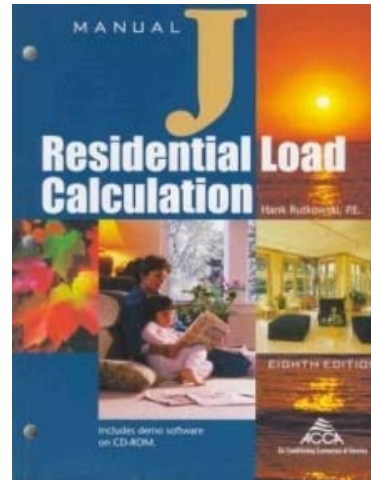




Isaac Savage



CALCS-PLUS

Dennis Stroer

Verifying HVAC Load Calculations

RESNET Conference 2013

What We'll Cover...

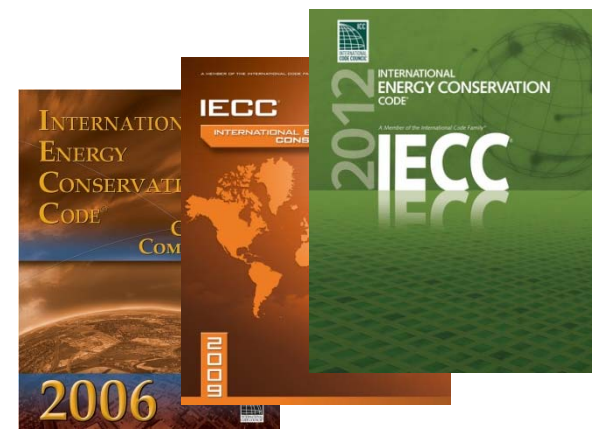
- Who requires loads and load reviews?
- What are the challenges in reviewing loads?
- What variables affect the load?
- How do you verify these variables were accounted for correctly?
- Suggestions on which reports to ask for, so you can do your job easily.
- How to interpret the reports from design software.



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Who Requires Load Calculations?

- Required by Programs
 - ENERGY STAR Version 3
 - LEED for Homes
 - Utility Rebates
- Required by Building Code!
 - 2006, 2009, 2012 IECC
- Many programs require 3rd party review (that's you).



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Common Challenges

- Tracking down the information in reports.



- Some variables don't show up on the reports.
- Sometimes things just look funny on the reports. "What does that mean?"



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What Are The Variables That Matter?

- Design conditions
- Envelope details
- Ductwork specifications
- Internal Loads
- Infiltration
- Ventilation



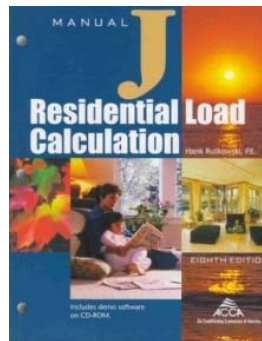
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Design Conditions (Outdoor)

Table 1A
Outdoor Design Conditions for the United States

Location	Elevation Feet	Latitude Degrees North	Winter	Summer					
			Heating 99% Dry Bulb	Cooling 1% Dry Bulb	Coincident Wet Bulb	Design Grains 55% RH	Design Grains 50% RH	Design Grains 45% RH	Daily Range (DR)
Texas									
Abilene AP	1790	32	22	97	71	2	9	15	M
Alice AP	178	27	34	98	77	37	44	50	M
Amarillo AP	3604	35	12	94	66	-17	-10	-4	H
Austin AP	597	30	30	96	74	22	29	35	M
Bay City	45	29	33	94	77	59	66	72	M
Beaumont	16	30	32	92	79	61	68	74	M

Outdoor design conditions come from Table 1-A



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Indoor Design Conditions

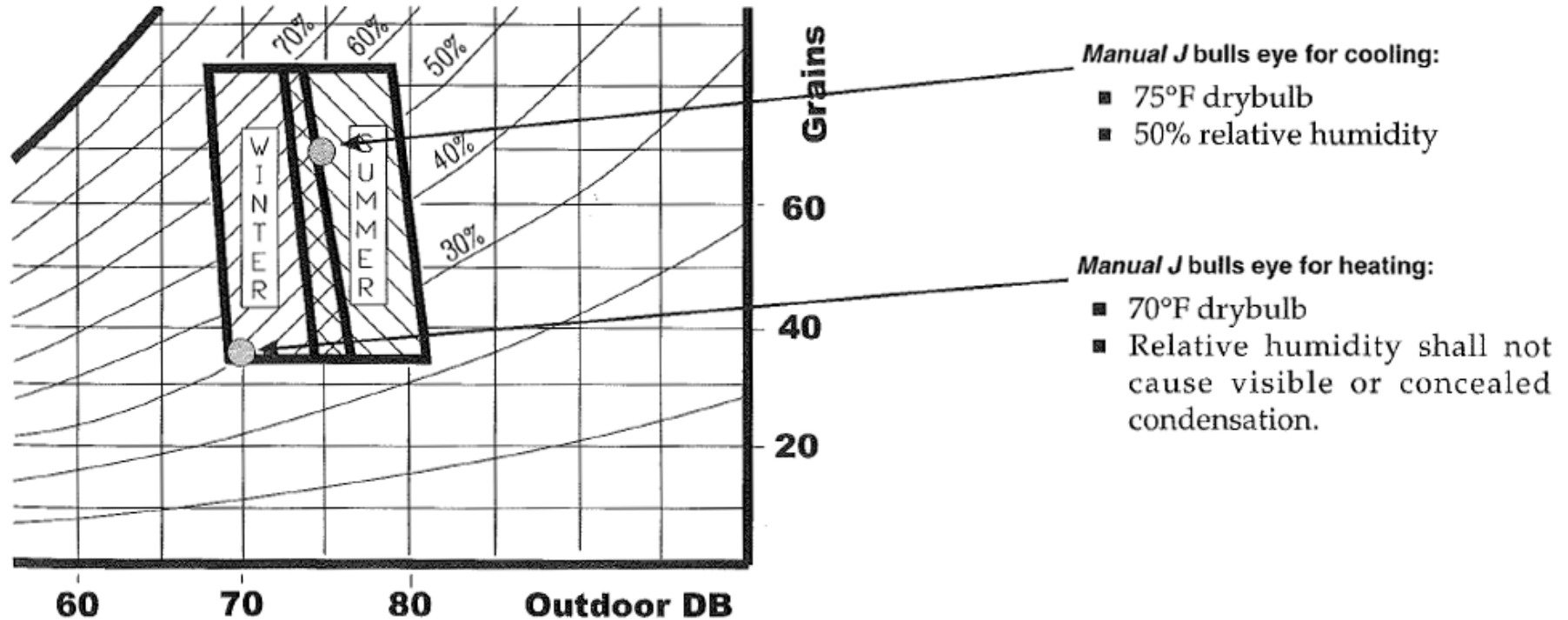


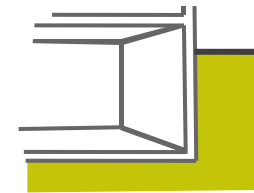
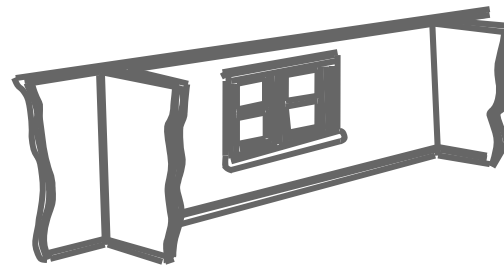
Figure 3-2



Envelope Details

- Walls/Doors

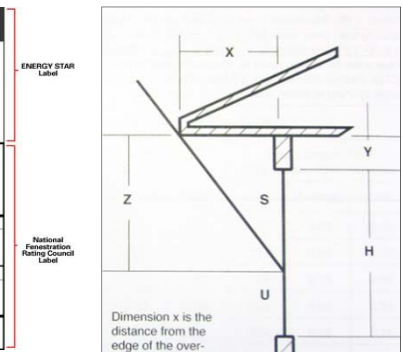
- Sqft, U-value, # of Types



- Windows

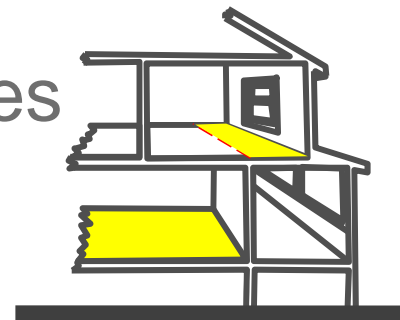
- Sqft, Orientation, Overhangs, U-value & SHGC

ENERGY STAR® Qualified In All 50 States	
	World's Best Window Co. Millennium 2000® High-Qual Insulated Frame Double Glazing / Argon Fill / Low-E Product Type: Window Sashes (See NFRC 100-87)
ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./IP)	Solar Heat Gain Coefficient
0.35	0.32
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	Air Leakage (U.S./IP)
0.51	0.2
<small>Manufacturer declares that these ratings conform to applicable NFRC procedures for determining window product performance. NFRC ratings are determined by a third party accreditation organization and a specific product size. Consult manufacturer's literature for other product performance information.</small>	



- Floors/Ceilings

- Sqft, U-value, # of Types



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Ductwork Specifications

- Inputs
 - Location (temperature of that space)
 - Sqft surface area
 - Leakage
 - Insulation levels
 - Supply discharge temp (heating)
- Unfortunately, these inputs **don't show up in the reports**. Reports only show the resulting duct loads.



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Evaluating Duct Loads

Summary of Default Duct Load Tables

Location	Supply System Geometry ¹	Return System Geometry ¹	Table Number
Unvented attic or attic knee wall space above 16A ceiling (150 °F attic when OAT = 95 °F).	Radial with outlets in center of rooms.	Radial, 400 CFM per return, returns close to air handler.	7A-R
	Trunk and branch with outlets in center of rooms.	Trunk and branch, 400 CFM per return, returns close to air handler.	7A-T
Vented attic or attic knee wall space above 16B ceiling (130 °F attic when OAT = 95 °F).	Radial with outlets in center of rooms.	Radial, 400 CFM per return, returns close to air handler.	7B-R
	Trunk and branch with outlets in center of rooms.	Trunk and branch, 400 CFM per return, returns close to air handler.	7B-T
	Radial with outlets in center of rooms.	Single ceiling return close to air handler.	7A-AE
	Radial with outlets in center of rooms.	Closet air handler, return in closet door.	7B-AE
	Trunk and branch with outlets in center of rooms.	Grille at floor of conditioned space, return riser to attic air handler.	7C-AE
Vented attic or attic knee wall space above 16C ceiling (120 °F attic when OAT = 95 °F).	Radial with outlets in center of rooms.	Radial, 400 CFM per return, returns close to air handler.	7C-R
	Trunk and branch with outlets in center of rooms.	Trunk and branch, 400 CFM per return, returns close to air handler.	7C-T
Vented attic or attic knee wall space above 16D ceiling (110 °F attic when OAT = 95 °F).	Radial with outlets in center of rooms.	Radial, 400 CFM per return, returns close to air handler.	7D-R
	Trunk and branch with outlets in center of rooms.	Trunk and branch, 400 CFM per return, returns close to air handler.	7D-T
Vented attic or attic knee wall space above 16E ceiling (105 °F attic when OAT = 95 °F).	Radial with outlets in center of rooms.	Radial, 400 CFM per return, returns close to air handler.	7E-R
	Trunk and branch with outlets in center of rooms.	Trunk and branch, 400 CFM per return, returns close to air handler.	7E-T



Evaluating Duct Loads

- Combines these variables to generate a multiplier that is applied to the surface area.
- Ambient Temp
- R-value
- Leakage Rate
- Actual Surface Area
- This Multiplier x Envelope Load = Duct Load

Table 7C-AE -- Trunk and Branch Supply System in 16'

7C-AE	Ambient drybulb temperature = Outdoor db + 11 (heating) and Outdoor db + 35 (cooling)	Supply location =
	Duct leakage Cfm per SqFt of duct surface area (supply / return) = 0.06/0.06; 0.09/0.15; 0.12/0.24; 0.24/0.47; 0.35/0.70	

Base Case Heat Loss Factor (BHLF) R6 Insulation, ASHRAE Sealed (Supply = 0.12, Return = 0.24)					
Square Feet of Floor Area					
OAT	1000	1500	2000	2500	3000
-10	0.138	0.157	0.176	0.195	0.217
0	0.131	0.145	0.164	0.184	0.199
10	0.118	0.133	0.148	0.166	0.188
20	0.111	0.122	0.138	0.150	0.170
30	0.098	0.119	0.129	0.141	0.153
40	0.085	0.103	0.120	0.135	0.148

Base Case Sensible Gain R6 Insulation, ASHRAE Sealed (Supply = 0.12, Return = 0.24)			
Square Feet of Floor Area			
OAT	1000	1500	2000
85	0.137	0.170	0.199
90	0.146	0.161	0.188
95	0.157	0.175	0.199
100	0.158	0.180	0.200
105	0.160	0.185	0.205

R-Value Correction (WIF - Heat Loss)	R2	R4	R6	R8
	2.02	1.28	1.00	0.84

R-Value Correction (WIF - Sensible Gain)	R2
	2.19

Leakage Correction (LCF) for Heat Loss				
Leakage	R2	R4	R6	R8
0.06 / 0.06	0.87	0.83	0.78	0.75
0.09 / 0.15	0.92	0.89	0.86	0.86
0.12 / 0.24	1.00	1.00	1.00	1.00
0.24 / 0.47	1.40	1.56	1.68	1.81
0.35 / 0.70	1.84	2.21	2.47	2.76

Leakage Correction (LCF) for Sensible Gain		
Leakage	R2	R4
0.06 / 0.06	0.96	0.85
0.09 / 0.15	0.95	0.91
0.12 / 0.24	1.00	1.00
0.24 / 0.47	1.26	1.35
0.35 / 0.70	1.56	1.74

Default Duct Wall Surface Area (SqFt)									
Floor Area Look-Up Value									
1000 SqFt		1500 SqFt		2000 SqFt		2500 SqFt		3000 SqFt	
Supply	Return	Supply	Return	Supply	Return	Supply	Return	Supply	Return
189	5	276	7	361	9	431	11	481	12

See Sections 6-8 and 23-6 for instruction for determining the floor area look-up value.

Surface Area Adjustment Factor (SAA) for Heat Loss or Sensible Gain	
SAA = Ks x (Actual supply area / Default supply area) + Kr x (Actual return area / Default return area)	
Example: Floor area lookup value = 2,000 SqFt; duct leakage = 0.09 / 0.15; default areas = 361 and 9 SqFt. Actual system has 285 SqFt on supply side and 19 SqFt on return side	
Ks = 0.072; Kr = 0.002	



Duct Leakage

- Here's how Manual-J terminology lines up with duct testing standard of $\text{cfm}_{25}/100$ sqft of conditioned floor area (based on trunk & branch system in attic – Table 7B-T)
 - Extreme = ~1.8%
 - Notable = ~3.3%
 - Average = ~4.7%
 - Partially = ~9.4%
 - Unsealed = ~13.8%



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Internal Loads

- # of people (230 sensible / 200 latent)
- Appliances
 - Kitchens are a must. Others are optional.
- Plants, etc.
 - Ask for clarification about “other” loads.



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Infiltration

Manual-J has ACH charts in 1000 sqft increments.
Example of Single Story Residence - 2001-3000 sqft

Construction Quality	ACH Heating	ACH Cooling
Tight	.11	.06
Semi-Tight	.22	.11
Average	.32	.16
Semi-Loose	.49	.25
Loose	.66	.34

The most accurate method is based on blower door testing.
Enter the CFM50 straight into the software.



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Ventilation

- Type
 - None
 - Outdoor Air
 - HRV (efficiency)
 - ERV (efficiency)
 - Ventilating Dehumidifier (Leaving Air State)
- CFM
 - Based on ASHRAE 62.2-2010?



Where To Find The Information

Load Variable	Elite Load Reports	Wrightsoft Load Reports
Design Temps	Project Report Miscellaneous Report	Short Form Building Analysis Component Constructions Project Summary AED Assessment
Envelope Details	Total Building Summary Loads System Summary Loads	Component Constructions Right-J Worksheet
Orientation	Project Report – Frond Door Orientation Building Rotation General Overview Detailed Room Loads – Window Orientation	Multiple Orientations Report Component Constructions (Use window directions)
Ductwork Details Note that all duct characteristics do not show up on reports.	Duct Size Preview Building Rotation Duct Size Graphic Manual D Duct Size – Tabular Manual D Duct Size -	Loads show in: Building Analysis Project Summary Right-J Worksheet
Infiltration	Miscellaneous Report Total Building Summary Loads System Summary Loads	Building Analysis Component Constructions Project Summary
Ventilation Note that type & efficiency does not show up on reports.	Miscellaneous Report Total Building Summary Loads System Summary Loads	Loads show in: Load Short Form (“Other Equip. Loads”) Building Analysis Project Summary
Appliance Loads	Total Building Summary Loads System Summary Loads	Right-J Worksheet

Design Temps in Reports

R HVAC - Residential & Light Commercial HVAC Loads		Elite Software Development, Inc.				
Calcs-Plus North Venice, FL 34275		Mr & Mrs Smith Page 2				
Design Data						
Reference City:	Sarasota, Florida					
Building Orientation:	Front door faces South					
Daily Temperature Range:	Medium					
Latitude:	27	Degrees				
Elevation:	26	ft.				
Altitude Factor:	0.999					
Elevation Sensible Adj. Factor:	1.000					
Elevation Total Adj. Factor:	1.000					
Elevation Heating Adj. Factor:	1.000					
Elevation Heating Adj. Factor:	1.000					
	<u>Outdoor Dry Bulb</u>	<u>Outdoor Wet Bulb</u>	<u>Outdoor Rel.Hum</u>	<u>Indoor Rel.Hum</u>	<u>Indoor Dry Bulb</u>	<u>Grains Difference</u>
Winter:	42	39.4	80%	n/a	70	n/a
Summer:	92	77	51%	50%	75	51
Design Conditions						
Location:			Indoor:	Heating	Cooling	
Example City, XX			Indoor temperature (°F)	70	75	
Elevation: 77 ft			Design TD (°F)	83	24	
Latitude: 33°N			Relative humidity (%)	30	50	
Outdoor:	Heating	Cooling	Moisture difference (gr/lb)	30.6	40.3	
Dry bulb (°F)	-13	99	Infiltration:			
Daily range (°F)	-	10 (L)	Method	Simplified		
Wet bulb (°F)	-	77	Construction quality	Average		
Wind speed (mph)	15.0	7.5	Fireplaces	1 (Tight)		



Envelope Details in Reports

Component Description	Area Quan
1A-cb-o: Glazing-Single pane, operable window, clear, metal frame with break, outdoor insect screen with 50% coverage, white or reflective color drapes with tight weave with 50% coverage, u-value 1.08, SHGC 0.75	115.4
1A-cb-d: Glazing-Single pane, sliding glass door, clear, metal frame with break, outdoor insect screen with 100% coverage, u-value 1.08, SHGC 0.75	80.4

Construction descriptions	Or	Area ft ²	U-value Btuh/ft ² -°F	Insul R ft ² -°F/Btuh	Htg HTM Btuh/ft ²	Loss Btuh	Clg HTM Btuh/ft ²	Gain Btuh
Walls								
12E-0sw: Frm wall, wd ext, 1/2" wood shth, r-19 cav ins, 1/2" gypsum board int fsh, 2"x6" wood frm	n	184	0.068	19.0	5.64	1038	2.14	393
	e	275	0.068	19.0	5.64	1550	2.14	586
	s	214	0.068	19.0	5.64	1208	2.14	457
	w	221	0.068	19.0	5.64	1245	2.14	471
	all	893	0.068	19.0	5.64	5042	2.14	1907



Orientation in Reports

Design Data

Reference City: Sarasota, Florida
 Building Orientation: Front door faces Southwest
 Daily Temperature Range: Medium
 Latitude: 27 Degrees
 Elevation: 26 ft.
 Altitude Factor: 0.999

	<u>Outdoor Dry Bulb</u>	<u>Outdoor Wet Bulb</u>	<u>Outdoor Rel.Hum</u>	<u>Indoor Rel.Hum</u>	<u>Indoor Dry Bulb</u>	<u>Grains Difference</u>
Winter:	42	39.4	n/a	n/a	70	n/a
Summer:	92	77	51%	45%	75	58

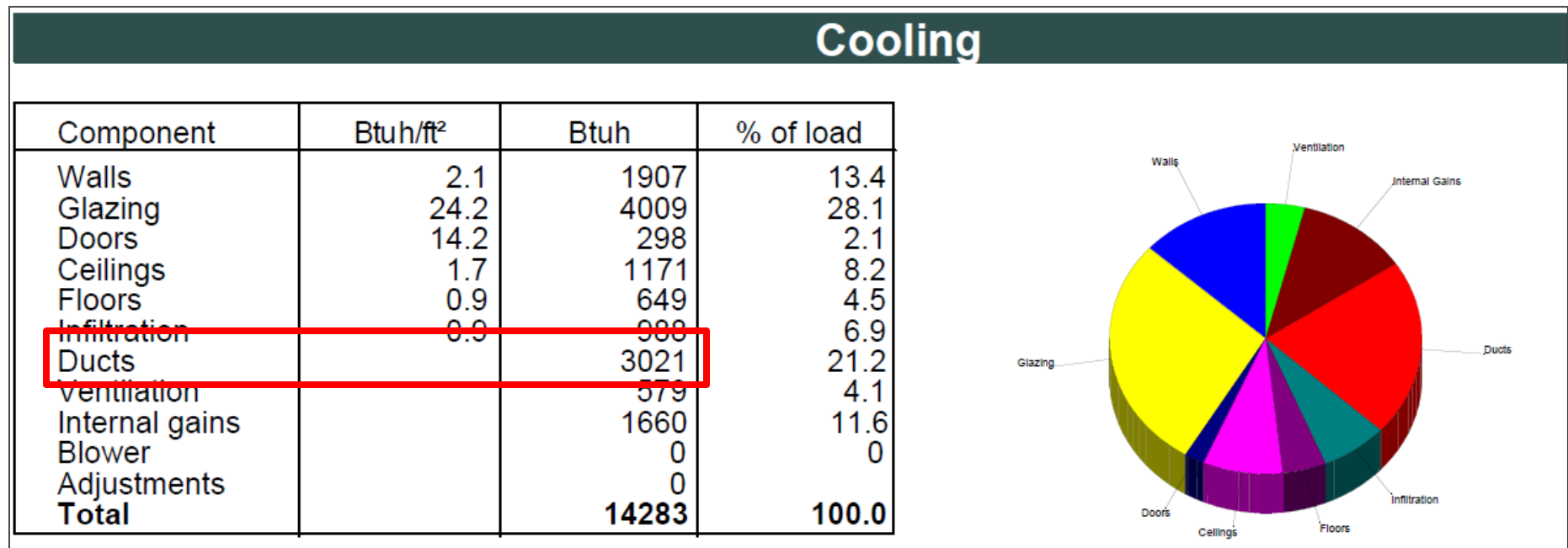
	North	Northeast	East	Southeast	South	Southwest	West	Northwest
Sensible Load (Btuh)	12735	13206	11484	12846	11154	11581	11449	12964
Latent Load (Btuh)	2543	2591	2525	2543	2517	2525	2523	2586
Total Load (Btuh)	15278	15797	14009	15389	13671	14107	13972	15549
Heating AVF (cfm)	542	564	488	547	473	492	486	554
Cooling AVF (cfm)	542	564	488	547	473	492	486	554



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Ductwork in Reports

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Ductwork:		4,747	569	4,899	5,468



Inputs for Ducts (not in reports)

Duct Loads for Room1

Supply
 Location: Conditioned space

Roof material: Asphalt shingle, Tar and gravel, Metal or membrane, Wood shake, Tile, slate, or concrete
 Roof color: Dark, Light, White
 Radiant barrier

Configuration: Radial, perimeter outlets

Sealing: Average Insul R: 6.0 ft²·F/Btuh

Heating discharge air temperature: 100 °F

Ambient temperature: Heat [70] °F, Cool [75] °F
 Surface area: [14.5] ft²

Return
 Location: Conditioned space

Roof material: Asphalt shingle, Tar and gravel, Metal or membrane, Wood shake, Tile, slate, or concrete
 Roof color: Dark, Light, White
 Radiant barrier

Configuration: Radial

Sealing: Average Insul R: 6.0 ft²·F/Btuh

Ambient temperature: Heat [70] °F, Cool [75] °F
 Surface area: [10.5] ft²

Results
 Description: Supply: Conditioned space, radial, perimeter outlets, average sealing, R-6
 Return: Conditioned space, radial, average sealing, R-6

Heat loss: [0.0] % Sensible gain: [0.0] % Latent gain: [0] Btuh

Help OK Cancel

System 1 Duct Load Factors - Scenario 1 of 5

System 1 Duct Properties

	Supply	Return
Duct Location:	Attic	Attic
Attic Ceiling Type:	16B	16B
Duct Leakage Rate:	0.06	0.06
Duct Insulation R-Value:	6	6
Duct Surface Area:	369	137
Update SA from [T]MDD:	No	No

Results

	System 1 Duct Load	Percent of Total Load	Manual Override
Sensible Loss:	4,704	18	<input type="checkbox"/>
Sensible Gain:	4,166	17	<input type="checkbox"/>
Latent Gain:	591	22	<input type="checkbox"/>

Multiple Duct Scenarios (Optional)
 If the ducts in this system are in more than one location or have other properties that differ, you can change the Duct Scenario Number below and enter "Duct Properties" data for additional scenarios (up to 5 total).

Duct Scenario No.: 1 Desc.: Main

<< >> [Icons]

	Supply	Return
Total Duct Surface Area for System 1:	369	137
Scenario 1 Percentage:	100%	100%

OK Cancel



Infiltration in Reports

	<u>Winter</u>		<u>Summer</u>	
Infiltration Specified:	0.310	AC/hr	0.160	AC/hr
	65	CFM	33	CFM
Infiltration Actual:	0.310	AC/hr	0.160	AC/hr
Above Grade Volume:	X 12,535	Cu.ft.	X 12,535	Cu.ft.
	3,886	Cu.ft./hr	2,006	Cu.ft./hr
	X 0.0167		X 0.0167	
Total Building Infiltration:	65	CFM	33	CFM

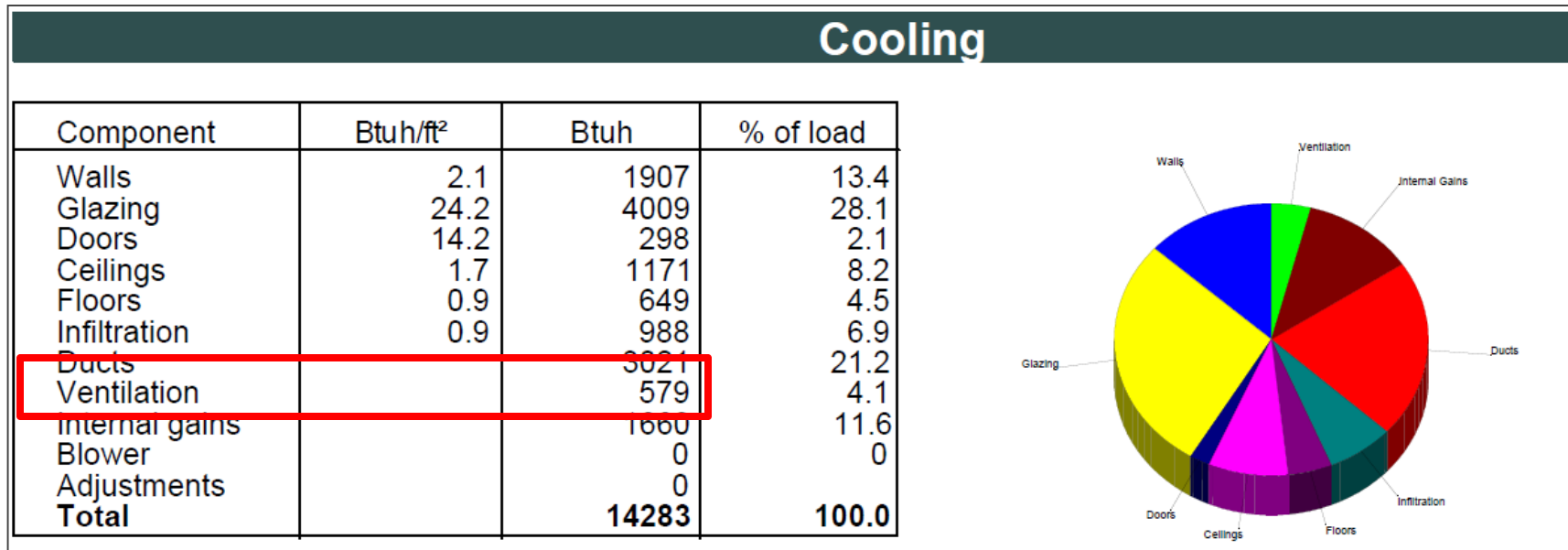
Design Conditions					
Location:			Indoor:	Heating	Cooling
Example City, XX			Indoor temperature (°F)	70	75
Elevation: 77 ft			Design TD (°F)	83	24
Latitude: 33°N			Relative humidity (%)	30	50
Outdoor:	Heating	Cooling	Moisture difference (gr/lb)	30.6	40.3
Dry bulb (°F)	-13	99	Infiltration:		
Daily range (°F)	-	10 (L)	Method	Simplified	
Wet bulb (°F)	-	77	Construction quality	Average	
Wind speed (mph)	15.0	7.5	Fireplaces	1 (Tight)	



Ventilation in Reports

Infiltration: Winter CFM: 65, Summer CFM: 33
 Ventilation: Winter CFM: 0, Summer CFM: 0

1,993 1,166 625 1,791
 0 0 0 0



Inputs for Ventilation (not in reports)

- Outdoor Air
 - Via Location
- HRV/ERV
 - Efficiency
- Dehumidifier
 - Dry bulb temp
 - Humidity Ratio

Infiltration:	0	▼	0	▼
Ventilation:	0	▼	0	▼
Exhaust:	0	▼	0	▼
Do Heat Recovery:	No	▼	No	▼
Heat Recovery SER:	60	▼	60	▼

Central Vent System Details for Entire House

	Heating	Cooling
Type	Ventilating dehumidifier	Ventilating dehumidifier
Recovery effectiveness		
Sensible (SER)	50 %	0 %
Latent (LER)	50 %	0 %
Leaving air state		
Dry bulb temperature	19 °F	101 °F
Humidity ratio	12.2 gr/lb	84.7 gr/lb

Help OK Cancel



Appliances & People in Reports

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
People:	4		800	920	1,720
Equipment:			1,200	1,200	2,400
Lighting:	0			0	0

1 Room name					Dining				Kitchen					
	2 Exposed wall	3 Room height	4 Room dimensions	5 Room area	12.0 ft		heat/cool		10.0 ft		23.5 ft		heat/cool	
12.0 x 13.5 ft							10.0 x 13.5 ft							
Ty	Construction number	U-value (Btuh/ft ² ·°F)	Or	HTM (Btuh/ft ²)		Area (ft ²) or perimeter (ft)		Load (Btuh)		Area (ft ²) or perimeter (ft)		Load (Btuh)		
				Heat	Cool	Gross	N/P/S	Heat	Cool	Gross	N/P/S	Heat	Cool	
13	Internal gains:	Occupants @ Appliances/other		230	0			0	0	1			230	1200



Building Load Results

Building Loads

Total Heating Required Including Ventilation Air:	26,307 Btuh	26.307 MBH
Total Sensible Gain:	19,568 Btuh	84 %
Total Latent Gain:	3,735 Btuh	16 %
Total Cooling Required Including Ventilation Air:	23,303 Btuh	1.94 Tons (Based On Sensible + Latent)

ROOM NAME	Area (ft ²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Entire House	704	25599	13704	587	587
Other equip loads		2003	579		
Equip. @ 1.04 RSM			14854		
Latent cooling			2596		
TOTALS	704	27602	17450	587	587



Spray Foamed Attics (Wrightsoft)

Construction descriptions	Or	Area ft ²	U-value Btuh/ft ² -°F	Insul R ft ² -°F/Btuh	Htg HTM Btuh/ft ²	Loss Btuh	Clg HTM Btuh/ft ²	Gain Btuh
Ceilings 16X19-0md: Attic ceiling, mtl roof mat, r-20 roof ins, 1/2" gypsum board int fnsh		704	0.408	19.0	4.70	3308	2.11	1488

- This is indicating the U-value of a ceiling below an encapsulated attic. The Clg HTM represents an attic temp of 85°.
- As the R-value of foam changes, the HTM's will change, but the U-value will not.



What We Covered

- Who requires loads and load reviews?
- What are the challenges in reviewing loads?
- What variables affect the load?
- How do you verify these variables were accounted for correctly?
- Suggestions on which reports to ask for, so you can do your job easily.
- How to interpret the reports from design software.



Thanks for Attending!



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