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SHIELDING CALCULATIONS
for
APPR-1 DEMINERALIZER
SHIPPING CONTAINERS

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I. INTRODUCTION

Calculations have been performed to determine the thickness of lead shielding required for a shipping container for a demineralizer used with the APPR-1 reactor facility. The shielding is based on a 24 hour shutdown time.

II. ACTIVITY ON DEMINERALIZER

The activity on the demineralizer has been determined by the method and with the assumptions presented in Reference 1. Activities for several periods of demineralizer loading have been calculated. The loading period is defined as that period of time with reference to continuous reactor operation during which the demineralizer was in use.

The cobalt activity has been calculated on the assumption that the cobalt in the system, neglecting the flux suppressors, is 0.5% of the nickel content and that flux suppressors of the type described in Reference 2 are present.

The calculated activities are presented in Table 1.

TABLE I

DEMINERALIZER ACTIVITY

Loading Period Months	Activity Due to Specific Isotopes (Disintegrations / sec-cm^3 x 10^{-6})				Total Activity Curves
	Cr^{51}	Fe^{55}	Fe^{59}	Co^{60}	
3-6	15.2	2.9	0.4	2.1	31.62
6-9	15.5	4.3	0.4	3.3	36.08
9-12	15.5	6.0	0.4	4.2	40.07
12-15	15.5	7.2	0.4	5.1	43.29
15-18	15.5	8.2	0.4	5.9	46.05

III. SHIELDING CALCULATIONS

The gamma sources were based on the activities presented in Table I. The gamma yield from Co^{60} was taken to be one 1.17 Mev. and one 1.33 Mev. gamma per disintegration. For Fe^{59} every two disintegrations were assumed to give one 1.10 Mev. and one 1.30 Mev. gamma. Activities from other isotopes did not influence the shielding calculations for various reasons; small gamma yield, low gamma energy, short half-life, etc.

For the shielding calculations the demineralizer was assumed to be a cylinder 12 inches in diameter and 30 inches in height. The resin was assumed to be water in determining the source self-shielding.

It was assumed, on the basis of the dimensions shown on drawings B9-48-2007 and B9-48-2032, that 1.218 inches of steel would be associated with the lead in the shield.

The buildup factors were calculated by weighting the build-up factors for Fe and Pb, (Reference 3), by the respective mean free paths associated with each.

The absorption coefficients were obtained from Reference 4.

Based on I.C.C. requirements the shield thickness was found to be determined by the allowable dose rate one meter from the shield surface. The calculations were based on the equations and curves presented in Reference 4.

The results of the calculations are graphically presented in Figure 1.

IV. CONCLUSIONS

From Figure 1 the required lead thickness to adequately shield an APPR-1 demineralizer during transfer is 3.5 inches. This is believed to be a conservative answer based on the

assumptions made for the analysis. The reliability of the values assumed for many parameters; corrosion rates, flow rate through demineralizer, distance traveled in recoil, etc. is doubtful. However, measurements taken during operation can determine any serious deviation from the expected activity and, in this event, steps can be taken to guarantee that the source will not exceed that for which the shipping container has been designed.

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FIGURE 1

SHIELD THICKNESS FOR APPR-1 DEMINERALIZER CASK

NOTES: LOADING PERIOD DENOTES PERIOD OF CONTINUOUS REACTOR OPERATION DURING WHICH DEMINERALIZER IS IN USE. ALL PERIODS ARE 3 MONTHS LONG