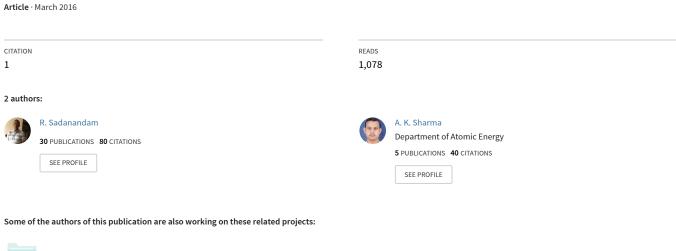
Boron Equivalent For Nuclear Grade Natural Uranium – An Explanation



Project

Recovery of high purity Co and Ni from carbonate raw material of Ca, Co and Ni as major constituents by Hydrometallurgy. View project

Boron Equivalent For Nuclear Grade Natural Uranium – An Explanation

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<u>Abstract</u>

Boron equivalent for nuclear grade natural uranium is estimated using fundamental data to be 6 ppm and the procedure is explained.

Various impurities in nuclear grade natural uranium have a number of isotopes at different % natural abundances and also have widely varying thermal neutron absorption cross-sections. These impurities are permitted at different levels in the nuclear grade material. A product of concentration levels in ppm(c), percentages natural abundances of impurity element's isotopes (p) and thermal neutron absorption cross-sections in barns(n) divided by 100 (c.p.n/100) gives an impact factor as given in Table.2. These are added to give total impact factor. Table.1 gives the list of impurities and their allowed levels in nuclear grade natural uranium. Table 2 deals with isotopes of impurity elements, their % natural abundances, thermal neutron absorption cross – sections (barns, n) and respective impact factors.

Impurity	Maximum		
Elements	concentration		
	(c), μg/g		
В	0.12		
Cd	0.12		
Sm	0.10		
Eu	0.04		
Gd	0.04		
Dy	0.10		
Er	0.10		
Y	0.10		
Ce	0.20		
Yb	0.10		
Th	10		
Mg	25		
Al	100		
С	800		
Cr	65		
Mn	25		
Fe	150		
Co	1.2		
Ni	100		

Table1: Impurity elements and their concentration in nuclear grade natural uranium¹

Total impact is obtained by sum of individual impact factors, which works out to be 4571.08. For 6ppm Boron as the only impurity, the estimated impact factor is 4535.33. Therefore, boron equivalent of the material is 6 ppm. For low enriched uranium fuels, the boron equivalent permitted may vary depending on the average neutron flux to be maintained. Part specification for nuclear grade uranium oxide which is in the enrichment level between 0.72% and 5% is given in ASTM standard³.

Isotopes of	% natural	Thermal neutron	Impact
impurity	abundance	absorption cross –	factor
elements	(p)	sections (barns),(n)	(c.p.n/100)
B^{10}	19.70	3837	90.71
Cd ¹¹³	12.30	20000	295.20
Sm ¹⁴⁹	13.82	41500	573.53
Eu ¹⁵³	52.23	320	6.69
Gd ¹⁵⁵	14.70	58000	341.04
Gd ¹⁵⁷	15.68	240000	1505.28
Dy ¹⁶¹	18.88	600	11.33
Dy^{162}	25.53	140	3.57
Dy ¹⁶³	24.97	130	3.25
Dy ¹⁶⁴	28.18	2000	56.36
Er ¹⁶⁷	22.94	700	16.06
Y^{89}	100.00	1.3	0.13
Ce ¹⁴⁰	88.48	0.6	0.11
Ce ¹⁴²	11.07	1	0.02
Yb ¹⁶⁸	0.014	11000	0.15
Yb ¹⁷⁴	31.84	46	1.46
Yb ¹⁷⁶	12.73	7	0.09
Th ²³²	100.00	7.4	74.00
Mg^{24}	78.60	0.03	0.59
Mg^{25}	10.11	0.3	0.76
Mg^{26}	11.29	0.027	0.08
Al^{27}	100.00	0.235	23.5
C^{12}	99.89	0.0034	2.72
Cr ⁵⁰	4.81	17	46.63
Cr ⁵²	83.76	0.8	43.56
Cr ⁵³	9.55	18	111.74
Mn ⁵⁵	100.00	13.3	332.50
Fe ⁵⁴	5.84	2.9	25.40
Fe ⁵⁶	91.68	2.7	371.30
Fe ⁵⁷	2.17	2.5	8.14
Co ⁵⁹	100.00	19	22.80
Ni ⁵⁸	67.76	4.4	298.14
Ni ⁶⁰	26.16	2.6	68.02
Ni ⁶²	3.66	15	54.90
Total impact factor			4571.08

Table 2: Isotopes of impurity elements, their % natural abundances, thermal neutron absorption cross – sections (barns, n) and respective impact factors²

Reference:

- 1. http://bts.barc.gov.in/AuthStatic/auth_static.php/UED/Pages/Uranium.html#U_NukGrade
- 2. Lange's handbook of chemistry 8th edition, 1952. Handbook publishers Inc., Sandusky, Ohio, USA.
- 3. Standard Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder, ASTM Designation C 753-99.