**CMGT 235 – Electrical and Mechanical Systems**

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

Solution #1

**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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**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:**
2. **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 |

1. **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 |

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

Wall Assembly

1/2" wabbit's foot wallboard

2 x 4 studs (8 in. on Center)

Wookie fiber insulation

Weevil hide sheathing

Wildebeest snout siding with single layer building paper



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

1. **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 |

1. **Building Construction Data**

160 ft

100 ft

1. **Calculate Building Volume**

**Building Dimensions**

|  |  |
| --- | --- |
| Length (ft) | 160 |
| Width (ft) | 100 |
| Ceiling Height (ft) | 15 |
| Volume per floor (ft3) = | 240,000 |
| Total Building Volume (ft3) = | 720,000 |

1. **Calculate Wall, Window, and Door Area**

**Wall Schedule**

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | **Length (ft)** | **Height (ft)** | **Area (ft2)** |
| North | 160 | 15 | 2400 |
| East | 100 | 15 | 1500 |
| South | 160 | 15 | 2400 |
| West | 100 | 15 | 1500 |
| **Total** | 7800 (per floor) |

**Window Schedule**

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Width (ft)** | **Height (ft)** | **Area (ft2)** |
| 30 | 8 | 6 | 1440 |
| **Total** | 1440 (per floor |

**Door Schedule**

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Width (ft)** | **Height (ft)** | **Area (ft2)** |
| 8 | 4 | 8 | 256 |
| 4 | 4 | 10 | 160 |
| **Total** | 416 |

1. **Calculate Net Wall Area**

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

Net Wall Area = 23,400 – 4,320 – 416 = 18,664 ft2

1. **HEAT LOAD CALCULATION**
2. **Heat Loss Due to Infiltration**

Method 1

|  |  |
| --- | --- |
|  | **Convection: BTUH heat gain/loss due to infiltration**qinfil = C x ACH x V x ∆T |
|  | C = | 0.018 Btu/ft3 |  |
|  | ACH = | 3.0 |  |
|  | V = | 720,000 ft3 |  |
|  | ∆T = | 42 °F |  |
| (Round q to Whole Number) | qinfil = | 1,632,960 | BTUH |

Method 2 (check of Method 1)

Step 1: Find cfm

|  |  |
| --- | --- |
|  | **CFM = (ACH x V) / 60**  |
|  | ACH = | 3.0 |  |
|  | V =  | 720,000 ft3 |  |
|  | time | 60 min/hr |  |
|  | CFM = | 36,000 |  |

|  |  |
| --- | --- |
|  | **BTUH = CFM x 1.08 x ∆T**  |
| Step 2: Insert step 1 cfm | CFM = | 36,000 |  |
|  | 1.08 |  |  |
|  | ∆T = | 42 °F |  |
|  | BTUH =  | 1,632,9600 |  |

1. **Heat Loss Due to Ventilation**

|  |  |
| --- | --- |
|  | **Convection: BTUH heat/gain loss due to ventilation**qventilation = 1.08 x cfm total vent. x ∆T 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 |  |  |
|  | ∆T = | 47 °F |  |  |
| (Round q to Whole Number) | qventilation | 289,332 BTUH |

1. **Design Conditions**

|  |  |  |
| --- | --- | --- |
| **Infiltration Data** |  | **Winter Design Criteria** |
| Building Volume | 720,000 |  | Mixed Air Temp  | 55 ⁰F |
| Air Changes/Hour | 3.0 |  | Return Air Temp | 62 ⁰F |
| Infiltration CFM | 36,000 |  | **Outside Temp**  | 36 ⁰F |
|  |  |  | Supply Air Temp | 108 ⁰F |
|  |  |  | **Daytime Setpoint** | 78 ⁰F |
|  |  |  | **Design ΔT** | 42 ⁰F |
|  |  |  | Heating Coil Air ΔT | 47 ⁰F |
|  |  |  | Heating Coil Water ΔT  | 27 ⁰F |

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Component** | **U-Factor****(Btu/h x ft2 x ⁰F)** | **Area (ft2**) | **ΔT (⁰F)** | **qTransmission = U x A x ΔT****(BTUH)** |
| Walls (Net) | 0.045 | 18,664 | 42 | 35,275 |
| 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** | 125,392 |

1. **Heat Loss Due to Convection** (From Page 5)

|  |  |
| --- | --- |
| **qInfiltration (BTUH)** | 1,632,960 |
| **qVentilation (BTUH)** | 289,332 |

1. **Total Building Heat Load (qtotal = qTransmission** + **qInfiltration** + **qVentilation**)

|  |  |
| --- | --- |
| **Total Heat Coil Load (BTUH)** | 2,047,685 |

**Extra Credit**

1. **FAN AND PUMP DATA**
2. CFM Req. to move across heating coil = [Total Space Heat Loss/Gain / Heating coil air ∆T] \* 1.08

= (2,047,685/ 47) x 1.08 = 47,053 CFM

1. GPM Req. to flow through heating coil = Total Coil Load / (Heating coil water ∆T \* 500)

= 2,047,685/ (27 x 500) = 152 GPM