New York City College of Technology

DEPARTMENT OF MECHANICAL ENGINEERING TECHNOLOGY

MECH-2430 THERMODYNAMICS

Summer 2023

LAB #2: Analysis of Heat Transfer

Anil Persaud

Alastair Rozario

Jephthey Pierre-Louis

Sammuel Sexton

6/26/2023

PROFESSOR AKM RAHMAN

Objective

The objective of this lab is to familiarize students with commercially available HVAC software and equip them with the skills to accurately determine the required loads for different HVAC systems in a building. By the end of the lab, we will be able to Understand the capabilities and features of commercially available HVAC software. Analyze relevant data about a building, including its location, floor plans, insulation details, occupancy rates, and internal heat sources. Perform load calculations using the HVAC software, taking into account factors such as climate, building size and orientation, insulation, occupancy, and internal heat gains. Select suitable HVAC systems based on the calculated loads, considering factors like equipment efficiency, capacity, air distribution, and ventilation requirements. Choose specific HVAC equipment, such as boilers, chillers, air handlers, and ventilation units, by evaluating various options using the software. Analyze and optimize the HVAC system design using simulation tools provided by the software, aiming for optimal performance and energy efficiency. Generate comprehensive reports summarizing the load calculations, system design, equipment selection, and other relevant information. By achieving these objectives, we will help develop practical skills in utilizing HVAC software to accurately determine the required loads for various HVAC systems in a building. They will also gain an understanding of system selection, equipment sizing, and design optimization, which are crucial aspects of HVAC engineering and design.

Procedure

1. **Introduction to the Lab**: Start the lab session by providing an overview of the objectives and the importance of calculating HVAC loads in residential apartment buildings. Explain how the use of commercial software, specifically Chvac, can aid in accurately determining these loads.

2. **Familiarize with Chvac Software**: Introduce students to Chvac software and its features and provide instructions on how to access and install the software.

3. **General Information Collection**: Collect and provide general information about the residential apartment project. This information is typically required at the beginning of load calculation processes and is presented in Figure 6, 7, 8, and 9. The information may include:

   a. ***Location Details****:* Students should gather information about the building's location, such as the city, state, and local weather conditions. This data is essential for accurate load calculations, as climate variations influence heating and cooling requirements.

   b. ***Floor Plans***: Ask students to obtain the floor plans of the residential apartment building. These plans should include the dimensions and layouts of each unit, including

rooms, corridors, and common areas. It will help in assessing the size and configuration of the spaces.

c. ***Insulation Details*****:** Gather information about the insulation materials and R-values used in the building's walls, roof, and windows. This information influences the thermal performance of the building envelope.

d. ***Occupancy Rates***: Determine the estimated occupancy rates for each residential unit. Occupancy rates impact the internal heat gains generated by occupants and their activities.

e. ***Internal Heat Sources*****:** Students need to identify and quantify internal heat sources within each residential unit, such as lighting, appliances, and electronics. This data is crucial for accurate load calculations.

4. ***Inputting General Information into Chvac***: Input the collected general information into Chvac software. Demonstrate the software's interface and fields where the data should be entered. Emphasize the importance of accuracy in data input for reliable load calculations.

5. ***Verification and Load Calculation***: Verify the inputted information in Chvac software, ensuring all data is correctly entered. Guide them through the process of performing load calculations using the software. Explain the parameters and calculations involved in determining the heating and cooling loads for the residential apartment.

6. ***Analysis of Load Calculation Results***: Once the load calculations are complete, students should analyze and interpret the results obtained from Chvac. Discuss the significance of the calculated loads in terms of system selection, equipment sizing, and overall HVAC design.

7. ***Reporting***: Generate comprehensive reports summarizing the load calculations, system design, and equipment selection using Chvac's reporting features. Emphasize the importance of clear and organized reports for effective communication with stakeholders.

8. ***Discussion and Conclusion***: Conclude the lab session with a discussion on the importance of accurate load calculations in HVAC design and the benefits of using commercial software like Chvac. Encourage students to reflect on the skills they have acquired and how they can apply them in real-world HVAC projects.

SUMMARY

In this lab, we were introduced to the use of commercially available HVAC software, specifically Chvac, to accurately determine the required loads for different HVAC systems in a residential apartment building. The objectives of the lab are to understand the capabilities of HVAC software, analyze relevant data about the building, perform load calculations, select suitable HVAC systems and equipment, optimize system design, and generate comprehensive reports summarizing the findings.We learned how to input the collected information into Chvac and verify its accuracy. They are guided through the process of performing load calculations using the software, taking into account various factors such as climate, building size and orientation, insulation, occupancy, and internal heat gains. The results of the load calculations are then analyzed to inform system selection, equipment sizing, and HVAC design.The lab concludes with us generating comprehensive reports summarizing the load calculations, system design, equipment selection, and other relevant information using Chvac's reporting features. The importance of clear and organized reports for effective communication with stakeholders is emphasized. Finally, a discussion on the significance of accurate load calculations in HVAC design and the skills acquired through the lab is held, encouraging us to reflect on their application in real-world HVAC projects.

Chipotle CHVAC Load Calculation
HVAC Load Analysis

for

Moe Lester
331 Rockaway Turnpike, Lawrence, NY 1155
Lawrence, NY 11559

Prepared By:

Rozario A, Persaud A, Pierre Louis J.
Chipotle

Monday, June 26, 2023

Building Envelope Report

Envelope Report Using Summer U-Factors

Material Types		Gross Area	Glass Area	Net Area	-U-Factor	Area x U-Factor	Average U-Factor
Roof	1	896.0	0.0	896.0	0.030	26.880	0.030
Tot.Roof		896.0	0.0	896.0	N/A	26.880	0.030
Wall	1	320.0	21.0	299.0	0.067	20.033	0.067
Wall	2	21.0	0.0	21.0	0.300	6.300	0.300
Tot.Wall		341.0	21.0	320.0	N/A	26.333	0.082
Totals				1,216.0		53.213	0.044

Wall Direction	Wall Area	Glass Area	Wall Net Area	Wall Avg U-Factor	Glass Avg U-Factor	Glass Avg Shd.Coef
N	0.0	0.0	0.0	0.000	0.000	0.000
NE	0.0	0.0	0.0	0.000	0.000	0.000
E	0.0	0.0	0.0	0.000	0.000	0.000
SE	0.0	0.0	0.0	0.000	0.000	0.000
S	0.0	0.0	0.0	0.000	0.000	0.000
SW	0.0	0.0	0.0	0.000	0.000	0.000
W	341.0	0.0	341.0	0.082	0.000	0.000
NW	0.0	0.0	0.0	0.000	0.000	0.000
Totals	341.0	0.0	341.0	0.082	0.000	0.000

Building Summary Loads

Building peaks in August at 5pm.

Bldg Load Descriptions	Area Quan	Sen Loss	%Tot Loss	Lat Gain	Sen Gain	Net Gain	%Net Gain
Roof	896	1,892	4.63	0	1,316	1,316	1.08
Wall	320	1,854	4.53	0	939	939	0.77
Glass	0	0	0.00	0	0	0	0.00
Floor Slab	32	1,622	3.96	0	0	0	0.00
Skin Loads		5,368	13.12	0	2,255	2,255	1.84
Lighting	396	0	0.00	0	1,446	1,446	1.18
Equipment	14,000	0	0.00	0	51,113	51,113	41.78
Pool Latent	0	0	0.00	0	0	0	0.00
People	63	0	0.00	18,191	18,538	36,729	30.02
Partition	120	891	2.18	0	520	520	0.43
Cool. Pret.	0	0	0.00	0	0	0	0.00
Heat. Pret.	0	0	0.00	0	0	0	0.00
Cool. Vent.	473	0	0.00	11,577	7,785	19,362	15.82
Heat. Vent.	473	32,612	79.72	0	0	0	0.00
Cool. Infil.	0	0	0.00	0	0	0	0.00
Heat. Infil.	0	0	0.00	0	0	0	0.00
Draw-Thru Fan	0	0	0.00	0	0	0	0.00
Blow-Thru Fan	0	0	0.00	0	0	0	0.00
Reserve Cap.	0	0	0.00	0	0	0	0.00
Reheat Cap.	0	0	0.00	0	0	0	0.00
Supply Duct	0	2,038	4.98	0	8,231	8,231	6.73
Return Duct	0	0	0.00	0	2,697	2,697	2.20
Misc. Supply	0	0	0.00	0	0	0	0.00
Misc. Return	0	0	0.00	0	0	0	0.00
Building Totals		40,909	100.00	29,768	92,584	122,353	100.00

Building Summary	Sen Loss	%Tot Loss	Lat Gain	Sen Gain	Net Gain	%Net Gain
Ventilation	32,612	79.72	11,577	7,785	19,362	15.82
Infiltration	0	0.00	0	0	0	0.00
Pretreated Air	0	0.00	0	0	0	0.00
Room Loads	6,259	15.30	18,191	73,871	92,063	75.24
Plenum Loads	0	0.00	0	0	0	0.00
Fan/Duct/Misc Loads	2,038	4.98	0	10,928	10,928	8.93
Building Totals	40,909	100.00	29,768	92,584	122,353	100.00

Check Figures

Total Building Supply Air (based on a 20° TD):	3,747	CFM
Total Building Vent. Air (12.61% of Supply):	473	CFM
Total Conditioned Air Space:	896	Sq.ft
Supply Air Per Unit Area:	4.1815	CFM/Sq.ft
Area Per Cooling Capacity:	87.9	Sq.ft/Ton
Cooling Capacity Per Area:	0.0114	Tons/Sq.ft
Heating Capacity Per Area:	45.66	Btuh/Sq.ft
Total Heating Required With Outside Air:	40,909	Btuh
Total Cooling Required With Outside Air:	10.20	Tons

Air Handler #1 - AHU-1 - Summary Loads

Rm No	Description Room Peak Time	Area People Volume	Htg.Loss Htg.CFM CFM/Sqft	Sen.Gain Clg.CFM CFM/Sqft	Lat.Gain S.Exh W.Exh	Htg.O.A. Req.CFM Act.CFM	Clg.O.A. Req.CFM Act.CFM
1	Chipotle Floor	896	6,259	74,075	18,191	7.5/P	7.5/P
	7pm August	63	473	3,747	50	473	473
		7,168	0.53	4.18	50	473	472
1	Plenum	0	0	0	0	None	None
	10pm in August	0	0	0	0	0	0
		0	0	0	0	0	0
	Room Peak Totals:	896	6,259	74,075	18,191		
	Total Rooms: 1	63	473	3,747	50	473	473
	Unique Rooms: 1	7,168	0.53	4.18	50	473	472

Air Handler #1 - AHU-1 - Total Load Summary

Air Handler Description: AHU-1 Constant Volume - Sum of Peaks
Sensible Heat Ratio: 0.82 --- This system occurs 1 time(s) in the building. ---

Air System Peak Time: 5pm in August.
Outdoor Conditions: Clg: 90° DB, 74° WB, 100.49 grains, Htg: 11° DB
Indoor Conditions: Clg: 75° DB, 50% RH, Htg: 75° DB

Summer: Ventilation controls outside air, ----- Winter: Ventilation controls outside air.

Room Space sensible loss:	6,259	Btuh			
Infiltration sensible loss:	0	Btuh	0	CFM	
Outside Air sensible loss:	32,612	Btuh	473	CFM	
Supply Duct sensible loss:	2,038	Btuh			
Return Duct sensible loss:	0	Btuh			
Return Plenum sensible loss:	0	Btuh			
Total System sensible loss:					40,909 Btuh
Heating Supply Air: 8,297 / (.999 X 1.08 X 16) =			473	CFM	
Winter Vent Outside Air (100.0% of supply) =			473	CFM	
Room space sensible gain:	73,871	Btuh			
Infiltration sensible gain:	0	Btuh			
Draw-thru fan sensible gain:	0	Btuh			
Supply duct sensible gain:	8,231	Btuh			
Reserve sensible gain:	0	Btuh			
Total sensible gain on supply side of coil:					82,102 Btuh
Cooling Supply Air: 82,306 / (.999 X 1.1 X 20) =			3,747	CFM	
Summer Vent Outside Air (12.6% of supply) =			473	CFM	
Return duct sensible gain:	2,697	Btuh			
Return plenum sensible gain:	0	Btuh			
Outside air sensible gain:	7,785	Btuh	473	CFM	
Blow-thru fan sensible gain:	0	Btuh			
Total sensible gain on return side of coil:					10,482 Btuh
Total sensible gain on air handling system:					92,584 Btuh
Room space latent gain:	18,191	Btuh			
Infiltration latent gain:	0	Btuh			
Outside air latent gain:	11,577	Btuh			
Total latent gain on air handling system:					29,768 Btuh
Total system sensible and latent gain:					122,353 Btuh

Check Figures

Total Air Handler Supply Air (based on a 20° TD):	3,747	CFM
Total Air Handler Vent. Air (12.61% of Supply):	473	CFM
Total Conditioned Air Space:	896	Sq.ft
Supply Air Per Unit Area:	4.1815	CFM/Sq.ft
Area Per Cooling Capacity:	87.9	Sq.ft/Ton
Cooling Capacity Per Area:	0.0114	Tons/Sq.ft
Heating Capacity Per Area:	45.66	Btuh/Sq.ft
Total Heating Required With Outside Air:	40,909	Btuh
Total Cooling Required With Outside Air:	10.20	Tons

Room Detailed Loads (At Room Peak Times)

Load Description	Unit Quan	-SC- CFAC	CLTD SHGF	U.Fac -CLF-	Sen. Gain	Lat. Gain	Htg. Mult.	Htg. Loss
Room 1-Chipotle Floor peaks (sensible) in August at 7pm, Air Handler 1 (AHU-1), Zone 0, 32.0 x 28.0, Construction Type: 10 (Medium)								
Roof-1-6-Susp.C-D	896	1.00	51.8	0.030	1,391		1.920	1,720
Wall-1-W-C-D	299	1	29.9	0.067	598		4.288	1,282
Door-3-W-G-D	21	1	48.9	0.300	308		19.200	403
Partition-2-1	120		15/25	0.270	486		6.750	810
Lights-Prof=2	396	1.000			1,351			
Equipment-Prof=3	14,000	1.000			47,769	0		
People-Prof=1	63.0	1.000			17,325	17,325		
Floor slab	32						46.080	1,475
Sub-total					69,229	17,325		5,690
Safety factors:					+7%	+5%		+10%
					---	---		---
Total w/ safety factors:					74,075	18,191		6,259

Notes about Room 1:
Eating Chipotle quesadilla cahnged my life forever ong.
End of notes about Room 1

Equipment Cooling Loads

Item Name	Nominal Output Sensible	Quantity Type Sensible	Nominal Output Latent	Quantity Type Latent	Sensible Load (Btuh)	Latent Load (Btuh)
Broiler: underfired 3 ft	11,688	watts	0	Btuh	30,708	0
Griddle: flat 3 ft	16,087	watts	0	Btuh	12,625	0
Oven: convection full-size	3,704	watts	0	Btuh	3,412	0
Rice cooker	30,000	watts	0	Btuh	1,024	0
Total					47,769	0

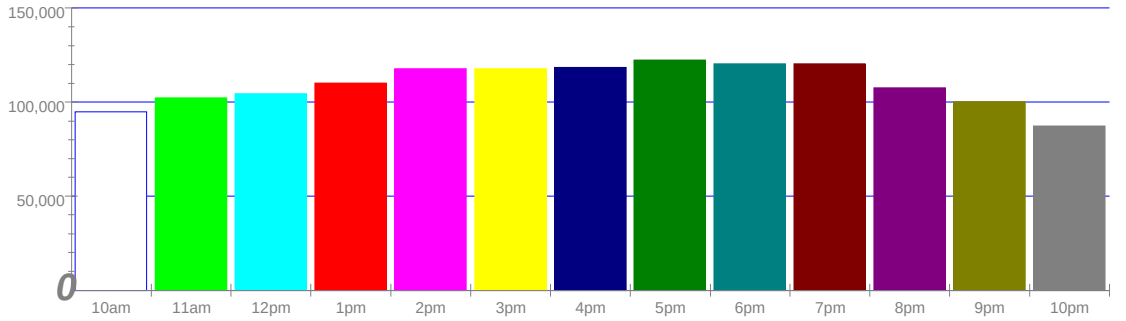
Lighting Cooling Loads

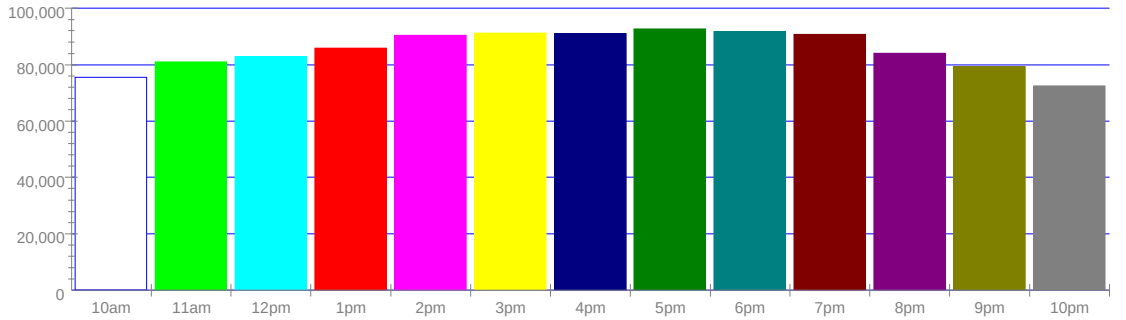
Item Name	Quantity	Quantity Type	Special Allowance Factor	Space Fraction	Occur-rences	Usage Factor	Load (Btuh)
LED, Daybright LED, 4', n/a ballast	33	watts	1	1	12	1	1,351
Total							1,351

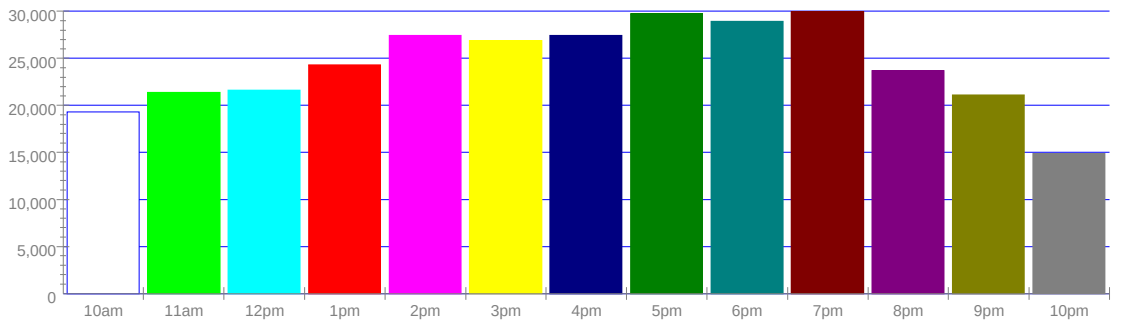
Room Detailed Loads (At Room Peak Times) (cont'd)

Load Description	Unit Quan	-SC- CFAC	CLTD SHGF	U.Fac -CLF-	Sen. Gain	Lat. Gain	Htg. Mult.	Htg. Loss
Plenum 1- peaks in August at 10pm., Construction Type: 10 (Medium)								
Sub-total					0	0		0
Safety factors:					+5%	+5%		+10%
Total w/ safety factors:					0	0		0

Building Profile Graphs







Air System #1 (AHU-1) Psychrometric Analysis

System Load Analysis	Latent	Grains	Sensible	Temp	CFM
Leaving Coil Condition		57.585		55.000	
Draw-Thru Fan			0	0.000	0
Misc Load on Supply Side	0	0.000	0	0.000	0
Supply Air Duct			8,231	2.000	375
Room Loads	18,191	7.151	74,075	18.000	3,372
Sensible Reserve			0	0.000	0
Room Condition	18,191	64.735	82,306	75.000	3,747
Return Air Duct			2,697	0.750	
Return Air Plenum			0	0.000	
Misc Load on Return Side	0	0.000	0	0.000	
Vent Air 473 CFM	11,577	4.551	7,785	1.797	
Blow-Thru Fan			0	0.000	
Entering Coil Condition	29,768	69.286	92,788	77.547	3,747

Air-Side Check Figure Psychrometric Equations:

PR = (Barometric pressure of site / Standard ASHRAE pressure of 29.921)
TSH = PR x 1.10 x CFM x (DB entering - DB leaving)
TLH = PR x 0.68 x CFM x (Grains entering - Grains leaving)
GTH = PR x 4.50 x CFM x (Enthalpy entering - Enthalpy leaving)

TSH	=	0.999	x	1.10	x	3,747	x (	77.5	-	55.0	) =	92,789 Btuh
TLH	=	0.999	x	0.68	x	3,747	x (	69.3	-	57.6	) =	29,768 Btuh
SUM	=											122,557 Btuh
GTH	=	0.999	x	4.50	x	3,747	x (	29.5	-	22.1	) =	123,322 Btuh
Total System Load											=	122,353 Btuh

Chilled and Hot Water Flow Rates and Steam Requirement

Cooling GPM	=	123,322 / (	0.00	x	500	)	=	0.0 GPM
Heating GPM	=	40,909 / (	0.00	x	500	)	=	0.0 GPM
Steam Req.	=	40,909 /	970				=	42.2 lb./hr

Entering Cooling Coil Conditions

Dry bulb temperature:	77.55	
Wet bulb temperature:	64.37	
Relative humidity:	49.12	
Enthalpy:	29.46	Btu/lbm

Entering Heating Coil Conditions

Dry bulb temperature:	11.00

Leaving Cooling Coil Conditions

Dry bulb temperature:	55.00	
Wet bulb temperature:	53.24	
Relative humidity:	89.47	
Enthalpy:	22.13	Btu/lbm

Leaving Heating Coil Conditions

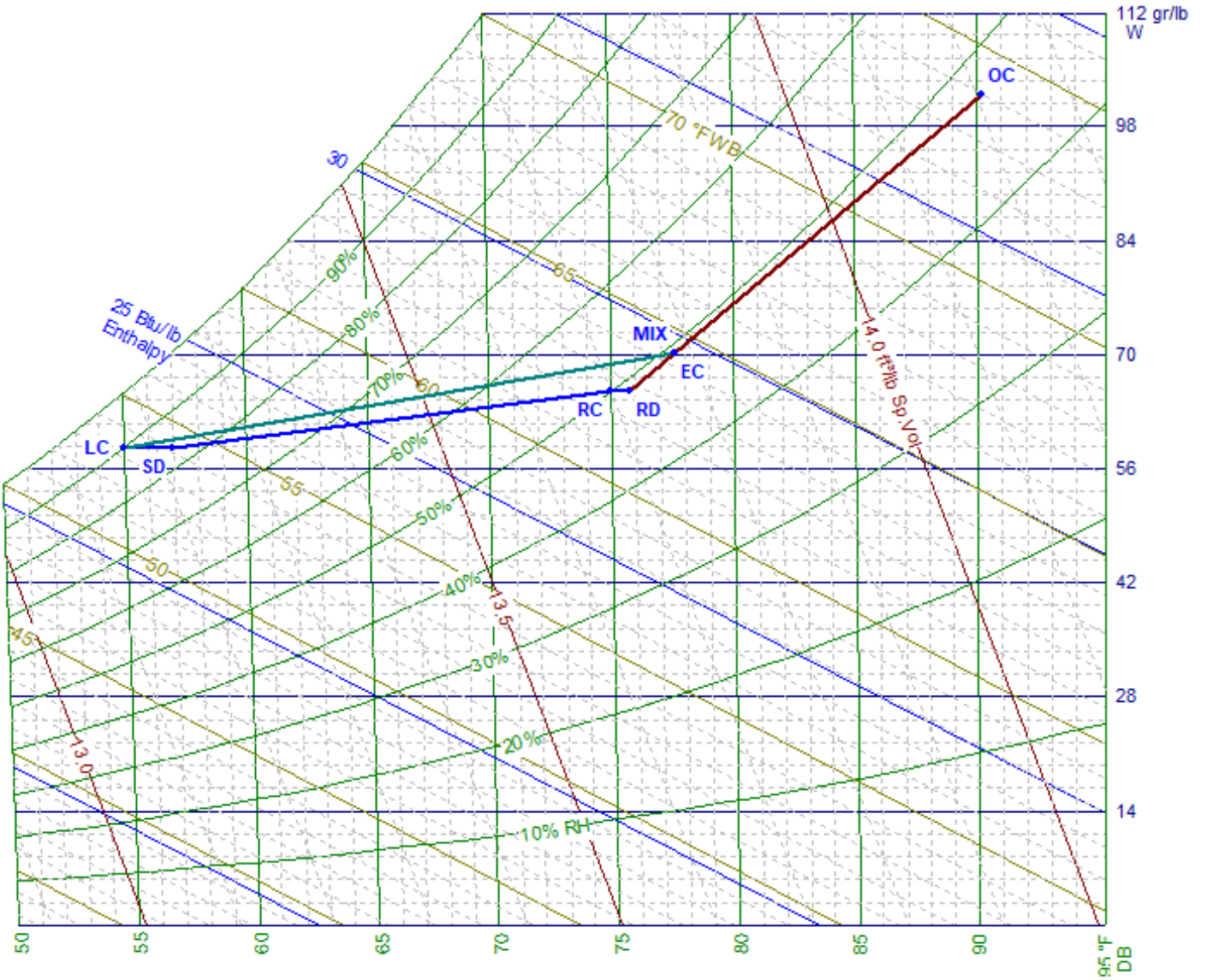
Dry bulb temperature:	91.28

Calculated Room to Plenum Temperature Differences

Room-Plenum TD Cooling:	0	Room-Plenum TD Heating:	0

Air System #1 (AHU-1) Psychrometric Chart

RC	Room Condition	OC	Outdoor Condition
LC	Leaving Coil Condition	EC	Entering Coil Condition
SD	Supply Duct Temperature Rise	RD	Return Duct Temperature Rise
DTF	Draw Through Fan Sensible Gain	BTF	Blow Through Fan Sensible Gain
RE	Reserve or Reheat Sensible Gain	PL	Return Air Plenum Sensible Gain
SM	Supply Side Miscellaneous Sensible Gain	MR	Return Side Miscellaneous Gain
PRE	Pretreated Air Condition	HRV	Heat Recovery Ventilator Condition
MIX	Mixed Air Condition	RML	Return Miscellaneous Latent Gain



Load Preview

Scope	Peak Time	Area	Volume	Sensible Gain	Latent Gain	Net Gain	Net Tons	Sensible Loss	Cooling Supply Airflow	Heating Supply Airflow	Duct Size
Building	August 5pm	896	7,168	92,584	29,768	122,353	10.20	40,909	3,747	473	
System 1	August 5pm	896	7,168	92,584	29,768	122,353	10.20	40,909	3,747	473	0 in. dia
Zone 0	August 7pm	896	7,168	74,075	18,191	92,266		6,259	3,747	473	0 in. dia
1-Chipotle Floor	August 7pm	896	7,168	74,075	18,191	92,266		6,259	3,747	473	1--0 in. dia
Plenum	August 10pm	0	0	0	0	0		0	0	0	

Building Pie Charts

Building peaks in August at 5pm.