NBL Program Office

U.S. Department of Energy

Certificate of Analysis

Certified Reference Material C123 (1-7)

Uranium (U_3O_8) 18 Element Impurity Standard in Powder Form

This Certified Reference Material (CRM) is an impurity standard intended for use in determining the non-volatile impurity content of uranium fuel materials. Each unit of C123 (1-7) consist of six (6) bottles containing normal uranium oxide-U_3O_8 as matrix material, approximately 25 gram per bottle, to which eighteen selected elements have been added in varying concentrations. A seventh bottle, completing the unit, consists of matrix material alone.

The U_3O_8 matrix material was pulverized, sieved and blended before the impurity elements were added in solution form. As each of the seven levels was prepared, it was subjected to a wet-dry mixing procedure, then dried, ignited, milled, reblended and bottled. NOTE: NBL does not guarantee C123(1-7) will be absolutely dry when received therefore, *it is recommended that the material be dried at 110°C for one (1) hour before use.*

Most of the elements certified (thirteen out of eighteen) were determined by two different methods of analysis. Ten separate sample were analyzed for each level by each method indicated and the data were combined. The certified value is the mean of these measurements. Where only one analytical method was used, the indicated uncertainties are 95% confidence intervals for the mean. Where two analytical methods were used and a t-test indicated no statistically significant difference, the indicated uncertainties are 95% confidence interval for the mean. Where two analytical methods were used and a t-test indicated a statistically significant difference the indicated uncertainties include the 95% confidence limits of both methods. In the calculation to U metal basis 0.848 gram U per one gram U_3O_8 was assumed.

Preparation of C123 (1-7) was carried out by P. M. Santoliquido, M. K. Marsaile and K. S. Scheidelman. Determinations by spectrophotometric method were performed by C. C. Marcelo (for boron and tin) M. K. Marsailes (for iron, molybdenum, and nickel), K. S. Scheidelman (for chromium and iron), G. A. Sowell (for vanadium), and A. M. Voeks (for silicon, tin, and zirconium). Measurements by flame atomic absorption spectrometry were made by A. J. Busch and V. M. Drabek; K. S. Scheidelman assisted them with ample preparation. Determinations by graphite furnace atomic absorption spectrometry, inductively coupled plasma emission spectrometry, tungsten filament Zeeman atomic absorption spectrometry, and anodic tripping voltammetry were performed by P. M. Santoliquido. Statistical assessment of the data was performed by M. M. Smith. Project technical direction was performed by P. M. Santoliquido; overall direction and coordination of the preparation certification and issuance of this CRM were provided by N. M. Trahey and P. M. Santoliquido.

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Micrograms of Impurity Element per gram of Uranium (as metal)

Element	123-1	123-2	123-3	123-4	123-5	123-6	123-7	Method
Aluminum	205.1 ± 4.4	98.4 ± 1.7	49.1 ± 3.5	21.6 ± 2.6	11.1 ± 1.7	5.6 ± 0.8	<2	(2,3)
Calcium	218 ± 13	107 ± 14	52.2 ± 4.4	24.1 ± 2.6	12.6 ± 1.4	7.9 ± 2.5	4.1 ± 2.5	(3,4)
Iron	212.2 ± 3.1	109.7 ± 2.4	58.5 ± 2.2	27.2 ± 1.1	17.5 ± 1.4	12.2 ± 1.1	7.9 ± 2.7	(1,3)
Nickel	200.0 ± 7.5	100.1 ± 4.3	52.1 ± 0.6	21.3 ± 0.9	11.3 ± 1.4	6.3 ± 0.5	2.0 ± 0.1	(1,3)
Silicon	245 ± 21	120.2 ± 7.2	56.5 ± 3.6	24.2 ± 1.3	14.8 ± 0.6	10.9 ± 0.6	8.0 ± 0.8	(1)
Sodium	390.9 ± 9.0	174.0 ± 4.1	79.5 ± 2.0	42.4 ± 1.8	24.2 ± 2.4	14.5 ± 1.1	4.0 ± 1.2	(3)
Zinc	222.0 ± 5.4	112 ± 11	52.7 ± 5.4	20.4 ± 1.7	11.7 ± 0.7	6.1 ± 0.6	0.3 ± 0.1	(3,4)
Zirconium	256 ± 39	134 ± 15	60 ± 15	20 ± 8	13 ± 1	<10	<10	(1,3)
Chromium	105.9 ± 5.4	54.9 ± 2.3	23.1 ± 0.7	12.9 ± 0.4	7.6 ± 0.4	4.3 ± 0.5	2.3 ± 0.4	(1,2)
Magnesium	102.3 ± 3.0	50.8 ± 1.3	20.3 ± 0.4	11.1 ± 0.9	5.5 ± 0.2	2.9 ± 0.7	1.8 ± 0.3	(2,3)
Molybdenum	97.7 ± 6.9	48.9 ± 5.0	20.6 ± 0.4	10.1 ± 0.2	5.0 ± 0.2	2.3 ± 0.3	<0.2	(1,3)
Copper	52.8 ± 4.8	25.6 ± 2.5	10.8 ± 2.5	5.9 ± 1.4	2.6 ± 0.2	1.17 ± 0.07	0.20 ± 0.05	(2,3)
Lead	43.9 ± 9.7	22.8 ± 3.2	9.5 ± 0.9	4.9 ± 0.7	2.8 ± 0.3	1.3 ± 0.7	0.4 ± 0.1	(5,6)
Manganese	51.9 ± 2.0	27.4 ± 2.4	11.8 ± 1.1	5.6 ± 0.3	3.1 ± 0.2	1.2 ± 0.2	0.27 ± 0.05	(2,3)
Tin	48.0 ± 3.9	23.7 ± 0.9	9.5 ± 0.7	5.9 ± 0.3	2.8 ± 0.5	1.3 ± 0.1	0.2 ± 0.1	(1)
Vanadium	50.5 ± 2.1	25.0 ± 1.7	9.4 ± 1.3	4.9 ± 0.5	2.7 ± 0.3	1.0 ± 0.3	0.2 ± 0.1	(1,3)
Boron	6.0 ± 0.9	2.3 ± 0.3	1.07 ± 0.08	0.51 ± 0.04	0.28 ± 0.05	0.11 ±0.01	<0.07	(1)
Cadmium	5.3 ± 0.2	2.4 ± 0.1	1.10 ± 0.04	0.48 ± 0.12	0.28 ± 0.04	0.12 ±0.01	<0.02	(2)

Method Code: (1) = Spectrophotometry
(2) = Graphite Furnace Atomic Absorption
(3) = Inductively Coupled Plasma Emission
(4) = Flame Atomic Absorption
(5) = Tungsten Filament Zeeman AA
(6) = Anodic Stripping Voltammetry