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Market Available Virgin Nickel Analysis Data Summary Interpretation Report

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Introduction

Assessment of Commercial Nickel Overview

Collection, analysis, and assessment of market available nickel samples for their radionuclide content is being conducted to support efforts of the Purchase Area Community Reuse Organization (PACRO) to identify and implement a decontamination method that will allow for the sale and recycling of contaminated Paducah Gaseous Diffusion Plant (PGDP) nickel-metal stockpiles. In order to plan, conduct, and assess analytical work on commercially available nickel-metal samples, a Nickel Project Team was formed. The Project Team is comprised of personnel with technical and regulatory expertise from the University Of Kentucky – Kentucky Research Consortium for Energy and Environment (UK-KRCEE), University of Kentucky College of Chemical and Materials Engineering, the Commonwealth of Kentucky Radiation Control Branch - Radiation and Environmental Monitoring Laboratory, the United States Enrichment Corporation (USEC), and the USEC Radiation Laboratory.

The objectives of the Nickel Project address the lack of radionuclide data in market available nickel metal. The lack of radionuclide data for commercial-recycled nickel metal or commercial-virgin nickel metal has been detrimental to assessments of the potential impacts of the free-release of recycled PGDP nickel on public health. The nickel project, to date, has only evaluated "virgin" nickel metal which is derived from non-recycled sources.

The objectives of the nickel project were to:

- Assess levels of selected radionuclides in commercial virgin nickel that can be use to evaluate Paducah Gaseous Diffusion Plant (PGDP) decontaminated nickel.

- Establish a validated and defensible dataset for commercial virgin nickel that can be use for contaminant assessment, and

- Provide a dataset for commercial virgin nickel to evaluate potential radiation dose and risk for contaminants in nickel from PGDP.

Once established, the dataset for selected radionuclides in market-available virgin-nickel metal can be used in the assessment of potential radiation impacts resulting from use of decontaminated/recycled PGDP nickel metal. Assessments of impacts from the use of decontaminated/recycled PGDP nickel will be conducted for industrial products and for the use of decontaminated/recycled PGDP nickel in consumer products.

The activities of radionuclides in market-available virgin nickel metal will be compared to the activities of radionuclides in recycled/decontaminated PGDP nickel metal. If the levels of radioactivity in the recycled/decontaminated PGDP nickel can be demonstrated to be equivalent to or less than the levels of radionuclides in market-available virgin nickel metal, documentation will be provided to federal and state radiation regulatory agencies requesting an exemption from release restrictions for the commercial use of the decontaminated/recycled PGDP nickel. Additionally, such information could be provided to congress, the scrap metal industry, and the public in order to gain support for the release and recycling of decontaminated PGDP nickel.

Analytical results from seven nickel ingot samples did not detect the presence of cobalt-60 (^{60}Co), strontium-90 (^{90}Sr), cesium-137 (^{137}Cs), uranium-238 (^{238}U), uranium-235 (^{235}U), uranium-234 (^{234}U), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), thorium-228 (^{228}Th) and americium-241 (^{241}Am). Thorium-232 (^{232}Th), thorium-230 (^{230}Th) and neptunium-237 (^{237}Np) were detected in one to four samples. Technetium-99 (^{99}Tc) was detected in four of the seven samples.

Based on process knowledge and the results of the above analyses for PGDP nickel, it was determined commercial virgin nickel should be analyzed for the following radionuclides: ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, ^{238}U, ^{235}U, ^{234}U, ^{228}Th, ^{230}Th, ^{232}Th, ^{238}Pu, $^{239/240}$Pu, ^{241}Am, ^{237}Np, and potassium-40 (^{40}K).

Data Quality Objectives

The lack of existing data for radionuclides that could be present in commercial nickel represented the major problem that required assessment. Based on the lack of data for commercial nickel metal, the scope of the study was the development of a validated radiation baseline dataset for radionuclides in commercial nickel that could be used to assess PGDP recycled nickel. Because there was lack of validated data, it was determined that new data to characterize commercial nickel was essential in assessing the "potential radiation dose" from commercially available and for recycled nickel.

The lack of radiation data for commercial nickel necessitated the acquisition of nickel samples. Furthermore to ensure a non-biased basis for the radiation baseline dataset, two independent analytical laboratories were employed to analyze the radionuclide activity in commercially available nickel.

Sampling and Analysis Plan

A sampling and analysis plan was developed (see Attachment 1 for details) to address the lack of radiation data for commercial available nickel. Commercially nickel was obtained from three suppliers. The purchased of nickel from different suppliers was necessary to ensure multiple source of commercial virgin nickel were utilized to establish a radiation baseline dataset. A solid nickel and a powdered nickel were obtained from each vendor. Sample nickel was obtained from the following sources:

Alfa Aesar Ward Hill, MA	Nickel Rod Powder	99.5% Purity 99.8% Purity –325 Mesh
Belmont Metals Brooklyn, NY	Nickel Cathodes Powder	99.9% Purity 99.9% Purity 100-325 Mesh
Atlantic Equipment Engrs Bergenfield, NJ	Metal Squares Powder	99.99+% Purity 99.9% Purity-325 Mesh

The analytical approach utilized two independent radioanalytical laboratories, the USEC laboratory and the Kentucky Cabinet for Health and Family Services' Radiation Health and Toxic Agents Branch laboratory, for analysis of the commercial nickel. Each laboratory employed their established laboratory procedures to analyze the nickel samples. Data was provided by each laboratory to a third party for verification and assessment.

To ensure analytical results can be compared the laboratories agreed on the following analytical methods. Gamma Spectroscopy on solid or dissolved nickel will be used to quantify ^{40}K, ^{60}Co, ^{137}Cs and ^{241}Am. Alpha Spectroscopy will be used to quantify ^{238}U, ^{235}U, ^{234}U, ^{228}Th, ^{230}Th, ^{232}Th, ^{238}Pu, $^{239/240}$Pu, and ^{237}Np. USEC will use an extraction and alpha counting for 237Np. Liquid Scintillation was used to quantify ^{99}Tc. Gas Proportional Counting will be used to quantify ^{90}Sr.

Since the Nuclear Regulatory Commission has not promulgated regulatory limits for release of nickel or other material, both laboratories were to use analytical method detection limits as low as achievable.

Sample Preparation

The bar and plate nickel obtained from suppliers were size-reduced by the University of Kentucky in order to provide both laboratories with material that was readily usable for laboratory analysis. One hundred grams of each sample was provided to the laboratories and the remainder reserved for future needs. One duplicate sample was prepared for analysis. The University of Kentucky distributed the prepared samples to the analytical laboratories with appropriate chain-of-custody or sample information.

Results

Table 1 provides the data for the analyses conducted by each of the laboratories. Although the dataset is small; averages, standard deviation, and confidence intervals were developed for each set of laboratory data. These descriptive statistics were used to compare data from the two (2) laboratories. Because of the small sample size, the descriptive statistics were not used for assessment of the datasets.

As shown In Table 1, the MDAs for some radionuclide datasets are orders of magnitude less than the other set of data. In order, to assess the differences in MDAs provided by the laboratories, the raw data for plutonium-238 and plutonium-239 from both

laboratories was used to recalculate the MDAs. NRC's "*NUREG 1507, Minimum Detectable Concentrations with Typical Survey Instruments for Various Contaminants and Field Conditions*", June 1998 was used as guidance. Table 2 presents the recalculated MDAs for plutonium-238 and plutonium-239 based on the raw data provided by both laboratories. Table 2 shows the recalculated MDAs are similar for plutonium analyses conducted by the two laboratories and the resulting data can be utilized for data assessment. The recalculated MDAs for plutonium-238 and plutonium-239 are provided in **bold** in Table 3.

A critical level for each of the isotopic analytical methods was not provided by the laboratories. Without critical levels being provided by the laboratories, decisions regarding the presence or absence of radiation in the material could not be assessed for the data. Specifically, the question as to the presence or absence of radiation utilizing a specific method for analysis could not be answered for the nickel samples.

Table 3 provides the assessment of the data utilizing sample specific minimum detectable activities (MDAs). Values greater than the MDA demonstrate the presence of the radionuclide and values greater than the MDA also provide a high degree of certainty for the reported result. Values greater than the MDA but with counting uncertainties greater than 50% of the reported value may or may not indicate the presence of radiation.

The very low levels of activity and the counting uncertainties observed for nickel sample analytes makes it difficult to determine with certainty whether radiation is indeed present in the nickel samples. Based on the analysis using sample specific MDAs and sample counting uncertainties of less than 50% of the state activity, it was determined the data supports and indicates the presence of plutonium-238, plutonium-239, thorium-230, and uranium-234.

Conclusions

The objective of the study was to establish a dataset for radionuclide activity associated with commercially available virgin nickel and demonstrate any potential radiation impact. With the understanding that a small number of samples were analyzed in the study, the dataset can be utilized for assessing background levels in commercially available virgin nickel.

The objectives of the nickel project were to:

- Assess levels of selected radionuclides in commercial virgin nickel that can be use to evaluate Paducah Gaseous Diffusion Plant (PGDP) decontaminated nickel.

- Establish a validated and defensible dataset for commercial virgin nickel that can be use for contaminant assessment, and

- Provide a dataset for commercial virgin nickel to evaluate potential radiation dose and risk for contaminants in nickel from PGDP.

Nickel from three different vendors was obtained for use in the project. A solid nickel and a powdered nickel were obtained from each vendor. Nickel samples were received from the following sources:

Alfa Aesar	Nickel Rod	99.5% Purity
Ward Hill, MA	Powder	99.8% Purity –325 Mesh
Belmont Metals	Nickel Cathodes	99.9% Purity
Brooklyn, NY	Powder	99.9% Purity 100-325 Mesh
Atlantic Equipment Engrs	Metal Squares	99.99+% Purity
Bergenfield, NJ	Powder	99.9% Purity -325 Mesh

Based on process knowledge and analytical data for PGDP nickel material, analyses were conducted by the two laboratories for radionuclides that could be present in PGDP nickel. Datasets were provided by each of the two laboratories for the following radionuclides: ^{40}K, ^{60}Co, ^{137}Cs and ^{241}Am, ^{238}U, ^{235}U, ^{234}U, ^{228}Th, ^{230}Th, ^{232}Th, ^{238}Pu, $^{239/240}$Pu, ^{237}Np, ^{237}Np, ^{99}Tc, and ^{90}Sr.

The objectives of the study have been accomplished through analysis of the commercially available virgin nickel from the above sources. Radionuclide analyses were completed in two radiation laboratories and the data validated by an independent third party.

Assessment of the data was based on sample specific MDAs and sample counting uncertainties of less than 50% of the stated activity. Based on the assessment of the validated analytical results, a dataset has been established for radionuclides in the commercial virgin nickel analyzed in the study.

Although, there is some uncertainty associated with the data, the dataset for the commercially available virgin nickel samples used in the study can provide a useful tool for assessment of the radiation levels and dose resulting from the use of recycled or decontaminated PGDP nickel. If the radioactivity in the recycled or decontaminated PGDP nickel is equivalent to or less than the levels of radiation in the commercial virgin nickel dataset for the study, the PGDP recycled or decontaminated nickel could be exempted by federal and state radiation control agencies from restrictions on its use.

In conjunction with oversight by federal and state radiation control agencies recycled or decontaminated PGDP nickel can be assessed utilizing the present dataset. If the evaluation by federal and state agencies concur that the material is equivalent to the radiation levels in commercial virgin nickel dataset used in the study, the recycled or decontaminated nickel could possibly be released for industrial and commercial uses.

APPENDICES

Table 1. Analytical results for radionuclides in Commercial Nickel
Activity = pCi/g

Sample	Neptunium-237	CU	MDA	Technium-99	Cu	MDA	Plutonium-238	CU	MDA
AEE-S-102103	-0.2270	0.1010	0.3520	1.1800	1.6100	2.2900	0.0622	0.1470	0.5350
	-0.0300	1.0700	3.0200	-1.8200	0.6200	2.0900	0.0200	0.0200	0.0100
AA-S-102103	0.0108	0.0033	0.3564	1.4600	1.6300	2.2900	0.1420	0.1550	0..532
	-1.5500	1.4000	3.7400	-0.8900	0.6500	2.1700	0.0100	0.0200	0.0400
BM-S-102103	0.0540	0.0159	0.3520	0.7710	1.6100	2.2900	0.9580	0.0885	0.5100
	0.1000	1.0400	2.9200	-1.0300	0.0541	1.8400	0.1200	0.0500	0.0400
AA-P-121703	-0.1510	0.0582	0.3520	1.9100	1.6500	2.2900	0.0940	0.0853	0.5090
	0.5400	1.1100	3.2000	-0.9300	0.5800	1.9300	0.0000	0.0100	0.0300
AAE-P-121703	-0.2810	0.1450	0.3520	2.6000	1.6700	2.2900	0.1400	0.0880	0.5090
	1.3000	0.8500	2.5600	-1.9900	0.6100	2.0600	0.1100	0.0500	0.0400
BM-P-121703	-0.0216	0.0069	0.3520	1.0500	1.6200	2.2900	0.0942	0.0765	0.5070
	0.8400	0.9400	2.7700	-0.7700	0.6100	2.0200	0.0000	0.0200	0.0400
	Avg Act			**Avg Act**			**Avg Act**		
	-0.1026			1.4952			0.2484		
	0.2000			-1.2383			0.0280		
	STDEV			**STDEV**			**STDEV**		
	0.1368			0.6657			0.3490		
	0.9860			0.5767			0.0561		
	CI			**CI**			**CI**		
	0.1095			0.5327			0.2792		
	0.7889			0.4615			0.0449		

Table 1. Continued
Analytical results for radionuclides in Commercial Nickel
Activity = pCi/g

Sample	Plutonium-239/240	CU	MDA	Thorium228	CU	MDA	Thorium230	CU	MDA
AEE-S-102103	-0.0408	0.0563	0.1630	0.0287	0.0394	0.0998	0.1910	0.0920	0.4500
	0.0500	0.0300	0.0300	0.1200	0.1000	0.1200	1.0900	0.2300	0.0800
AA-S-102103	0.0415	0.0753	0.1550	0.0205	0.0201	0.1070	0.2640	0.1210	0.4530
	-0.0100	0.0300	0.0600	0.0800	0.0700	0.0800	0.4500	0.1300	0.0300
BM-S-102103	0.0171	0.0348	0.1260	0.0215	0.0259	0.0963	-0.0083	0.0494	0.4470
	0.0900	0.0400	0.0100	0.1500	0.1100	0.1100	0.5200	0.1600	0.0300
AA-P-121703	-0.0120	0.0257	0.1250	0.1420	0.0532	0.1710	0.0278	0.0504	0.4790
	0.0100	0.0200	0.0400	0.1200	0.0900	0.1000	0.2100	0.0800	0.0200
AAE-P-121703	0.0036	0.0319	0.1250	0.0057	0.0231	0.0938	-0.0100	0.0363	0.4470
	0.0800	0.0500	0.0600	0.1500	0.1200	0.1500	2.0200	0.3500	0.0200
BM-P-121703	0.0184	0.0305	0.1230	0.0000	0.0000	0.0945	0.0213	0.0466	0.4450
	0.0100	0.0200	0.0400	0.0800	0.0700	0.0800	0.2200	0.0900	0.0300
	Avg Act			**Avg Act**			**Avg Act**		
	0.0046			0.0364			0.0810		
	0.0280			0.1100			0.7980		
	STDEV			**STDEV**			**STDEV**		
	0.0284			0.0528			0.1168		
	0.0412			0.0314			0.6991		
	CI			**CI**			**CI**		
	0.0228			0.0423			0.0935		
	0.0330			0.0251			0.5594		

Table 1. Continued
Analytical results for radionuclides in Commercial Nickel
Activity = pCi/g

Sample	Thorium-232	CU	MDA	Uranium-235	CU	MDA	Uranium-234	CU	MDA
AEE-S-102103	0.0287	0.0393	0.0786	-1.7600	1.6500	5.2700	-1.7600	2.7100	5.4300
	0.1000	0.0600	0.0300	-0.0200	0.0500	0.1200	0.0700	0.0800	0.1200
AA-S-102103	0.0003	0.6170	0.1100	-1.7700	1.0600	3.1900	-4.6400	1.2200	2.4600
	0.0900	0.0600	0.0300	0.0600	0.0400	0.0500	0.1600	0.0700	0.0600
BM-S-102103	0.0047	0.0232	0.0641	0.6630	3.8000	6.0700	-0.2020	3.5500	5.0800
	0.0700	0.0700	0.0900	0.0300	0.0500	0.0800	0.1900	0.0800	0.0500
AA-P-121703	0.0096	0.0186	0.2090	-0.6070	1.3600	4.2200	-5.2100	2.1500	2.2700
	0.0700	0.0500	0.0200	0.0100	0.0400	0.0800	0.0500	0.0600	0.1000
AAE-P-121703	-0.0050	0.0101	0.0633	-0.8410	1.6000	2.9300	-3.4000	1.6300	4.1400
	0.0800	0.0600	0.0400	-0.0200	0.0300	0.0800	0.0500	0.0400	0.0400
BM-P-121703	0.0054	0.0178	0.0623	-1.4300	1.4300	3.3100	-1.8200	2.2800	2.6400
	0.0800	0.0600	0.0700	0.0400	0.0300	0.0200	0.1400	0.0600	0.0400
	Avg Act			**Avg Act**			**Avg Act**		
	0.0073			-0.9575			-2.8387		
	0.0840			0.0140			0.0940		
	STDEV			**STDEV**			**STDEV**		
	0.0116			0.9263			1.9150		
	0.0117			0.0327			0.0610		
	CI			**CI**			**CI**		
	0.0093			0.7412			1.5323		
	0.0094			0.0261			0.0488		

Table 1. Continued
Analytical results for radionuclides in Commercial Nickel
Activity = pCi/g

Sample	Uranium-238	CU	MDA	Americum-241	CU	MDA	Cesium-137	CU	MDA
AEE-S-102103	-0.0856	2.1100	3.7000	0.4100	0.8210	1.7800	-0.4680	0.9350	0.6010
	-0.0200	0.0400	0.0900	0.0500	0.0500	0.0300	0.1800	0.0600	0.2100
AA-S-102103	-0.2940	0.6170	2.5400	0.4800	0.9620	1.8300	-0.0028	0.0055	0.7620
	0.0500	0.0300	0.0200	0.1500	0.0800	0.0700	0.0500	0.0800	0.2300
BM-S-102103	-1.2000	0.9890	4.9800	1.4900	1.5300	1.7300	-4.1500	0.8300	0.6630
	0.0200	0.0500	0.0900	0.0700	0.0400	0.0400	0.0800	0.0800	0.2300
AA-P-121703	-0.9590	1.3800	3.2400	0.9090	1.8200	1.8200	-0.2340	0.4670	0.6390
	0.0100	0.0400	0.0700	0.0800	0.0500	0.0500	0.0200	0.0800	0.2300
AAE-P-121703	-0.6550	0.6860	1.9900	0.8830	1.7700	1.8500	0.1000	0.2000	0.7510
	0.0300	0.0300	0.0400	0.0400	0.0300	0.0400	0.0800	0.0600	0.1800
BM-P-121703	-0.0683	1.4600	2.6400	-0.3230	0.6450	1.8000	0.3030	0.6070	0.6250
	0.0300	0.0300	0.0100	0.1000	0.0700	0.0700	0.0400	0.0700	0.2000
	-0.0856	2.1100	3.7000	0.4100	0.8210	1.7800	-0.4680	0.9350	0.6010
	-0.0200	0.0400	0.0900	0.0500	0.0500	0.0300	0.1800	0.0600	0.2100
	-0.2940	0.6170	2.5400	0.4800	0.9620	1.8300	-0.0028	0.0055	0.7620
	0.0500	0.0300	0.0200	0.1500	0.0800	0.0700	0.0500	0.0800	0.2300
	-1.2000	0.9890	4.9800	1.4900	1.5300	1.7300	-4.1500	0.8300	0.6630
	0.0200	0.0500	0.0900	0.0700	0.0400	0.0400	0.0800	0.0800	0.2300
	-0.9590	1.3800	3.2400	0.9090	1.8200	1.8200	-0.2340	0.4670	0.6390
	0.0100	0.0400	0.0700	0.0800	0.0500	0.0500	0.0200	0.0800	0.2300

Table 1. Continued
Analytical results for radionuclides in Commercial Nickel
Activity = pCi/g

Sample	Cobalt-60	CU	MDA	Potassium-40	CU	MDA	Strontium-90	CU	MDA
AEE-S-102103	-0.0211	0.0414	0.7580	0.8730	1.7500	14.2000	-0.245	0.041	1.520
	0.1100	0.0600	0.2000	1.1700	0.6300	2.8100	0.7200	0.330	0.320
AA-S-102103	0.0211	0.1420	0.7180	-3.6400	7.2800	13.7000	0.3910	0.059	1.410
	-0.0600	0.0900	0.2200	4.0800	1.0600	3.7000	-0.4700	0.310	0.330
BM-S-102103	-8.9900	0.0180	0.7770	-1.3400	2.6800	14.1000	-0.2170	0.036	1.470
	0.0300	0.0800	0.2100	4.8000	0.7600	3.1300	0.5200	0.320	0.300
AA-P-121703	0.1480	0.2950	0.7350	-0.5020	1.0000	13.6000	-0.4440	0.077	1.590
	0.1200	0.0600	0.2100	4.7800	0.8900	3.4600	-0.0500	0.220	0.360
AAE-P-121703	-0.1130	0.2260	0.6500	-5.7700	11.5000	13.5000	-0.3670	0.064	1.450
	-0.0200	0.0700	0.1700	3.7300	0.8200	2.9300	-0.1500	0.200	0.320
BM-P-121703	-0.2640	0.5280	0.7080	-5.4900	11.0000	13.6000	-0.3150	0.054	1.550
	0.0100	0.0700	0.1900	6.2200	0.0700	3.4600	0.0000	0.320	0.310
	Avg Act		**Avg MDA**	**Avg Act**		**Avg MDA**			
	-1.5365		0.7243	-2.6448		13.7833	-0.1995		1.4983
	0.0320		0.2000	3.9960		3.2483	0.0100		0.3233
	STDEV		**STDEV**	**STDEV**		**STDEV**	**STDEV**		**STDEV**
	3.6541		0.0444	2.7394		0.2927	0.3007		0.0671
	0.0714		0.0179	1.6831		0.3467	0.4428		0.0207
	CI		**CI**	**CI**		**CI**	**CI**		**CI**
	2.9238		0.0355	2.1919		0.2342	0.2406		0.0537
	0.0571		0.0143	1.3467		0.2774	0.3543		0.0165

Table 2. Recalculated MDA values for plutoniun-238 and plutonium-239.

Sample ID	MDA Pu238 (pCi/g)	MDA Pu238 (pCi/g)	MDA Pu239 (pCi/g)	MDA Pu239 (pCi/g)
AA-S-102103	3.59E-02	3.94E-02	8.98E-02	6.33E-02
AEE-S-102103	3.84E-02	1.33E-02	1.20E-01	3.40E-02
BM-S-102103	3.17E-02	3.65E-02	1.27E-02	1.43E-02
AA-P-121703	7.44E-02	3.40E-02	2.38E-02	4.25E-02
AEE-P-121703	1.03E-02	3.75E-02	2.58E-02	6.04E-02
BM-P-121703	2.39E-02	4.29E-02	9.52E-03	4.29E-02

Table 3. Assessment of Radionuclides in Commercial Nickel

Activity = pCi/g

Values less than or equal to MDA= Green coded cells
Values greater than MDA and counting uncertainty less than 50%= Yellow coded cells
Values greater than MDA with a counting uncertainty of greater than 50%= Blue coded cells

Sample	Neptunium-237	CU	MDA	Technetium-99	Cu	MDA	Plutonium-238	CU	MDA
AEE-S-102103	-0.2270	0.1010	0.3520	1.1800	1.6100	2.2900	0.0622	0.1470	**0.0384**
	-0.0300	1.0700	3.0200	-1.8200	0.6200	2.0900	0.0200	0.0200	**0.0133**
AA-S-102103	0.0108	0.0033	0.3564	1.4600	1.6300	2.2900	0.1420	0.1550	**0.0359**
	-1.5500	1.4000	3.7400	-0.8900	0.6500	2.1700	0.0100	0.0200	**0.0394**
BM-S-102103	0.0540	0.0159	0.3520	0.7710	1.6100	2.2900	0.9580	0.0885	**0.0217**
	0.1000	1.0400	2.9200	-1.0300	0.0541	1.8400	0.1200	0.0500	**0.0365**
AA-P-121703	-0.1510	0.0582	0.3520	1.9100	1.6500	2.2900	0.0940	0.0853	**0.0744**
	0.5400	1.1100	3.2000	-0.9300	0.5800	1.9300	0.0000	0.0100	**0.0340**
AAE-P-121703	-0.2810	0.1450	0.3520	2.6000	1.6700	2.2900	0.1400	0.0880	**0.0103**
	1.3000	0.8500	2.5600	-1.9900	0.6100	2.0600	0.1100	0.0500	**0.0375**
BM-P-121703	-0.0216	0.0069	0.3520	1.0500	1.6200	2.2900	0.0942	0.0765	**0.0239**
	0.8400	0.9400	2.7700	-0.7700	0.6100	2.0200	0.0000	0.0200	**0.0429**

Table 3. Continued
Assessment of Radionuclides in Commercial Nickel
Activity = pCi/g

Values less than or equal to MDA= Green coded cells
Values greater than MDA and counting uncertainty less than 50%= Yellow coded cells
Values greater than MDA with a counting uncertainty of greater than 50%= Blue coded cells

Sample	Plutonium-239/240	CU	MDA	Thorium-228	CU	MDA	Thorium-230	CU	MDA
AEE-S-102103	-0.0408	0.0563	**0.0898**	0.0287	0.0394	0.0998	0.1910	0.0920	0.4500
	0.0500	0.0300	**0.0633**	0.1200	0.1000	0.1200	1.0900	0.2300	0.0800
AA-S-102103	0.0415	0.0753	**0.1200**	0.0205	0.0201	0.1070	0.2640	0.1210	0.4530
	-0.0100	0.0300	**0.0340**	0.0800	0.0700	0.0800	0.4500	0.1300	0.0300
BM-S-102103	0.0171	0.0348	**0.0127**	0.0215	0.0259	0.0963	-0.0083	0.0494	0.4470
	0.0900	0.0400	**0.0143**	0.1500	0.1100	0.1100	0.5200	0.1600	0.0300
AA-P-121703	-0.0120	0.0257	**0.0238**	0.1420	0.0532	0.1710	0.0278	0.0504	0.4790
	0.0100	0.0200	**0.0425**	0.1200	0.0900	0.1000	0.2100	0.0800	0.0200
AAE-P-121703	0.0036	0.0319	**0.0258**	0.0057	0.0231	0.0938	-0.0100	0.0363	0.4470
	0.0800	0.0500	**0.0604**	0.1500	0.1200	0.1500	2.0200	0.3500	0.0400
BM-P-121703	0.0184	0.0305	**0.0095**	0.0000	0.0000	0.0945	0.0213	0.0466	0.4450
	0.0100	0.0200	**0.0429**	0.0800	0.0700	0.0800	0.2200	0.0900	0.0300

Table 3. Continued
Assessment of Radionuclides in Commercial Nickel
Activity = pCi/g

Values less than or equal to MDA= Green coded cells
Values greater than MDA and counting uncertainty less than 50%= Yellow coded cells
Values greater than MDA with a counting uncertainty of greater than 50%= Blue coded cells

Sample	Thorium-232	CU	MDA	Uranium-235	CU	MDA	Uranium-234	CU	MDA
AEE-S-102103	0.0287	0.0393	0.0786	-1.7600	1.6500	5.2700	-1.7600	2.7100	5.4300
	0.1000	0.0600	0.0300	-0.0200	0.0500	0.1200	0.0700	0.0800	0.1200
AA-S-102103	0.0003	0.6170	0.1100	-1.7700	1.0600	3.1900	-4.6400	1.2200	2.4600
	0.0900	0.0600	0.0300	0.0600	0.0400	0.0500	0.1600	0.0700	0.0600
BM-S-102103	0.0047	0.0232	0.0641	0.6630	3.8000	6.0700	-0.2020	3.5500	5.0800
	0.0700	0.0700	0.0900	0.0300	0.0500	0.0800	0.1900	0.0800	0.0500
AA-P-121703	0.0096	0.0186	0.2090	-0.6070	1.3600	4.2200	-5.2100	2.1500	4.1400
	0.0700	0.0500	0.0200	0.0100	0.0400	0.0800	0.0500	0.0600	0.1000
AAE-P-121703	-0.0050	0.0101	0.0633	-0.8410	1.6000	2.9300	-3.4000	1.6300	2.9900
	0.0800	0.0600	0.0400	-0.0200	0.0300	0.0800	0.0500	0.0400	0.0400
BM-P-121703	0.0054	0.0178	0.0623	-1.4300	1.4300	3.3100	-1.8200	2.2800	2.6400
	0.0800	0.0600	0.0700	0.0400	0.0300	0.0200	0.1400	0.0600	0.0400

Table 3. Continued
Assessment of Radionuclides in Commercial Nickel
Activity = pCi/g

Values less than or equal to MDA= Green coded cells
Values greater than MDA and counting uncertainty less than 50%= Yellow coded cells
Values greater than MDA with a counting uncertainty of greater than 50%= Blue coded cells

Sample	Uranium-238	CU	MDA	Americium-241	CU	MDA	Cesium-137	CU	MDA
AEE-S-102103	-0.0856	2.1100	3.7000	0.4100	0.8210	1.7800	-0.4680	0.9350	0.6010
	-0.0200	0.0400	0.0900	0.0500	0.0500	0.0300	0.1800	0.0600	0.2100
AA-S-102103	-0.2940	0.6170	2.5400	0.4800	0.9620	1.8300	-0.0028	0.0055	0.7620
	0.0500	0.0300	0.0200	0.1500	0.0800	0.0700	0.0500	0.0800	0.2300
BM-S-102103	-1.2000	0.9890	4.9800	1.4900	1.5300	1.7300	-4.1500	0.8300	0.6630
	0.0200	0.0500	0.0900	0.0700	0.0400	0.0400	0.0800	0.0800	0.2300
AA-P-121703	-0.9590	1.3800	3.2400	0.9090	1.8200	1.8200	-0.2340	0.4670	0.6390
	0.0100	0.0400	0.0700	0.0800	0.0500	0.0500	0.0200	0.0800	0.2300
AAE-P-121703	-0.6550	0.6860	1.9900	0.8830	1.7700	1.8500	0.1000	0.2000	0.7510
	0.0300	0.0300	0.0400	0.0400	0.0300	0.0400	0.0800	0.0600	0.1800
BM-P-121703	-0.0683	1.4600	2.6400	-0.3230	0.6450	1.8000	0.3030	0.6070	0.6250
	0.0300	0.0300	0.0100	0.1000	0.0700	0.0700	0.0400	0.0700	0.2000

Table 3. Continued
Assessment of Radionuclides in Commercial Nickel
Activity = pCi/g

Values less than or equal to MDA= Green coded cells
Values greater than MDA and counting uncertainty less than 50%= Yellow coded cells
Values greater than MDA with a counting uncertainty of greater than 50%= Blue coded cells

Sample	Cobalt-60	CU	MDA	Potassium-40	CU	MDA	Strontium-90	CU	MDA
AEE-S-102103	-0.0211	0.0414	0.7580	0.8730	1.7500	14.2000	-0.245	0.041	1.520
	0.1100	0.0600	0.2000	1.1700	0.6300	2.8100	0.7200	0.330	0.320
AA-S-102103	0.0211	0.1420	0.7180	-3.6400	7.2800	13.7000	0.3910	0.059	1.410
	-0.0600	0.0900	0.2200	4.0800	1.0600	3.7000	-0.4700	0.310	0.330
BM-S-102103	-8.9900	0.0180	0.7770	-1.3400	2.6800	14.1000	-0.2170	0.036	1.470
	0.0300	0.0800	0.2100	4.8000	0.7600	3.1300	0.5200	0.320	0.300
AA-P-121703	0.1480	0.2950	0.7350	-0.5020	1.0000	13.6000	-0.4440	0.077	1.590
	0.1200	0.0600	0.2100	4.7800	0.8900	3.4600	-0.0500	0.220	0.360
AAE-P-121703	-0.1130	0.2260	0.6500	-5.7700	11.5000	13.5000	-0.3670	0.064	1.450
	-0.0200	0.0700	0.1700	3.7300	0.8200	2.9300	-0.1500	0.200	0.320
BM-P-121703	-0.2640	0.5280	0.7080	-5.4900	11.0000	13.6000	-0.3150	0.054	1.550
	0.0100	0.0700	0.1900	6.2200	0.0700	3.4600	0.0000	0.320	0.310