



JETS Challenge 132 Three Mile Island

Thirty years ago on March 28, 1979 the Three Mile Island nuclear reactor in Middletown, PA had a loss of coolant accident and began a meltdown. Over the next week, steam and hydrogen were removed from the reactor using a recombiner and, more controversially, by venting straight to the atmosphere. It is estimated that a maximum of 13×10^6 curies of radioactive noble gases were released by the event. Each curie represents 3.7×10^{10} decays/sec. The noble gases could be represented by krypton, Kr^{137} , which has a half-life of 3.9 minutes and emits radiation energy at $E = 3.5$ MeV. The energy absorption coefficient, μ , at this energy is $\mu = 0.022$ (cm^2/gm). The dose rate is given by

$$D = 1.6 \times 10^{-9} \frac{(\phi \mu E) \Delta t}{4 \pi R^2} \quad \text{where}$$

- D = radiation dose in millirem
- ϕ = source strength in total decays per second (decays/s)
- μ = energy absorption coefficient (cm^2/gm)
- E = emitted radiation energy (MeV)
- Δt = time duration of exposure (sec)
- $\pi = 3.14159$ – you knew that
- R = distance from source (meters)

The Challenge: Find the radiation dose (millirem) for an individual standing 16 km away who is exposed for 6 minutes?

13×10^6 curies

1 curie = 3.7×10^{10} decays/sec \times 13×10^6 curies \times 1 curie = 3.7×10^{10} decays/sec = 4.81×10^{17} decays/sec

$$D = \frac{(1.6 \times 10^{-9}) (4.81 \times 10^{17}) (0.22 \text{cm}^2 / \text{gm}) (3.5 \text{MeV})}{4\pi(1600\text{m})^2} \bullet 360 \text{sec} = 6.63145 \text{ millirem}$$

ANSWER:

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JETS Challenge problems are generously provided by Dave Meredith, Associate Professor, Penn State University-Fayette