

QUESTION 9

Part of the reactor coolant clean-up system of a pressurized water reactor includes demineralizers that are loaded with resin to reduce the concentration of radioactive material in the reactor coolant system (RCS). Assume that only ^{60}Co is present in the reactor coolant system and that the clean-up system has been operating continuously for the 200 consecutive days of reactor operation.

GIVEN**Vertical Demineralizer:**

- Composition material: Stainless steel
- Diameter: 4 ft
- Top thickness: 0.1 inches (neglect attenuation and build-up in steel top)

Operational Data:

- Flow rate through demineralizer: 480 lpm
- Demineralizer efficiency: 100%
- Concentration of ^{60}Co in RCS: $8.0 \times 10^{-5} \mu\text{Ci/ml}$

Radiological Data for ^{60}Co :

- Gamma constant (Γ): $1.3 \text{ R}\cdot\text{m}^2/\text{hr}\cdot\text{Ci}$
- Half-life: 5.26 y
- Gamma emissions: 1.173, 1.332 MeV each at 100%
- Beta emissions: 1.480 MeV @ 0.12 %
0.314 MeV @ 99.0 %

Additional data:

- Assume dose rate in air equals dose rate in tissue
- Attenuation Coefficients for Lead:

E(MeV)	0.60	0.70	0.80	1.0	1.25	1.50	2.75
$\mu(\text{cm}^{-1})$	1.36	1.12	0.97	0.78	0.65	0.58	0.47

- Dose Build-up Factors for an Isotropic Point Source:

MeV	1(μx)	2(μx)	4($\text{m}\mu\text{x}$)	7($\text{m}\mu\text{x}$)	10($\text{m}\mu\text{x}$)	15($\text{m}\mu\text{x}$)	20($\text{m}\mu\text{x}$)
0.5	1.24	1.42	1.69	2.00	2.27	2.65	2.73
1.0	1.37	1.69	2.26	3.02	3.74	4.81	5.86
2.0	1.39	1.76	2.51	3.66	4.84	6.87	9.00
3.0	1.34	1.68	2.43	2.75	5.30	8.44	12.30

POINTS

40 A Calculate the gamma dose equivalent rate in rem/hour at a point 1 foot above the centerline of the surface of the demineralizer bed immediately after the 200 day run. Assume that the demineralizer contains no water above the resin bed and that all radioactive material is distributed uniformly over the top of the demineralizer bed. Also assume that the dose rate in the bed can be approximated by a thin disc source. Account for decay in your answer. **Show all work.**

60 B A valve located on the centerline, nine feet above the end of the demineralizer bed requires lapping. When isolated six months ago, the demineralizer contained 60 Ci of ^{60}Co . There is no water above the resin bed.

The lapping operation requires 30 minutes and is to be performed by a mechanic who has 300 mrem remaining on his annual administrative exposure limit. Because of physical limitations, a mat equivalent to 2 inches of lead is all the shielding that can be used. Is the shielding sufficient to prevent the worker from exceeding the administrative exposure limit? This is the mechanic's only source of exposure. **State all assumptions. Show all work.**