ORISE

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

June 17, 2009

Bruce Watson, CHP
U.S. Nuclear Regulatory Commission
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SUBJECT: REVISED FINAL—INPUT FOR THE SITE-SPECIFIC DECOMMISSIONING INSPECTION REPORT FOR THE HEMATITE DECOMMISSIONING PROJECT, HEMATITE, MISSOURI (DOCKET NO. 070-036, RFTA NO. 08-004) DCN:1768-TR-01-2

Dear Mr. Watson:

Enclosed is the revised document providing input for the decommissioning inspection report for the Hematite Decommissioning Project in Hematite, Missouri. The information contained in the report provides the results of the inspection items that the Oak Ridge Institute for Science and Education (ORISE) performed during the U.S. Nuclear Regulatory Commission's January 5-8, 2009 inspection. The previous final report was issued on March 2, 2009. However, the alpha spectroscopy data is being revised due to a problem with the tracer used for the uranium isotopic analysis. The wrong decay date for the tracer was entered into the certificate file that was used to process the spectra. We apologize for this error and we are reviewing our process to keep this type of problem from occurring in the future. The samples were analyzed by gamma spectroscopy (GS) for uranium and for depleted uranium by alpha spectroscopy (AS). As you will see, the revised AS uranium concentrations did not increase significantally. The data in the tables are reported as natural uranium. The GS results are presented in Table 1. The revised AS results are presented in Table 2.

ORISE's Quality Control (QC) requirements were met for these analyses. The QC files are available for your review upon request.

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Sincerely,

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MGJ:km

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INPUT FOR THE DECOMMISSIONING INSPECTION REPORT FOR THE HEMATITE DECOMMISSIONING PROJECT HEMATITE, MISSOURI

INTRODUCTION

Personnel from the Oak Ridge Institute for Science and Education (ORISE) provided assistance to the U.S. Nuclear Regulatory Commission (NRC) during the period of January 5-8, 2009 at the Westinghouse Electric Corporation's (WEC) Hematite Decommissioning Project (HDP) site in Hematite, Missouri. ORISE was requested to review HDP documentation and procedures related to the calibration of radiation instrumentation used for estimating enriched uranium activity concentrations on building surfaces and the application of *In Situ* Object Counting System (ISOCS) procedures for measuring enriched uranium hold-ups in process piping and duct work. ORISE was also requested by the NRC to re-survey and collect duplicate judgmental soil samples from the rail spur construction area as a follow up to the ORISE letter dated September 26, 2008 due to differences in the Tc-99 results reported by WEC (ORISE 2008a). In addition, the NRC requested that ORISE gamma scan and collect soil samples at the Outfall 001area due to WEC cleaning the effluent discharge in late 2007. Finally, information was gathered for the purpose of developing a confirmatory survey plan for implementation once cleanup of the HDP site begins.

ORISE reviewed the following information: the ISOCS training activities, verification procedures, field survey instrumentation calibration and performance check procedures and data forms, field measurement results, and calculations of U-235 gram quantities made by HDP. The goal of this review was to verify that the instrumentation being used for surface activity measurements and subsequent U-235 gram calculations are being properly calibrated. This ensures that defensible surface activity measurements are being obtained. This was accomplished by: determining if HDP's current calibration procedures would account for any environmental or other factors that could potentially impact performance, evaluating the appropriateness of the calibration source energies in determining instrument efficiencies and any applied weighting factors relative to the radionuclides of concern, evaluating the selection of surface efficiency value(s), and reviewing the survey instrumentation operational check out procedures and acceptance parameters.

FIELD SURVEY INSTRUMENT CALIBRATIONS

HDP is currently using the Ludlum Model 43-89 dual phosphor alpha/beta scintillator for surface activity measurements. Tc-99, with an average beta energy of 84.6 keV, is the source currently being used for calibration. Sr/Y-90, with an average beta energy of 565 keV, was used as the calibration source for surface activity measurements collected in the 2005 and 2006 time period. The appropriateness of these calibration sources to represent the average energies of the beta-emitting progeny of U-235 and U-238—Th-231, Pa-234m, and Th-234—was evaluated. The respective approximate average beta energies of these progeny are: 76, 819, and 43 keV. The weighted average energy of the mixture, based on a normalized beta fraction, is 380 keV as shown in the following table.

BETA			
	Beta Fraction	**Energy (keV)**	**Weighted Energy (keV)**
Th-231	0.13	76	9.8
Th-234	0.43	43	18.5
Pa-234m	0.43	819	352
	Weighted Average Beta Energy		380

These results show that the use of Tc-99 as the beta calibration source to represent the average energy of the beta-emitting progeny mixture is appropriate, while erring on the conservative side. The alpha calibration process was also reviewed. HDP's selection of Pu-239 as the calibration source was appropriate. Both the beta and alpha efficiencies that HDP reported were consistent with the manufacturer's reported values of 5% for Tc-99, 16% for Sr-90, and 15% for Pu-239. However, two issues were noted and are explained further. First, it is important to note that the manufacturer's specifications and the HDP efficiencies represent 4π geometry efficiencies. Using a 4π efficiency can underestimate the activity present because lower particle backscatter rates and surface attenuation factors that are encountered in the field are not accounted for. Because of this, ORISE recommended that HDP follow the current decommissioning guidance provided in NUREG 1507 and ISO 7503-1. According to NUREG 1507 and ISO 7503-1, a total efficiency should be determined. The total efficiency consists of two terms, instrument efficiency (ε_i) and source efficiency (ε_s).

The instrument efficiency, as defined in NUREG 1507, is the ratio between the net count rate of the instrument and the 2π surface emission rate of a calibration source for a specified geometry. The equation is shown below:

$$Instrument\ Efficiency = \epsilon_i = \frac{R_{(s+b)} - R_{(b)}}{q_{2\pi}}$$

where,

$R_{(s+b)}$ = Gross count rate in cpm

$R_{(b)}$ = Background count rate in cpm

$q_{2\pi}$ = 2π surface emission rate

Source efficiencies can be obtained from guidance in ISO 7503-1 or NUREG 1507. The ε_s default values are: 0.25 for alpha emitters and beta emitters with maximum beta energies less than 400 keV and 0.5 for beta emitters with a maximum energy greater than 400 keV. Multiplying the instrument efficiency by the source efficiency yields the total efficiency which is then used in the surface activity calculation as shown below:

$$Total\ Surface\ Activity = A_s = \frac{R_{(S+b)} - R_{(b)}}{(\epsilon_i)(W)(\epsilon_s)}$$

where,

W = Area of the detector window

The tables below represent example total weighted efficiency calculations that would be used in calculating total uranium surface activity levels. The yields (fractions correspond to uranium alpha fractions) for the various 4.8% enriched uranium emissions shown, in addition to Ludlum product information, were used to estimate the alpha, beta, and alpha plus beta efficiencies.

ALPHA				
	Alpha Fraction[a]	ε_i	ε_s	**Weighted Efficiency**
U-234	0.86	0.32	0.25	0.068
U-235	0.035	0.32	0.25	0.0028
U-238	0.11	0.32	0.25	0.0088
			Total efficiency	0.08

[a]Alpha fraction used for calculating the weighted efficiency.

The estimated alpha efficiency of 0.08 is approximately one-half the efficiency HDP is using to calculate U-235 hold-ups on structural surfaces.

In addition to alpha measurements, HDP is also collecting beta measurements. The second issue is that a total beta efficiency is not being calculated to represent uranium activity. The following two tables provide an example for determining a beta and an alpha plus beta weighted efficiency for calculating total uranium activity (4.8% enriched).

BETA				
	Alpha Fraction[a]	**ε_i**	**ε_s**	**Weighted Efficiency**
U-234	0.86	0.00	0.25	0.00
U-235	0.035	0.00	0.25	0.00
Th-231	0.035	0.10	0.25	0.0009
U-238	0.11	0.00	0.25	0.00
Th-234	0.11	0.10	0.25	0.0027
Pa-234m	0.11	0.32	0.50	0.017
		Total efficiency		0.021

[a]Alpha fraction used for calculating the weighted efficiency.

Simply stated, the Tc-99 beta efficiency HDP uses is approximately two to ten times greater than what the efficiency should be as the efficiency has not been calculated in relation to total uranium activity. The efficiencies reported by HDP in their records entitled "Hematite Decommissioning Project Process Building Radiological Survey Records from 2005 to 2006" and Appendix A from their September 23, 2008 Radiological Survey Report showed efficiencies ranging from 8.4% to 23.0%. The following table represents the calculation of efficiency in the case where alpha plus beta measurements are made and the emissions are discriminated.

ALPHA + BETA				
	Alpha Fraction[a]	**ε_i**	**ε_s**	**Weighted Efficiency**
U-234	0.86	0.32	0.25	0.068
U-235	0.035	0.32	0.25	0.0028
Th-231	0.035	0.10	0.25	0.0009
U-238	0.11	0.32	0.25	0.0088
Th-234	0.11	0.10	0.25	0.0027
Pa-234m	0.11	0.32	0.50	0.017
		Total efficiency		0.10

[a]Alpha fraction used for calculating the weighted efficiency.

ORISE then used the calculated alpha and beta total efficiencies to recalculate surface activity levels using HDP raw data. The HDP data used were: counts per minute (cpm), background count rates, and the HDP reported results (dpm/100 cm^2) for comparison. The tables below compare ORISE calculated results to HDP results.

Alpha Background (cpm)	ORISE Efficiency Alpha	Beta Background (cpm)	ORISE Efficiency Beta
14	0.08	114	0.021

Alpha (cpm)	Alpha-net (cpm)	ORISE Alpha (dpm)	Beta (cpm)	Beta-net (cpm)	ORISE Beta (dpm)	HDP Alpha (dpm)	HDP Beta (dpm)
1,476	1,468	18,000	1,184	1,060	50,000	10,000	4,800
500	492	6,200	592	468	22,000	3,400	2,100
316	308	3,900	276	152	7,200	2,100	700
1,506	1,498	19,000	2,854	2,730	130,000	10,000	12,000
37,932	37,924	470,000	254,672	254,548	12,000,000	260,000	120,0000
8,210	8,202	100,000	10,652	10,528	500,000	56,000	48,000
940	932	12,000	11,276	11,152	530,000	6,300	51,000
2,002	1,994	25,000	3,744	3,620	170,000	14,000	17,000
1,668	1,660	21,000	2,610	2,486	120,000	11,000	11,000
658	650	8,100	714	590	28,000	4,400	2,700

Calculations were performed to validate the HDP U-235 calculations. The input parameter was the revised, estimated alpha surface activity. Results of these calculations showed a substantial difference between ORISE and HDP results. For example, one result reported by HDP was 38.2g U-235 while ORISE calculations resulted in 61g.

HOLD-UP MEASUREMENT EVALUATION

HDP hold-up records have shown that microR meters were used to select judgmental locations for follow-up measurements with the ISOCS. HDP has more efficient detectors available that can more readily identify contamination. HDP has Ludlum Model 44-10 2" x 2" NaI scintillation detectors available on site which are significantly more sensitive than the microR meters used (900 cpm/μR/h vs. the microR meter's 175 cpm/μR/h relative to Cs-137 response).

For the ISOCS procedures and use, reviews of previous QA reports showed that source checks were performed with the ISOCS system where zero activity was registered. These results were recorded and used in the calculation of the standard deviation. In addition, inaccurate decays were calculated for Eu-155 and Na-22 check sources, leading to a 10%-20% decrease in actual activity values.

More importantly, ORISE noted that HDP has not developed and implemented a verification process and test plan for ensuring that the ISOCS is properly quantifying sources in the field. The site relies completely on the manufacturer's templates for calibration and source geometries and assumed source configurations. There has been little validation where a known source is measured using a similar hold-up geometry to those being measured in the field; only the previous measurement of a small metal container of 10.6 grams of U-235 was implemented as a validation standard. Typically, a test plan is developed that includes validation measurements of known quantities in expected geometries and to obtain and report the minimum detectable concentration and the total measurement uncertainty for the system.

GAMMA SCANS AND SOIL SAMPLING

Gamma scans were performed at the rail spur area to relocate areas of known contamination; six judgmental soil samples were collected. Field duplicate samples were taken and given to HDP personnel for analysis. Gamma scans were also performed at Outfall 001 and two judgmental soil samples were collected at locations with elevated gamma readings. Figure 1 shows soil sampling locations. Readings at the rail spur area reached a maximum of 120 Kcpm; at Outfall 001 the maximum reading reached a range of 8 to 10 Kcpm. Background in both areas was approximately 6 Kcpm. Duplicate samples from the Outfall 001 area were not collected. Survey and sampling procedures were in accordance with the ORISE Survey Procedures Manual (ORISE 2008b).

Soil samples were returned to the ORISE laboratory in Oak Ridge, TN for analysis in accordance with the ORISE Laboratory Procedures Manual (ORISE 2008c). Soil samples were initially analyzed by gamma spectroscopy to determine uranium-238 (U-238) and uranium-235 (U-235) concentrations. These data are provided in Table 1. Samples were then subjected to wet chemistry separations for isotopic uranium and technetium-99 (Tc-99) and analyzed by alpha spectroscopy and liquid scintillation analysis, respectively. These results are presented in Table 2. All analytical results are presented in units of picocuries per gram (pCi/g).

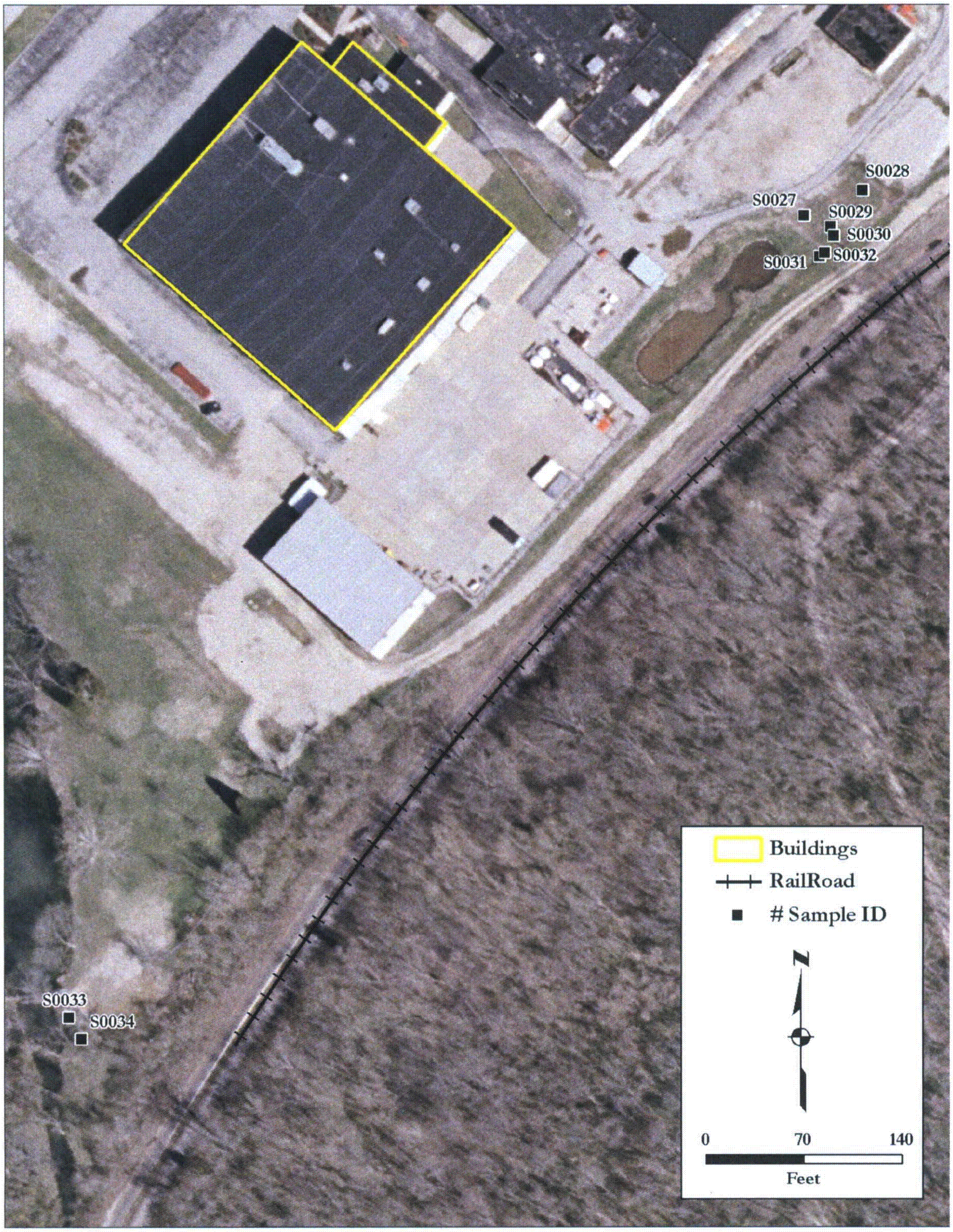

FIGURE 1: HEMATITE DECOMMISSIONING PROJECT—SOIL SAMPLE LOCATIONS

TABLE 1
RADIONUCLIDE CONCENTRATIONS IN SOIL
BY GAMMA SPECTROSCOPY
HEMATITE DECOMMISSIONING PROJECT
HEMATITE, MISSOURI

Sample ID[a]	Sample Coordinates	Sample Area	Radionuclide Concentration (pCi/g dry weight)				
			Th-228[b]	Th-232[c]	Total Th[d]	U-235	U-238[e]
S027	864650N, 827314E	Railroad Spur	2.06 ± 0.17[h]	2.37 ± 0.31	4.43 ± 0.35	42.9 ± 2.9	118.5 ± 7.8
S028	864668N, 827356E	Railroad Spur	0.77 ± 0.08	1.03 ± 0.16	1.80 ± 0.18	19.4 ± 1.2	59.9 ± 4.1
S029	864642N, 827333E	Railroad Spur	1.64 ± 0.14	2.14 ± 0.26	3.78 ± 0.30	33.4 ± 2.0	99.4 ± 6.5
S030	864636N, 827335E	Railroad Spur	1.22 ± 0.11	1.04 ± 0.17	2.26 ± 0.20	25.5 ± 1.6	153.2 ± 9.9
S031	864621N, 827325E	Railroad Spur	1.06 ± 0.10	1.09 ± 0.18	2.15 ± 0.21	34.1 ± 2.3	96.7 ± 6.4
S032	864624N, 827329E	Railroad Spur	13.6 ± 1.0	13.8 ± 1.4	27.4 ± 1.7	535 ± 32	1,095 ± 71
S033	864080N, 826791E	Outfall 001	0.86 ± 0.08	0.96 ± 0.16	1.82 ± 0.18	15.17 ± 0.97	57.8 ± 3.9
S034	864065N, 826800E	Outfall 001	0.99 ± 0.09	0.95 ± 0.16	1.94 ± 0.18	3.24 ± 0.27	11.9 ± 1.0

[a]Refer to Figure 1.
[b]Th-228 concentrations are obtained by measuring the 238 keV gamma emission of Pb-212.
[c]Th-232 concentrations are obtained by measuring the 911 keV gamma emission of Ac-228.
[d]Total Th is the sum of Th-228 + Th-232.
[e]U-238 concentrations are obtained by measuring the 63 keV gamma emission of Th-234.
[f]Uncertainties are at the 95% confidence level based on total propagated uncertainties.

TABLE 2 REVISED
RADIONUCLIDE CONCENTRATIONS IN SOIL BY ALPHA SPECTROSCOPY AND LIQUID SCINTILLATION ANALYSIS
HEMATITE DECOMMISSIONING PROJECT
HEMATITE, MISSOURI

Sample ID[a]	Sample Coordinates	Sample Area	Radionuclide Concentration in Soil Samples (pCi/g)				
			Tc-99[b]	U-234[c]	U-235	U-238	Total U[d]
S027	864650N, 827314E	Railroad Spur	27.4 ± 3.2[e]	1,260 ± 110	44.4 ± 9.9	143 ± 18	1,450 ± 110
S028	864668N, 827356E	Railroad Spur	76.4 ± 8.8	574 ± 49	26.4 ± 5.0	75.4 ± 9.2	676 ± 50
S029	864642N, 827333E	Railroad Spur	44.1 ± 5.1	876 ± 75	36.5 ± 6.6	101 ± 12	1013 ± 77
S030	864636N, 827335E	Railroad Spur	49.3 ± 5.7	1,750 ± 140	59.9 ± 8.7	145 ± 15	1,960 ± 150
S031	864621N, 827325E	Railroad Spur	47.9 ± 5.6	1,410 ± 120	61.9 ± 8.9	152 ± 16	1630 ± 120
S032	864624N, 827329E	Railroad Spur	174 ± 20	16,700 ± 1500	650 ± 130	1,510 ± 200	18,900 ± 1500
S033	864080N, 826791E	Outfall 001	19.2 ± 2.3	390 ± 40	18.4 ± 4.9	63.3 ± 9.1	475 ± 38
S034	864065N, 826800E	Outfall 001	9.0 ± 1.1	72.2 ± 6.3	3.31 ± 0.65	10.0 ± 1.2	85.5 ± 6.4

[a]Refer to Figure 1.
[b]Tc-99 results and uncertainties are presented in pCi/g wet weight.
[c]Uranium isotopic and total uranium results are presented in pCi/g dry weight.
[d]Total U is the sum of U-234 + U-235 + U-238.
[e]Uncertainties are at the 95% confidence level based on total propagated uncertainties.

REFERENCES

Oak Ridge Institute for Science and Education (ORISE). Letter Report for Analytical Results for 26 Soil Samples from the Westinghouse Decommissioning Project, Festus, Missouri [DCN: 1768-LR-01-0]. Oak Ridge, TN; September 26, 2008a.

Oak Ridge Institute for Science and Education. Survey Procedures Manual for the Independent Environmental Assessment and Verification Program. Oak Ridge, TN; May 1, 2008b.

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