity)
Direct Exhaust Airflow:	0.00 CFM
Direct Exhaust kW:	0.0 kW

Click on the Thermostat schedule drop down and select <create new>, select the Fan/Thermostat Schedule radio button and create the following T-stat schedule and profiles.

Figure 2.9B - Create Fan/Thermostat Schedule

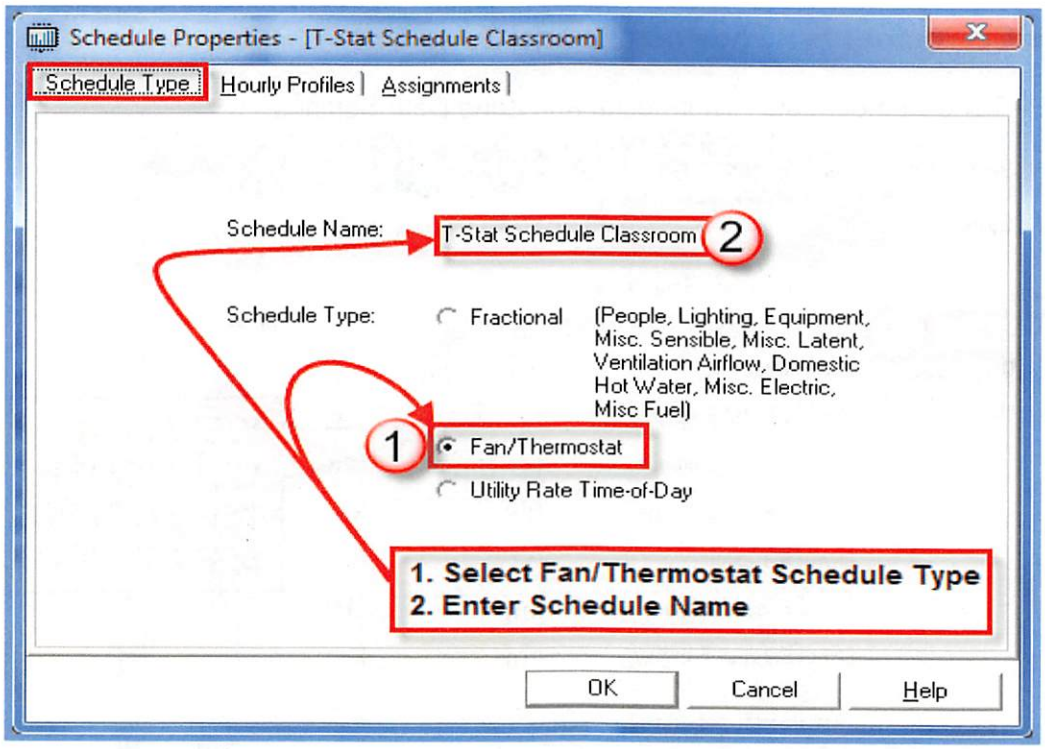


Figure 2.9C – Create Fan/Thermostat Hourly Profiles

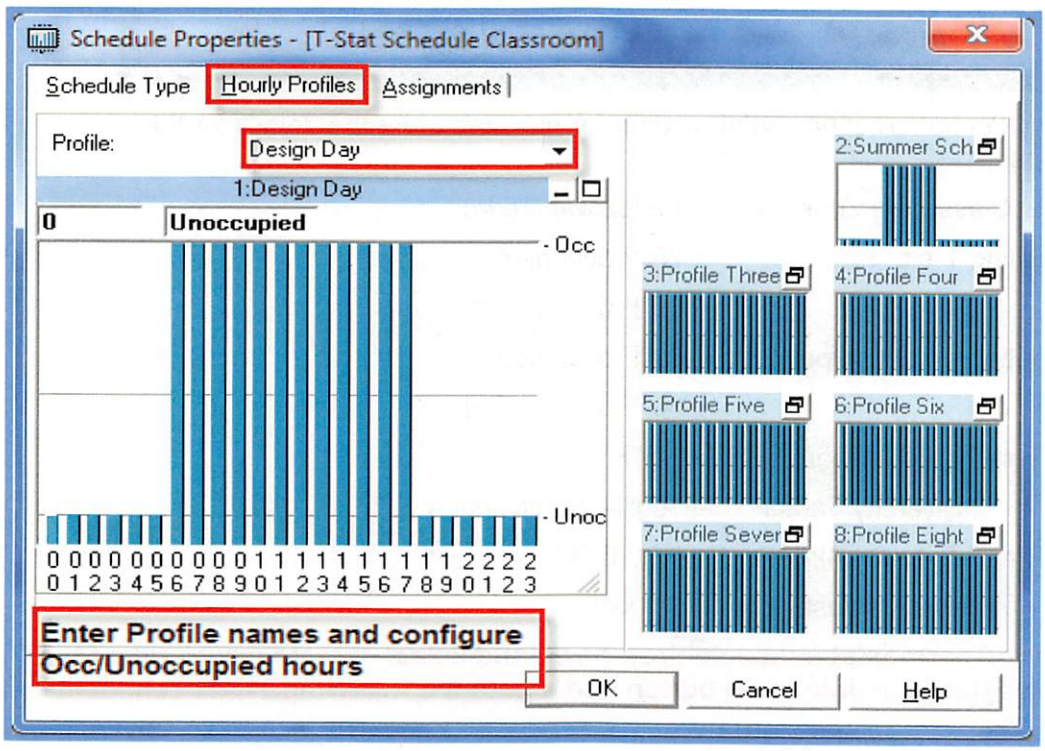
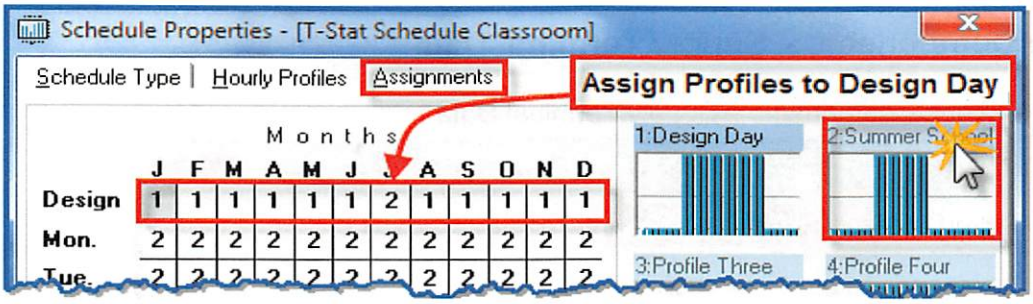


Figure 2.9D – Fan/Thermostat Schedule Assignments



Schedule Name:	**Occupied Schedule Classroom**
Profile One:	**Design Day**
Hours 00 – 05:	**Unoccupied**
Hours 18 – 23:	**Unoccupied**
Hours 06 – 17:	**Occupied**
Profile Two:	**Summer School**
Hours 00 – 05:	**Unoccupied**
Hours 14 – 23:	**Unoccupied**
Hours 06 – 13:	**Occupied**

Assign Profile 1 to Design Day all months except July. Assign Profile 2 to Design Day for July only. Upon completing this exercise, click the OK button, which returns you to the T-stat settings input screen. Select the Unoccupied Cooling "Available" radio button.

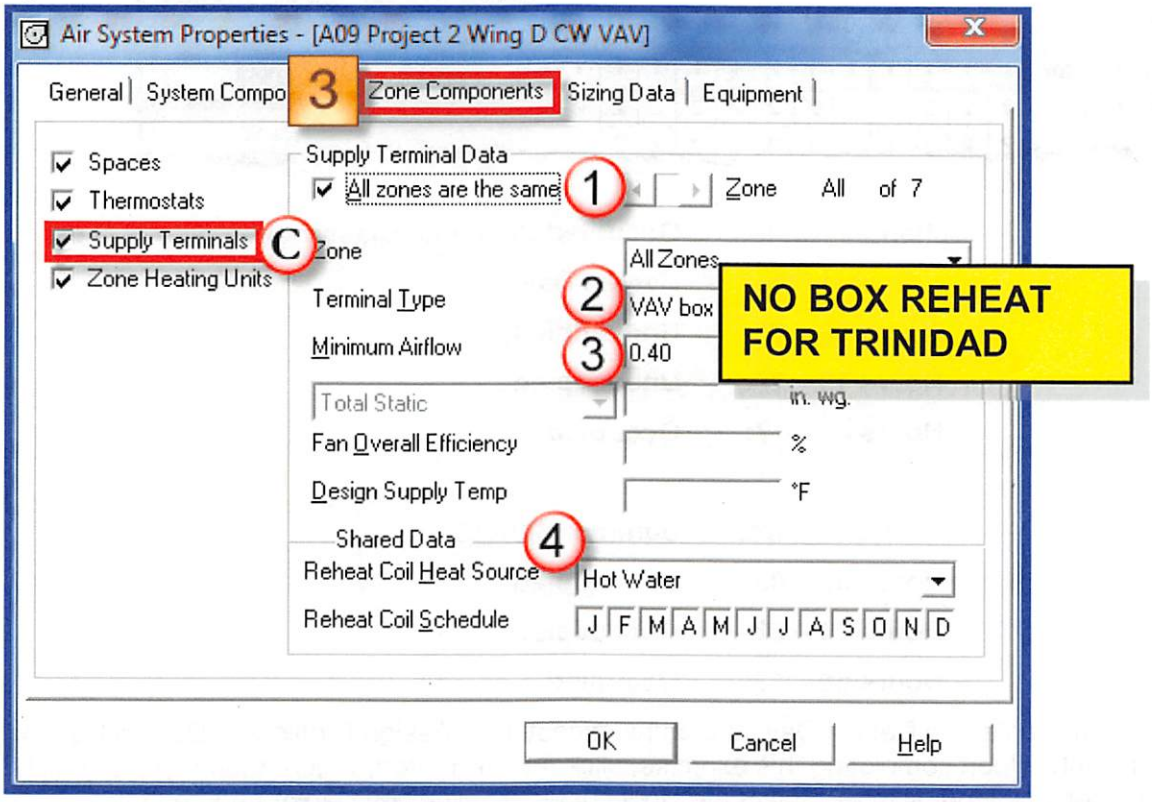
Return to the "All Zones Set the Same" check box and remove the checkmark, then **navigate to Zone D100 IT Room (Zone 1) and enter the following data for the IT room.**

Cooling T-stat Setpoint:	**78°F occupied (ZONE 1,6,7)**
	85°F unoccupied
Heating T-stat Setpoint:	70°F occupied
	60°F unoccupied
T-stat Throttle Range:	1.5°F
Diversity Factor:	100% (No diversity)
Direct Exhaust Airflow:	0.00 CFM
Direct Exhaust kW:	0.0 kW

Enter these same values for the D105 South Vestibule (Zone 6) and the D114 Corridor Zones (Zone 7).

3C-Zone Components – Supply Terminal Data

Figure 2.10 - Zone Components – Supply Terminal Data



1. Leave the check in the checkbox All zones are the same.
2. Select Terminal Type from the dropdown. For this wing of the project we chose VAV boxes without reheat coils.
3. Select the CFM/ft² Minimum Airflow setting from the dropdown and enter the minimum airflow as 0.40 CFM/person. We defaulted to this value to meet the ASHRAE 90.1-2013 Appendix G requirements. Note: Minimum airflow is calculated based on the maximum number of occupants in the zone.

3D-Zone Components – Zone Heating Unit Discussion

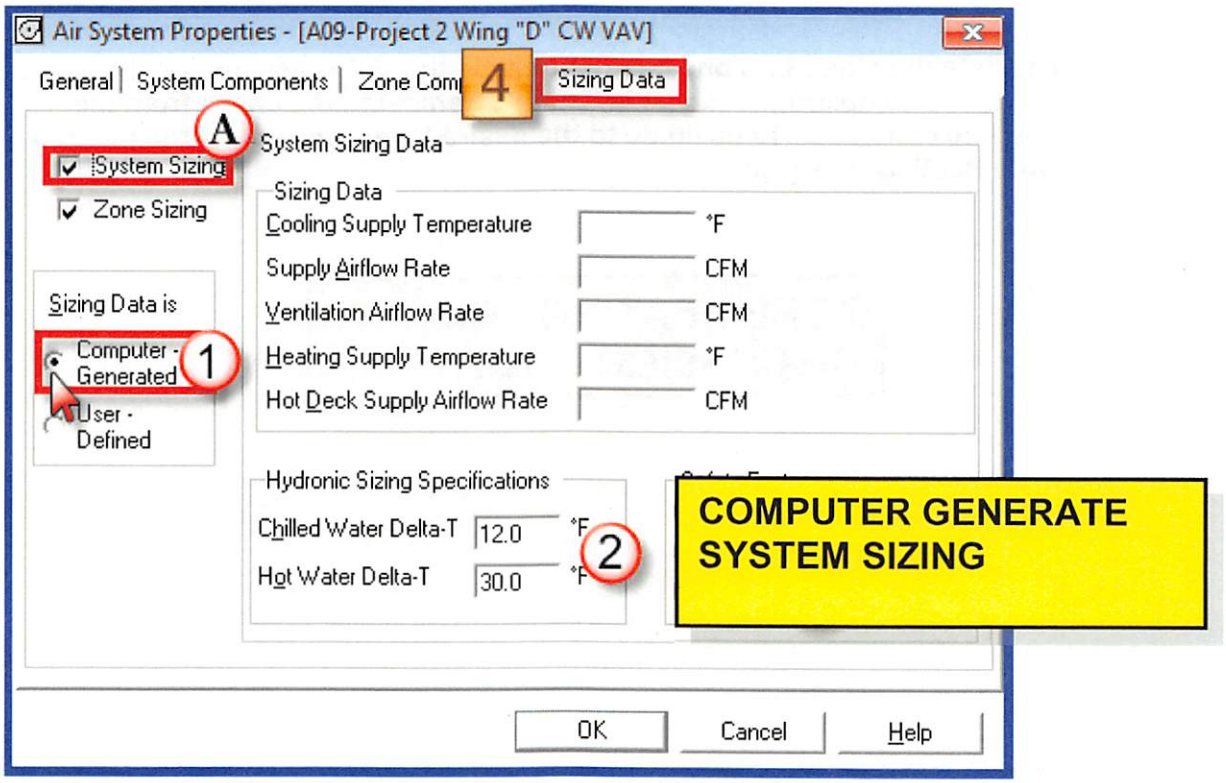
Figure 2.11 - Zone Components – Zone Heating Units

1. **The default setting for zone heating units is that All zones are set the same and the zone heating unit type is "none". Removing the check from the checkbox allows us to navigate to the desired zone and select the desired Zone Heating Unit Type.**

ZONE HEATING FOR DISCUSSION ONLY.

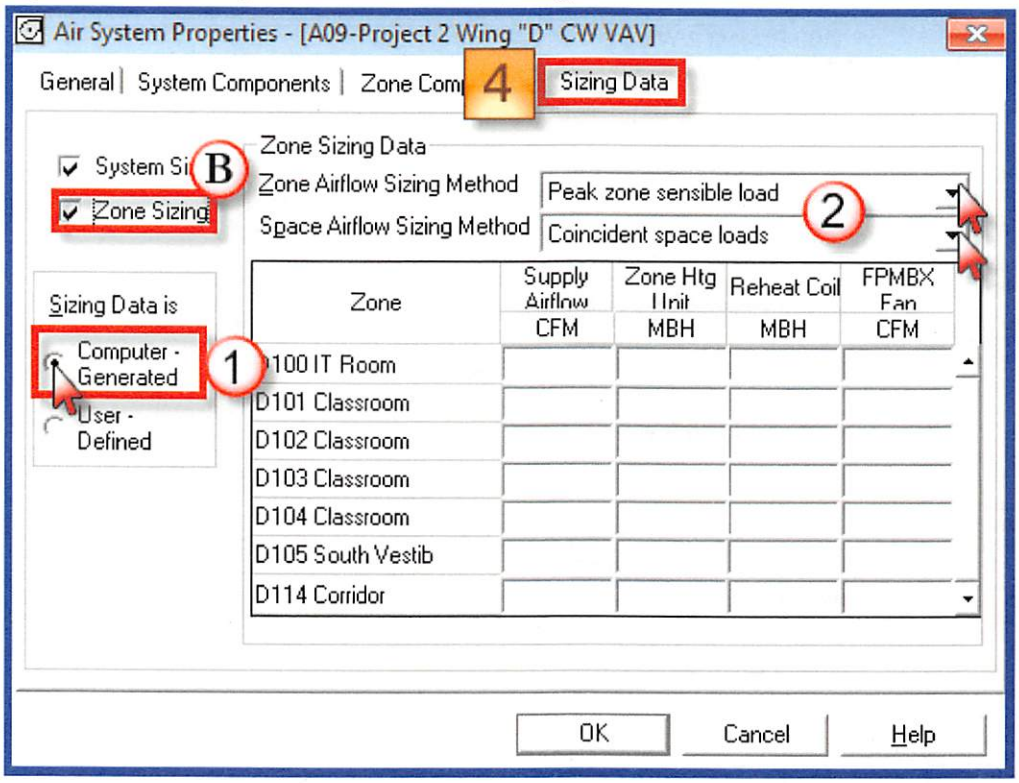
4A-Sizing Data – System Sizing Data

Figure 2.12 - Sizing Data – System Sizing Data



4B-Sizing Data – Zone Sizing Data

Figure 2.13 - Sizing Data Tab – Zone Sizing Data



For sizing the Zone and Space airflows enter the following data in the Sizing Data Tab-Zone Sizing:

1. Select Computer Generated to have HAP calculate the sizing results.
2. Select "Peak zone sensible load" from the Zone Airflow Sizing Method to calculate the zone terminal unit required peak airflow rate. Then select the "Coincident space loads" from the Space Airflow Sizing Method dropdown to calculate the space airflow rates.

Please refer to Appendix B "The Sizing Dilemma" for a detailed discussion on the Sizing Data method options.

At this point we are ready to calculate the air system design load. In the HAP programs window with the Systems displayed on the detail screen, highlight the newly created air system and select the reports to preview. The following pages contain the air system input details and the design load reports.

Air System Input Details

A09 Project 2 Wing D CW VAV Input Data

Project Name: TRINIDAD LOADS ARCHIVE 1 SOLVED — 10/13/2013
Prepared by: carrier corporation — 09:51PM

1. General Details:

Air System Name	A09 Project 2 Wing D CW VAV
Equipment Type	Chilled Water AHU
Air System Type	VAV
Number of zones	7

2. Ventilation System Components:

Ventilation Air Data:

Airflow Control	Constant Ventilation Airflow	
Ventilation Sizing Method	ASHRAE Std 62.1-2007	
Unocc. Damper Position	Closed	
Damper Leak Rate	3	%
Outdoor Air CO2 Level	385	ppm

Economizer Data:

Control	Integrated enthalpy control	
Upper Cutoff	65.0	°F
Lower Cutoff	-10.0	°F

Central Cooling Data:

Supply Air Temperature	55.0	°F
Coil Bypass Factor	0.050	
Cooling Source	Chilled Water	
Schedule	JFMAMJJASOND	
Capacity Control	Temperature Reset by Greatest Zone Demand	
Max. Supply Temperature	65.0	°F

Supply Fan Data:

Fan Type	BI/AF with Variable Speed Drive	
Configuration	Draw-thru	
Fan Performance	3.00	in wg
Overall Efficiency	42	%

% Airflow	100	90	80	70	60	50
% kW	100	77	57	42	30	21

% Airflow	40	30	20	10	0
% kW	15	13	10	7	5

Duct System Data:
Supply Duct Data:
Duct Heat Gain ..... 0 %
Duct Leakage ..... 0 %

Return Duct or Plenum Data:
Return Air Via ..... Return Air Plenum
Wall Heat Gain to Plenum ..... 25 %
Roof Heat Gain to Plenum ..... 70 %
Lighting Heat Gain to Plenum ..... 30 %

3. Zone Components:
Space Assignments:

Zone 1: D100 IT Room	
D 100 IT Server Room	x1
Zone 2: D 101 Classroom	
D 101 Classroom	x1
Zone 3: D 102 Classroom	
D 102 Classroom	x1
Zone 4: D 103 Classroom	
D 103 Classroom	x1
Zone 5: D 104 Classroom	
D 104 Classroom	x1
Zone 6: D 105 South Vestibule	
D 105 South Vestibule	x1
Zone 7: D 114 Corridor	
D 114 Corridor	x1

Thermostats and Zone Data:

Zone	Cooling T-Stat Occ. (°F)	Cooling T-Stat Unocc. (°F)	Heating T-Stat Occ. (°F)	Heating T-Stat Unocc. (°F)	T-Stat Throttling Range (°F)	Diversity Factor (%)	Direct Exhaust Airflow (CFM)	Direct Exhaust Fan (kW)
1	78.0	88.0	70.0	60.0	1.50	100	0.0	0.0
2	75.0	85.0	70.0	60.0	1.50	100	0.0	0.0
3	75.0	85.0	70.0	60.0	1.50	100	0.0	0.0
4	75.0	85.0	70.0	60.0	1.50	100	0.0	0.0
5	75.0	85.0	70.0	60.0	1.50	100	0.0	0.0
6	78.0	85.0	70.0	60.0	1.50	100	0.0	0.0
7	78.0	85.0	70.0	60.0	1.50	100	0.0	0.0

Thermostat Schedule ..... T-Stat Schedule Classroom
Unoccupied Cooling is ..... Available

Supply Terminals Data:
Zone ..... All
Terminal Type ..... VAV box
Minimum Airflow ..... 0.40 CFM/ft²

Zone Heating Units:

Zone Unit Heat Source ..... Hot Water
Zone Heating Unit Schedule ..... JFMAMJJASOND

NO ZONE HEATING UNITS

4. Sizing Data (Computer-Generated):
System Sizing Data:
Hydronic Sizing Specifications:
Chilled Water Delta-T ..... 12.0 °F
Hot Water Delta-T ..... 30.0 °F

Safety Factors:
Cooling Sensible ..... 0 %
Cooling Latent ..... 0 %
Heating ..... 0 %

Zone Sizing Data:
Zone Airflow Sizing Method ..... Peak zone sensible load
Space Airflow Sizing Method ..... Coincident space loads

Air System Design Load reports

Air System Sizing Summary Report

Air System Information

Air System Name	A09 Project 2 Wing D CW VAV		Number of zones	7	
Equipment Class	CW AHU		Floor Area	4433.0	ft²
Air System Type	VAV		Location	Port of Spain, Trinidad & Tobago	

Sizing Calculation Information

Calculation Months	Jan to Dec	Zone CFM Sizing	Peak zone sensible load
Sizing Data	Calculated	Space CFM Sizing	Coincident space loads

Central Cooling Coil Sizing Data

Total coil load	17.7	Tons	Load occurs at	Aug 1500	
Total coil load	212.6	MBH	OA DB / WB	93.0 / 78.2	°F
Sensible coil load	120.7	MBH	Entering DB / WB	87.4 / 73.0	°F
Coil CFM at Aug 1500	3194	CFM	Leaving DB / WB	52.3 / 51.9	°F
Max block CFM at Aug 1500	3194	CFM	Coil ADP	50.5	°F
Sum of peak zone CFM	3344	CFM	Bypass Factor	0.050	
Sensible heat ratio	0.568		Resulting RH	51	%
ft²/Ton	250.2		Design supply temp.	55.0	°F
BTU/(hr·ft²)	48.0		Zone T-stat Check	4 of 7	OK
Water flow @ 12.0 °F rise	35.45	gpm	Max zone temperature deviation	0.6	°F

Preheat Coil Sizing Data

No heating coil loads occurred during this calculation.

Supply Fan Sizing Data

Actual max CFM at Aug 1500	3194	CFM	Fan motor BHP	3.37	BHP
Standard CFM	3189	CFM	Fan motor kW	2.68	kW
Actual max CFM/ft²	0.72	CFM/ft²	Fan static	3.00	in wg

Outdoor Ventilation Air Data

Design airflow CFM	1832	CFM	CFM/person	16.66	CFM/person
CFM/ft²	0.41	CFM/ft²			

Zone Sizing Summary Report

Zone Terminal Sizing Data

Zone Name	Design Supply Airflow (CFM)	Minimum Supply Airflow (CFM)	Zone CFM/ft²	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 30.0 °F	Zone Htg Unit Coil Load (MBH)	Zone Htg Unit Water gpm @ 30.0 °F	Mixing Box Fan Airflow (CFM)
D100 IT Room	210	14	5.99	0.0	0.00	0.0	0.00	0
D 101 Classroom	620	351	0.74	0.0	0.00	0.0	0.00	0
D 102 Classroom	620	351	0.74	0.0	0.00	0.0	0.00	0
D 103 Classroom	620	351	0.74	0.0	0.00	0.0	0.00	0
D 104 Classroom	780	351	0.93	0.0	0.00	0.0	0.00	0
D 105 South Vestibule	114	35	1.30	0.0	0.00	0.0	0.00	0
D 114 Corridor	380	380	0.40	0.0	0.00	0.0	0.00	0

Zone Peak Sensible Loads

Zone Name	Zone Cooling Sensible (MBH)	Time of Peak Sensible Cooling Load	Zone Heating Load (MBH)	Zone Floor Area (ft²)
D100 IT Room	5.2	Aug 1200	0.0	35.0
D 101 Classroom	13.4	Aug 1500	0.1	840.0
D 102 Classroom	13.4	Aug 1500	0.1	840.0
D 103 Classroom	13.4	Aug 1500	0.1	840.0
D 104 Classroom	16.8	Nov 1500	0.2	840.0
D 105 South Vestibule	2.8	Dec 1500	0.0	88.0
D 114 Corridor	4.8	Aug 1500	0.0	950.0

Space Loads and Airflows

Zone Name / Space Name	Mult	Cooling Sensible (MBH)	Time of Peak Sensible Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
D100 IT Room							
D 100 IT Server Room	1	5.2	Aug 1200	210	0.0	35.0	5.99
D 101 Classroom							
D 101 Classroom	1	13.4	Aug 1500	620	0.1	840.0	0.74
D 102 Classroom							
D 102 Classroom	1	13.4	Aug 1500	620	0.1	840.0	0.74
D 103 Classroom							
D 103 Classroom	1	13.4	Aug 1500	620	0.1	840.0	0.74
D 104 Classroom							
D 104 Classroom	1	16.8	Nov 1500	780	0.2	840.0	0.93
D 105 South Vestibule							
D 105 South Vestibule	1	2.8	Dec 1500	114	0.0	88.0	1.30
D 114 Corridor							
D 114 Corridor	1	4.8	Aug 1500	380	0.0	950.0	0.40

Ventilation Sizing Summary Report

Ventilation Sizing Summary for A09 Project 2 Wing D CW VAV

Project Name: TRINIDAD LOADS SOLVED 2017 POS ASHRAE — 07/23/2017
Prepared by: carrier — 01:06PM

1. Summary

Ventilation Sizing Method ..... ASHRAE Std 62.1-2013
Design Condition ..... Minimum flow (cooling)
Occupant Diversity (D) 1.000
Uncorrected Outdoor Air Intake (Vou) ..... 1470 CFM
System Ventilation Efficiency (Ev) 0.802
Outdoor Air Intake (Vot) ..... 1832 CFM

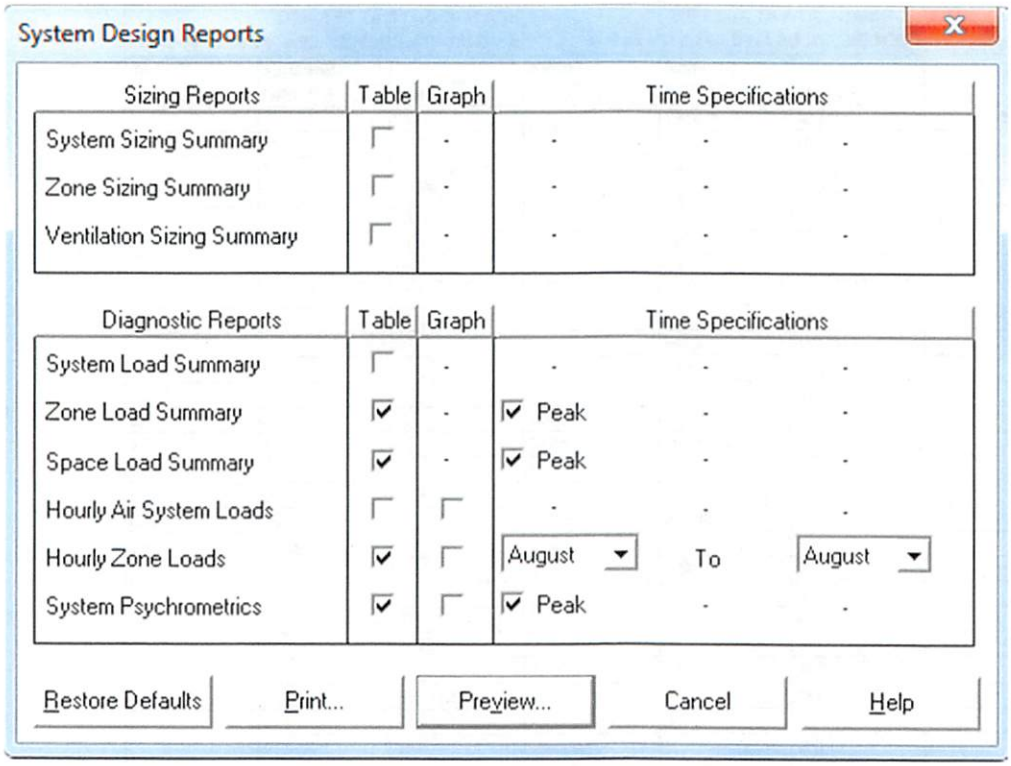
2. Space Ventilation Analysis

Zone Name / Space Name	Mult.	Minimum Supply Air (CFM) (Vpz)	Space Floor Area (ft²) (Az)	Area Outdoor Air Rate (CFM/ft²) (Ra)	Time Averaged Occupancy (Occupants) (Pz)	People Outdoor Air Rate (CFM/person) (Rp)	Air Distribution Effectiveness (Ez)	Space Outdoor Air (CFM) (Voz)	Breathing Zone Outdoor Air (CFM) (Vbz)	Space Ventilation Efficiency (Evz)
D100 IT Room										
D 100 IT Server Room	1	14	35.0	0.06	0.6	5.00	1.00	5	5	1.456
D 101 Classroom										
D 101 Classroom	1	351	840.0	0.12	25.0	10.00	1.00	351	351	0.802
D 102 Classroom										
D 102 Classroom	1	351	840.0	0.12	25.0	10.00	1.00	351	351	0.802
D 103 Classroom										
D 103 Classroom	1	351	840.0	0.12	25.0	10.00	1.00	351	351	0.802
D 104 Classroom										
D 104 Classroom	1	351	840.0	0.12	25.0	10.00	1.00	351	351	0.802
D 105 South Vestibule										
D 105 South Vestibule	1	35	88.0	0.06	1.0	0.00	1.00	5	5	1.652
D 114 Corridor										
D 114 Corridor	1	380	950.0	0.06	8.0	0.00	1.00	57	57	1.652
Totals (Incl. Space Multipliers)		1832							1470	0.802

Air System Design Load Summary Report

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1500 COOLING OA DB / WB 93.0 °F / 78.2 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 69.4 °F / 57.7 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	480 ft²	9891	-	480 ft²	-	-
Wall Transmission	982 ft²	738	-	982 ft²	27	-
Roof Transmission	4433 ft²	3142	-	4433 ft²	107	-
Window Transmission	480 ft²	2579	-	480 ft²	100	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	48 ft²	796	-	48 ft²	16	-
Floor Transmission	4433 ft²	0	-	4433 ft²	46	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	4708 W	8914	-	0	0	-
Task Lighting	2784 W	7520	-	0	0	-
Electric Equipment	2680 W	8535	-	0	0	-
People	110	18259	13965	0	0	0
Infiltration	-	5791	10644	-	293	139
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	66166	24609	-	589	139
Zone Conditioning	-	73631	24609	-	-2668	139
Plenum Wall Load	25%	457	-	0	0	-
Plenum Roof Load	70%	7332	-	0	0	-
Plenum Lighting Load	30%	4819	-	0	0	-
Return Fan Load	3194 CFM	0	-	1832 CFM	0	-
Ventilation Load	1832 CFM	25946	66857	1832 CFM	-6027	0
Supply Fan Load	3194 CFM	9133	-	1832 CFM	-2524	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	-	121317	91466	-	-11219	139
Central Cooling Coil	-	120747	91841	-	-11219	0
Preheat Coil	-	0	-	-	0	-
>> Total Conditioning	-	120747	91841	-	-11219	0
Key:	Positive values are clg loads Negative values are htg loads			Positive values are htg loads Negative values are clg loads		

Let's now run these reports....



THESE REPORTS WE WILL REVIEW LIVE IN CLASS

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Workshop 3 Inputs

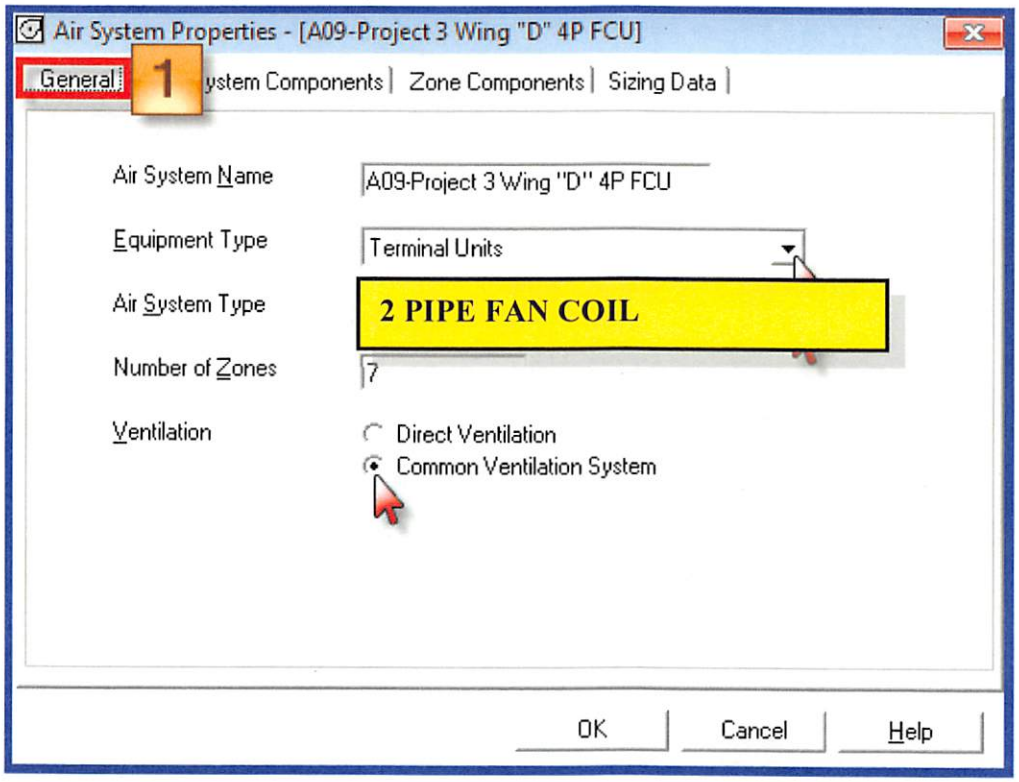
In the third workshop of our project, we investigate an alternate air system for the classroom wing "D." The alternate system design consists of a Terminal Unit Equipment Type and a seven (7) Zone 2 Pipe Fan Coil air system type with a DOAS Common Ventilation unit that provides tempered neutral ventilation air to each terminal fan coil unit.

We can reuse the spaces created in workshop 2 which include all linked schedules and building envelope items. We assign the spaces to this alternate air system using the same zoning strategy as the VAV system design. This allows for a quick comparison between systems.

Air System inputs for 2 Pipe Fan Coil Unit with DOAS

Under the General Tab of the air system properties form, enter the following data. Refer to Figure 3.1 for details.

Figure 3.1 - Air System Properties – General Tab

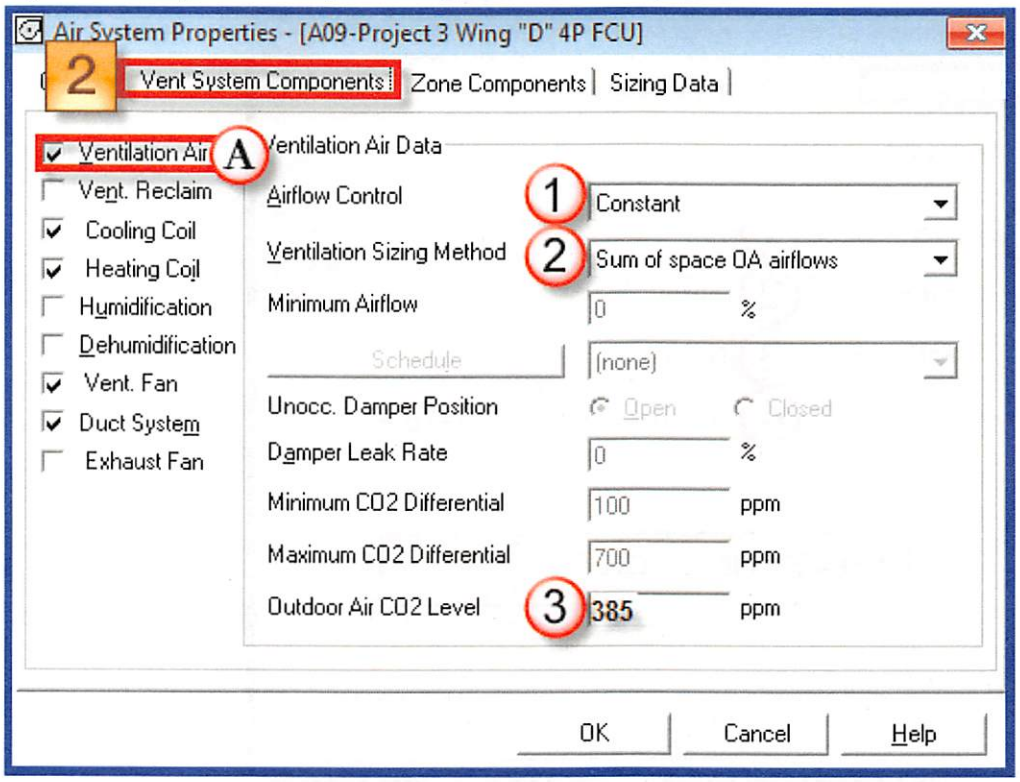


Select Terminal Units Equipment Type from the drop down and select 2-Pipe fan Coil as the Air System Type. We model this system using the same zoning scheme as the VAV system in workshop 2, but include a Common Ventilation unit also known as a DOAS system to provide neutral temperature ventilation air to the terminal units.

The System Components tab includes inputs for the DOAS (COMMON VENTILATION) system only.

2A-Vent System Components – Ventilation Air Data

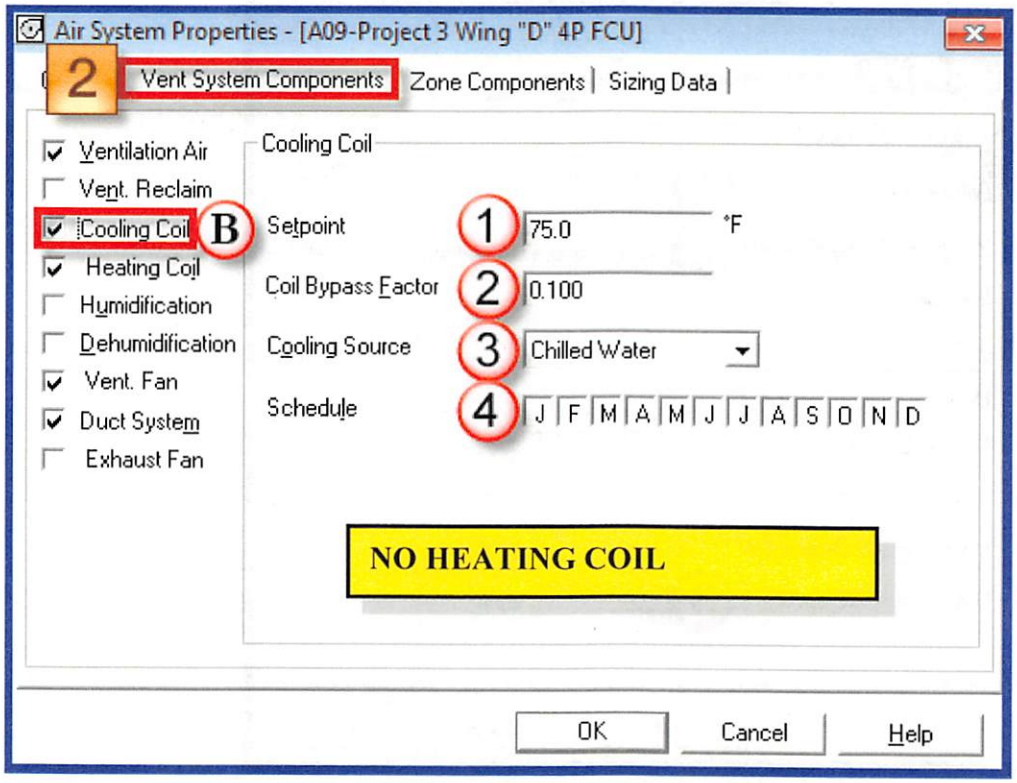
Figure 3.2 - System Components Ventilation Air Input Data



1. Select Constant Airflow Control from dropdown.
2. Select "Sum of space OA airflow" from dropdown for the Ventilation Sizing Method.
3. Enter 385 ppm for Outdoor Air CO_2 Level.

2B-Vent System Components – Cooling Coil Data

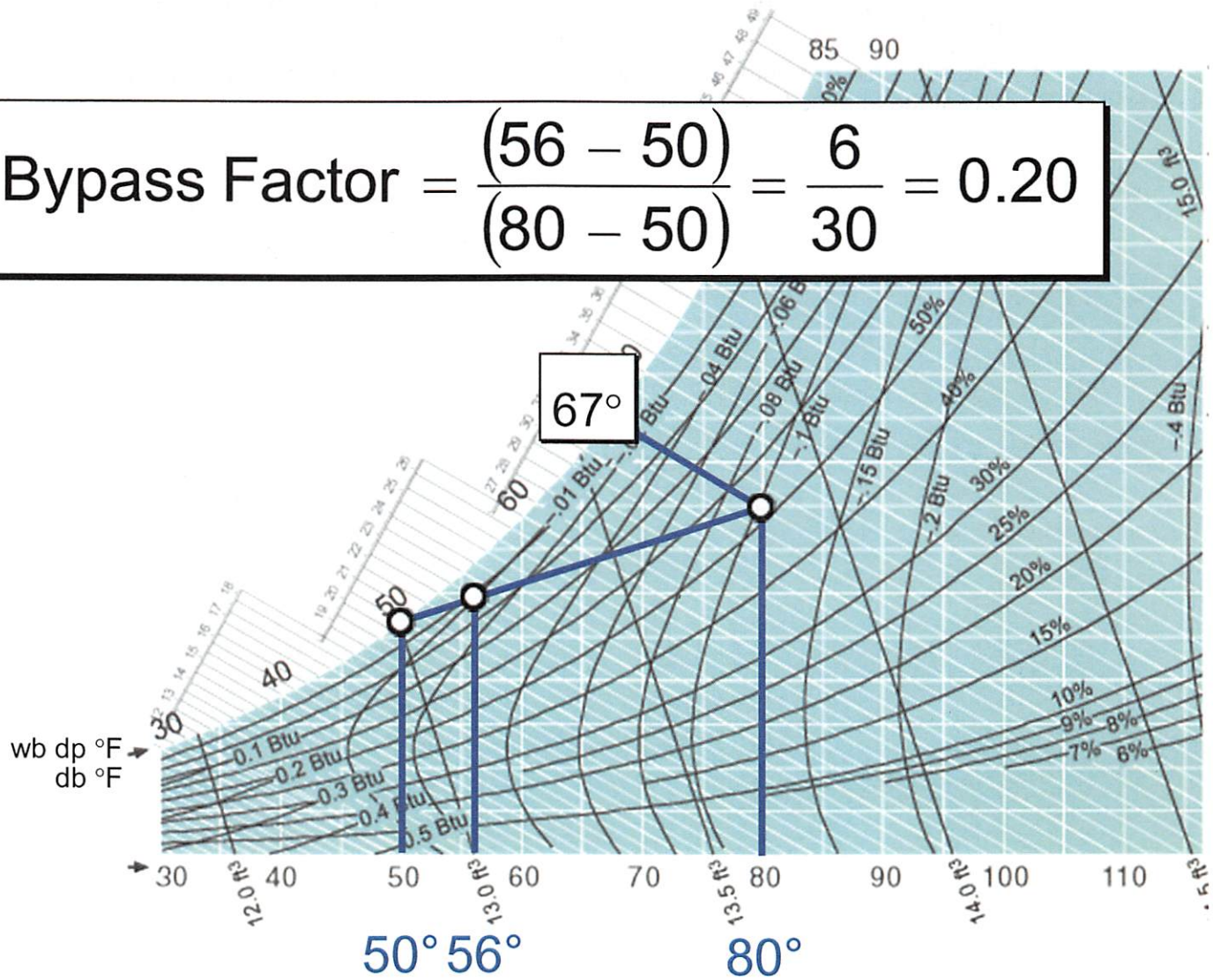
Figure 3.3 - Vent System Components Cooling Coil Data Input



1. Enter a neutral temperature for cooling. This typically is the same as the t-stat cooling occupied set point for the zones.
2. Enter a coil bypass factor which represents the air side efficiency of the coil. These values are published by manufacturers and are calculated as follows:

Coil Bypass Factors are determined by the entering air conditions, leaving air conditions and average surface temperature as detailed below:

$$\text{Bypass Factor} = \frac{(56 - 50)}{(80 - 50)} = \frac{6}{30} = 0.20$$



The ***Bypass Factor - BPF*** - (or *BF*) is commonly used to express cooling coil efficiency:

$BPF = (h_B - h_C) / (h_A - h_C)$

$= (t_B - t_C) / (t_A - t_C)$

$= (x_B - x_C) / (x_A - x_C)$ (2)

where

BPF = Bypass Factor (BF)

β = Contact Factor

x = specific humidity (kg/kg)

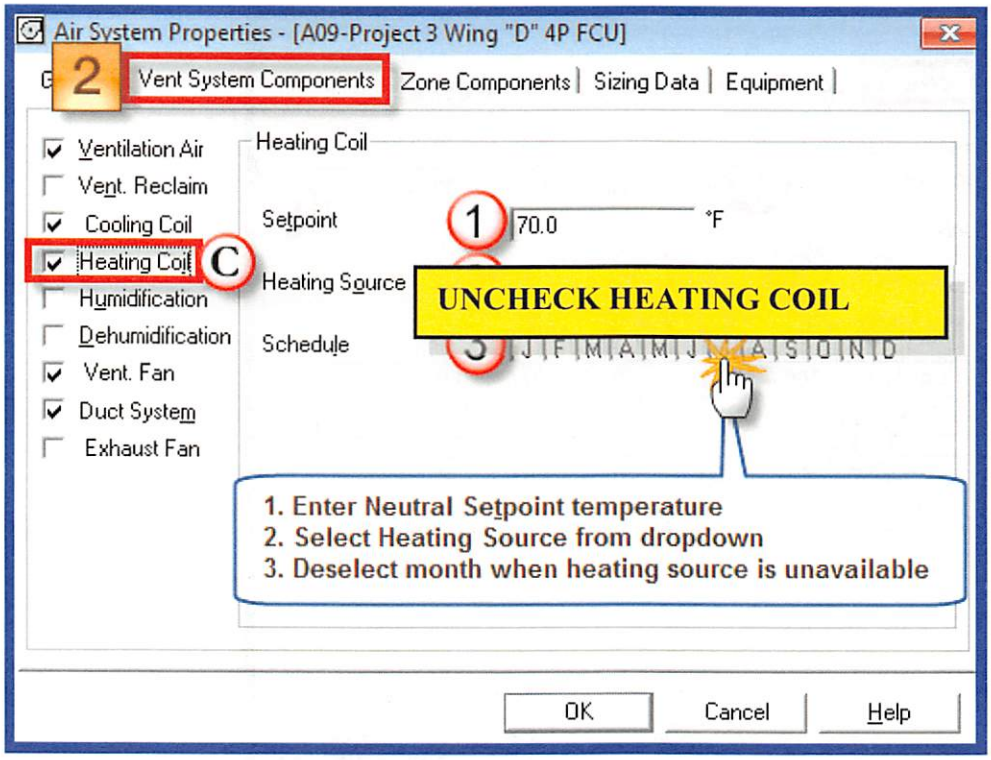
h = enthalpy (kJ/kg)

t = temperature (°C)

3. The Cooling source defaults to chilled water from our selection on the general tab for a 4 pipe fan coil system.
4. The schedule of months with chilled water available defaults to all 12 months active. Click on any of the months to deactivate.

2C-Vent System Components – Heating Coil Data

Figure 3.4 - Vent System Components – Heating Coil Data

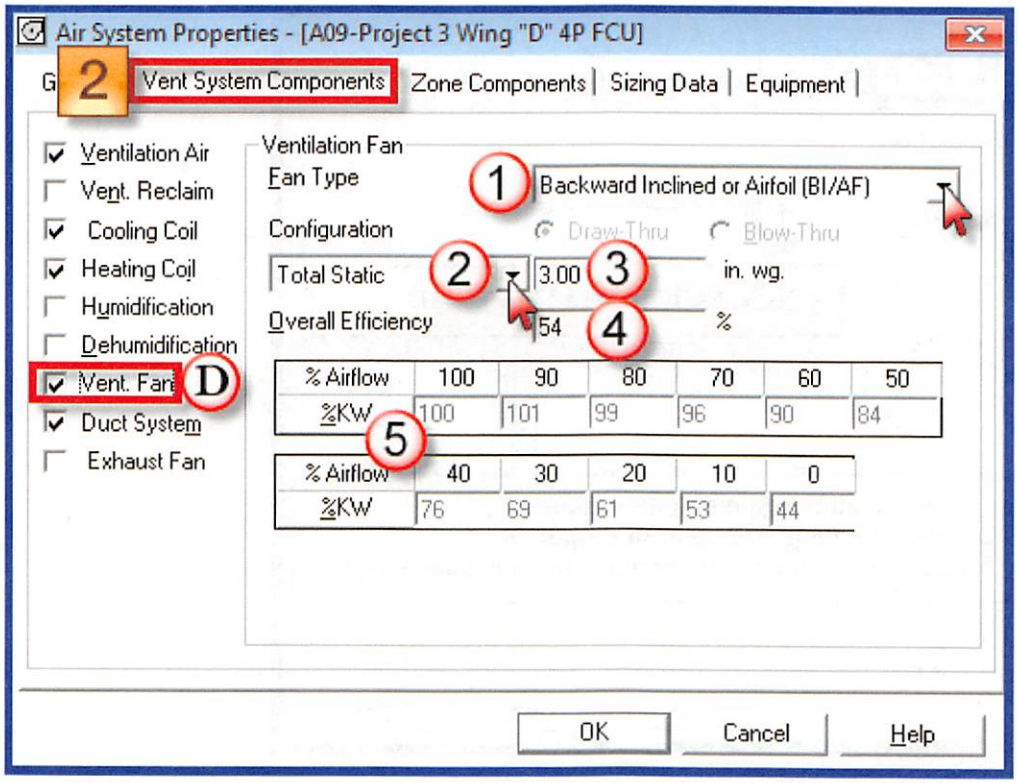


In our case we are not providing additional de-humidification in the summer or adding humidification in the winter. To activate these inputs, check the box and complete the required inputs for these components.

Next we model the fan characteristics for the DOAS. Refer to details in Figure 3.5

2D-Vent System Components – Vent Fan Data

Figure 3.5 - Vent System Components – Vent Fan Data

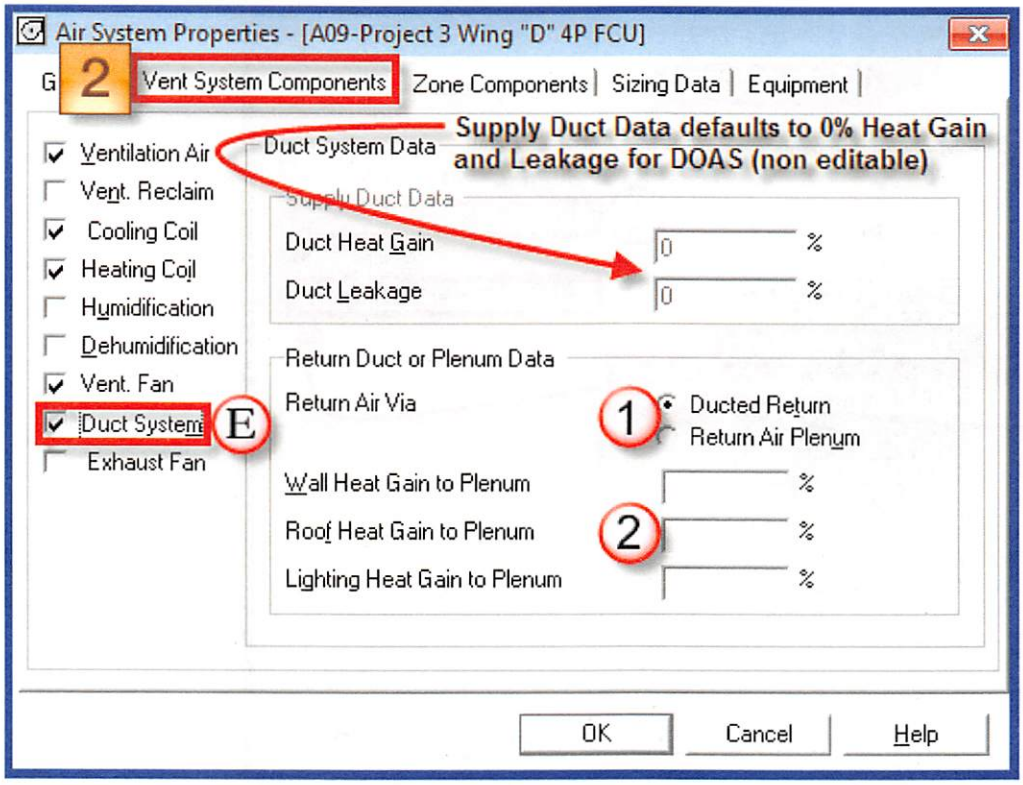


1. Select the Fan Type from the dropdown. Note: the only option for the Fan Configuration in a DOAS is Draw-Through.
2. Select Fan performance type from dropdown.
3. Enter appropriate value for fan performance. When using Total Static enter inches water gauge.
4. When using Total Static enter the overall Fan Efficiency value in percent. This is a three prong value derived from taking the fan efficiency from the fan curve times the mechanical loss times the motor electrical efficiency.
5. This part-load performance curve derives from the fan type selected and is based on a generic fan performance. These values represent the % motor kW at the % airflow. These values are defaulted for all but user defined fan types.

Next we model the duct system impact on the coil sizing requirements for this DOAS. Check the box for duct system if not already defaulted and enter the values displayed in Figure 3.6 below.

2E-Vent System Components – Duct System Data

Figure 3.6 - Vent System Components – Duct System Data



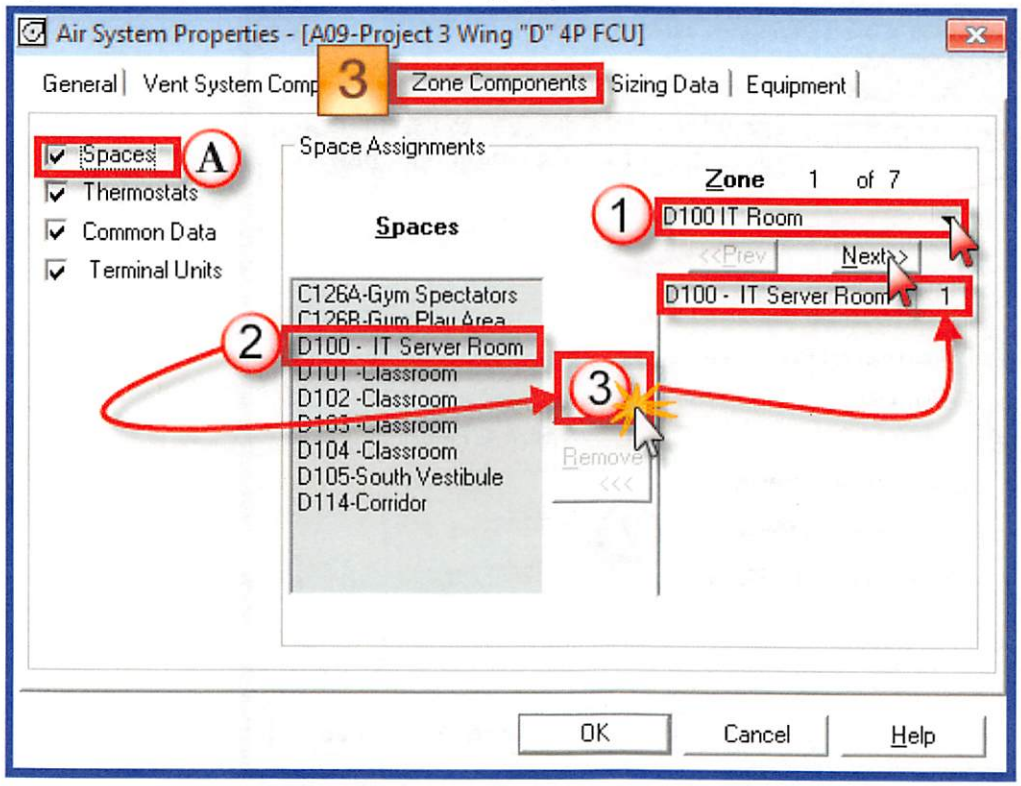
1. Select the appropriate radio button for the return duct configuration.
2. If using a plenum to return the air to the DOAS unit, specify the percent heat gain to the plenum from the Walls, Roof and Recessed Lighting.

If there is an exhaust fan in the DOAS unit to exhaust the stale ventilation air from the building, check the box to add the exhaust fan and enter the exhaust fan properties in the input form. Note, the exhaust fan inputs are similar to the Vent. Fan inputs as previously performed in step 2D.

Next we move to the Zone Components Tab and add the spaces to the DOAS, define the t-stat settings, enter the common data related to the 2 pipe fan coil terminal units and finally the terminal unit fan data. Please refer to the steps outlined below in section 3 of this workshop.

3A-Zone Components Tab – Spaces

Figure 3.7 - Zone Components – Assign Spaces to DOAS and Terminal Units



1. Enter Zone Name
2. Highlight space(s) to assign to zone
3. Click the "Add" button to add highlighted space(s) to zone. Note you can assign multiples of a single space to the zone by either clicking on the add button again or by clicking on the number field behind the assigned space and type in the number of spaces.

To advance to a different Zone, either click on the zone dropdown or click on the Next button to move forward one zone. You can also click on the previous button to move to the previous zone. After assigning spaces to all zones we can move to the thermostat input data form by clicking on the thermostat item.

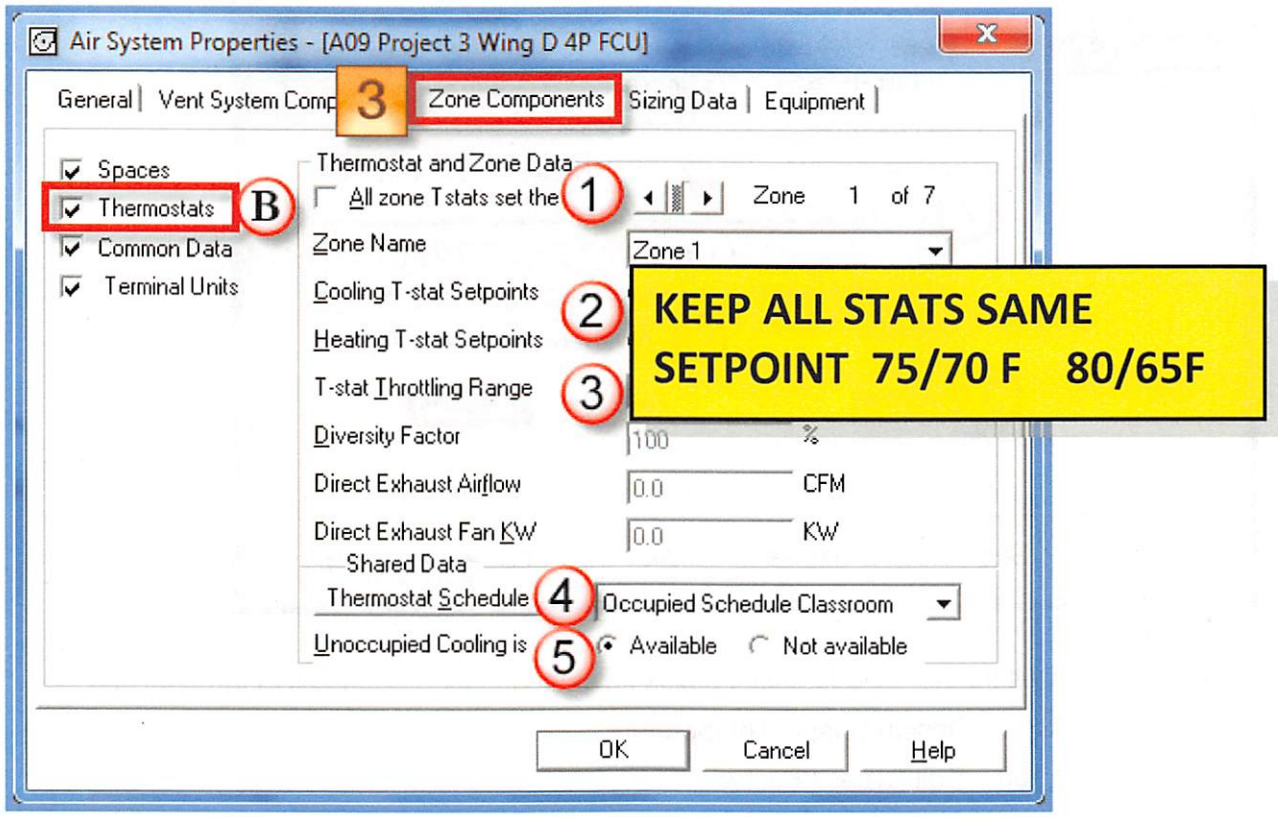
Please assign the following spaces to these renamed Zones:

Zones	Spaces
Zone #1 D100 IT Room	D100 IT Server Room
Zone #2 D101 Classroom	D101 Classroom
Zone #3 D102 Classroom	D102 Classroom
Zone #4 D103 Classroom	D103 Classroom
Zone #5 D104 Classroom	D104 Classroom
Zone #6 D105 South Vestibule	D105 South Vestibule
Zone #7 D114 Corridor	D114 Corridor

The next input under Zone Components is the Thermostat settings for the seven (7) zones created in the previous step. The T-Stat input form defaults with the check box selected to have all zones set the same. Enter the same T-Stat setpoint data as the VAV system in the previous workshop.

3B-Zone Components Tab – Thermostats

Figure 3.8 - Zone Components – Thermostat and Zone Data

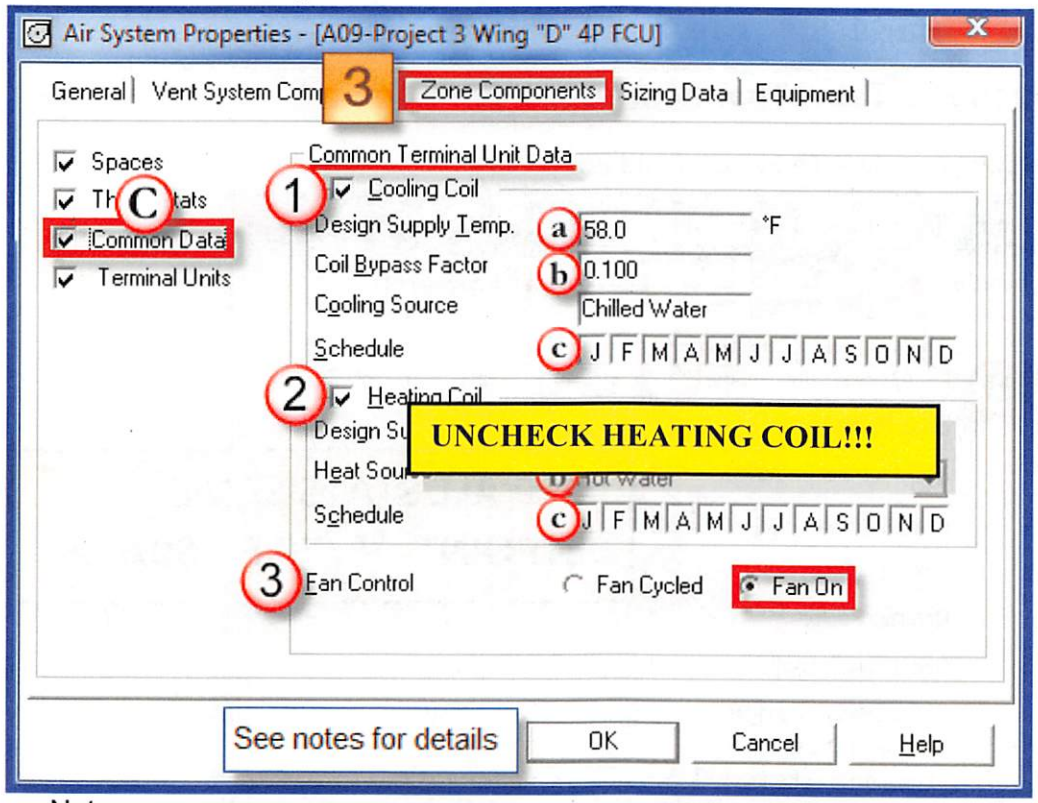


1. Keep all the thermostat setpoints the same
2. Enter occupied and unoccupied Cooling and Heating T-Stat set points.
3. Enter 1.5° F T-stat Throttling Range.
4. Link the previously created Thermostat Schedule by selecting it from the dropdown.
5. Select the Unoccupied Cooling is "Available" radio button.

Now highlight the Common Data item on the left portion of the screen to view and edit the terminal unit data. Refer to Figure 3.9 for details.

3C-Zone Components Tab – Common Data

Figure 3.9 - Zone Components – Common Terminal Unit Data.



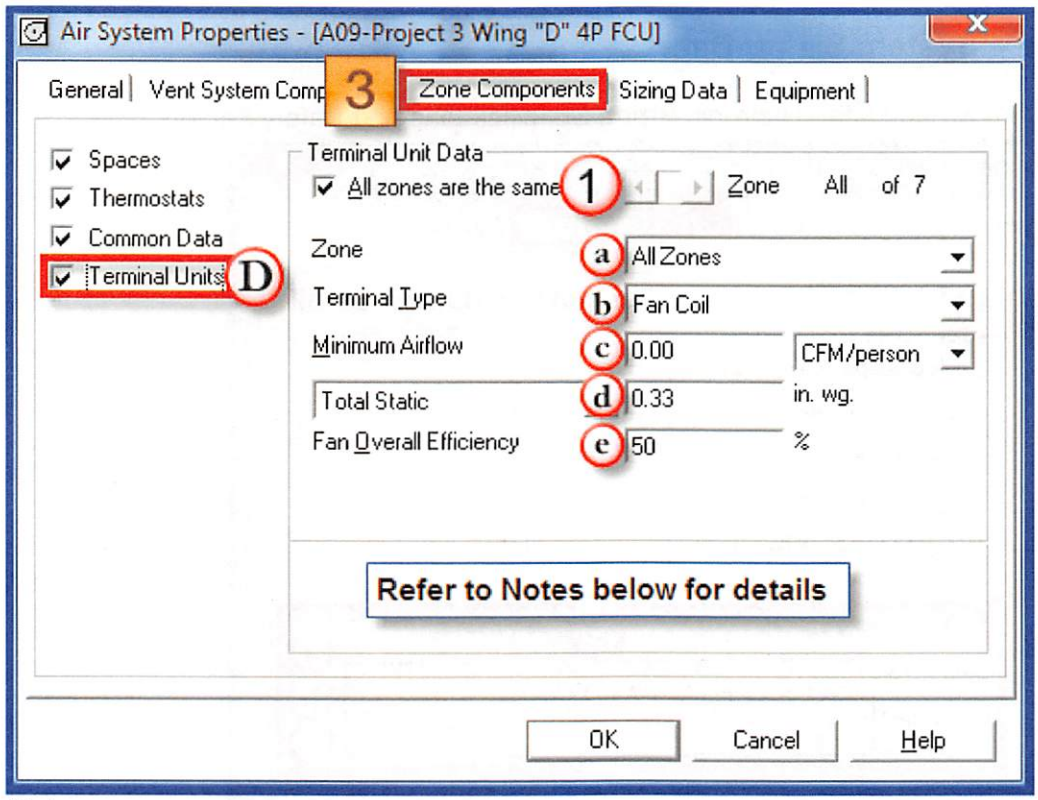
Notes:

1. Cooling Coil Inputs – Verify check box is selected to link cooling coil to terminal unit.
    a. 58° F – Design Supply Temperature
    b. 0.100 – Coil Bypass Factor
    c. Cooling Source defaults to Chilled water based on the Equipment Type selected under the General Tab of the Air System Properties form. The Schedule defaults to all 12 months active.
    d. System Properties form.
2. Select the "Fan On" radio button for the terminal unit Fan Control.

The final input for the Air System Zone Components, configures the terminal units' supply fan assembly. Highlight the Terminal Units on the left portion of the input form and refer to Figure 3.10 for input details.

3D-Zone Components Tab – Terminal Unit

Figure 3.10 - Zone Components Tab – Common Terminal Unit Data.



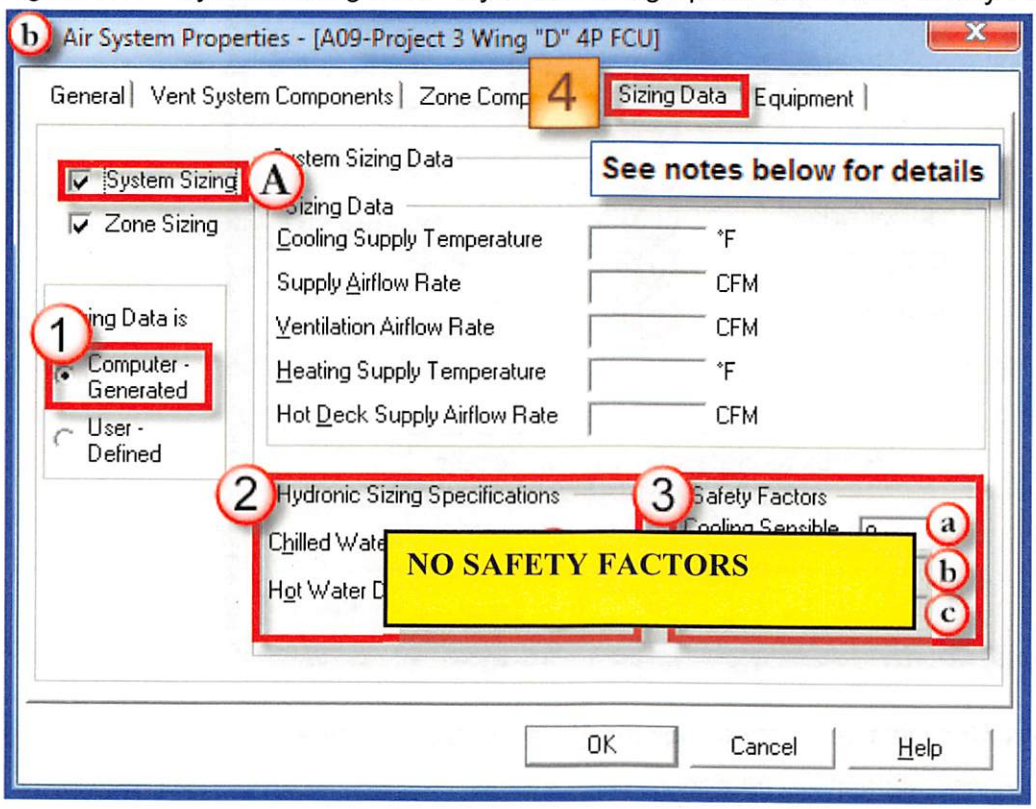
Notes :

1. Terminal Unit Data verify check box for All Zones are the same.
    a. Zone – defaults to All Zones
    b. Terminal Type – defaults to Fan Coil
    c. Minimum Airflow defaults to 0.00 CFM/person
    d. Total Static – 0.33" wg.
    e. Fan Overall Efficiency – 0.50%

The final tab for this air system properties input is the Sizing Data Tab which includes System and Zone Sizing options. Under the System Sizing item on the left portion of the input form highlight the System Sizing checkbox. Enter the data detailed in Figure 3.11.

4A Sizing Data – System Sizing Data

Figure 3.11 - System Sizing Data - Hydronic Sizing Specifications and Safety Factors



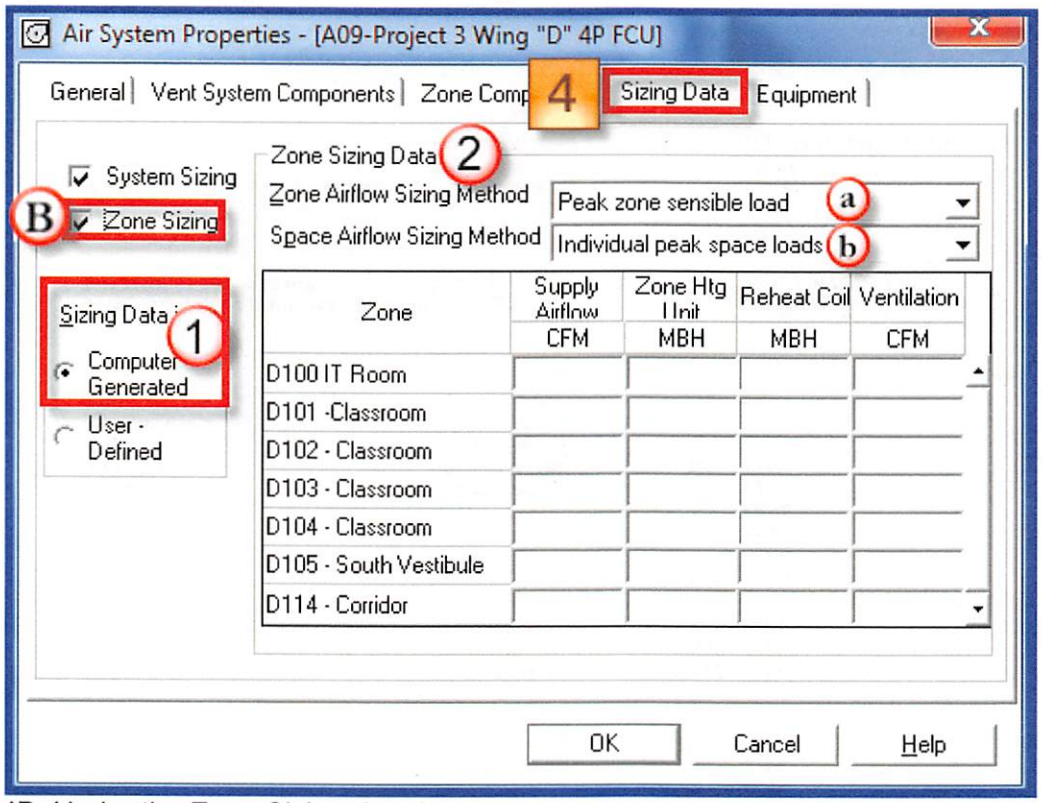
Notes: Enter the following details into the Air System Properties form

1. Select the Sizing Data is Computer Generated radio button.
2. Safety Factors
    a. 0.00% Cooling Sensible
    b. 0.00% Cooling Latent
    c. 0.00 % Heating

Next, highlight the Zone Sizing item on the left portion of the screen. Enter the following data into the sizing data fields as detailed in Figure 3.12.

4B Sizing Data – Zone Sizing

Figure 3.12 - Sizing Data – Zone Sizing Data



4B. Under the Zone Sizing data inputs:

1. Select the Computer Generated radio button
2. Set Zone Sizing Data to:
    a. Set Zone Airflow Sizing Method to Peak zone sensible load
    b. Set Space Airflow Sizing Method to Individual peak space loads

Because the Equipment providing the source of Cooling and Heating are hydronic plants there are no required fields for data entry under the Equipment Tab. At this juncture we are ready to calculate the System loads. To accomplish this save the air system inputs and at the main program window under the systems, highlight the newly created system and generate the design reports as we did for the previously created air systems.

The following are details of the design reports for this terminal equipment type 4 -pipe fan coil air system.

Air System Design Load Reports

Air System (DOAS) Sizing Summary Report

Air System Information

Air System Name	A09 Project 3 Wing D 2P FCU		Number of zones	7	
Equipment Class	TERM		Floor Area	4433.0	ft²
Air System Type	2P-FC		Location	Port of Spain, Trinidad & Tobago	

Sizing Calculation Information

Calculation Months	Jan to Dec	Zone CFM Sizing	Sum of space airflow rates
Sizing Data	Calculated	Space CFM Sizing	Individual peak space loads

Cooling Coil Sizing Data

Total coil load	3.3	Tons	Load occurs at	Aug 1500	
Total coil load	39.9	MBH	OA DB / WB	93.0 / 78.2	°F
Sensible coil load	31.9	MBH	Entering DB / WB	93.0 / 78.2	°F
Coil CFM at Aug 1500	1473	CFM	Leaving DB / WB	72.9 / 71.5	°F
Max coil CFM	1473	CFM	Bypass Factor	0.100	
Sensible heat ratio	0.799				
Water flow @ 10.0 °F rise	7.98	gpm			

Ventilation Fan Sizing Data

Actual max CFM	1473	CFM	Fan motor BHP	1.21	BHP
Standard CFM	1470	CFM	Fan motor kW	0.96	kW
Actual max CFM/ft²	0.33	CFM/ft²	Fan static	3.00	in wg

Outdoor Ventilation Air Data

Design airflow CFM	1473	CFM	CFM/person	13.39	CFM/person
CFM/ft²	0.33	CFM/ft²			

Terminal Unit Sizing Data - Cooling

Zone Name	Total Coil Load (MBH)	Sens Coil Load (MBH)	Coil Entering DB / WB (°F)	Coil Leaving DB / WB (°F)	Water Flow @ 10.0 °F (gpm)	Time of Peak Coil Load	Zone CFM/ft²
1 D100 IT Server Room	5.9	5.4	75.9 / 64.1	58.5 / 57.4	1.17	Aug 0800	8.24
2 D101 Classroom	30.1	16.4	75.9 / 68.7	58.3 / 57.8	6.02	Aug 1000	1.02
3 D102 Classroom	30.1	16.4	75.9 / 68.7	58.3 / 57.8	6.02	Aug 1000	1.02
4 D103 Classroom	30.1	16.4	75.9 / 68.7	58.3 / 57.8	6.02	Aug 1000	1.02
5 D104 Classroom	32.9	19.5	76.1 / 68.1	58.7 / 58.0	6.58	Oct 1300	1.23
6 D105 South Vestibule	3.9	3.3	76.5 / 65.1	59.0 / 57.9	0.77	Dec 1400	2.00
7 D114 Corridor	13.7	8.1	76.6 / 68.2	58.0 / 57.3	2.75	Aug 1500	0.42

Terminal Unit Sizing Data - Heating, Fan, Ventilation

Zone Name	Heating Coil Load (MBH)	Heating Coil Ent/Lvg DB (°F)	Htg Coil Water Flow @20.0 °F (gpm)	Fan Design Airflow (CFM)	Fan Motor (BHP)	Fan Motor (kW)	OA Vent Design Airflow (CFM)
1 D100 IT Server Room	0.0	-1.0 / -1.0	0.00	288	0.028	0.022	7
2 D101 Classroom	0.0	-1.0 / -1.0	0.00	861	0.084	0.067	351
3 D102 Classroom	0.0	-1.0 / -1.0	0.00	861	0.084	0.067	351
4 D103 Classroom	0.0	-1.0 / -1.0	0.00	861	0.084	0.067	351
5 D104 Classroom	0.0	-1.0 / -1.0	0.00	1037	0.101	0.080	351
6 D105 South Vestibule	0.0	-1.0 / -1.0	0.00	176	0.017	0.014	5
7 D114 Corridor	0.0	-1.0 / -1.0	0.00	402	0.039	0.031	57

Zone Peak Sensible Loads

Zone Name	Zone Cooling Sensible (MBH)	Time of Peak Sensible Cooling Load	Zone Heating Load (MBH)	Zone Floor Area (ft²)
1 D100 IT Server Room	5.3	Aug 1200	0.0	35.0
2 D101 Classroom	15.8	Aug 1500	0.1	840.0
3 D102 Classroom	15.8	Aug 1500	0.1	840.0
4 D103 Classroom	15.8	Aug 1500	0.1	840.0
5 D104 Classroom	19.0	Nov 1500	0.2	840.0
6 D105 South Vestibule	3.2	Dec 1500	0.0	88.0
7 D114 Corridor	7.4	Aug 1500	0.0	950.0

Ventilation Sizing Summary

1. Summary

Ventilation Sizing Method ..... Sum of Space OA Airflows
Design Ventilation Airflow Rate ..... 1473 CFM

2. Space Ventilation Analysis

2.1 Zone: 1 D100 IT Server Room

Zone Name / Space Name	Mult.	Floor Area (ft²)	Maximum Occupants	Maximum Supply Air (CFM)	Required Outdoor Air (CFM/person)	Required Outdoor Air (CFM/ft²)	Required Outdoor Air (CFM)	Required Outdoor Air (% of supply)	Uncorrected Outdoor Air (CFM)
1 D100 IT Server Room									
D 100 IT Server Room	1	35.0	1.0	288.4	5.00	0.06	0.0	0.0	7.1
Totals (incl. Space Multipliers)				288.4					7.1

2.2 Zone: 2 D101 Classroom

Zone Name / Space Name	Mult.	Floor Area (ft²)	Maximum Occupants	Maximum Supply Air (CFM)	Required Outdoor Air (CFM/person)	Required Outdoor Air (CFM/ft²)	Required Outdoor Air (CFM)	Required Outdoor Air (% of supply)	Uncorrected Outdoor Air (CFM)
2 D101 Classroom									
D 101 Classroom	1	840.0	25.0	860.7	10.00	0.12	0.0	0.0	350.8
Totals (incl. Space Multipliers)				860.7					350.8

2.3 Zone: 3 D102 Classroom

Zone Name / Space Name	Mult.	Floor Area (ft²)	Maximum Occupants	Maximum Supply Air (CFM)	Required Outdoor Air (CFM/person)	Required Outdoor Air (CFM/ft²)	Required Outdoor Air (CFM)	Required Outdoor Air (% of supply)	Uncorrected Outdoor Air (CFM)
3 D102 Classroom									
D 102 Classroom	1	840.0	25.0	860.7	10.00	0.12	0.0	0.0	350.8
Totals (incl. Space Multipliers)				860.7					350.8

2.4 Zone: 4 D103 Classroom

Zone Name / Space Name	Mult.	Floor Area (ft²)	Maximum Occupants	Maximum Supply Air (CFM)	Required Outdoor Air (CFM/person)	Required Outdoor Air (CFM/ft²)	Required Outdoor Air (CFM)	Required Outdoor Air (% of supply)	Uncorrected Outdoor Air (CFM)
4 D103 Classroom									
D 103 Classroom	1	840.0	25.0	860.7	10.00	0.12	0.0	0.0	350.8
Totals (incl. Space Multipliers)				860.7					350.8

2.5 Zone: 5 D104 Classroom

Zone Name / Space Name	Mult.	Floor Area (ft²)	Maximum Occupants	Maximum Supply Air (CFM)	Required Outdoor Air (CFM/person)	Required Outdoor Air (CFM/ft²)	Required Outdoor Air (CFM)	Required Outdoor Air (% of supply)	Uncorrected Outdoor Air (CFM)
5 D104 Classroom									
D 104 Classroom	1	840.0	25.0	1036.8	10.00	0.12	0.0	0.0	350.8
Totals (incl. Space Multipliers)				1036.8					350.8

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	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Sep 1300 COOLING OA DB / WB 89.5 °F / 76.8 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 69.4 °F / 57.7 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	480 ft²	11014	-	480 ft²	-	-
Wall Transmission	982 ft²	1198	-	982 ft²	27	-
Roof Transmission	4433 ft²	10188	-	4433 ft²	107	-
Window Transmission	480 ft²	2020	-	480 ft²	100	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	48 ft²	1017	-	48 ft²	16	-
Floor Transmission	4433 ft²	0	-	4433 ft²	46	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	4671 W	12191	-	0	0	-
Task Lighting	2758 W	8175	-	0	0	-
Electric Equipment	3080 W	9508	-	0	0	-
People	109	17127	13760	0	0	0
Infiltration	-	4713	8333	-	293	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**77150**	**22093**	-	**589**	**0**
Zone Conditioning	-	84430	22093	-	495	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Exhaust Fan Load	1473 CFM	0	-	1473 CFM	0	-
Ventilation Load	1473 CFM	21008	41273	1473 CFM	780	0
Ventilation Fan Load	1473 CFM	3275	-	1473 CFM	-3275	-
Space Fan Coil Fans	-	1185	-	-	-1185	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	-	**109898**	**63366**	-	**-3185**	**0**
Cooling Coil	-	26256	3701	-	0	0
Terminal Unit Cooling	-	83642	59432	-	-3162	0
Terminal Unit Heating	-	0	-	-	0	-
>> Total Conditioning	-	**109898**	**63133**	-	**-3162**	**0**
Key:	Positive values are clg loads Negative values are htg loads			Positive values are htg loads Negative values are clg loads		

Workshop 4 Inputs USING THE EQUIPMENT WIZARD

In the fourth workshop of our project, we investigate an alternate air system for the classroom wing "D." The alternate system design consists of a Terminal Unit Equipment Type and a seven (7) Zone Variable Refrigerant Flow (VRF) air system type with a DOAS Common Ventilation unit that provides tempered neutral ventilation air to each terminal fan coil unit. Ventilation calculations are based on implementing Demand Controlled Ventilation (DCV) and an energy recovery ventilator (ERV) in the DOAS system.

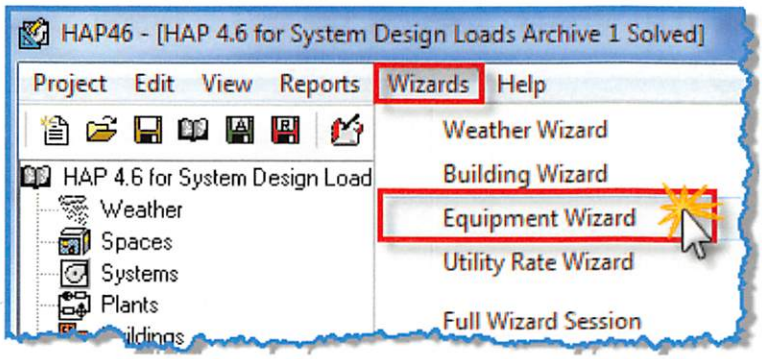
We can reuse the spaces created in workshop 2 which include all linked schedules and building envelope items. We assign the spaces to this alternate air system using the same zoning strategy as the VAV system and 4 Pipe Fan Coil Unit (FCU) design. This allows for a quick comparison between systems.

Air System inputs for VRF Unit with DOAS, DCV and ERV

We use the "Equipment Wizard" to enter this air system. Refer to Figure 4.1 through 4. for details.

Launch the Equipment Wizard from the Wizard item on the menu bar as detailed in Figure 4.1.

Figure 4.1 – Launch Equipment Wizard



This opens the first Equipment Wizard screen displaying the project spaces. We enter the number of floors in our building as shown in Figure 4.2.

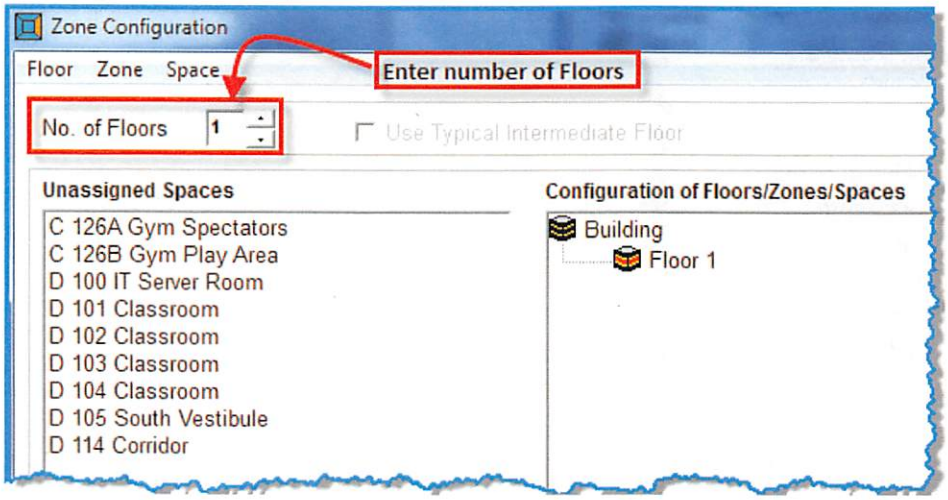
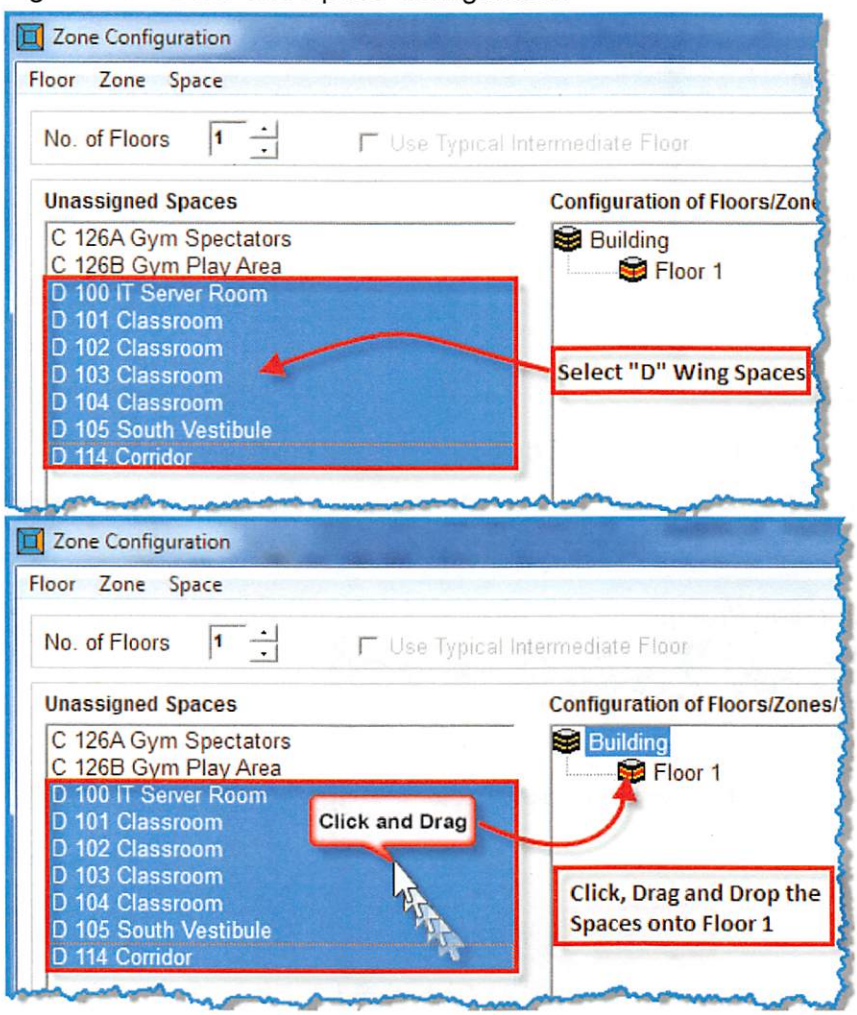
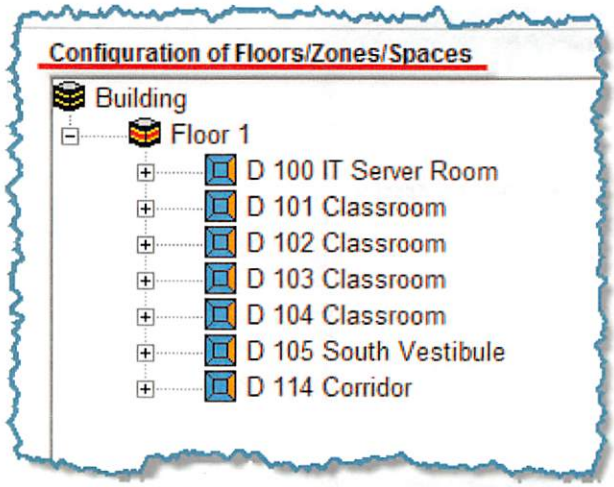
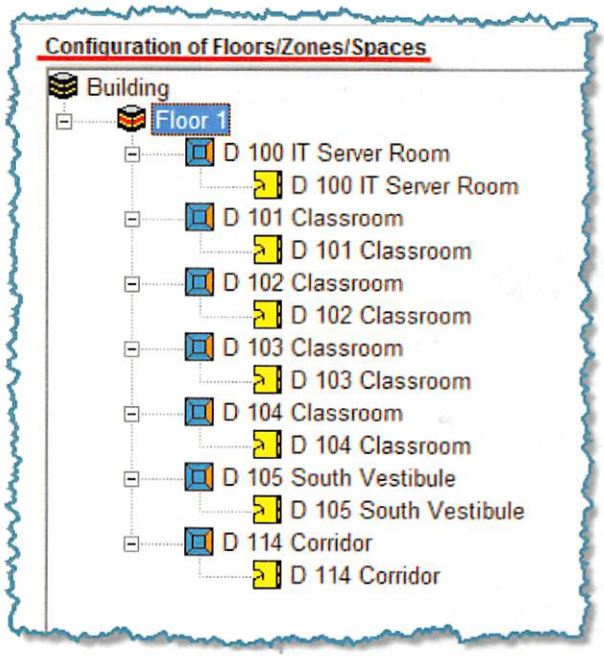


Figure 4.3 details the next step where we Drag and Drop the spaces onto Floor 1, which creates Zones with an attached Space to each Zone.

Figure 4.3 – Zone and Space Configuration



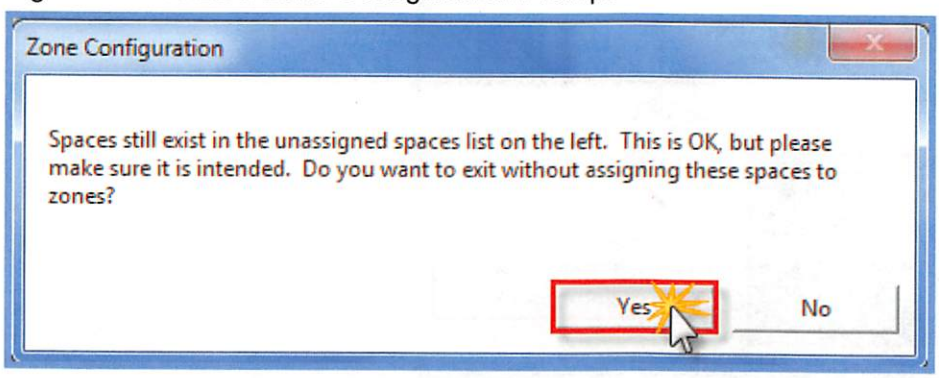




Click the OK button to advance to the next step in the Equipment Wizard configuration.

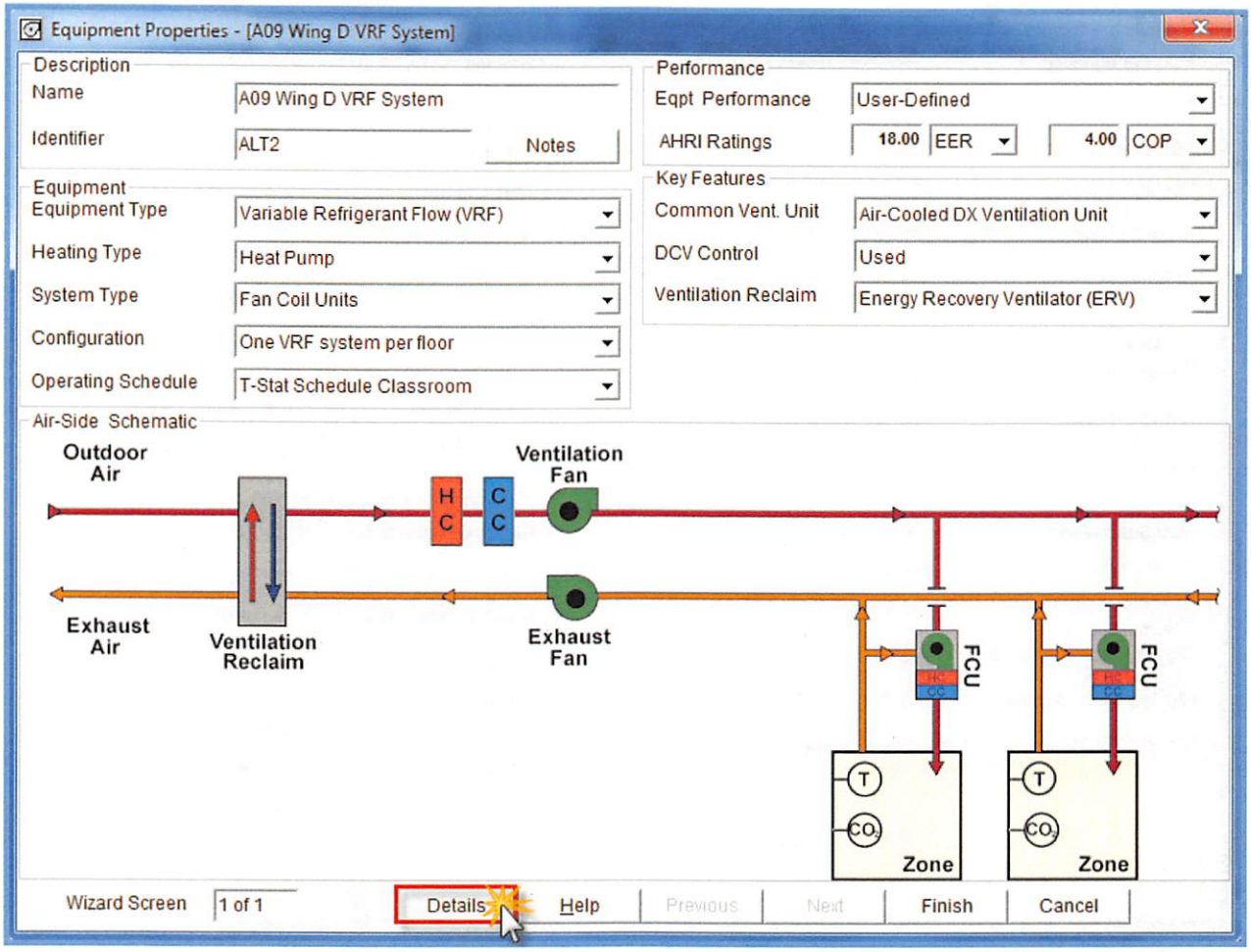
Because we have two unassigned spaces, the Wizard prompts us to with the following message:

Figure 4.4 - Wizard Zone Configuration Prompt



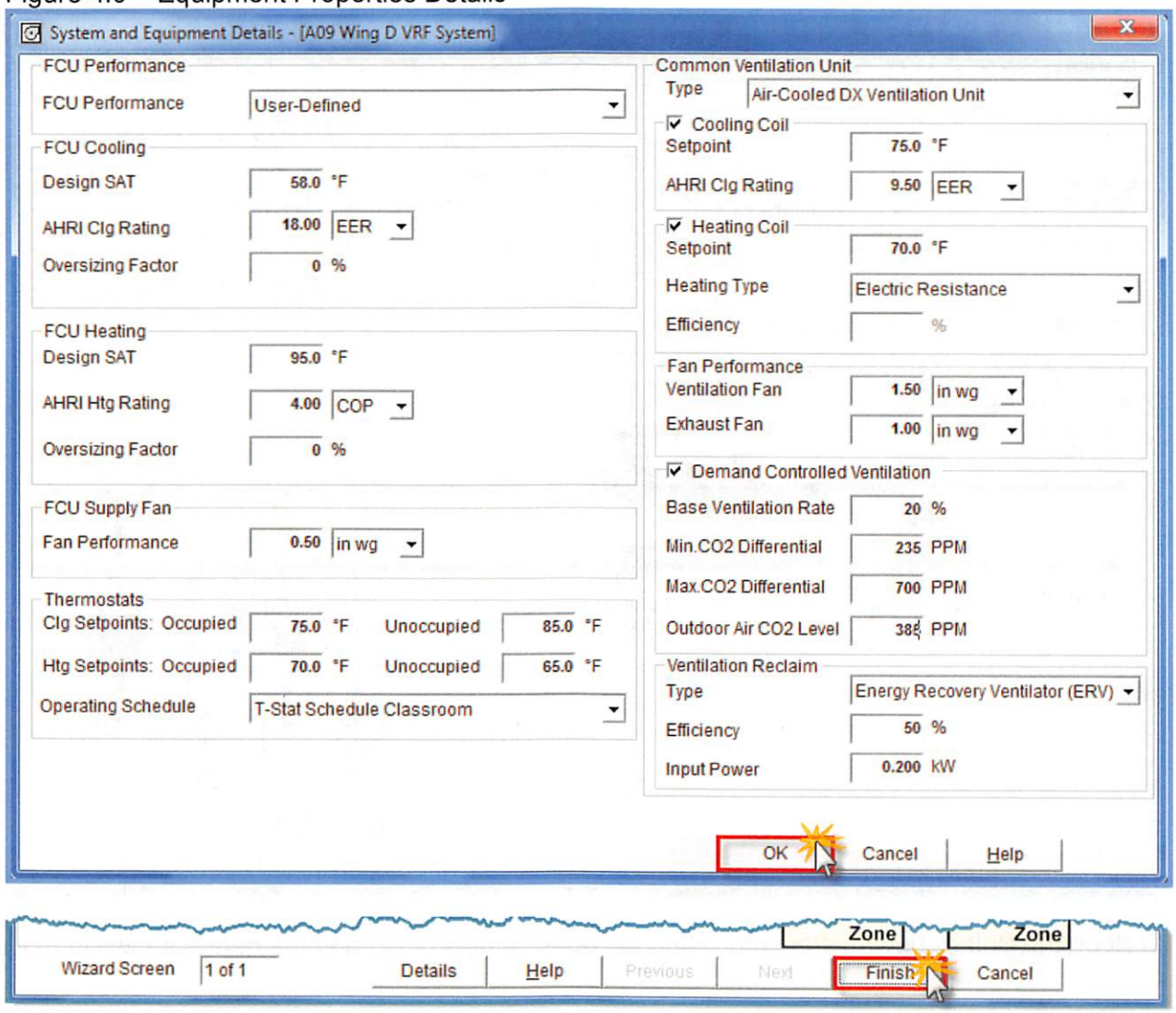
Clicking on Yes brings up the next Wizard Screen. Configure the system as detailed in Figure 4.5.

Figure 4.5 – Equipment Properties Screen 1



Click on the Details button after completing the above inputs, and enter the details shown in Figure 4.6.

Figure 4.6 – Equipment Properties Details



Clicking on OK after completing the above inputs takes us back to the Equipment Properties screen, then click Finish.

HAP generates an Equipment Wizard Input Summary Report which you can Print or Save as an RTF file. After closing the report HAP displays the following advisory message detailed in Figure 4.7 below.

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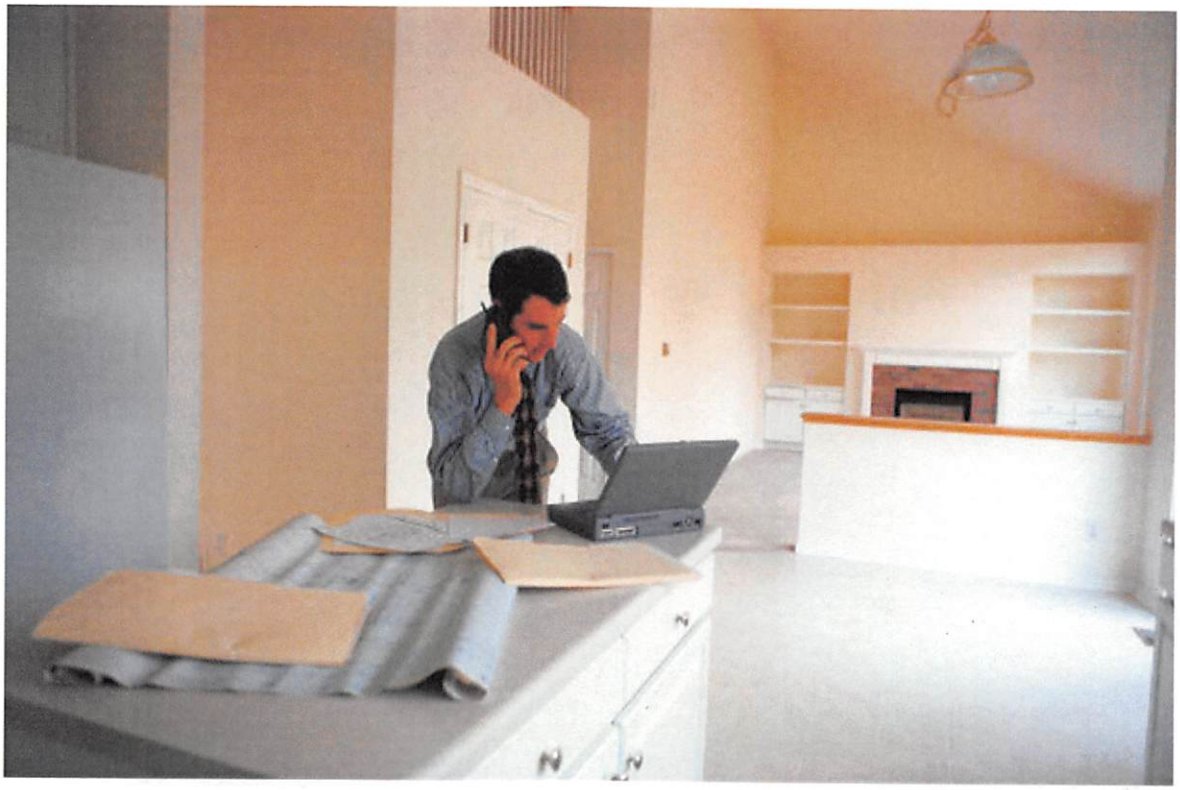
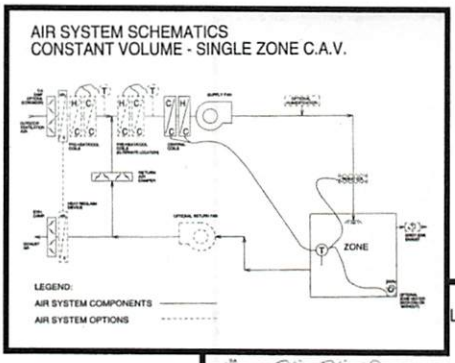
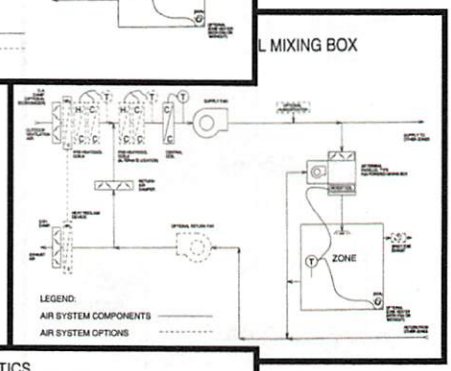
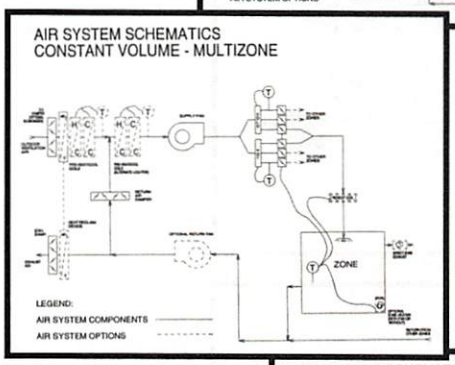
Appendix "A"

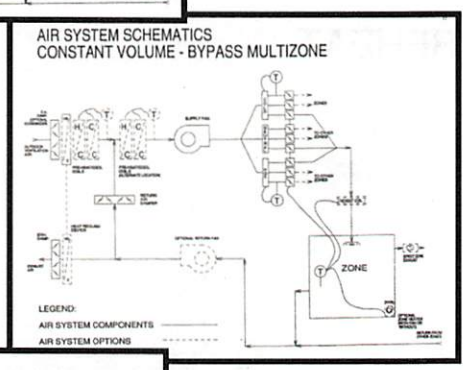


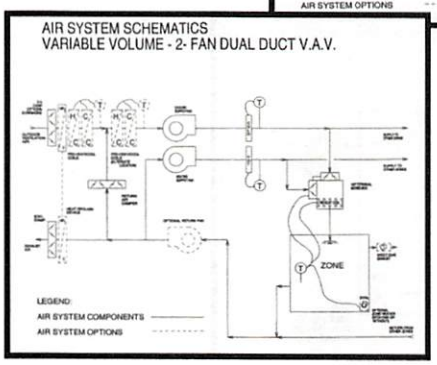
Air System Schematics



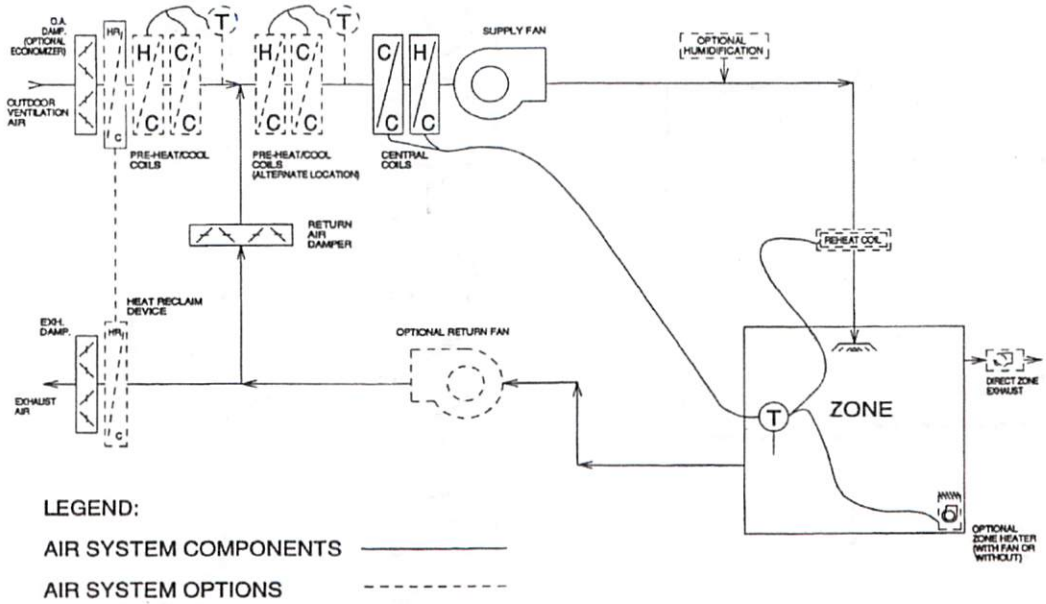








AIR SYSTEM SCHEMATICS
CONSTANT VOLUME - SINGLE ZONE C.A.V.

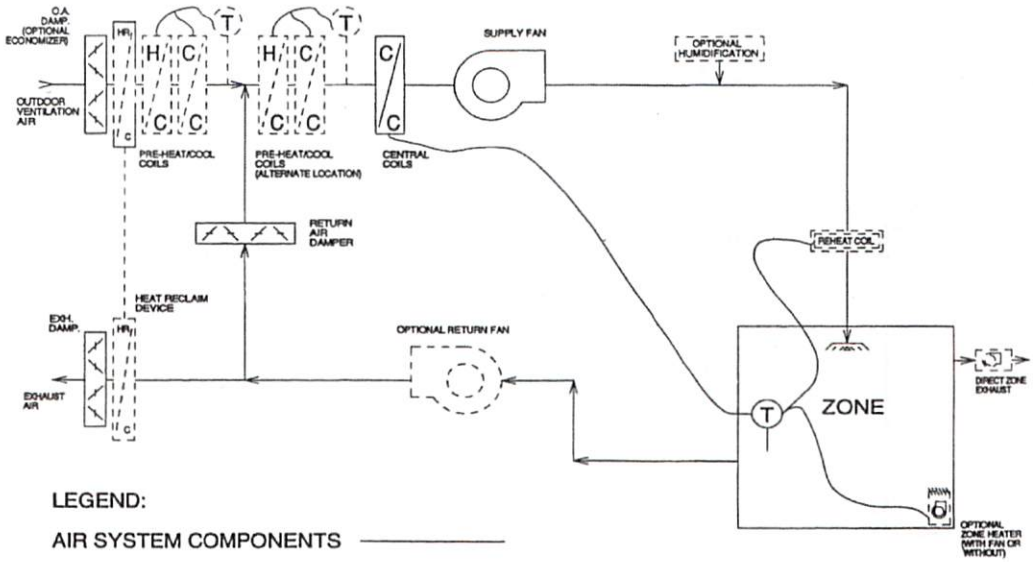


LEGEND:

AIR SYSTEM COMPONENTS ————————

AIR SYSTEM OPTIONS - - - - - - - - - -

AIR SYSTEM SCHEMATICS
CONSTANT VOLUME - C.A.V. REHEAT

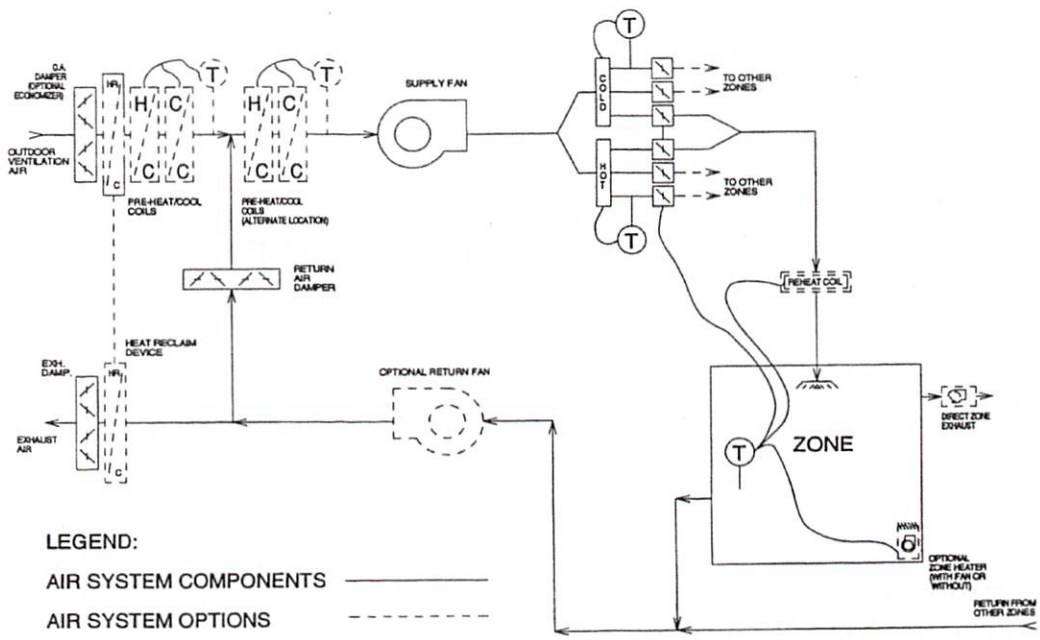


LEGEND:

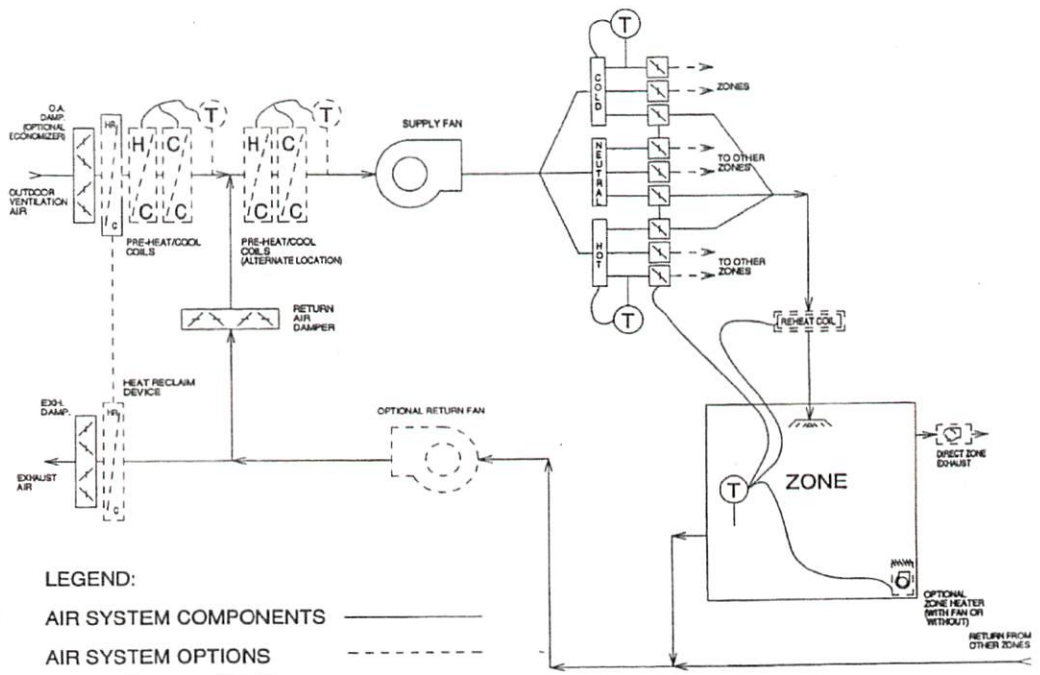
AIR SYSTEM COMPONENTS ————————

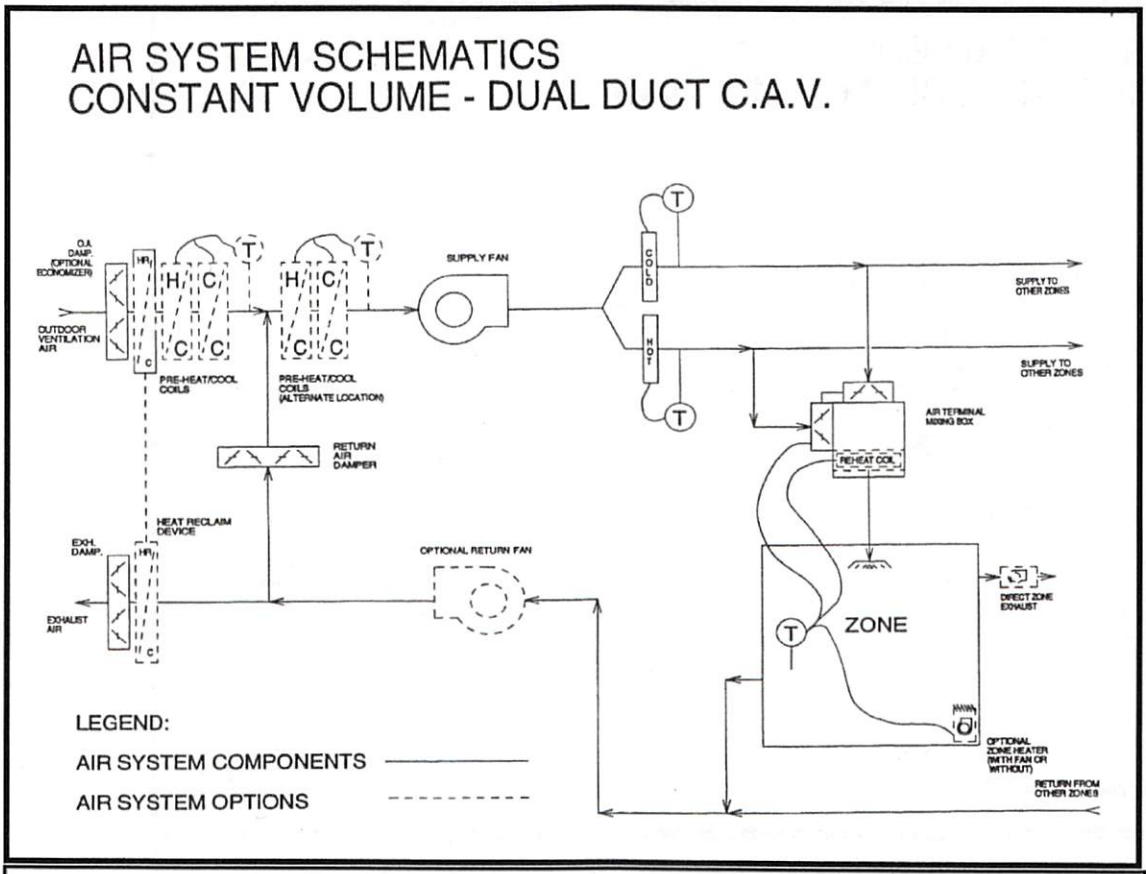
AIR SYSTEM OPTIONS - - - - - - - - - -

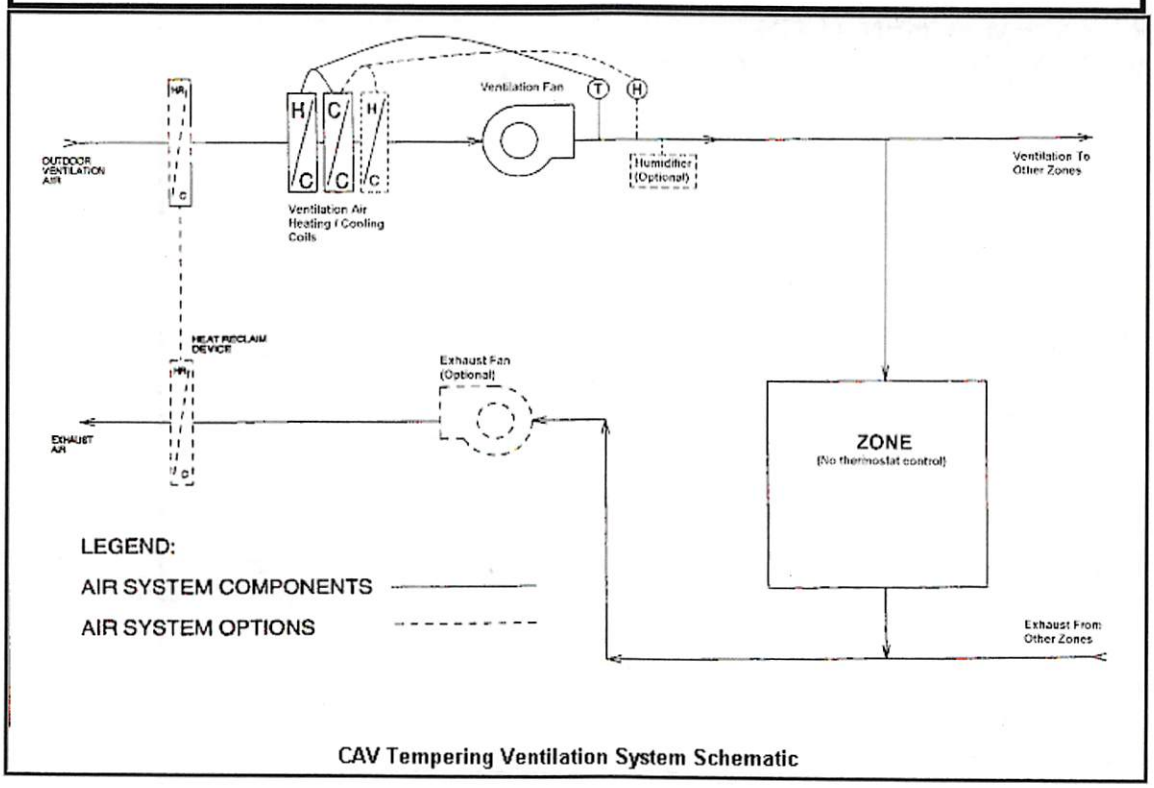
AIR SYSTEM SCHEMATICS
CONSTANT VOLUME - MULTIZONE



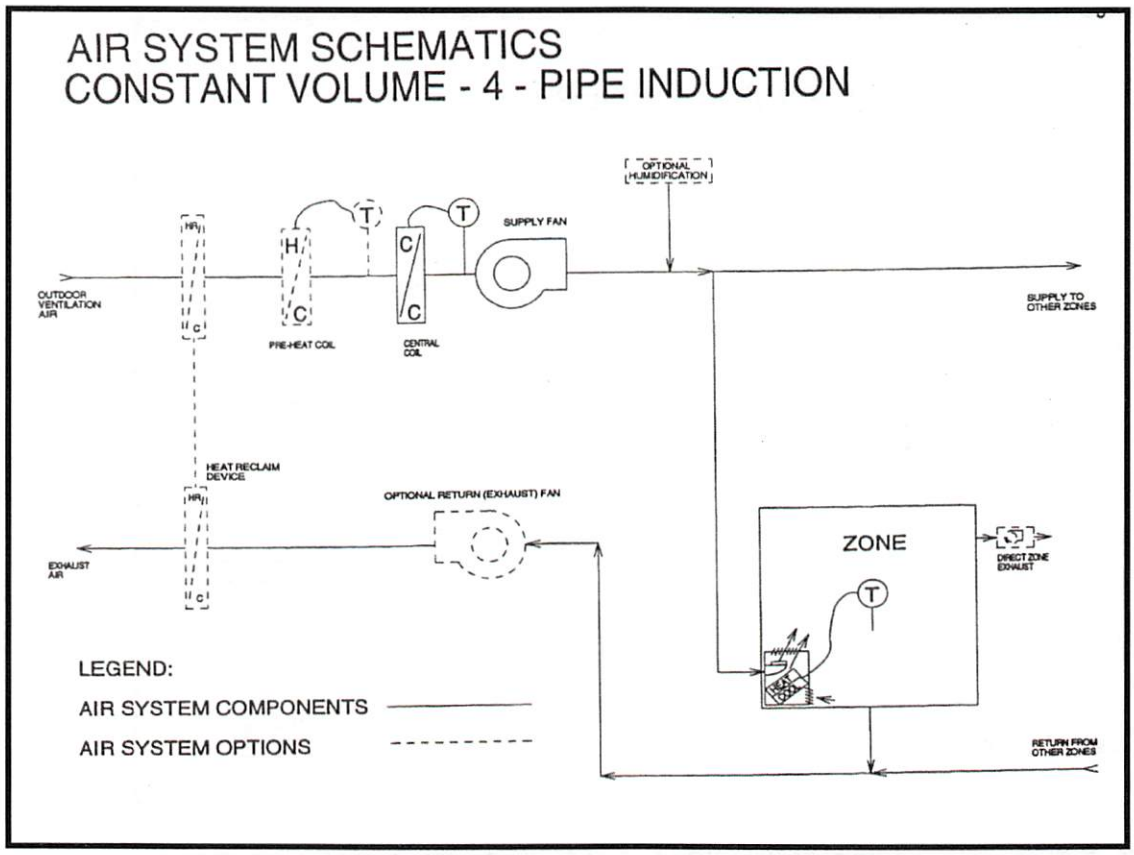
AIR SYSTEM SCHEMATICS
CONSTANT VOLUME - BYPASS MULTIZONE

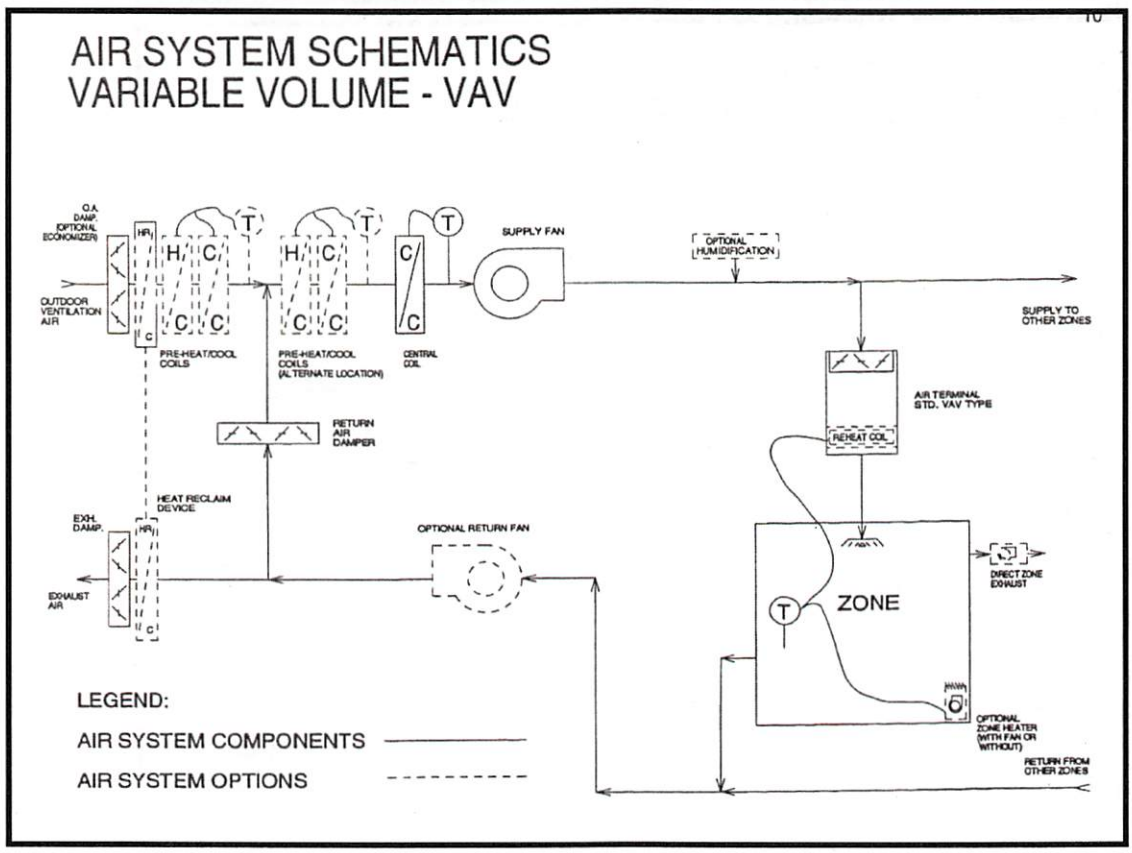




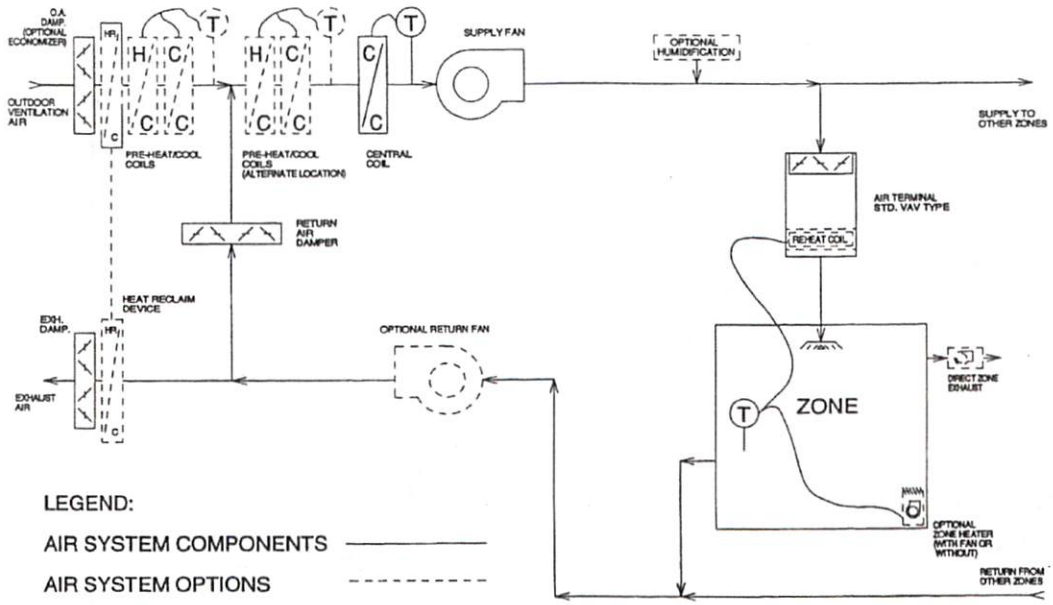


CAV Tempering Ventilation System Schematic

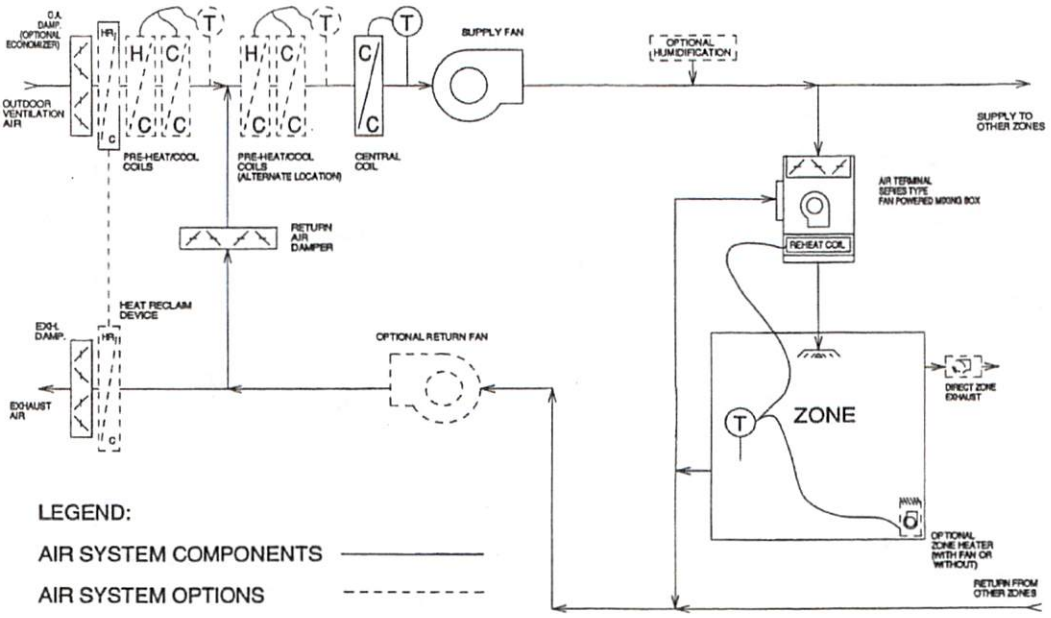

AIR SYSTEM SCHEMATICS
CONSTANT VOLUME - 4 - PIPE INDUCTION
OPTIONAL HUMIDIFICATION
SUPPLY FAN
OUTDOOR VENTILATION AIR
PRE-HEAT COIL
CENTRAL COIL
SUPPLY TO OTHER ZONES
HEAT RECLAIM DEVICE
OPTIONAL RETURN (EXHAUST) FAN
EXHAUST AIR
ZONE
DIRECT ZONE EXHAUST
RETURN FROM OTHER ZONES
LEGEND:
AIR SYSTEM COMPONENTS
AIR SYSTEM OPTIONS


AIR SYSTEM SCHEMATICS
VARIABLE VOLUME - VAV
O.A. DAMP. (OPTIONAL ECONOMIZER)
OUTDOOR VENTILATION AIR
PRE-HEAT/COOL COILS
PRE-HEAT/COOL COILS (ALTERNATE LOCATION)
CENTRAL COIL
SUPPLY FAN
OPTIONAL HUMIDIFICATION
SUPPLY TO OTHER ZONES
AIR TERMINAL STD. VAV TYPE
REHEAT COIL
RETURN AIR DAMPER
HEAT RECLAIM DEVICE
EXH. DAMP.
OPTIONAL RETURN FAN
EXHAUST AIR
ZONE
DIRECT ZONE EXHAUST
OPTIONAL ZONE HEATER (WITH FAN OR WITHOUT)
RETURN FROM OTHER ZONES
LEGEND:
AIR SYSTEM COMPONENTS
AIR SYSTEM OPTIONS

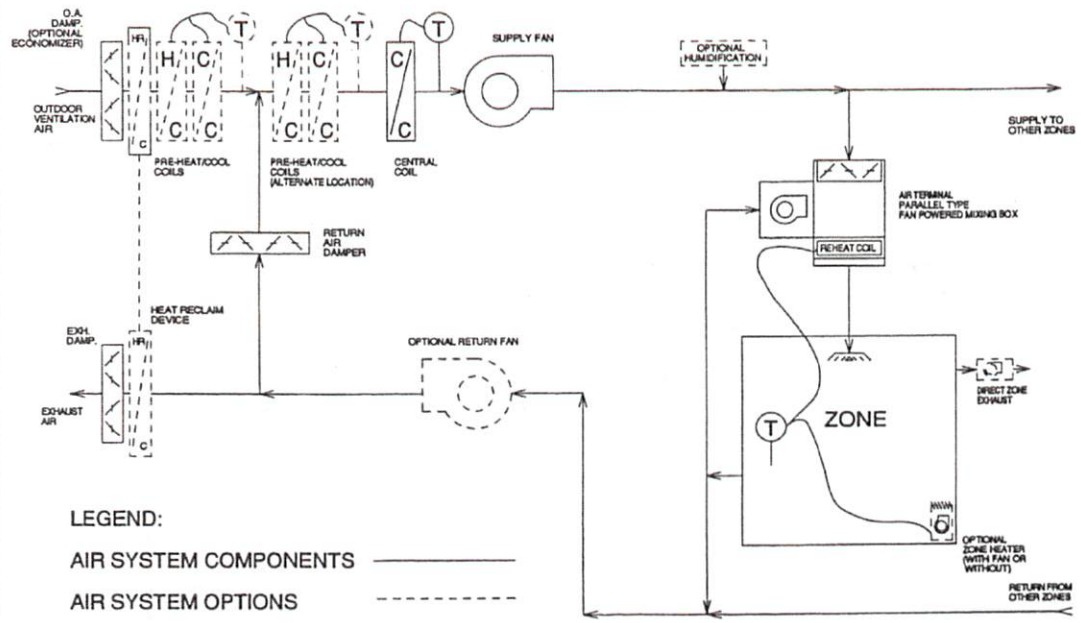
AIR SYSTEM SCHEMATICS
VARIABLE VOLUME - V.A.V. REHEAT



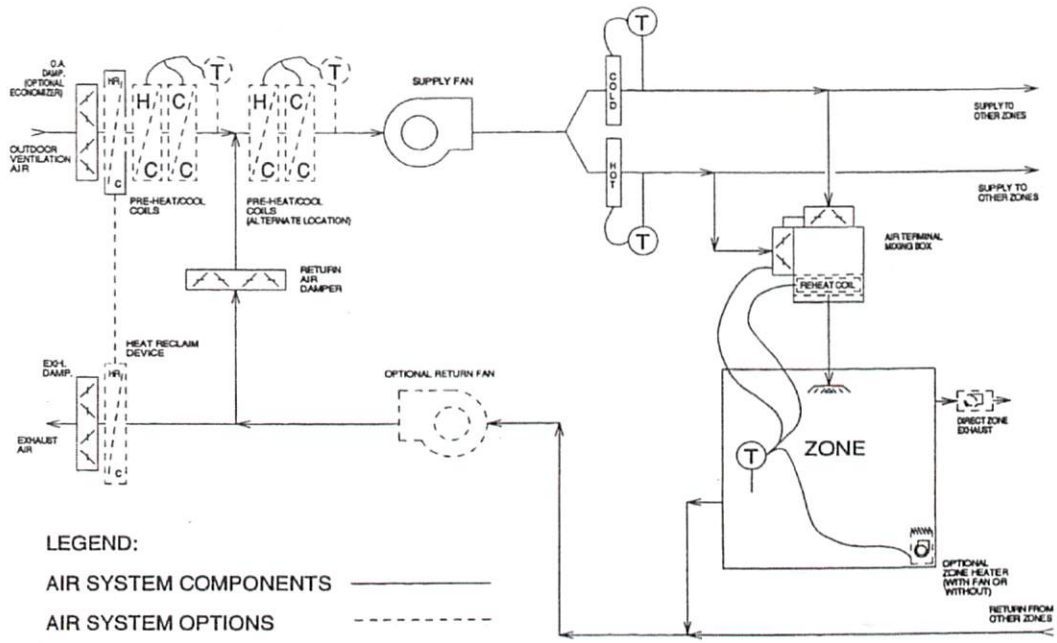
AIR SYSTEM SCHEMATICS
VARIABLE VOLUME - SERIES MIXING BOX



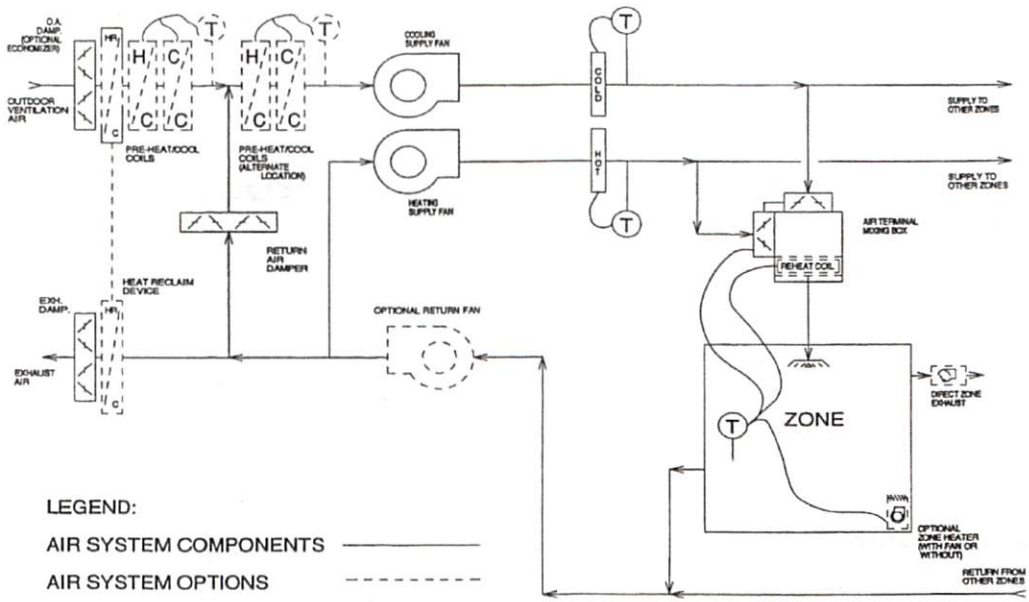
AIR SYSTEM SCHEMATICS
VARIABLE VOLUME - PARALLEL MIXING BOX



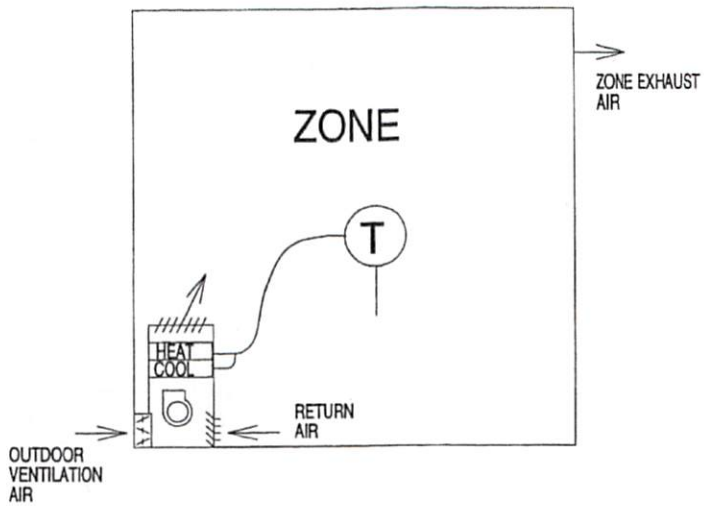
AIR SYSTEM SCHEMATICS
VARIABLE VOLUME - DUAL DUCT V.A.V.



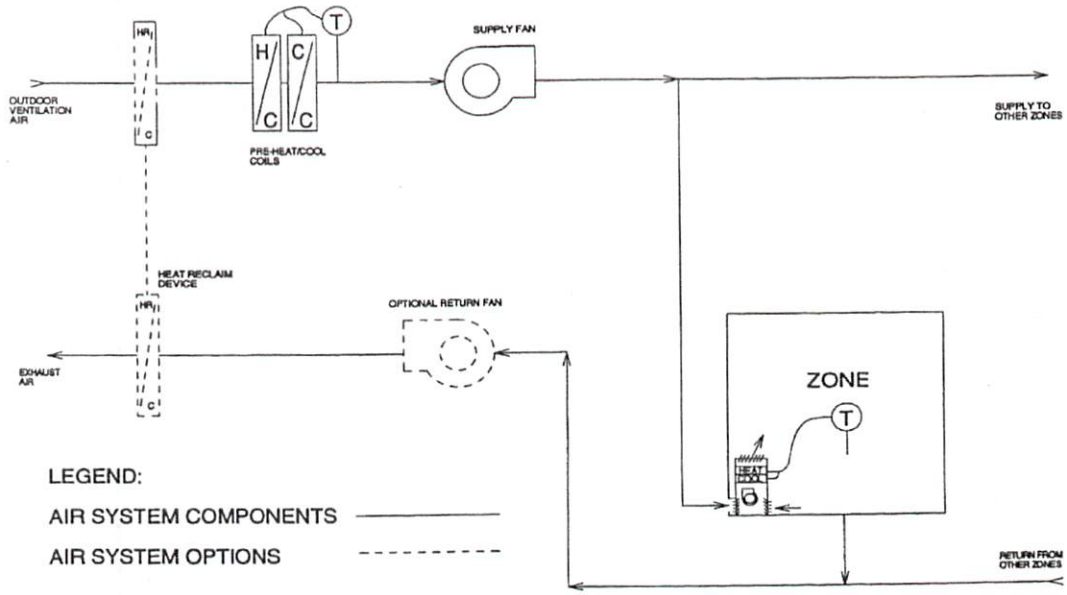
AIR SYSTEM SCHEMATICS
VARIABLE VOLUME - 2- FAN DUAL DUCT V.A.V.



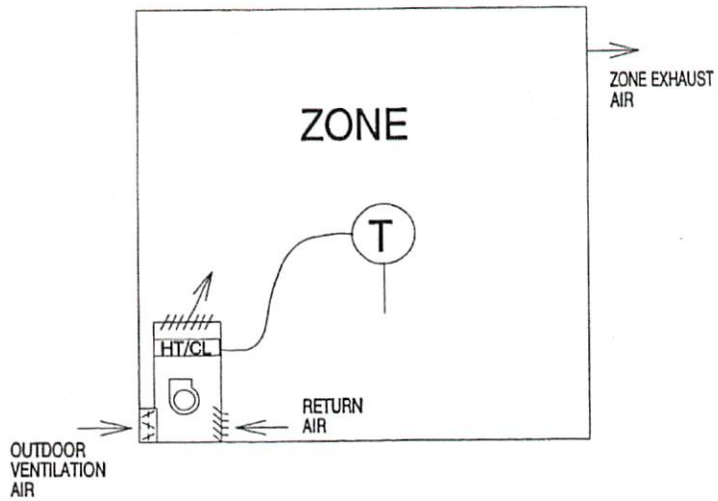
AIR SYSTEM SCHEMATICS
PTAC TERMINALS WITH DIRECT VENTILATION



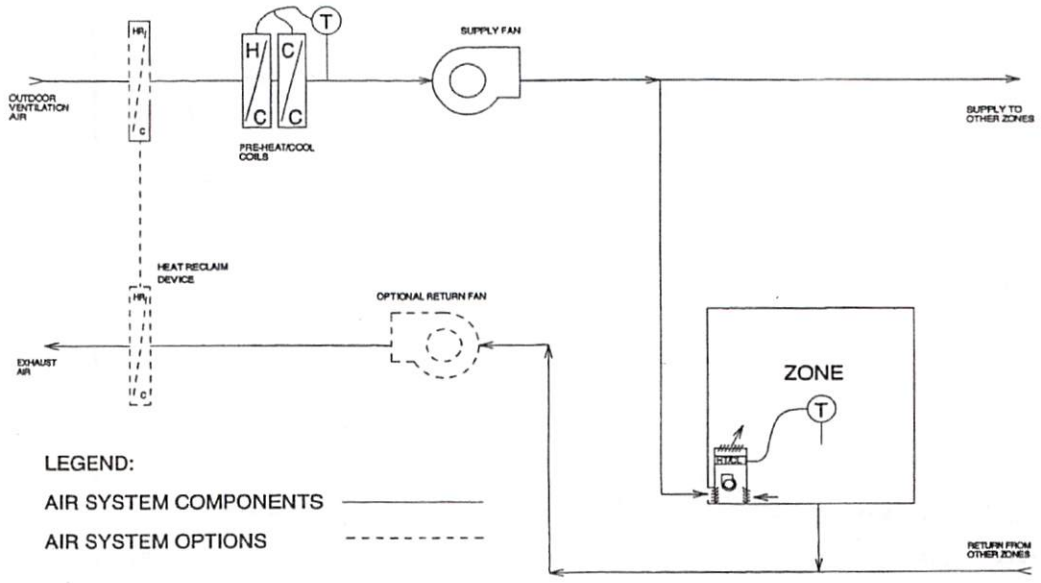
AIR SYSTEM SCHEMATICS
PTAC TERMINALS WITH CENTRAL VENTILATON



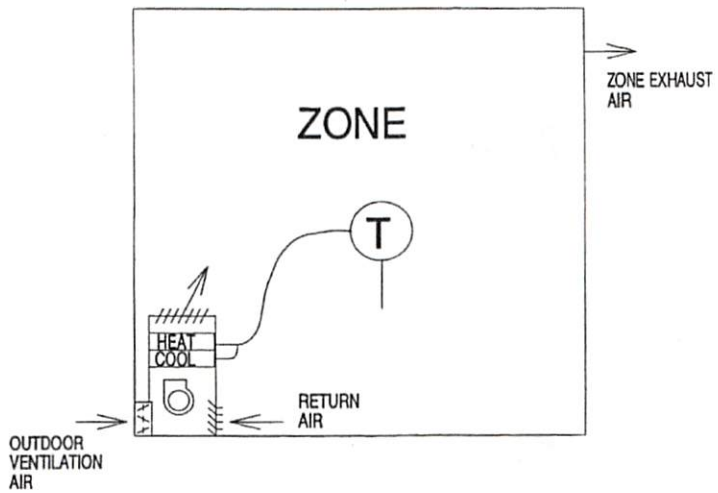
AIR SYSTEM SCHEMATICS
2 PIPE FAN COILS WITH DIRECT VENTILATION



AIR SYSTEM SCHEMATICS
2 PIPE FAN COILS WITH CENTRAL VENTILATION



AIR SYSTEM SCHEMATICS
4 PIPE FAN COILS WITH DIRECT VENTILATION



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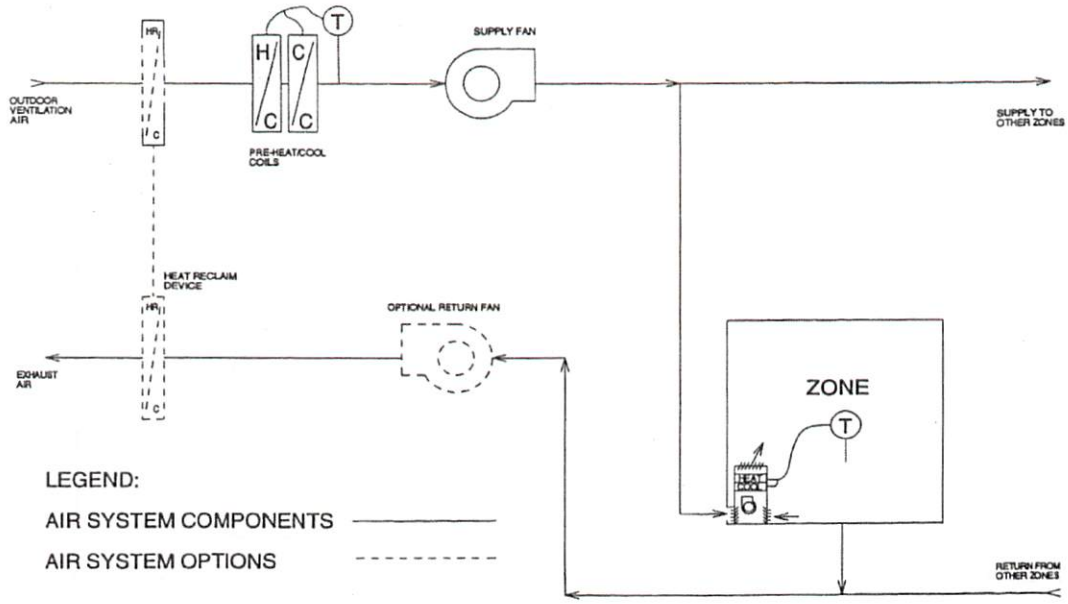
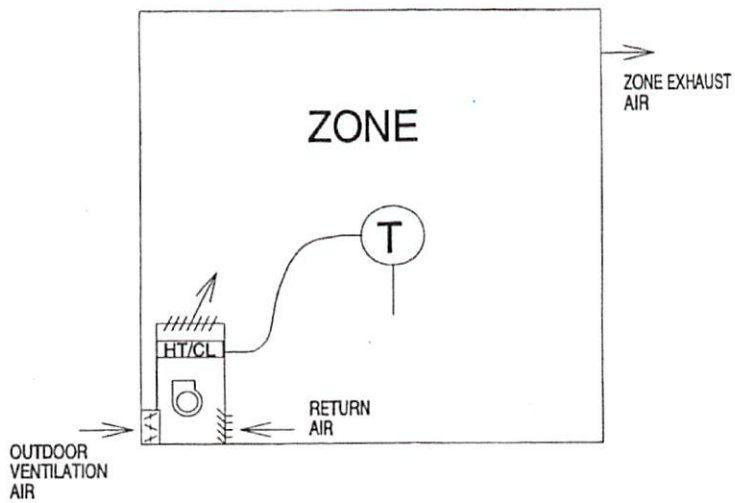
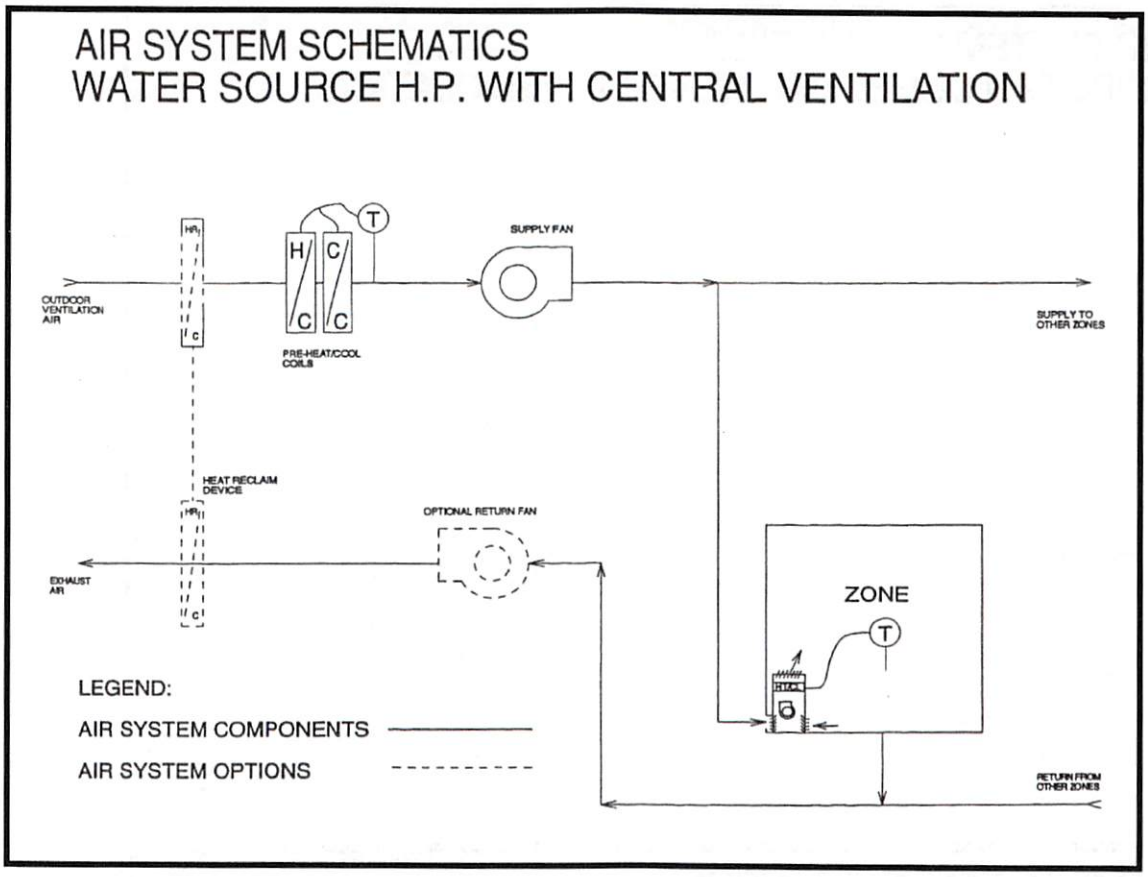
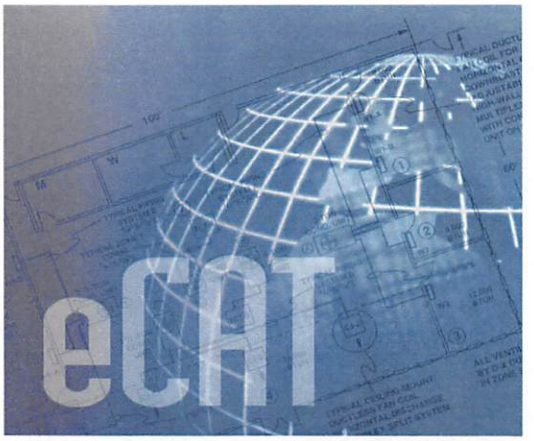
AIR SYSTEM SCHEMATICS
4 PIPE FAN COILS WITH CENTRAL VENTILATION



AIR SYSTEM SCHEMATICS
WATER SOURCE H.P. WITH DIRECT VENTILATION




AIR SYSTEM SCHEMATICS
WATER SOURCE H.P. WITH CENTRAL VENTILATION
OUTDOOR VENTILATION AIR
HR
c
H
C
C
C
T
PRE-HEAT/COOL COILS
SUPPLY FAN
SUPPLY TO OTHER ZONES
HEAT RECLAIM DEVICE
HR
c
OPTIONAL RETURN FAN
EXHAUST AIR
ZONE
T
RETURN FROM OTHER ZONES
LEGEND:
AIR SYSTEM COMPONENTS
AIR SYSTEM OPTIONS



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Carrier SOFTWARE SYSTEMS NETWORK

Load Calculations for Commercial Buildings 2013 Jan 08