

**QUESTION 11**

You are the Radiation Safety Officer (RSO) at a large fuel reprocessing facility. The facility includes a tank used to process highly enriched uranium. During a batch processing operation, a technician violates the plant's operating procedures, which leads to a critical geometry in the tank. The technician is standing behind a 30-cm thick, polyethylene shield, and is 3 meters from the center of the tank.

**GIVEN**

- $1.0 \times 10^{16}$  fissions occur during the criticality incident
- Each fission event produces three (3) neutrons and eight (8) gamma rays
- Density of polyethylene shield is  $1.5 \text{ g cm}^{-3}$
- Dose conversion factor for 2.5 MeV neutrons is  $2.0 \text{ mrem hr}^{-1}$  per  $20 \text{ neutrons cm}^{-2} \text{ sec}^{-1}$
- Gamma exposure rate conversion factor is  $6.0 \times 10^5 \text{ gamma rays cm}^{-2} \text{ sec}^{-1}$  per  $1 \text{ R hr}^{-1}$
- Mean neutron and gamma energies are 2.5 MeV and 1.0 MeV, respectively
- Neutron dose attenuation factor for 2.5 MeV neutrons through 30 cm of polyethylene is 0.005
- Mass attenuation coefficient for polyethylene for a fission gamma spectrum is  $0.073 \text{ cm}^2 \text{ g}^{-1}$
- The dimensions of the tank are 45 cm by 45 cm
- The quality factor for 2.5 MeV neutrons is 10
- The quality factor for 1.0 MeV gamma rays is 1.0
- $0.95 \text{ rad} = 1 \text{ R}$

**POINTS****STATE ALL ASSUMPTIONS**

- 50**    A.    What is the neutron dose equivalent in rem received by the technician during the criticality incident? **Show all calculations.** What is the gamma dose equivalent in rem received by the technician during the same incident? **Show all calculations.**
- 30**    B.    The facility criticality monitor is a  $\gamma$ -response instrument with an alarm set point of  $500 \text{ mR hr}^{-1}$ . If, during a short transient, the detector response corresponds to  $1/3500$  of the actual gamma exposure rate, what is the maximum distance over which the device will be effective in signaling an unshielded, 1-msec criticality incident with  $1.0 \times 10^{16}$  fissions? **Neglect air absorption. Assume that an incident with  $1.0 \times 10^{15}$  fissions results in a gamma exposure of 2.0 R at 2 meters. Show all calculations.**
- 20**    C.    List four (4) factors that affect criticality. **Number your responses. Only the first four will be graded.**