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^{3}He DETECTOR DESIGN FOR LOW-LEVEL TRANSURANIC WASTE ASSAY

by

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A logical configuration of ^{3}He detector tubes imbedded in CH_2 for nondestructive assay of low-level transuranic waste has been determined by Monte Carlo calculations.

The present NaI based instrumentation[1] used for the quantitative assay of transuranic materials at low concentrations in low density ($\sim$0.1 g/cm^3) wastes requires the wastes to be nearly free of interfering beta and photon emitting fission products. When both transuranics and fission products are present in the waste, the interference between the emitted photons from the transuranics and the fission products can be considerably reduced with the addition of high-resolution germanium photon detectors. This interference can be further reduced by using ^{3}He detector banks to monitor the spontaneous fission neutrons emitted by the even isotopes of some of the transuranics. This neutron detection system is very insensitive to high photon backgrounds. A transuranic waste assay system is now being developed at Los Alamos that combines both neutron and high-resolution photon detectors into a true hybrid assay instrument.

In order to determine an optimum ^{3}He detector design, the reference detector configuration of Figure 1 was first assumed, then the parameters

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[1] C. J. Umbarger and L. R. Cowder, "Measurement of Transuranic Solid Wastes at the 10 nCi/g Activity Level," Nucl. Tech. 27, 500 (1975).

ρ, d, x, t, h, and N (which are defined in Figure 1) were varied. The relationships between the different parameter changes and the resulting calculated detector response changes were then studied. The findings are summarized in Table 1. Use of these data makes it possible to extrapolate to almost any design. For example, Monte Carlo calculations indicate that the reference design of Figure 1 has a detector response of 0.00634 counts per source neutron born in the transuranic waste with a typical spontaneous fission spectrum. From Table 1, the response is increased by a factor of 1.18 when 5.08 cm of CH_2 is added behind the detectors. Another factor of 1.5 is gained by doubling the tube height, and a factor of 1.4 is gained by increasing the number of tubes from 5 to 8. Hence, the response of a detector with eight 2.54 cm diamter tubes at 1 atmosphere with h = 122 cm, t = 15.24 cm, and x= 5.08 cm should be

$$0.00634 \times 1.18 \times 1.5 \times 1.4 = 0.0157 \text{ counts/source neutron.}$$

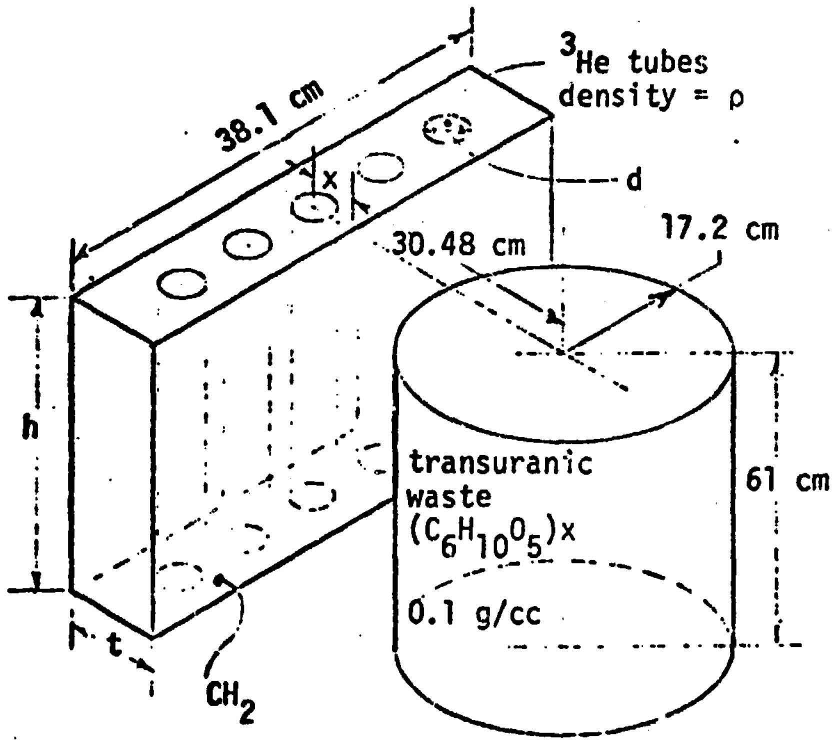
Monte Carlo calculations indicate that the actual response would be 0.0153 counts/source neutron. Note that the ^3He gas requirement is increased by a factor of 3.2, but the detector response is increased by only a factor of 2.4.

Similarly, configurations of 5.08 cm diameter tubes can be predicted given that the response of four 5.08 cm diameter detectors at 1 atmosphere with h = 61 cm, t = 17.78 cm, and x = 5.08 cm is 0.0131 counts per source neutron. Note that the ^3He requirement for this configuration is also 3.2 times that of the reference design (Figure 1) but that the dotector response gain is only a factor of 2.1. Hence 2.54 cm diameter tubes are preferable to 5.08 cm diameter tubes. Resonanco self-shielding is clearly a factor in these diminishing returns.

From this study it appears that a logical configuration of ^3He detectors imbedded in CH_2 for nondestructive assay of low-level transuranic waste is: ρ = 1 atmosphere, d = 2.54 cm, x = 5.08 cm, t = 15.24 cm, h = 61 cm, and N = 5. If a greater detector response is desired, the best way to achieve it is to first double the detector height, h, and then to increase the number of tubes, N, and/or increase the ^3He density, ρ.

Figure 1

^{3}He DETECTOR CONFIGURATION



For reference design:
ρ = 1 atmosphere
d = 2.54 cm   t = 10.16 cm
x = 5.08 cm   h = 61 cm
N = number of tubes = 5

Table 1

Summary of Monte Carlo Results

Change from ρ=1 atmosphere, x=5.08 cm, t=10.16 cm, h=61 cm	% increase in detector response N=5 d=2.54 cm	% increase in detector response N=4 d=5.08 cm
t=15.24 cm	18%	27%
t=20.32 cm	20%	31%
x=3.81 cm	-4%	-9%
h=122 cm	50%	55%
ρ=2 atmos.	41%	22%
ρ=4 atmos.	83%	-
N=8 tubes	40%	-
N=6 tubes	13%	12%
d=5.08 cm	68%	-