

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani Campus
Semester-I, 2017-2018

Plant Process Safety (CHE F413)
Mid Semester Exam
(CLOSED BOOK)

Max Marks: 25

Date: 12-10-2017

Duration: 45 min.

Answer all questions

1. Briefly explain the following: (a) Distinction between Puff and Plume, (b) Risk, (c) Inherent Safety, (d) Entry routes for toxicants, (e) Boiling Liquid Expanding Vapour Explosion (BLEVE). *[10 Marks]*

2. There are 2000 employees in a chemical plant. How many fatalities are expected in a period of 2 years if the plant has a FAR of 2? Assume that the employees work a standard 8-hour shift per day, 300 days in a year. *[2 Marks]*

3. A chemical storage tank has exploded in a chemical facility and the peak overpressure is approximated by the following equation, $\log P = 5 - 2 \log r$, where P is in N/m^2 and distance r is in m. There are 500 people working in an area from 10 to 200 m from the blast site. Determine the maximum distance where the people are affected in (a) death due to lung haemorrhage, and (b) ear drum rupture.
The probit equation for death due to lung haemorrhage is given by $Y = -77.1 + 6.91 \ln P$, and ear drum rupture is given by $Y = -15.6 + 1.93 \ln P$, where P is in N/m^2 . *[5 Marks]*

4. Develop the source model for flow of liquid through a hole in a tank:
 - a. Obtain the instantaneous mass flow rate, and rate of change of liquid height in the tank.
 - b. Obtain the hole height at which we get maximum range for the jet that comes out, and what is the maximum horizontal distance the jet from the leak can travel.Show all steps in the derivation. State any assumptions made in arriving at the final equation.

[8 Marks]

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1. Calculate the mass flux ( $\text{kg/m}^2\text{s}$ ) for a propane tank leak given that the storage pressure is equal to the vapour pressure (0.95 MPa) at 25 °C; heat of vaporization equal to  $3.33 \times 10^5$  J/kg; difference of specific volumes of vapour and liquid is  $0.048 \text{ m}^3/\text{kg}$  and heat capacity of ammonia is  $2.23 \times 10^3$  J/kg K. *[2 Marks]*
  
2. Assume Cyclohexane ( $\text{C}_6\text{H}_{12}$ ) TLV of 100 ppm, and n-Hexane ( $\text{C}_6\text{H}_{14}$ ) TLV forms an ideal liquid mixture. A liquid mixture of 60% Cyclohexane and 40 % n-Hexane is used in a chemical process in industry. The temperature is 26 °C, and the pressure is 1 atm. Determine the ventilation rate ( $\text{kg/s}$ ) required to maintain the concentration of the vapour mixture below the value of TLV. *[8 Marks]*
  
3. A pipeline carrying liquid Toluene has developed a large hole and the liquid leaked is contained on the ground in a dike of an area  $20 \text{ m} \times 10 \text{ m}$ . It is a cloudy night with wind speed of 2 m/s, the ambient pressure is 1 atm and temperature is 300 K. Evacuations need to performed in all downwind areas where the concentration exceeds  $8 \text{ mg/m}^3$  (4 times the OSHA PEL value).
  - a. Determine the evaporation rate ( $\text{kg/s}$ ) from the dike. *[5 Marks]*
  - b. Assuming evaporation as continuous and steady state plume, determine the distance (in m) downwind that must be evacuated. *[10 Marks]*

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