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POTENTIAL PROBLEMS IN U-233 PRODUCTION

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POTENTIAL PROBLEMS IN U-233 PRODUCTION

By

R. J. Kofoed

Advance Technical Planning
Research and Engineering Operation
Chemical Processing Department

November 19, 1963

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POTENTIAL PROBLEMS IN U-233 PRODUCTION

The interaction of alpha particles with elements of low atomic number ($Z < 19$) leads to the emission of neutrons by way of the so called "(α, n)" reaction. The α emission rate and α particle energy of U-233 (specific activity of 2.09×10^{10} d/m/gm and α energy of 4.8 Mev) are low and as such neutrons from (α, n) reactions are negligible. However, U-232 has a much higher α emission rate and α energy (specific activity of 4.52×10^{13} d/m/gm and α energy of 5.3 Mev) and (α, n) neutrons are not negligible. In this situation, the light element concentration may become one of the limiting factors in the production of U-233 acceptable for projected uses. Neutron production by the (α, n) reaction was therefore calculated by the method presented by E. D. Arnold*, as functions of U-232 and light element concentrations. Table I below shows the concentration of the light element which gives a neutron emission rate of 20 neutrons per kilogram-second and 20 neutrons per gram-second, if no other (α, n) elements are present, as a function of U-232 content. The spontaneous fission neutron production in U-233 is insignificant compared with the (α, n) reactions and has been ignored.

If a specification of 20 n/kg-sec is placed on U-233, the sensitivity of the (α, n) reaction to U-232 and impurity contents will place severe demands on processing and analytical capabilities. Much tighter process control would have to be exercised to maintain the light element impurity content (as compared to plutonium processing) at acceptable levels. It is probable that a new or modified process would be necessary to produce U-233 of the desired purity.

Work would be needed to improve or develop new analytical methods for light element impurities to place our analytical capabilities in a position to meet the requirements imposed by the more restrictive (α, n) neutron emission rate. Neutron counting of the metal button and/or the fabricated shape would be needed for process control.

Table I also shows that the current processing capabilities would produce a uranium product which would easily meet a 20 n/g-sec specification. In fact, if the current levels of light elements found in plutonium are assumed, it would be possible to produce material of the following neutron emission rate:

0 ppm U-232	0.340 n/g-sec	(340 n/kg-sec)
1 ppm U-232	0.353 n/g-sec	(353 n/kg-sec)
10 ppm U-232	0.446 n/g-sec	(446 n/kg-sec)
100 ppm U-232	1.377 n/g-sec	(1.377 n/kg-sec)

* Reference: "Radiation Limitations on Recycle of Fuels", E.D. Arnold. Second United Nations Conference on Peaceful Uses of Atomic Energy, Geneva - 1958, Volume 13, p 237; Paper 1838, Session B-15.

TABLE I

POTENTIAL LIMITATION ON IMPURITIES IN U-233
BY THE (α, n) REACTION

The values quoted below are the concentrations of each element required to produce neutrons at the indicated rate assuming (1) no other light element is present, and (2) U-232 is present in the indicated concentrations.

Neutrons from (α, n)	20 Neutrons/Kg-sec				20 Neutrons/g-sec			
U-232 Content (ppmp U-233)	0 ppm	1 ppm	10 ppm	100 ppm	0 ppm	1 ppm	10 ppm	100 ppm
Element	Impurity Concentration (ppmp U-233)				Impurity Concentration (ppmp U-233)			
Lithium	3.3	3.3	3.1	2.1	3.3×10^3	3.3×10^3	3.1×10^3	2.03×10^3
Beryllium	0.25	0.25	0.23	0.11	256	253	228	115
Boron	1.1	1.1	1.0	0.6	1.1×10^3	1.1×10^3	1.0×10^3	585
Fluorine	3.8	3.7	3.2	1.1	3.8×10^3	3.6×10^3	3.1×10^3	1.2×10^3
Carbon	185	178	135	39	1.85×10^5	1.8×10^5	1.35×10^5	3.9×10^4
Oxygen	430	429	375	169	4.3×10^5	4.3×10^5	3.75×10^5	1.7×10^5
Sodium	45	43	31	8	4.5×10^4	4.3×10^4	3.1×10^4	7.7×10^3
Magnesium	58	49	21	3	5.8×10^4	4.9×10^4	2.1×10^4	3.1×10^3
Aluminum	96	89	55	11	9.6×10^4	8.9×10^4	5.5×10^4	1.1×10^3
Silicon	400	365	32	3	4.0×10^5	3.65×10^5	3.2×10^4	3.4×10^3
Phosphorous	3.0×10^3	2.6×10^3	1.3×10^3	218	3.0×10^6	2.6×10^6	1.3×10^6	2.2×10^4
Sulfur	3.5×10^4	3.4×10^3	375	38	3.5×10^7	3.4×10^6	3.8×10^5	3.8×10^4
Chlorine	1.1×10^3	429	65	7	1.1×10^6	4.3×10^5	6.5×10^4	6.8×10^3
Potassium	3.1×10^3	1.5×10^3	267	26	3.1×10^6	1.5×10^6	2.6×10^5	2.6×10^4