ORDRE DES INGÉNIEURS DU QUÉBEC

SESSION DE NOVEMBRE 2020

Open-book examination
Calculators : only authorized models
Duration : 3 hours

14-BA-B3 BUILDING AIR QUALITY

This exam has 8 questions for a total of 20 points

Question 1 (2 points)

ASHRAE Standard 62.1 imposes a minimal outdoor air flowrate in the breathing zone which depends on the number of occupants but also on the floor area. Why would it not be acceptable to base the outdoor air requirements only on the number of occupants?

Question 2 (2 points)

Poor indoor air quality inside buildings can cause the *Sick Building Syndrome (SBS)*, but it can also cause a *Building Related Illness, BRI*. Explain the differences between those two consequences of poor indoor air quality and provide examples of their causes and symptoms.

Question 3 (3 points)

ASHRAE Standard 62.1 is used to design a ventilation system providing outdoor air and heating to a childcare facility with 3 rooms:

- Two children playrooms (*daycare through age 4*), each room having a floor area of 100 m^2
- A cafeteria (*cafeteria/fast food dining*) with a floor area of 40 m^2

In design conditions, warm air at 35 °C is supplied at ceiling level to maintain the room temperature at 21 °C. Air is exhausted at ceiling level as well. There are nominally 40 persons in the building, the occupant density is 0.20 pers./m² in the playrooms and 1 pers./m² in the cafeteria.

The VAV (Variable Air Volume) system has system-level recirculation but no secondary recirculation. The design primary flowrate is 475 L/s in each playroom and 1175 L/s in the cafeteria. Calculate the following air flowrates according to ASHRAE 621. Standard:

a) The required zone outdoor airflow (Voz) in each room, in L/s.
b) The required system-level outdoor air intake flowrate (Vot), in L/s.

Indicate your assumptions and which ASHRAE standard 62.1 version was used for calculations.

Question 4 (2 points)

The concentration of radon is assessed in a 2-story house with slab-on-grade during a cold day with no wind (the house is heated). A high concentration is measured in the bedrooms on the second floor. After opening windows in the bedrooms in an attempt to bring in more fresh air, the radon concentration increases instead of decreasing. How can this be explained?

Question 5 (2 points)

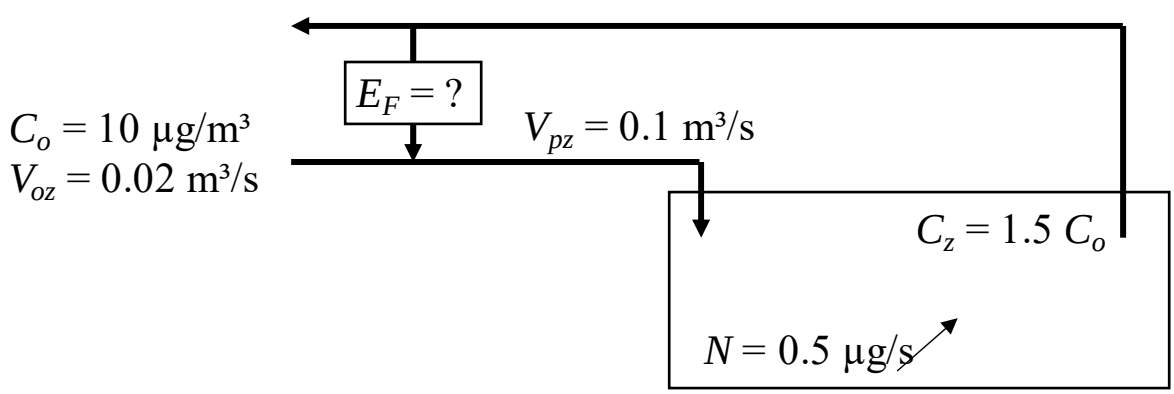
ASHRAE Standard 62.1 uses the concept of *zone air distribution effectiveness,* E_z. That effectiveness is for example 1 for a system with ceiling supply of cool air. Provide an example when the zone air distribution effectiveness is higher than 1 and explain why.

Question 6 (3 points)

A single-zone ventilation system supplies a total primary flowrate V_{pz} = 0.1 m³/s to a room. The outdoor air fraction is 20 %, so that the outdoor air flowrate V_{oz} = 0.02 m³/s.

A contaminant is present in ambient air with a concentration C_o = 10 µg/m³ and generated in the room with an emission rate N = 0.5 µg/s. Air in the room is assumed to be fully mixed.

In order to limit the contaminant concentration in the room, a filter is installed in the recirculation branch (see figure). What should the filter efficiency E_F be to maintain the room concentration C_z at 150 % of the outdoor concentration (C_z = 1.5 C_o) ?



Question 7 (3 points)

Methods to reduce contaminant concentration in buildings can be classified in 4 broad categories:

a) source control (reduce production of contaminant)

b) isolation of contaminant sources

c) filtration

d) dilution through ventilation.

Indicate the best method applicable to the 4 contaminants listed below and justify your choice (you are asked to associate each method (a, b, and c) to one contaminant (1, 2, 3 and 4).

Contaminants:

1) Carbon dioxyde (CO_2) from occupant breathing

2) Volatile Organic Compounds (VOCs) from building surfaces and furniture

3) Gaseous anhydrous ammonia from a chemical experiment

4) Pollen from trees surrounding the building

Question 8 (3 points)

80 occupants are present in a 100-m² courtroom multiuse assembly room within a university (*Public assembly spaces / courtroom*). Air is assumed to be fully mixed, and a 100 % outdoor air system supplies a flowrate of 525 CFM (cubic feet per minute). The room is in cooling mode and cool air is supplied at ceiling level.

a) Calculate the steady-state CO_2 concentration in the room in ppm

b) Does the supplied outdoor air flowrate meet the requirements of ASHRAE Standard 62.1? Justify your answer and indicate the standard version used to answer this question.

Additional information:

- Outdoor CO_2 concentration: 400 ppm
- CO_2 molar mass: 44 g/mol
- You can assume that an occupant emits 32 g/h of CO_2
- Room temperature is 25 °C, atmospheric pressure is 101.325 kPa