

TECHNICAL REPORT 2

MECHANICAL

---

**Building and Plant Energy &  
Emissions Analysis**

---

*Author:*

Tessa BAUMAN

*technical consultant:*

Laura Miller, PH.D, P.E.

October 4, 2013

## Contents

<b>Executive Summary</b>	<b>2</b>
<b>Mechanical Systems Summary</b>	<b>2</b>
<b>Building Load Calculations</b>	<b>3</b>
Design Conditions . . . . .	3
Model Design . . . . .	3
Load Assumptions . . . . .	6
Occupancy Assumptions . . . . .	6
Ventilation Assumptions . . . . .	7
Lighting and Equipment Electrical Load Assumptions . . . . .	7
Construction . . . . .	8
Heating and Cooling Model Design . . . . .	8
Calculated Load Vs. Designed Load . . . . .	9
<b>Energy Calculation and Operating Cost</b>	<b>9</b>
Energy Consumption . . . . .	9
Cost Analysis . . . . .	10
<b>Appendix A</b>	<b>11</b>
<b>Appendix B</b>	<b>14</b>
<b>Appendix C</b>	<b>20</b>
<b>Appendix D</b>	<b>26</b>

## Executive Summary

This technical report is the analysis of building loads and energy consumption. The analysis is performed with the computer program Trane TRACE 700. This is a HVAC design based program that allows for accurate building modeling. Many inputs to this program are available in libraries that evaluate the occupancy categories of the building.

Twin Rivers Elementary/Intermediate will have a very large heating load during the school year. The cooling load is considerably lower due to in-occupancy during summer break. The outcome of the calculations is a little skewed due to over simplification of the building model and system design.

The cost of the

## Mechanical Systems Summary

The Twin Rivers Elementary/Intermediate School will house 800 students of the Mckeesport Area School District. It is a two story building of 30,000 sq. ft. The Mechanical system is designed to save 30% of energy when compared to ASHRAE standard 90.1-2007. ASHRAEs Advanced Energy Design Guide for K-12 School Buildings also had a major impact on the design.

The main heating and cooling will come from a geothermal system. This will be an earth coupled water loop directly connected to water-to-air heat pumps. There will be 2 well fields located slightly north of the building's foundation. The earth coupled water loop will also be connected to a chiller, serving air handling units.

The ventilation system consists of 2 dedicated outside air systems (DOAS) which serve the classrooms and most of the building. The library, cafeteria, gymnasium, and offices each have individual air handling units (AHU). The library and office AHUs will have zone reheat coils. The gym and cafeteria AHUs will consist of just a single zone.

## Building Load Calculations

This building energy analysis was performed using the computer program Trane TRACE 700. This program is able to calculate both load design and energy analysis. Input data came from Construction Documents of the Twin Rivers Project and also assumptions were made for any missing information by taking ASHREA standards into account.

## Design Conditions

Twin Rivers Elementary/Intermediate is in McKeesport, PA. This is less than 20 miles from downtown Pittsburgh, PA. This area is mostly a urban area. For this report, weather data is taken from Pittsburgh. The climate that the school is located in is zone 5A according to 90.1's table B-1. Type A is considered to be very humid in the summers, where the OA needs to be air conditioned to be considered comfortable. Table 1 demonstrates the necessary design conditions of the indoor air.

Space	Summer Design		Winter Design	
	db (deg F)	% RH Max	db (deg F)	% RH Max
Computer Labs/Classrooms	75	60	72	20
Offices	75	60	72	20
Library	75	60	72	40
Gymnasium	75	60	72	20
Cafeteria	75	60	72	20
Restrooms	78	60	70	20

Table 1: Design Interior Temp and Relative Humidity

## Model Design

The calculations performed for this report were based on a block load and energy analysis. This is a simplified design. Similar areas were formed into blocks for the entire school. for example, a large grouping of classrooms are considered to be one block. Within Trace, templates for different zone types were created (see appendix B and C). Eleven zone types summarize the school. These include:

- |                 |                            |                   |
|-----------------|----------------------------|-------------------|
| 1. Cafeteria    | 5. Gymnasium               | 9. Nurse's area   |
| 2. Classroom    | 6. Kitchen                 | 10. Offices       |
| 3. Computer Lab | 7. Library                 |                   |
| 4. Corridor     | 8. Mechanical & Electrical | 11. Water Closets |

The building can be broken into blocks using these zone types. Twin Rivers has 61 blocks and can be seen below. The different colors represent the different zone types.

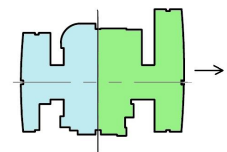
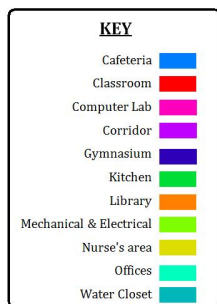


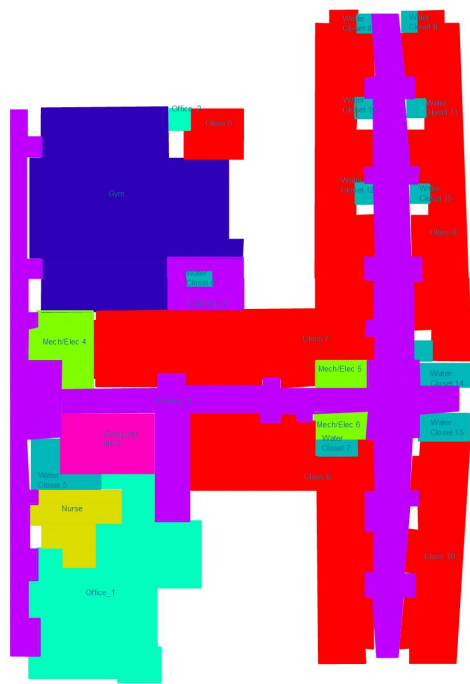
Figure 2: Building Plan Key

Figure 1: Zone Type Key

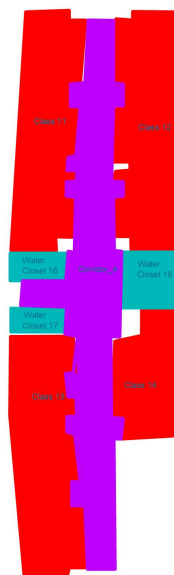
First Floor South Blocks



First Floor North Blocks



Second Floor South Blocks



## Second Floor North Blocks



The school is nearly oriented to the cardinal directions. For simplicity, the TRACE model uses 0 °, 90°, 180 °, and 270 ° to represent the North, East, South, and West sides of the building respectfully. The main entrance to the building is located on the eastern side.

## Load Assumptions

Data was taken from mechanical drawings and schedules. If information was not available, ASHREA standards were taken into consideration.

## Occupancy Assumptions

There were no occupancy values given in the construction documents. Because of this, assumptions were made. In ASHREA standard 62.1, table 6-1 gives density values for certain occupancy categories in persons per 1000 sqft. However, TRACE automatically fills in a correct density for this value. My zones correlated to these categories so this table was not needed. The exception to this was the mechanical spaces and the restrooms(water closets). Both of these are not available in the ASHREA table. The mechanical spaces were assumed to have 2 people within the space. The restrooms were assumed to have the density equivalent to a reception area, which was available in the TRACE library.

## Ventilation Assumptions

The building was designed to use ASHREA standard 62.1. The given value for breathing zone CFM rate in the documents is exactly the same as the automatic fill in of TRACE of the CFM/person and CFM/sqft values within the airflow tab. Flow rates not given in the document, such as for mechanical spaces, were taken from the automatic fill by occupancy. The zone type mechanical/electrical was placed under the occupancy of "Electrical Equipment Rooms". The ventilation values are shown in the table below. All of these zones will have air supplied through the ceiling and also have a ceiling return.

Table 2: Modeled Ventilation Rates

Zone Type	Minimum Ventilation Rates (CFM/person)	Minimum Ventilation (cfm/SF)	Infiltration (ACH)
Cafeteria	7.5	0.18	13
Classroom	10	0.12	6
Computer Lab	10	0.12	10
Corridor	0	0.06	4
Gym	0	0.3	8
Kitchen	7.5	0.12	15
Library	5	0.12	4
Mech/Elec	0	0.06	4
Nurse	10	0.18	8
Office	5	0.06	4
Water Closet	20	0.06	10

## Lighting and Equipment Electrical Load Assumptions

Due to incomplete electrical drawings, the true lighting values are unknown. ASHREA Standard 90.1 gives design values for lighting power densities for specific spaces. These were used in the TRACE model. Extra load was applied where it was known to have either computers or printers. A laser printer adds an additional 300 Watts. (load of workstations is not tabulated below)



Table 3: Lighting and Misc. Loads

Zone Type	LPD (W/SF)	Misc. Loads (W/SF)
Cafeteria	0.9	0
Classroom	1.24	0.22
Computer Lab	1.23	300 [W]
Corridor	0.66	0
Gym	1.2	0
Kitchen	0.99	0
Library	1.18	300 [W]
Mech/Elec	0.95	Per Equip.
Nurse	0.87	0
Office	1.11	300 [W]
Water Closet	0.98	0

## Construction

For simplicity, there was only one wall type considered in the model. This was the exterior wall construction. The glazing was also reduced to one single type. The chosen construction model were the ones that best resembled the U-values of the designed building's values. A view of the TRACE construction tab is available in Appendix A.

Table 4: Designed Insulation Values

Wall type	R-Value	U-Value	Shading coefficient
Exterior	14.5	0.0690	
Roof	30	0.03333	
Windows		0.293	0.48

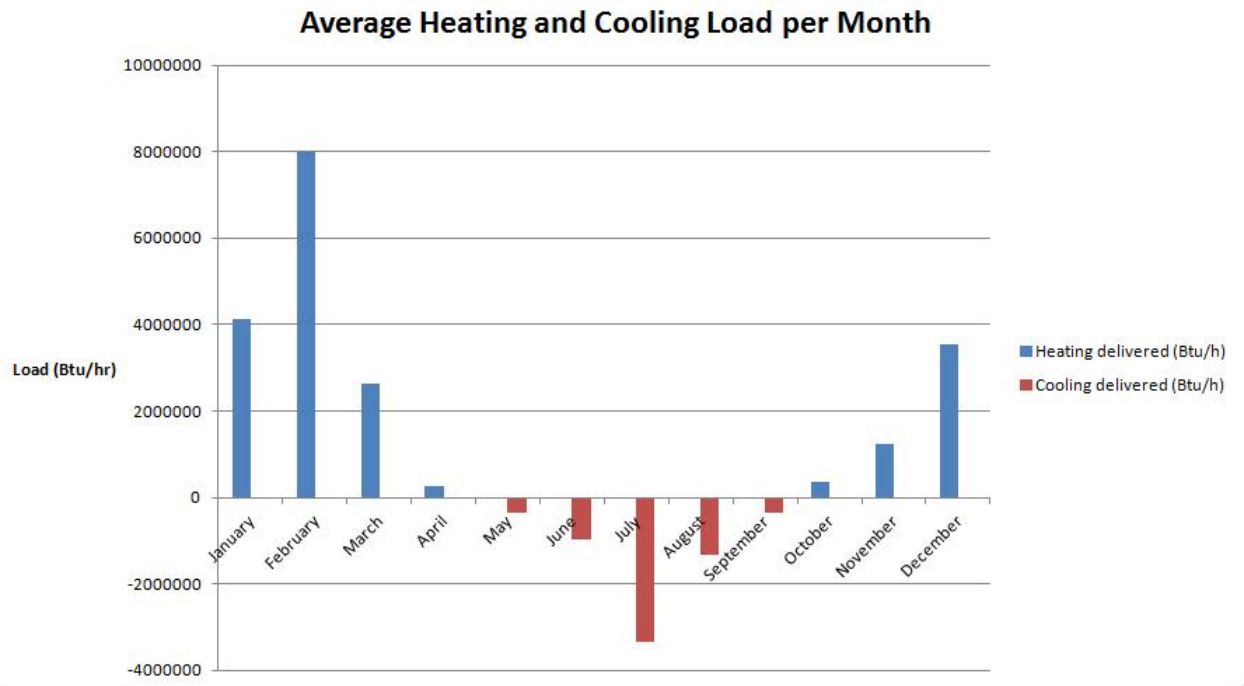
## Heating and Cooling Model Design

Multiple ventilation systems were created for this model. There is 2 DOASs and 4 AHU. These were all supplied with hot and chilled water from the geothermal system. The ground source heat pumps from the vertical, closed loop geothermal system, were modeled by a water source heat pump. In reality, this is a hybrid system with direct piping to the room heat pumps and piping to a chiller which then supplies the AHU's coils. This is a complex system and difficult to model in this program. In this model, there is only cooling from the wells and all hot water coils are connected to a back up boiler. This causes the model to be slightly inaccurate.

## Calculated Load Vs. Designed Load

There is no load calculation from the mechanical engineers of the Twin Rivers Project with which to compare these results.

The building peak load for heating is calculated to be 10,998 MBh. The building peak load for cooling is 430 tons. The cooling load is about half of the heating load. This makes sense because a school building is not needed for the hot summer days.



It is assumed that a more advanced model done by the mechanical engineers would be more accurate portrayal of the building load. The peak heating load is rather high. This may be due to the lack of an exact heating and cooling model, blocking instead of individual room analysis, one wall and window type construction, and other inaccuracies.

Other TRACE Load Calculation Outputs can be viewed in appendix D

## Energy Calculation and Operating Cost

### Energy Consumption

The following table summarizes the school's energy consumption for the entire year. The building runs mainly on electricity but, it also has a natural gas line to the auxiliary boiler. This gas line should be minimal compared to the electricity going into the building.

## **Cost Analysis**

# Appendix A

## Miscellaneous TRACE input data

		Alternative 1
	Enter Project Information	Twin Rivers Elementary/Intermediate
	Select Weather Information	Pittsburgh, Pennsylvania
	Create Templates	35 Templates
	Create Rooms	61 Rooms
	Create Systems	6 Systems
	Assign Rooms to Systems	61 Assigned Rooms
	Create Plants	2 Plants
	Assign Systems to Plants	System Assignments
	Define Economics	A sample with all utilities 0(\$)

**Construction Templates - Project** ✖

Alternative:  Apply

Description:  Close

Construction...		U-factor Btu/h ft <sup>2</sup> ·°F
Slab	<input concrete"="" hw="" type="text" value="4\"/>	<input type="text" value="0.587084"/>
Roof	<input 6\"="" conc,="" hw="" ins,="" rts"="" type="text" value="6\"/>	<input type="text" value="0.033"/>
Wall	<input ins"="" type="text" value="Face brick, 2.42\"/>	<input type="text" value="0.0692529"/>
Partition	<input frame"="" gyp="" type="text" value="0.75\"/>	<input type="text" value="0.387955"/>

Glass type...		U-factor Btu/h ft <sup>2</sup> ·°F	Shading coeff
Window	<input type="text" value="6mm Dbl Low-E (e2=.04) Clr 13mm Air"/>	<input type="text" value="0.293"/>	<input type="text" value="0.48"/>
Skylight	<input "="" type="text" value="Single Clear 1/4\"/>	<input type="text" value="0.95"/>	<input type="text" value="0.95"/>
Door	<input type="text" value="Standard Door"/>	<input type="text" value="0.2"/>	<input type="text" value="0"/>

Height...

Wall	<input type="text" value="14"/> ft	Pct wall area to underfloor plenum	<input type="text" value=""/> %
Fir to fir	<input type="text" value="14"/> ft	Room type	<input type="text" value="Conditioned"/>
Plenum	<input type="text" value="4"/> ft		

Create Rooms - Single Worksheet

Alternative 1

Room description:

Templates...

Room:  Length:  ft Width:  ft

Internal:  Floor...:  ft Roof...:  ft

Airflow:   Equals floor

Tstat:

Constr:

Wall...

Description	Length (ft)	Height (ft)	Direction	% Glass or Qty	Length (ft)	Height (ft)	Window
Wall - 1	90	14	180	28	0	0	<input checked="" type="checkbox"/>
	0	14	0	0	0	0	<input type="checkbox"/>
	0	14	0	0	0	0	<input type="checkbox"/>

Internal loads...

People:

Lighting:

Misc loads:

Airflows...

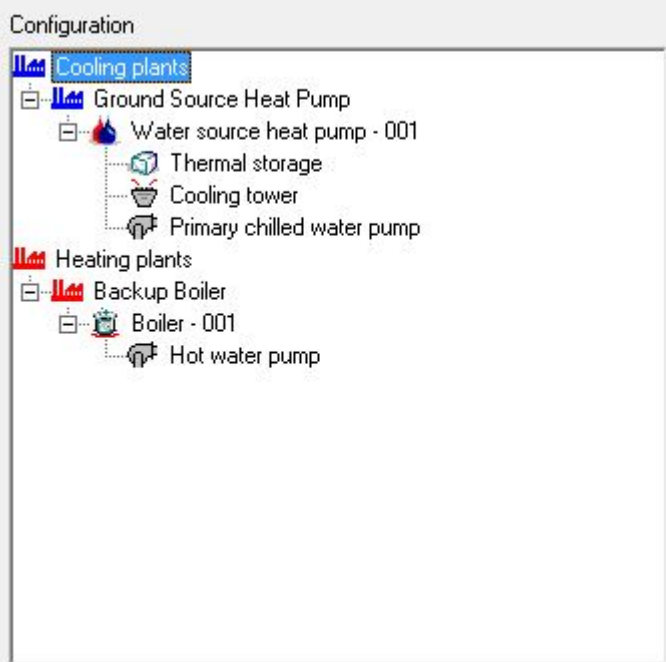
Peop-based:

Area-based:

Cooling VAV min:

Heating VAV max:

Single Sheet | Rooms | Roofs | Walls | Int Loads | Airflows | Patrn/Floors



Create Plants
⏏
⏏
⏏

**Cooling Equipment - Alternative 1**

Cooling plant:

Equipment tag:

Category:

Equipment type:

Sequencing type:

Backup heat source:

Reject condenser heat:

Reject heat to plant:

**Heat Rejection**

Type:

Hourly ambient wet bulb offset:  °F

**Thermal Storage**

Type:

Capacity:  gal/ton

Schedule:

Operating mode	Capacity	Energy rate
Cooling	tons	0.761 kW/ton
Heat recovery	10.88 Mbh/ton	0.0637 kW/Mbh
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Cnst vol chill water pump	15 hp
Condenser water	None	0 ft water
Heat recovery or aux condenser	None	0 ft water

Apply

Close

New Equip

Copy Equip

Delete Equip

Controls...

Packaged Energy Breakout...

Configuration
**Cooling Equipment**
Heating Equipment
Base Utility / Misc. Accessory

Economics
⏏
⏏
⏏

**Alternative 1**

Equipment installed cost:  \$

Yearly maintenance expense:  \$

Additional first cost:  \$

Revenue penalty:  \$

Building area override:  ft<sup>2</sup>

Building capacity override:  ton

**Utility Rate**

<input type="text" value="A sample with all utilities"/>	<input type="text" value="Electric consumption"/>	<input type="text" value="A sample with all utilities"/>	<input type="text" value="Gas"/>
--	---	--	----------------------------------

Company:

Utility:

Inflation:  %

Time-of-day schedule:

**Recurring/Additional Depreciable Cost**

Cost	Year Incur	Econ Life	Depr. Taxes
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Cost:  \$      Economic life:  Yrs

Year cost incurred:       Depr. life taxes:  Yrs

**Utility Rates & Life Cycle Costs**
Economic Information

# Appendix B

## Internal Load Templates

**Internal Load Templates - Project**

Alternative:

Description:

People...

Type:

Density:

Schedule:

Sensible:  Btu/h Latent:  Btu/h

Workstations...

Density:

Lighting...

Type:

Heat gain:

Schedule:

Miscellaneous loads...

Type:

Energy:

Schedule:

Energy meter:

**Internal Load** |  |  |  |

**Internal Load Templates - Project**

Alternative:

Description:

People...

Type:

Density:

Schedule:

Sensible:  Btu/h Latent:  Btu/h

Workstations...

Density:

Lighting...

Type:

Heat gain:

Schedule:

Miscellaneous loads...

Type:

Energy:

Schedule:

Energy meter:

**Internal Load** |  |  |  |



**Internal Load Templates - Project** [X]

Alternative:  [Apply]

Description:  [Close]

People...

Type:  [New]

Density:   [Cooling Only (Design)] [Copy]

Sensible:  Btu/h Latent:  Btu/h [Delete]

Workstations...

Density:   [Add Global]

Lighting...

Type:  [Cooling Only (Design)]

Heat gain:   [Cooling Only (Design)]

Miscellaneous loads...

Type:  [Cooling Only (Design)]

Energy:   [Cooling Only (Design)]

Energy meter:

**Internal Load** |  |  |  |

**Internal Load Templates - Project** [X]

Alternative:  [Apply]

Description:  [Close]

People...

Type:  [New]

Density:   [Cooling Only (Design)] [Copy]

Sensible:  Btu/h Latent:  Btu/h [Delete]

Workstations...

Density:   [Add Global]

Lighting...

Type:  [Cooling Only (Design)]

Heat gain:   [Cooling Only (Design)]

Miscellaneous loads...

Type:  [Cooling Only (Design)]

Energy:   [Cooling Only (Design)]

Energy meter:

**Internal Load** |  |  |  |

**Internal Load Templates - Project**

Alternative:

Description:

People...

Type:

Density:

Schedule:

Sensible:  Btu/h Latent:  Btu/h

Workstations...

Density:

Lighting...

Type:

Heat gain:

Schedule:

Miscellaneous loads...

Type:

Energy:

Schedule:

Energy meter:

**Internal Load** |  |  |  |

**Internal Load Templates - Project**

Alternative:

Description:

People...

Type:

Density:

Schedule:

Sensible:  Btu/h Latent:  Btu/h

Workstations...

Density:

Lighting...

Type:

Heat gain:

Schedule:

Miscellaneous loads...

Type:

Energy:

Schedule:

Energy meter:

**Internal Load** |  |  |  |

**Internal Load Templates - Project** [X]

Alternative:  [Apply]

Description:  [Close]

People...

Type:  [New]

Density:   [Schedule: ] [Copy]

Sensible:  Btu/h Latent:  Btu/h [Delete]

Workstations...

Density:   [Add Global]

Lighting...

Type:  [New]

Heat gain:   [Schedule: ] [Copy]

Miscellaneous loads...

Type:  [New]

Energy:   [Schedule: ] [Copy]

Energy meter:  [Delete]

**Internal Load** |  |  |  |

**Internal Load Templates - Project** [X]

Alternative:  [Apply]

Description:  [Close]

People...

Type:  [New]

Density:   [Schedule: ] [Copy]

Sensible:  Btu/h Latent:  Btu/h [Delete]

Workstations...

Density:   [Add Global]

Lighting...

Type:  [New]

Heat gain:   [Schedule: ] [Copy]

Miscellaneous loads...

Type:  [New]

Energy:   [Schedule: ] [Copy]

Energy meter:  [Delete]

**Internal Load** |  |  |  |

**Internal Load Templates - Project**

Alternative:

Description:

People...

Type:

Density:

Schedule:

Sensible:  Btu/h Latent:  Btu/h

Workstations...

Density:

Lighting...

Type:

Heat gain:  W/sq ft

Schedule:

Miscellaneous loads...

Type:

Energy:  W/sq ft

Schedule:

Energy meter:

**Internal Load** |  |  |  |

**Internal Load Templates - Project**

Alternative:

Description:

People...

Type:

Density:

Schedule:

Sensible:  Btu/h Latent:  Btu/h

Workstations...

Density:

Lighting...

Type:

Heat gain:  W/sq ft

Schedule:

Miscellaneous loads...

Type:

Energy:  W

Schedule:

Energy meter:

**Internal Load** |  |  |  |

**Internal Load Templates - Project** [X]

Alternative:  [v]  
Description:  [v]

People...  
Type:  [v]  
Density:   [v]    Schedule:  [v]  
Sensible:  Btu/h    Latent:  Btu/h

Workstations...  
Density:  [v]

Lighting...  
Type:  [v]  
Heat gain:   [v]    Schedule:  [v]

Miscellaneous loads...  
Type:  [v]  
Energy:   [v]    Schedule:  [v]  
Energy meter:  [v]

**Internal Load**               

Buttons: Apply, Close, New, Copy, Delete, Add Global

# Appendix C

## Airflow Templates

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Cafeteria

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Cafeteria/fast food dining  
 Peop-based: 7.5 cfm/person  
 Area-based: 0.18 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > trm+15°F[8°C] 80 %  
 Er: Default based on system type %  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 13 air changes/hr  
 Heating: 13 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Internal Load    **Airflow**    Thermostat    Construction    Room

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Classroom

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Classrooms (age 9 plus)  
 Peop-based: 10 cfm/person  
 Area-based: 0.12 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > trm+15°F[8°C] 80 %  
 Er: Default based on system type %  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 6 air changes/hr  
 Heating: 6 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Internal Load    **Airflow**    Thermostat    Construction    Room

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Computer Lab

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Computer lab  
 Peop-based: 10 cfm/person  
 Area-based: 0.12 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > trm+15°F(8°C) 80 %  
 Er: Default based on system type  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 10 air changes/hr  
 Heating: 10 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Internal Load | **Airflow** | Thermostat | Construction | Room

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Corridor

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Corridors  
 Peop-based: 0 cfm/person  
 Area-based: 0.06 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > trm+15°F(8°C) 80 %  
 Er: Default based on system type  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 4 air changes/hr  
 Heating: 4 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Internal Load | **Airflow** | Thermostat | Construction | Room

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Gym

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Gym, stadium (play area)  
 Peop-based: 0 cfm/person  
 Area-based: 0.3 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > trm+15°F(8°C) 80 %  
 Er: Default based on system type %  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 8 air changes/hr  
 Heating: 8 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Internal Load | **Airflow** | Thermostat | Construction | Room

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Kitchen

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Kitchen - cooking  
 Peop-based: 7.5 cfm/person  
 Area-based: 0.12 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > trm+15°F(8°C) 80 %  
 Er: Default based on system type %  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 15 air changes/hr  
 Heating: 15 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Internal Load | **Airflow** | Thermostat | Construction | Room



**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Library

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Libraries  
 Peop-based: 5 cfm/person  
 Area-based: 0.12 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > tm+15°F(8°C) 80 %  
 Er: Default based on system type %  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 4 air changes/hr  
 Heating: 4 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Buttons: Apply, Close, New, Copy, Delete, Add Global

Internal Load | **Airflow** | Thermostat | Construction | Room

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Mech/Elec

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Electrical Equipment Rooms  
 Peop-based: 0 cfm/person  
 Area-based: 0.06 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > tm+15°F(8°C) 80 %  
 Er: Default based on system type %  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 4 air changes/hr  
 Heating: 4 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Buttons: Apply, Close, New, Copy, Delete, Add Global

Internal Load | **Airflow** | Thermostat | Construction | Room

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Nurse

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Daycare (through age 4)  
 Peop-based: 10 cfm/person  
 Area-based: 0.18 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > trm+15°F(8°C) 80 %  
 Er: Default based on system type %  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 8 air changes/hr  
 Heating: 8 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Buttons: Apply, Close, New, Copy, Delete, Add Global

Internal Load | **Airflow** | Thermostat | Construction | Room

**Airflow Templates - Project**

Alternative: Alternative 1  
 Description: Office

Main supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Auxiliary supply...  
 Cooling: To be calculated  
 Heating: To be calculated

Ventilation...  
 Apply ASHRAE Std62.1-2004/2007: Yes  
 Type: Office space  
 Peop-based: 5 cfm/person  
 Area-based: 0.06 cfm/sq ft  
 Schedule: Available (100%)

Std 62.1-2004/2007...  
 Clg Ez: Ceiling clg supply, ceiling retu 100 %  
 Htg Ez: Ceiling supply > trm+15°F(8°C) 80 %  
 Er: Default based on system type %  
 DCV Min OA Intake: None

Infiltration...  
 Type: None  
 Cooling: 4 air changes/hr  
 Heating: 4 air changes/hr  
 Schedule: Available (100%)

Room exhaust...  
 Rate: 0 air changes/hr  
 Schedule: Available (100%)

VAV control...  
 Clg VAV min: % Clg Airflow  
 Htg VAV max: % Clg Airflow  
 Schedule: Available (100%)  
 Type: Default

Buttons: Apply, Close, New, Copy, Delete, Add Global

Internal Load | **Airflow** | Thermostat | Construction | Room

**Airflow Templates - Project** ✖

Alternative:  Apply

Description:  Close

Main supply... Auxiliary supply...

Cooling:  Cooling:

Heating:  Heating:

Ventilation... Std 62.1-2004/2007...

Apply ASHRAE Std62.1-2004/2007:  Clg Ez:  100 %

Type:  Htg Ez:  80 %

Peop-based:  cfm/person Er:  %

Area-based:  cfm/sq ft DCV Min OA Intake:

Schedule:  Room exhaust...

Infiltration... Rate:  air changes/hr

Type:  Schedule:

Cooling:  air changes/hr VAV control...

Heating:  air changes/hr Clg VAV min:  % Clg Airflow

Schedule:  Htg VAV max:  % Clg Airflow

Schedule:

Type:

# Appendix D

## TRACE Calculation Output

**SYSTEM SUMMARY**  
**DESIGN HEATING CAPACITIES**  
 By ACADEMIC

Alternative 1

System Coil Capacities

System Description	System Type	Main System Btu/h	Aux System Btu/h	Preheat Btu/h	Reheat Btu/h	Humid. Btu/h	Optional Vent Btu/h	Stg 1 Desic Regen Btu/h	Stg 2 Desic Regen Btu/h	Stg 1 Frost Prevention Btu/h	Stg 2 Frost Prevention Btu/h	Heating Totals Btu/h
DOAS_1	Water Source Heat Pump	-3,403,028	0	0	0	0	0	0	0	0	0	-3,403,028
DOAS_2	Water Source Heat Pump	-4,233,042	0	0	0	0	0	0	0	0	0	-4,233,042
AHU_1	Single Zone Variable Air Volume	-1,557,616	0	0	0	0	0	0	0	0	0	-1,557,616
AHU_2	Variable Volume Reheat (30% Min Flow Default)	-328,172	0	-71,434	-27,544	0	0	0	0	0	0	-399,607
AHU_3	Single Zone Variable Air Volume	-900,159	0	0	0	0	0	0	0	0	0	-900,159
AHU_4	Variable Volume Reheat (30% Min Flow Default)	-421,106	0	-83,339	-24,219	0	0	0	0	0	0	-504,445
<b>Totals</b>		<b>-10,843,122</b>	<b>0</b>	<b>-154,773</b>	<b>-51,763</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>-10,997,896</b>

Building Plant Capacities

Plant	System	Peak Loads												
		Main Coil MBh	Preheat Coil MBh	Reheat Coil MBh	Humid. Coil MBh	Aux Coil MBh	Opt Vent Coil MBh	Misc Load MBh	Stg 1 Desic. Regen. MBh	Stg 2 Desic. Regen. MBh	Stg 1 Frost Prev. MBh	Stg 2 Frost Prev. MBh	Base Utility MBh	Absorption Load MBh
Backup Boiler		10,843	155	0	0	0	0	0	0	0	0	0	0	0
DOAS_1		3,403	0	0	0	0	0	0	0	0	0	0	0	0
DOAS_2		4,233	0	0	0	0	0	0	0	0	0	0	0	0
AHU_1		1,558	0	0	0	0	0	0	0	0	0	0	0	0
AHU_2		325	71	0	0	0	0	0	0	0	0	0	0	0
AHU_3		900	0	0	0	0	0	0	0	0	0	0	0	0
AHU_4		421	83	0	0	0	0	0	0	0	0	0	0	0

Building peak load is 10,997.9 MBh.

**SYSTEM SUMMARY**  
**DESIGN COOLING CAPACITIES**  
 By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

Plant	System	Peak Plant Loads								Block Plant Loads								
		Main Coil ton	Aux Coil ton	Opt Vent ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Peak Total ton	Time Of Peak mol/hr	Main Coil ton	Aux Coil ton	Opt Vent ton	Misc Load ton	Stg 1 Desic Cond ton	Stg 2 Desic Cond ton	Base Utility ton	Block Total ton
Ground Source Heat Pump		429.8	0.0	0.0	0.0	0.0	0.0	0.0	429.8	7/15	413.1	0.0	0.0	0.0	0.0	0.0	0.0	413.1
DOAS_1		128.6	0.0	0.0	0.0	0.0	0.0	0.0	128.6	7/15	125.7	0.0	0.0	0.0	0.0	0.0	0.0	125.7
DOAS_2		169.0	0.0	0.0	0.0	0.0	0.0	0.0	169.0	7/15	165.3	0.0	0.0	0.0	0.0	0.0	0.0	165.3
AHU_1		60.1	0.0	0.0	0.0	0.0	0.0	0.0	60.1	7/15	60.1	0.0	0.0	0.0	0.0	0.0	0.0	60.1
AHU_2		17.2	0.0	0.0	0.0	0.0	0.0	0.0	17.2	7/15	17.2	0.0	0.0	0.0	0.0	0.0	0.0	17.2
AHU_3		39.9	0.0	0.0	0.0	0.0	0.0	0.0	39.9	7/15	39.9	0.0	0.0	0.0	0.0	0.0	0.0	39.9
AHU_4		15.1	0.0	0.0	0.0	0.0	0.0	0.0	15.1	7/15	5.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
<b>Building totals</b>		<b>429.8</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>429.8</b>		<b>413.1</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>413.1</b>

Building peak load is 429.8 tons.

Building maximum block load of 413.1 tons occurs in July at hour 15 based on system simulation.

**System Checksums**  
By ACADEMIC

AHU\_1

Single Zone Variable Air Volume

COOLING COIL PEAK				CLG SPACE PEAK				HEATING COIL PEAK				TEMPERATURES		
Peaked at Time: Mo/Hr: 7 / 15 Outside Air: OADB/WB/HR: 86 / 71 / 95				Mo/Hr: 7 / 15 OADB: 86				Mo/Hr: Heating Design OADB: 5				SADB	Cooling	Heating
Space Sens. + Lat.	Plenum Sens. + Lat.	Net Total	Percent Of Total	Space Sensible	Percent Of Total	Space Peak	Coil Peak	Percent	Space Sens	Tot Sens	Of Total	Ra Plenum	75.1	69.3
Btu/h	Btu/h	Btu/h	(%)	Btu/h	(%)	Btu/h	Btu/h	(%)	Btu/h	Btu/h	(%)	Return	75.1	69.3
<b>Envelope Loads</b>				<b>Envelope Loads</b>				<b>Envelope Loads</b>				<b>AIRFLOWS</b>		
SkyLite Solar	0	0	0	0	0	SkyLite Solar	0	0	SkyLite Solar	0	0	Diffuser	Cooling	Heating
SkyLite Cond	0	0	0	0	0	SkyLite Cond	0	0	SkyLite Cond	0	0	Infil	16,745	16,745
Roof Cond	0	4,722	4	0	0	Roof Cond	0	0	Roof Cond	-15,742	1.01	Terminal	18,984	5,695
Glass Solar	21,884	0	21,884	3	21,884	5	0	0	Glass Solar	0	0	Main Fan	18,984	5,695
Glass/Door Cond	1,361	0	1,361	0	1,361	0	0	0	Glass/Door Cond	-13,638	0.88	Sec Fan	0	0
Wall Cond	551	449	999	0	551	0	0	0	Wall Cond	-3,068	0.36	Nom Vent	6,238	5,439
Partition/Door	0	0	0	0	0	0	0	0	Partition/Door	0	0	AHU Vent	6,238	5,439
Floor	0	0	0	0	0	0	0	0	Floor	0	0	Infil	16,745	16,745
Adjacent Floor	0	0	0	0	0	0	0	0	Adjacent Floor	0	0	MinStop/Rh	5,695	5,695
Infiltration	242,975	0	242,975	34	196,601	49	0	0	Infiltration	-1,161,735	74.58	Return	35,728	22,440
Sub Total ==>	266,770	5,171	271,941	38	220,397	54	0	0	Sub Total ==>	-1,178,441	76.83	Exhaust	22,983	22,184
<b>Internal Loads</b>				<b>Internal Loads</b>				<b>Internal Loads</b>				<b>ENGINEERING CKS</b>		
Lights	23,513	0	23,513	3	23,513	6	0	0	Lights	0	0	% OA	Cooling	Heating
People	338,346	0	338,346	47	161,024	40	0	0	People	0	0	cfm/ft²	32.9	95.5
Misc	0	0	0	0	0	0	0	0	Misc	0	0	cfm/ton	2.56	0.77
Sub Total ==>	361,859	0	361,859	50	184,537	46	0	0	Sub Total ==>	0	0	ft³/ton	315.84	
Ceiling Load	300	-300	0	0	300	0	0	0	Ceiling Load	-1,628	0	Btu/hr-ft²	97.23	-209.98
Ventilation Load	0	0	90,595	13	0	0	0	0	Ventilation Load	0	0	No. People	651	
Adj Air Trans Heat	0	0	0	0	0	0	0	0	Adj Air Trans Heat	-377,357	24.23			
Dehumid. Ov Sizing	0	0	0	0	0	0	0	0	Dehumid. Ov Sizing	0	0			
Ov/Undr Sizing	0	0	0	0	0	0	0	0	Ov/Undr Sizing	0	0			
Exhaust Heat	0	-3,137	-3,137	0	0	0	0	0	Exhaust Heat	16,401	-1.05			
Sup. Fan Heat	0	0	0	0	0	0	0	0	OA Preheat Diff.	0	0			
Ret. Fan Heat	0	0	0	0	0	0	0	0	RA Preheat Diff.	0	0			
Duct Heat PkUp	0	0	0	0	0	0	0	0	Additional Reheat	0	0			
Underfrl Sup Ht PkUp	0	0	0	0	0	0	0	0	Underfrl Sup Ht PkUp	0	0			
Supply Air Leakage	0	0	0	0	0	0	0	0	Supply Air Leakage	0	0			
Grand Total ==>	628,930	1,734	721,258	100.00	405,235	100.00	0	0	Grand Total ==>	-1,180,069	-1,557,616			

Project Name: Elementary  
Dataset Name: Thesis.trc

TRACE® 700 v6.2.10 calculated at 10:56 PM on 10/03/2013  
Alternative - 1 System Checksums Report Page 1 of 6

**System Checksums**  
By ACADEMIC

AHU\_2

Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK				CLG SPACE PEAK				HEATING COIL PEAK				TEMPERATURES		
Peaked at Time: Mo/Hr: 7 / 15 Outside Air: OADB/WB/HR: 86 / 71 / 95				Mo/Hr: 7 / 15 OADB: 86				Mo/Hr: Heating Design OADB: 5				SADB	Cooling	Heating
Space Sens. + Lat.	Plenum Sens. + Lat.	Net Total	Percent Of Total	Space Sensible	Percent Of Total	Space Peak	Coil Peak	Percent	Space Sens	Tot Sens	Of Total	Ra Plenum	75.4	68.1
Btu/h	Btu/h	Btu/h	(%)	Btu/h	(%)	Btu/h	Btu/h	(%)	Btu/h	Btu/h	(%)	Return	75.4	68.1
<b>Envelope Loads</b>				<b>Envelope Loads</b>				<b>Envelope Loads</b>				<b>AIRFLOWS</b>		
SkyLite Solar	0	0	0	0	0	SkyLite Solar	0	0	SkyLite Solar	0	0	Diffuser	Cooling	Heating
SkyLite Cond	0	0	0	0	0	SkyLite Cond	0	0	SkyLite Cond	0	0	Terminal	5,735	1,720
Roof Cond	0	3,828	2	0	0	Roof Cond	0	0	Roof Cond	-12,668	3.17	Main Fan	5,735	1,720
Glass Solar	20,754	0	20,754	10	20,754	17	0	0	Glass Solar	0	0	Sec Fan	0	0
Glass/Door Cond	1,112	0	1,112	1	1,112	0	0	0	Glass/Door Cond	-11,142	2.79	Nom Vent	1,338	1,338
Wall Cond	829	512	1,341	0	829	0	0	0	Wall Cond	-4,417	1.79	AHU Vent	1,338	1,338
Partition/Door	0	0	0	0	0	0	0	0	Partition/Door	0	0	Infil	4,056	4,056
Floor	0	0	0	0	0	0	0	0	Floor	0	0	MinStop/Rh	1,720	1,720
Adjacent Floor	0	0	0	0	0	0	0	0	Adjacent Floor	0	0	Return	9,791	5,776
Infiltration	83,674	0	83,674	41	47,822	39	0	0	Infiltration	-281,403	70.42	Exhaust	5,394	5,394
Sub Total ==>	108,368	4,340	110,709	54	70,317	57	0	0	Sub Total ==>	-296,962	-312,357	Rm Exh	0	0
<b>Internal Loads</b>				<b>Internal Loads</b>				<b>Internal Loads</b>				<b>ENGINEERING CKS</b>		
Lights	24,502	0	24,502	12	24,502	20	0	0	Lights	0	0	% OA	Cooling	Heating
People	44,759	0	44,759	22	25,899	21	0	0	People	0	0	cfm/ft²	23.3	77.8
Misc	1,024	0	1,024	0	1,024	0	0	0	Misc	0	0	cfm/ton	0.94	0.28
Sub Total ==>	70,285	0	70,285	34	51,425	42	0	0	Sub Total ==>	0	0	ft³/ton	333.12	
Ceiling Load	676	-676	0	0	676	0	0	0	Ceiling Load	-3,567	0	Btu/hr-ft²	33.96	-65.68
Ventilation Load	0	0	27,612	13	0	0	0	0	Ventilation Load	0	0	No. People	122	
Adj Air Trans Heat	0	0	0	0	0	0	0	0	Adj Air Trans Heat	-92,863	23.24			
Dehumid. Ov Sizing	0	0	0	0	0	0	0	0	Dehumid. Ov Sizing	0	0			
Ov/Undr Sizing	0	0	0	0	0	0	0	0	Ov/Undr Sizing	0	0			
Exhaust Heat	0	-2,019	-2,019	0	0	0	0	0	Exhaust Heat	10,953	-2.74			
Sup. Fan Heat	0	0	0	0	0	0	0	0	OA Preheat Diff.	0	0			
Ret. Fan Heat	0	0	0	0	0	0	0	0	RA Preheat Diff.	-5,340	1.34			
Duct Heat PkUp	0	0	0	0	0	0	0	0	Additional Reheat	0	0			
Underfrl Sup Ht PkUp	0	0	0	0	0	0	0	0	Underfrl Sup Ht PkUp	0	0			
Supply Air Leakage	0	0	0	0	0	0	0	0	Supply Air Leakage	0	0			
Grand Total ==>	177,330	1,645	206,597	100.00	122,418	100.00	0	0	Grand Total ==>	-300,629	-399,607			

System Checksums  
By ACADEMIC

AHU\_3

Single Zone Variable Air Volume

COOLING COIL PEAK				CLG SPACE PEAK				HEATING COIL PEAK				TEMPERATURES			
Peaked at Time: Mo/Hr: 7 / 15 Outside Air: OADB/WB/HR: 86 / 71 / 95				Mo/Hr: 7 / 15 OADB: 86				Mo/Hr: Heating Design OADB: 5				Cooling	Heating		
Space Sens. + Lat	Plenum Sens. + Lat	Net Total	Percent Of Total	Space Sensible	Percent Of Total	Space Peak Space Sens	Coil Peak Tot Sens	Percent Of Total	SADB	Ra Plenum	Return	Ret/OA	Fn MtrTD	Fn BldTD	Fn Frier
Btu/h	Btu/h	Btu/h	(%)	Btu/h	(%)	Btu/h	Btu/h	(%)	49.1	237.4	75.2	68.9	77.3	31.0	0.0
Envelope Loads															
SkyLite Solar	0	0	0	0	0	0	0	0							
SkyLite Cond	0	0	0	0	0	0	0	0							
Roof Cond	0	5,270	1	0	0	0	0	-17,547							
Glass Solar	9,903	0	9,903	2	9,903	3	0	0							
Glass/Door Cond	626	0	626	0	626	0	0	-6,277							
Wall Cond	893	459	1,352	0	893	0	0	-4,834							
Partition/Door	0	0	0	0	0	0	0	0							
Floor	0	0	0	0	0	0	0	0							
Adjacent Floor	0	0	0	0	0	0	0	0							
Infiltration	204,446	0	204,446	43	122,491	42	0	-723,812							
Sub Total ==>	215,868	5,729	221,597	46	133,913	46	0	-734,924							
Internal Loads															
Lights	32,775	0	32,775	7	32,775	11	0	0							
People	175,197	0	175,197	37	122,469	42	0	0							
Misc	1,456	0	1,456	0	1,456	0	0	0							
Sub Total ==>	209,429	0	209,429	44	156,701	54	0	0							
Ceiling Load	604	-604	0	0	604	0	0	-2,912							
Ventilation Load	0	0	50,419	11	0	0	0	-168,190							
Adj Air Trans Heat	0	0	0	0	0	0	0	0							
Dehumid. Ov Sizing	0	0	0	0	0	0	0	7,824							
Ov/Undr Sizing	0	0	0	0	0	0	0	15,156							
Exhaust Heat	0	-3,187	-3,187	-1	0	0	0	0							
Sup. Fan Heat	0	0	0	0	0	0	0	0							
Ret. Fan Heat	0	0	0	0	0	0	0	0							
Dust Heat PkUp	0	0	0	0	0	0	0	0							
Underfr. Sup Ht PkUp	0	0	0	0	0	0	0	0							
Supply Air Leakage	0	0	0	0	0	0	0	0							
Grand Total ==>	425,901	1,937	478,258	100.00	291,219	100.00	0	-730,012							

COOLING COIL SELECTION				AREAS				HEATING COIL SELECTION			
Total Capacity	Sens. Cap.	Coil Airflow	Enter DB/WB/HR	Gross Total	Glass	Area	Capacity	Coil Airflow	Ent	Lvg	
ton	MBh	cfm	F F g/rlb		ft² (%)		MBh	cfm	F	F	
Main Clg	39.9	478.3	323.7 13,615 77.3 66.7 65.8 49.1 49.0 53.9	Floor	8,322	0	-900.2	4,085	31.0	237.4	
Aux Clg	0.0	0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Part	0	0	0.0	0.0	0.0	0.0	
Opt Vent	0.0	0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Int Door	0	0	0.0	0.0	0.0	0.0	
Total	39.9	478.3		ExFlr	0	0	0.0	0.0	0.0	0.0	
				Roof	8,322	0	0.0	0.0	0.0	0.0	
				Wall	1,960	326	17	0.0	0.0	0.0	
				Ext Door	0	0	0	0.0	0.0	0.0	

System Checksums  
By ACADEMIC

AHU\_4

Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK				CLG SPACE PEAK				HEATING COIL PEAK				TEMPERATURES			
Peaked at Time: Mo/Hr: 7 / 15 Outside Air: OADB/WB/HR: 86 / 71 / 95				Mo/Hr: 7 / 15 OADB: 86				Mo/Hr: Heating Design OADB: 5				Cooling	Heating		
Space Sens. + Lat	Plenum Sens. + Lat	Net Total	Percent Of Total	Space Sensible	Percent Of Total	Space Peak Space Sens	Coil Peak Tot Sens	Percent Of Total	SADB	Ra Plenum	Return	Ret/OA	Fn MtrTD	Fn BldTD	Fn Frier
Btu/h	Btu/h	Btu/h	(%)	Btu/h	(%)	Btu/h	Btu/h	(%)	55.0	315.8	75.3	68.4	76.6	24.9	0.0
Envelope Loads															
SkyLite Solar	0	0	0	0	0	0	0	0							
SkyLite Cond	0	0	0	0	0	0	0	0							
Roof Cond	0	3,993	3,993	0	0	0	0	-13,258							
Glass Solar	0	0	0	0	0	0	0	0							
Glass/Door Cond	0	0	0	0	0	0	0	0							
Wall Cond	806	312	1,117	11	806	11	0	-5,402							
Partition/Door	0	0	0	0	0	0	0	-7,509							
Floor	0	0	0	0	0	0	0	0							
Adjacent Floor	0	0	0	0	0	0	0	0							
Infiltration	96,421	0	96,421	53	65,707	61	0	-388,270							
Sub Total ==>	97,226	4,305	101,531	56	66,513	62	0	-409,037							
Internal Loads															
Lights	22,099	0	22,099	12	22,099	21	0	0							
People	31,654	0	31,654	16	17,360	16	0	0							
Misc	1,024	0	1,024	1	1,024	1	0	0							
Sub Total ==>	54,777	0	54,777	30	40,483	38	0	0							
Ceiling Load	647	-647	0	0	647	1	0	-3,215							
Ventilation Load	0	0	26,904	15	0	0	0	-72,035							
Adj Air Trans Heat	0	0	0	0	0	0	0	14,28							
Dehumid. Ov Sizing	0	0	0	0	0	0	0	0							
Ov/Undr Sizing	0	0	0	0	0	0	0	0							
Exhaust Heat	0	-2,461	-2,461	-1	0	0	0	11,339							
Sup. Fan Heat	0	0	0	0	0	0	0	-27,926							
Ret. Fan Heat	0	0	0	0	0	0	0	-6,786							
Dust Heat PkUp	0	0	0	0	0	0	0	0							
Underfr. Sup Ht PkUp	0	0	0	0	0	0	0	0							
Supply Air Leakage	0	0	0	0	0	0	0	0							
Grand Total ==>	152,650	1,197	180,751	100.00	107,643	100.00	0	-396,887							

COOLING COIL SELECTION				AREAS				HEATING COIL SELECTION			
Total Capacity	Sens. Cap.	Coil Airflow	Enter DB/WB/HR	Gross Total	Glass	Area	Capacity	Coil Airflow	Ent	Lvg	
ton	MBh	cfm	F F g/rlb		ft² (%)		MBh	cfm	F	F	
Main Clg	15.1	180.8	127.2 5,043 78.6 67.8 69.6 55.0 55.0 67.4	Floor	6,337	0	-421.1	1,513	55.0	315.8	
Aux Clg	0.0	0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Part	0	0	0.0	0.0	0.0	0.0	
Opt Vent	0.0	0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Int Door	0	0	0.0	0.0	0.0	0.0	
Total	15.1	180.8		ExFlr	0	0	-83.3	1,562	5.0	55.0	
				Roof	6,337	0	-24.2	1,513	55.0	70.0	
				Wall	1,680	0	0.0	0.0	0.0	0.0	
				Ext Door	0	0	0.0	0.0	0.0	0.0	

**System Checksums**  
By ACADEMIC

DOAS\_1

COOLING COIL PEAK				CLG SPACE PEAK				HEATING COIL PEAK				TEMPERATURES		
Peaked at Time: Outside Air: Mo/Hr: 7 / 15 OADB/BW/HR: 86 / 71 / 95				Mo/Hr: Sum of OADB: Peaks				Mo/Hr: Heating Design OADB: 5				Cooling	Heating	
Space Sens. + Lat. Btu/h	Plenum Sens. + Lat. Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)	Space Peak Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)	Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)	SADB	Return	Ret/OA
Envelope Loads												57.1	120.4	
SkyLite Solar	0	0	0	0	0	0	0	0.00	0	0	0.00	Ra Plenum	75.3	69.1
SkyLite Cond	0	0	0	0	0	0	0	0.00	0	0	0.00	Return	75.3	69.1
Roof Cond	0	0	0	0	0	0	-86,533	2.54	0	0	0.00	Fn MtrTD	0.1	0.0
Glass Solar	86,095	0	86,095	6	86,095	9	0	0.00	0	0	0.00	Fn BldTD	0.1	0.0
Glass/Door Cond	5,650	0	5,650	0	5,650	0	-56,630	1.66	0	0	0.00	Fn FricT	0.3	0.0
Wall Cond	2,964	1,838	4,802	0	2,964	0	-22,439	-35,844	1.05	0	0.00			
Partition/Door	0	0	0	0	0	0	0	0.00	0	0	0.00			
Floor	0	0	0	0	0	0	0	0.00	0	0	0.00			
Adjacent Floor	0	0	0	0	0	0	0	0.00	0	0	0.00			
Infiltration	607,495	0	607,495	39	439,290	46	-2,595,808	76.28	0	0	0.00			
Sub Total ==>	702,204	27,716	729,920	47	533,999	56	-2,674,877	81.54						
Internal Loads														
Lights	138,242	0	138,242	9	138,242	14	0	0.00	0	0	0.00			
People	495,246	0	495,246	32	281,945	27	0	0.00	0	0	0.00			
Misc	17,808	0	17,808	1	17,808	2	0	0.00	0	0	0.00			
Sub Total ==>	651,296	0	651,296	42	417,996	44	0	0.00	0	0	0.00			
Ceiling Load	3,384	-3,384	0	0	3,384	0	-12,202	0.00	0	0	0.00			
Ventilation Load	0	0	151,526	10	0	0	-682,540	20.06	0	0	0.00			
Adj Air Trans Heat	0	0	0	0	0	0	0	0.00	0	0	0.00			
Dehumid. Ov Sizing	0	0	0	0	0	0	0	0.00	0	0	0.00			
Ov/Undr Sizing	0	0	0	0	0	0	0	0.00	0	0	0.00			
Exhaust Heat	0	-15,066	-15,066	-1	0	0	54,326	-1.60	0	0	0.00			
Sup. Fan Heat	0	1	25,164	2	0	0	0	0.00	0	0	0.00			
Rel. Fan Heat	0	0	0	0	0	0	0	0.00	0	0	0.00			
Duct Heat PkUp	0	0	0	0	0	0	0	0.00	0	0	0.00			
Underfrl Sup Ht PkUp	0	0	0	0	0	0	0	0.00	0	0	0.00			
Supply Air Leakage	0	0	0	0	0	0	0	0.00	0	0	0.00			
Grand Total ==>	1,356,884	9,267	1,542,841	100.00	954,778	100.00	-2,687,079	-3,403,028	100.00					

COOLING COIL SELECTION								AREAS			HEATING COIL SELECTION									
Total Capacity ton	Sens Cap. MBh	Coil Airflow cfm	Enter DB/WB/HR °F	Leave DB/WB/HR °F	Gross Total	Glass ft²	(%)	Floor	Part	Int Door	ExFlr	Roof	Wall	Ext Door	Main Htg	Aux Htg	Preheat	Humidif	Opt Vent	Total
128.6	1,542.8	1,062.1	49,956	76.7	40,934	0		40,934	0	0	0	40,934	0	0	-3,403.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0	0		0	0	0	0	0	2,942	27	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0	0		0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	128.6	1,542.8			10,948	2,942		0	0	0	0	0	0	0	-3,403.0	0.0	0.0	0.0	0.0	0.0

**System Checksums**  
By ACADEMIC

DOAS\_2

COOLING COIL PEAK				CLG SPACE PEAK				HEATING COIL PEAK				TEMPERATURES		
Peaked at Time: Outside Air: Mo/Hr: 7 / 15 OADB/BW/HR: 86 / 71 / 95				Mo/Hr: Sum of OADB: Peaks				Mo/Hr: Heating Design OADB: 5				Cooling	Heating	
Space Sens. + Lat. Btu/h	Plenum Sens. + Lat. Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)	Space Peak Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)	Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)	SADB	Return	Ret/OA
Envelope Loads												57.5	119.5	
SkyLite Solar	0	0	0	0	0	0	0	0.00	0	0	0.00	Ra Plenum	75.3	69.1
SkyLite Cond	0	0	0	0	0	0	0	0.00	0	0	0.00	Return	75.3	69.1
Roof Cond	0	0	30,262	1	0	0	-101,171	2.39	0	0	0.00	Fn MtrTD	0.1	0.0
Glass Solar	122,936	0	122,936	6	122,936	10	0	0.00	0	0	0.00	Fn BldTD	0.1	0.0
Glass/Door Cond	8,959	0	8,959	0	8,959	1	-89,807	2.12	0	0	0.00	Fn FricT	0.3	0.0
Wall Cond	4,752	2,974	7,726	0	4,752	0	-54,133	1.28	0	0	0.00			
Partition/Door	0	0	0	0	0	0	0	0.00	0	0	0.00			
Floor	0	0	0	0	0	0	0	0.00	0	0	0.00			
Adjacent Floor	0	0	0	0	0	0	0	0.00	0	0	0.00			
Infiltration	753,386	0	753,386	37	534,358	43	-3,157,573	74.59	0	0	0.00			
Sub Total ==>	890,033	33,236	923,270	46	671,006	54	-3,280,742	80.38						
Internal Loads														
Lights	171,781	0	171,781	8	171,781	14	0	0.00	0	0	0.00			
People	688,210	0	688,210	34	362,361	29	0	0.00	0	0	0.00			
Misc	25,180	0	25,180	1	25,180	2	0	0.00	0	0	0.00			
Sub Total ==>	885,171	0	885,171	44	559,322	45	0	0.00	0	0	0.00			
Ceiling Load	3,868	-3,868	0	0	3,868	0	-14,192	0.00	0	0	0.00			
Ventilation Load	0	0	206,804	10	0	0	-898,148	21.22	0	0	0.00			
Adj Air Trans Heat	0	0	0	0	0	0	0	0.00	0	0	0.00			
Dehumid. Ov Sizing	0	0	0	0	0	0	0	0.00	0	0	0.00			
Ov/Undr Sizing	0	0	0	0	0	0	0	0.00	0	0	0.00			
Exhaust Heat	0	-18,476	-18,476	-1	0	0	67,792	-1.60	0	0	0.00			
Sup. Fan Heat	0	1	31,403	1	0	0	0	0.00	0	0	0.00			
Rel. Fan Heat	0	0	0	0	0	0	0	0.00	0	0	0.00			
Duct Heat PkUp	0	0	0	0	0	0	0	0.00	0	0	0.00			
Underfrl Sup Ht PkUp	0	0	0	0	0	0	0	0.00	0	0	0.00			
Supply Air Leakage	0	0	0	0	0	0	0	0.00	0	0	0.00			
Grand Total ==>	1,779,072	10,893	2,028,172	100.00	1,234,195	100.00	-3,294,934	-4,233,040	100.00					

COOLING COIL SELECTION								AREAS			HEATING COIL SELECTION									
Total Capacity ton	Sens Cap. MBh	Coil Airflow cfm	Enter DB/WB/HR °F	Leave DB/WB/HR °F	Gross Total	Glass ft²	(%)	Floor	Part	Int Door	ExFlr	Roof	Wall	Ext Door	Main Htg	Aux Htg	Preheat	Humidif	Opt Vent	Total
169.0	2,028.2	1,374.1	62,343	76.8	47,855	0		47,855	0	0	0	47,855	0	0	-4,233.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0	0		0	0	0	0	16,758	4,865	26	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0	0		0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	169.0	2,028.2			16,758	4,865		0	0	0	0	0	0	0	-4,233.0	0.0	0.0	0.0	0.0	0.0