



Let's Get Mechanical: Outside Air Requirements and Heating Load Student Activity Sheet

Task 1

Clean, fresh air plays a vital factor in the role of today's building designers.

How do technicians determine the amount of air that must flow into a certain space?

You are working to calculate the outside air requirements for the first floor of the provided floor plan. Using the provided information, determine the outside air requirements for each space.

Minimum Ventilation Rates Per NC Mechanical Code

| | Occupant Density $\left(\frac{\text{Person}}{1000 \text{ ft}^2}\right)$ | People Outdoor Airflow Rate, $R_p\left(\frac{\text{CFM}}{\text{person}}\right)$ | Area Outdoor Airflow Rate, $R_a\left(\frac{\text{CFM}}{\text{ft}^2}\right)$ |
|-----------------|--|--|--|
| Office | 6 | 5 | 0.06 |
| Library | 25 | 10 | 0.12 |
| Conference room | 50 | 5 | 0.06 |
| Corridor | 0 | 0 | 0.06 |
| Lobby/Reception | 30 | 5 | 0.06 |
| Multi-function | 100 | 7.5 | 0.06 |

Note: $CFM = \frac{\text{ft}^3}{\text{min}}$

Formula for required ventilation rate (airflow rate):

$$V = R_p P_z + R_a A_z,$$

where the variables/components of the formula are:

V = Ventilation rate in CFM

R_p = People outdoor airflow rate in $\left(\frac{\text{CFM}}{\text{person}}\right)$

P_z = Space occupancy, the whole # of people that the ventilation rate needs to account for

R_a = Area outdoor airflow rate in $\left(\frac{\text{CFM}}{\text{ft}^2}\right)$

A_z = Space floor area in ft^2

Exploration

1. Which two of the four components (variables) of the formula are provided in the table?
2. Which two components will you need to determine?
3. Which one of the two components which you must determine depends on the other?
4. What are the units of the product $R_a A_z$?
5. What are the units of the product $R_p P_z$?
6. The occupant density for Lobby is listed as 30 people per 1000 sq. ft. Suppose the area of a lobby is 710 sq. ft.
 - a. A spreadsheet set up by a coworker is calculating the space occupancy as 21300 people. What is wrong with the spreadsheet?
 - b. The space occupancy is the number of people which the ventilation system will have to account for when used in other calculations. Keeping this in mind, how should the correct space occupancy be rounded?
7. Complete the Outside Air Requirements Table for the remaining spaces: library, conference, corridor, multi-function, lobby/reception.

Outside Air Requirements

| | Space Floor Area A_z | Space Occupancy P_z | Ventilation Rate V |
|-------------------|---------------------------|--------------------------|-------------------------|
| Offices (3 total) | | | |
| Library | | | |
| Conference room | | | |
| Corridor | | | |
| Lobby/Reception* | | | |
| Multi-function | | | |

*Include hallway between toilets and elevators and stairway in Lobby/Reception

Discussion:

Compare the outside air requirements for each space and discuss the results with your group.

Task 2

Keeping a building warm in the winter and cool in the summer is a main concern for architectural design companies.

For our scenario, you are working to keep the building occupants warm in the winter by calculating the heating load for the exterior walls and windows of the rooms on the first floor. Which component contributes more to the heating load?

Formula for heating or cooling load:

$$Q = UA (T_i - T_o),$$

where the variables/components of the formula are:

Q = Heating or cooling load in BTU/hr (amount of energy needed to keep space heated)

U = Total U-value for assembly in $BTU/(hr \times ft^2 \times ^\circ F)$

A = Area in ft^2

T_i = Indoor temperature in $^\circ F$

T_o = Outdoor temperature in $^\circ F$

The temperatures for Raleigh, NC, are given below.

| | Winter | Summer |
|---|-----------------|---------------|
| Peak Outdoor Design Conditions for Raleigh, NC, T_o | 20.4 $^\circ F$ | 95 $^\circ F$ |
| Indoor Design Conditions for Building, T_i | 70 $^\circ F$ | 75 $^\circ F$ |

The exterior components of the building are insulated to prevent heat exchange. Each component is assigned a U-Value, which has units $BTU/(hr \times ft^2 \times ^\circ F)$. The unit BTU is a measure of energy (1000 BTU is approximately 0.293071 kWh) called a British thermal unit.

| | U-Value in $BTU/(hr \times ft^2 \times ^\circ F)$ |
|--------|---|
| Wall | 0.064 |
| Window | 0.4 |
| Roof | 0.048 |

For this floor plan, the exterior wall height is 13', and a typical window is 3' \times 4'.

Exploration

1. Why should we only include exterior walls in the calculation for heating load?
2. Which three of the four components (variables) of the formula are provided in the information above?
3. Which component will you need to determine?

Exercises

1. Determine the heating load for the conference room. Only consider external walls/windows.

| Conference Room | Area (ft^2) | Heating Load (BTU/hr) |
|-----------------|-----------------|---------------------------|
| Windows | | |
| Walls | | |

2. Determine the heating load for the library. Only consider external walls/windows; you may treat the double door onto the patio as a wall.

| Library | Area (ft^2) | Heating Load (BTU/hr) |
|---------|-----------------|---------------------------|
| Windows | | |
| Walls | | |

Discussion:

1. For each room above (corner office, conference room, library) determine the component which contributes the most to the heating load.
2. Explain why all three rooms did not have the same component that contributed the most to the heating load.
3. Why is it not enough to just compare the area of windows to the area of walls?
4. Consider the formula for the heating load $Q = UA(T_i - T_o)$.
 - a. What will happen to the heating load if the height of the wall is decreased?
 - b. Suppose another wall assembly is chosen with "better" insulation. Should this correspond to a greater or smaller U-value?
 - c. Which month(s) of the year will the heating/cooling bills be most expensive? How does this relate to the formula?