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CALCULATED α -INDUCED THICK-TARGET NEUTRON AND RADIONUCLIDE YIELDS FOR $E_\alpha \leq 50$ MEV

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ABSTRACT

Thick target yields for α s incident on elements $1 \leq Z \leq 15$ and $Z = 17$ have been calculated using the α stopping data of Ziegler with radionuclide production cross sections calculated with the GNASH code. Comparisons are made of the calculated cross sections with sparse measured data. Radionuclide production yields are tabulated at 5, 10, 20, 30, 40 and 50 MeV.

INTRODUCTION

Thick target α -induced yield calculations have been performed by two of the authors (RTP & WBW) at Los Alamos for nearly a decade. These calculations have been based on the production of neutrons and fission by α -induced decays or interacting with α s having thresholds below a few MeV. In a recent paper¹ we described the calculation and calculations of spontaneous fission and α -induced thick target neutron yields with SOURCES code. The SOURCES data library contains the following:

- α -n cross section data for isotopes of Be, B, C, N, O, F, Ne, Na, Mg, Al, Si, P, S, Cl, Br, and Cm having α -n thresholds below 6 MeV. The present α -n cross section data are from the library.
- radionuclide decay data for all the isotopes that have α -n thresholds below 6 MeV, including the spontaneous fission data.
- α stopping power section functions S_p and S_n for α s below 50 MeV and the summing of those functions given by Ziegler for $E_\alpha > 50$ MeV. The S_p and S_n are in the same form as the data for the S_p and S_n data given by Ziegler. The S_p and S_n curves of North et al.² are given with the S_p and S_n data of Ziegler.

In the present work we have extended the target elements to include the elements 16 and 18 and the isotopes of the elements 16 and 18 target elements. The present work is for $E_\alpha \leq 50$ MeV.

DEFINITIONS AND NOTATION

The thick target yield Y is defined as the number of neutrons or radionuclides produced per unit area of the target per unit incident α flux Φ_α and is given by

$$Y = \frac{N}{\Phi_\alpha} = \frac{N}{N_0} \frac{N_0}{\Phi_\alpha}$$

where N is the number of neutrons or radionuclides produced per unit area of the target, N_0 is the number of α s incident per unit area of the target, and Φ_α is the incident α flux. The thick target yield Y is given by

$$Y = \frac{N}{\Phi_\alpha}$$

where N_{Zm} is the atom density of element Z within the material. The stopping power, S , or $e_{\gamma} + I_{\gamma}$, for an impure element Z with atom density N_Z is defined by

$$e_{\gamma} + I_{\gamma} = -\frac{dI_{\gamma}}{N_Z dr}$$

Eq. (1) may be written in terms of its elemental constituents and the I_{γ} isotopes, $I_{\gamma i}$, as

$$Y_{m, \gamma} I_{\gamma} = \sum_{Z=1}^Z \frac{N_{Zm}}{N_m} \sum_{i=1}^{I_{\gamma}} \frac{N_{m,i}}{N_{Zm,i}} \int_0^{I_{\gamma}} \frac{N_Z}{N_{m,i}} \frac{I_{\gamma i}}{I_{\gamma}} dI_{\gamma i} \quad (2)$$

where N_{Zm} is the atom density of element Z within the material. Since the ratio of $N_{m,i}$ to $N_{Zm,i}$ is the ratio of element Z atoms within the material to the pure element Z atoms,

$$Y_{m, \gamma} I_{\gamma} = \sum_{Z=1}^Z \frac{N_Z}{N_m} \sum_{i=1}^{I_{\gamma}} \frac{N_{Z,i}}{N_Z} \int_0^{I_{\gamma}} \frac{N_Z}{N_{Z,i}} \frac{I_{\gamma i}}{I_{\gamma}} dI_{\gamma i} \quad (3)$$

Noting the similarity of the above expression to eq. (1), we may, for simplicity, approximate that

$$e_{\gamma} + I_{\gamma} = \sum_{i=1}^{I_{\gamma}} e_{\gamma i} + I_{\gamma i} \quad (4)$$

and, therefore, that $Y_{m, \gamma} = Y_m$, so

$$Y_{m, \gamma} I_{\gamma} = \sum_{Z=1}^Z \frac{N_Z}{N_m} \sum_{i=1}^{I_{\gamma}} \frac{N_{Z,i}}{N_Z} \int_0^{I_{\gamma}} \frac{N_Z}{N_{Z,i}} \frac{I_{\gamma i}}{I_{\gamma}} dI_{\gamma i} \quad (5)$$

where the $I_{\gamma i}$ represent the isotopes of the element Z and $N_{Z,i}$ is the atom density of $I_{\gamma i}$ within the material. The N_Z and $N_{Z,i}$ are the atom densities of the element Z and the isotope $I_{\gamma i}$ within the material, respectively. The N_Z and $N_{Z,i}$ are related by

$$N_Z = \sum_{i=1}^{I_{\gamma}} N_{Z,i} \quad (6)$$

and, therefore, the expression for $Y_{m, \gamma} I_{\gamma}$ may be written in terms of the $N_{Z,i}$ only. The $N_{Z,i}$ are related to the $N_{Z,i}$ by the expression $N_{Z,i} = N_{Z,i} / \sum_{i=1}^{I_{\gamma}} N_{Z,i}$. The $N_{Z,i}$ are the atom densities of the isotopes of the element Z within the material. The $N_{Z,i}$ are related to the $N_{Z,i}$ by the expression $N_{Z,i} = N_{Z,i} / \sum_{i=1}^{I_{\gamma}} N_{Z,i}$. The $N_{Z,i}$ are the atom densities of the isotopes of the element Z within the material.

Therefore, the expression for $Y_{m, \gamma} I_{\gamma}$ may be written in terms of the $N_{Z,i}$ only. The $N_{Z,i}$ are related to the $N_{Z,i}$ by the expression $N_{Z,i} = N_{Z,i} / \sum_{i=1}^{I_{\gamma}} N_{Z,i}$. The $N_{Z,i}$ are the atom densities of the isotopes of the element Z within the material. The $N_{Z,i}$ are related to the $N_{Z,i}$ by the expression $N_{Z,i} = N_{Z,i} / \sum_{i=1}^{I_{\gamma}} N_{Z,i}$. The $N_{Z,i}$ are the atom densities of the isotopes of the element Z within the material.

of product nuclides within a range of $-6 \leq \delta Z \leq 0$ and $-7 \leq \delta N \leq 0$ relative to the composite system formed by the incident α and the target nuclide. These calculations were made for all 25 stable isotopes of the 14 elements given above.

There exist little measured data for energetic α s incident on these targets, leading to the production of radionuclides, with which comparisons can be made. Figure 1 compares the calculated $^{10}\text{Be} + 2\text{ }^{12}\text{C}$ cross section with the measured data of Anders, Herges and Seitz.¹ Figure 2 compares the calculated $^{27}\text{Al} + \alpha$ ^{10}B cross section with the data extracted by Morita and Mairiel from their thick target yield measurements.² Figure 3 compares the calculated $^{27}\text{Al} + \alpha$ ^{24}Na cross section with the data of Martens and Schwennert³ and Glatzer.⁴ These comparisons suggest an uncertainty in calculated cross section data of about a factor of two.

RESULTS

The cross sections calculated with GNASH were grouped by target element and then by target yields were calculated for α s of each element using the naturally abundant isotopes of each stable isotope. In all yields for some 400 combinations of elemental target and product pattern or nuclide were calculated on a grid of α energies. For the purpose of this report, yields to all patterns other than neutrons and all stable product nuclides were removed from the tabulated yields; however, yields of other patterns and stable product nuclides can be tabulated and are available upon request.

The thick target yields were listed for α s incident on the 14 target elements, totaling 1400 yields for 28 different distributions and reactions, designated as in Table 1. The 200 α energies for each target were on a logarithmic scale. The uncertainty associated with the calculations was estimated at a factor of two, as indicated earlier with the comparison of the calculated $^{10}\text{Be} + 2\text{ }^{12}\text{C}$ cross section with the measured data of Anders et al. (Figure 1).

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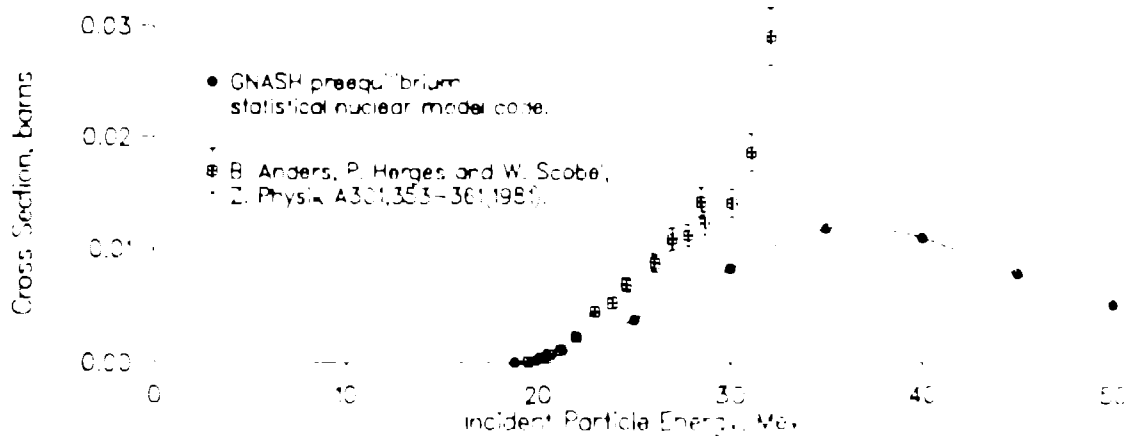


Fig. 1 Comparison of measured and GNASH calculated $^9\text{Be}(\alpha, n)^{12}\text{C}$ cross section

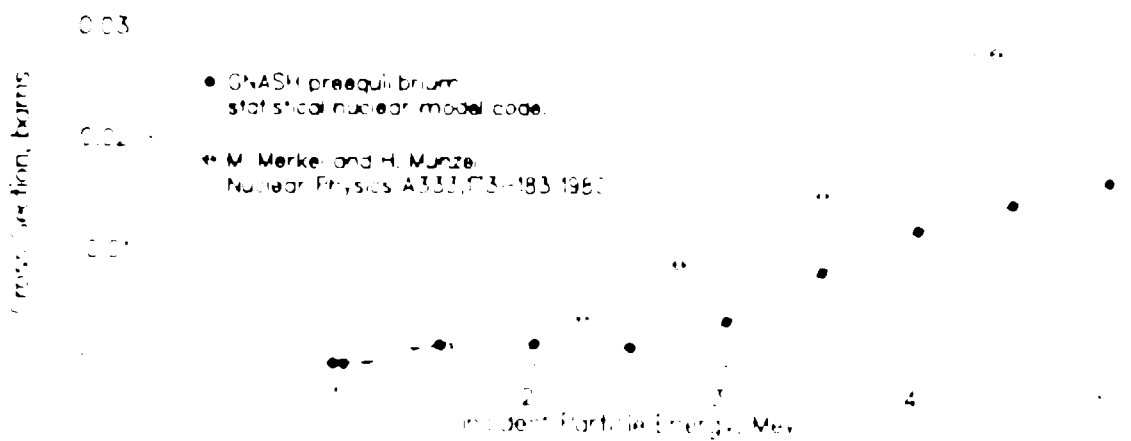


Fig. 2 Comparison of measured and GNASH calculated $^9\text{Al}(\alpha, n)^{12}\text{Si}$ cross section

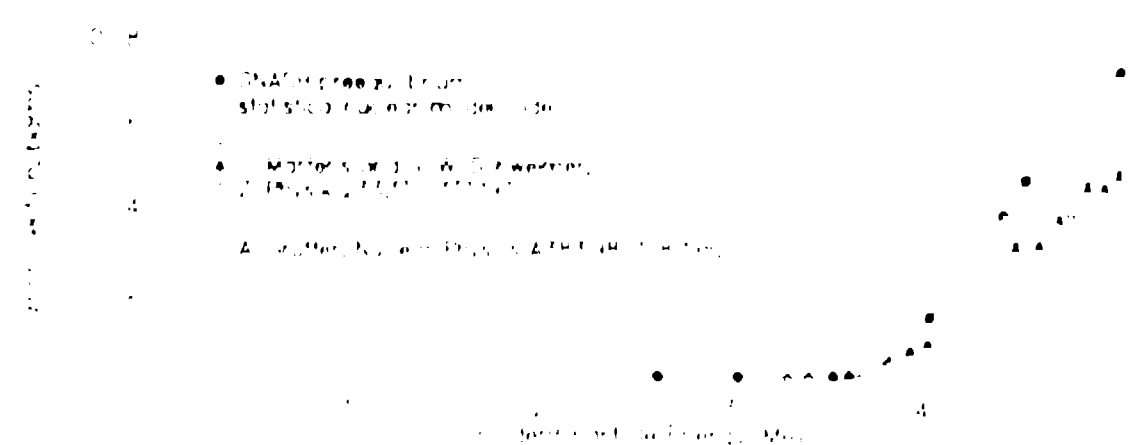


Fig. 3 Comparison of measured and GNASH calculated $^9\text{Al}(\alpha, p)^{10}\text{Si}$ cross section

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

[illegible][illegible]

Date	E		M		M		M		M		M		M	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1945	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1946	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1947	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1948	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1949	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1950	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1951	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1952	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1953	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1955	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1956	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1957	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1958	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1959	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1960	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1961	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1962	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1963	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1964	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1965	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1966	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1967	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1968	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1969	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1970	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1971	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1972	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1973	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1974	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1976	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1977	1	2	3	4	5	6	7	8	9	10	11	12	13	14

$\frac{1}{2} \times 10^{-6}$ m. $\frac{1}{2} \times 10^{-6}$ m. $\frac{1}{2} \times 10^{-6}$ m.

Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses was significantly higher than the number of incorrect responses in all cases. The number of correct responses was significantly higher than the number of incorrect responses in all cases. The number of correct responses was significantly higher than the number of incorrect responses in all cases.

[illegible]

Table 4 (Continued)

[illegible]

Table 5

Alphas on C-Triple-Target Radionuclide Yields

[illegible]

• **At the time**

At the end of the 19th century, the first attempts were made to

	A. A. C. P. 2						
	M ₀	M ₁	M ₂	M ₃	M ₄	M ₅	M ₆
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
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11	11	11	11	11	11	11	11
12	12	12	12	12	12	12	12
13	13	13	13	13	13	13	13
14	14	14	14	14	14	14	14
15	15	15	15	15	15	15	15
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18	18	18	18	18	18	18	18
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35	35	35	35	35	35	35	35
36	36	36	36	36	36	36	36
37	37	37	37	37	37	37	37
38	38	38	38	38	38	38	38
39	39	39	39	39	39	39	39
40	40	40	40	40	40	40	40
41	41	41	41	41	41	41	41
42	42	42	42	42	42	42	42
43	43	43	43	43	43	43	43
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45	45	45	45	45	45	45	45
46	46	46	46	46	46	46	46
47	47	47	47	47	47	47	47
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71	71	71	71	71	71	71	71
72	72	72	72	72	72	72	72
73	73	73	73	73	73	73	73
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75	75	75	75	75	75	75	75
76	76	76	76	76	76	76	76
77	77	77	77	77	77	77	77
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93	93	93	93	93	93	93	93
94	94	94	94	94	94	94	94
95	95	95	95	95	95	95	95
96	96	96	96	96	96	96	96
97	97	97	97	97	97	97	97
98	98	98	98	98	98	98	98
99	99	99	99	99	99	99	99
100	100	100	100	100	100	100	100

Table 7

Alphas on Ne Thick-Target Radiochemical Yields

Product	Incident Alpha Energy					
	5 Mev	10 Mev	20 Mev	30 Mev	40 Mev	50 Mev
Ne-19	1.9E-06	4.6E-05	1.9E-04	9.7E-04	2.9E-03	2.3E-03
Ne-20	0	0	2.0E-07	1.4E-06	3.2E-05	3.6E-05
Ne-21	0	0	0	0	0	1.53E-11
Ne-22	0	0	0	0	0	1.83E-10
Ne-23	0	0	0	6.5E-07	5.3E-06	1.21E-05
Ne-24	0	0	0	0	0	5.45E-11
Ne-25	0	0	0	0	0	1.7E-20
Ne-26	0	0	0	0	6.9E-14	2.8E-08
Ne-27	0	0	0	0	0	2.04E-06
Ne-28	0	0	0	8.1E-12	6.0E-08	1.30E-08
Ne-29	0	0	0	0	3.9E-10	1.30E-08
Ne-30	0	0	0	4.6E-10	1.1E-07	6.24E-06
Ne-31	0	0	0	0	5.3E-09	5.15E-08
Ne-32	0	0	0	4.7E-14	7.9E-07	5.05E-04
Ne-33	0	0	0	3.6E-07	1.0E-05	2.21E-04
Ne-34	0	0	4.6E-09	1.0E-07	2.1E-06	1.19E-05
Ne-35	0	0	2.34E-12	1.3E-07	5.6E-06	6.89E-05
Ne-36	0	0	0	0	1.5E-11	1.44E-07
Ne-37	0	0	0	0	2.6E-11	2.25E-07
Ne-38	0	0	0	4.1E-07	2.1E-06	1.67E-05
Ne-39	0	0	4.55E-09	1.2E-07	1.7E-06	6.18E-06
Ne-40	0	0	4.43E-09	1.30E-07	4.85E-07	1.41E-06
Ne-41	0	0	0	0	0	3.94E-09
Ne-42	0	0	0	6.13E-07	1.1E-05	3.79E-05
Ne-43	0	0	1.37E-05	2.33E-04	3.7E-04	4.22E-04
Ne-44	9.06E-09	1.32E-07	4.67E-06	2.7E-05	3.8E-05	3.81E-05
Ne-45	1.72E-08	1.13E-06	1.39E-06	8.97E-06	9.6E-06	9.07E-06
Mg-24	0	0	0	0	0	1.33E-13
Mg-25	0	0	0	0	0	1.76E-17
Mg-26	0	5.69E-07	1.40E-05	3.50E-05	3.7E-05	3.61E-04

Table 8

Alphas on Na Thick-Target Radiochemical Yields

Product	Incident Alpha Energy					
	5 Mev	10 Mev	20 Mev	30 Mev	40 Mev	50 Mev
Na-22	3.9E-06	5.0E-05	6.6E-04	1.0E-03	2.0E-03	6.21E-03
Na-23	0	0	2.00E-06	7.0E-05	2.3E-04	5.81E-04
Na-24	0	0	0	0	2.2E-11	4.42E-10
Na-25	0	0	0	0	0	1.7E-17
Na-26	0	0	0	0	0	2.54E-17
Na-27	0	0	0	3.2E-12	6.8E-06	8.61E-05
Na-28	0	0	0	0	4.33E-15	1.35E-07
Na-29	0	0	0	0	6.15E-09	3.92E-07
Na-30	0	0	0	0	0	3.33E-07
Na-31	0	0	0	0	1.12E-11	2.50E-07
Na-32	0	0	0	8.9E-12	1.0E-06	1.29E-05
Na-33	0	0	5.56E-06	1.62E-05	9.1E-04	6.73E-04
Na-34	0	0	0	5.8E-06	7.5E-05	1.34E-04
Na-35	0	0	1.23E-07	1.5E-06	6.6E-05	1.54E-04
Mg-24	0	0	0	0	0	1.91E-12
Mg-25	0	0	0	0	0	2.93E-17
Mg-26	0	0	0	2.1E-15	1.1E-06	2.93E-05
Al-27	0	0	1.94E-06	1.2E-05	1.2E-05	1.12E-04
Al-28	0	0	0	1.7E-04	3.44E-04	1.47E-04

Table 9

Alphas on Mg Thick-Target Radiochemical Yields

Product	Incident Alpha Energy					
	5 Mev	10 Mev	20 Mev	30 Mev	40 Mev	50 Mev
Mg-24	2.9E-06	3.0E-05	3.9E-04	6.0E-04	1.2E-03	1.64E-03
Mg-25	0	0	0	0	0	4.87E-17
Mg-26	0	0	0	0	0	1.1E-17
Mg-27	0	0	0	0	0	1.1E-17
Mg-28	0	0	0	0	0	1.1E-17
Mg-29	0	0	0	0	0	1.1E-17
Mg-30	0	0	0	0	0	1.1E-17
Mg-31	0	0	0	0	0	1.1E-17
Mg-32	0	0	0	0	0	1.1E-17
Mg-33	0	0	0	0	0	1.1E-17
Mg-34	0	0	0	0	0	1.1E-17
Mg-35	0	0	0	0	0	1.1E-17
Mg-36	0	0	0	0	0	1.1E-17
Mg-37	0	0	0	0	0	1.1E-17
Mg-38	0	0	0	0	0	1.1E-17
Mg-39	0	0	0	0	0	1.1E-17
Mg-40	0	0	0	0	0	1.1E-17
Mg-41	0	0	0	0	0	1.1E-17
Mg-42	0	0	0	0	0	1.1E-17
Mg-43	0	0	0	0	0	1.1E-17
Mg-44	0	0	0	0	0	1.1E-17
Mg-45	0	0	0	0	0	1.1E-17
Mg-46	0	0	0	0	0	1.1E-17
Mg-47	0	0	0	0	0	1.1E-17
Mg-48	0	0	0	0	0	1.1E-17
Mg-49	0	0	0	0	0	1.1E-17
Mg-50	0	0	0	0	0	1.1E-17

1. *Journal of the American Medical Association*, 1990; 263: 1025-1028.

M ₁		M ₂		M ₃		M ₄		M ₅		M ₆		M ₇		M ₈		M ₉		M ₁₀		M ₁₁		M ₁₂		M ₁₃		M ₁₄		M ₁₅		M ₁₆		M ₁₇		M ₁₈		M ₁₉		M ₂₀		M ₂₁		M ₂₂		M ₂₃		M ₂₄		M ₂₅		M ₂₆		M ₂₇		M ₂₈		M ₂₉		M ₃₀		M ₃₁		M ₃₂		M ₃₃		M ₃₄		M ₃₅		M ₃₆		M ₃₇		M ₃₈		M ₃₉		M ₄₀		M ₄₁		M ₄₂		M ₄₃		M ₄₄		M ₄₅		M ₄₆		M ₄₇		M ₄₈		M ₄₉		M ₅₀		M ₅₁		M ₅₂		M ₅₃		M ₅₄		M ₅₅		M ₅₆		M ₅₇		M ₅₈		M ₅₉		M ₆₀		M ₆₁		M ₆₂		M ₆₃		M ₆₄		M ₆₅		M ₆₆		M ₆₇		M ₆₈		M ₆₉		M ₇₀		M ₇₁		M ₇₂		M ₇₃		M ₇₄		M ₇₅		M ₇₆		M ₇₇		M ₇₈		M ₇₉		M ₈₀		M ₈₁		M ₈₂		M ₈₃		M ₈₄		M ₈₅		M ₈₆		M ₈₇		M ₈₈		M ₈₉		M ₉₀		M ₉₁		M ₉₂		M ₉₃		M ₉₄		M ₉₅		M ₉₆		M ₉₇		M ₉₈		M ₉₉		M ₁₀₀	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																				

25

1. *Phragmites* L. Trin. *Phragmites communis* Trin.

[illegible]

1. *Journal of the American Medical Association*, 1997; 277: 1033-1038.

1. *Journal of the American Medical Association*, 1990; 263: 1001-1005.

Table 12

Alpha on 0.5 Thick Target Radonclide Yields

Product Nuclide	Z	Mass	Incident Alpha Energy				
			5 Mev	10 Mev	20 Mev	30 Mev	50 Mev
Ne-20	10	20	1.38E-04	1.43E-04	1.52E-04	1.44E-04	2.64E-03
Ne-21	10	21	0	1.40E-07	1.15E-06	5.49E-06	1.96E-05
Ne-22	10	22	0	0	0	0	1.01E-18
Ne-23	10	23	0	0	0	0	5.75E-11
Ne-24	10	24	0	0	0	0	3.27E-15
Ne-25	10	25	0	0	2.54E-14	1.76E-06	5.60E-05
Ne-26	10	26	0	0	0	2.01E-06	5.73E-06
Ne-27	10	27	0	0	1.65E-11	8.03E-07	1.66E-05
Ne-28	10	28	0	0	0	9.90E-08	4.31E-06
Ne-29	10	29	0	0	9.00E-12	3.20E-07	1.98E-06
Ne-30	10	30	0	5.10E-16	8.10E-05	1.13E-04	3.99E-04
Ne-31	10	31	0	0	1.73E-06	9.13E-06	2.18E-04
Ne-32	10	32	0	4.11E-06	4.13E-05	1.91E-04	4.40E-04
Ne-33	10	33	0	0	0	0	3.18E-12
Ne-34	10	34	0	0	3.43E-15	1.85E-07	2.66E-06
Ne-35	10	35	0	0	0	1.15E-10	1.15E-08
Ne-36	10	36	0	3.55E-09	1.08E-06	1.61E-06	1.68E-06
Ne-38	10	38	1.20E-08	6.20E-08	9.58E-07	9.49E-06	9.49E-05

Table 13

Alpha on 0.5 Thick Target Radonclide Yields

Product Nuclide	Z	Mass	Incident Alpha Energy				
			5 Mev	10 Mev	20 Mev	30 Mev	50 Mev
Ne-20	10	20	1.38E-04	1.43E-04	1.52E-04	1.44E-04	2.64E-03
Ne-21	10	21	0	1.40E-07	1.15E-06	5.49E-06	1.96E-05
Ne-22	10	22	0	0	0	0	1.01E-18
Ne-23	10	23	0	0	0	0	5.75E-11
Ne-24	10	24	0	0	0	0	3.27E-15
Ne-25	10	25	0	0	2.54E-14	1.76E-06	5.60E-05
Ne-26	10	26	0	0	0	2.01E-06	5.73E-06
Ne-27	10	27	0	0	1.65E-11	8.03E-07	1.66E-05
Ne-28	10	28	0	0	0	9.90E-08	4.31E-06
Ne-29	10	29	0	0	9.00E-12	3.20E-07	1.98E-06
Ne-30	10	30	0	5.10E-16	8.10E-05	1.13E-04	3.99E-04
Ne-31	10	31	0	0	1.73E-06	9.13E-06	2.18E-04
Ne-32	10	32	0	4.11E-06	4.13E-05	1.91E-04	4.40E-04
Ne-33	10	33	0	0	0	0	3.18E-12
Ne-34	10	34	0	0	3.43E-15	1.85E-07	2.66E-06
Ne-35	10	35	0	0	0	1.15E-10	1.15E-08
Ne-36	10	36	0	3.55E-09	1.08E-06	1.61E-06	1.68E-06
Ne-38	10	38	1.20E-08	6.20E-08	9.58E-07	9.49E-06	9.49E-05