CMGT 235 – Electrical and Mechanical Systems

In Class Activity #1 – Heat Load Calculation for a Small Building

Name: Solution #2

Name: _____

Name: _____

R-Value Table

Building Component	R-Value
Wildebeest snout siding	0.81
Weevil Hide sheathing	0.98
Wookie fiber insulation	3.78 per inch of thickness
Wombat Fur insulation	3.70 per inch of thickness
Wabbit foot wallboard	16.80 per inch of thickness
2x4 Wood Stub	4.38
Walleye Scales	0.78
Walrus Tusk	0.33
Windows per/sf	2.30
Doors	5.60
Inside Air Film	0.68
Outside Air Film	0.17
Air space	0.72 per inch of thickness

1. Determine the R-Value and U-Factor for the Wall:

A. Wall Assembly (At Framing)

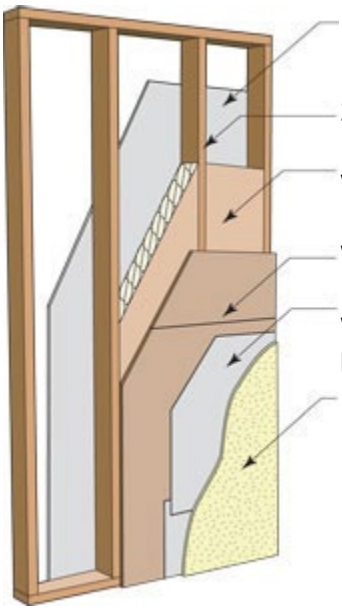
Wall R Value	R-Value		Total R-Value
Outside Air Film	0.17		0.17
Wildebeest Snout Siding	0.81		0.81
Weevil Hide Sheathing	0.98		0.98
2x4 Wood Stud	4.38		4.38
1/2" Wabbit Foot Wallboard	16.80	per/in	8.40
Inside Air Film	0.68		0.68
Total R			15.42
U-Factor (use three decimals)			0.065

B. Wall Assembly (At Insulation)

Wall R Value	R-Value		Total R-Value
Outside air film value	0.17		0.17
Wildebeest snout siding	0.81		0.81
Weevil Hide sheathing	0.98		0.98
3-1/2” Wookie fiber insulation	3.78	per/in	13.23
1/2" Wabbit foot wallboard	16.80	per/in	8.40
Inside air film value	0.68		0.68
Total R			24.27
U-Factor (use three decimals)			0.041

C. Determine the average U-Factor for the wall assembly. SHOW ALL WORK

Wall Assembly



Hint: Determine the percentage of wall that is 2x4 stud and the percentage that is insulated.

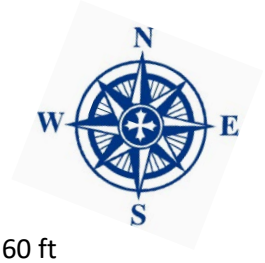
U-Factor Average = 0.065 x (1.5/8) + 0.041 x (6.5/8) = 0.065 x 0.1875 + 0.041 x 0.8125 = 0.045

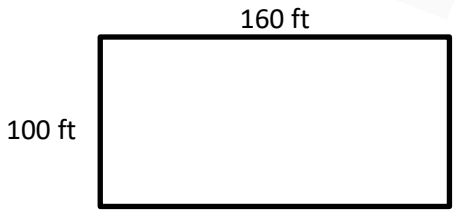
D. Ceiling Assembly

Ceiling R Value	**R-Value**		**Total R-Value**
18” Wombat fur	3.70	per/in	66.60
1/2" Wabbit foot wallboard	16.80	per/in	8.40
10” air space	0.72	per/in	7.20
Inside air film value	0.68		0.68
Outside air film value	0.17		0.17
Total R			83.05
U-Factor (use three decimals)			0.012

2. Building Construction Data

A. Calculate Building Volume





Building Dimensions

Length (ft)	160
Width (ft)	100
Ceiling Height (ft)	15 (1&2) and 12 ft(3)
Volume per floor (ft^3) =	480,000 and 192,000
Total Building Volume (ft^3) =	672,000

B. Calculate Wall, Window, and Door Area

Wall Schedule

Description	Length (ft)	Height (ft)	Area (ft^2)
North	160	42	6720
East	100	42	4200
South	160	42	6720
West	100	42	4200
		Total	21,840

Window Schedule

Quantity	Width (ft)	Height (ft)	Area (ft^2)
30	8	6	1440
		Total	1440 (per floor

Door Schedule

Quantity	Width (ft)	Height (ft)	Area (ft^2)
8	4	8	256
4	4	10	160
		Total	416

C. Calculate Net Wall Area

Net Wall Area = Total Wall Area – Total Window Area – Total Door Area

Net Wall Area = 21,840 – 4,320 – 416 = 17,104 ft^2

3. HEAT LOAD CALCULATION

A. Heat Loss Due to Infiltration

Method 1

Convection: BTUH heat gain/loss due to infiltration

q_{infil} = C x ACH x V x ΔT

C =	0.018 Btu/ft^3	
ACH =	3.0	
V =	672,000 ft^3	
ΔT =	42 °F	
(Round q to Whole Number) q_{infil} =	1,524,096	BTUH

Method 2 (check of Method 1)

Step 1: Find cfm

CFM = (ACH x V) / 60

ACH =	3.0
V =	672,000 ft^3
time	60 min/hr
CFM =	33,600

BTUH = CFM x 1.08 x ΔT

Step 2: Insert step 1 cfm

CFM =	33,600
1.08	
ΔT =	42 °F
BTUH =	1,524,096

B. Heat Loss Due to Ventilation

Convection: BTUH heat/gain loss due to ventilation

$q_{ventilation}$ = 1.08 x cfm $_{total\ vent.}$ x ΔT Heating Coil

	Number of	CFM	
15 CFM/Wallaby X	80 =	1200 CFM	
5 CFM/Weasels X	900 =	4500 CFM	
		5700	CFM total ventilation

CFM $_{total\ ventilation}$	5700
ΔT =	47 °F
(Round q to Whole Number) $q_{ventilation}$	289,332 BTUH

C. Design Conditions

Infiltration Data	
Building Volume	672,000
Air Changes/Hour	3.0
Infiltration CFM	33,600

Winter Design Criteria	
Mixed Air Temp	55 ^{o}F
Return Air Temp	62 ^{o}F
Outside Temp	36 ^{o}F
Supply Air Temp	108 ^{o}F
Daytime Setpoint	78 ^{o}F
Design ΔT	42 ^{o}F
Heating Coil Air ΔT	47 ^{o}F
Heating Coil Water ΔT	27 ^{o}F

D. Heat Loss Due to Transmission (Round q to Whole Number)

Component	**U-Factor (Btu/h x ft^2 x ^{o}F)**	**Area (ft^2)**	**ΔT (^{o}F)**	**$q_{Transmission}$ = U x A x ΔT (BTUH)**
Walls (Net)	0.045	17,104	42	32,327
Windows	0.435	4,320	42	78,926
Doors	0.179	416	42	3,127
Ceiling	0.012	16,000	42	8,064
Total Envelope Heat Loss Due to Transmission				122,444

E. Heat Loss Due to Convection (From Page 5)

$q_{Infiltration}$ (BTUH)	1,524,096
$q_{Ventilation}$ (BTUH)	289,332

F. Total Building Heat Load (q_{total} = $q_{Transmission}$ + $q_{Infiltration}$ + $q_{Ventilation}$)

Total Heat Coil Load (BTUH)	1,935,872

Extra Credit

4. FAN AND PUMP DATA

A. CFM Req. to move across heating coil = [Total Space Heat Loss/Gain / Heating coil air ΔT] * 1.08

= (1,935,872/ 47) x 1.08 = 44,484 CFM

B. GPM Req. to flow through heating coil = Total Coil Load / (Heating coil water ΔT * 500)

= 1,935,872/ (27 x 500) = 143 GPM