Quiz-5 on Chapters 8 and 9 (June 11, 2001)

Problem 5-1 Based upon the "Continuous Gaussian Plume Model," for the elevated release," the atmospheric dispersion factor is given by:

$$\frac{\overline{\chi}}{Q}(x,y,z) = \frac{1}{2\pi\sigma_y\sigma_z\overline{u}}\exp\left(-\frac{y^2}{\sigma_y^2}\right)\left\{\exp\left[-\frac{1}{2}\left(\frac{(z-h)^2}{\sigma_z^2}\right)\right] + \exp\left[-\frac{1}{2}\left(\frac{(z+h)^2}{\sigma_z^2}\right)\right]\right\}.$$

1) Assuming the ground level release of gaseous effluent, derive the atmospheric dispersion factor at a location (x,y,z) in the air away from the release point located at the origin.

Solution:

$$\frac{\overline{\chi}}{Q}(x,y,z) = \frac{1}{\pi\sigma_y\sigma_z\overline{u}}\exp\left[-\frac{1}{2}\left(\frac{y^2}{\sigma_y^2} + \frac{z^2}{\sigma_z^2}\right)\right]$$

2) Find the maximum (or centerline) chi-over-cue on the ground at x-meter away from the release point.

Solution:

$$\frac{\overline{\chi}}{Q}(x) = \frac{1}{\pi\sigma_y(x)\sigma_z(x)\overline{u}}$$

3) Assuming the average wind speed of 2m/sec, compute the maximum chi-over-cue at the EAB (Exclusion Area Boundary) distance of 700 meters from a nuclear power plant. The horizontal and vertical standard deviations, $\sigma_y(x)$, $\sigma_z(x)$ at x=700 meters are 25 m, and 10 m, respectively.

Solution:

$$\frac{\overline{\chi}}{Q}(x) = \frac{1}{\pi\sigma_y(x)\sigma_z(x)\overline{u}} = \frac{1}{\pi\times 25\times 10\times(2m/\sec)} = 6.37\times 10^{-4}\ \sec/m^3$$

Problem 5-2 In a 3,400 MWt PWR, the equilibrium activity of I-133 in the core is 2 million curies during normal operation. Following a postulated design basis accident (maximum credible accident in this case) for site evaluation, we assume that 25% of I-133 activities release into the containment atmosphere immediately following the accident, and then subsequently release to the environment via containment leakage with the leak rate of 0.1%/day. The half-life of I-133 is 20 hours.

1) Compute the integrated I-133 release into the environment for the first 2 hours following the accident.

Solution:

$$A_{I-133} = A_0 e^{-\lambda_{I-133}t}$$

$$A_0 = 0.25\times(2\times 10^6) = 0.5\times 10^6\,Ci$$

leakage rate R=0.1%/day

$$\int_0^{2hr} R \times A_0 \times e^{-\lambda_{I-133}t} dt = \frac{RA_0}{\lambda_{I-133}}[1 - e^{-\lambda_{I-133}\times 2hr}] = 40.26Ci$$

2)If the average release rate of I-133 via the containment leakage is 20 Ci/hour, assuming the atmospheric dispersion factor of 3.5×10^{-4} sec/m^3 at EAB, compute the average I-133 concentration in the air at EAB.

Solution:

$$\frac{\overline{\chi}}{Q} = 3.5\times10^{-4}\ \sec/m^3$$

$$Q = 20Ci/hr$$

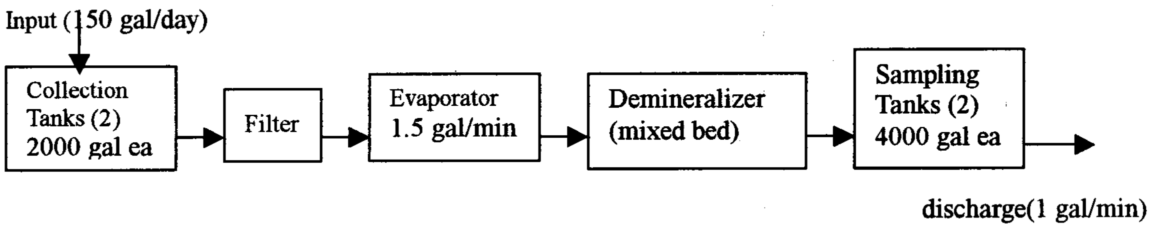
$$(20Ci/hr)(3.5\times10^{-4}\ \sec/m^3)(1hr/3600\sec) = 1.94\times10^{-6}Ci/m^3$$

Problem 5-3 Let's assume the average I-133 concentration in the air at EAB is estimated to be 2×10^{-3} Ci/m^3. The breathing rate of a human is 3.5×10^{-4} m^3/second, and the dose conversion factor of I-133 to thyroid through inhalation is 2.69×10^{-4} mrem per pCi inhaled. If the critical organ for iodine is thyroid, compute the thyroid dose commitment for a person exposed by this contaminated air at EAB for 2 hours immediately following the postulated accident.

Solution:

$$(2\times10^{-3}Ci/m^3)(3.5\times10^{-4}m^3/s)(2.69\times10^{-4}mrem/pCi)(2hr)(3600s/hr) = 1355760mren$$

Problem 5-4 A process system of clean waste is given as follows:



1) Find the system DF for I-133.:데이터가 부족하여 답을 구할 수 없으므로 모두 맞다고 하겠습니다.
2) Find the credit for decay time of this liquid waste processing system.

Solution:

$$T_c = \frac{0.8\times2000}{150gal/day} = 10.67$$

$$T_p = \frac{0.8\times2000}{(1.5gal/\min)\times(60\times24\min/day)} = 0.74$$

$$T_d = \frac{0.8\times4000}{(1gal/\min)(60\times24\min/day)} = 2.22$$

Check for decay credit $\frac{0.8V_s}{F_p + F_o} = \frac{0.8 \times 4000}{1.5 \times 60 \times 24 + 0} = 1.48 day > T_p$

$\therefore T_p + 0.5T_d = 0.74 + 0.5 \times 2.22 = 1.85 days$