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Public Service
Company of Colorado

April 8, 1996
Fort St. Vrain
P-96025

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Docket No. 50-267

SUBJECT: **Response to Unresolved Item and Inspection Report Concerns (NRC Inspection Report No. 50-267/96-01)**

REFERENCE: NRC Letter, Scarano to Crawford, dated March 5, 1996 (G-96019)

Gentlemen:

This letter provides responses from Public Service Company of Colorado (PSCo) and our decommissioning contractor, the Westinghouse Team (WT), to an unresolved item and four additional NRC concerns identified in the referenced letter. The NRC conducted an on-site inspection of the Fort St. Vrain (FSV) final survey program from January 22-26, 1996, and requested that PSCo provide a written response to the following items:

- **Unresolved Item (267/9601-01):** Explain the method for determining shielded background measurements to ensure that local area background values are not being overestimated (and net activity measurements therefore under-reported).

- **Concern 1:** Determine whether there is a bias in instrumentation response which overestimates the amount of contamination present.

- **Concern 2:** Determine whether corrections for "hard to detect nuclides" (HTDNs) should be made to survey results in unaffected areas that exceed 25 percent of the surface contamination limits.

- **Concern 3:** Determine whether investigations of suspect measurements were adequately conducted to justify removing the original measurement from the survey data base.

- **Concern 4:** Determine whether scan survey coverage percentage in nonsuspect affected areas should be increased.

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PSCo/WT's responses to these items are provided in the attachment to this letter. It is noted that several of these issues are based on differences between survey data taken by the WT/Scientific Ecology Group (SEG) and data taken by the NRC's consultant, the Oak Ridge Institute for Science and Education (ORISE). The NRC has provided PSCo with a copy of ORISE's report on these measurements, however this report does not include the raw measurement data or calibration information. The attached responses are based on available information and we believe they adequately support FSV Final Survey Procedures currently in use. If, however, a more detailed response is required, this additional information will be needed.

If you have any questions regarding this information, please contact Mr. Michael H. Holmes at (303) 620-1701.

Sincerely,

Frederick J. Borst

Frederick J. Borst
Decommissioning Program Director

FJB/SWC

cc: Regional Administrator, NRC Region IV

Mr. Robert M. Quillin, Director
Radiation Control Division
Colorado Department of Public Health and Environment

RESPONSE TO QUESTIONS RESULTING FROM NRC INSPECTION 96-01

NRC Unresolved Item (267/9601-01):

Explain the method for determining shielded background measurements to ensure that local area background values are not being overestimated (and net activity measurements therefore under-reported). Demonstrate the following:

- *That background measurements collected by different licensee technicians using instruments with different detector shields were consistent.*
- *That background values applied do not increase as the radioactivity level increases, resulting in an underestimate of net survey results.*

PSCo/WT Response:

PSCo/WT's response to this unresolved item is provided in two parts:

Part 1 provides a comprehensive evaluation of background shield materials and a comparison of measurements collected by different technicians.

Part 2 discusses the reasons why local area background measurements may in fact increase as surface activity increases, due to gamma interaction with the detector, but will not result in an underestimate of net survey results.

These responses are provided in the following pages:

PSCo/WT Response to Unresolved Item 267/9601-01

Part 1

Evaluation of Background Shield Materials and Comparison Measurements

Evaluation of Background Shield Materials and Comparison Measurements

Introduction

This information is provided to present the experimental testing and analysis performed to evaluate recent comparison survey data and the questions raised during the comparison study concerning background measurement protocols. This survey was performed by two independent SEG teams using Ludlum Measurements Inc. (LMI) 43-68 gas flow detectors and plexiglass beta shields. As a result of the comparison survey, a question was raised concerning the appropriateness of plexiglass as a shield material for total surface activity measurements. It is therefore the intent of this review to address this concern as well as to provide an evaluation of the comparison survey data.

Three specific questions are intended to be answered by this review. These are:

1) Do photon interactions with a plexiglass shield create a significant background measurement problem?,

2) Is the thickness of plexiglass used as a beta shield sufficient to adequately shield for FSV beta emitters?, and

3) Did the comparison survey data agree within statistical allowances, and if not, why not?

These questions were answered by both analytical calculations and experimental testing conducted to evaluate the background measurement protocols used at FSV.

Summary of Results

1.) Analytical calculations performed to verify the choice of plexiglass as a shield material indicate photon interactions with the shield are not significant.

2.) The 1/8" thickness of plexiglass used is sufficient to provide adequate beta shielding to correct gross measurements.

3.) After evaluating the initial and follow-up comparison survey data in consideration of all statistical factors, the results are within agreement (at 95% confidence). There was not a significant difference between plexiglass and steel as a background shield material, which further supports the choice of plexiglass as a shield material for background measurements.

1. Effect of Photon Interactions with a Plexiglass Beta Shield on Background Count Rate

The following analysis is performed to evaluate the effects of using a plexiglass shield over the detector window when performing background measurements with the Ludlum Measurements Inc. (LMI) 43-68 detector (rectangular gas flow detector). In question, is whether the shield material causes a significant increase in background from secondary particles that result from photon interactions within the shield.

Assumptions:

To perform this analysis, the following conditions are assumed:

1) A 1/8" thick shield of plexiglass is used as the shield material

2) The shielded detector is placed over a 125 cm^2 area contaminated to a level of 4,000 dpm/100cm^2 with Co-60, which results in 5,000 dpm Co-60 under the shield

3) Each Co-60 disintegration emits two 1.25 MeV photons (i.e., average of 1.173 and 1.332 MeV)

4) 50% of the Co-60 emissions potentially interact with the shield (i.e., 2π geometry)

5) All photons are considered to be incident upon the shield at average angle of 0°

6) Photon interactions are conservatively assumed to occur uniformly throughout the shield (interaction density will actually decrease through shield resulting in a smaller number of actual compton electrons generated within range of detector/shield surface)

7) Shield interactions are dominated by compton scattering collisions (i.e., $\sigma/\rho \sim \mu/\rho$)

8) All compton electrons may potentially enter the detector (i.e., moving toward the detector)

Calculations:

Photons incident upon shield:

$$(5{,}000\ dpm) * (0.5) * (2\gamma/dis) = 5{,}000\ \gamma/\text{min}$$

Attenuation is determined by use of the following equation:

$$N = N_o\, e^{-\left[\left(\frac{\mu}{\rho}\right)(\rho t)\right]}$$

For a plexiglass shield (with thickness 1/8" or 0.3175 cm) ρ is 1.2 g/cm^3 and μ/ρ is equal to 0.0622 g/cm^2 [1]. This results in the following:

$$5{,}000\ \gamma/\text{min} * e^{-[(0.0622)\cdot(1.2)\cdot(0.3175)]} = 4883\ \gamma/\text{min}$$

or 117 photons/min interact with the shield, which are assumed to produce 117 compton electrons per minute.

The angular differential cross-section for compton scattered photons is given by the following equation [2]:

$$\frac{d\sigma}{d\Omega} = Zr_o^2 \left(\frac{1}{1 + \alpha\,(1 - \cos\theta)}\right)^2 \left(\frac{1 + \cos^2\theta}{2}\right) \left(1 + \frac{\alpha^2(1 - \cos\theta)^2}{(1 + \cos^2\theta)\,[1 + \alpha(1 - \cos\theta)]}\right)$$

where α is $h\nu/m_oc^2$, which is 1.25/0.511 or 2.446, and θ is the scattered photon angle.

Using the preceding equation, the relative probability at incremented scatter angles was determined (letting $Zr_o^2 = 1$). Table 1 lists the calculated probabilities for photon scatter angles in increments of 5° (relative probability in column 1, photon scatter angle in column 2). To determine the compton electron scatter angle at each photon angle, the following equation was used [1]:

$$\cot\phi = (1 + \alpha)\tan\left(\frac{\theta}{2}\right)$$

where ϕ is the average compton electron scatter angle.

The average scatter photon energy, is given by the equation below [2]:

$$h\nu' = \frac{h\nu}{1 + \alpha\,(1 - \cos\theta)}$$

The average compton electron energy is then equal to (1.25 - hν') in MeV.

Using the preceding equations, the compton electron scatter angle, and scatter photon and electron energies are determined for each selected photon scatter angle. Table 1 shows the values calculated for each selected photon scatter angle.

The average photon and electron angles and energies are calculated by a weighted mean of the individual values (i.e., $\Sigma p_i V_i / \Sigma p_i$), where p_i is the relative probability of the ith value, V_i. The results are an average photon scatter angle of 45.0°, electron scatter angle of 48.9°, and electron energy of 0.387 MeV.

The range of 0.387 MeV electrons in plexiglass is conservatively estimated to be 0.15 g/cm^2 [3], which with an average scatter angle of 48.9°, indicates compton electrons within 0.082 cm of the detector could reach the detector (i.e., cos (48.9°)*0.15/1.2 = 0.082). This results in a correction factor of (0.082)/(0.3175) = 0.26 to account for compton electrons generated in the shield within range of the detector surface. Compton electrons potentially entering the shield then equates to (0.26)*(117) = 30 electrons/min. With a nominal detector efficiency of 20%, a 40% efficiency is assumed (to correct for the fact that all compton electrons are considered to be moving toward the detector). This results in a 12 cpm background count rate increase, which is below the counting error for a 1 minute background count yielding a result of 400 cpm (as typically observed with the LMI 43-68 detector).

Conclusion:

The preceding analysis, although average based, is considered reasonable and sufficiently conservative to provide an estimate of expected photon/shield induced background from licensed activity beneath the shield. The result indicates that contamination from licensed material beneath a plexiglass (or closely similar material) would not create a significant increase in background from photon/shield interactions (i.e., only about 3%). Calculations were specifically performed for a 1/8" shield; however, it should be evident that a larger shield thickness would not increase the contribution because once the secondary compton electron range is exceeded additional shield does not result in additional secondary particle detections.

This conclusion is further supported by the experimental data provided later in this review.

Table 1 - Compton Scattering Data For 1.25 MeV Gamma

Scatter Photon Angle Probability (relative)	Scatter Photon Angle (degrees)	Scatter Electron Angle (degrees)	Recoil Photon Energy (MeV)	Compton Electron Energy (MeV)	Product of Probability and Photon Angle	Product of Probability and Electron Angle	Product of Probability and Photon Energy	Product of Probability and Electron Energy
1.000	0.0	90.0	1.250	0.000	0.000	90.000	1.250	0.000
0.978	5.0	81.4	1.238	0.012	4.890	79.648	1.211	0.011
0.916	10.0	73.2	1.205	0.045	9.162	67.089	1.104	0.041
0.826	15.0	65.6	1.154	0.096	12.394	54.200	0.953	0.079
0.722	20.0	58.7	1.089	0.161	14.444	42.405	0.787	0.116
0.617	25.0	52.6	1.017	0.233	15.423	32.463	0.627	0.144
0.519	30.0	47.3	0.941	0.309	15.580	24.554	0.489	0.160
0.434	35.0	42.6	0.867	0.383	15.198	18.509	0.376	0.166
0.363	40.0	38.6	0.795	0.455	14.524	14.003	0.289	0.165
0.305	45.0	35.0	0.728	0.522	13.740	10.691	0.222	0.159
0.259	50.0	31.9	0.667	0.583	12.964	8.270	0.173	0.151
0.223	55.0	29.1	0.612	0.638	12.265	6.498	0.136	0.142
0.195	60.0	26.7	0.562	0.688	11.674	5.192	0.109	0.134
0.172	65.0	24.5	0.518	0.732	11.201	4.220	0.089	0.126
0.155	70.0	22.5	0.479	0.771	10.845	3.488	0.074	0.119
0.141	75.0	20.7	0.444	0.806	10.595	2.927	0.063	0.114
0.131	80.0	19.1	0.414	0.836	10.441	2.490	0.054	0.109
0.122	85.0	17.6	0.387	0.863	10.370	2.144	0.047	0.105
0.115	90.0	16.2	0.363	0.887	10.370	1.865	0.042	0.102
0.110	95.0	14.9	0.342	0.908	10.431	1.635	0.038	0.100
0.105	100.0	13.7	0.323	0.927	10.544	1.443	0.034	0.098
0.102	105.0	12.6	0.306	0.944	10.702	1.279	0.031	0.096
0.099	110.0	11.5	0.292	0.958	10.896	1.138	0.029	0.095
0.097	115.0	10.5	0.279	0.971	11.123	1.013	0.027	0.094
0.095	120.0	9.5	0.268	0.982	11.377	0.902	0.025	0.093
0.093	125.0	8.6	0.258	0.992	11.655	0.801	0.024	0.093
0.092	130.0	7.7	0.249	1.001	11.954	0.709	0.023	0.092
0.091	135.0	6.9	0.242	1.008	12.270	0.623	0.022	0.092
0.090	140.0	6.0	0.235	1.015	12.603	0.543	0.021	0.091
0.089	145.0	5.2	0.229	1.021	12.950	0.467	0.020	0.091
0.089	150.0	4.4	0.225	1.025	13.310	0.395	0.020	0.091
0.088	155.0	3.7	0.221	1.029	13.683	0.325	0.019	0.091
0.088	160.0	2.9	0.218	1.032	14.067	0.258	0.019	0.091
0.088	165.0	2.2	0.215	1.035	14.462	0.192	0.019	0.091
0.087	170.0	1.5	0.213	1.037	14.868	0.127	0.019	0.091
0.087	175.0	0.7	0.212	1.038	15.287	0.063	0.019	0.091
0.087	180.0	0.0	0.212	1.038	15.717	0.000	0.019	0.091
Weighted Average Values:	45.0	48.9	0.863	0.387				

2. Evaluation of Beta Shielding Effectiveness of 1/8" Plexiglass

Evaluation

When performing background measurements for plant surfaces and structures, a 1/8" thick slab of plexiglass is used to shield beta radiation. This corresponds to 381 mg/100cm^2 (i.e., 0.125"* 2.54 cm/"*1200 mg/cm^3 = 381 mg/cm^2). To verify the effectiveness of the shield for the detectable nuclides at FSV, the following analysis has been performed.

A 381 mg/100 cm^2 shield of plexiglass is conservatively estimated to stop up to 740 keV beta particles [3]. In other words, only particles with energy greater than 740 keV will be able to penetrate the shield. To determine percentage of beta particles from detectable contamination at Fort St. V'rain that would penetrate this amount of shielding, a decay distribution shape is assumed as shown in Figure 1 below superimposed on a typical (curved line) beta decay distribution (i.e., typical for β^- decay, which is decay scheme of interest at Fort St. Vrain, a β^+ decay distribution would involve a shift to higher energies due to Coulomb interaction with the nucleus) [2, 4].

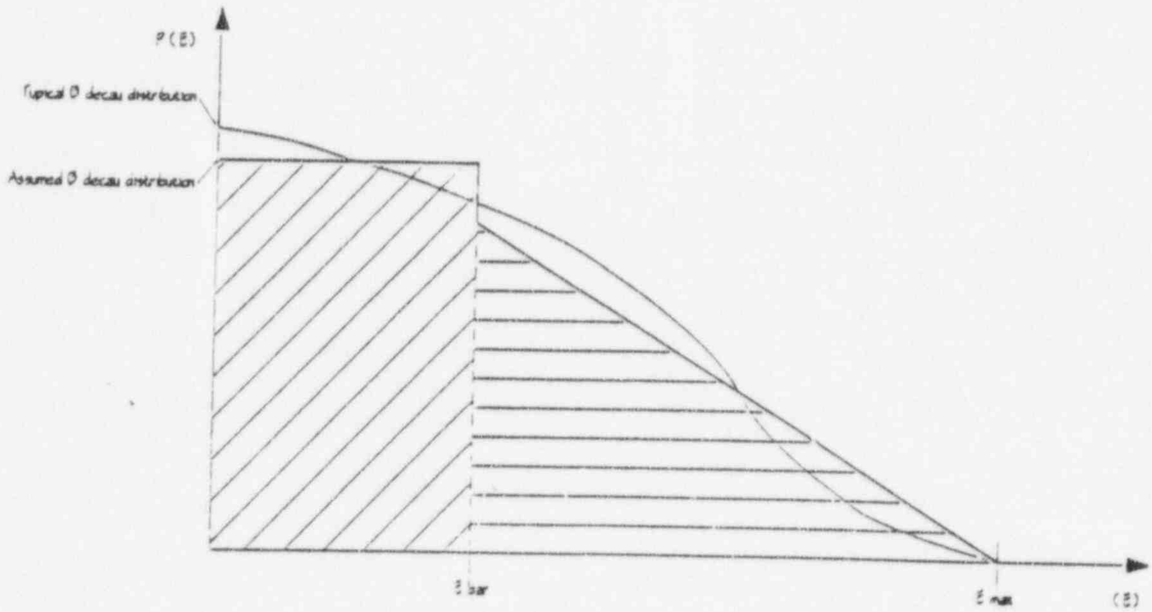

Figure 1 - Typical and Assumed β^- Decay Distributions

As seen in Figure 1, the distribution is assumed to be composed of two segments. The first segment assumes a uniform energy probability for beta particle energies up to Ebar. The second segment assumes a triangular shape terminating at Emax. Under each segment, the normalized area is defined to be 0.5, which, in effect, assumes that half the beta particles have energy below Ebar and half above Ebar. To determine attenuated area under the second segment of assumed distribution when Ebar is < 740 keV and Emax is > 740 keV, the following equation is used:

$$P(E) = P(Ebar) - \frac{P(Ebar)}{(Emax - Ebar)}(E - Ebar)$$

Since area under second segment of assumed distribution (i.e., triangular region) is by definition equal to 0.5, solving for area of the triangular region results in the following expression for P(Ebar):

$$P(Ebar) = \frac{1}{(Emax - Ebar)}$$

which by substitution results in the following expression for P(E):

$$P(E) = \frac{1}{(Emax - Ebar)} - \frac{(E - Ebar)}{(Emax - Ebar)^2}$$

Using this equation, attenuated area under second segment of assumed distribution can be determined for a given energy (i.e., 740 keV).

Assumptions used to determine attenuation for each decay line of a given radionuclide are as follows:

1) For beta particle distributions whose Ebar is greater than 740 keV, the fraction of beta particles that are attenuated by the shield is determined by:

$$\%\ attenuated = \left[\frac{740}{Ebar}\right] * 50$$

where Ebar is in keV.

2) Beta decay distributions whose Emax is < 740 keV and internal conversion and auger electron emissions whose mono-energetic energies are < 740 keV are attenuated 100% (internal conversion and auger electron emissions < 740 keV are grouped together with a summed abundance).

3) Internal conversion electron emissions with mono-energetic energies > 740 keV are not attenuated.

4) For beta particle distributions whose Ebar is less than 740 keV, but whose Emax is greater than 740 keV, the fraction of beta particles that are attenuated by the shield is determined by:

$$\%\ attenuated = 50 + 100 * \left(0.5 - \frac{(Emax - 740)\left[\dfrac{1}{(Emax - Ebar)} - \dfrac{(740 - Ebar)}{(Emax - Ebar)^2}\right]}{2}\right)$$

where Ebar and Emax are in keV.

Total attenuation for a given nuclide is given by weighted averaging of all individual decay lines of the nuclide (i.e., weighted by individual line abundances). Total attenuation for Fort St. Vrain nuclide mix is determined by weighted averaging of individual nuclide total attenuations where weight is based on fraction present in the average nuclide mix.

The following table lists specific radionuclides identified in "detectable" contamination at Fort St. Vrain and % attenuated for each decay line of the nuclide and total effective attenuation for the nuclide. These radionuclides are the values and fractions identified in the sample set used to determine SGLVs. Total attenuation for Fort St. Vrain contamination by 1/8" thick plexiglass is estimated at 99.4%.

Conclusion

The 1/8" thick plexiglass shield is adequate to shield beta emitters encountered at FSV. Attenuation was calculated to be over 99% for the average FSV nuclide composition as well as over 99% for key nuclides (i.e., Cs-137 and Co-60). The effectiveness of plexiglass to shield FSV beta has also been evaluated by experimental tests. The following section presents the results of this testing which included additional measurements by two SEG teams using both the normal plexiglass shield and a 0.2" thick steel shield.

Shielding Effectiveness of 1/8" Plexiglass Shield

Nuclide	Average Fraction of Nuclide	Mean # of Beta Particles per Decay	Ebar (keV) per Line	Emax (keV) per Line	% Beta Attenuated per Line	Overall % Attenuated per Nuclide
Co-60	0.62000	1.000	95.8 (100%)	317.9 (100%)	100.0	99.9
			1460 (0.12%)	1460 (0.12%)	0.0	
Sr-90	0.00234	2.000	195.8 (Sr-90, 100%)	546.0 (Sr-90)	100.0	67.3
			934.8 (Y-90, 100%)	2283.9 (Y-90)	34.5	
Cs-134	0.00746	1.015	23.1 (27.4%)	88.5 (27.4%)	100.0	99.8
			123.4 (2.48%)	415.1 (2.48%)	100.0	
			210.1 (70.1%)	657.9 (70.1%)	100.0	
			758.4 (0.22%)	758.4 (0.22%)	0.0	
			< 740 (1.28%)	< 740 (1.28%)	100.0	
Cs-137	0.15500	1.174	156.8 (94.6%)	511.6 (94.6%)	100.0	99.3
			415.2 (5.4%)	1173.2 (5.4%)	83.7	
			< 740 (17.4%)	< 740 (17.4%)	100.0	
Eu-152	0.19900	1.424	47.5 (1.78%())	176 (1.78%)	100.0	98.1
			112.5 (2.4%)	385 (2.4%)	100.0	
			221.8 (13.6%)	696 (13.6%)	100.0	
			227 (0.23%)	710 (0.23%)	100.0	
			295.3 (0.29%)	889 (0.29%)	96.9	
			364.8 (0.89%)	1064 (0.89%)	89.3	
			535.6 (8.44%)	1475 (8.44%)	70.1	
			< 740 (114.4%)	< 740 (114.4%)	100.0	
Eu-154	0.01480	1.838	68.8 (27.9%)	247.4 (27.9%)	100.0	96.8
			86.9 (0.77%)	306.1 (0.77%)	100.0	
			91.7 (0.149%)	321.2 (0.149%)	100.0	
			100.9 (1.58%)	349.8 (1.58%)	100.0	
			119.8 (0.117%)	407.4 (0.117%)	100.0	
			129.3 (0.281%)	435.7 (0.281%)	100.0	
			168.3 (0.188%)	548.6 (0.188%)	100.0	
			175.7 (36.5%)	569.4 (36.5%)	100.0	
			224.5 (0.64%)	703.2 (0.64%)	100.0	
			229 (0.245%)	715.4 (0.245%)	100.0	
			276 (17.4%)	839.2 (17.4%)	98.4	
			327.5 (2.0%)	970.7 (2.0%)	93.6	
			400.4 (0.29%)	1151.5 (0.29%)	85.0	
			587.4(0.24%)	1596 (0.24%)	64.0	
			695 (11.4%)	1843.9 (11.4%)	53.8	
			< 740 (83.6%)	< 740 (83.6%)	100.0	
Tc-99	0.00168	1.000	84.6 (100%)	293.6 (100%)	100.0	100.0
				Overall Attenuation (%) =		**99.4**

3. Experimental Testing

Review of Comparison Survey Data

Comparison measurements were previously taken (at time of NRC visit) at four locations by two survey teams. A summary of the corrected results is provided in the table below.

	SEG Team 1 Result (dpm/100cm²)	SEG Team 2 (dpm/100cm²)	Difference (dpm/100cm²)
Battery Room	729.8	828.2	98.4
Lube Oil Room	-133.7	-82.5	51.1
Rx Bld - #2500	2199.5	2476.5	277
Rx Bld - #5000	4334.7	4212.7	122

To determine if the measured differences are statistically significant, means testing can be performed using the following equation:

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_1^2}{n} + \frac{s_2^2}{n}}}$$

When this is calculated for each of the survey locations surveyed for the comparison study the following values for t and corresponding probability are obtained.

Survey Location	Calculated t value	Probability*
Battery Room	0.964	37 %
Lube Oil Room	0.676	51 %
Rx Bld - #2500	1.944	7 %
Rx Bld - #5000	0.942	38 %

* Probability (as shown) is the probability that the observed difference or greater between data sets would be observed even if taken from the same population (i.e., 95% confidence requires that the probability be ≥ 5%).

As shown in the table, comparison data at each location was in statistical agreement (at 95% confidence). These values were calculated using the sample standard deviation listed with the mean net result for all but the Rx Bld - #2500 location. For the Rx Bld - #2500 location, an initial calculation yielded a t value of 2.579 and corresponding probability of 1.9%. However, the initial calculation (i.e., using the sample standard deviation of the net results) did not allow for background measurement uncertainty (because the sample standard deviation associated with the net results are each corrected with the same background value). When background uncertainty was included, the results of the previous table were obtained. The total uncertainty of each comparison result would also include the uncertainty of the efficiency determination, but including this uncertainty was not necessary to show agreement between the comparison data.

Additional Testing

Despite the understandable differences with the initial comparison survey data, re-survey of the initial comparison locations was performed by two independent SEG survey teams. Two additional locations of higher surface activity were also selected for evaluation. Each team surveyed each location using both the normal plexiglass shield (381 mg/cm^2) and a 0.2" thick slab of steel (about 4,000 mg/cm^2). Unshielded and shielded measurements were also taken one meter from the location surface to provide additional information. Contact background readings (i.e., 6 measurements) were taken in the immediate area surrounding the survey location. The results of these surveys are provided in the attached tables.

Measurements were also taken by placing the shields (including a third thin metal shield) over a Tc-99 (pure beta emitter) and a Co-60 gamma source to evaluate the shield materials. Although desired to also evaluate a Cs-137 source, this nuclide also emits gamma and, as was noted by the Co-60 source response, would not provide any meaningful information as the nuclides gamma penetrates the shields.

Conclusion

Significant differences in survey data between plexiglass and steel shields was not observed. Comparisons between Team 1 and Team 2 survey results were also acceptable. As shown on each table, a 95% confidence allowed difference was calculated by allowing for counting uncertainty in background, gross and efficiency measurements. Efficiency uncertainty was included for these measurements because some measurements were also taken at higher surface activity locations and as activity increases the absolute counting uncertainty decreases but the absolute uncertainty due to efficiency increases. With two comparisons at each location (i.e., one with steel shielding and one with plexiglass shielding) 12 total comparisons have been made. Only one comparison (i.e., the Battery Room with steel shields) was slightly outside of 95% confidence. With 95% confidence, a failure rate of 1 in 20 is expected. Therefore, a 1 in 12 failure rate is not surprising (actually the odds are greater that there would be a 1 in 12 failure than 0 in 12).

The evaluation of the shields effectiveness to shield Tc-99 beta indicated that significant beta does not penetrate the shields. Evaluations with the Co-60 source resulted in an expected decrease in count rate with increasing shield thickness.

SEG MEASUREMENT COMPARISON

SEG Team 1 Download 1099 Battery Room (Background)	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	436	344	276	236	248	288
	424	332	284	284	252	288
	420	376	224	280	240	240
	440	316	276	256	260	288
	388	368	272	264	292	200
	404	312	264	296	296	248
	412	352				
	536	392				
	432	316				
	416	300				
Std Dev	40.1	30.8	21.6	21.7	23.7	36.0
Mean	430.8	340.8	266.0	269.3	264.7	258.7
Efficiency	0.225					
Net Result with Plexiglass Shield (dpm/100cm2)			586.0	Net Result with Steel Shield (dpm/100cm2)		590.7

SEG Team 2 Download 1100 Battery Room (Background)	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	636	408	352	396	336	288
	636	384	388	280	400	348
	480	428	300	300	344	292
	556	384	384	336	316	292
	612	392	312	364	340	316
	528	348	360	304	300	256
	604	408				
	548	456				
	576	420				
	532	428				
Std Dev	51.3	30.2	36.5	43.9	34.1	30.8
Mean	570.8	405.6	349.3	330.0	339.3	298.7
Efficiency	0.219					
Net Result with Plexiglass Shield (dpm/100cm2)			809.0	Net Result with Steel Shield (dpm/100cm2)		845.5

Comparisons:		
Beta Shield	Plexiglass	Steel
Team 1	586.0	590.7
Team 2	809.0	845.5
Difference	223.1	254.8
95% Delta	236.7	249.4

SEG MEASUREMENT COMPARISON

SEG Team 1 Download 1099 Lube Oil Room	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	436	304	280	256	212	252
	468	340	224	256	208	232
	492	304	260	292	260	184
	472	356	288	272	192	248
	428	324	320	304	252	220
	444	316	320	312	260	264
	400	336				
	404	320				
	496	352				
	400	340				
Std Dev	36.8	18.5	36.8	24.2	30.1	28.7
Mean	444.0	329.2	282.0	282.0	230.7	233.3
Efficiency	0.225					
Net Result with Plexiglass Shield (dpm/100cm2)			-10.0	Net Result with Steel Shield (dpm/100cm2)		167.8

SEG Team 2 Download 1100 Lube Oil Room	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	508	436	340	284	312	300
	480	380	356	308	328	364
	508	376	344	280	296	316
	536	380	268	184	292	212
	516	408	336	328	304	352
	496	444	404	344	280	316
	624	436				
	532	408				
	468	452				
	548	380				
Std Dev	43.7	30.1	43.7	56.6	16.7	53.8
Mean	521.6	410.0	341.3	288.0	302.0	310.0
Efficiency	0.219					
Net Result with Plexiglass Shield (dpm/100cm2)			-150.5	Net Result with Steel Shield (dpm/100cm2)		-43.3

Comparisons:		
Beta Shield	Plexiglass	Steel
Team 1	-10.0	167.8
Team 2	-150.5	-43.3
Difference	140.5	211.1
95% Delta	262.2	275.3

SEG MEASUREMENT COMPARISON

SEG Team 1 Download 1099 Rx Bld Lv 9 (2500	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	1032	476	420	352	344	348
	880	484	304	328	308	324
	1076	360	324	264	288	360
	912	372	308	412	296	296
	1068	376	380	372	344	364
	980	432	312	368	328	308
	968	412				
	1004	336				
	888	408				
	972	460				
Std Dev	69.5	51.0	47.6	50.1	24.2	28.2
Mean	978.0	411.6	341.3	349.3	318.0	333.3
Efficiency	0.225					
Net Result with Plexiglass Shield (dpm/100cm2)			1677.7	Net Result with Steel Shield (dpm/100cm2)		1756.0

SEG Team 2 Download 1100 Rx Bld Lv 9 (2500	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	1096	392	504	424	380	424
	920	500	428	364	364	316
	984	460	440	384	392	380
	1032	520	444	352	452	416
	1188	472	404	404	372	372
	1052	480	392	432	344	344
	1020	496				
	1076	464				
	1096	384				
	1092	484				
Std Dev	72.9	44.4	39.3	32.3	37.0	41.4
Mean	1055.6	465.2	435.3	393.3	384.0	375.3
Efficiency	0.219					
Net Result with Plexiglass Shield (dpm/100cm2)			1456.8	Net Result with Steel Shield (dpm/100cm2)		1607.8

Comparisons:		
Beta Shield	Plexiglass	Steel
Team 1	1677.7	1756.0
Team 2	1456.8	1607.8
Difference	220.9	148.1
95% Delta	360.3	336.2

SEG MEASUREMENT COMPARISON

SEG Team 1 Download 1099 Rx Bld Lv 9 (~5k)	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	1600	368	332	380	356	316
	1520	384	340	420	332	256
	1600	356	412	300	292	300
	1432	352	408	392	340	308
	1648	384	388	356	340	316
	1500	364	432	376	308	340
	1620	364				
	1472	480				
	1660	436				
	1768	366				
Std Dev	101.3	40.8	40.8	40.5	23.6	27.9
Mean	1582.0	385.6	385.3	370.7	328.0	306.0
Efficiency	0.225					
Net Result with Plexiglass Shield (dpm/100cm2)			3668.8	Net Result with Steel Shield (dpm/100cm2)		3868.0

SEG Team 2 Download 1100 Rx Bld Lv 9 (~5k)	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	1624	452	384	416	464	336
	1688	420	432	364	368	360
	1648	368	444	408	380	368
	1784	160	480	380	500	356
	1676	504	432	352	384	344
	1788	524	464	352	380	372
	1540	464				
	1812	352				
	1736	528				
	1628	484				
Std Dev	87.0	60.4	33.0	27.9	55.2	13.9
Mean	1692.4	455.6	439.3	378.7	412.7	356.0
Efficiency	0.219					
Net Result with Plexiglass Shield (dpm/100cm2)			3768.4	Net Result with Steel Shield (dpm/100cm2)		3829.3

Comparisons:		
Beta Shield	Plexiglass	Steel
Team 1	3668.8	3868.0
Team 2	3768.4	3829.3
Difference	99.6	38.6
95% Delta	449.7	424.0

SEG MEASUREMENT COMPARISON

SEG Team 1 Download 1099 Rx Bld Lv 9 (~10k	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	3132	524	404	304	316	296
	2940	392	312	332	368	344
	3036	396	312	364	248	384
	2916	408	408	332	360	280
	3064	400	380	312	308	312
	3056	500	348	280	324	328
	3168	384				
	3124	460				
	2988	420				
	3136	396				
Std Dev	86.6	49.4	43.3	28.8	43.0	37.1
Mean	3056.0	428.0	360.7	320.7	320.7	324.0
Efficiency	0.225					
Net Result with Plexiglass Shield (dpm/100cm2)			8997.4	Net Result with Steel Shield (dpm/100cm2)		9134.9

SEG Team 2 Download 1100 Rx Bld Lv 9 (~10k	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	3316	460	364	328	468	320
	3052	480	416	476	380	300
	3592	384	424	328	396	348
	3232	404	436	372	424	272
	3364	552	472	428	376	376
	3100	508	372	368	464	356
	3200	444				
	3168	528				
	3208	476				
	3336	476				
Std Dev	154.3	51.9	40.5	58.4	40.9	38.7
Mean	3256.8	471.2	414.0	383.3	418.0	328.7
Efficiency	0.219					
Net Result with Plexiglass Shield (dpm/100cm2)			9575.7	Net Result with Steel Shield (dpm/100cm2)		9524.5

Comparisons:		
Beta Shield	Plexiglass	Steel
Team 1	8997.4	9134.9
Team 2	9575.7	9524.5
Difference	578.3	389.6
95% Delta	737.5	732.6

SEG MEASUREMENT COMPARISON

SEG Team 1 Download 1099 Rx Bld Lv 9 (~15k	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	5028	404	412	320	280	376
	5132	496	336	380	364	328
	5252	400	320	348	320	272
	5168	420	312	332	380	356
	5156	428	344	344	428	332
	5064	420	408	408	408	304
	5116	416				
	4952	392				
	5108	408				
	5160	484				
Std Dev	83.2	35.1	43.8	32.7	55.3	36.9
Mean	5113.6	426.8	355.3	355.3	363.3	328.0
Efficiency	0.225					
Net Result with Plexiglass Shield (dpm/100cm2)			16332.3	Net Result with Steel Shield (dpm/100cm2)		16299.1

SEG Team 2 Download 1100 Rx Bld Lv 9 (~15k	Unshielded Meas. Contact (cpm)	Unshielded Meas. 1 meter (cpm)	Shielded Meas. (plexiglass) Contact (cpm)	Shielded Meas. (plexiglass) 1 meter (cpm)	Shielded Meas. (steel) Contact (cpm)	Shielded Meas. (steel) 1 meter (cpm)
	4792	504	352	404	464	348
	5072	520	420	444	424	332
	5104	396	368	348	424	332
	4812	440	392	304	448	336
	4896	512	392	388	388	392
	5056	400	428	412	484	516
	5228	456				
	5120	488				
	5104	480				
	5196	412				
Std Dev	152.7	46.9	29.2	50.0	34.0	72.3
Mean	5038.0	460.8	392.0	383.3	438.7	376.0
Efficiency	0.219					
Net Result with Plexiglass Shield (dpm/100cm2)			16162.7	Net Result with Steel Shield (dpm/100cm2)		15955.7

Comparisons:		
Beta Shield	Plexiglass	Steel
Team 1	16332.3	16299.1
Team 2	16162.7	15955.7
Difference	169.6	343.4
95% Delta	1049.4	1069.7

Source and Background Measurements from 2.4 nCi Tc-99 Source

Shield Material	Background (cpm)	Shielded Source (cpm)
Plexiglass (1/8")	384 ± 20	388 ± 11
Steel (0.2")	365 ± 19	363 ± 11
Sheet Metal (0.08")	348 ± 19	377 ± 11

Source and Background Measurements from 1 μCi Co-60 Source

Shield Material	Background (cpm)	Shielded Source (cpm)
Plexiglass (1/8")	283 ± 17	9,291 ± 56
Steel (0.2")	293 ± 17	6,168 ± 45
Sheet Metal (0.08")	322 ± 18	10,104 ± 58

Summary of Results

1.) Analytical calculations performed to verify the choice of plexiglass as a shield material indicate photon interactions with the shield are not significant.

2.) The 1/8" thickness of plexiglass used is sufficient to provide adequate beta shielding to correct gross measurements.

3.) After evaluating the initial and follow-up comparison survey data in consideration of all statistical factors, the results are within agreement (at 95% confidence). There was not a significant difference between plexiglass and steel as a background shield material, which further supports the choice of plexiglass as a shield material for background measurements.

References

1. Attix, F.H., "Introduction to Radiological Physics and Radiation Dosimetry", John Wiley & Sons, New York, 1986.

2. Knoll, G.F., "Radiation Detection and Measurement", John Wiley & Sons, New York, 1989.

3. Lederer et.al., "Table of Isotopes" 7th edition, John Wiley & Sons, New York, 1978.

4. Krane K.S., "Introductory Nuclear Physics", John Wiley & Sons, New York, 1988.

PSCo/WT Response to Unresolved Item 267/9601-01

Part 2

Evaluation of Local Area Background Variations As Surface Activity Increases

Evaluation of Local Area Background Variations As Surface Activity Increases

Where gamma emitting radionuclides are present, the local area background may increase as surface activity increases due to gamma interaction with the detector. However, this will not result in an underestimate of net survey results because surface activity is quantified in terms of the detector response to beta radiation. On average, one disintegration of FSV surface activity will emit one beta particle (slightly more than one "beta" when conversion electrons are included). Tc-99, a pure beta emitter with an average energy of 85 keV and having an intensity of 1, is used as the calibration source. Therefore, the number of disintegrations per unit time is correctly determined by quantifying the number of beta particles emitted per unit time from the surface.

When considering gamma radiation as a component of local area background, three possibilities related to interaction exist: (1) gamma radiation passes through the shield and the detector without interaction, (2) gamma radiation passes through the shield without interaction, but does interact with the detector, and (3) gamma radiation interacts with the shield.

1. For instances where gamma radiation passes through the shield and the detector without interaction there is no effect on the shielded or the unshielded measurement due to photon interaction. This would be the ideal condition when quantifying surface activity based on the response of the detector to the beta radiation. For this condition, there would be no effect on the net measurement result.

2. For local area background measurements collected with the detector shield in place, gamma radiation passing through the shield without interaction, but interacting with the detector, would cause a slight increase in the detector response to the local area background (gamma efficiency is approximately 1 to 2 percent). This condition would be identical to subsequent measurements collected without the detector shield in position. For this condition, there would be no effect on the net measurement result.

3. For local area background measurements collected with the detector shield in place, gamma radiation interacting with the shield such that secondary radiation interacts with the detector, but the gamma radiation does not interact with the detector, a slight increase in the detector response to the local area background

could occur. For this condition, there would be no significant effect on the net measurement result.[1]

Evaluations were also performed to determine if using different detector shields would cause significantly different responses. The results of measurements collected by two survey teams (i.e., Team 1 and Team 2) were used for this testing. This evaluation included the effect of photon interactions with plexiglass (the material used for detector shields). Results of these evaluations, and a comparison of the Team 1 and Team 2 measurement results are included in Part 1 of this response discussion.

In summary, the evaluation indicates that local area background measurements collected using steel shields were generally slightly lower than local area background measurements collected using plexiglass shields. This is as expected since a greater fraction of gamma radiation is shielded by the steel. The reduction in the local area background measurement caused by the use of a steel shield would amplify any high bias caused by using the plexiglass shield due to the larger differential in the gamma flux for subsequent measurements collected without the shield in position.

Overall, there was not a statistically significant difference in net results collected using the plexiglass or steel shields due to the low detection efficiency for gamma radiation and the minimal amount of secondary radiation detected. Therefore, background measurement protocols and the use of plexiglass as the background shield are appropriate.

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[1] The fraction of the photons interacting with the shield, and the effect of any secondary radiation produced as a result of this photon interaction has been evaluated and determined to be approximately 3 percent for contamination levels at the SGLV. This is less than our typical counting error of $\pm$ 10 percent (1 standard deviation). Refer to Part 1 of this response discussion for the details of this evaluation.

NRC Concern 1:

Determine whether there is a bias in instrumentation response which overestimates the amount of contamination present.

PSCo/WT Response:

The basis for this concern is a side-by-side measurement comparison performed by PSCo and ORISE at FSV. At the time of the comparison, several concerns were expressed by PSCo related to the method of efficiency determination, the method used to assign background values, and the calibration parameters used by ORISE. At the conclusion of the comparison measurements, information related to the above, and the individual gross measurement results were requested by PSCo in order to adequately evaluate the relative responses of the instrumentation used for the side-by-side measurement comparison. In the absence of this information, only a limited evaluation of the relative response can be performed. This evaluation focused on the effects of differing source-to-detector geometry used during efficiency determination.

The method of efficiency determination used by PSCo includes positioning the source at a distance of approximately 1/8" from the detector; and evaluating the response across 3 regions of the sensitive area. (e.g., the heel, the center and the toe of the detector) Positioning the source at a distance of approximately 1/8" from the detector is intended to more closely match the counting geometry encountered during field measurements. (e.g., face plate thickness prevents survey surfaces from contacting the screen, irregular surfaces, etc.). Evaluating the response across 3 regions of the sensitive area is intended to define the efficiency of the LMI 43-68 detector over the entire detector area, and to ensure uniform response within the established bounds.

It is understood that the method of efficiency determination used by ORISE includes positioning the source on contact with the detector at approximately the midpoint of the sensitive area. This method should result in a greater solid angle of detection than the average solid angle over the entire detector area, and would not evaluate the response of the detector across the entire sensitive area. PSCo evaluated the effect on the detection efficiency by using each of the above methods.

Results of testing indicate that the detection efficiency can be increased by as much as 10% (relative) by placing the source on contact with the detector at approximately the midpoint of the sensitive area. (e.g., a 20% efficiency becomes 22%). This would cause ORISE measurement results to be biased low by as much as 10% relative to the PSCo measurement results.

To determine if the differences in the methods used for efficiency determination explain the discrepancy between PSCo and ORISE measurement results, the results of the side-by-side measurements were reviewed. For the two locations where licensed surface activity was present, the ORISE measurement results were about 18% lower than the PSCo measurement results. Therefore, although measured efficiency differences would explain about half of this difference, there is apparently additional bias present.

Although limited comparison data was taken, review of the side by side measurement results revealed that ORISE detectors consistently yielded a lower response than PSCo detectors. The lower response was observed for all measurements (i.e., average gross, background and net results). The lower results reported by ORISE is indicative of lower detection efficiency than PSCo detection efficiency, although ORISE detectors are assumed to be more efficient. In order to determine the cause of lower response by ORISE detectors, information concerning ORISE instrument parameter settings (e.g., plateaus/operating voltages, cable lengths, threshold settings, etc.) would be needed. Although one might expect specific parameter differences between detectors to be accounted for in the calibration, this cannot be confirmed unless specific differences are known and tested. Additionally, differences will not be accounted for when measuring licensed material if different calibration techniques are used (e.g., threshold setting, source position(s), source construction, back scattering correction, etc.).

By reporting higher measurement results than ORISE, PSCo measurement results are conservative (relative to ORISE) assuming that ORISE measurement results are not biased low significantly. This condition will not result in inappropriate classification and/or inappropriate conclusions regarding suitability for release for unrestricted use. If further explanation is required, or to allow more efficient evaluation of future comparison measurements, specific details concerning comparison instrument parameters and calibration techniques are required.

PSCo side-by-side measurement comparisons with GPUN were also evaluated. Better agreement was obtained between PSCo and GPUN than was observed between PSCo and ORISE. Raw measurement results were very consistent between PSCo and GPUN. When corrected for efficiency, GPU results were about 6 to 7 percent lower than PSCo results. This minor discrepancy is within PSCo efficiency determination tolerances (± 10 percent) and shows PSCo survey methods to be more conservative. For information, the GPUN Comparison Data is attached to this response.

Based on the above evaluation, PSCo does not consider that there is a bias in PSCo instrumentation response which overestimates the amount of contamination present.

GPUN Comparison Data

TURBINE BUILDING - LEVEL 5
BATTERY ROOM - CONCRETE FLOOR

Location Number	Sample Number	Count Time	GPUN	SEG	GPUN	SEG	GPUN	SEG
			cts/15 sec/125 cm2		cpm/125 cm2		dpm/100 cm2	
Battery Room	1	15	127	148	508	592	1822	2310
Battery Room	2	15	167	155	668	620	2396	2420
Battery Room	3	15	160	143	640	572	2296	2232
Battery Room	4	15	155	137	620	548	2224	2139
Battery Room	5	15	157	154	628	616	2253	2404
Battery Room	6	15	139	152	556	608	1995	2373
Battery Room	7	15	146	145	584	580	2095	2263
Battery Room	8	15	138	155	552	620	1980	2420
Battery Room	9	15	170	135	680	540	2439	2107
Battery Room	10	15	159	174	636	696	2282	2716
		AVERAGE	152	150	607	599	2178	2339

GPUN Comparison Data

ELECTRICAL WAREHOUSE - #14
CONCRETE FLOOR

Location Number	Sample Number	Count Time	GPUN	SEG	GPUN	SEG	GPUN	SEG
			cts/15 sec/125 cm2		cpm/125 cm2		dpm/100 cm2	
Electrical Shop	1	15	N/T	205	N/T	820	N/T	3200
Electrical Shop	2	15	N/T	194	N/T	776	N/T	3028
Electrical Shop	3	15	N/T	202	N/T	808	N/T	3153
Electrical Shop	4	15	N/T	212	N/T	848	N/T	3309
Electrical Shop	5	15	N/T	201	N/T	804	N/T	3138
Electrical Shop	6	15	N/T	189	N/T	756	N/T	2950
Electrical Shop	7	15	212	188	848	752	3042	2935
Electrical Shop	8	15	201	172	804	688	2884	2685
Electrical Shop	9	15	170	158	680	632	2439	2466
Electrical Shop	10	15	195	188	780	752	2798	2935
Electrical Shop	11	15	180	183	720	732	2583	2857
Electrical Shop	12	15	187	187	748	748	2683	2919
Electrical Shop	13	15	193	187	772	748	2770	2949
Electrical Shop	14	15	197	184	788	736	2827	2872
Electrical Shop	15	15	194	176	776	704	2784	2747
Electrical Shop	16	15	196	192	784	768	2813	2997
Electrical Shop	17	15	174	183	696	732	2497	2857
Electrical Shop	18	15	215	169	860	676	3085	2638
Electrical Shop	19	15	169	168	676	672	2425	2622
Electrical Shop	20	15	169	168	676	672	2425	2622
		AVERAGE	189	185	758	741	2718	2892

N/T = NOT TAKEN, SEG AND ORISE SURVEY OF THESE POINTS HAD BEEN COMPLETED PRIOR TO OUR ARRIVAL AT ELECTRICAL WAREHOUSE #14. THESE POINTS HAD NOT BEEN MARKED, HENCE GPUN COULD NOT PERFORM A REPLICATE SURVEY AT THESE LOCATIONS.

GPUN Comparison Data

REACTOR BUILDING - LEVEL 3
RESIN CHANGE OUT AREA - CONCRETE FLOOR

Location Number	Sample Number	Count Time	GPUN	SEG	GPUN	SEG	GPUN	SEG
			cts/15 sec/125 cm2		cpm/125 cm2		dpm/100 cm2	
RESIN CHANGE OUT AREA	1	15	364	326	1456	1304	5223	5089
RESIN CHANGE OUT AREA	2	15	942	1008	3768	4032	13517	15735
RESIN CHANGE OUT AREA	3	15	421	400	1684	1600	6041	6244
RESIN CHANGE OUT AREA	4	15	324	311	1296	1244	4649	4855
RESIN CHANGE OUT AREA	5	15	333	366	1332	1464	4778	5713
RESIN CHANGE OUT AREA	6	15	392	419	1568	1676	5625	6540
RESIN CHANGE OUT AREA	7	15	398	378	1592	1512	5711	5900
RESIN CHANGE OUT AREA	8	15	1515	1481	6060	5924	21740	23118
RESIN CHANGE OUT AREA	9	15	439	465	1756	1860	6300	7259
RESIN CHANGE OUT AREA	10	15	336	337	1344	1348	4822	5260
RESIN CHANGE OUT AREA	11	15	487	467	1948	1868	6988	7290
RESIN CHANGE OUT AREA	12	15	2137	1989	8548	7956	30665	31048
RESIN CHANGE OUT AREA	13	15	490	521	1960	2084	7031	8133
RESIN CHANGE OUT AREA	14	15	349	407	1396	1628	5008	6353
RESIN CHANGE OUT AREA	15	15	1449	1350	5796	5400	20793	21073
RESIN CHANGE OUT AREA	16	15	711	662	2844	2648	10203	10334
RESIN CHANGE OUT AREA	17	15	346	335	1384	1340	4965	5229
RESIN CHANGE OUT AREA	18	15	961	1018	3844	4072	13790	15891
RESIN CHANGE OUT AREA	19	15	694	665	2776	2660	9959	10380
RESIN CHANGE OUT AREA	20	15	326	323	1304	1292	4678	5042
	AVERAGES		671	661	2683	2646	9624	10324

NRC Concern 2:

Determine whether corrections for "hard to detect nuclides" (HTDNs) should be made to survey results in unaffected areas that exceed 25 percent of the surface contamination limits.

PSCo/WT Response:

PSCo does not believe that the FSV Final Survey Plan and procedures should be revised to account for HTDNs when contamination is found in unaffected areas.

For unaffected areas where licensed material is not expected, the guideline values (GLV) are the levels included in Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors, which are 5,000 dpm/100 cm^2 (average) and 15,000 dpm/100 cm^2 (maximum). The FSV Final Survey Plan requires the following for unaffected areas:

- Surveys will be conducted with instruments having an MDA less than 25% of the GLV (1,250 dpm/100 cm^2).

- An investigation will be performed if greater than 10% of the measurements exceed 25% of the GLV (1,250 dpm/100 cm^2), or if any one individual measurement indicates the presence of licensed material in excess of 50% of the GLV (2,500 dpm/100 cm^2).

- If as a result of the investigation, greater than 25 percent of the measurements are verified to exceed 25% of the GLV (1,250 dpm/100 cm^2), or if any one individual measurement is verified to indicate the presence of licensed material in excess of 50% of the GLV (2,500 dpm/100 cm^2), the area will be reclassified as affected.

In affected areas, site-specific guideline values (SGLV) have been established which account for the presence of HTDNs. The FSV SGLVs are 4,000 dpm/100 cm^2 (average) and 12,000 dpm/100 cm^2 (maximum). In affected areas, an investigation is performed for individual measurements in excess of 75 percent of the SGLV (3,000 dpm/100 cm^2).

The only effect of using the existing, uncorrected GLVs for unaffected survey units is slightly different action levels. Using corrected release limits for unaffected areas would result in total surface activity reclassification action levels of 2,000 dpm/100 cm^2 (individual measurement) and 1,000 dpm/100 cm^2 (greater than 25% of the measurements), versus the current requirements of 2,500 dpm/100 cm^2 (individual measurement); and 1,250 dpm/100 cm^2 (greater than 25% of the measurements).

PSCo considers that the current action level of 2,500 dpm/100 cm^2 (50% of the GLV) for reclassification of unaffected areas is sufficient for the following reasons:

- Licensed material is not expected in unaffected areas;

- The action level provides sufficient margin to ensure that areas do not exceed the SGLV of 4,000 dpm/100 cm^2;

- The 25% GLV (1,250 dpm/100 cm^2) action level for 10% of the measurements in unaffected areas is less than the 75% SGLV (3,000 dpm/100 cm^2) action level for 10% of the measurements for suspect affected areas;

- The 50% GLV (2,500 dpm/100 cm^2) action level for individual measurements in unaffected areas is less than the 100% SGLV (4,000 dpm/100 cm^2) action level for individual measurements for suspect affected areas; and

- Revising the action level to 2,000 dpm/100 cm^2 to account for HTDNs would require revisions to procedures, training plans, and numerous release records that are nearly complete. PSCo does not consider that this effort is justified.

NRC Concern 3:

Determine whether investigations of suspect measurements were adequately conducted to justify removing the original measurement from the survey data base.

PSCo/WT Response:

PSCo believes that the documentation describing the investigation and disposition of the measurement results in the referenced survey packages is adequate. In all instances, the investigation states that the initial result could not be duplicated, that the initial result would be removed from the measurement set used for statistical evaluation, and that the additional measurements would instead be included for statistical evaluation.

FSV Final Survey Plan for Site Release, Section 3.8.11, Investigation, describes the general considerations for conducting an investigation, and for the disposition of measurement results depending upon the outcome of the investigation.

For instances where investigative actions include the collection of additional fixed point measurements, a scan survey is performed at the initial measurement location and surrounding surfaces to identify the presence of elevated activity. The additional measurements are then collected at the initial measurement location and from the surrounding surfaces, ensuring that a measurement is also collected from any location of elevated activity identified during the scan.

The initial measurement result of final survey may be removed from the measurement set used for statistical evaluation in the event that the result cannot be duplicated at the same survey measurement location, appears to be an anomaly, or investigative actions determine that the result is unlikely to be due to licensed material. For such instances, the initial measurement result is not simply excluded from the Final Report, rather the initial measurement result is referenced in the text of the Investigation section of the Final Report. The additional measurements collected during the investigation are then substituted for the initial result, included in the statistical evaluation, and are considered by PSCo to be most representative of the final condition.

NRC Concern 4:

Determine whether scan survey coverage percentage in nonsuspect affected areas should be increased.

PSCo/WT Response:

The minimum requirements for final survey of unaffected survey units is defined by the FSV Final Survey Plan for Site Release as follows:

> " ... a scan of approximately 10% of the accessible surface area *comprising floors and walls below 2 meters*, ...
>
> | | |
> |---|---|
> | For survey units ≤1500 square meters | A minimum of 30 measurement locations |
> | For survey units >1500 square meters | A minimum of 1 measurement location for each 50 square meters surveyed." |

The minimum requirements for final survey of non-suspect affected survey units is defined by the FSV Final Survey Plan for Site Release as follows:

> " ... non-suspect affected survey units *above 2 meters* ...
>
> | | |
> |---|---|
> | For survey units ≤600 square meters | A minimum of 30 measurement locations |
> | For survey units >600 square meters | A minimum of 1 measurement location for each 20 square meters surveyed." |

For non-suspect affected survey units, the minimum frequency established for fixed point measurements of total surface activity is 1 measurement per 20 square meters. This is implemented at FSV through the performance of a scan survey over an area of not less than 1 square meter at each measurement location to identify the location of highest residual activity, at which the fixed point measurement is then collected. This practice results in a minimum scan fraction of 5% of the surfaces included in non-suspect affected survey units.

PSCo believes that the minimum scan fraction established in the FSV Final Survey Plan for Site Release for non-suspect affected survey units is adequate based on the following additional considerations.

1. For unaffected survey units, there is no requirement to perform scan surveys on the upper walls and ceiling surfaces as is required for non-suspect affected survey units which are by definition, comprised of upper wall and ceiling surfaces. Instead, the approach for unaffected survey units involves the selection of those surfaces to be included in the scanned fraction from those surfaces having the highest potential for residual activity. (e.g., floor and lower wall surfaces)

2. Similarly, in affected areas, the floor and lower wall surfaces are considered as having the highest potential for residual activity and are classified as suspect affected. These surfaces receive 100% scan survey coverage, which is far in excess of the minimum scan coverage required for unaffected survey units.

3. For non-suspect affected survey units, FSV has implemented the practice of collecting the fixed point measurements at the locations of highest activity identified within the scanned fraction. This serves to ensure that locations where significant residual activity exists will be included in the measurement set for comparison against the Administrative Action Levels.

4. FSV has established Administrative Action Levels for individual measurement results, and for the average of the measurement results collected from within a given survey unit. These action levels are based on a fraction of the site-specific guideline value established for affected survey units at FSV. Measurement results in excess of the action levels serve to initiate investigative actions. Investigative actions often include additional scan survey and fixed-point measurements which result in an increase in the scan fraction in excess of the minimum requirement for instances where residual activity is present.

5. Prior to final survey, the surfaces above 2 meters within affected areas are routinely scanned during the performance of Characterization and/or Remediation surveys. These surveys are performed where the potential exists for residual activity (e.g., the identification of significant activity on the floor and lower wall surfaces, the identification of airborne radioactivity, the incidence of leaks or spills, etc.). The extent of the scan survey is dependent upon the magnitude of the residual activity found on the floor and lower wall surfaces, and upon the results of the scan survey performed on upper wall and ceiling surfaces. In the event that residual

activity is identified on upper wall and ceiling surfaces at levels which approach the action levels for final survey, the scope of the Characterization survey is increased. Although the minimum scanned fraction is currently not formally defined for Characterization and/or Remediation surveys, and is dependent upon the results of these scan surveys, these surveys also serve to increase confidence that residual activity above 2 meters has been adequately characterized.